AP AGRO PRODUCTIVIDAD

Colegio de Postgraduados

Forage yield of African star grass (*Cynodon nlemfuensis* Vanderyst) at different cut heights

Sánchez-Hernández Miguel A.[1]; **Morales-Terán Gladis**[1*]; **Rivas-Jacobo Marco A.**[2]; **Mendoza-Pedroza Sergio I.**[3]; **Sánchez-Hernández César**[4]; **Fraire-Cordero Silvia**[5]

[1] Instituto de Agroingenieria, Universidad del Papaloapan, Campus Loma Bonita, Av. Ferrocarril S/N, Loma Bonita, Oaxaca, México, C.P. 68400. mangelsan@hotmail.com

[2] Facultad de Agronomía y Veterinaria de la UASLP, San Luis Potosí, México, C.P. 78321. marco.rivas@uaslp.mx

[3] Colegio de Post graduados-Campus Montecillo, Carretera México-Texcoco km 36.5, Montecillo, Texcoco, Estado de México, C.P. 56230. sergiomp@colpos.mx

[4] Nova Universitas, Carretera a Puerto Ángel km. 34.5, Ocotlán de Morelos, Oaxaca, México, C.P. 71513. cesarsh79@hotmail.com

[5] Conacyt-Colegio de Postgraduados, Campus Campeche, Carretera Haltuchén-Edzná, km. 17.5, Champotón, Campeche, México, C.P. 24050. frairec@colpos.mx

* Correspondence: gteran_75@hotmail.com

ABSTRACT

Objective: To determine the effect of cutting height, season, and year on the forage yield of African Star grass (*Cynodon nlemfuensis* Vanderyst) in Loma Bonita, Oaxaca, México.

Design/Methodology/Approach: A randomized block design was used in plots divided using a factorial arrangement and three replications. The treatments consisted of the combination of cutting heights, seasons, and years of evaluation with four repetitions. The following variables were taken into consideration: fresh and dry forage yield (kg ha^{-1}), leaf weight (kg FM ha^{-1}), stem weight (kg FM ha^{-1}), dead material (kg ha^{-1}), leaf-steam ratio, and total yield per hectare (kg ha^{-1}). An analysis of variance was carried out and the means were compared using Tukey's test.

Results: The cutting heights did not have an effect on the DM yield. The uniformity cut can be made between 7 and 10 cm. DM performance for the 6 characters evaluated was better in 2018 than in 2016.

Study limitations/Implications: Applying dolomite calcium to increase soil pH, N, P, and K levels under irrigated conditions could improve growth rates and DM production.

Findings/Conclusions: Cutting heights did not have an impact on forage yield. The uniformity cut could be made at a 7-10 cm height. The rainy season had a higher dry matter yield (3,310 kg ha^{-1}) than the dry season (1,902 kg DM ha^{-1}) and the cold front season (1,914 kg DM ha^{-1}).

Key words: *Cynodon nlemfuensis*, African Star grass, dry matter, forage yield.

Citation: Sánchez-Hernández, M. A., Morales-Terán, G., Rivas-Jacobo, M. A., Mendoza-Pedroza, S. I., Sánchez-Hernández, C., & Fraire-Cordero, S. (2022). Forage yield of African star grass (*Cynodon nlemfuensis* Vanderyst) at different cut heights. *Agro Productividad*. https://doi.org/10.32854/agrop.v15i7.2322

Academic Editors: Jorge Cadena Iñiguez and Libia Iris Trejo Téllez

Received: March 21, 2022.
Accepted: July 14, 2022.
Published on-line: August 08, 2022.

Agro Productividad, *15*(7). July. 2022. pp: 27-33.

INTRODUCTION

The African Star grass (*Cynodon nlemfuensis* Vanderyst) is native to Rhodesia, Africa (Barrón-Arredondo *et al.*, 2020). This grass has a C_4 photosynthetic mechanism (Huang *et al.*, 2020). It is a major crop in the tropical and subtropical regions of the world due to its productive potential for animal feed, ease of establishment, persistence under grazing, and crude protein content (7.6-13.1%) (Dormond *et al.*, 1998; Hernández *et al.*, 2004; Brighenti *et al.*, 2020; Torres *et al.*, 2020). Ruminants feed on this forage species, in extensive and intensive grazing systems (Namihira *et al.*, 2019), and it can be used with cut-and-carry, hay making or ensilage systems.

