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Productive characteristics of natal grass [*Melinis repens* (Willd.) Zizka]

Características productivas del pasto rosado [*Melinis repens* (Willd.) Zizka]

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ABSTRACT

This work aimed to characterize the morphology, forage production, nutritional quality, and drought resistance Natal grass. The assessed variables were: botanical composition (point line), forage production (cut into 0.25 m^2 quadrants), pasture morphology (separation of plant components), in the growth stage the CP analysis (Kjeldahl method), and *In vitro* Organic Matter Digestibility (Daysy method), and Acid and Neutral Fibers (Van Soest method). the germination percentage and its response to drought (0, -1.0, and -2.0 MPa). Data were analyzed using a completely randomized analysis. The botanical composition was integrated mainly by grasses, followed by herbaceous and shrubs with 67.45%, 16.90%, and 15.65%, respectively. Production in the study area was from 244 to 2118 kg DM ha^{-1}. The germination percentage of natal grass decreases by 72 % when it is subjected to osmotic pressure levels of -1.0 MPa. During the growth stage, the natal grass presented levels of 11.53 % Crude Protein. The crude protein levels could be due to the amount of leaves that appeared during the growing season. It is recommended to make crude protein measurements throughout the year to observe change dynamics in natal grass.

KEY WORDS: Forage quality, production, morphology, adaptation.

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RESUMEN

Los objetivos del trabajo fueron caracterizar la morfología, producción forrajera, calidad nutricional y resistencia a la sequía del pasto rosado. Las variables evaluadas fueron: composición botánica (línea de puntos), producción de forraje (corte en cuadrantes de 0.25 m^2), morfología del pasto (separación de los componentes de la planta), en la etapa de crecimiento se le realizó el análisis de Proteína Cruda (CP; método Kjeldahl), Fibras Ácida y Neutra (método Van Soest) y digestibilidad *in vitro* de la Materia Orgánica y de la semilla se obtuvo el porcentaje de germinación y su respuesta a sequía (0, -1.0 y -2.0 MPa). Los datos se analizaron mediante un diseño completamente al azar. La composición botánica estuvo integrada principalmente por pastos, seguida de herbáceas y arbustos con 67.45%, 16.90% y 15.65%, respectivamente. La producción en el área de estudio fue desde 244 a 2118 kg DM ha^{-1}. El porcentaje de germinación del pasto rosado disminuye en un 72 % cuando es sometido a niveles de presión osmótica de -1.0 MPa. Durante la etapa de crecimiento el pasto rosado presentó niveles de 11.53 % CP. Los niveles de CP podrían deberse a la cantidad de hoja que se presentaron en la época de crecimiento. Se recomienda hacer mediciones de proteína cruda a través del año con la finalidad de observar dinámicas de cambio en pasto rosado.

PALABRAS CLAVE: Calidad forrajera, producción, morfología, adaptación.

Introduction

Grassland represent the greatest importance in cattle feeding in extensive conditions. However, the nutritional value of these species found in this ecosystem will define whether cattle can meet their dietary requirements, since the botanical composition and therefore their forage value is different during the growth stages (Reyes *et al*., 2012; Reyes-Estrada *et al*., 2014). Therefore, it is essential to evaluate and select productive characteristics in species present in grassland ecosystems, since they constitute the cheapest food for grazing cattle. Another aspect to consider is that the subsistence of a species in nature will depend on its distribution, seed quality, and capacity to be conserved in natural soil banks (Rzedowski, 1975). In addition, dry matter yield and forage quality are productive aspects to consider when selecting genotypes that are used to control erosion and protect the soil in deteriorated areas (Wagner & Colón, 2014). Drought resistance is another important trait for grass species that must be analyzed, due to the erratic rainfall environmental conditions of the Chihuahuan Desert. Hence, the ability of seeds to germinate and emerge is an essential factor for establishment and survival (Springer, 2005), since not all species have the same ability to tolerate the lack of water.

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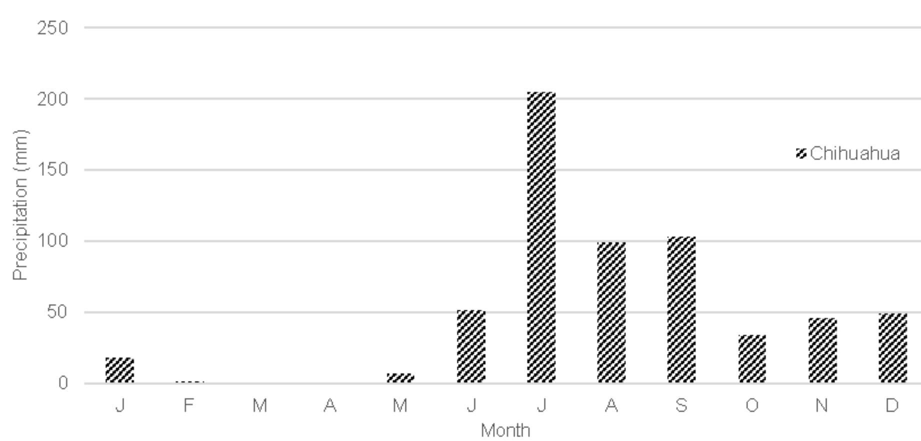
The natal grass [*Melinis repens* (Willd.) Zizka] is a species cataloged as invasive, originally from southeastern Africa and introduced to America as an ornamental species in the 19th century (David & Menges, 2011; Stokes, 2011). In Mexico, the presence of this species has been reported since 1977 and it is currently considered an invasive species in the grasslands (Melgoza-Castillo *et al*., 2014), however, during the last few years it has expressed greater invasive behavior in the grasslands of the state of Chihuahua and other states in Northern Mexico (Melgoza-Castillo *et al*., 2014). It is characterized by invading overgrazed areas and land devoid of vegetation (Melgoza-Castillo *et al*., 2014; Sánchez, 2012). In addition, its drought resistance capacity and nutritional value are not known. Given this background, it is required to know the productive behavior of this grass and conduct research leading to the selection of desirable characteristics to take advantage of its dispersal potential and design schemes for its adequate utilization (Crowl *et al*., 2008; Gutiérrez-Gutiérrez *et al*., 2022). This is because there are few studies related to the productive characteristics of natal grass (Carrillo-Saucedo *et al*., 2009; Díaz-Romo *et al*., 2012; Stokes *et al*., 2011). Thus, this study aimed to characterize the morphology, forage production, nutritional quality, and drought resistance of natal grass.

