



FORAGE YIELD, ELONGATION RATE AND BOTANICAL COMPOSITION OF *Lolium multiflorum* LAMB. IN RESPONSE TO DIFFERENT GRAZING INTERVALS AND INTENSITIES †

[RENDIMIENTO DE FORRAJE, TASA DE ELONGACIÓN Y COMPOSICIÓN BOTÁNICA DE *Lolium multiflorum* LAMB. EN RESPUESTA A DIFERENTES INTERVALOS E INTENSIDADES DE PASTOREO]

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SUMMARY

Background. The intensity and grazing interval are two very important factors in the management of grasslands that can affect the morphological and productive behavior of the forage species. Due to its productivity and persistence to grazing, ryegrass (*Lolium multiflorum* Lamb.) is the main source of pasture for backgrounding cattle during winter-spring in northwestern México. Therefore, it is important to generate knowledge of established pasture with grasses to generate information that will serve producers to improve the economic profitability of livestock activities. **Objective.** The objective of this study was to evaluate the influence of grazing intensity (GI) and grazing interval (GIv) on forage yield, elongation rate and botanical composition of ryegrass, under ambient conditions of this arid region. **Hypothesis.** It is evident to observe that GIv and GI modify the forage yield, elongation rate and botanical composition of *L. multiflorum* established in irrigated grassland in temperate climate zones. **Methodology.** The study involved 1008 crossed bull calves (*Bos indicus* × *Bos taurus*) of 16 months of age. Calves were distributed in a 3 × 2 factorial arrangement in an RCB design, with three repetitions. Three GIv (21, 28 and 35-d) and two GI (grazed to 4 to 6 cm vs 10 to 12 cm) were evaluated. This 105-d trial was initiated on January 16, 2019, 90 days post-planting and finished on May 01, 2019, using an intensive grazing system with stocking rate of 56 calves per ha. The main effects of grazing interval were evaluated by means of orthogonal polynomials. **Results.** Forage yield increased linearly ($P < 0.01$) with increasing GIv; whereas with GIv of 28 and 35 days, yield increased with increased GI (interaction, $P < 0.01$). Stem contribution to yield increased linearly ($P < 0.01$) with increasing GIv. Forage leaf to stem ratio decreased with increasing

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GIv and GI; however, at 28-d GIv, GI did not affect this ratio. **Implications.** The results of the present study contribute to know the productive parameters of an established *L. multiflorum* meadow in zones of arid climates under two intensities and three grazing intervals. **Conclusions.** In conclusion, both grazing intensity and grazing interval are effective management tools to modify ryegrass performance during the hot ambient conditions of the Sonoran Desert region, associated with late-spring grazing period.

Key words: Grazing frequency; stubble height; grazing management; pastures; Mexicali and Sonoran Desert.

RESUMEN

Antecedentes. La intensidad e intervalo de pastoreo son dos factores muy importantes en el manejo de las praderas que pueden afectar el comportamiento morfológico y productivo de la especie forrajera. Debido a su productividad y persistencia al pastoreo, el raigrás (*Lolium multiflorum* Lamb.) constituye la principal fuente de forraje para alimentar al ganado bovino durante la primavera-verano en el noroeste de México. Por lo anterior, es importante generar conocimientos de pradera establecida con gramíneas para generar información que les sirva a los productores para mejorar la rentabilidad económica las actividades pecuarias. **Objetivo.** El objetivo de este estudio fue evaluar la influencia de la intensidad (IP) y el intervalo de pastoreo (IvP) sobre el rendimiento de forraje, tasa de elongación y composición botánica de raigrás, bajo las condiciones ambientales áridas de esta región. **Hipótesis.** La IvP y la IP modifican el rendimiento de forraje, tasa de elongación y composición botánica del *L. multiflorum* en una pradera irrigada en zonas de clima árido. **Metodología.** El estudio incluyó 1008 toretes cruzados (*Bos indicus* × *Bos taurus*) de 16 meses de edad. Los toretes se distribuyeron en un arreglo factorial en un diseño de BCA, con tres repeticiones. Tres IvP (21, 28 y 35-d) y dos IP (pastoreo de 4 a 6 cm vs 10 a 12 cm) fueron evaluados. Esta prueba de 105 d se inició el 16 de enero de 2019, 90 días después de la siembra y finalizó el 1 de mayo de 2019, utilizando un sistema de pastoreo intensivo con una carga ganadera de 56 terneros por ha. Los principales efectos del intervalo de pastoreo se evaluaron mediante polinomios ortogonales. **Resultados.** El rendimiento de forraje incrementó de manera lineal ($P < 0.01$) al incrementar el IvP; mientras que con IvP de 28 y 35 días, los rendimientos aumentaron al incrementar la IP (interacción, $P < 0.01$). La contribución de tallos al rendimiento incrementó de forma lineal ($P < 0.01$) al incrementar el IvP. La relación hojas:tallos en el forraje decreció al aumentar el IvP y la IP; sin embargo, al IvP de 28-d la IP no afectó esta relación. **Implicaciones.** Los resultados del presente estudio contribuyen a conocer los parámetros productivos de una pradera establecida *L. multiflorum* en zonas de climas templados, áridos y semiáridos bajo dos intensidades y tres intervalos de pastoreo. **Conclusiones.** En Conclusión, tanto la intensidad como la frecuencia del pastoreo son herramientas de manejo efectivas para modificar el comportamiento del raigrás durante las condiciones ambientales cálidas de la región del Desierto del Valle de Mexicali, asociadas al pastoreo durante finales de primavera.

