https://doi.org/10.22319/rmcp.v15i3.5702

Article

Effect of grazing, cutting, and irrigation on the production and nutritional value of Buffelgrass

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Abstract:

This study aimed to determine the effect of the type and intensity of utilization of buffelgrass grown under natural rainfall or irrigation conditions on the production and nutritional value of the dry matter. Sixteen plots (64 m^2 each) were grazed by Charolais cattle to obtain a utilization intensity of 50 % (GR 50) or 75 % (GR 75). Eight plots (40 m^2 each) were hand-cut up to 50 % (CU 50). The annual forage harvest was higher ($P \leq 0.05$) for GR 50 than for CU 50 (1,491 *vs* 954 kg DM/ha). No differences ($P \geq 0.05$) were found in dry matter production per hectare between GR 50 and GR 75 (1,707 *vs* 1,491 kg DM/ha). Irrigation increased dry matter production by 22 % ($P \leq 0.05$) compared to rainfed conditions (1,524 *vs* 1,245 kg DM/ha). There were no differences ($P > 0.05$) due to the type and intensity of utilization in the content of CP, NDF, and ADF; however, ADF increased ($P \leq 0.05$) in irrigated plots. In the same way, the *in vitro* digestibility of

DM was higher ($P \leq 0.05$) in CU 50 than in grazing plots GR 50 and G75 (55.7, 53.0, and 52.7 %). Finally, it can be conclude that buffelgrass production increased with grazing, but the IVDDM was better in hand-cut forage.

Keywords: Grazing, Irrigation, Rainfed conditions, Buffel.

Received: 15/09/2020

Accepted: 06/06/2024

Introduction

For livestock farmers, the rational use of forage resources is of great importance; one of the grass species that prevails is buffelgrass (*Cenchrus ciliaris* L); this grass is widely grown in tropical and subtropical areas around the world due to its high tolerance to drought and the ability to withstand intensive grazing(1). Its development in the semi-arid Northeast of Mexico intensified and reached, after its introduction in the fifties of the twentieth century, at least 500,000 ha in the state of Nuevo León(2).

During grazing, forage is not uniformly removed from all stems, as is the case with that harvested by mechanical cutting(3). In addition, animals produce indirect effects such as soil compaction and recycling of nutrients from manure and urine(4). On the other hand, the cutting intensity can generate differences in photosynthetic activity, influencing biomass production(5). The determination of the optimal amount of residual forage is of fundamental importance to establish the limits of grazing, taking care that the plant retains enough forage for adequate production and storage of reserves for the next regrowth; the production of forages also depends largely on the water that is stored in the soil and reaches it through rain or irrigation. In the same way, by intensifying grazing, stem reforestation is promoted, and the highest values can occur with a medium and high grazing intensity(6). This work aimed to evaluate the effect of different grazing, cutting, and irrigation conditions on the production and nutritional value of buffelgrass.

Material and methods

The work was carried out in the Experimental Field of the Faculty of Agronomy of the Autonomous University of Nuevo León (FAUNL, for its acronym in Spanish), located at 25° 52' N and 100° 03' W, and with an altitude above sea level of 393 m. The reports of the last 10 yr from the FAUANL meteorological station indicate that the average temperature for September (the date of the start of the experiment) is slightly higher than that of the present work (26.3 °C). The average for January, in which the lowest temperatures were recorded, was 14.1 °C, and the maximum monthly average corresponds to June with 29.4 °C.

The total rainfall during this work was 386 mm. For the last 10 yr, the station recorded an average rainfall of 355 mm, 8 % lower than that recorded in this work. The soils are calcareous, and the texture is sandy loam to clay loam.

The experiment was conducted over 10 months distributed over two calendar years (September to July); by virtue of the above, there are three records: the first in the autumn of the first year (A1Y) and the second and third in the summer (S2Y) and autumn of the second year (A2Y). Out of 24 plots, half were irrigated (I), and the other half were used under rainfed conditions (R). Of the 12 plots used under rainfed conditions, four received moderate grazing at 50 % utilization (GR 50), another four plots received intense grazing at 75 % utilization (GR 75), and the remaining four received moderate cutting at 50 % utilization (CU 50); in all cases the grazing was continuous. The grazing plots had 8 x 8 m (64 m^2) dimensions, while the cutting plots measured 8 x 5 m (40 m^2). The 12 irrigated plots were assigned to the previous treatments but with the application of 70 mm of irrigation water per m^2 on two dates: first at the beginning of autumn and second at the beginning of spring.

