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Article

La poda aérea como práctica cultural en vivero para *Caesalpinea coriaria* (Jacq.) Willd

Top pruning as a nursery cultural practice for *Caesalpinea coriaria* (Jacq.) Willd

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Resumen

Las prácticas culturales de vivero tienen como objetivo mejorar la calidad de las plantas e incrementar la supervivencia de las reforestaciones; sin embargo, para cada especie debe examinarse el efecto de las diversas prácticas para definir su factibilidad de implementación. Este estudio analiza el efecto de la poda aérea en la calidad morfológica de plantas de *Caesalpinea coriaria* para determinar su potencial como práctica cultural. En condiciones de invernadero, se evaluaron tres niveles de poda: 0 %, 25 % y 50 %. El efecto de las podas se examinó en plantas de seis meses por medio de atributos e índices morfológicos de calidad, tales como: altura de la parte aérea, diámetro del tallo, peso seco aéreo, de raíz y total, relación entre peso seco aéreo y raíz, Índice de Esbeltez e Índice de Calidad de *Dickson*. No hubo un efecto significativo de la poda, excepto en la altura y en el Índice de Esbeltez (p<0.05). Los valores mayores de 37.08 cm de altura y 12.81 de Índice de Esbeltez, correspondieron a plantas sin poda, mientras que los menores se presentaron en las plantas podadas al 25 % (29.06 cm y 10.75, para altura e Índice de Esbeltez, respectivamente). Con base en los resultados, se concluye que la poda aérea no mejora la calidad morfológica de los individuos de *C. coriaria*, por lo que no es recomendable como práctica cultural para producir plantas de esta especie en vivero.

Palabras clave: Árbol multipropósito, cascalote, reforestación, sistemas agroforestales, trópico seco, viveros forestales.

Abstract

Nursery cultural practices are aimed both to enhance seedling quality and to increase survival of reforestations, however the effects of several cultural practices should be examined for each species in order to define their feasibility of implementation. This study analyses the effects of top pruning on the morphological quality of *Caesalpinea coriaria* seedlings to determine its potential as a cultural practice. In greenhouse conditions, three level of top pruning were evaluated: 0 %, 25 % and 50 %. The effects of pruning were examined on six-month old seedling by measuring some morphological attributes and quality indexes such as: shoot height, stem diameter, shoot, root, and total dry weight, shoot-to-root ratio, slenderness index, and Dickson quality index. There was not a significant effect of pruning, except on the shoot height and the slenderness index (p<0.05). The greatest values of 37.08 cm for shoot height and 12.81 of slenderness index belonged to no-pruned seedlings, while the lowest values were found for the pruned-seedlings at 25 % (29.06 cm and 10.75 for shoot height and slenderness index, respectively). Based on these results, it is concluded that top pruning does not enhance the morphological quality of plants of *C. coriaria*; therefore, it is not recommended as a cultural practice to produce plants of *C. coriaria* in nursery.

Key words: Multipurpose tree, *cascalote*, reforestation, agroforestry systems, tropical dry forest, forest nurseries.

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Introduction

Nursery cultural practices play an important role in the production of quality plant for reforestation projects; with them, morphological and physiological attributes are manipulated that regulate the development of plants in the field, in terms of survival and growth (Grossnickle and MacDonald, 2018).

In Mexico, the low survival of reforestations is a persistent problem. Therefore, improving the quality of the plants for these programs through nursery practices continues to be necessary (Burney *et al*., 2015). Most of the research made in this field is aimed at producing quality plants for temperate climates (Burney *et al.,* 2015); however, the need to generate information on cultural nursery management practices for other species, such as those of the dry tropics, which are required in various reforestation or restoration projects, is evident (Conafor, 2014; Riikonen and Luoranen, 2018). The use of forest species from the dry tropics is limited by the lack of sufficient knowledge for their production in the nursery, particularly under the quality plant approach (Bonfil and Trejo, 2010).

In the context of defining cultural practices to produce quality plants, it is convenient to explore those whose background with other species have shown satisfactory results. In this regard, aerial pruning or stem pruning is an example. It is argued that pruning as a cultural practice in the nursery favors the maintenance of woody species because it stimulates their growth and allows it to be directed in a certain way (Wade and Westerfield, 2009). In this area, pruning has shown potential to increase the quality of some forest species. For example, *Pinus greggii* Engelm specimens improved their morphological quality and increased the photosynthetic rate and carbohydrate content after being pruned in 50 % of their aerial biomass (Cetina-Alcalá *et al.,* 2001, 2002). Another experimental support is provided by a study with seedlings of *Nothofagus nervosa* (Phil.) Dim. (Donoso *et al.,* 2009), whose response in the field was positive after being pruned at the nursery.