Palabras clave: Frecuencia de pastoreo, altura residual, manejo de praderas, praderas, Mexicali, Desierto de Sonora.

INTRODUCTION

Annual ryegrass (*Lolium multiflorum* Lam.) is a temperate forage with high dry matter yield (Wang *et al.* 2013) and persistence to grazing (Baggio *et al.*, 2009; Bartholomew *et al.*, 2009). It is planted as a monoculture under irrigation in temperate, arid, and semi-arid zones (Kusvuran *et al.*, 2014) and is commonly grazed as an alternative to bailing or green chopping (Fulkerson and Donaghy, 2001; Hernandez-Garay *et al.*, 2000). Adequate grazing intensities reduce dry matter losses and increase yields (Carvalho *et al.*, 2010; Wesp *et al.*, 2016). This practice allows for faster postharvest recovery (Schönbach *et al.*, 2011; Glindemann *et al.*, 2009). Increasing grazing pressure decreases forage selectivity, enhancing forage production and livestock performance (Biondini *et al.*, 1998; Leriche *et al.*, 2003).

Reduced forage yield is attributed to several factors, including decreased exposure to light for photosynthetic activity, depletion of organic reserves of the plant, reduced uptake of water and nutrients, and

damage to apical meristems (Campbell 1996; Hernández-Garay *et al.*, 1997a). The relative importance of each of these factors is normally influenced by both ambient and grazing management conditions (Chaparro, 1991). Various authors (Thomas, 1998) have reported that grazing intervals (GIv) and/or grazing intensities (GI) are closely associated with plants carbohydrate reserves. Low grazing intensities reduce forage yield and pastures botanical composition, and increase the abundance of dead material (Bryan *et al.*, 2000). Poor grazing management leads to deterioration of otherwise well-established pasture (Milchunas and Lauenroth, 1993; Carvalho 2013). The objective of the present study was to evaluate the interaction of grazing intensity and grazing interval on yield, elongation rate, botanical composition and proportion of morphological components of an irrigated ryegrass pasture in the Mexicali valley, located in the Sonoran desert, in northwestern Mexico.

MATERIALS AND METHODS

Site description

This experiment was conducted on an annual ryegrass pasture located 20 km south of Mexicali, in the Ejido Saltillo, Baja California, Mexico (32° 24' LN and 115° 23' LO), with an altitude of 12 msnm. Climatic conditions were monitored at weather station located 2 km from the experimental site.

Pasture establishment, grazing animals and grazing management

Seedbed preparation was carried out by plowing (30 cm deep), double disking (10 cm deep), and floating. The pasture was planted on October 18, 2018, with a seeding rate of 44 kg ha⁻¹ and 70 kg ha⁻¹ of fertilizer (14 % nitrogen, 8 % phosphorus and 21 % potassium oxide; Nutrisol®, Fertilizantes Tepeyec Gpe., Mexicali, México) was applied at planting and again after each grazing rotation. The pasture was irrigated to field capacity after each grazing rotation. A calendar of irrigation and fertilizer schedules, along with dates of grazing rotation is shown in Table 1. Weeds were not controlled during the productive cycle of the pasture.

A total of 1008 crossbred bull calves (*Bos indicus* x *Bos Taurus*, 11 months of age and 120 ± 5 kg LW) were used in the study. Calves were vaccinated against IBR, BVD, PI₃, BRSV, Vibriosis, and Leptospirosis (BOVI-SHIELD Gold, Zoetis Kalamazoo, MI, USA), and implanted with Synovex G (Zoetis Kalamazoo, MI, USA). The animals were placed on the grazing plots and allowed grazing for 10-h, from 06:00 a.m. to 4:00 p.m. Plots were grazed either at 4 to 6 cm (Figure, 1A) or 10 to 12 cm (Figure, 1B) of residual forage.

This 105-d trial was initiated on January 16, 2019, 90 days post-planting and finished on May 01, 2019 (Table 1), using an intensive grazing system with stocking rate of 56 calves per ha. Grazing was controlled using electrical fencing. Fencing was moved every hour for 10 hours. Animals had access to a continuous supply of fresh water in each grazing unit. After each day of grazing, calves were then removed from the pasture to a holding area where they had *ad libitum* access to water and provided with 0.5 kg chopped corn stubble animal⁻¹.

Treatment structure and experimental design

The total experimental area was 180,000 m² (18 plots of 10,000 m² each), divided in nine plots for each of two grazing intensity (GI); 4-6 or 10-12 cm of residual forage height; each containing three plots for each grazing interval (GIv); 21, 28, and 35 days. Treatments were assigned in 3 × 2 factorial arrangement in a randomized complete block design.