Grazing intensity at 50 % utilization of available forage was achieved using two animals of the Charolais breed; the animals were two-year-old males weighing approximately 400 kg. Three animals with similar characteristics were used for grazing at 75 % utilization of the available dry matter. The cutting at 50 % utilization was done manually at the same time as the grazing of the plots. A first cut was made to standardize the plots (FC), and the treatments were applied two months later (autumn cut of the first year; A1Y), subsequently (5 months later) a cut was made in summer (S2Y), and finally, another in autumn of the second year (5 months later, A2Y).

To determine the dry matter per hectare (DM/ha) of forage available before each use (Pre), the amount of forage was recorded in each plot in two areas of one square meter taken randomly by cutting the grass at ground level to weigh it immediately. After cutting or grazing, the data corresponding to after cutting or grazing (Post) were recorded.

The dried samples were ground in a Willey mill with a 2 mm sieve and stored at room temperature for chemical analysis. The amount of dry matter of forage in each experimental plot before (Pre) and after (Post) use (cutting or grazing) was determined by weighing a representative sample of the cut forage and drying it in an oven at 62 °C for 48 h. Forage production was calculated as the difference between the quantity recorded after each use (post) and before (pre) the next. The utilization intensity was calculated by dividing the amount of forage recorded after (post) each use and before (pre) it.

The grass samples from the cutting and grazing plots were analyzed to determine their contents of dry matter, ash[7], and crude protein (CP) by the Kjeldahl method[8]. The contents of neutral detergent fiber (NDF) and acid detergent fiber (ADF) and *in vitro* digestibility of dry matter (IVDDM) were also analyzed[9,10].

During the 10 months of the experiment, soil moisture content was determined biweekly. To do this, a site from each plot was randomly selected, and a soil sample was extracted at a depth of 30 cm with the help of an auger. The samples obtained were placed in glass jars, weighed on a scale, and taken to an oven at 100 °C for 48 h; then, they were weighed to calculate the content and gravimetric moisture[11].

$$Gravimetric\ moisture\ (\%) = \frac{Wetsoilmass - drysoilmass}{drysoilmass} x100$$

The results obtained were analyzed under a split-block design; this arrangement is used when evaluating two factors, and both can be assessed more easily in large plots. The SPSS program was used[12]. The effect of the type of utilization (cutting and grazing), the intensities of utilization (50 and 75 % utilization), and moisture levels (irrigation and rainfed) on the production of dry matter and nutritional value of buffelgrass was evaluated. For each treatment, four replications were performed. The statistical model used was:

Yijk= μ + βi + Lj t Eij(a) + Hk + Eik(b) + (LH)jk + Eijk(c)

Yijk is the observation of the type or intensity j at the level k of moisture in block i;
μ is the overall true mean;
βi is the effect of block i, i= 1,2 r;
Lj is the effect of the level j of type or intensity, j= 1,2 a;
Eij(a) is the experimental error of the ij-th plot for the types or intensities;
Hk is the effect of the moisture level k, k= 1,2 b;
Eik(b) is the experimental error of the ik-th plot for moisture levels;
LHjk is the effect of the interaction of the type or intensity j and the moisture k;
Eijk(c) is the experimental error of the ijk-th subplot.

Results

Table 1 presents the data before the assignment of each treatment, the amount of forage used in the first treatment (FC), and its residue. What was initially planned as GR 50, CU 50, and GR 75 resulted in the use of FC in actual utilization rates of 57 % for moderate grazing, 54 % for moderate cutting, and 71 % (69 % under rainfed conditions and 73 % under irrigation) for intense grazing ($P \leq 0.05$).

Table 1: Available, residual, and used forage, and intensity of utilizations of the plots assigned to each treatment prior to the start of the experiment (kg DM/ha)

Factor	Available forage	Residual forage	Used forage	% Utilization
GR 50	4,167[a]	1,805[a]	2,362[a]	57[b]
CU 50	3,892[a]	1,792[a]	2,100[a]	54[b]
GR 75	3,974[a]	1,172[a]	2,802[a]	71[a]

GR 50= moderate grazing at 50 % utilization; CU 50= moderate cutting at 50 % utilization; GR 75= intensive grazing at 75 % utilization.
[ab] Different letters in the same column indicate significant differences ($P < 0.05$).