Material and Methods

Study Area Description

The study was performed at Rancho "Salinas", located in the municipality of Satevó, Chihuahua, 27°57' N and 106°07' W. The altitude is 1540 masl, the mean annual temperature is 18.1 °C, and the mean annual precipitation is 450 mm (Graph 1; Medina-García *et al*., 2006). The soils in the area are shallow (less than 30 cm) of alluvial origin with a sandy loam texture, regular internal drainage, moderate surface runoff, and a pH of 5.3 to 6.6 (COTECOCA, 1978).



Graph 1. Monthly average precipitation (mm) in Chihuahua state.

Evaluated Variables

The botanical composition of the area was determined in July (vegetative growth stage) using the dotted line method (Herrick *et al*., 2005). For species identification of the species present in the area, reference samples were taken (three per species), stems, leaves, and fruit were collected. Then, samples were identified with the support of the herbarium of the Facultad de Zootecnia y Ecología (FZyE-UACH). Obtained weights were used to estimate the percentage of presence of each species during the phenological stage.

Field sampling. Four sampling periods were established during August to February to estimate forage yield, in the different phenological stages of the grasses present in the area. The first sampling was carried out from August 3 to 7 during the growth stage after the first rains, and 15 to 20 days after the first rains in the area. The second sampling corresponding to the development stage was from October 1 to 5. The period for the maturity stage was from December 3 to 7 and for the latency stage, it was from February 1 to 5.

Natal grass morphology. The morphological distribution (leaf, stem, inflorescence, and dead material) of natal grass was determined in 10 plants on each sampling date. Each plant was transported to the laboratory and sorted according to its morphology. The material was then weighed and the percentage for each plant component was determined.

Forage yield (kg DM ha^{-1}). In the study area, aerial biomass was measured at 25 randomly distributed points. To estimate the available forage, a 0.25 m^2 quadrat was used, the grasses remaining within the quadrat were counted and cut, and samples of each species were placed in individual bags, previously labeled. The collected samples were taken to the Laboratorio de Nutrición Animal of the FZyE and placed in a forced air oven at 65 °C for a period of 72 h for drying and subsequent weighing. A Tor Rey L-EQ scale was used to weigh the samples. The dry weight obtained was extrapolated to DM production ha^{-1}, using the following formula:

$$DM= (w\ (g)*4)/1000 * 10000$$

Where:

DM = dry matter, w = weight, g = grams, w = weight, g = grams.

Crude protein (CP). The CP content was determined by the Kjeldahl method (AOAC, 2012).

Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF). These variables were estimated using the method of Van Soest (1963).

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In vitro Digestibility coefficient of Organic Matter (*iv*DOM). To obtain the data for this variable, the Daysi II analyzer was used, following the methodology of the Ankom® guide (Ankom Technology, 2014).

Standard germination (%). Petri dishes of 90 mm diameter with cotton and filter paper were used. The experimental unit was the Petri dish with 50 seeds in florets. Four replicates were used and each Petri dish was irrigated with 25 ml of distilled water. The Petri dish were placed in a growth chamber (Precision Scientific, model 6M) at a temperature of 27 ± 2 °C. The germinated seed was considered as that which reached 0.5 cm of aerial part or radicle.

Radicle length (cm). It was measured on the seventh day after seed germination with the help of a ruler graduated to 1 mm.

Length of aerial part (cm). It was measured on the seventh day after seed germination with the help of a ruler graduated to 1 mm.

Root:Shoot ratio. It was evaluated on the seventh day with the measurement of the aerial part and radicle. It was observed which quantity corresponded to the radicle in proportion to the aerial part.

Osmotic potential. Three osmotic levels were used to simulate drought and determine the effect of osmotic stress. Before this evaluation, a germination test was carried out with and without a seed coat. For this purpose, 90 mm diameter Petri dishes were used, provided with cotton and filter paper with four replicates for each osmotic level, and 50 seeds (caryopses) were deposited in each one of them. Each Petri dish was irrigated with 25 ml of the corresponding solution. The Petri dishes were placed in a growth chamber at a temperature of 25±2 ºC. The seed was considered germinated when the radicle or aerial part reached approximately 0.5 cm. Water stress treatments were 0.0, -1.0, and -2.0 MPa, and mannitol was used as an osmotic agent. Mannitol concentrations were calculated according to its molecular weight (182.17 g/mol), from the equation proposed by Vant'Hoff (Ruiz & Terenti, 2012):

$$\Psi\pi = -CiRT.$$

Where: $\Psi\pi$ = osmotic potential, C = concentration of the solution expressed as molarity (moles of solute per kg of water), i = constant for solute ionization (0.00545), R = gas constant (0.00831 kg MPa mol-1 K-1), T = temperature in degrees Kelvin (298.15 °K).