Response variables

Forage yield

For the estimation of pasture forage yield (pre-grazing forage and residual forage post grazing forage), 36 samples were taken before and after grazing (0.25 m² per experimental animal unit), as described by Haydock and Shaw (1975). Samples were placed in paper bags, transferred to the laboratory and a subsample, equivalent to 30% of the total material collected, was dried (DM) in a forced air-drying oven (65 °C for 72 h). Ryegrass yield (kg DM ha⁻¹) was determined as indicated: $FY = ((DM \times 10) \times 10000)/1000$ was determined as described by Hodgson (1990); where: FY= Ryegrass yield, in dry matter bases (kg DM ha⁻¹).



Figure 1. Severe grazing intensity (A: 4 to 6 cm of residual forage) and light grazing intensity (B: 10 to 12 cm of residual forage). Original pictures taken by. G. Tilus during the development of the experiment in each treatment.

Table 1. Calendar dates of grazing rotation, irrigation and fertilizer on experiment testing the effect of grazing interval and intensity on ryegrass performance.

Grazing rotation	Grazing activities	Grazing intervals		
		21 days [†]	28 days [†]	35 days [†]
1st	Beggining of grazing period	01/16/19	01/23/19	01/30/19
	Ending of grazing period	01/23/19	01/30/19	02/06/19
	Irrigation and fertilizer application	02/06/19	02/14/19	02/21/19
2nd	Beggining of grazing period	02/13/19	02/27/19	03/13/19
	Ending of grazing period	02/20/19	03/05/19	03/20/19
	Irrigation and fertilizer application	03/06/19	03/20/19	04/04/19
3rd	Beggining of grazing period	03/13/19	04/02/19	04/24/19
	Ending of grazing period	03/20/19	04/09/19	05/01/19
	Irrigation and fertilizer application	04/03/19	04/24/19	05/16/19
Seed collection	Irrigation and fertilizer application [‡]	04/18/19	05/09/19	05/31/19

[†]= Every grazing interval was subjected to either severe grazing intensity (4-6 cm) or light grazing intensity (10-12 cm) and [‡]= the last irrigation and fertilizer was applied to support seed production, after the razing season had finished.

Plant morphology

In each sampling of each grazing interval and intensity. Samples were collected and separated into leaves and stems to measure the contribution each of these components. Each separated component was dried in a forced air oven, at a temperature of 55 °C for 72 h and the partial dry matter was determined. The proportions of morphological components were determined by the following formulas by Gustavsson and Martinsson (2004): $P_{\text{Stems}} = Y_{\text{Stems}}/Y_{\text{Ryegrass}}$; $P_{\text{Leaf}} = Y_{\text{Leaves}}/Y_{\text{Ryegrass}}$; where: P_{Leaves} = proportion of leaves (%) to the total forage yield; and P_{Stems} = proportion of stems (%) to the total forage yield (kg DM ha⁻¹).

Ryegrass height and elongation rate

Plant height from the ligule to the apex of the green leaves was measured in each experimental unit using a ruler. The elongation rate of plant (elongation rate; cm stem⁻¹ d⁻¹), was calculated for growing leaves, by the difference between the sum of the lengths of the final (Lf) and initial (Li), at end of two successive measurements, divided by the number of days elapsed for each grazing frequency (D) between both successive measurements with the following formula, suggested by Cruz-Hernández *et al.* (2017): elongation rate= (Lf-Li) / D.

Pasture botanical composition

For botanical composition determination, subsamples (approximately 30%) of material harvested to measure yields were separated into ryegrass and dead material

and weeds (WDM). Each component was dried separately in a forced air oven (65 °C for 72 hours). Botanical composition was determined in accordance with equation suggested by Prieto and Sanchez (2004): $BC_{\text{Ryegrass}} = Y_{\text{Ryegrass}}/(Y_{\text{Ryegrass}} + Y_{\text{WDM}})$ and $BC_{\text{WDM}} = Y_{\text{WDM}}/(Y_{\text{Ryegrass}} + Y_{\text{WDM}})$, where: BC_{Ryegrass} = botanical composition of ryegrass (%), BC_{WDM} = botanical composition of weeds and dead matter (%), Y_{Ryegrass} = Yield of *L. multiflorum* (kg DM ha⁻¹), Y_{WDM} = Yield of weeds and dead matter (kg DM ha⁻¹).

Statistical analyses

The trial was analyzed as a randomized complete block design with a 3 × 2 factorial arrangement of treatments. Where grazing interval by grazing intensity interactions were appreciable ($P \leq 0.05$), individual means comparisons were evaluated using the Tukey test ($P \leq 0.05$). using the Least-Squares Means (LSMEANS) procedure of SAS version 9.2 (SAS, 2009)..

RESULTS

Weather conditions

Weather conditions during the course of the study are given in Figure 2. During the experimental grazing period (January to May), daily average temperature ranged between 14.4 and 20.1 °C, with minimums between 8 and 14 °C, and maximums between 20.4 and 26.4 °C. Precipitation during the course of the study was characteristically low averaging 20 mm.