As a result of their evaluation of the forage yield of African Star grass in Tabasco, Mexico, in three seasons of the year, Barrón-Arredondo *et al.* (2020) recorded the highest yield of fresh forage in the rainy season, with 10,041.8 kg FM ha^{-1}. This value was significantly different from that obtained in the dry and cold front seasons, when 5,851.3 and 5,851.5 kg FM ha^{-1} were recorded, respectively. However, the dry matter yield did not vary significantly, with averages of 2,649.8, 2,213.0, and 1,990.5 kg DM ha^{-1} for the rainy, cold front, and dry seasons, respectively. Therefore, in order to increase the biomass yield of African Star grass per unit of area, management strategies should be implemented (Barrón-Arredondo *et al.*, 2020) to protect the meristematic tissues associated with grass regrowth (Taiz and Zeiger, 2006). This process would identify the use level of the grassland and the grazing intensity, avoiding overgrazing and, consequently, achieving a better use of the areas destined for animal production. In Loma Bonita, Oaxaca, Mexico, local ranchers grow the African Star grass without fully understanding either its productive behavior throughout the year or its fresh forage yield and dry matter per hectare. These data would allow them to enhance animal productivity in the lower basin of the Papaloapan river. Therefore, the objective of this study was to determine the effects of cutting height, season, and year on the forage yield of African Star grass in Loma Bonita, Oaxaca, Mexico.

MATERIALS AND METHODS

The research was carried out in the experimental plots of the Zootechnical Post of the Universidad del Papaloapan, Loma Bonita Campus, Oaxaca, Mexico. It is located at 18° 06’ N, 95° 52’ W, and 25 m.a.s.l. Rainfall reaches 1,845 to 1,910 mm and the average temperature is 24.7 °C (Soto *et al.*, 2019).

For the establishment, we used 40-50 cm long stolons with developed roots and a 90-day regrowth age. The soil conditions were: 4.8 pH; 2.6% organic matter; 29.7, 35.3, 32.0, 148, and 107 mg kg^{-1} of N, P, K, Ca, and Fe; and sandy loam texture (53, 29, and 18% sand, silt, and clay, respectively).

From 2015 to 2018, the plots were fertilized with sheep manure (2,500 kg ha^{-1}) during the pasture rest, and the grass was fertilized using the 100-00-00 of the N, P_2O_5, K_2O formula, plus urea (46-00-00). In December 2015, a uniformity cut was made with 40 sheep, which initially remained only two days in each grassland to avoid overgrazing; the cut was standardized to a 10-cm average height with garden shears. This procedure guaranteed that 48 sheep (28 ewes and 20 lambs of approximately 4 months of age) could graze for five days in each plot, once the sampling sites had been isolated.

We used a randomized block design, in split plots, with a factorial arrangement and three replications. The experimental plots were traced in four 43-m long × 15-m wide African Star grass pastureland. Each experimental plot measured 5.0 m × 10.75 m (experimental unit = 53.75 m^2). Over the course of a two-year evaluation (2016 and 2018), the treatments combined four cutting heights (7, 8, 9, and 10 cm) with three production seasons: dry (March-May), rainy (June-August), and cold front (November-December). Figure 1 shows the temperature and precipitation data for the evaluation years.