Data analysis

Data analysis Data were analyzed using a completely randomized analysis with the statistical program SAS 9.1.3 (2006).

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Results and Discussion

Botanical Composition

The botanical composition of the area consisted mainly of grasses (Table 1). The natal grass was the species with the highest botanical composition (95.7 %). The fairyduster legume (*Calliandra eriophylla*) had the highest composition (57 %). Among the herbaceous plants present in the area, the one with the highest botanical composition (61.3 %) was slender dwarf morning-glory (*Evolvolus alsynoides*). According to the previous results, Fuentes-Ramírez *et al*. (2010) report that when there is the presence of an invasive species in ecosystems, the key species of that type of vegetation tend to decrease and there are changes in the structure of the communities and a reduction in the regeneration rate of native species (Mata-Balderas *et al*., 2020). Obtained data suggested by other authors, it is likely that native species are being displaced, since the natal grass in these areas contributes from 72 to 89 % of aboveground biomass production (Lavandera-Barreras *et al*., 2019).

Table 1. Botanical composition of the study area, corresponding to a grassland invaded by natal grass (*Melinis repens*) in Chihuahua.

Species	Botanical composition (%)
Grasses	
Bouteloua curtipendula	0.61
Bouteloua gracilis	3.70
Melinis repens	95.70
Total	67.45
Shrubs	
Aloysia wrightii	8.64
Calliandra eriophylla	56.80
Condalia sp	1.24
Juniperus monosperma	7.40
Mimosa biuncifera	9.88
Prosopis glandulosa	14.79
Tecoma stans	1.24
Total	16.90
Forbs	
Bulbostylis juncoides	4.03
Dichondra argentea	2.62
Euphorbia sp	1.34
Evolvulus alsinoides	61.34
Haplopappus gracilis	1.34
Macrosiphonia hypoleuca	1.34
Millia biflora	3.96
Sida abutifolia Mill	24.03
Total	15.65

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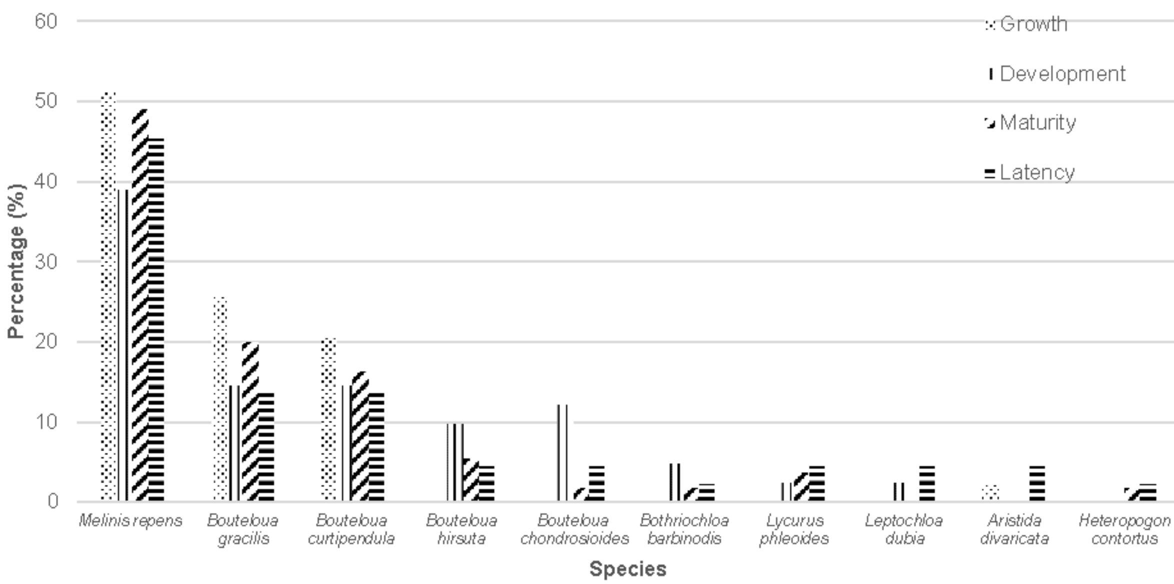
The number of grasses present in the study area increased over time. During the first sampling date, only three species of grasses were observed, where natal grass represented more than 51% of the production per species. The natal grass, having a persistent seed bank, could have an advantage over the other grasses present. For the last sampling date, ten species of grasses were observed, however, the natal grass maintained a botanical composition of 45%, which is superior to the other grasses (Graph 2). Most of the grasses present in the study area are native and of livestock importance, important aspects to conserve biodiversity in the grasslands of the Chihuahua state (Jurado-Guerra *et al*., 2021; Leis *et al*., 2012; McGranahan *et al*., 2013). The botanical composition that can occupy the natal grass, Miranda (2012) reported similar values (82 %) in terms of its botanical composition.



Graph 2. Botanic composition in an area invaded by natal grass (*Melinis repens*) through the phenological stages.

