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Artículo

Efecto de diferentes sustratos en el crecimiento de plántulas de *Dasylirion acrotrichum* (Schiede) Zucc.

Effect of different substrates in *Dasylirion acrotrichum* (Schiede) Zucc. seedling growth

Abraham Palacios-Romero[1], Rodrigo Rodríguez-Laguna[2] *, Ramón Razo-Zárate[2] y Edith Jiménez-Muñoz[3]

Resumen

Dasylirion acrotrichum es una especie usada, principalmente, como ornamento religioso, que los productores de Oaxaca quieren empezar a utilizarla en la industria licorera. A pesar de esto, no existe ningún tipo de estudio técnico o científico del taxon, por lo que es imperativo generar conocimiento del mismo. Por ello, se evaluó el efecto de tres diferentes sustratos en el crecimiento de plántulas de *D. acrotrichum*. Se estableció un ensayo en un invernadero perteneciente a la Universidad Autónoma del Estado de Hidalgo. Las semillas fueron germinadas y trasplantadas a contenedores de polietileno con tres tratamientos: tierra agrícola-tezontle (2:1), tierra agrícola (100 %) y tierra agrícola–tezontle (1:1). Las variables estudiadas fueron: biomasa de raíz, aérea, total y número de hojas. Se realizaron dos mediciones: a los seis y 18 meses de efectuado el trasplante y los datos obtenidos se sometieron a un análisis de varianza. A los seis meses, el tratamiento de tierra agrícola–tezontle (1:1) tuvo la mayor biomasa radicular y biomasa total, datos que fueron superiores a los otros tratamientos hasta 31.94 % y 23.75 %, respectivamente. A los 18 meses, el tratamiento de tierra agrícola–tezontle (1:1), alcanzó la mayor biomasa aérea y total, superó hasta 25.5 % y 24.6 %, respectivamente al resto de los tratamientos. Por lo que se infiere que este sustrato mejora el crecimiento inicial de esta especie.

Palabras clave: Biomasa aérea, biomasa radicular, crecimiento, sotol, sustrato, tezontle.

Abstract

Dasylirion acrotrichum is a species used primarily as a religious ornament and is beginning to be exploited by the liquor industry in *Oaxaca*. Despite this, there is no technical or scientific study of the species, so it is imperative to generate knowledge of it. Therefore, the effect of three different substrates on the growth of *D. acrotrichum* seedlings was evaluated. The trial was established within the greenhouse belonging to *Universidad Autónoma del Estado de Hidalgo*. The seeds were germinated and transplanted to polyethylene containers with three different treatments: agricultural land-*tezontle* (2:1), agricultural land (100 %) and agricultural land-*tezontle* (1:1). The variables studied were: root biomass, aerial, total and number of leaves. Two measurements were made at 6 and 18 months after the transplant and the data obtained were subjected to a variance analysis. At 6 months, the treatment of agricultural land-*tezontle* (1:1) had the highest root biomass and total biomass surpassing the other treatments by up to 31.94 % and 23.75 %, respectively. At 18 months, the treatment of agricultural land-*tezontle* (1:1), reaches the highest aerial and total biomass, surpassing in up to 25.5 % and 24.6 % respectively to the rest of the treatments. Therefore, it is inferred that this substrate improves the initial growth in this species.

Keywords: Aerial biomass, root biomass, growth, *sotol*, substrate, *tezontle*.

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[1]Departamento de Bioingenierías y Ciencias, Tecnológico de Monterrey, *Campus* Hidalgo. México.
[2]Instituto de Ciencias Agropecuarias, Universidad Autónoma del Estado de Hidalgo, México.
[3]Instituto de Biología, Universidad Nacional Autónoma de México, México.
*Autor por correspondencia Correo-e: rlaguna@uaeh.edu.mx

Introduction

The vegetation that grows in arid climates is a source of various resources for the communities that live in those areas, *e.g*. medicinal and edible plants, fruits, seeds, resins, raw materials for a variety of industries (wood, charcoal, crafts, liquors, etc.). It also contributes valuable environmental services, such as soil protection and shelter and food for wildlife (López *et al*., 2005).

