






# Implementation of the roller chopping for the rehabilitation of rangelands with microphyllous scrubland

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## ABSTRACT

**Objective:** Was to evaluate the roller chopping implementation in five sites (rangelands) from July 2013 in order to increase the production of dry matter (*DM*) and the basal coverage (*BC*) development of grasslands with microphilic scrub in the Peñón Blanco, Durango.

**Design/methodology/approach:** The *BC* was measured at five points of each rangeland with treatment (5) and at the control (1) using the Canfield method. Random forage sampling was conducted during October to estimate the *DM* production and the animal carrying capacity (*ACC*) for each rangeland. The *DM* production was analyzed with a completely random block design with 30 replications.

**Results:** The *BC* of the grasslands at the sites with the use of the roller chopping ranged between 23.9 and 26.6%, while in the control it was 3.6%. A significant increase ( $P \leq 0.01$ ) of the *DM* produced in the rangelands treated (787.7 to 876.8 kg ha<sup>-1</sup>) compared to the control (120 kg ha<sup>-1</sup>). The treated sites reached values in the *ACC* between 35 and 39 AU ha<sup>-1</sup>, except for the control who obtained only 5 AU ha<sup>-1</sup>.

**Limitations on study/implications:** The limitations will be reflected depending on the specific conditions of the site where the study is replicated, since the results are largely linked to factors such as climate and soil.

**Findings/conclusions:** The implementation of the roller chopping favored the rehabilitation of the grasslands to increase their forage productivity and, therefore, the cattle feeding in its extensive modality that takes place in the region's rangelands.

**Keywords:** Animal carrying capacity, basal coverage, rangeland coefficient, animal unit.



## INTRODUCTION

Arid and semi-arid zones are primarily composed of rangeland, characterized by scrubland and grasslands that are crucial for feeding cattle (*Bos taurus*) raised under extensive grazing systems. These zones account for 94.7% of the nation's scrubland and 50.2% of its grasslands (SIAP, 2014), equivalent to approximately 854,000 km<sup>2</sup> of natural grasslands used for raising various livestock species (Ramírez-López and Coronado-Minjarez, 2017).

However, extensive areas of native grasslands within the arid and semi-arid regions of northern Mexico are below their productive potential due to poor management, overgrazing, and drought, resulting in little or no grassland recovery (González-Palma and Moreno-Valenzuela, 2001). Therefore, it is estimated that 65% of the native grasslands in central and northern Mexico are experiencing problems due to erosion and the disappearance of forage species important to livestock farming (Gauthier *et al.*, 2003). Furthermore, grasslands exhibit the lowest levels of environmental protection compared to other natural ecosystems worldwide, compounded by the general degradation of biodiversity due to land-use change (Sarukhán *et al.*, 2015; SEMARNAT, 2016). Grassland degradation leads to a loss of natural soil fertility, resulting in decreased livestock productivity and significant economic losses (Padilla *et al.*, 2009).

Mexican livestock farming is one of the main productive activities generating food considered a source of animal protein for human consumption (Guevara, 2001). While grazing on natural grasslands by diverse livestock is generally for income generation, the population's consumption of milk and meat depends to a greater or lesser extent on this activity (Contreras-Hinojosa *et al.*, 2003; Bautista-Martínez *et al.*, 2017). In Mexico, between 2018 and 2019, annual per capita consumption of beef was 15.1 kg, and carcass meat production reached 2.028 million tons (t) (SIAP, 2020a). In Durango, approximately 105,194 t of beef carcass meat and 1.24 billion liters (L) of milk were produced during 2019 (SIAP, 2020b).

The state of Durango has an area of 12.3 million hectares (ha), and vegetation covers 66.1% of the state's surface area, distributed as follows: forest (31.5%), semi-desert xerophytic scrubland (19.7%), grasslands (11.3%), and the remaining 3.6% corresponds to lowland rainforest (INEGI, 2012a). Although approximately 2.8 million ha of natural grassland, rangelands, and scrubland are recorded (INEGI, 2012b), this area shows alarming deterioration, mainly caused by raising a greater number of animals than the rangeland can sustain (Flores-Gallardo *et al.*, 2013). However, to mitigate the effects of rangeland degradation in Durango, rehabilitation strategies have been implemented, including rotational grazing of the animal unit (*AU*) considering the animal carrying capacity (*ACC*) and the rangeland coefficient (*RC*), as well as the use of mechanical equipment to improve soil structure, complemented by pasture reseeding (Flores-Gallardo *et al.*, 2013).