Forage Yield

When characterizing the natal grass in the study area based on its forage yield, a production of 244 kg DM ha^{-1} was achieved during the initial sampling date (Growth phase), with natal grass accounting for 78.6% of the total production (Table 2). On the second and third sampling dates, yields were 1310 and 1444 kg DM ha^{-1}, respectively. On the second sampling date (Flowering), natal grass accounted for 72 % of the total production and by the third sampling date (Maturity) it increased to 87 %. By the fourth sampling date (Latency) forage yield reached a production of 2118 kg DM ha^{-1}. This can be attributed to the presence of winter rains, which could have favored the growth of the natal grass since it contributed 88.5 % of the available biomass. Díaz-Romo *et al*. (2012) reported biomass production in *Melinis repens* from 1736 to 2913 kg DM ha^{-1} in rainy years, while in dry years it ranged from 707 to 1488 kg DM ha^{-1}. The above determines that forage production of natal grass can vary depending on rainfall (Stokes *et al*., 2011). However, it can be assumed that natal grass, despite being an invasive species, is slow-growing (Gutiérrez-Gutiérrez *et al*., 2022; Melgoza-Castillo *et al*., 2014; Morales *et al*., 2014) and is related to unfavorable environments (water and nutrient limitations), which favors its establishment in arid areas (Mata-González & Meléndez-González, 2005). In comparison with other native species such as sideoats grama (*Bouteloua curtipendula*), Beltrán-López *et al*. (2013) reported values between 1835 and 2000 kg DM ha^{-1} similar to those obtained during the latency stage in this study. However, studies where introduced species were evaluated report yields from 2000 to 2500 kg DM ha^{-1} (Esqueda & Carrillo, 2001).

Table 2. Forage production (Kg DM ha^{-1}) of natal grass in the four sampling stages.

	Forage Yield	
Stage	Total Kg DM ha^{-1}	Natal Grass (%)
Growth	244.20	78.59
Development	1310.25	72.38
Maturity	1444.15	87.47
Latency	2118.20	88.55

Natal Grass Morphology

When analyzing the structural components of the natal grass, it was observed that the amount of leaves decreased throughout the sampling periods. It was found that leaves represented about 50 % on the first sampling date, however, by latency it decreased to 23 % (Graph 3). Likewise, the number of stems increased considerably during the sampling stages. Likewise, in the growth stage, only 17 % was observed and for the flowering stage, it increased up to 43 %, however, the highest quantity of stems occurred during the latency stage (56 %). During the latency stage, the lowest digestibility is presented due to the Lignin content in the plant, making its palatability lower (Gutiérrez-Gutiérrez *et al*., 2019). Regarding the amount of inflorescences, a considerable increase was not observed throughout the sampling stages, since it only fluctuated

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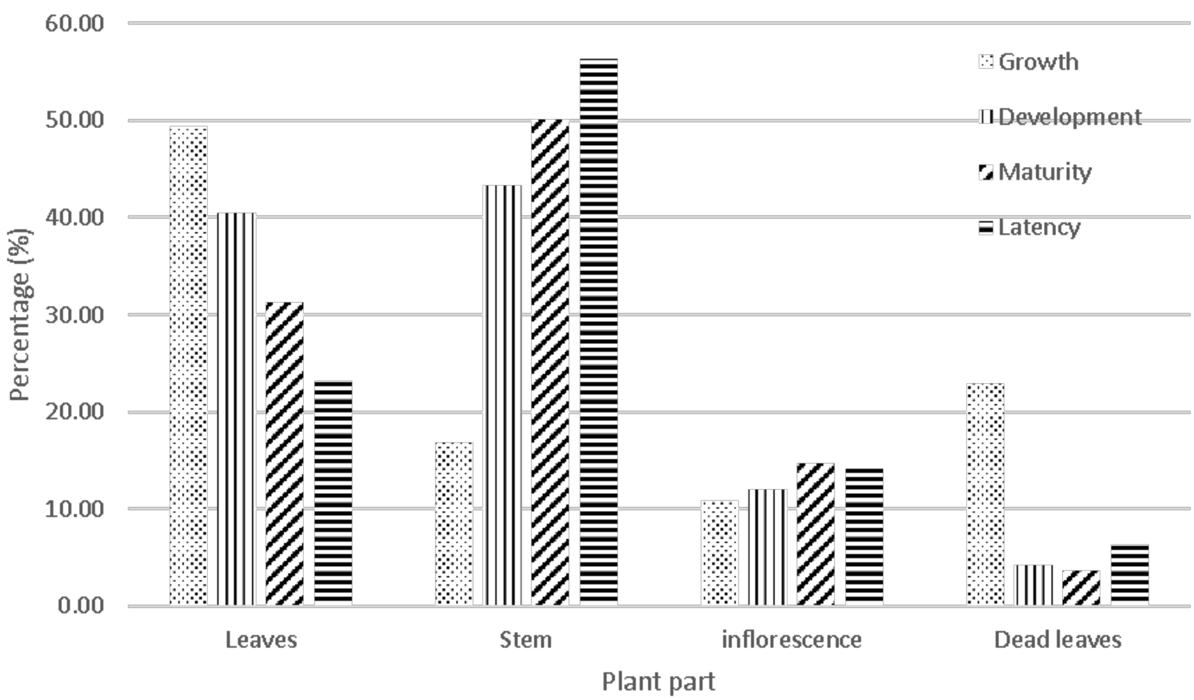
from 10 to 14 % in flowering and latency, respectively. As for dead material, 23 % was obtained in the growing season, which is attributed to the high percentage of material from the previous cycle; however, for the flowering and latency stages, it fluctuated from 3 to 6 %, respectively. Similar studies have been reported by Pérez-Amaro *et al*. (2004) with mulatto grass, which found a decrease in the percentage of leaves and an increase in stems and inflorescence during the growth stage. In elephant grass, something similar happened, since there was a decrease in leaf weight and an increase in the number of stems (Calzada-Marín *et al*., 2014). Regarding the above, Melgoza-Castillo *et al*. (2014) mentioned that in the latency stage, the crude protein content of natal grass decreases to 4%, which is perhaps due to the increase in the number of stems and inflorescences during this stage (Calzada-Marín *et al*., 2014). Another aspect to consider is that when there is a higher stem content, palatability and digestibility by cattle decrease, which is why is possible its permanence in cattle farms (Chávez & González, 2008). However, although the biomass distribution has not been quantified, it is observed that natal grass has a high proportion of stems to leaves, which is why it is considered a poor-quality grass during the last phenological stages (Melgoza-Castillo *et al*., 2014).



