



DOI: [10.29298/rmcf.v13i70.1264](https://doi.org/10.29298/rmcf.v13i70.1264)

Research note

**Reforestación con esquejes de *Myrtillocactus geometrizans* (Mart. ex Pfeiff.) Console en Guanajuato**  
**Reforestation with cuttings of *Myrtillocactus geometrizans* (Mart. ex Pfeiff.) Console in Guanajuato**

Ricardo Rivera Vázquez<sup>1\*</sup>

María Guadalupe Herrera Hernández<sup>1</sup>

Salvador Horacio Guzmán Maldonado<sup>1</sup>

### Resumen

Para conservar los recursos naturales se ha propuesto la reforestación con especies nativas que tengan una utilidad. Ejemplo de lo anterior es *Myrtillocactus geometrizans*, conocido comúnmente como garambullo; esta cactácea crece en zonas áridas de México y su fruto se considera como un alimento nutraceutico por su alto contenido de compuestos fitoquímicos. Por ello, la finalidad del proyecto aquí descrito consistió en evaluar dos sistemas de reforestación directa, con esquejes y con esquejes desarrollados en vivero. Se seleccionaron ejemplares de acuerdo con las características de los frutos y condiciones de sanidad de la planta; como resultado se obtuvieron 1 000 esquejes para usarlos en reforestación directa y 1 000 esquejes para cultivarlos en vivero. Fueron cinco viveros rústicos bajo las mismas condiciones de manejo para producir planta de garambullo; se registró el desarrollo de estructuras nuevas (como raíces) y vigor del esqueje. La reforestación se realizó en la comunidad de El Garabatillo, municipio Dolores Hidalgo, Guanajuato, donde crece la especie de forma natural. En el caso de la reforestación directa, la supervivencia de la planta fue de 70.3 % con una buena evolución de los ejemplares, mientras que la supervivencia de la planta en vivero fue de 90.6 % con un buen desarrollo radicular al momento de la plantación en campo. Se determinó que ambos sistemas (plantación directa y desarrollo en vivero) son confiables para reforestar predios con garambullo, sobre todo en regiones donde la especie existe en forma natural.

**Palabras clave:** Calidad de planta, enraizamiento, esqueje, garambullo, plantación, vivero rústico.

### Abstract

To preserve natural resources, reforestation with useful native species has been proposed. An example of the above is *Myrtillocactus geometrizans*, commonly known as *garambullo*. This cactus grows in arid areas of Mexico and its fruit is considered a nutraceutical food due to its high content of phytochemical compounds. Therefore, the purpose of the project here described was to assess two reforestation direct systems: with cuttings and with cuttings developed at a nursery. Specimens were selected according to the characteristics of the fruits and health conditions of the plant; as a result, 1 000 cuttings were obtained to use in direct reforestation and 1 000 cuttings to be developed in the nursery. There were five rustic nurseries under the same management conditions to produce *garambullo* plants, recording new structures (such as roots) and vigor of the cutting.

Reforestation was carried out in the *El Garabatillo* community, *Dolores Hidalgo* municipality, state of *Guanajuato*, where the species grows naturally. In the case of direct reforestation, the survival of the plant was 70.3 % with good plant development, while the survival of the plant at the nursery was 90.6 % with good root growth at the time of planting in the field. It was determined that both systems (direct planting and nursery development) are reliable for reforesting lands with *garambullo*, especially in regions where the species naturally exists.

**Key words:** Plant quality, rooting, cutting, *garambullo*, planting, rustic nursery.

Fecha de recepción/Reception date: 8 de diciembre de 2021

Fecha de aceptación/Acceptance date: 24 de febrero de 2022

---

<sup>1</sup>Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Campo Experimental Bajío. México.