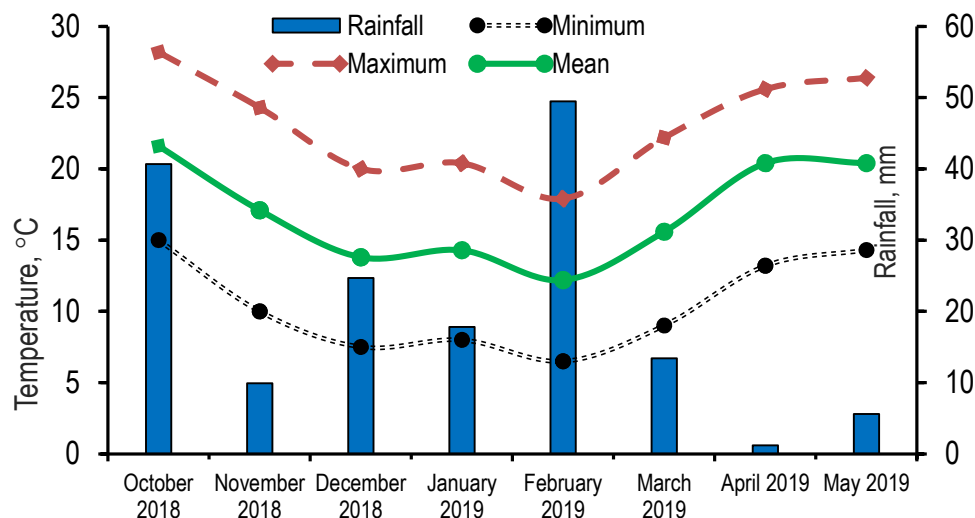


Figure 2. Temperature and precipitation register from October 2018 to May 2019 at the experimental site.

Forage yield

Forage yield recorded a significant GI x GIv interaction (Table 2). Figure 3 illustrate how this interaction occurred. The interaction was significant due to the difference of magnitudes of increment between the groups of GIv across the two GI, recording a greater lineal increment as the GIv increased at the 4-6 GI, than at 10-12 GI. The influence of grazing intensities and intervals on yield is shown in Table 2. Forage yield increased linearly ($P < 0.01$) with increasing grazing interval. However, with the 21-d GIv, GI did not affect yield; whereas, with GIv of 28 and 35 days, yield increased 61 and 79 %, respectively, with increased GI.

Plant morphology

Table 2 shows that the stems fraction of the forage was affected by a significant GI x GIv interaction. The interaction is explained by a fast linear increment of stems in the forage as the GIv increased from 21 to 35 days in the 4-6 cm GI treatment, compared with the increment observed for the 10-12 cm GI. Increasing both GI and GIv increased the stems fraction (Figure 4). Independently of GI, stems contribution to yield increased linearly with increasing GIv. At GIv of 35 days, a greater contribution of stems to yield was recorded, compared with 21 or 28 days.

The leaves proportion of the forage was significantly affected by both GI and GIv, however this variable was

the only one in the present study that was not affected by the GI x GIv interaction (Table 2). Among GI treatments, the 4-6 cm significantly yielded more biomass as leaves ($1,821 \text{ kg ha}^{-1}$), than grazing at 10-12 cm ($1,433 \text{ kg ha}^{-1}$). Among GIv, as the GI decreased, the production of leaves increased, with 796, 1,436, and $2,649 \text{ kg ha}^{-1}$, for 21, 28, and 35 days intervals, respectively (data not shown). This effect is consistent with corresponding differences in forage yield; leaf fraction as a morphological plant component to forage yield increased as pasture yield increased.

Leaf to stem ratio in the forage recorded a significant GI x GIv interaction (Table 2). Figure 5 illustrates this interaction. The interaction occurred due to the disproportional decrement in leaf to stem ratio in the 4-6 cm GI as GIv increased, as compared with the much more drastic fall in the 10-12 cm GI, particularly when moving from 21 days interval to 28 days interval.

Plant height

Plant height was also affected by a significant GI x GIv interaction (Table 2). This interaction is illustrated in Figure 6. The interaction occurred because the plant height was similar when grazing changed from 28 to 35 days in the 4-6 cm GI, as compared with a significant difference recorded for the same GIv in the 10-12 cm GI. Plant height increased with increasing GIv. However, at 21- and 35-d grazing intervals GI did not affect plant height; whereas, at the 28-d GI plant height was greater with increased GI.

Table 2. ANOVA's for pasture yield, plant morphology components and weeds a dead material plant height, elongation rate, and botanical composition, of ryegrass in response to two grazing intensities and three grazing intervals.

Yield				Stems			
Source of variation	DF	Mean Square	p	Source of variation	DF	Mean Square	p
Block	2	3540339	0.2471	Block	2	4559398	0.0594
GI	1	46506049	<.0001	GI	1	32293822	<.0001
GIv	2	380321080	<.0001	GIv	2	162561392	<.0001
GI x GIv	2	23512691	0.0002	GI x GIv	2	11768085	0.0009

Leaves				Leaf to stem ratio			
Source of variation	DF	Mean Square	p	Source of variation	DF	Mean Square	p
Block	2	278053	0.4986	Block	2	0.42009972	0.0009
GI	1	4071889	0.0018	GI	1	1.21202326	<.0001
GIv	2	31874006	<.0001	GIv	2	5.96942837	<.0001
GI x GIv	2	754102	0.1548	GI x GIv	2	0.46612953	0.0005