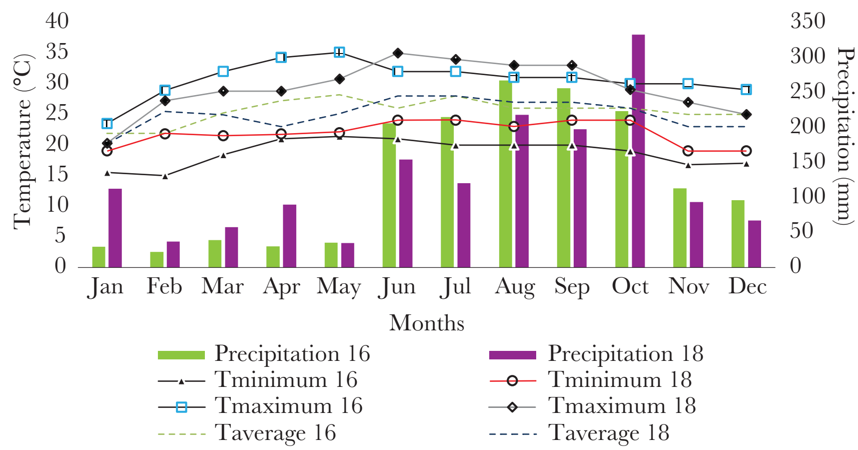

Figure 1. Precipitation (mm) and maximum, minimum, and average temperature (°C) in Loma Bonita, Oaxaca, Mexico (2016 and 2018).

The following variables were studied: fresh forage yield, leaf weight, stem weight, dead material, leaf-stem ratio, and dry matter yield. Fresh forage yield (FFY, kg ha^{-1}) was estimated from a 250-g sample harvested in a 0.25 m^2 area. The leaf blade and the stems of the plant were separated from this sample to obtain the weight of leaves (Wl, kg ha^{-1}), the fresh stems (Ws, kg ha^{-1}), and the dead material (Dm, kg ha^{-1}).

The leaf-stem ratio (LSR) was obtained by dividing the leaf component by the stem yield. To determine the dry matter yield (kg DM ha^{-1}), 250-g samples of harvested fresh forage (kg FM ha^{-1}) were collected 30 days after the uniformity cut and were put in paper bags, labeled, and dried in a forced air stove at 65 °C for 72 h. Subsequently, the dry weight was determined using a Scout Pro® digital scale.

The statistical analysis of the information consisted of an analysis of variance (Padilla *et al.*, 2019) performed under a randomized block experimental design, in subdivided plots with a factorial arrangement and three repetitions. The SAS 9.4 statistical package (SAS, 2013) was used to perform a mean comparison test (Tukey, $p \leq 0.05$) of the significant variables.

RESULTS AND DISCUSSION

Influence of the year and seasons in the African Star grass production

There were significant statistical differences ($p \leq 0.01$) between the evaluation years; the year 2018 stood out regarding 5 of the 6 variables measured for the African Star grass (Table 1). This situation is the result of the correct agronomic management of the grasslands and a better distribution of rain during the said year (Figure 1). In 2018, the average dry matter yield, in the rainy, dry, and cold front seasons was 2,811.7 kg DM ha^{-1}, 30% higher than in the average yield of 2016 (Table 1). In a study of African Star grass carried out in Tabasco, Mexico, an average of 2,017.7 kg DM ha^{-1} was recorded in the same seasons of the year (Barrón-Arredondo *et al.*, 2020). Meanwhile, in an evaluation carried out on *Cynodon plectostachyus* under tropical climate conditions in Ecuador, after 30 days of grass regrowth and an average of four cuts, a 2,413.7 kg

DM ha^{-1} yield was obtained, which amounted to 2,850.9 kg DM ha^{-1}, according to the nutritional contribution received by the grass (Vera *et al*., 2019). A similar yield was obtained in the present research for the year 2018.

In 2016, only the leaf-stem ratio (0.65) was favored, a situation attributed to the recent establishment of the grasslands. This situation could change over time, as a consequence of grazing by animals and the soil compaction caused by their trampling. Rodriguez *et al*. (2015) indicate that the yield decreases over time, even when the stocking rate is adequate, mainly as a consequence of the said compaction. In this regard, Ramón-Castro *et al*. (2015) reported a leaf:stem ratio of 0.6 in African Star grass, six weeks after the uniformity cut.