\*Autor para correspondencia; correo-e: [rivera.ricardo@inifap.gob.mx](mailto:rivera.ricardo@inifap.gob.mx)

*Myrtillocactus geometrizans* (Mart. ex Pfeiff.) Console (*garambullo*) is an endemic plant of Mexico that is part of natural systems mainly in xerophytic scrub and transition areas with low deciduous forest; It grows on dry plains, plateaus and slopes at altitudes of 1 650 to 2 200 m. Its distribution in Mexico covers the states of *Aguascalientes*, *Durango*, *Guanajuato*, *Guerrero*, *Hidalgo*, *Jalisco*, *Estado de Mexico*, *Michoacán*, *Nuevo León*, *Oaxaca*, *Puebla*, *Querétaro*, *San Luis Potosí*, *Tamaulipas*, *Veracruz* and *Zacatecas* (Terrones et al., 2014).

The natural systems where this species grows are in arid and semi-arid zones, where a dry, arid, semi-warm climate prevails, with summer rains; average annual rainfall between 380 and 450 mm and average temperature of 21 °C. Soils are usually rocky, sandy, very permeable (pH 6.5 to 7.0), without waterlogging and have significant contents of gypsum, limestone and salts (Meyrán and López, 2003).

*M. geometrizans* is an arborescent succulent plant with a well-defined trunk and abundant branching that forms a wide crown; its average height is 3 to 4 m. The main branches separate into curved bluish-green structures. Each branch has six rounded ribs with radial spines and a larger central one. The flowers are greenish-white, and the fruit is an ellipsoid globose berry, purple-red, 1 to 2 cm in diameter,

and without thorns, with small flattened seeds (Bravo and Sánchez, 1978; Terrones *et al.*, 2004).

An outstanding characteristic of the fruit is its nutritional quality, since it has a high content of fiber (up to 36.9 %), vitamin C (26.5 mg 100 g<sup>-1</sup>) and minerals such as potassium, iron and zinc (Guzmán-Maldonado *et al.*, 2010).

The study area shows a high population of *garambullos* in adult stages, but not in juvenile stages, due to overgrazing that prevents natural regeneration.

Due to the productive potential of the fruit, it is possible to consider *M. geometrizans* as an alternative crop (Moreno-Hernández *et al.*, 2011), which allows contributing to the conservation of biodiversity, through reforestation and an adequate use plan of the fruit, in addition to improving the socioeconomic conditions of the communities, as they get an income from the commercialization of the fruit. Therefore, the purpose of the described project consisted on evaluating the field survival of *garambullo* through two reforestation systems: with cuttings planted directly in the field and with plants produced in rustic nurseries.

The work was carried out in the community of *Garabatillo*, in the *Dolores Hidalgo* municipality, *Guanajuato*, Mexico. The community has a common use area of 300 hectares located between 21.317925 N and -100.748816 W. The climate is BShw type (semi-dry with summer rains), and the predominant soil type is Feozem (INEGI, 2017). The communities around the area collect the fruit for sale.

The methodology consisted of six stages:

First stage: selection of specimens. Based on the experience of the producer, the first individuals were chosen according to the desired characteristics of the fruits (large, with good flavor and early ripening), an activity carried out in 2018 during the production season (June-August). Subsequently, from the identified specimens, a selection was made according to a simple plant material collection protocol (Johnson and Emino, 1979 cited by Villavicencio *et al.*, 2011), in which adult plants

with a large number of vigorous branches were chosen, in production stage and without apparent damage caused by the sun, pests or diseases (Figure 1).



A



B

A = Initial selection of the samples; B = Final selection of the samples.

**Figure 1.** Selection process of *Garambullo* samples

Second stage: collection of plant material. The collection was made at the end of spring (June) 2019. Two thousand cuttings were cut that met the length of 20 to 50 cm on average, tangentially at the base of the stem of the branch, with a *machete* previously disinfected in alcohol. They were transported the same day of the cut (Figure 2), to prevent fungal problems; so, the cuttings were disinfected in a sodium hypochlorite (5 % for five minutes) solution, the excess was removed with running water, then they were drained and left for 15 to 20 days in a shaded and ventilated area to allow the cut healing. A thousand cuttings were destined for nurseries and the other thousand for direct reforestation.



