Colegio de Postgraduados

Germination, survival, and growth of *Cordia dodecandra* A.DC. under Field Conditions

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ABSTRACT

Objective: *Cordia dodecandra* A.DC., an endemic species of the Yucatán Peninsula, Mexico, is valued for its fruit and timber production in the market. This study evaluated seedling emergence and growth from seeds directly sown in the field using pregerminative treatments.

Design/methodology/approach: The research was conducted in the town of Castamay, Campeche. The land was prepared using agricultural machinery. Scarification treatments consisted of T1: 10%, T2: 20%, and T3: 50% hydrogen peroxide in purified water, as well as an untreated control, using seeds harvested in the same year.

Results: The highest number of seedlings emerged in the control treatment. Height and diameter growth varied across measurement periods, and both temperature and ambient humidity significantly affected these variables.

Findings/conclusions: The use of *C. dodecandra* seeds for reforestation in deforested areas is viable, with up to 80% success. Scarification is not required when seeds are sown in the same year they are harvested. Seedlings of *C. dodecandra* grown from directly sown seeds in the field exhibit steady growth, which is influenced by temperature and humidity conditions.

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INTRODUCTION

Cordia dodecandra A.DC. (commonly known as Ciricote) (Boraginaceae) is native to the forests of Mesoamerica and is adapted to a variety of environments. It is a multipurpose species that provides several products, including timber, its rough leaves that can be used as sandpaper, edible flowers and fruits (Yam *et al.*, 2014; Morales & Herrera, 2009), and is also used in traditional medicine according to local knowledge, in addition to its ornamental value due to its beauty (Yam *et al.*, 2014). However, there are no studies on the geographic distribution of this tree species in Mexico (Cámara *et al.*, 2020).

It is a heliophilous species of great ecological importance, making it a key component of tropical forests due to its fruit production during dry seasons, which is essential for wildlife. It serves as a year-round nectar source for bees, and its abundant foliage protects the soil surface against erosion through the production of organic matter (Yam-Chin *et al.*, 2014). On the international market, *C. dodecandra* wood is in high demand, which has been the main cause of the decline in its populations since the 1990s. Today, it has been reported that populations in tropical forests are either nonexistent or reduced to a single individual per hectare (Vester & Navarro, 2007). *C. dodecandra* has been classified by the National Forestry Commission (CONAFOR) as a priority species for conservation due to overexploitation and the destruction of its ecosystem. One factor contributing to this destruction is vegetation fragmentation, which reduces and isolates its populations (Morales & Herrera, 2009; Yam *et al.*, 2014).

This situation has prompted various studies on different aspects related to the growth of this species in forest plantations (Cámara-Romero, 2021), ethnobotany (Yam *et al.*, 2014), domestication (Ferrer *et al.*, 2020), and agroforestry systems (Campos-Bobadilla *et al.*, 2016). However, studies on its population dynamics under natural and managed conditions are still lacking, which are necessary to design effective recovery strategies for this species. Changing climatic conditions have led to prolonged droughts or, conversely, excessive rainfall in the forest, both of which reduce the number of seedlings. Most seedlings are found beneath or near the mother plant, leading to competition for resources such as light and water (Urrego & Valle, 2001). In addition, herbivory by wild animals can increase mortality during early developmental stages (Ferrufino *et al.*, 2016). Therefore, the aim of this study was to evaluate the emergence and growth performance of seedlings obtained from seeds directly sown in the field under different pregerminative treatments.

MATERIALS AND METHODS

The research was conducted in the town of Castamay, Campeche, Mexico (Longitude −90.430556, Latitude 19.838611), located 11 kilometers east of the state capital, at an elevation of 19 meters above sea level. The predominant climate is warm sub-humid with summer rainfall, with an average annual precipitation of 1,124.67 mm and a mean temperature of 27.02 °C (Figure 1).

Land preparation

The soil in the experimental area was classified as Ferric Luvisol. Land preparation was carried out in May 2022 using agricultural machinery for brush removal and soil harrowing. This process loosens the soil, thus improving the rooting zone conditions for the plants by enhancing the soil's capacity to retain and store water and oxygen, all with the aim of facilitating seed germination, seedling emergence, and subsequent growth (Martínez, 2015).