Table 2 shows the data on available, residual, and used forage for the three periods into which the experiment was divided: autumn of the first year, summer of the second year, and autumn of the second year. The forage available for use in A1Y was similar ($P > 0.05$) for the plots assigned to the different treatments; the amount of residual forage was different ($P \leq 0.05$) for GR 50, CU 50, and GR 75.

Table 2: Available, residual, and used forage, and intensity of utilization according to type and intensity of utilization (kg DM/ha)

Factor	Available forage	Residual forage	Used forage	% Utilization
		Autumn of the first year=A1Y		
GR 50	2365[a]	822[a]	1543[a]	64[a]
CU 50	1809[a]	509[b]	1300[a]	72[a]
GR 75	1842[a]	557[b]	1285[a]	70[a]
		Second and third cut in summer= S2Y		
GR 50	3147[a]	1397.5[a]	1749.5[a]	56[b]
CU 50	2425[a]	1077[a]	1348[a]	56[b]
GR 75	2871[a]	737.5[a]	2134.5[a]	74[a]
		Autumn of the second year= A2Y		
GR 50	3581[a]	1663[a]	1919[a]	54[a]
CU 50	2895[a]	1476[a]	1419[a]	49[a]
GR 75	3636[a]	1294[a]	2343[a]	65[a]

GR 50= moderate grazing at 50 % utilization; CU 50= moderate cutting at 50 % utilization; GR 75= intensive grazing at 75 % utilization.
[ab] Different letters in the same column indicate significant differences ($P \leq 0.05$).

For the use in S2Y, what was initially planned as GR 50, CU 50, and GR 75 resulted in actual utilization rates of 56 % for moderate grazing, 56 % for moderate cutting, and 74 % for intense grazing ($P \leq 0.05$). For A2Y utilization, the amounts of forage available before (Pre) utilization were similar ($P > 0.05$) for GR 50 and GR 75, and CU 50. For that same season, what was initially planned as GR 50, CU 50, and GR 75 resulted in actual utilization rates of 54 % for moderate grazing, 49 % for moderate cutting, and 65 % for intense grazing ($P \geq 0.05$).

On average, for the 10 months of the experiment, what was initially planned as GR 50, CU 50, and GR 75 resulted in actual utilization rates of 57 % for moderate grazing, 58 % for moderate cutting, and 70 % for intense grazing.

Forage production in the period between the first cut (FC) and the autumn of the first year (A1Y), between A1Y and the summer of the second year (S2Y), and finally, between S2Y and the autumn of the second year (A2Y), for each of the six treatments established is shown in Table 3.

Table 3: Buffelgrass production by type and intensity of utilization (kg DM/ha)

Factor	**FC-A1Y**	**A1Y-S2Y**	**S2Y-A2Y**	**Total**
GR 50	559[a]	1,604[a]	2,184[a]	4347[a]
CU 50	18[b]	1,280[a]	1,818[a]	3,115[b]
GR 75	670[a]	1,587[a]	2,899[a]	5,155[a]

GR 50= moderate grazing at 50 % utilization; CU 50= moderate cutting at 50 % utilization; GR 75= intensive grazing at 75 % utilization.

[ab] Different letters in the same column indicate significant differences ($P \leq 0.05$).

The forage production recorded according to the type of utilization (moderate cutting or grazing) between FC and A1Y (2 mo) was minimal, as there was a decrease in soil temperature and moisture due to an absence of precipitation. In the period between A1Y and S2Y and between S2Y and A2Y, forage production under the two types and intensities of grazing was similar ($P \geq 0.05$).

For the three seasons of utilization, plots used in moderate grazing (GR 50) produced, on average, 26 % more forage ($P<0.05$) than CU 50. Likewise, the total forage produced in more intensive grazing (75 %) was 16 % higher ($P>0.05$) than that produced in moderate grazing (50 %).