However, the proper implementation of aerial pruning depends on understanding how and when to do it, since reactions can vary between species (Wade and Westerfield,

2009). For example, in *Enterolobium cyclocarpum* (Jacq.) Griseb. and *Swietenia humillis* Zucc. subject to three pruning intensities (0 %, 25 % and 50 %), aerial pruning is not recommended as a nursery practice because, according to the results provided by Basave *et al.* (2014 and 2015), the quality of the plants did not improve.

The differences consigned by the previously mentioned experimental evidence, regarding the feasibility of aerial pruning, suggest the need to evaluate its effects in a greater number of species, especially in those with high ecological and social value such as *Caesalpinea coriaria* (Jacq.) Willd, commonly known as *cascalote*. *Cascalote* is a multipurpose arboreal legume species of the dry tropics present in the pastures, where it is used as shade, forage, live fences and firewood (Olivares-Pérez *et al*., 2011; Palma-García and González-Rebeles, 2018). In recent years, the importance of this type of species has been highlighted to reforest and rehabilitate grasslands degraded by extensive livestock farming through the promotion of silvopastoral systems (Murgueitio *et al.*, 2011). This aspect justifies the need to generate relevant information on the production of *C. coriaria* nursery plants, in relation to cultural practices that improve their quality. For this reason, the present study evaluated the effect of aerial pruning on the morphological quality of *C. coriaria* plants.

Materials and Methods

Location of the experiment

The study was carried out under controlled greenhouse conditions with plastic cover in the forest nursery of the *Colegio de Postgraduados, Montecillo Texcoco campus,* State of Mexico, Mexico. Average maximum and minimum temperatures of 35 °C and 18 °C, respectively, were recorded. Relative humidity was 25 % during the day and 80 % at night.

Handling the experiment

A lot of 500 plants per seed was produced in a container system, which began on May 24, 2018. Sowing was direct inside 380 mL rigid plastic containers that contained a mixture of substrate made with peat moss (peat moss), perlite and vermiculite in proportions 2: 1: 1. The plant density was 128 per m^2. Multicote (8) ™ 18-6-12 + 2Mgo + ME (Haifa Chemicals Ltd.) controlled release fertilizer was added to the substrate, in doses of 6 g L^{-1} of substrate. Prior to sowing, the seeds were soaked for 18 h in running water as a pre-germination treatment (Cervantes *et al.*, 2014). Seed of similar size was used, preferring the largest one from a lot that was collected in March 2018 from trees located in the community of *La Bajada, Coyuca de Catalán* (*Tierra Caliente* Region, state of *Guerrero*, Mexico). The seedlings emerged in their entirety within the third week of being sown and were watered three times a week at field capacity. The pH and electrical conductivity values were monitored by the Pourthru method (Cavins *et al.*, 2008) every 15 days with a pH and conductivity combo meter (HI98130 Hanna Instruments Inc.). The pH was kept between 5.5 and 6.5, and the electrical conductivity between 2.0 and 3.0 dS m^{-1}.

Application of treatments and experimental design

Aerial pruning treatments were performed in three intensities in a batch of 300 three-month-old plants with heights between 15 and 20 cm: 0% (without pruning), 25 % and 50 %. Aerial pruning consisted in the removal of the aerial biomass fraction according to the intensity of each treatment, for which the length of the stem with foliage was taken as a reference, from the first leaves to the main apex. Pruning was carried out only once, and each treatment had five replications. The experimental design used was completely random and the experimental unit consisted of 20 plants.

Morphological quality variables evaluated

Measurements were made after three months of aerial pruning, variables related to standards and morphological indices of plant quality were evaluated in a sample of 50 plants per treatment. The variables were: height of the aerial part (*APA*; cm), diameter of the stem at the root neck (*DCR*; mm), aerial dry weight (*PSA*; g), root dry weight (*PSR*; g) and weight total dry (*PST*; g). The height was measured with a millimeter ruler and the diameter with the Mitutoyo® Digimatic CD-4" caliper. The dry weights were recorded with an analytical balance (AND® GR-120, A&D Company, Ltd), after drying each component in a forced air oven (FELISA® FE291-D) until obtaining a constant weight, at 70 °C for 72 h.