Graph 3. Structural components of rosacea (*Melinis repens*) during phenological stages.

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Nutritional Value

The crude protein (CP) content of all grasses varies according to their phenological stage. During the growing season, grasses present their highest nutrient levels. In this case, the natal grass presented an average CP value of 11.53 % during the growing season. In a similar study where different grasses were analyzed, *Melinis repens* was reported to have a CP value of 11.2 % in the growing season (Ramírez *et al*., 2009). This could be because, during the growing season, the natal grass has the highest leaf content. Other authors mention that the CP content of natal grass is lower than that reported in this study (3-6 %), however, these levels are observed for the maturity stage (González-García *et al*., 2017; Melgoza-Castillo *et al*., 2014; Sánchez-Maldonado *et al*., 2014). In another study conducted in Aguascalientes, Mexico, values of 12.6 % CP were found in the growth stage (Flores-Ancira *et al*., 2016) which are higher than those obtained in this study, unlike the data reported by Sánchez-Maldonado (2014) where he found CP values of 3.58 % in the growing season.

Neutral Detergent Fiber (NDF) contains the cell walls of the plant and is composed of cellulose, hemicellulose, and lignin (Holechek *et al*., 2011). In this regard, it can be observed in Table 3 how *Melinis repens* was the species that presented the highest value (71.36 %) of NDF compared to species such as *Bouteloua gracilis* (69.07 %) and *Bouteloua curtipendula* (67.78 %). The data obtained by Flores-Ancira *et al*. (2016) were similar to those reported in this study, where values of 66.4 % NDF were obtained. Ramírez *et al*. (2009) found higher values (74.1 %) than those reported in this study. However, other research carried out in the 80s in the central grasslands of the state of Chihuahua, Chávez *et al*. (1986) found NDF values between 72.1 and 76.5 % in native species during the growing season. These values are within those reported for *Melinis repens* in this study. The Acid Detergent Fiber (ADF) data differ from those reported by Flores-Ancira *et al*. (2016) where values of 33.2 % are reported, which are lower than those obtained (44.07 %) in this study during the growing season. However, the NDF and ADF values reported by Sánchez-Maldonado (2014) were similar to those obtained in this research.

Table 3. Content of CP, ADF, NDF, and *iv*DOM of three different grasses in the growth stage.

Species	CP (%)	ADF (%)	NDF (%)	*iv*DOM (%)
Natal grass (*Melinis repens*)	11.53[a]	44.07[b]	71.36[b]	26.40[a]
Blue grama (*Bouteloua gracilis*)	11.94[a]	49.03[c]	69.07[a]	31.83[b]
Sideoats grama (*Bouteloua curtipendula*)	13.74[b]	39.69[a]	67.78[a]	44.43[c]

[abc] different literals in columns indicate significant differences (P<0.05)

CP= Crude protein; ADF= Acid Detergent Fiber; NDF= Neutral Detergent Fiber; *iv*DOM= *in vitro* digestibility coefficient of organic matter

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Sideoats grama grass had the highest CP content (13.74 %) compared to natal and Blue grama (11.53 and 11.94 %, respectively). In the case of Blue grama, Morales *et al*. (2009) reported values of between 12-15 % thus, it can be more consumed by cattle compared to natal grass. Similarly, other authors have mentioned that *Bouteloua gracilis* presents 8.6 % of CP during the flowering stage (Beltrán-López *et al*., 2013). In addition, Reyes-Estrada *et al*. (2014) analyzed the diet of cattle in pastures in Durango state, where *Melinis repens* is present, and reported CP values of 10.49 ± 1.20 %.

Osmotic Potential

The results obtained from the germination test for natal-covered grass yielded maximum germination of 30 %, which is high compared to other reports where values between 2 % and 25 % are reported (Díaz-Romo, 2012; Gutiérrez-Gutiérrez *et al*., 2022; Stokes *et al*. 2011). Only Carrillo-Saucedo *et al*. (2009) obtained similar results, 31 %. On the other hand, by eliminating the seed coat and only germinating the caryopses, the germination percentage increased to 76 %. Therefore, only the caryopses were used to evaluate the osmotic potential. Table 4 shows the germination behavior when caryopses were subjected to water stress up to 2.0 MPa. Stokes *et al*. (2011) reported similar results when studying the biology of natal grass seed; they did not obtain germination at - 2.0 MPa. Another fundamental aspect is high values in the Root:Shoot (R:S) ratio, which represents a greater effort by the species for water acquisition (Ervin *et al*., 2009; Mastalerczuk & Borawska-Jarmułowicz, 2021). Due to the above, it can be observed in Table 4 how the natal grass increases its R:S ratio, which would be beneficial for obtaining water during low precipitation events.