Height				Elongation rate			
Source of variation	DF	Mean Square	p	Source of variation	DF	Mean Square	p
Block	2	3434.18	0.223	Block	2	0.18	0.0091
GI	1	41598.94	<.0001	GI	1	0.67	<.0001
GIv	2	209004.99	<.0001	GIv	2	0.40	<.0001
GI x GIv	2	19119.27	0.0004	GI x GIv	2	0.17	0.0094

<u>Botanical composition</u>							
Ryegrass				WDM			
Source of variation	DF	Mean Square	p	Source of variation	DF	Mean Square	p
Block	2	11.50	0.7862	Block	2	866.87	<.0001
GI	1	176.12	0.0575	GI	1	4023.08	<.0001
GIv	2	1563.52	<.0001	GIv	2	677.24	0.0003
GI x GIv	2	575.92	<.0001	GI x GIv	2	1066.30	<.0001

Plant elongation rate

A significant GI x GIv interaction was recorded for plant elongation rate (Table 2). A second order polynomial (quadratic) curve was recorded across GIv in the 4-6 cm group of treatments; while, in the 10-12 cm GI, no significant effect was recorded, as the GIv increased from 21 to 35 days (Figure 7).

Pasture botanical composition

Ryegrass. There was a significant GI × GIv interaction on plant botanical composition (Table 2). Figure 8 illustrates this interaction. With lesser GI, BC increased linearly with increasing GIv. With greater GI, BC increased at 21- and 28-d grazing intervals.

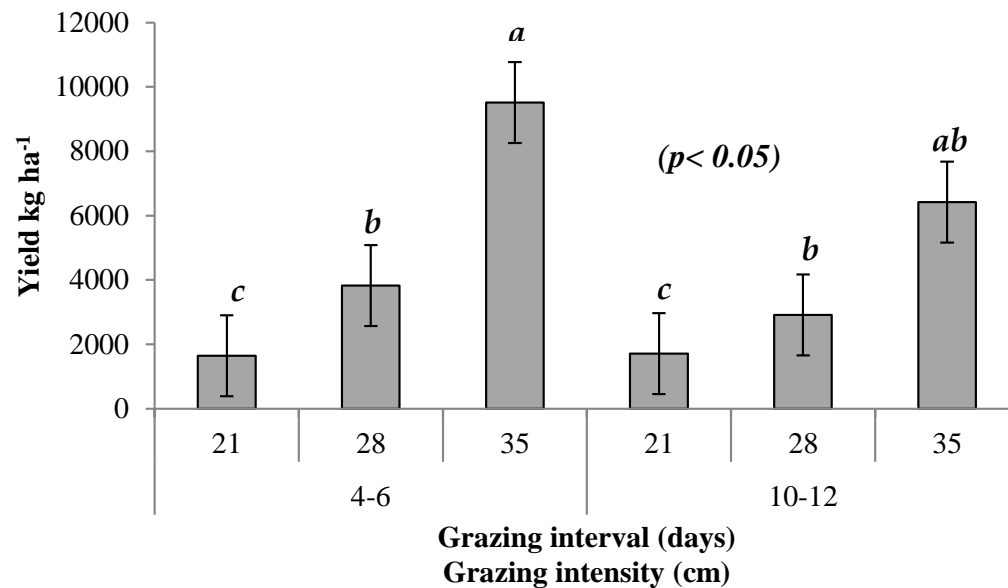


Figure 3. GI x GIv interaction for ryegrass forage yield production in experiment conducted in an arid environment, in Northwest, Mexico in the grazing season of 2019.

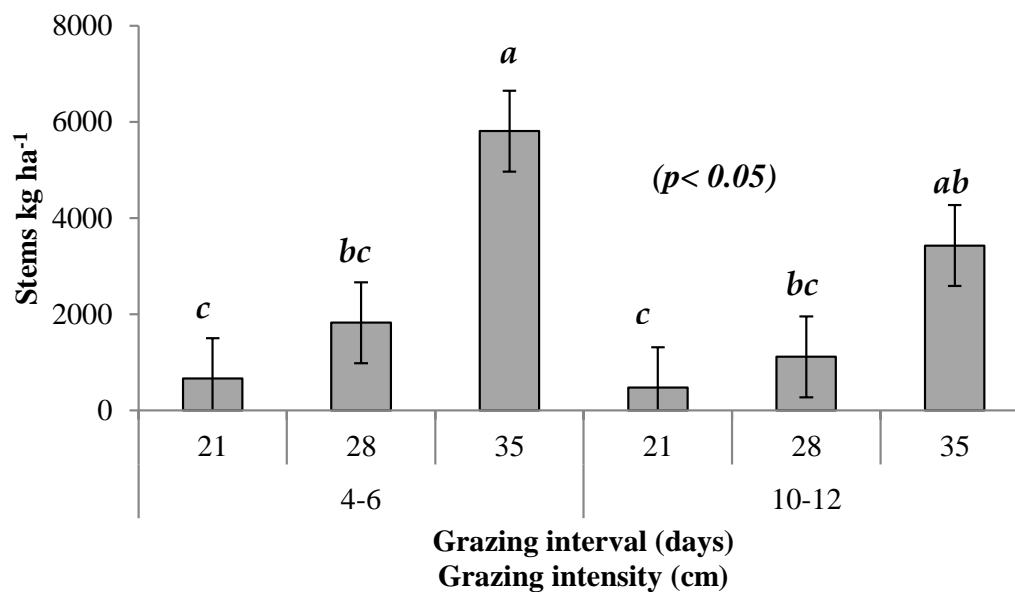


Figure 4. GI x GIv interaction for ryegrass stems production in experiment conducted in an arid environment, in Northwest, Mexico in the grazing season of 2019.