Seed collection and scarification

Ripe fruits were collected in June from healthy and vigorous trees located in the town of Castamay and the city of Campeche. To extract the seeds, the pulp was removed through soaking and maceration. Once the pulp was eliminated, the seeds were left to dry in the sun for two days.

Treatments

The experiment consisted of three treatments and one control, using 30 seeds per treatment. The treatments were as follows: 10%, 20%, and 50% hydrogen peroxide solution

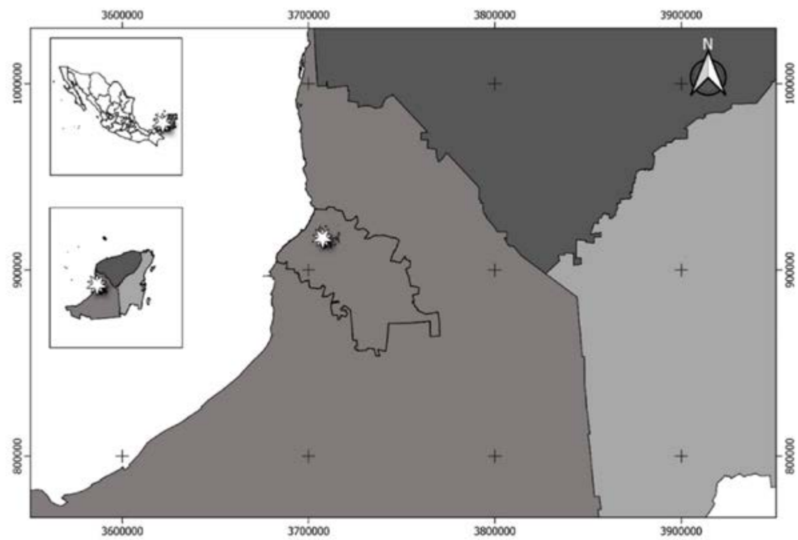

Figure 1. Location of the research site in the town of Castamay, Campeche, Mexico.

in purified water. Seeds were soaked for 10 minutes in each solution, then rinsed with water before being sown in the field. The control group did not receive any treatment. Seeds were sown directly in the field in July using a randomized block design, with the treatments distributed across the entire area.

Sowing was done in four blocks with a spacing of 1.5×1.5 m between planting points, with 30 seeds per block. After sowing, seedling emergence was recorded weekly until emergence ceased.

Seed viability

To determine the viability of *C. dodecandra* seeds, 100 seeds were selected and sown in trays filled with substrate (50% Luvisol soil and 50% coconut fiber). Observations were recorded as seedlings emerged from the substrate. In the field, data on seedling emergence, height, and stem diameter were collected once all seedlings had emerged from the soil. The data were analyzed using INFOSTAT software (Di Rienzo, 2020).

The experiment was conducted at the agroforestry research area of the Instituto Tecnológico de Chiná, located in the town of Chiná, Campeche, Mexico, at coordinates 19.77° N latitude and −90.50° W longitude. The predominant climate is warm sub-humid with an average annual temperature of 27 °C (García, 2004). This experiment was established in November 2017, and the evaluation period lasted 153 days.

Evaluated variables

The basal stem diameter at substrate level (mm) was measured using a Cadena® digital caliper model A020. Total height (cm) was measured with a graduated ruler from the substrate level to the plant apex. These measurements were taken every seven days, recording 12 data points over a period of 114 days. Using the height and diameter data, growth increments for each seven-day period, averages, and total increments were calculated. The increment for each period was obtained by subtracting the previous measurement from the subsequent one, continuing this process for all data points. The survival percentage of plants established in each treatment was recorded by counting living and dead plants.

For statistical analysis, the Shapiro-Wilks normality test was applied to determine data distribution ($P<0.0001$), which indicated the need for a non-parametric analysis. Variance analysis was performed using the Kruskal-Wallis test to compare means and identify differences between treatments, using the INFOSTAT statistical software (Di Rienzo *et al.*, 2020).