Table 4. Behavior of natal grass (*Melinis repens*) seeds subjected to different osmotic pressure (MPa).

Osmotic pressure (MPa)	Germination (%)	Root (mm)	Shoot (mm)	Root:Shoot ratio R:S
0.0	76.0[a]	14.2[a]	8.0[a]	1.9:1 *[b]
-1.0	4.5[b]	5.5[b]	2.6[b]	2.3:1[a]
-2.0	0.0[c]	0.0[c]	0.0[c]	0.0:0[c]

[abc] different literals in columns indicate significant differences (P<0.05)

*Root:Shoot ratio 1.9 mm in the root by 1 mm in the shoot

Conclusions

Although natal grass is an invasive exotic species, it represents a source of forage. However, its nutritional value, as well as its high stem production, are not characteristics of a species considered a good forage source. It is important to continue evaluating this species in the field to know its response to environmental variation between years. This information is basic to establish grazing management patterns in ecosystems dominated by this species, which continues to expand throughout Mexico.

Authors contribution

Work conceptualization, OGGG, CRMN; methodology development, OGGG, CRMN; software management, OGGG; experimental validation, OGGG, CRMN, AMC; results analysis, OGGG, CRMN, AMC; data management, OGGG, CRMN, AMC; manuscript writing and preparation, OGGG, CRMN, AMC; writing, revising and editing, OGGG, CRMN, AMC; project manager, CRMN; fund acquisition, CRMN.

All authors of this manuscript have read and accepted the published version of the manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

References

Ankom Technology (2014). Procedures for fiber and *in vitro* analysis. [consultada: 16 noviembre, 2014]. https://www.ankom.com/product-catalog/daisy-incubator

AOAC. (2012). Official methods of analysis of the assoc. off anal. chem. 19ª ed. Wahington, D.C. USA.

Beltrán-López, S., García Díaz, C. A., Hernández Alatorre, J. A., Loredo Osti, C., Urrutia Morales, J., González Eguiarte, L. A., & Gámez Vázquez, H. G. (2013). “Banderilla Diana” *Bouteloua curtipendula* (Michx.) Torr., nueva variedad de pasto para zonas áridas y semiáridas. *Revista mexicana de ciencias pecuarias*, 4(2), 217-221. https://www.scielo.org.mx/pdf/rmcp/v4n2/v4n2a7.pdf

Calzada-Marín, J. M., Enríquez-Quiroz, J. F., Hernández-Garay, A., Ortega-Jiménez, E., & Mendoza-Pedroza, S. I. (2014). Análisis de crecimiento del pasto maralfalfa (*Pennisetum* sp.) en clima cálido subhúmedo. *Revista mexicana de ciencias pecuarias*, 5(2), 247-260. https://www.scielo.org.mx/scielo.php?pid=S2007-11242014000200009&script=sci_arttext

Carrillo-Saucedo, S. M., Arredondo Moreno, J. T., Huber-Sannwald, E., & Flores Rivas, J. D. (2009). Comparación en la germinación de semillas y crecimiento de plántulas entre gramíneas nativas y exóticas del pastizal semiárido. Técnica Pecuaria en México,47(3), 99-312

Chávez, A., Fierro, L. C., de Peña, R. H., Sánchez, E., & Ortíz, V. (1986). Composición botánica y valor nutricional de la dieta de bovinos en un pastizal mediano abierto en la región central de chihuahua. *Revista Mexicana de Ciencias Pecuarias*, (50), 90-105.

Chávez, S. A. H., & González, G. F. (2008). Estudios zootécnicos I (animales en pastoreo). A. Chávez A, Carrillo R editores. Rancho Experimental La Campana, 50.

COTECOCA. (1978). Comisión Técnico Consultiva para la Determinación Regional de los Coeficientes de Agostadero Secretaría de Agricultura y Recursos Hidráulicos. Subsecretaria de Ganadería. México, D.F. 151 p.

Crowl, T. A., Crist, T. O., Parmenter, R. R., Belovsky, G., & Lugo, A. E. (2008). The spread of invasive species and infectious disease as drivers of ecosystem change. *Frontiers in Ecology and the Environment*, 6(5), 238-246. https://doi.org/10.1890/070151

David, A. S., & Menges, E. S. (2011). Microhabitat preference constrains invasive spread of non-native natal grass (*Melinis repens*). *Biological Invasions*, *13*, 2309-2322. https://doi.org/10.1007/s10530-011-0044-5

Díaz-Romo, A., Flores Ancira, E., De Luna Jiménez, A., Luna Ruiz, J. D. J., Frías Hernández, J. T., & Olalde Portugal, V. (2012). Biomasa aérea, cantidad y calidad de semilla de *Melinis repens* (Willd.) Zizka, en Aguascalientes, México. *Revista mexicana de ciencias pecuarias*, 3(1), 33-47. https://www.scielo.org.mx/scielo.php?pid=S2007-11242012000100003&script=sci_arttext

Ervin, E. H., LaBranche, A., & Zhang, X. (2009). Kentucky bluegrass and creeping bentgrass responses to foliar application of glycinebetaine at three ET replacement levels. *International Turfgrass Society*, *11*, 755-763.