Table 4 shows the values of forage production under irrigation and rainfed conditions. In the FC-A1Y period (2 months), there was a higher forage production ($P \leq 0.05$) in the irrigated plots compared to the rainfed plots (890 *vs* -59 kg DM/ha). This can be explained by the fact that even with a drop in temperature in the autumn months (average values of 13 °C were recorded for November), soil moisture increased considerably in irrigated plots (soil moisture values were 23 % in irrigated plots, compared to values of 13 % in rainfed plots).

Table 4: Buffelgrass production according to moisture level (kg DM/ha)

Factor	FC-A1Y	A1Y-S2Y	S2Y-A2Y	Total
Irrigation	890[a]	1514[a]	2272[a]	4676[a]
Rainfed	-59[b]	1466[a]	2328[a]	3735[b]

[ab] Different letters in the same column indicate significant differences ($P \leq 0.05$).

The effect of irrigation was mainly seen in the period from FC (first cut to standardize the plots) to A1Y and the total for the entire period (Table 4). For AIY-S2Y and S2Y-A2Y, dry matter production both under irrigation and rainfed conditions was similar. The total rainfall for the 10 mo was 386 mm; the highest levels occurred in week 4 of October of A1Y with 55 mm and between May and June of the second year, just before the cut of the S2Y, with rainfall that varied between 16 and 116 mm. The presence of rainfall at that year's season equaled these two markers. In total, for the three periods in the study years, 21 % more forage ($P<0.05$) was produced due to irrigation than in the rainfed plots.

The interaction of the factors indicated that the highest total forage production (10 mo duration in two calendar years) corresponded to the most intense grazing that received irrigation, with 5,585 kg DM/ha; 50 % grazing with irrigation produced 4,896 kg, and intense grazing under rainfed conditions produced 4,622 kg. The lowest forage productions were recorded in rainfed and irrigated moderate cutting, with 2,788 and 3,444 kg, respectively. There were no statistical differences for the interaction of the factors.

Table 5 presents the average nutritional values of buffelgrass before and after grazing in each of the established treatments. It includes both rainfed and irrigated treatments.

Table 5: Average values for the entire experiment of crude protein CP, neutral NDF and acid detergent fiber ADF, and *in vitro* digestibility of dry matter IVDDM of buffelgrass according to the type and intensity of utilization and moisture level

Factor	Moisture level	CP		NDF		ADF		IVDDM	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
GR 50	Rainfed	6.7	6.6	74.3	79.6	43.8	46.0	53.4	49.9
GR 50	Irrigation	6.7	6.4	77.7	78.5	46.2	47.7	52.6	48.5
CU 50	Rainfed	6.8	5.9	75.6	77.1	43.9	45.3	56.0	52.2
CU 50	Irrigation	6.7	6.5	76.9	76.0	45.3	47.5	54.9	49.1
GR 75	Rainfed	7.4	5.4	73.9	79.2	43.7	46.1	53.0	50.6
GR 75	Irrigation	6.8	6.5	73.7	78.5	45.3	47.1	52.5	46.6

GR 50= moderate grazing at 50 % utilization; CU 50= moderate cutting at 50 % utilization; GR 75= intensive grazing at 75 % utilization
($P>0.05$).

No significant differences were recorded for CP either before or after grazing at any season of the year. The difference in CP in irrigated plots compared to rainfed meadows was insignificant. The NDF content of forage produced in rainfed and irrigated plots was higher after use than before use for all periods of the experiment (Table 5). On the other hand, the NDF content for forage in GR 50, CU 50, and GR 75 was higher after each use (post) compared to the values found before (pre) use in all study periods. After use, the grass NDF content in the cut plots was lower than in the grazed plots. The highest value for NDF was recorded in GR 50 after use in rainfed meadows in S1Y, with 80.9 %. The lowest NDF values were recorded in GR 75 before use in A1Y and A2Y, with 73.7 %.

For the three seasons of the year and on average for the entire study period, the content of NDF before use was lower than that recorded after use for the types and intensities of utilization. The proportion of stems is higher than that of leaves after the plants are grazed or cut.

For NDF, it is highlighted that, in the autumn of the second year of study (data not shown), the NDF content in the grass before its use was similar ($P>0.05$) for GR 50, CU 50, and GR 75, with 75.6, 75, and 74.9 %, respectively. After use, CU 50 recorded lower values of NDF ($P<0.05$) than those of GR 50 and GR 75 (76.5, 79.1, and 78.8 %, respectively).