Weeds and dead material

A significant GI × GIv interaction was recorded for WDM (Table 2). WDM production in the 4-6 cm GI changed little as the GIv changed. In contrast, in the 10-12 cm GI, a clear reduction was recorded when moving to 35 days DIv, as compared with either 21 or 28 days (Figure 9).

DISCUSSION

Forage yield

Forage yield in the present study are consistent with several studies involving annual ryegrass (Velázquez *et al.*, 2009). Bribiesca *et al.* (2002) did not observe an interaction between GI × GIv on ryegrass yield. A lack

of interaction between GI and GIv may have been due to differences in forage yield with increasing grazing intervals, as reported by Kallenbach *et al.*, (2004) and Mullenix (2016). Cruz-Hernández *et al.* (2020) observed a yield increase of 1,500 kg DM ha⁻¹, as

grazing interval increased from 21 to 35 d. Whereas, in the present study, as the grazing interval increased from 21 to 35 days the impact of grazing intensity on forage yield was much greater (7618 and 4761 kg DM ha⁻¹, for GI of 4-6 vs 10-12, respectively).

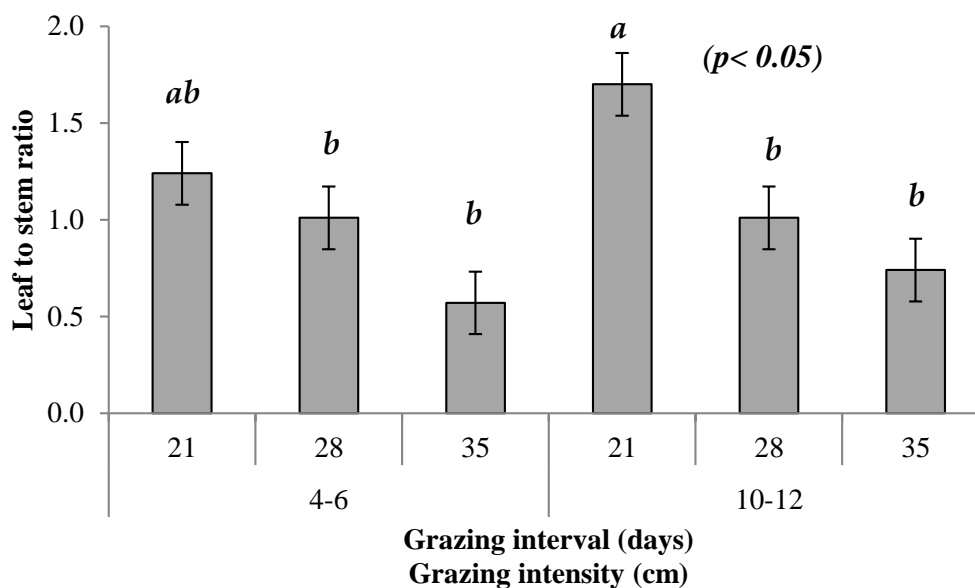


Figure 5. GI x GIv interaction for ryegrass leaf to stem ratio production in experiment conducted in an arid environment, in Northwest, Mexico in the grazing season of 2019.

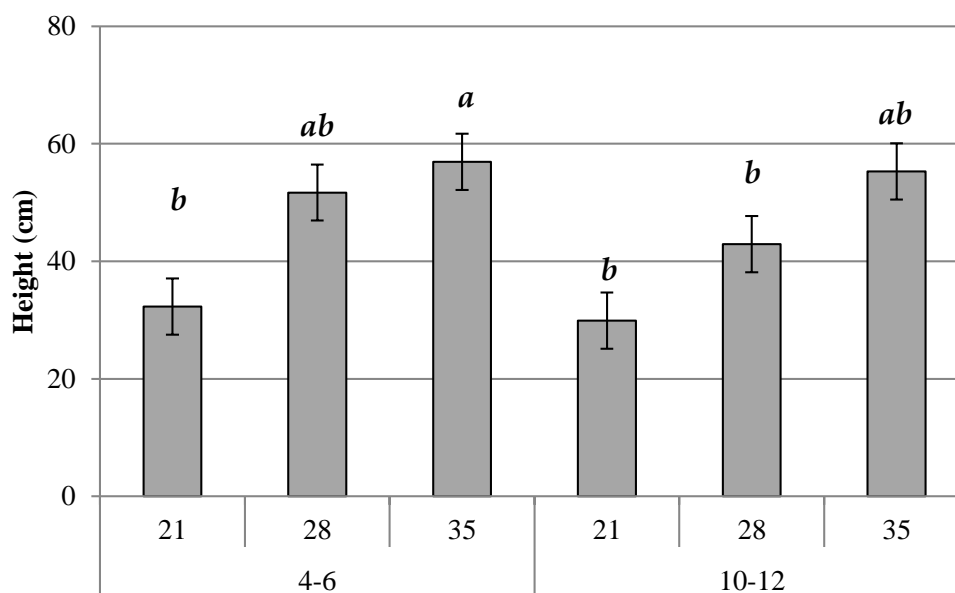


Figure 6. GI x GIv interaction for ryegrass plant height in experiment conducted in an arid environment, in Northwest, Mexico in the grazing season of 2019.