The 1,533.1 mm rainfall registered in 2018 accounts for the effect of the year on the African Star grass yield. Although it was similar to the 2016 rainfall (Figure 1), it was better distributed among the seasons, allowing a better yield among the components. In addition, the higher yield recorded in 2018 is the result of a greater accumulation of leaf and stem biomass. However, as a consequence of a higher productivity, senescent or dead material also increased (Table 1).

It is evident that the time factor (years) caused changes in the grass variables measured, mainly due to the climatic conditions that caused different responses in the forage accumulated in the grasslands used. Villalobos-Villalobos and WingChing-Jones (2019) mentioned that temperature, solar radiation, relative humidity, cloudiness, and water content in the soil —which change from one year to the next— directly affect the grassland's growth and speed of recovery for its subsequent use.

The sampling seasons caused significant differences ($p \leq 0.01$) in the 6 characters evaluated in African Star grass. Statistical significance indicates that the time of year influenced the behavior of the different variables. The FFY, Wl, Ws, Dm, LSR, and DM characteristics made the rainy season stand out (Table 1).

The dry matter yield was higher in the rainy season (3,310.4 kg DM ha^{-1}), surpassing the cold front season (1,914.6 kg DM ha^{-1}) and the dry season (1,902.3 kg DM ha^{-1}) by 42.2% and 42.5%, respectively (Table 1). In this regard, Barrón-Arredondo *et al*. (2020) recorded 2,649.8 kg DM ha^{-1} in the rainy season, exceeding the dry matter

Table 1. African Star grass (*Cynodon nlemfuensis*) forage yield, depending on years and seasons (dry, rainy, and cold front; average of two years). Loma Bonita, Oaxaca, Mexico.

Variable	X	2016	2018	MSD	Dry season	Rainy season	Cold front	MSD
FFY (kg ha^{-1})	8419.2	6837.5 b	10000.9 a	1279.1	6580.2 b	12234.4 a	6443.0 b	2126.1
Wl (kg ha^{-1})	2748.4	2216.6 b	3280.3 a	486.7	1790.7 b	4418.8 a	2035.9 b	701.9
Ws (kg ha^{-1})	4312.9	3490.6 b	5135.3 a	668.7	3408.9 b	6225.5 a	3304.6 b	1082.7
Dm (kg ha^{-1})	1357.4	1130.4 b	1584.5 a	130.0	1308.7 ab	1589.0 a	1102.6 b	359.4
LSR	0.63	0.65 a	0.62 b	0.006	0.52 c	0.71 a	0.62 b	0.01
DM (kg ha^{-1})	2375.8	1939.9 b	2811.7 a	320.8	1902.3 b	3310.4 a	1914.6 b	590.4

FFY=Fresh forage yield, Wl=Fresh leaf weight, Ws=Fresh stem weight, Dm=Dead material, LSR=Leaf-stem ratio, DM=Dry matter, X=Average value, MSD=Minimum significant difference (Tukey $p \leq 0.05$), abc=Different letters within rows indicate a significant difference ($p \leq 0.05$).

yield per hectare of the dry season (1,990.5 kg) and the cold front season (2,213.0 kg) by 25% and 16.5%, respectively. These results are lower than those obtained in a very humid tropical climate in Costa Rica (where it rains up to 4,000 mm per year) and a production of 4,796 kg DM ha^{-1} $cycle^{-1}$ was recorded (Villalobos-Villalobos and WingChing-Jones, 2019).

African Star grass yield per grassland

The study showed a statistically different DM yield ($p \leq 0.05$) between grasslands in which rotational grazing had been enabled. Grasslands I, II, and III surpassed grassland IV in the FFY, Wl, Wt, Dm, and DM variables, but not in LSR. Consequently, the DM productivity recorded in grasslands I, II, and III was 27.6, 25.6, and 12.2% higher, respectively, than the productivity obtained in grassland IV (2,041.8 kg ha^{-1}) (Table 2).

The results indicate that soil fertility has an impact on the DM yield of African Star grass, since grassland IV is located in an area with a slight slope; although the evaluations were carried out three years after the grasslands had been established (under similar management between them), soil fertility could affect the results obtained. This information should be taken with caution, because the soil of each grassland was not analyzed.