The grass ADF content in GR 50, CU 50, and GR 75 plots was lower before than after use, both for irrigation and rainfed conditions, at all seasons of the two years of study; however, there were no statistical differences. In general, before use, the average ADF content of rainfed plots was 43.8 %, and that of irrigated plots was 45.6 % ($P<0.05$). After use, the average ADF content under rainfed conditions was 45.8, and under irrigation, it was 47.4 ($P<0.05$). The highest value for ADF was recorded in CU 50 plots subjected to irrigation after use in A1Y, with 49.5; on the other hand, the minimum value was recorded in GR 75 in rainfed plots in A2Y, with 42.2.

The buffelgrass ash content before and after each use, in each of the three periods of the experiment and on average, was similar ($P\geq0.05$) for type and intensity of utilization and moisture level.

In general, the IVDDM recorded lower values before than after use. Before the autumn use, there were higher values ($P<0.05$) of IVDDM for GR 50 (59.3 %) and CU 50 (60.3 %) compared to GR 75 (56.4 %). Before use in the autumn of 2000, IVDDM values of CU 50 were higher ($P<0.05$) than those recorded for GR 50 and GR 75 (53, 50.2, and 50.2 %, respectively). After use, the values were higher ($P<0.05$) for GR 50 (48.8 %) and for GR 75 (47.4 %) compared to CU 50 (45.9 %). Before use, the average IVDDM of buffelgrass was higher ($P<0.05$) in CU 50 (55.7 %) than the values of GR 50 (53 %) and GR 75 (52.7 %). After use, the average IVDDM was 50.6 % for CU 50, 49.2 % for GR 50, and 48.6 % for GR 75 ($P\geq0.05$).

In A1Y, 56.7 % of IVDDM was recorded in rainfed plots after moderate cutting, while irrigated plots registered 52.0 % ($P<0.05$). At the same intensity of utilization and after it, in S2Y, the rainfed plots recorded 52.4, while irrigated plots recorded 42.4 ($P<0.05$). Before use, the average IVDDM was higher ($P<0.05$) in CU 50 (55.5 %) compared to GR

50 (53 %). After use, there was no statistical difference in rainfed plots compared to irrigated plots. In A1Y, the highest value for IVDDM was recorded before use in CU 50 and in rainfed plots, with 61.0; in contrast, in S2Y, the lowest value was recorded after use in GR 75 and in irrigated plots, with 42.4 %.

Discussion

In the present study, plots subjected to moderate grazing produced 35 % more dry matter than plots subjected to cutting. When grazing, cattle tend to be more selective in choosing the consumed parts of the plant, improving the renewal of the grasses and their palatability; on the other hand, the forage harvested by mechanical cutting is more uniform[(4)]. Animals trample, move seeds and minerals, and select when and how they eat; likewise, the populations of nitrogen-fixing bacteria may be in greater quantity in grazed meadows than in cut meadows[(13)].

The selective consumption of certain plants depends on external and intrinsic factors of the animal that modulate the consumption behavior. The factors affecting consumption behavior and selectivity are those of the animal, social factors, and environmental factors[(14)]. Compared to cut plants, higher production of grazed plants may be due to greater photosynthetic activity caused by a higher incidence of light and microclimate changes resulting from different cutting heights in grazed plants. In cutting, its uniformity means that lower parts of the plant are left without photosynthesis, as light does not penetrate[(3)].

Intensive cutting or grazing affects the production of new shoots either by the elimination of organic reserves or non-structural carbohydrates located in the stems and crowns or by lack of leaf area for the resumption of photosynthesis[(15)]. In the same way, a higher forage production in grazed plots can also be explained by a greater exchange of CO_2 as a result of greater light penetration and a warmer microclimate near the soil surface[(16)]. Increasing grazing intensity promotes stem reforestation, and the highest values were recorded at medium and high grazing intensity[(6)].

Large herbivores affect plants by removing biomass, but also due to indirect effects on soil microorganism communities; grazing causes a decrease in vegetation cover, a reduction in organic matter, and with it, changes in the soil microbiome; this produces a reduction of nutrients, mainly phosphorus and nitrogen[(17)]. One of the alternatives to increase the concentration of nitrogen is the application of manure; in a study that evaluated the effect of pig manure on the yield of *Cenchrus americanus*, they reported no differences in growth between fertilized and unfertilized forage, but they did report a protein increase in the fertilized forage in addition to higher concentrations of nitrogen in the soil[(18)].