RESULTS AND DISCUSSION

Germination

Seed germination showed a viability of 75%, a value obtained from seeds sown in trays. This was achieved over a period of 24 days, with the highest germination occurring between days 12 and 18 of the evaluation period, which started on August 18 and ended on September 10 (Figure 2).

Seedling emergence from direct seeding in the field

Seedling emergence in the field under different scarification treatments showed no statistically significant differences ($P=0.05$). Despite this, it can be observed that the highest emergence occurred in the control (T1=30%, T2=37%, T3=13%, and Control 80%) (Figure 3).

Seedling Growth

Height increment analysis using the non-parametric Kruskal-Wallis test showed statistically significant differences ($P=0.0001$) in height growth between measurement periods. The greatest height increases occurred during the initial stages of *C. dodecandra* seedling growth. The first data collection was on August 25 and the last measurement on

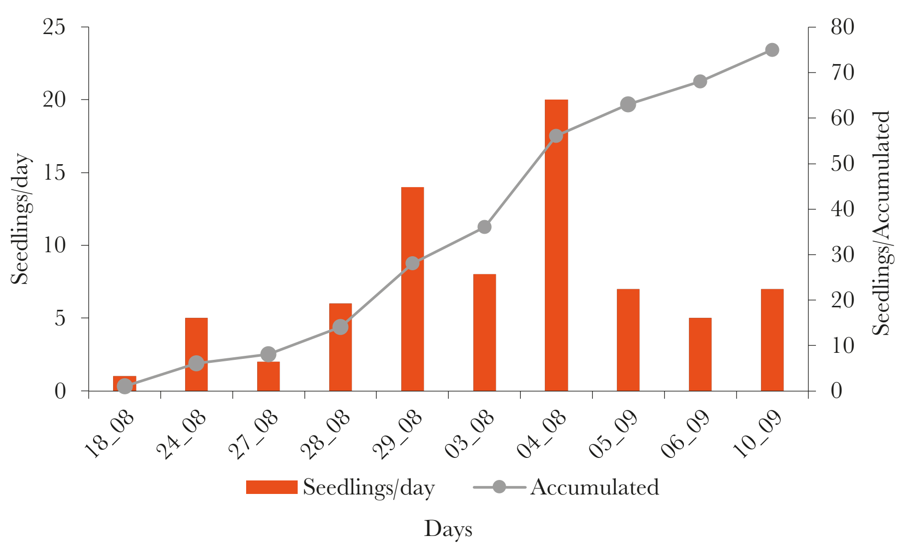

Figure 2. Germination behavior of *Cordia dodecandra* A.DC. seeds in trays under shade conditions and temperatures between 30 and 38 °C.

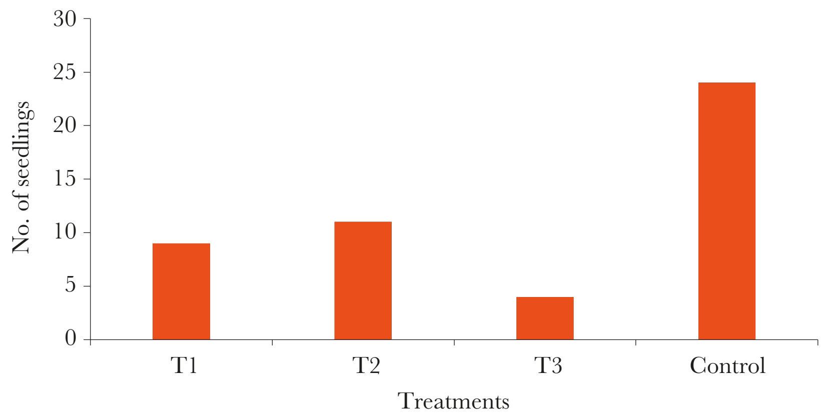

Figure 3. Seedling emergence in the field on a Ferric Luvisol soil in Campeche, Mexico. Using seeds treated with hydrogen peroxide at 10%, 20%, and 50%, soaked for 10 minutes, and a control without treatment.

December 17, covering a total of 114 days. Measurement periods were spaced seven days apart. The highest growth increment was observed during the weeks from September 24 to October 2, while the lowest increase occurred between October 8 and 15 (Figure 4). On average, seedling growth per period was 2.27±1.27 cm, with a total average height increase of 35.3 ± 7.8 cm over the 3.5-month evaluation period.