Esqueda C. M. H. & R. R. L Carrillo. (2001). Producción de forraje y carne en pastizales resembrados con gramíneas introducidas. *Técnica pecuaria en México*, 39(2), 139-152. https://www.redalyc.org/pdf/613/61339205.pdf

Flores-Ancira, E., Luna Luna, M., Haubi Segura, C., Díaz Romo, A., & Luna Ruiz, J. D. J. (2016). Efecto del fuego en producción y calidad de zacate rosado en Aguascalientes. *Revista Mexicana de Ciencias Agrícolas*, *7*(6). 1271-1281. https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-09342016000601271

Fuentes-Ramírez, A., Pauchard, A., Marticorena, A., & Sánchez, P. (2010). Relación entre la invasión de *Acacia dealbata* Link (Fabaceae: Mimosoideae) y la riqueza de especies vegetales en el centro-sur de Chile. *Gayana. Botánica*, *67*(2), 188-197. http://dx.doi.org/10.4067/S0717-66432010000200004

González-García, H., Sánchez-Maldonado, A., Sánchez-Muñoz, A. J., Orozco-Erives, A., Castillo-Castillo, Y., Martínez-De la Rosa, R., & González-Morita, J. A. (2017). Valor nutritivo del zacate rosado (*Melinis repens*) y del zacate africano (*Eragrostis lehmanniana*) en Chihuahua. *Ciencia en la Frontera*, 14(2).

Gutiérrez-Gutiérrez, O. G., Morales Nieto, C. R., Villalobos González, J. C., Ruíz Barrera, O., Ortega Gutiérrez, J. Á., & Palacio Nuñez, J. (2019). Composición botánica y valor nutritivo de la dieta consumida por bovinos en un área invadida por pasto rosado [*Melinis repens* (willd.) Zizka]. *Revista mexicana de ciencias pecuarias*, 10(1), 212-226. https://doi.org/10.22319/rmcp.v10i1.4451

Revista Bio ciencias
ISSN 2007-3380

Gutiérrez-Gutiérrez, O. G., Rivero-Hernández, O., Vega-Mares, J. H., & Melgoza-Castillo, A. (2022). Patrones de germinación en gramíneas presentes en el Desierto Chihuahuense. *Botanical Sciences*, 100(4), 989-999. https://doi.org/10.17129/botsci.3007

Herrick, J. E., Van Zee, J. W., Havstad, K. M., Burkett, L. M., & Whitford, W. G. (2005). Monitoring manual for grassland, shrubland and savanna ecosystems. Volume I: Quick Start. Volume II: Design, supplementary methods and interpretation. *Monitoring manual for grassland, shrubland and savanna ecosystems.*

Holechek, J. L.; Pieper R. D. & Herbel, C. H. (2011). Range management principles and practices. 6th (Ed). Prentice Hall. Upper Saddle River, New Jersey. 444 p.

Jurado-Guerra, P., Velázquez-Martínez, M., Sánchez-Gutiérrez, R. A., Álvarez-Holguín, A., Domínguez-Martínez, P. A., Gutiérrez-Luna, R., Garza-Cedilloe R.D., Luna-Luna, M., & Chávez-Ruiz, M. G. (2021). Los pastizales y matorrales de zonas áridas y semiáridas de México: Estatus actual, retos y perspectivas. *Revista mexicana de ciencias pecuarias*, 12, 261-285. https://doi.org/10.22319/rmcp.v12s3.5875

Lavandera-Barreras, G., Gil León, M. E., Mojica Zárate, H. T., & Arvizu Valencia, R. A. (2019). Presencia de flora exótica en el sitio Ramsar ecosistema Arroyo Verde Sierra de Álamos Río Cuchujaqui, Sonora México. *Conrado*, 15(70), 95-101.

Leis, S., Morrison, L. W., & Debacker, M. D. (2012). Spatiotemporal variation in vegetation structure resulting from pyric-herbivory. *Prairie Naturalist*, *45*, 13-20. https://digitalcommons.unl.edu/tpn/122/

Mastalerczuk, G., & Borawska-Jarmułowicz, B. (2021). Physiological and morphometric response of forage grass species and their biomass distribution depending on the term and frequency of water deficiency. Agronomy, 11 (12): 2471. https://doi.org/10.3390/agronomy11122471

Mata-Balderas, J. M., Hernández-Cárdenas, S. E., Alanís-Rodríguez, E., & Mora-Olivo, A. (2020). Riqueza, composición y abundancia de especies en una comunidad vegetal ribereña en el río Santa Catarina, Monterrey, Nuevo León. *CienciaUAT*, 14(2), 6-20. https://doi.org/10.29059/cienciauat.v14i2.1248

Mata-González, R., & Meléndez-González, R. (2005). Growth characteristics of Mexican oregano (*Lippia berlandieri* Schauer) under salt stress. *The southwestern naturalist*, *50*(1), 1-6. https://www.jstor.org/stable/3672632

McGranahan, D. A., Engle, D. M., Fuhlendorf, S. D., Winter, S. L., Miller, J. R., & Debinski, D. M. (2013). Inconsistent outcomes of heterogeneity-based management underscore importance of matching evaluation to conservation objectives. *Environmental Science & Policy*, 31, 53-60. https://doi.org/10.1016/j.envsci.2013.03.005

Medina-García, G., Díaz Padilla, G., Berzoza Martínez, M., Silva Serna, M. M., Chávez Silva, A. H., & Báez González, A. D. (2006). Estadísticas climatológicas básicas del estado de Chihuahua (1961-2003).