In the case of cattle, the amount of manure excreted per animal unit can be 5 to 6 t of fresh matter per hectare when using rotational grazing. However, trampling influences the soil, which could increase its bulk density (compacting it), decreasing its aeration and, therefore, decreasing soil moisture retention(19). In the present study, buffelgrass produced 62 % more forage when used under grazing than cutting (2,750 *vs* 1,700 kg DM/ha). A little further north, in Pennsylvania, the Trailblazer species produced only 8 % more when grazing it compared to two cuts per year; however, the Cave-in-Rock and Shawnee species produced more forage by cutting them two and three times per year compared to grazing(20).

On the other hand, when studying the influence of grazing on soil characteristics, it was found that rotational grazing positively influenced physical characteristics by not increasing bulk density values, keeping penetration resistance values low, increasing porosity, and producing a lower average pore radius size compared to continuous grazing. These characteristics would also be positively affected in mechanical cutting(21). In this study, more intense grazing (GR 75) recorded a 16 % increase in dry matter compared to less intense grazing. When cutting buffelgrass in a greenhouse at 4, 8, 12, and 16 cm, respectively, it was found that it produces the highest forage yield when cut twice a week at 8 cm. Plants harvested at 12 and 16 cm caused a greater increase in the accumulation of dead material(22).

In *Cenchrus ciliaris* and *Chloris gayana*, cutting significantly increased the crude protein content and the digestibility of the organic matter; in contrast, the ash and lignin contents decreased by increasing the cutting frequencies(23). In the present study, due to irrigation, 31 % more forage ($P\leq0.05$) was produced than in rainfed plots (1,558 *vs* 1,245 kg DM/ha). By using a sprinkler irrigation system at different percentages of evo transpiration, a maximum of 28 t/ha of dry matter were reported in 12 cuts per year(24). The results suggest that forage quality depends on various factors such as species, soil, season of the year, temperature, water availability, and solar radiation, among others. In livestock production, low forage quality may be associated with low forage consumption and low livestock behavior. Ideal pasture management is achieved when the quality and quantity available to the animals is maximized.

As for nutritional quality, the first aspect to determine is the effect of grazing intensity. In the present study, there was no statistical difference in CP, NDF, ADF, and IVDDM; however, more intense grazing was recorded in rainfed pastures, 10 % more CP (7.4 *vs* 6.7 %). In *Dactylis glomerata* L., under two grazing intensities (severe: 3 to 5 cm and light: 6 to 8 cm residual forage height), there were similar values of protein and digestibility. A significant effect was only observed during autumn ($P\leq0.05$), with severe grazing showing the highest IVDDM (64 *vs* 56 %)(25).

Minerals are a key element for plant growth in addition to being essential for animal feeding; in *Cenchrus purpureus*, it was reported that the total contents of ash, magnesium, and phosphorus were variable, contrary to nitrogen, which decreased with regrowth;

however, the magnesium and phosphorus contents were below what was required for plant growth[26]. On the other hand, in *Trifolium repens* under intense grazing, there was an increase in protein in forage (17.4 %) compared to that produced in plots subjected to moderate grazing (14.9 %); in contrast, no differences were found in ADF content when it was subjected to moderate or intense grazing (26.2 and 25.6 %, respectively)[27].

In the present study, there was no difference in nutritional quality when the type of utilization (cutting or grazing) was compared. There was an increase in CP of plots already grazed compared to those already cut and when these were not irrigated (6.6 *vs* 5.9 %). Similar values of CP and NDF digestibility of trailblazer grass subjected to cutting or grazing were reported. The authors only reported differences in both cutting and grazing for NDF. In this regard, the biggest changes in both yield and nutritional quality are due to the climate and crop management[20].

An increase in soil moisture due to rain or irrigation directly impacts the fiber content and, therefore, the digestibility of forages. In *Stipa grandis* P. Smirn. and *Leymus chinensis* (Trin.) Tzvel., from Mongolia, an increase of 0.1 g kg^{-1} in the digestibility of cellulose from organic matter was reported for every 50 mm increase in precipitation and a decrease of 0.1 g kg^{-1} of NDF[28]. In the present work, the NDF content was higher (P>0.05) in rainfed plots compared to irrigated plots.

