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Pruning height and frequency of *Moringa oleifera* and *Leucaena leucocephala* in a silvopastoral system

Cauich-Cauich, Issac I.[1]; Uicab-Brito, Luis A.[2]; Rosales-Martínez, Verónica[3]; Flota-Bañuelos, Carolina[3]; Sánchez-Hernández, Miguel A.[4]; Fraire-Cordero, Ma. L.[5]; Fraire-Cordero, Silvia[3*]

[1] Colegio de Postgraduados Campus Campeche, Carretera Haltunchén-Edzná km 17.5, Champotón, Campeche, México, C. P. 24450.
[2] Tecnológico Nacional de México, Instituto Tecnológico Superior de Hopelchén, Carretera Campeche-Hopelchén km 83, Hopelchén, Campeche, México, C. P. 24600.
[3] CONACYT-Colegio de Postgraduados Campus Campeche, Carretera Haltunchén-Edzná km 17.5, Champotón, Campeche, México, C. P. 24450.
[4] Universidad del Papaloapan Campus Loma Bonita, Av. Ferrocarril s/n, Loma Bonita, Oaxaca, México, C. P. 68400.
[5] Investigador Independiente, Punta Juriquilla, Querétaro, Querétaro, México. C. P. 76230.
* Correspondence: frairec@colpos.mx

Citation: Cauich-Cauich, I. I., Uicab-Brito, L. A., Rosales-Martínez, V., Flota-Bañuelos, C., Sánchez-Hernández, M. A., Fraire-Cordero, Ma. L.& Fraire-Cordero, S.(2022). Pruning height and frequency of *Moringa oleifera* and *Leucaena leucocephala* in a silvopastoral system. *Agro Productividad*. https://doi.org/10.32854/agrop.v15i4.2058

Editor in Chief: Dr. Jorge Cadena Iñiguez

Received: July 27, 2021.
Accepted: February 23, 2022.
Published on-line: April 1, 2022.

Agro Productividad, 15(3). March. 2022. pp: 21-27.

ABSTRACT

Objective: To evaluate two different heights (50 and 70 cm) and pruning frequencies (60 and 135 days) in *Moringa oleifera* and *Leucaena leucocephala* in a developing silvopastoral system.

Design/methodology/approach: Four treatments were established: T1=*Moringa oleifera* with pruning at 50 cm; T2=*Moringa oleifera* with pruning at 70 cm; T3=*Leucaena leucocephala* with pruning at 50 cm; and T4=*Leucaena leucocephala* with pruning at 70 cm. In all cases, pruning frequencies were 60 and 135 days. The number of sprouts, diameter, and length of the largest sprout, as well as the amount of biomass, were recorded. A mixed model, variance analysis, and Tukey's test were used to analyze the data.

Results: The number of regrowths for *L. leucocephala* was higher than for *M. oleifera*. Treatment T2 had the highest performance at day 60; in the case of *L. leucocephala*, performance was similar between pruning frequencies. For T2, diameter and length were larger at both frequencies; for T3, at 60 days; and for T4, at 135 days. Biomass was higher for *M. oleifera* than for *L. leucocephala*, while pruning at 70 cm was better than at 50 cm. Pruning at 135 days produced a higher biomass than at 60 days. For T2, biomass was higher at 60 days, while for T1 and T4, it was higher at 135 days.

Study limitations/implications: Forage species, as well as pruning frequencies and heights, determine tree growth potential and the amount of biomass available for animals.

Findings/conclusions: The agronomic performance of *Leucaena leucocephala* has a better response to pruning, regardless of pruning height and frequency, in a silvopastoral system.

Key words: Multipurpose trees, Forage, Sprout, Biomass.

INTRODUCTION

The use of silvopastoral systems (SSP) as a livestock production alternative in tropical environments is a valuable tool to deal with the problems related to climate change, and to livestock food shortage and quality (Pinheiro and Ramachandran, 2018). The inclusion of forage trees in these production systems for grazing or pruning purposes increases

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productivity. Trees of the *Moringa oleifera* and *Leucaena leucocephala* species can be used in tropical SSPs, given the quality of the nutrients that they provide for animals and to the easiness with which they adapt to and grow in this climate. For these trees to have an adequate productivity, they must be pruned in timely manner, since their capacity to produce grazing material for animals and the control of leaf biomass growth depend on that activity (Strnad *et al*., 2020). The lack of an adequate pruning could make trees susceptible to illnesses, reduce forage quality, or cause irregular yields (Mohammadi *et al*., 2013). Various works show that both pruning height and frequency are related to the number and size of regrowths and, therefore, to biomass yield and forage production for animals (Ramos *et al*., 2015).