C



D

C = Collection of cuttings; D = Transfer of cuttings.

**Figure 2.** Collection and transport of the cuttings.

Third stage: establishment in rustic nurseries. One thousand cuttings were established in five rustic nurseries - so considered because there was a natural shade under trees and other larger *garambullos* - with a 200 specimens capacity each one; these nurseries were in charge of five women who collect the *garambullo* fruit on a daily basis. Soil and management conditions were similar in the five nurseries. Light fortnightly watering and manual weeding were applied.

In each production bed of the nursery, the same soil that was in the area was used as substrate, which is "solarized" for 30 days. The solarization of the substrate consists of increasing its temperature to cause the death of microorganisms; In this case, a black plastic was used in the lower part and a transparent plastic in the upper part, the edges were covered to avoid aeration. At the time of establishment of the cuttings in the substrate, the base of the cutting was submerged in a powdered rooter (Rootex<sup>®</sup> 300 ppm).

The cuttings in the nursery lasted one year; at the end the period, an assessment of the live specimens for reforestation was made (Figure 3). Those that underwent a process of losing turgency (the root did not fix in the ground), that did not have new shoots, and that, when removed from the soil, the root system was poorly developed, were discarded.



E



F

E = Establishment in nursery; F = Nursery evaluation.

**Figure 3.** Monitoring and evaluation of cuttings in rustic nurseries.

Fourth stage: reforestation with unrooted cuttings. One thousand cuttings were used for direct reforestation in the area where the species exists, but there were hardly any. This work was carried out at the beginning of the rainy season (June 2019) using a 40X40X40 cm box in which a third of the cutting was incorporated into the soil. Efforts were made to establish them in most cases next to "nurse" plants to protect them from the sun. A nurse plant is considered any plant that provides shade and improves the microclimate in terms of temperature and humidity. According to Neri-Luna *et al.* (1993), plants in early stages are sensitive to excess solar radiation that causes chlorophyll to photo-oxidize.

Fifth stage: reforestation with rooted cuttings. Before the end of the rooting period in each nursery, the survival of the cuttings in the nursery (200 in each one) was evaluated by recording the number of living cuttings in the, six<sup>th</sup>, seven<sup>th</sup>, eight<sup>th</sup>, ten<sup>th</sup> and twelve<sup>th</sup> month (Table 1). The survival average was 62.6 %, an acceptable value when there is no history of its propagation by cuttings, but it can improve the process in terms of substrate or handling.

**Table 1.** Cuttings survival of in the established nurseries.

Month	Live cuttings percentage					Average cuttings (%)
	Nursery 1	Nursery 2	Nursery 3	Nursery 4	Nursery 5	
6	88.0	79.0	89.0	90.0	80.0	85.2
7	78.5	70.0	76.0	86.5	72.0	76.6
8	74.0	61.5	71.5	78.5	64.0	70.1
10	69.0	56.5	68.0	71.0	57.5	65.0
12	66.5	54.5	65.0	69.0	55.0	62.6

To select the cuttings that would be used in reforestation, the quality of the plant was determined based on the descriptive parameters of vigor or appearance (Good: turgency and defined color; Regular: turgency and indefinite color; Bad: little turgency and opaque color), of new growth (Presence: with development of leaves and flowers; Non- presence: without leaves and flowers); root development (Good: high presence of roots; Fair: few roots; Bad: no presence of roots) and pests or diseases (Presence: with areas damaged by pests and/or diseases; Non-presence: without areas damaged by pests and/or diseases). There was high quality only in one nursery as it had the four parameters at the maximum value, while in the remaining four, a medium quality was estimated due to failing in some of the parameters; however, in general terms, good growth was observed, so it was decided that it was possible to transplant the plants to the field (Table 2).