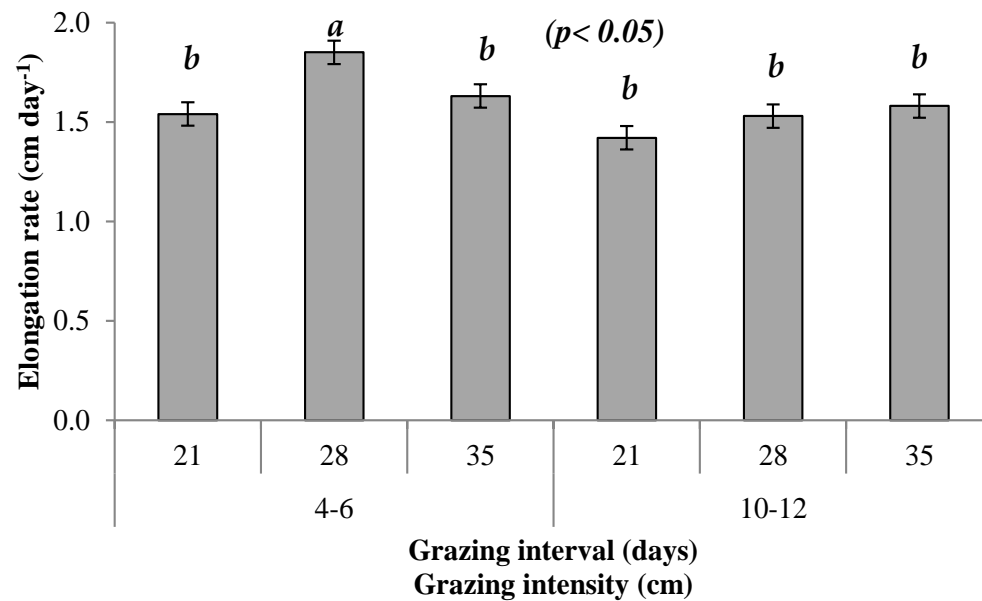


Figure 7. GI x GIv interaction for ryegrass elongation rate in experiment conducted in an arid environment, in Northwest, Mexico in the grazing season of 2019.

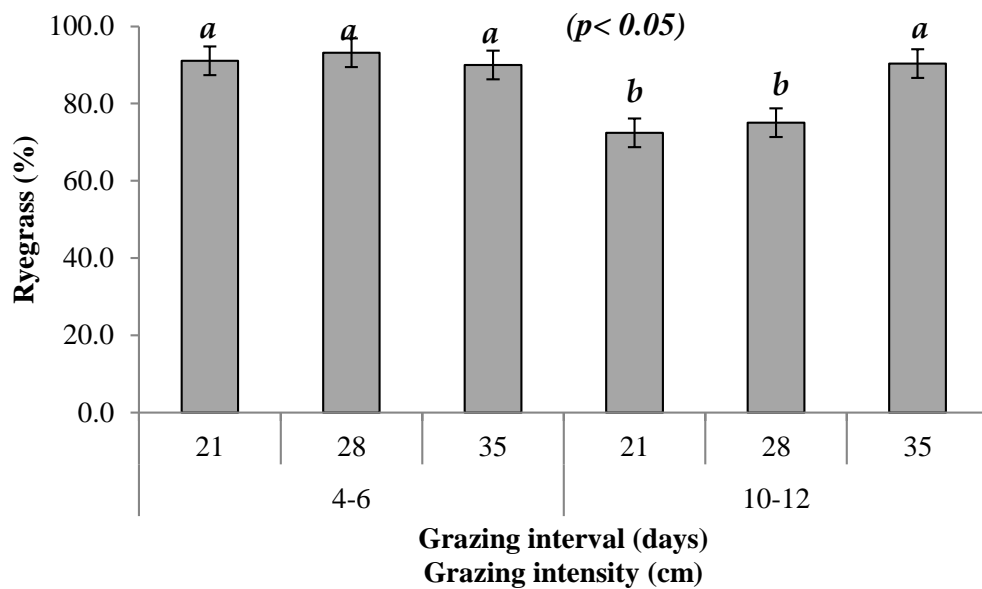


Figure 8. GI x GIv interaction for ryegrass proportion in forage production in experiment conducted in an arid environment, in Northwest, Mexico in the grazing season of 2019.