To increase the forage capacity available to cattle raised under extensive grazing in rangelands, the roller chopping has been primarily used to ensure the establishment and development of grasses and herbaceous plants (Rivera-Sanez *et al.*, 2017). It has been demonstrated that a well-managed rangeland can be maintained without the need for mechanical control and restoration measures. However, degraded rangelands, which show

low forage production, must be restored through the investment of economic and natural resources to accelerate regeneration processes (Flores-Gallardo *et al.*, 2013).

However, the use of various roller chopping models has been studied in primary sectors, such as forestry and livestock, with viable results obtained for weed control (Miller, 1980; Schindler and Fulbright, 2003; Medina-Guillén *et al.*, 2015; Medina-Guillén *et al.*, 2017a), grass establishment with reseeding (Blanco *et al.*, 2005; González-Palma and Moreno-Valenzuela, 2001; Velázquez-Martínez *et al.*, 2015) and their subsequent use due to the acceptable fuel consumption generated by their implementation with respect to the benefits in soil structure (Rubio-Granados, 2009; Medina-Guillén *et al.*, 2017b). Due to the aforementioned benefits, simulations of the aerator roller have also been conducted using different models to refine its implementation in terms of mechanics (Yi-yuan *et al.*, 2018; Borotov, 2020; Yam-Tzec *et al.*, 2021).

The objective of this research was to evaluate the implementation of the roller chopping in rangeland areas to increase dry matter (*DM*) production and basal cover (*BC*) development in grasslands with microphyllous scrub, comparing the results with an untreated (control) site of the same characteristics to determine the *ACC* and *AU* in the region of influence of the municipality of Peñón Blanco, Durango, Mexico.

## MATERIALS AND METHODS

### Description and location of the study area

The research was carried out in five sites (rangelands) worked with the implementation of the roller chopping and a control without treatment (natural rangeland) in the municipality of Peñón Blanco (Table 1), located in the state of Durango, Mexico and which is characterized by having an area of the semi-desert.

The predominant vegetation in the study area is microphyllous scrubland, and it has a temperate semi-arid climate (BS1 kw), with a summer rainfall regime, significant temperature variation, and an average annual temperature of 18 °C (García, 1987). During the evaluation period, accumulated rainfall (*Pp*) was recorded throughout the year to compare data fluctuations with previous years using the National Network of Automated Agrometeorological Stations (RENEAA), operated by the National Laboratory for Modeling and Remote Sensing (LNMySR) of INIFAP (<https://clima.inifap.gob.mx/lnmysr>), located in Pabellón de Arteaga, Aguascalientes, Mexico.

**Table 1.** Geographical coordinates of the sites evaluated with the implementation of the roller chopin and the control (natural grazing land without treatment).

Site	NL <sup>†</sup>	WL <sup>¶</sup>	Altitude (m)	Area (ha)
1	24° 54' 00.68"	-104° 09' 37.90"	1,626	20
2	24° 52' 25.21"	-104° 09' 23.71"	1,675	50
3	24° 51' 10.34"	-104° 10' 32.95"	1,743	64
4	24° 50' 45.54"	-104° 09' 21.45"	1,744	30
5	24° 53' 57.33"	-104° 10' 00.12"	1,634	36
Control <sup>§</sup>	24° 51' 16.88"	-104° 09' 34.54"	1,714	44

<sup>†</sup> North latitude, <sup>¶</sup> West longitude, <sup>§</sup> Control.

In this area, the aim was to promote the establishment of different endemic grass species through the implementation of an roller chopping during July 2013, before the start of the rainy season. These areas were designated as exclusion zones, preventing livestock from entering. Therefore, the treatment consisted of a single pass with a two-cylinder, tandem-type roller chopping (2.44×0.76 m), powered by a 120-horsepower (hp) tractor (bulldozer), on soils with a slope of less than 5%.

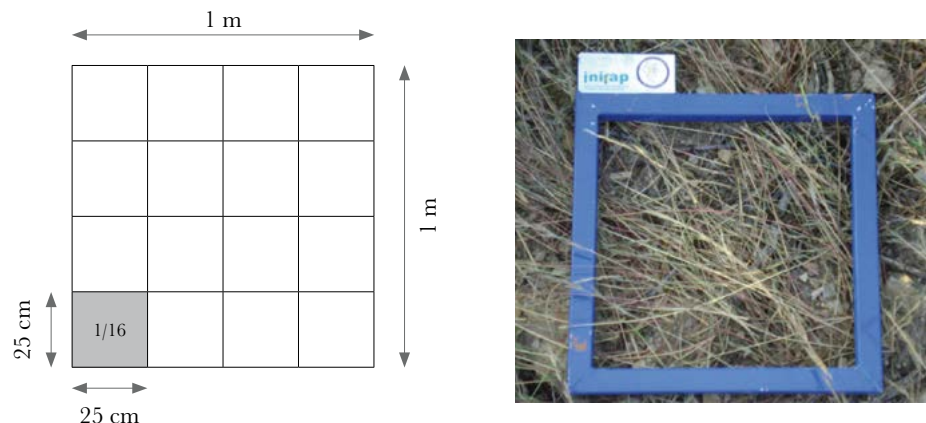
### Measurement and Recording of Variables in the Field