In Tejupilco, State of Mexico, with a semi-warm climate with summer rains, *Cynodon plectostachyus* was subject to an agronomic and chemical composition evaluation and differences were found in grassland height, net accumulation of forage, living material, dead material, leaves, and stems. Specifically, DM yield changed from 728 to 1,193 kg DM ha^{-1} (López-González *et al.*, 2010).

African Star grass yield, depending on cutting height

The modifications to the cutting height did not affect FFY and DM (Table 3), which means that a 7-10 cm cutting height did not affect the African Star grass' productive performance.

In their study about *Cynodon plectostachyus*, Namihira *et al.* (2019) reported that a 5-cm height was less favorable for morphological components than a 15-cm height, because regrowth height mainly depends on the amount of nonstructural carbohydrates present in the plant. Additionally, the largest amount of carbohydrates stored in African Star grass is located in the root crown; therefore, Namihira *et al.* (2019) suggest refraining from

Table 2. Components associated with forage yield per grassland for African Star grass (*Cynodon nlemfuensis*).

Variable	Grasslands I	Grasslands II	Grasslands III	Grasslands IV	MSD	SE
FFY	9205.6 a	9080.1 a	8132.8 ab	7258.3 b	1131.2	308.1
Wl	2979.3 a	2961.6 a	2652.6 ab	2400.2 b	383.9	104.5
Ws	4716.5 a	4637.2 a	4171.8 ab	3726.4 b	580.6	158.2
Dm	1509.8 a	1479.0 ab	1306.7 bc	1134.2 c	186.2	50.8
LSR	0.62 a	0.61 a	0.62 a	0.62 a	0.2	0.01
DM	2604.7 a	2565.3 a	2291.4 ab	2041.8 b	318.7	86.8

FFY=Fresh forage yield (kg ha^{-1}), Wl=Fresh leaf weight (kg ha^{-1}), Ws=Fresh stem weight (kg ha^{-1}), Dm=Dead material (kg ha^{-1}), LSR=Leaf-stem ratio, DM=Dry matter (kg ha^{-1}). MSD=Minimum significant difference (Tukey $p \leq 0.05$), SE=Standard Error, ab=Different letters within rows indicate a significant difference ($p \leq 0.05$).

using 5-cm cutting heights when the temperature falls below 20 °C, during the cold front season in Mexico, because it could affect the grassland forage production for the following growing season.

African Star grass behavior, depending on the interaction of years per seasons

In both 2016 and 2018, the rainy season favored the leaf-stem ratio (Table 4). The FFY, Wl, and Ws yield components also increased in 2018; the resulting increase in grass productivity was represented by a greater amount of leaf and stem dry matter (Table 4).

The interaction detected between years × seasons indicates that African Star is a perennial grass with a creeping habit, whose stolons can reach 3.0 m in length. It grows roots at the nodes. It forms a dense cover, lignifying during the drought, although it grows rapidly in the rainy season and low temperatures stop its rapid growth during the cold front season. Therefore, proper management of this grass must be ensured to guarantee its persistence for years (Enríquez *et al.*, 2013).

Table 3. Components associated with the forage yield of African Star grass (*Cynodon nlemfuensis*), depending on cutting heights (CH), average of two years and three study seasons.

Variable	CH7	CH8	CH9	CH10	DMS	EE
FFY	8300.9 a	8623.3 a	8246.4 a	8506.3 a	1594.2	411.9
Wl	2696.9 a	2817.3 a	2677.2 a	2802.3 a	533.0	137.7
Ws	4252.9 a	4399.6 a	4233.5 a	4365.9 a	812.6	209.9
Dm	1351.1 a	1406.5 a	1333.4 a	1338.8 a	260.1	67.2
LSR	0.62 a	0.62 a	0.61 a	0.62 a	0.2	0.01
DM	2347.2 a	2425.8 a	2336.3 a	2393.9 a	446.2	115.3

FFY=Fresh forage yield (kg ha^{-1}), Wl=Fresh leaf weight (kg ha^{-1}), Ws=Fresh stem weight (kg ha^{-1}), Dm=Dead material (kg ha^{-1}), LSR=Leaf-stem ratio, DM=Dry matter (kg ha^{-1}). MSD=Minimum significant difference (Tukey p≤0.05), SE=Standard Error, ab=Different letters within rows indicate significant difference (p≤0.05).