Due to the importance of forage trees as a strategy against climate change and as food for livestock in SSPs, the aim of this study was to evaluate two pruning heights (50 and 70 cm) and frequencies (60 and 135 days) in *Moringa oleifera* and *Leucaena leucocephala* trees in a silvopastoral system.

MATERIALS AND METHODS

We conducted this research from May to September 2019 at the Colegio de Postgraduados Campus Campeche, located in Carretera Haltunchén-Edzná km 17.5, Champotón, Campeche, México (19° 29' 51.79" N and 90° 32' 45.01" W) at an altitude of 24 m. The prevailing climate is hot sub-humid with summer rains, an average annual temperature of 28 °C (maximum: 40 °C ; minimum: 10 °C), and 1200 mm rainfall (García, 2004). The soil is Vertisol (VRnl), with high proportions of expandable clays (FAO, 2014). The *M. oleifera* and *L. leucocephala* plants were selected from a developing SSP with a row intercropping arrangement of the two species, 2.0 m between plants and 3.0 m between rows, 1.5-years-old plants, no previous pruning, and no irrigation. We established four treatments with 15 plants each: T1=*M. oleifera* with pruning at 50 cm from the ground; T2=*M. oleifera* with pruning at 70 cm; T3=*L. leucocephala* with pruning at 50 cm; and T4= *L. leucocephala* with pruning at 70 cm.

All plants were initially pruned crosswise with Truper® Tx-21 pruning shears. The number of total regrowths per plant was evaluated every 15 days until total pruning on days 60 and 135 (pruning frequency). During the first measurement, the sprout with the larger diameter for each plant was selected and its length and diameter were monitored until total pruning; to obtain the total fresh weight biomass, the total number of sprouts (foliage and stalks) per plant were weighted on days 60 and 135.

The total amount of regrowths and of regrowth length and diameter was subject to an statistical analysis, by means of repeated measurements using the mixed model. The biomass variable was subjected to a variance analysis and the means were compared with Tukey's test. All analyses were done with the SAS/STAT software (2002). The significance level for all tests was $\alpha=0.05$.

RESULTS AND DISCUSSION

The number of sprouts was different ($p\leq0.05$) between treatments and periods, while the interaction between periods and treatment was similar. *L. leucocephala* produced an average of 16.1 regrowths per plant, which is higher ($p \leq 0.05$) than the 8.7 regrowths produced by *M. oleifera* during the experiment. These differences could have been the result of the plant's biology, since the agronomic handling of both species was the same. In addition, the initial growth of new sprouts, after pruning, depends on the availability of carbohydrates and proteins, which play a very important role (García *et al.*, 2001). Plant performance was similar at both pruning heights and frequencies, although it tended to be better at 70 cm (70 cm: 13.9 and 50 cm: 11.0 regrowths) and 60 days (60 days: 12.9 and 135 days: 12.0 regrowths).

The highest number of sprouts was observed on days 30 and 75 for both species and heights. The highest number of sprouts appeared earlier when an initial pruning was carried out versus a 60-day pruning; subsequently this number tends to remain constant, with a better performance by *L. leucocephala* (Figure 1). When more foliage is taken from a plant, it tends to spontaneously react to recover the foliage and carry out different photosynthetic activities. Therefore, the sprout growth phase in forage trees is delayed when the trees are pruned at low heights (Bacab *et al.*, 2012), because reserve carbohydrates decrease as a consequence of pruning.

The performance of *L. leucocephala* was similar at both pruning heights and throughout time; taller plants were achieved with a 70 cm pruning. These results match the findings of González and Toral (2011), who obtained 7-24 regrowths per *L. leucocephala* plant; they considered it to be a good production. Wencomo and Ortíz (2011) found that the appearance of new sprouts was slow during the first 28 days, while it rapidly accelerated from day 35, which is similar to what was recorded in this study.

The best performance for *M. oleifera* was observed at a height of 70 cm and pruning frequencies at 60 days. During our research, the number of sprouts decreased with time. This could be the consequence of the dominance of the more developed sprouts, which demand more nutrients and cast shade on the smaller sprouts, causing their death. This also leads to a variability in the number of sprouts throughout time.