Base coverage (*BC*) was sampled at the sites treated with the aerator roller and the control plot. *BC* was defined as the amount of soil covered by the vertical projection of the grass plants (Sarmiento, 2000). *BC* sampling was performed at five points in each site, arranged in a rectangular pattern, with one point in the center. This procedure was carried out at each of the five sites treated with the aerator roller and at the control plot. The linear method, also known as the Canfield line or transect method, was used with the aid of a measuring tape (Canfield, 1941). A 30 m transect was used, and the intercepted grass cover was measured with a graduated ruler. In each transect, the *BC* was counted in cm and then the total figure intercepted by the grasses was calculated, by adding the values obtained in each line and subsequently, the percentage of the *BC* attributed to the grasses present in each area of the rangeland was obtained.

To evaluate the *BC* of the pastures, a plant height greater than 10 cm was considered and it was calculated with Equation 1:

$$BC(\%) = \frac{(\text{Sum of the coverage of each species}) \times 100}{\text{Transect length (m)}} \quad (1)$$

The dry matter (*DM*) content ( $\text{kg ha}^{-1}$ ) of the pastures produced at the evaluation sites was measured after the end of the heavy rainy season (October 2013). The procedure used to measure the *DM* content of the pastures involved using a 25×25 cm quadrat (Figure 1) for random sampling. Thirty samples were taken at each of the six sites to



**Figure 1.** Quadrat used to take forage samples in the field.

determine the *DM* content of the pastures. The quadrat was thrown randomly, and an attempt was made to cover as much of the tilled area as possible. At each point where the quadrat landed, the pasture was cut flush with the ground using scissors.

The plant samples obtained were placed in perforated paper bags, which were previously labeled with indelible ink to identify each sample according to the site. Subsequently, the samples were dried in a pressure drying oven (1600 Hafo Series, Shel Lab), set at 60 °C for 48 h, until a constant weight was recorded. After drying, they were weighed on a digital scale with a precision of 0.01 g.

To calculate *DM* production, the yield per square meter (m<sup>2</sup>) was multiplied by a constant of 16, and then calculations were performed to infer *DM* production in kg ha<sup>-1</sup>. According to Esqueda-Coronado *et al.* (2011), to properly calculate the recommended *CCA*, the use of a factor with a value of 60% (0.6) of the forage produced by the rangeland was considered, in order to protect the future growth and development of the pasture.

### Statistical analysis

The coefficient of variation (*CV*) was calculated using Equation 2 and the standard deviation ( $\sigma$ ) using Equation 3, the above was for the purpose of knowing the variability of the data obtained in the field.

$$CV = \frac{\sigma}{|\bar{x}|} \quad (2)$$

$$\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2} \quad (3)$$

Where  $\bar{x}$  is the average and  $x_i$  is each recorded data point. Therefore, the data obtained were further analyzed to determine their variation using the statistical package SAS<sup>®</sup> version 9.4 (SAS Institute Inc., 2013), performing an analysis of variance (ANOVA) in a completely randomized block design, and the comparison of means was performed using Tukey's test ( $P \leq 0.05$ ).

## RESULTS AND DISCUSSION

The *BC* increased considerably due to the use of the roller chopping in the rangelands, with values ranging from 23.9% to 26.6% recorded in the treated sites; while in the control area, which did not receive the aerator roller, a value of 3.6% was recorded (Table 2). The results obtained in this study were lower than those reported in other research conducted in the same area of influence, where an average value of 29.7% was reported in the areas treated with the aerator roller and 16% in the untreated sites (Cisneros *et al.*, 2009). This difference was due to the greater degree of deterioration of the pasture rehabilitated in 2013, which started from a low *BC* value (3.6% in 2013 compared to 16% in 2009).