Regarding grazing intensity, they only observed a significant effect during autumn ($P\leq0.05$), with severe grazing recording the highest IVDDM (64 *vs* 56 %). This can be attributed to the higher proportion of green leaves and a lower percentage of dead material present in the most severe grazing[25]. In the present work, the digestibility values were practically the same in the two grazing intensities. In a study conducted by Ordaz-Contreras *et al*[26] with King grass (*Pennisetum purpureum* Schumach), a decrease in protein was reported as the cutting interval increased. Finally, the height of the cut did not affect the percentages of ash, NDF, and ADF in Guinea [*Megathyrsus maximus* (Jaqc.)], Tanzania, and Mombasa pastures[29].

Conclusions and implications

It can be concluded that a grazing intensity of 70 % exercised for two years did not affect the productivity of buffelgrass compared to that recorded with an intensity of 57 %. The nutritional values of buffelgrass subjected to these two grazing intensities were similar. There was a higher forage production when buffelgrass was used for moderate grazing compared to moderate cutting. Plots subjected to moderate cutting registered higher values for IVDDM than those obtained with moderate grazing. In the cumulative for the two years of study, irrigation produced more forage (22 %) than non-irrigated meadows. When grazing was compared at different intensities of utilization, more intense grazing produced 14 % more forage than moderate grazing, with no significant differences between the two.

Acknowledgments

To the CONAHCyT 28623-B project and to Elías Martínez, José Juan Nava, and Benjamín Pérez for their collaboration in the fieldwork.

Literature cited:

1. Marshall VM, Lewis MM, Ostendorf B. Buffel grass (*Cenchrus ciliaris*) as an invader and threat to biodiversity in arid environments: A review. J Arid Environ 2012;(78):1-12.

2. Gómez E, Díaz H, Saldívar A, Briones F, Vargas V, Grant WE. Patrón de crecimiento de pasto buffel (*Pennisetum ciliare* Sin. *Cenchrus ciliaris* L.) en Tamaulipas, México. Téc Pecu Méx 2007;45(1):1–17.

3. Wallace LL. Comparative photosynthetic responses of big bluestem to clipping versus grazing. J Range Manage 1990;(43):58-61.

4. Bilotta GS, Brazier RE, Haygarth PM. The impacts of grazing animals on the quality of soils, vegetation, and surface waters in intensively managed grasslands. Adv Agron 2007;(94):237-280.

5. Velásquez MK, Bartolomé FJ, López BK. Efecto de la intensidad de corte y actividad fotosintética en el crecimiento de grama (*Paspalum notatum Flüggé*) en el trópico seco centroamericano (Mesas de Moropotente, Nicaragua). Rev Cient FAREM-Estelí 2014;(11):39-46.

6. Garduño S, Pérez J, Hernández A, Herrera J, Martínez P, Torres J, Bertín M. Rendimiento y dinámica de crecimiento estacional de ballico perenne, pastoreado con ovinos a diferentes frecuencias e intensidades. Téc Pecu Méx 2009;47(2):189-202.

7. American Association of Cereal chemists- AACC. Approved methods of the American Association of Cereal Chemists. 930.22. 9th ed. St Paul: AACC 1995.

8. American Association of Cereal chemists- AACC. Approved methods of the American Association of Cereal Chemists. 950.63. 9th ed. St Paul: AACC 1995.

9. Van Soest PJ, Robertson JB, Lewis BA. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J Anim Sci 1991;(74):3583-3597.

10. Tilley MA, Terry RA. A two stage for the *in vitro* digestion of forage crops. J British Grassl Soc 1963;(18):104-111.

11. Muñoz JA, Rodríguez HM, Rodríguez MP, Cano A. Rivera M. Efecto de la labranza de conservación sobre la humedad y la densidad aparente de un suelo. AGROFAZ 2014;14(2):39-44.

12. IBM Corp. Released IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. 2017.

13. Delgadillo J, Ferrera R, Galvis A, Hernández A, Cobos MA. Fijación biológica de nitrógeno en una pradera de trébol hubba/ballico de corte o de pastoreo. Terra Latinoam 2005;(23):73-79.