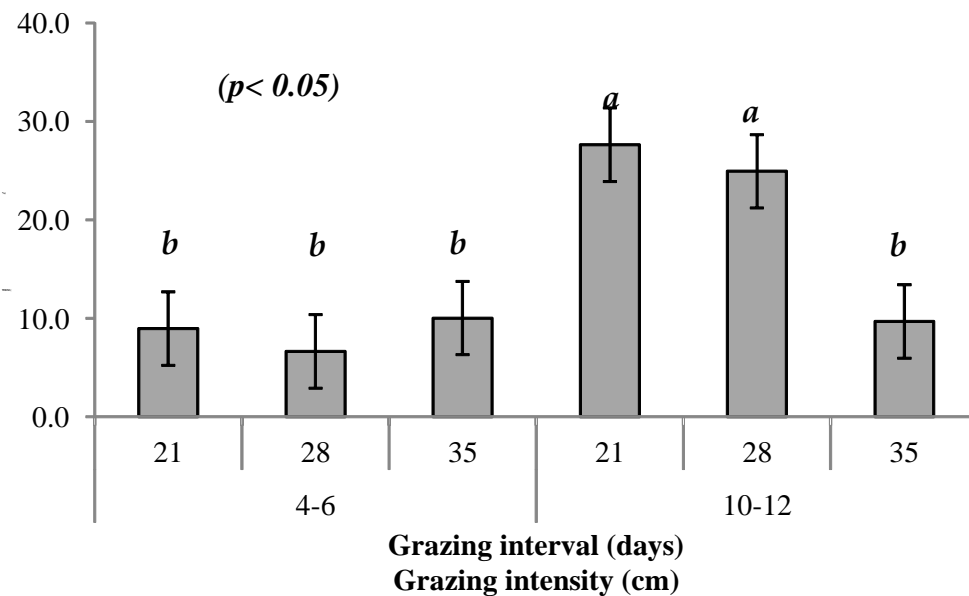


Figure 9. GI x GIv interaction for weeds and dead material proportion in forage production in experiment conducted in an arid environment, in Northwest, Mexico in the grazing season of 2019.

Plant morphology

The increased proportion of stems production with increasing GIv may have been due to climatic conditions favoring growth of the reproductive stems as plant matured (Kallenbach *et al.*, 2002). Consistent with Cruz-Hernández *et al.* (2020), leaf to stem ratio decreased with increasing GIv. This effect was due to the increased contribution of stem and dead material to total biomass yield. There was a positive correlation ($P < 0.01$) between leaves and stems of ryegrass with increasing the GIv (data not shown). Likewise, in an evaluation of Maralfalfa grass pasture (Calzada-Marín *et al.*, 2014) observed a positive correlation ($r = 0.85$) between leaf to stem ratio and GIv. Bribiesca *et al.* (2002) observed leaf to stem ratios of 1.4 and 1.1 in a perennial ryegrass pasture harvested at a plant height of 3 and 15 cm, respectively. Plant age affects yield of plant morphological components (Soares *et al.*, 2019; Beecher *et al.*, 2015; Hopkins *et al.*, 2006). As plants age with increasing grazing interval, leaf production drops and the proportion of both stem and senescent material increases or negatively affecting leaf to stem ratio (Soares *et al.*, 2019; Beecher *et al.*, 2015; Hopkins *et al.*, 2006). Results in the present study are consistent with previous studies in that plant height increased with increasing GIv (Barthram and Grant, 1984; Hurley *et al.*, 2013). Furthermore, the findings on plant height in the present study are in agreement with Lemaire *et al.* (2009) and Santos *et al.* (2013), who observed increased plant height with increased grazing

intensity. In regard to the response observed for elongation rate, environmental temperatures and relative humidity seems to be closely associated with elongation rate of grasses (especially the *Lolium* species). In an evaluation of *L. perenne* associated with *Trifolium repens* pasture, (Castro *et al.*, 2013) observed that elongation rate during the spring was 0.2 cm stems⁻¹ day⁻¹ greater than during the winter. With different GIv, plant elongation rate following grazing is dependent on root carbohydrate reserves and the number of initiated vegetative buds (Duru and Ducrocq, 2000).

Pasture botanical composition

The results of the present study regarding BC coincide with another study with alike climatic conditions, conducted at a close location (about 10 km away); Tilus *et al.* (2020) observed that the ryegrass fraction to the total yield decreased with increasing GIv; while the proportion of WDM increased. These finding agree with previous studies (Duchini *et al.*, 2016; Duchini *et al.*, 2014; Barth *et al.*, 2013), where increasing grazing intensity was observed to decrease WDM. Da Silva *et al.* (2010) noted that once the plant intercepts 95% of the solar radiation, there is a progressive increase in WDM. Elevated ambient temperature (greater than 50 °C) could have been another factor contributing to increased WDM, due to the death of leaves in the upper strata (Duru, 2000). This is particularly relevant to

pastures were grazing management maintained plants at a greater height (Beecher *et al.*, 2015).

CONCLUSIONS

In conclusion, both grazing intensity and grazing interval are effective tools to modify plant growth performance, morphological components, as well as weeds and dead material fractions, height and elongation rate of ryegrass. Research is needed to further evaluate grazing strategies during the warmer ambient conditions of the Sonoran Desert region associated with the late-spring phase of the annual ryegrass grazing period.

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