In these ecosystems, the species belonging to the genus *Dasylirion* (known as green *sotol*, great desert spoon or spoon yucca) stand out because they are a source of a large variety of products that are useful to human beings (Vega-Cruz *et al*., 2006). The species of the genus *Dasylirion* are distributed from southern USA to southern Mexico. Today, their economic importance is increasing, especially due to their use in the production of alcoholic beverages, such as *sotol*, and in the religious ornaments known as flower arches (Haeckel, 2008; Reyes-Valdés *et al*., 2012).

Dasylirion acrotrichum (Schiede) Zucc. is an endemic species of Mexico which, like the rest of the genus, grows in the arid areas of the country; on gravelly soils with good drainage; on hillsides and on creek edges where xerophyll and submontane shrubs occur (Torres, 2016). It is a slowly growing evergreen, polycarpic plant with a woody stem that has a high cultural value (Torres, 2016). The leaves are used for tying roofs and making ornaments for religious festivals (López-Gutiérrez, 2010). Its stem can be used as firewood (Arias *et al*., 2000), and its flowers are eaten by humans, while the floral scapus is used to feed the cattle during long droughts (Torres, 2016). According to the Mexican Official Norm NOM-059-SEMARNAT 2010, *Dasylirion acrotrichum* is classified as a threatened species due to certain factors that cause the deterioration of its habitat or which directly reduce the size of the wild populations (Torres, 2016).

Despite its cultural and economic importance and its “at risk” status, there is no technical or scientific information that allows a responsible management of its wild populations; therefore, it is a priority to carry out research aimed at determining the main details of its life cycle, in order to define the optimal conditions for its adequate exploitation, based on the generated information.

Thus, the objective of the present paper is to assess the effect of three substrates on the initial growth of *D. acrotrichum* plants in the greenhouse, in order to meet the producers' need to obtain a high-quality plant for the purpose of establishing commercial plantations without putting its wild populations at risk.

Materials and Methods

The assay was implemented at a nursery belonging to the *Instituto de Ciencias Agropecuarias de la Universidad Autónoma del Estado de Hidalgo* (Institute of Agricultural Sciences of the Autonomous University of the State of Hidalgo), with a white plastic cover with a 720 caliber located at the coordinates 20°3'36.44" N and 98°22'53.26" W, at an altitude of 2 165 masl, and with a mean annual precipitation of 50 mm to 553 mm and a mean annual temperature of 14 °C (INEGI, 2015).

The vegetal material was obtained by germinating seeds donated by producers of the community of *Guadalupe Hidalgo* in *Nochixtlán* municipality, in the state of *Oaxaca*, Mexico.

Seedlings were produced in plastic trays with 49, 170 cm^3 cavities. The substrate used for this purpose consisted of moss peat, perlite and vermiculate, at a ratio of 3:1:1, with six grams of Osmocote plus™ slow-release 8-months fertilizer (15-09-12) for every liter of mixture. Once the seedlings were one month old, they were transplanted, with bare roots, into 10 cm × 20 cm (0.40 L) polyethylene bags. The following treatments were applied: soil and *tezontle* at a ratio of 2:1 (T1); 100 % soil (T2); soil and *tezontle* at a ratio of 1:1 (T3). The experimental design was fully random. The soil utilized to create the substrates had 23 % baseline moisture, 56.5 % total porosity, 10.2 % capacity to retain available water, and 89.7 % airing porosity. Each treatment consisted of 125 seedlings, and the experiment comprised a total of 375 individuals (there were no deaths during the assay).