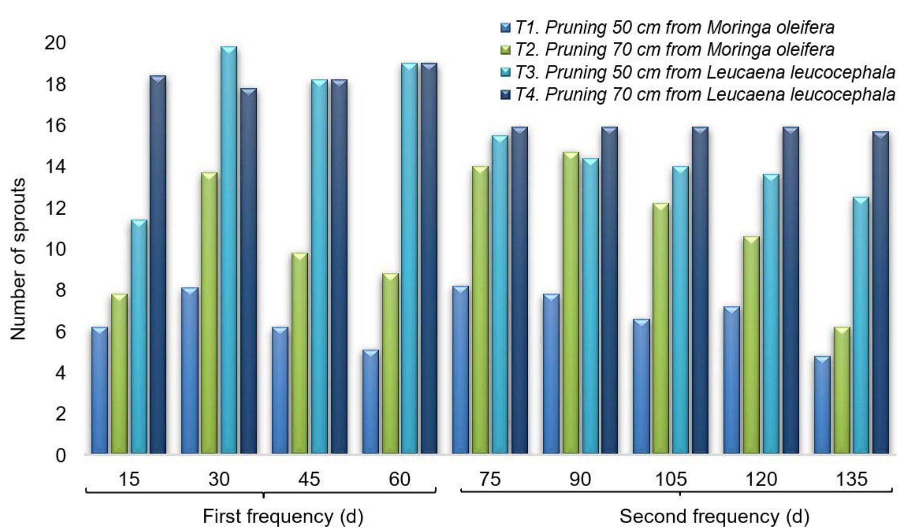

Figure 1. Number of regrowths for *Moringa oleifera* and *Leucaena leucocephala* at two heights and pruning frequencies.

Sprout length and diameter

The sprout length and diameter of *M. oleifera* varied ($p \leq 0.05$) depending on the pruning height. The largest sprout length and diameter were found in plants pruned at 70 cm. However, there was no difference between times of measurement: the growth after each total pruning was similar for both heights (Figure 2).

According to Figure 2, the increase in sprout length and diameter for the second pruning frequency was slower, possibly as a consequence of a larger number of sprouts (Figure 1); since the nutrients of the plant were distributed among a larger number of developing sprouts, the latter's length and diameter diminished during the second phase. Towards the end of the second pruning frequency, a larger loss of selected regrowths was observed; hence the evident reduction in the total regrowth length at 135 days (Figure 2). According to Herrera (2008), regrowths depend on the residual green area and the carbohydrate reserves in the lower stalk and roots, which means that the plant was not able to maintain all the new sprouts, possibly as a consequence of nutrient deficiency.

Regrowth length and diameter for *L. leucocephala* were larger ($p \leq 0.05$) for plants pruned at 50 cm up to the first 60 days, but they were smaller for the second frequency (Figure 3). Although differences were not observed throughout time, they were detected in the treatment-time interaction. Both variables tended to increase 15 days after total pruning. Bacab *et al.* (2012), among others, mention that the higher the pruning of *L. leucocephala*, the larger the size and the amount of its regrowths. On the contrary, Medina *et al.* (2007) suggest that a low cut favors a faster growth (plant) and a higher lengthwise development (regrowths).

In general, pruning at 70 cm favored longer and wider sprouts, especially during the second frequency. Apparently, plants pruned at this height have better reserves to favor the growth of existing sprouts, since the leaf:stalk ratio decreases at advanced ages, as a consequence of an increase in stalk length and width (Verdecia *et al.*, 2009), which matches the data obtained in this study.

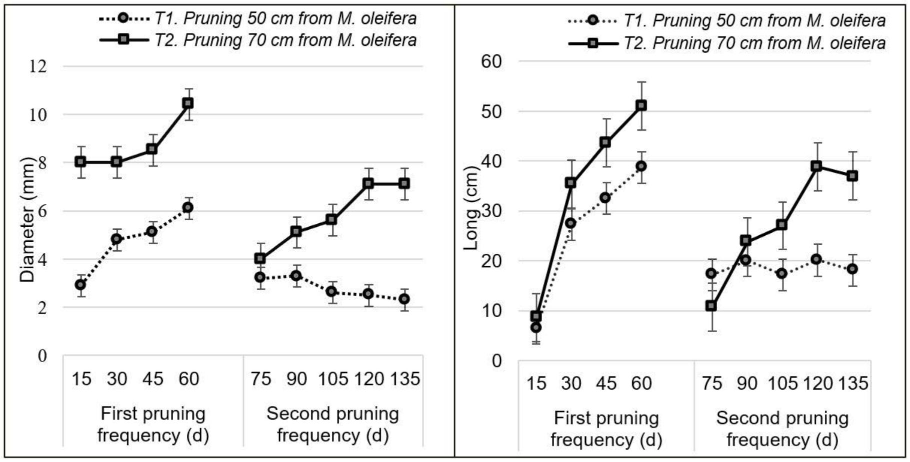

Figure 2. Length and diameter of *Moringa oleifera* sprouts at two pruning heights (50 and 70 cm) and frequencies.