With the previous observations, morphological quality indices were determined, such as the Air dry weight / root dry weight ratio (*PSA* / *PSR*), the Slenderness Index (*IE*; height / diameter) and the Dickson Quality Index (*ICD*) , the latter from the following formula (Birchler *et al*., 1998):

$$ICD = \frac{Total\ dry\ weight\ (g)}{\frac{Height\ (cm)}{Diameter\ (mm)} + \frac{Air\ dry\ weight\ (g)}{Root\ dry\ \ weight\ \ (g)}}$$

Statistical analysis

Statistical analysis was performed in infoStat (Di Rienzo *et al.,* 2012). A parametric analysis of variance was carried out to determine the effects of aerial pruning on the morphological quality of *C. coriaria* plants. The hypothesis test was based on a level of significance α = 0.05. The assumptions of normality and homogeneity of variances were validated. In cases of statistical differences, a post-hoc test of comparison of means was performed with the Tukey test at a confidence level of 95 %.

Results and Discussion

In general, aerial pruning did not affect the morphological quality of *C. coriaria* plants (p> 0.05), since only in the height of the aerial part (*APA*) and slenderness index (*IE*) variables, there were significant differences (p = 0.0001 and 0.02, respectively). The highest height (37.08 cm) was recorded in plants without pruning, while the lowest (29.06 cm) in plants pruned at 25 %. When comparing both values, a reduction of 28 % in the height of the plants stands out after receiving the 25 % pruning. In *IE*, the highest value also corresponded to plants without pruning, with 12.81, which was 29 % higher than the low value of 10.75 registered by plants pruned at 25 %. The aerial pruning at 50 % turned out to be the worst treatment, presenting values lower than those of the unpruned plants in most of the variables (Table 1).

Table 1. Average values ± standard error of *Caesalpinea coriaria* (Jacq.) Willd plants subjected to aerial pruning in the nursery.

Variable[1]	Pruning intensities (%)		
	0	25	50
APA (cm)	37.08±1.32b	29.06±1.32a	30.71±1.32a
DCR (mm)	2.92±0.09a	2.77±0.09a	2.72±0.09a
PSA (g)	1.61±0.16a	1.67±0.16a	1.51±0.16a
PSR (g)	0.68±0.06a	0.69±0.06a	0.62±0.06a
PST (g)	2.29±0.19a	2.36±0.19a	2.13±0.19a
PSA/PSR	2.43±0.20a	2.66±0.20a	2.43±0.2a
IE	12.81±0.53b	10.75±0.53a	11.36±0.53ab
ICD	0.16±0.02a	0.18±0.02a	0.16±0.02a

[1]*APA* = Height of the aerial part; *DCR* = Diameter at the root neck; *PSA* = Aereal dry weight; *PSR* = Root dry weight; *PST* = Total dry weight; *PSA* / *PSR* = Aereal dry weight / root dry weight ratio; *IE* = Slenderness index; *ICD* = Dickson's quality index. Different letters on the same line are significantly different (P≤0.05).

In the production of forest plants in nurseries, it has been proposed that aerial or stem pruning has potential as a cultural practice to improve the quality of the plant for reforestation work (South, 2016). This approach has been ratified in a study with *Pinus greggii* plants, in which such practice improved the morphological quality, increased the net assimilation rate and the carbohydrate content. These characteristics, together, contributed to a favorable performance of the plants in the field under a drought condition (Cetina-Alcalá *et al*., 2001, 2002). Contrary to *P. greggii*, the *C. coriaria* plants of the present study did not have results that support the potential of aerial pruning as a cultural practice. The divergence between the results obtained in *P. greggii* and in *C. coriaria* suggests a differential effect of pruning between species, attributed to the different growth and branching patterns that are controlled by mechanisms of dominance and apical extention (Wilson, 2000; Cline and Harrington, 2007). In this situation, the effects of hormones in apical growth could also be involved (Pallardy, 2008). The responses of *C. coriaria* are in agreement with those of other tropical broadleaf species.

In plants of *Swietenia humilis* (Basave *et al*., 2015) and *Enterolobium cyclocarpum* (Basave *et al.,* 2014) neither did aerial pruning as a cultural practice. In these two species, the effect that pruning had was to diminish the slenderness of the plants by reducing the relationship between the height of the aerial part and the diameter of the stem. This effect is one of the general responses of plants to pruning (Wade and Westerfield, 2009) and coincides with what was observed in pruned plants of *C. coriaria*.