The Pearson correlation analysis showed a negative correlation ($r=-0.52$, $P=0.04$) between humidity and height increment. This can be observed in Figure 5, where an increase or decrease in humidity corresponds to an inverse change in height growth. Meanwhile, temperature showed a positive correlation ($r=0.45$, $P=0.08$), with height increasing during a period as temperature decreased (Figure 6).

Diameter increments

The average total increment in stem diameter during the evaluated period was 10.31±1.85 mm, while the average increment per period was 1.31±0.44 mm. Analysis of variance showed statistically significant differences between the stem diameter increments of *C. dodecandra* seedlings across the increment periods (Figure 7). The greatest increases were observed from August 25 to September

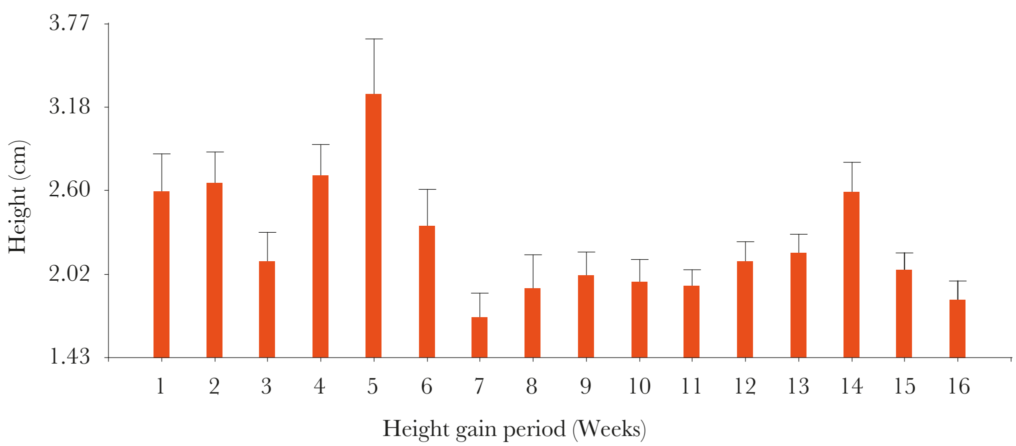

Figure 4. Height increments of seedlings obtained from direct seeding of *Cordia dodecandra* A.DC. in the field.

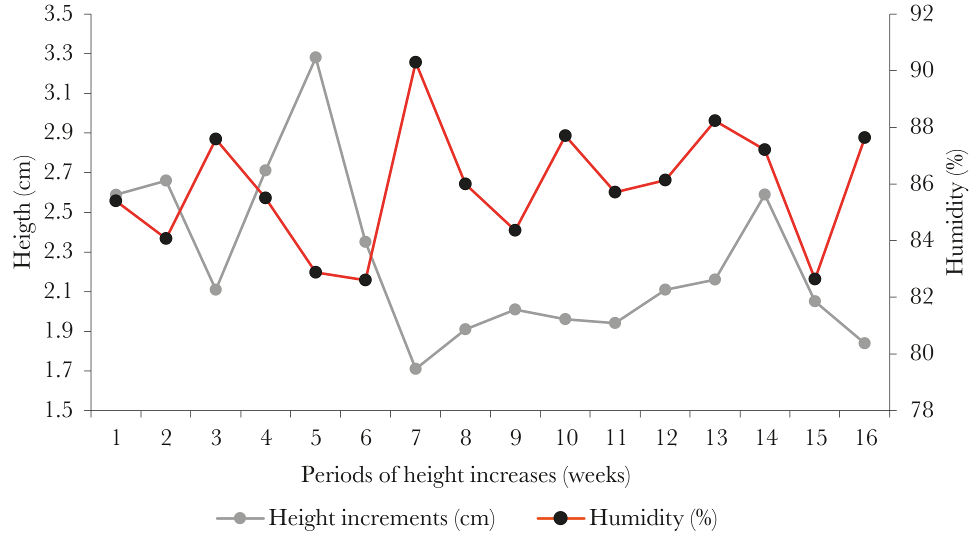

Figure 5. Behavior of height increment in *Cordia dodecandra* A.DC. seedlings in relation to humidity.