14. Tarazona AM, Ceballos MC, Naranjo JF, Cuartas CA. Factores que afectan el comportamiento de consumo y selectividad de forrajes en rumiantes. Rev Colombiana Cienc Pecu 2012;25(3):473-487.

15. Rincón A, Ligarreto GA, Garay E. Producción de forraje en los pastos *Brachiaria decumbens* cv. Amargo y *Brachiaria brizantha* cv. Toledo, sometidos a tres frecuencias y a dos intensidades de defoliación en condiciones del Piedemonte llanero colombiano. Rev Facul Nal Agr Medellín 2008;61(1):4336-4346.

16. Owensby CE, Ham JM, Auen LM. Fluxes of CO2 from grazed and ungrazed tallgrass prairie. Rangeland Ecol Manag 2006;59:111-127.

17. Silva-Bejarano C, Garcillán PP. Variabilidad temporal de la producción de praderas de zacate buffel (*Cenchrus ciliaris* L.) en regiones áridas. Ecosistemas y recursos agropecuarios 2016;3(9):357-366.

18. Ojo VOA, Adeshina FT, Adetokunbo GA, Jimoh SO, Adeyemi TA, Njie JL, Onifade OS. Effects of swine manure application and row spacing on growth of pearl millet (*Cenchrus americanus*) during the establishment period and quality of silage produced in Southwest Nigeria. Tropical Grasslands 2020;8(2):115-124.

19. Estupiñán LH, Gómez JE, Barrantes VJ, Limas LF. Efecto de actividades agropecuarias en las características del suelo en el páramo "El Granizo" (Cundinamarca - Colombia). Rev U.D.C.A 2009;12(2):79-89.

20. Sanderson M. Upland switchgrass yield, nutritive value, and soil carbon changes under grazing and clipping. Agron J 2008;(100):510-516.

21. Chairez F, Iñiguez L, Salinas H, Flores MJ, Aw-Hassan A, Serna Al, Meza-Herrera C. Hacia un enfoque de investigación participativa para mejorar los sistemas de producción de caprinos en regiones semiáridas de México: una caracterización socioeconómica y ecológica. Rev Chapingo, Serie Cienc Forest Amb 2011;(17):131-146.

22. Beltrán LS, Hernández GA, García ME, Pérez PJ, Kohashi SJ, Herrera HJG. Efecto de la altura y frecuencia de corte en el crecimiento y rendimiento del pasto buffel (*Cenchrus ciliaris* L.) en un invernadero. Agrociencia 2005;39(2):137-147.

23. Tuffa S, Hoag D, Treydte AC. Clipping and irrigation enhance grass biomass and nutrients: Implications for rangeland management. Acta Oecol 2017:(81):32–39.

24. Mazahrih N, Al Wahaibi H, Al Farsi S. Ouled BA. Yield and water productivity of Buffel and Rhodes grasses under different irrigation water regimes using the sprinkler line source system. Grassl Sci 2016;(62):112-118.

25. Villareal JA, Hernández A, Martínez PA, Guerrero J D, Velasco ME. Rendimiento y calidad de forraje del pasto ovillo (*Dactylis glomerata* L.) al variar la frecuencia e intensidad de pastoreo. Rev Mex Cienc Pecu 2014;5(2):231-245.

26. Ordaz-Contreras R, Sosa-Montes E, Mendoza-Pedroza SI, Améndola-Massiotti RD, Reyes-Castro S, Ortega-Jiménez E, Hernández-Garay A. Composición química del pasto king grass (*Pennisetum purpureum* Schumach) a diferente intervalo de corte. AGROProductividad 2018;11(5):134-140.

27. Mosquera M, González A, Rigueiro A. Sward quality affected by different grazing pressures on dairy systems. J Range Manage 2000;(3):603-610.

28. Schönbach P, Wan H, Gierus M, Loges R, Müller K, Lin L, Susenbeth A, Taube F. Effects of grazing and precipitation on herbage production, herbage nutritive value and performance of sheep in continental steppe. Grass Forage Sci 2012;67(4):535-545.

29. Patiño RM, Gómez R, Navarro OA. Calidad nutricional de Mombasa y Tanzania (*Megathyrsus maximus*, Jacq.) manejados a diferentes frecuencias y alturas de corte en Sucre, Colombia. Rev CES Med Zootec 2018;13(1):17-30.