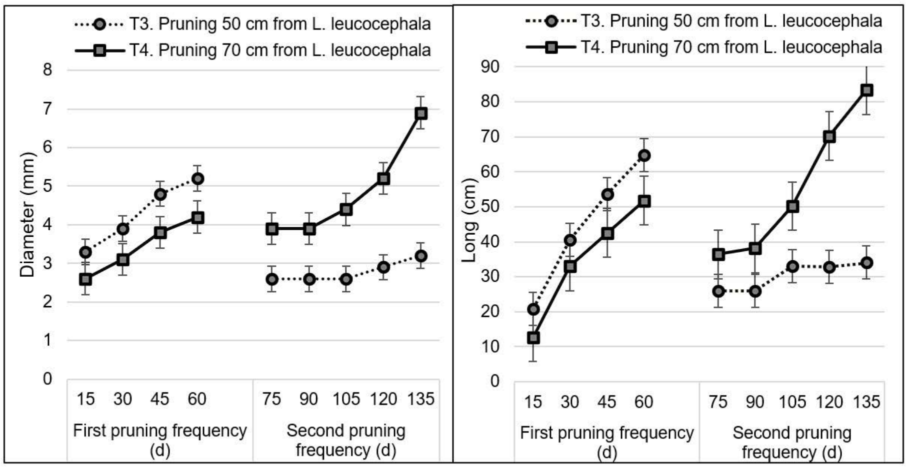

Figure 3. Length and diameter of *Leucaena leucocephala* sprouts at two pruning heights (50 and 70 cm) and frequencies.

According to Toral and Iglesias (2007), regrowth development at a height of 100 cm ensures an adequate area of reserve parenchymal tissue and active meristematic tissue, necessary for regrowth development and a better diameter.

Total biomass

M. oleifera produced more fresh weight biomass ($p \leq 0.05$) than *L. leucocephala* (3.2±0.2 and 2.9±0.2 kg, respectively). Pruning at a 70 cm height produced better biomass responses ($p \leq 0.05$) than pruning at 50 cm (3.3±0.2 and 2.8±0.2 kg, respectively). Likewise, pruning at 135 days produced more biomass than pruning at 60 days (3.6±0.2 and 2.6±0.2 kg, respectively).

At 60 days, T2 (*M. oleifera* pruned at 70 cm) produced the largest amount of fresh weight biomass among all assessed treatments (Table 1). However, Ramos *et al.* (2015) determined that the lowest pruning height (40, 80, 120 cm) of *M. oleifera* obtained the largest dry matter yield with pruning at 60 days. The greatest yields with pruning at 135 days were obtained in T1 and T4 ($p \leq 0.05$), which is different from the other two treatments (Table 1).

The results of pruning at 60 days are related to the largest number of sprouts recorded for the treatments (Figure 1). However, after this pruning the relation between the number of sprouts and the amount of biomass remained the same only for T4 (*L. leucocephala* with

Table 1. Fresh weight biomass for *Moringa oleifera* and *Leucaena leucocephala* at two pruning heights and frequencies.

Treatment	Total pruning at 60 d (kg±D.E)	Total pruning at 135 d (kg±D.E)
T1. *M. oleifera* pruning at 50 cm	0.54 ± 0.3^{a}	1.02 ± 0.2^{a}
T2. *M. oleifera* pruning at 70 cm	1.13 ± 0.3^{b}	0.60 ± 0.2^{b}
T3. *L. leucocephala* pruning at 50 cm	0.54 ± 0.3^{a}	0.77 ± 0.2^{b}
T4. *L. leucocephala* pruning at 70 cm	0.43 ± 0.3^{a}	1.16 ± 0.2^{a}

$^{a, b}$. Different letters within each column indicate a difference ($p \leq 0.05$). DE=Standard Deviation.

pruning at 70 cm). When plants rest for a longer time, photosynthesis increases, enabling more growth, development, and yield (Noda *et al*., 2007). These responses will depend on crop handling, as well as on plant physiology.

It is important to note that longer pruning intervals result in wider and woodier stalks, with high levels of lignin; this forage can therefore be considered low quality, although it does contribute to generate a higher biomass. Consequently, one handling strategy to favor higher yields and a larger proportion of leaf in leaf biomass would be to prune with a 60-day frequency, since at this age the stalks present a lower lignification level that allows for better animal grazing.

CONCLUSIONS

Based on research conditions, *L. leucocephala* plants respond better to pruning, regardless of height and frequency, than *M. oleifera*. Pruning at a 70 cm height produces more sprouts in both *M. oleifera* and *L. leucocephala*. The highest fresh weight biomass is produced at a pruning height of 70 cm in *M. oleifera* at 60 days and in *L. leucocephala* at 135 days.

ACKNOWLEDGEMENTS

We are indebted to the Consejo Nacional de Ciencia y Tecnología (CONACyT) through the Cátedras Project 2181 “Estrategias agroecológicas para la seguridad alimentaria en zonas rurales de Campeche” [*Agroecological strategies for food security in rural areas in Campeche*] and to the Colegio de Postgraduados - Campus Campeche.

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