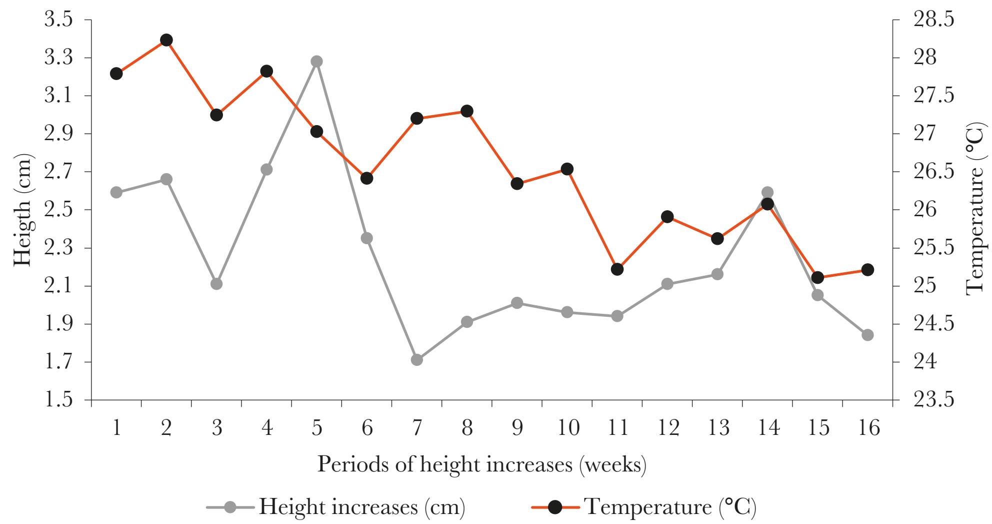

Figure 6. Behavior of height increment in *Cordia dodecandra* A.DC. seedlings in relation to temperature.

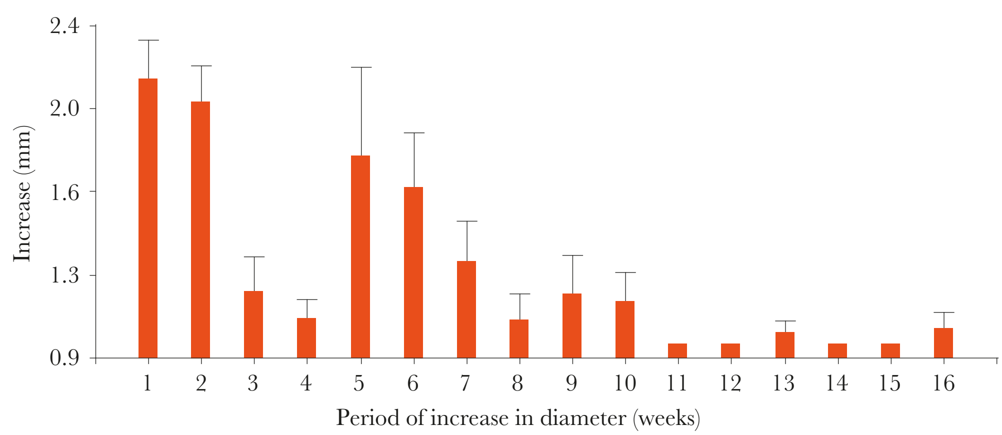

Figure 7. Stem diameter increments in *Cordia dodecandra* A.DC. seedlings obtained from direct seeding in the field.

2 and from September 3 to 10, while the smallest increments occurred starting November 5 (Figure 8). It was observed that when temperatures remained high, the diameter increment was low, and as temperature decreased, the increment increased (Figure 9).