Variables and performed analyses

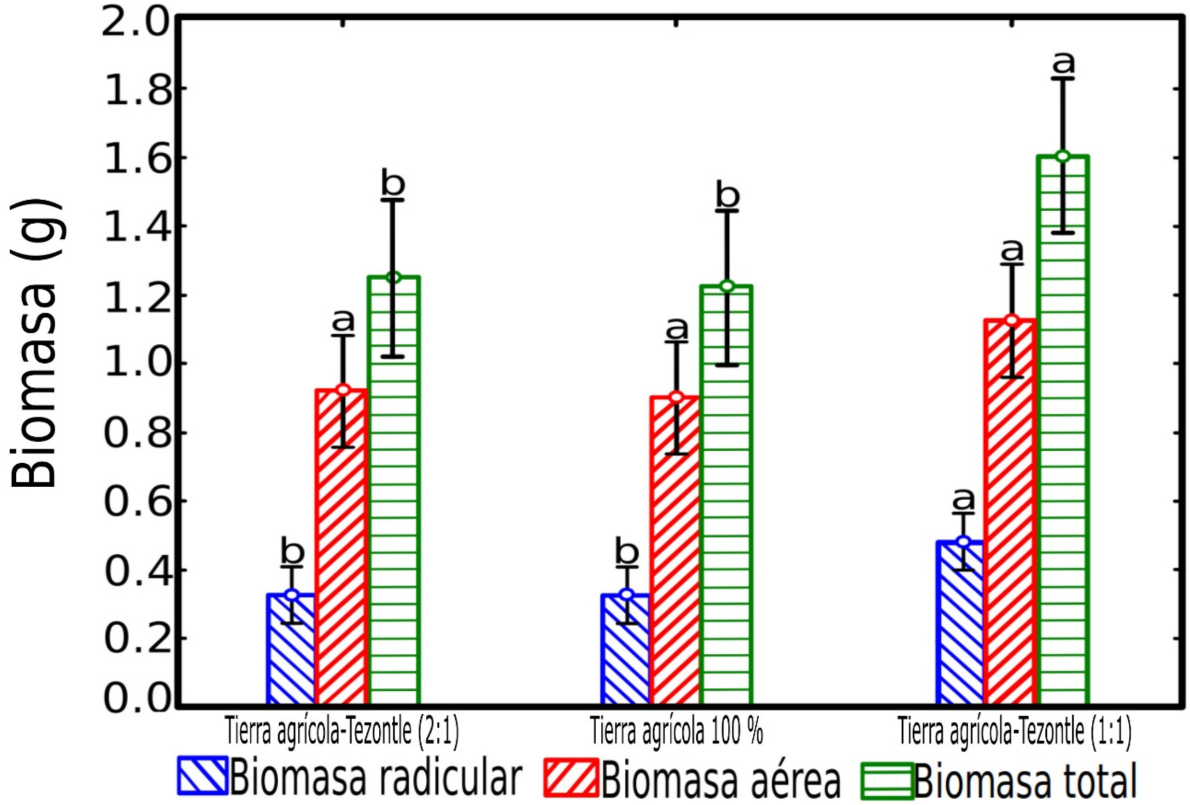
The studied variables were the increase in root, aerial and total biomass and in the number of leaves. Two assessments were carried out: at 6 months and at 18 months after the transplant; in each measurement, 15 individuals were selected completely at random for assessment. The biomass was estimated according to the methodology proposed by Schlegel *et al*. (2000), which consisted in extracting the plant, washing the root and placing the plants in JISICO, J-DH1 model drying stoves. The aerial, root and total biomass and the number of leaves were subjected to a variance analysis. Variables that exhibited significant statistical differences ($P \leq 0.05$) were subjected to Tukey's mean comparison, using the Statistica 7.0 statistical package.

Results and Discussion

Evaluation at six months after the transplant

The variance analysis performed 6 months after the transplant indicates the existence of significant differences in the root biomass ($P = 0.011$), total biomass ($P = 0.035$) and number of leaves ($P = 0.001$) variables.

Tukey's mean comparison test shows that the soil and *tezontle* (1:1) treatment yielded the best results in root and total biomass (Figure 1). With it, the former reached 0.48 g, while with other treatments produced only 0.32 g; this amount to a difference of 31.94 %; as for the total biomass, the soil and *tezontle* (1:1) treatment attained 1.60 g, surpassing the value attained with the 100 % soil treatment by 23.75 %, and with the soil and *tezontle* (2:1) treatment by 22.5 %.