Table 4. African Star grass (*Cynodon nlemfuensis*) yield during a two-year evaluation with three study seasons. Loma Bonita, Oaxaca, Mexico.

Variable	2016			2018			MSD	SE
	Dry season	Rainy season	Cold front	Dry season	Rainy season	Cold front		
FFY	6660.4 c	9333.3 b	4518.8 d	6500.0 c	15135.4 a	8367.3 b	1594.2	379.0
Wl	1815.9 d	3362.5 b	1471.5 d	1765.4 d	5475.0 a	2600.3 c	533.0	128.6
Ws	3401.0 c	4755.7 b	2315.3 d	3416.8 c	7695.3 a	4293.8 b	812.6	194.5
Dm	1443.6b c	1215.5 c	732.0 d	1317.8 bc	1962.5 a	1473.2 b	260.1	62.4
LSR	0.53 d	0.71 a	0.64 b	0.52 e	0.71 a	0.61 c	0.2	0.01
DM	1913.6 c	2560.9 b	1345.2 d	1891.1 c	4060.0 a	2484.0 b	446.2	106.7

FFY=Fresh forage yield (kg ha^{-1}), Wl=Fresh leaf weight (kg ha^{-1}), Ws=Fresh stem weight (kg ha^{-1}), Dm=Dead material (kg ha^{-1}), LSR=Leaf-stem ratio, DM=Dry matter (kg ha^{-1}). MSD=Minimum significant difference (Tukey p≤0.05), SE=Standard Error, ab=Different letters within rows indicate significant difference (p≤0.05).

CONCLUSIONS

No effect of the cutting heights was recorded for the forage yield of African Star grass. The uniformity cut could be made between 7 and 10 cm high. A higher dry matter yield in the 6 dry matter yield traits was registered in 2018 than in 2016. The rainy season surpassed the dry matter yield (3,310 kg ha^{-1}) of both the dry season (1,902 kg DM ha^{-1}) and the cold front season (1,914 kg DM ha^{-1}) in Loma Bonita, Oaxaca.

REFERENCES

Barrón-Arredondo, M., Granados-Zurita, L., Maciel-Torres, S. P., Jiménez-Ortiz, M. M., Quiroz-Valiente, J.; Granados-Rivera, L. D. (2020). Curvas de crecimiento del pasto estrella de África durante las tres épocas del año en trópico húmedo. *Ciencia e innovación 3*(1): 53-63

Brighenti, A. M., Benites, F. R. G., Sobrinho, F. S., Martins, C. E., Rocha, W. S. D. (2020). Behavior of five sulfonylurea herbicides and a low-dose glyphosate on *Cynodon nlemfuensis* pasture. *Journal of Agricultural Science. 12*(2). 160-166. DOI:10.5539/jas.v12n2p160.

Dormond, H., Boschini, C., Rojas-Bourrillón, A., Zúñiga, A. M. (1998). Efecto de cuatro niveles de cáscara de banano maduro sobre la degradabilidad ruminal de la materia seca de los pastos kikuyo (*Pennisetum clandestinum*) y estrella africana (*Cynodon nlemfuensis*) en vacas Jersey. *Agronomía Costarricense. 22*(2). 163-172.

Enríquez, Q. J. F., Esqueda, E. V. A., Nicolás, N. F., Cab, J. F. E. (2013). *Estrella de África* (*Cynodon plectostachyus* Vanderyst). pp: 135-142. *En*: Gramíneas introducidas: Importancia e impacto en ecosistemas ganaderos. Quero CAR (ed.). 1a Ed. Colegio de Postgraduados. Montecillo, Estado de México. 167 p.