**Table 2.** Plant quality produced at te nursery.

Plant quality	Parameters	Nursery 1	Nursery 2	Nursery 3	Nursery 4	Nursery 5	Average
Vigour	Good, Regular, Bad	B	B	R	B	R	B
New growths	Present, Non- present	P	P	P	P	P	P
Root development	Good, Fair, Bad	R	R	R	B	R	R
Plagues and diseases	Present, Non- present	Np	P	Np	Np	Np	Np
Average quality	High, Medium, Low	M	M	M	H	M	M

The rooted cuttings from the nurseries were taken to the field during the beginning of the 2020 rainy season (June) to reforest the areas where the species grows naturally, with the same method as the directly planted cuttings; no subsequent cultural activities were carried out (Figure 4).



G



H

G = Reforestation with cuttings; H = Survival evaluation.

**Figure 4.** *Garambullo* reforestation through cuttings.

Sixth stage: reforestation assessment. At the end of each reforestation process (direct or by plant rooted in the nursery), the survival of the cuttings was evaluated. The system proposed by the National Forestry Commission (Conafor, 2010) was applied, which recommends counting the number of live plants and the number of total plants planted; the process was carried out in three different sites and in two periods (replications).

Therefore, two random samplings were made in three observation sites for each type of cutting. On the reforestation lines, 100 plants per site were taken; the first sampling was done in the third month after planting and a second review in the same sites in the six<sup>th</sup> month. Results indicate that planting rooted cuttings in rustic nurseries offers a higher survival percentage in the field (90.6 %), compared to cuttings planted directly after harvesting (70.3 %) (Table 3).



**Table 3.** Survival percentage of reforestations.

Assessment month	Cuttings planted after collection (%)			Assessment month	Cuttings rooted at the nursery (%)		
	Site 1	Site 2	Site 3		Site 4	Site 5	Site 6
3	88.0	74.0	76.0	1	95.0	90.0	92.0
6	74.0	61.0	76.0	2	92.0	88.0	92.0
Average	81.0	67.5	76.0	Average	93.5	89.0	92.0

The reforestation of *garambullo* through cuttings is viable in both reforestation systems (Osuna *et al.*, 2016); however, better results were obtained in the field when the cuttings were previously rooted in the nursery than those planted directly in the field. But the particularities of both processes still need to be analyzed, since planting the cuttings directly, although more plants are lost at the destination, there is a greater number in absolute terms when compared to the number of cuttings developed in the nursery, even though they have a more successful survival in the field. In addition, nursery management can be improved with greater substrate safety, applying liquid rooters, or better irrigation (Monreal *et al.*, 2014) to have a greater number of rooted cuttings in the nursery.

### Acknowledgements

INIFAP is thanked for the fiscal project number 13375634106 entitled "Establishment of nurseries, determination of harvest quality and generation of industrial products of the *garambullo* (*Myrtillocactus geometrizans*)" and the producers of *garambullo* from the community of *Garabatillo*.

### **Conflict of interests**

The authors declare no conflict of interest.

### **Contribution by autor**

Ricardo Rivera Vázquez: research development, interpretation of results; María Guadalupe Herrera Hernández: correction of the manuscript; Salvador Horacio Guzmán Maldonado: correction of the manuscript.

### **References**

- Bravo H., H. y H. Sánchez M. 1978. Las cactáceas de México. Vol. 1. Universidad Nacional Autónoma de México. México, D. F., México. 743 p.
- Comisión Nacional Forestal (Conafor). 2010. Prácticas de reforestación: manual básico. Conafor, Semarnat. Zapopan, Jal., México. 64 p.
- Guzmán-Maldonado, S. H., G. Herrera-Hernández, D. Hernández-López, R. Reynoso-Camacho, A. Guzmán-Tovar, F. Vaillant and P. Brat. 2010. Physicochemical, nutritional and functional characteristics of two underutilised fruit cactus species (*Myrtillocactus*) produced in central Mexico. Food Chemistry 121 (2): 381-386. Doi: 10.1016/j.foodchem.2009.12.039.