**Table 2.** Physical and chemical properties of the soil.

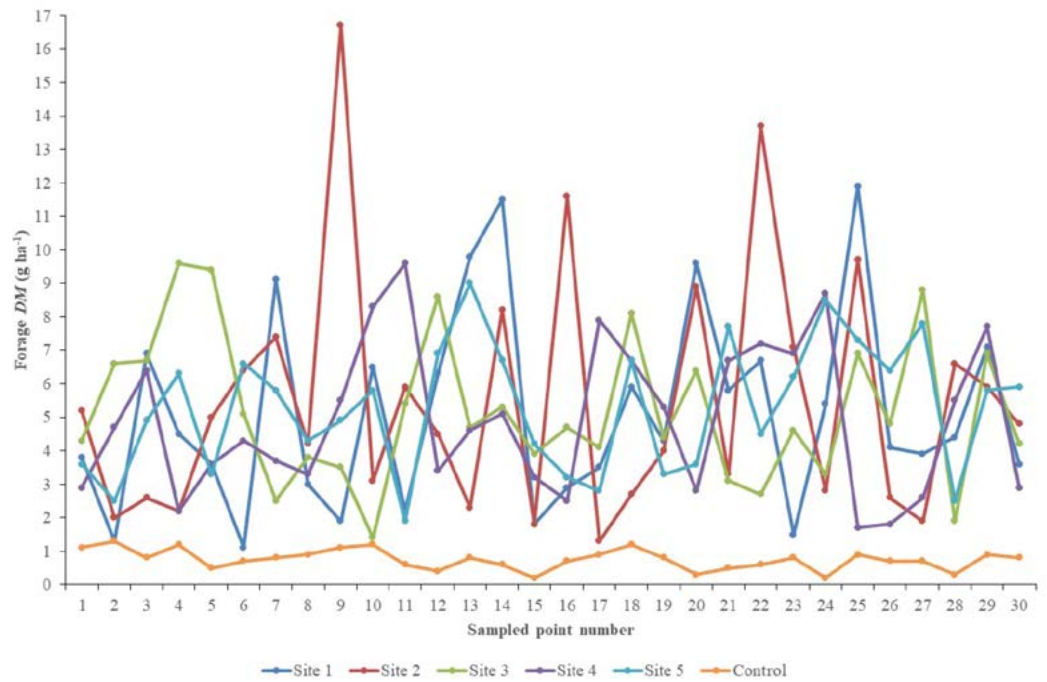
Site	BC (%)	DM (kg ha <sup>-1</sup> )	ACC (AU ha <sup>-1</sup> )
1	24.9	820.8 a	37
2	26.6	876.8 a	39
3	25.2	830.4 a	37
4	23.9	787.7 a	35
5	25.7	847.5 a	38
Control <sup>†</sup>	3.6	120.0 b	5
Average	21.7	713.9	31.8
$\sigma$		19.1	
CV (%)		63.8	

A significant increase ( $P \leq 0.01$ ) in dry forage production was observed in the areas treated with the aerator roller (Table 2). It is worth noting that all treated sites showed statistically similar forage production, ranging from 787.7 to 876.8 kg ha<sup>-1</sup>. In contrast, the control area registered a significantly lower yield of 120.0 kg ha<sup>-1</sup>. According to Cervantes-Anastacio *et al.* (2009), the Bobwhite quail (*Colinus virginianus* L.) prefers the aerator-treated sites, opting for native vegetation seeds over sorghum (*Sorghum bicolor*) supplementation.