Hernández, G. A., Sollenberger, L. E., McDonald, D. C., Ruegsegger, G. J., Kalmbacher, R. S., Mislevy, P. (2004). Nitrogen fertilization and stocking rate affect stargrass pasture and cattle performance. *Crop Science. 44*(4). 1348-1354.

Huang, C. Q., Long, T., Bai, C. J., Wang, W. Q., Tang, J., Liu, G. D. (2020). Establishment of a core collection of Cynodon based on morphological data. *Forrajes Tropicales 8*(3). 203-213. DOI: Doi: 10.17138/tgft(8)203-213.

López-González, F., Estrada-Flores, J. G., Avilés-Nova, F., Yong-Angel, G., Hernández-Morales, P., Martínez-Loperena, R., Pedroza-Beltrán, P. E., Castelán-Ortega, O. A. (2010). Evaluación agronómica y composición química del pasto estrella de África (*Cynodon plectostachyus*) en el sur del estado de México. *Tropical and Subtropical Agroecosystems. 12*(1). 151-159.

Namihira, T., Yara, T., Mura, Y., Hossain, A. (2019). Effect of cutting height on dry matter yield and nutritive values of giant stargrass over-seeded with Italian ryegrass sward in cool-season subtropical Okinawa, Japan. *Boletín de la Sociedad Japonesa de Ciencia Animal. 62*(2). 83-89. Doi: 10.11461/jwaras.62.83

Padilla, L. A., González, H. A., Pérez, L. D. J., Rubí, A. M.; Gutiérrez, R. F., Ramírez D, J. F. Franco, M. J., Serrato, C. R. (2019). Programas para SAS e InfoStat para analizar una serie de experimentos en parcelas subdivididas. Universidad Autónoma del Estado de México. 1ª ed. Toluca, Estado de Mexico, México. 45-55 p.

Ramón-Castro, M. A., García-Castillo, C. G., Aguirre-Medina, J. F. (2015). Productividad de *Cynodon plectostachyus* K. (Schum) Pilger y *Dolichos lablab* L. solos y asociados bajo diferentes frecuencias de corte. *Agroproductividad 8*(2): 65-70.

Rodríguez A, J., Gutiérrez O, E., Rodríguez F. H. (2015). Dinámica de sistemas de pastoreo. Editorial Trillas. 1ra ed. Odontología 69, Col. Copilco Universidad, CP 04360. Coyoacán, Ciudad de México. 272 p.

SAS. (2013). Base SAS® 9.4 Procedures Guide: Statistical procedures. Second edition. SAS Institute Inc. Cary NC, USA. 550 p.

Soto, M. V. H., Alanís, M. J. L., Pech, C. J. M. (2019). Un año de observaciones meteorológicas en Loma Bonita, Oax., México; una referencia climatológica para su industria agropecuaria. *Revista Científica Biológica Agropecuaria Tuxpan 7*(2). 206-221.

Taiz, L., Zeiger, E. C. (2006). Fisiología vegetal. Ed. Universitat Jaume-I. Traducción de Plant physiology, 3a ed. 580 p.

Torres, S. N., Moctezuma, V. M., Rojas, G. A. R., Maldonado, P. M. Á., Gómez, V. A., Sánchez, S. P. (2020). Comportamiento productivo y calidad de pastos híbridos de Urochloa y estrella pastoreados con bovinos. *Revista Mexicana De Ciencias Agrícolas 24*(4). 35-46. Doi: 10.29312/remexca.v0i24.2356.

Vera, A. D., Cedeño, G. G., Cedeño, G. G., Cargua, C. J., Garay, L. M. (2019). Eficiencia agronómica de nitrógeno y producción de *Cynodon plectostachyus* (K. Schum.) Pilg. En función de dos frecuencias de corte. *Chilean Journal of Agricultural & Animal Sciences. 35*(3). 251-260. Doi: 10.4067/S0719-38902019005000405

Villalobos-Villalobos, L. A., WingChing-Jones, R. (2019). Remoción mecánica del material senescente para la recuperación de pasturas. *Agronomía Mesoamericana 30*(3). 821-840. Doi: 10.15517/am.v30i3.36625.