Slender plants are not desirable in the nursery; it is better if they are robust, since it is assumed that they are more vigorous; therefore, during the production of plants in the nursery, to promote this characteristic is very important (Orozco *et al*., 2010). In several forest species, it has been shown that the greater the robustness, the better the probability of survival in the field (Tsakaldimi *et al*., 2013). However, in the nursery, it is preferred to induce robustness is with a larger growth in diameter and not by a low ratio defined by the height of the plants, as happened in the 25 % pruned plants.

In *C. coriaria*, the effect of pruning was null in stimulating plant growth, as is commonly assumed (Wade and Westerfield, 2009; South, 2016), so that the plants did not show an increase in stem diameter. This answer is negative in several forest species, because it is known that a thick diameter is a determining attribute in field survival under some environmental conditions (Grossnickle, 2012; Tsakaldimi *et al*., 2013). For example, it was shown that in *Prunus avium* L. seedlings survival becomes higher by increasing the initial stem diameter of the nursery plants to a measure of 7-8 mm (Esen *et al*., 2012).

The stem diameter of the *C. coriaria* plants did not exceed 3 mm in any of the treatments. This low value in diameter could be attributed to the fact that the species is slow growing (Palma and González-Rebeles, 2018); however, the morphology of plants produced in containers is also determined by the production period in the nursery and by the effect of various cultural practices, according to conclusions derived from a study with *Acacia macrostachya* Reichenb plants. ex Benth and *Pterocarpus erinaceus* Poir. (Zida *et al*., 2008).

In this sense, possibly the production time was not enough and the production conditions in the greenhouse were not adequate to optimize the growth of the *C. coriaria* plants. However, this hypothesis regarding production time is contradictory if compared, on the one hand, with the growth in diameter that *Caesalpinia platyloba* S. Watson, *C. eriostachys* Benth present in the nursery. and *C. velutina* Standl., whose stem diameter values vary between 2.5 and 4.4 mm at three -months old (Ngulube, 1989; Orozco *et al*., 2010), and, on the other hand, if contrasted with the time of four to five months in which other tropical species of the same family (Fabaceae) commonly occur, such as *Prosopis laevigata* (Humb. *et* Bonpl. ex Willd.) MC Johnston (Prieto *et al*., 2012; Basave *et al*., 2017) and *Enterolobium cyclocarpum* (Basave *et al*., 2014). Later studies should improve the growth of *C. coriaria* at the nursery.

Finally, the lack of significant effects of pruning on the morphological quality of *C. coriaria* could be attributed to the fact that pruning may have limited photosynthesis due to the loss of leaves, as occurs in plants subject to loss of foliar biomass from herbivory (Nabity *et al*., 2009), which causes a negative carbon balance (Kitajima,

2007) that limited the ability of plants to produce enough carbohydrates to promote vigorous regrowth in the face of damage induced by pruning. In addition, this effect could have been highlighted by the fact that, before pruning, the plants did not have sufficient reserve carbohydrates, which favored greater competition for resources for growth, as discussed in the storage theory (Lambers *et al*., 2008).

In this study, it was omitted to measure the content of reserve carbohydrates, but the previous proposals are based on its importance on the regrowth ability of plants (Von Fircks and Sennerby-Forsse, 1998), a condition that was corroborated by *Quercus crispula* Blume plants (Kabeya and Sakai, 2005). Furthermore, in other species, the regrowth capacity is determined by the same interspecific and intraspecific differences (Umeki *et al*., 2018), according to their age, size (Vesk, 2006), or nutritional status (Kabeya and Sakai, 2005), which are factors that could be analyzed in greater detail in later studies of this sort.

Conclusions

Aerial pruning at the evaluated intensities of 25 % and 50 % has no potential as a cultural practice to improve the quality of the *C. coriaria* plant in the nursery. The effects on the plants were the reduction in height and its relationship with the diameter at the root neck, which leads to less robust plants. It is recommended to analyze the interaction of pruning with other cultural practices.

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Conflict of interest

The authors declare no conflict of interests.

Contribution by author

Erickson Basave Villalobos: research approach, direction of the experiment and writing of the manuscript; Víctor M. Cetina Alcalá: management of financial support, supervision and administration of the investigation; Miguel Á. López López, Carlos Ramírez Herrera, Carlos Trejo and Víctor Conde Martínez: development and design of the experimental methodology, writing and review of the manuscript.

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