Instituto Nacional de estadística, Geografía e Informática (INEGI). 2017. Anuario estadístico y geográfico de Guanajuato 2017. INEGI. Aguascalientes, Ags., México. 604 p.

Meyrán, G. J. y L. López C. 2003. Las Crassuláceas de México. Sociedad Mexicana de Cactología, A.C. México, D. F., México. 234 p.

Monreal-Vargas, C. T., E. Espitia M. y O. Escandón Q. 2014. Hongos patógenos del garmbullo *Myrtillocactus geometrizan* (Mart. ex. Pfeiff) Console en Mexquitic de Carmona, San Luis Potosí, México. Revista Iberoamericana de Ciencias 1(6):45-59. <http://www.reibci.org/publicados/2014/noviembre/0600118.pdf> (20 de diciembre de 2021).

Moreno-Hernández, A., N. Estrella-Chulim, S. Escobedo-Garrido, A. Bustamante-González y P. W. Gerritsen 2011. Prácticas de manejo agronómico para la sustentabilidad: características y medición en *Agave tequilana* Weber en la región Sierra de Amula, Jalisco. Tropical and Subtropical Agroecosystems 14:159–169. Doi: 10.29312/remexca.v8i18.216.

Neri-Luna, C., E. Pimienta-Barrios y C. Robles M. 1993. Cambios fisiológicos durante el proceso de senescencia en cladodios jóvenes de nopal (*Opuntia ficus-indica* L. Miller). Agrociencia 4(1):7-18. [https://www.researchgate.net/publication/289507596\\_Cambios\\_fisiologicos\\_durante\\_el\\_proceso\\_de\\_senescencia\\_en\\_cladodios\\_jovenes\\_de\\_nopal\\_Opintia\\_ficus-indica\\_L\\_Miller](https://www.researchgate.net/publication/289507596_Cambios_fisiologicos_durante_el_proceso_de_senescencia_en_cladodios_jovenes_de_nopal_Opintia_ficus-indica_L_Miller) (15 de noviembre de 2021).

Osuna F., H. R., A. M. Osuna F. y A. Fierro A. 2016. Manual de propagación de plantas superiores. Universidad Nacional Autónoma de México, Universidad Autónoma Metropolitana. Ciudad de México, CDMX., México. 90 p.

Terrones, R. T. del R. L., C. González S. y S. A. Ríos R. 2004. Arbustivas nativas de uso múltiple en Guanajuato. Libro técnico Núm. 2. INIFAP, Campo Experimental Bajío. Celaya, Gto., México. 216 p.

Terrones R., T., V. Partida P. F., C. González S. y M. Tovar H. 2014. Plantas Silvestres en el Paisaje Urbano del Municipio de León, Gto. Publicación Técnica del Instituto Municipal de Planeación (IMPLAN). León, Gto., México. 211 p.

Villavicencio G., E. E., A. González C., A. Arredondo G., L. Iracheta D., S. Camparan S. y R. Casique V. 2011. Micropropagación de *Turbinacarpus knuthianus* (Boed.) John & Riha Cactacea ornamental del Desierto Chihuahuense, en estado de riesgo. Revista Mexicana de Ciencias Forestales. 2(6): 37-54. Doi:[10.29298/rmcf.v2i6.573](https://doi.org/10.29298/rmcf.v2i6.573).



Todos los textos publicados por la **Revista Mexicana de Ciencias Forestales** –sin excepción– se distribuyen amparados bajo la licencia *Creative Commons 4.0 Atribución-No Comercial (CC BY-NC 4.0 Internacional)*, que permite a terceros utilizar lo publicado siempre que mencionen la autoría del trabajo y a la primera publicación en esta revista.