Melgoza-Castillo, A., Balandrán Valladares, M. I., Mata-González, R., & Pinedo Álvarez, C. (2014). Biología del pasto rosado *Melinis repens* (Willd.) e implicaciones para su aprovechamiento o control: Revisión. *Revista mexicana de ciencias pecuarias*, 5(4), 429-442. https://www.scielo.org.mx/scielo.php?pid=S2007-11242014000400004&script=sci_arttext

Miranda, R. (2012). *Aplicación de fuego prescrito para el control del zacate rosado (Melinis repens)* (tesis licenciatura) México. Universidad Autónoma de Chihuahua. Chihuahua, Chih.

Morales, C.R., Madrid Pérez, L., Melgoza Castillo, A., Martínez Salvador, M., Arévalo Gallegos, S., Rascón Cruz, Q., & Jurado Guerra, P. (2009). Análisis morfológico de la diversidad del pasto navajita [*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Steud.], en Chihuahua, México. *Técnica pecuaria en México*, *47*(3), 245-256. https://cienciaspecuarias.inifap.gob.mx/index.php/Pecuarias/article/view/1472

Morales, N. C. R., C. E. Vélez, C. Pinedo, & O. G. Gutiérrez. (2014). Características del zacate rosado (*Melinis repens*) y su comportamiento como especie invasora en pastizales de Chihuahua. Manual técnico N° 12. Universidad Autónoma de Chihuahua. Facultad de Zootecnia y Ecología. Chihuahua, Chihuahua.

Pérez-Amaro, J. A., García-Moya, E., Enríquez-Quiroz, J. F., Quero-Carrillo, A. R., Pérez-Pérez, J., & Hernández-Garay, A. (2004). Análisis de crecimiento, área foliar específica y concentración de nitrógeno en hojas de pasto "mulato" (*Brachiaria* hibrido, CV). *Técnica pecuaria en México*, *42*(3), 447-458. https://cienciaspecuarias.inifap.gob.mx/index.php/Pecuarias/article/view/1397

Ramírez, R. G., González-Rodríguez, H., Morales-Rodríguez, R., Cerrillo-Soto, A., Juárez-Reyes, A., García-Dessommes, G. J., & Guerrero-Cervantes, M. (2009). Chemical Composition and Dry Matter Digestion of Some Native and Cultivated Grasses in Mexico. *Czech Journal of Animal Science*, 54(4), 150-162. https://www.old-aj.cz/publicFiles/05752.pdf

Reyes, O., Murillo, M., Herrera, E., Gutierrez, E., Juárez, A. S., & Cerrillo, A. (2012). Influencia de la época del año en indicadores nutricionales y metabólicos de bovinos en pastoreo en el norte de México. *Revista Cubana de Ciencia Agrícola*, *46*(4), 375-380.

Reyes-Estrada, O., Murillo-Ortiz, M., Herrera-Torres, E., Gurrola-Reyes, J. N., & Carrete-Carreón, F. O. (2014). Cambios estacionales en consumo, composición química y degradabilidad ruminal de la dieta seleccionada por novillos en pastoreo. *Ecosistemas y recursos agropecuarios*, *1*(2), 97-106. https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-90282014000200002

Rzedowski, J. (1975). An ecological and phytogeographical analysis of the grasslands of Mexico. Taxon, 24(1), 67-80. https://doi.org/10.2307/1219002

Ruiz, M., & Terenti, O. (2012). Germinación de cuatro pastos bajo condiciones de estrés salino. *Phyton (Buenos Aires)*, *81*(2), 169-176. http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1851-56572012000200006

Sánchez, J. J. (2012). *Caracterización de hábitat y riesgo de invasión por zacate rosado (Melinis repens) en pastizales áridos y semiáridos de Chihuahua, México* [tesis maestría]. México: Universidad Autónoma de Chihuahua).

Sánchez-Maldonado, A. (2014). *Especies invasoras de pastizales en Chihuahua: caracterización del valor nutricional y biológico del zacate rosado (Melinis repens) y del zacate africano (Eragrostis lehmanniana)* (Doctoral dissertation, Universidad Autónoma de Ciudad Juárez).

Springer, T. L. (2005). Germination and early seedling growth of chaffy-seeded grasses at negative water potentials. *Crop Science*, *45*(5), 2075-2080. https://doi.org/10.2135/cropsci2005.0061

Stokes, C. A., MacDonald, G. E., Adams, C. R., Langeland, K. A., & Miller, D. L. (2011). Seed biology and ecology of natalgrass (*Melinis repens*). *Weed science*, *59*(4), 527-532. https://doi.org/10.1614/WS-D-11-00028.1

Van Soest, P. J. (1963). Use of detergents in the analysis of fibrous feeds. 2. A rapid method for the determination of fiber and lignin. *Journal of the Association of Official Agricultural*

Revista Bio ciencias
ISSN 2007-3380

Chemists, *46(5)*, 829-835. https://doi.org/10.1093/jaoac/46.5.829

Wagner, B., & Colón, R. (2014). Comportamiento forrajero de tres *Pennisetum purpureum*. *Revista Agropecuaria y Forestal APF* 3(1), 61-66.