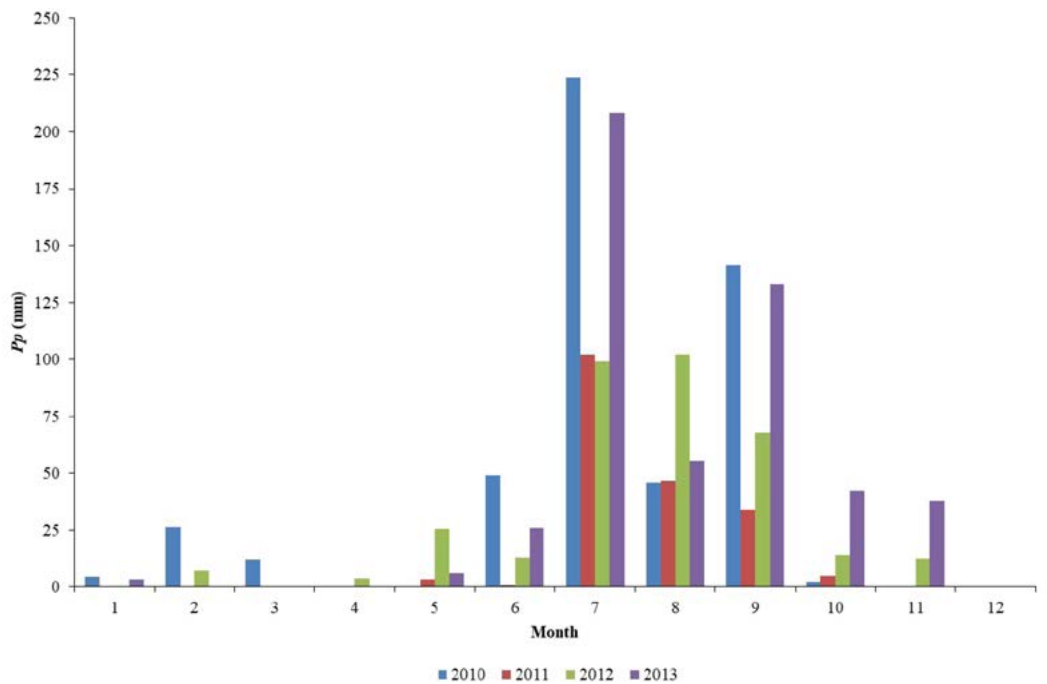
According to Villa-Herrera *et al.* (2014), the lack of information on the estimation of the ACC, which is considered a critical parameter in livestock management, limits efforts associated with establishing results-based government livestock support programs (specifically regarding the adjustment of the ACC), since the only reference for animal carrying (AC) at the national level is that developed by the Technical Advisory Commission for the Determination of Range Coefficients (COTECOCA, 1967), whose studies are outdated because most of them date back to the 1960s and 1970s. However, there is a record on AC for the state of Durango (COTECOCA, 1982) where a minimum of 4.50, a maximum of 41.44, and a weighted average of 15.70 (AU ha<sup>-1</sup>) are recommended. Therefore, it is imperative to update this information to ensure sustainable livestock management, something that was attempted in the state of Chihuahua with an action plan for the conservation and sustainable use of grasslands (PACP-Ch, 2011).

The results show that the use of the roller chopping had a high impact on the forage productivity of the grasslands in the sites studied in Peñón Blanco, Durango, because the DM values for each sample of forage were highly comparable to those of the control site, which did not receive treatment with the roller chopping (Figure 2).

Despite this being the first and only year of study, it is important to mention that the accumulated rainfall (*Pp*) during the evaluation year of 2013 (502.6 mm) favored the growth of plant species (Figure 3), as it was higher than the historical average (437.7 mm) for the area, and especially higher than the records for 2011 and 2012. A highly variable response was also recorded among the observations made for forage production, which resulted in a high ANOVA coefficient (63.8%). However, the  $\sigma$  (19.1%) indicates that the values are within an acceptable range because it is less than the 25% considered in a sample.



**Figure 2.** Forage dry matter (*DM*) record at each site treated with the aerator roller and control site in Peñón Blanco, Durango, Mexico



**Figure 3.** Comparative record of *Pp* during all months of the years 2010-2013.

The *ACC* that can be grazed in the rangelands worked with the roller chopping also increased considerably with the implementation of the equipment, since the rangeland areas treated with the roller obtained values between 35 and 39 *AU ha*<sup>-1</sup>; while the control

area registered a value of  $5 AU ha^{-1}$ , values higher than those reported by Negrete-Sánchez *et al.* (2016) in highly degraded rangelands with excessive ACC. Based on the results, the benefits obtained with the use of the roller chopping with respect to the forage productivity of the pasture are considerable, since Reyes-Estrada *et al.* (2014) report for Durango a dry matter intake by grazing steers of  $6.67 kg d^{-1}$  in summer,  $6.28 kg d^{-1}$  in autumn,  $4.43 kg d^{-1}$  in winter, and  $4.54 kg d^{-1}$  in spring. This allows for the development of management strategies to enhance the productive and reproductive performance of cattle raised in north-central Mexico. Furthermore, the appropriate use of the roller will increase the richness and diversity of endemic grass species, as well as maintain the ecological balance of the microphyllous scrubland ecosystem that predominates in the rangelands of the state of Durango.

## CONCLUSIONS

Treatment with the roller chopping increased the BC in rangelands and improved the level of ACC that can be fed per unit area, significantly influencing forage production in semi-desert areas of the state of Durango. However, the equipment must be implemented efficiently to maintain an ecological balance in scrubland areas and complemented with a comprehensive rangeland management plan, avoiding the loss of plants useful to other organisms in the ecosystem. The information obtained opens the possibility of updating the AC published in the 1960s, 70s, and 80s in subsequent studies, providing current data to livestock producers and technicians in different regions of Mexico.

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