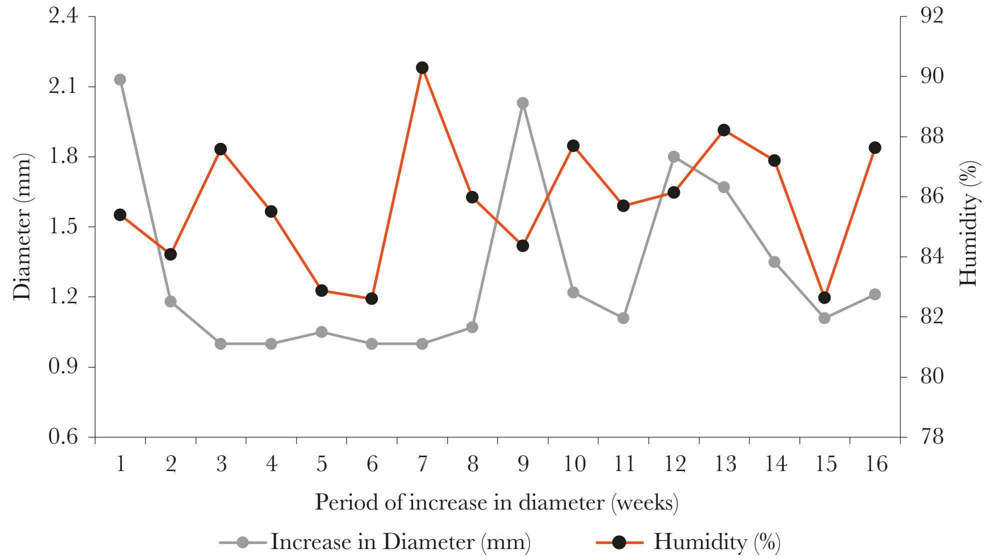

Figure 8. Stem diameter increment behavior of *Cordia dodecandra* A.DC. seedlings in relation to humidity.

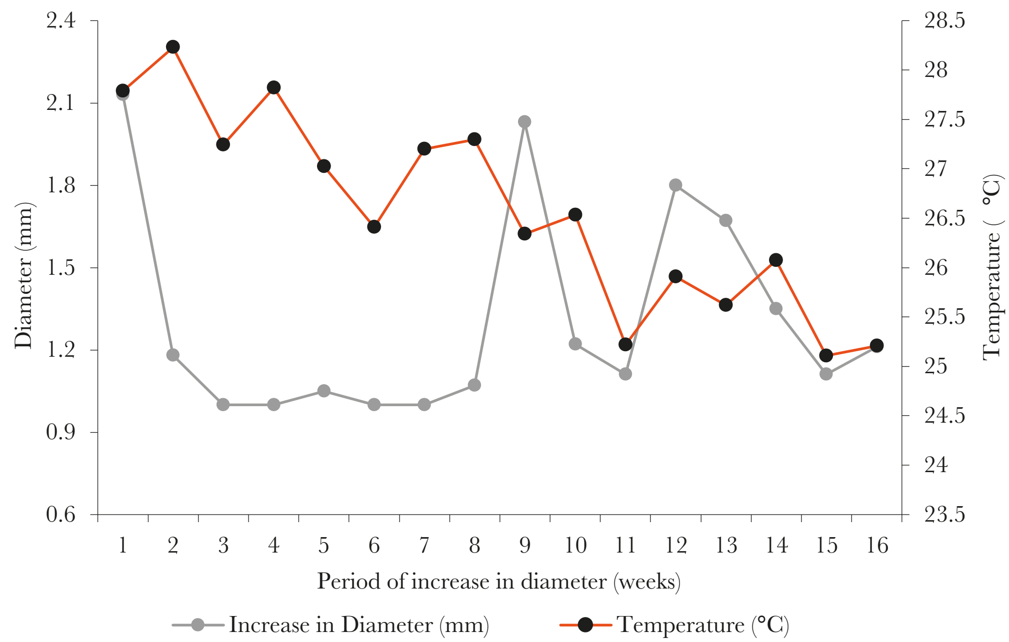

Figure 9. Behavior of diameter increment of *Cordia dodecandra* A.DC. seedlings in relation to temperature.

CONCLUSIONS

The use of *C. dodecandra* seeds for reforestation in deforested areas is viable up to 80%. Scarification of seeds is not required when seeds are from the same year of harvest and sowing. The growth of *C. dodecandra* seedlings obtained from seeds sown directly in the field shows a steady increase, which is influenced by temperature and humidity conditions.

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