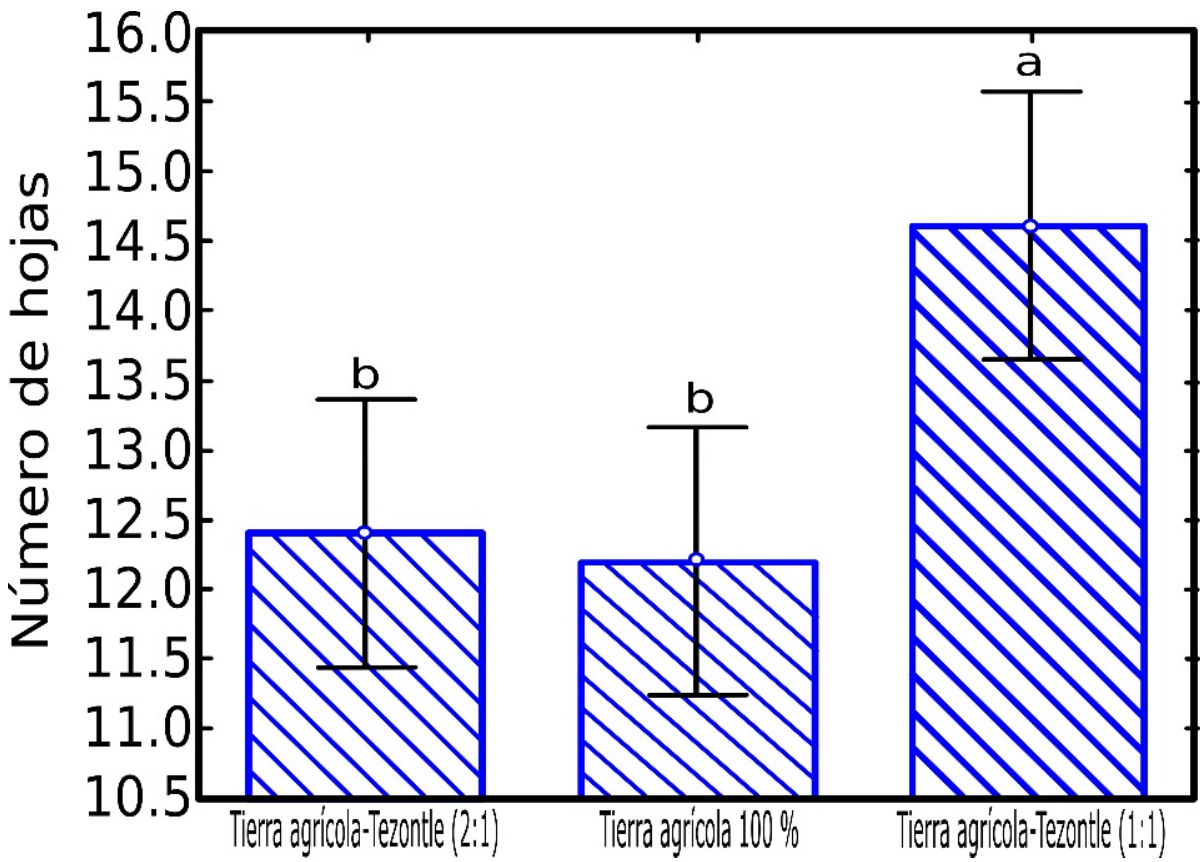
Biomasa = Biomass; *Biomasa radicular* = Root biomass; *Biomasa aérea* = Aerial biomass; *Biomasa total* = Total biomass; *Tierra agrícola* = Soil.

*Bars with the same pattern and a different letter indicate significant statistical differences (P≤0.05).

Figure 1. Biomass obtained in different substrates six months after the transplant.

From these results, it may be inferred that *D. acrotrichum* develops better during the seedling stage in well-drained, porous soils, which allow the roots to grow more easily, as pointed out by De Freitas *et al.* (1999) and Dexter (2002), according to whom the existence of an appropriate amount of continuous macropores that can be freely penetrated by the roots is an important requirement for their growth. As for the aerial biomass, no significant differences were detected between the treatments; however, a larger Furthermore, this is confirmed by the data documented by Granados-Sánchez *et al.* (2011) and Reyes-Valdés *et al*. (2012), who state that the individuals of the genus *Dasylirion* are naturally distributed in areas with this type of soils, and therefore the studied species would adapt better to these conditions. Tendency to a larger biomass was registered in plants grown in soil and *tezontle* (1:1).

For the number of leaves variable, Tukey's mean comparison test shows that plants grown in soil and *tezontle* (1:1) had a more abundant foliage than those in which the other treatments were used (Figure 2). This may be attributed to the presence of a more developed root system (a reflection of its larger biomass), which allowed a larger number of leaves to emerge, as Di Stéfano and Fouriere (1999) suggest.



Número de hojas = Number of leaves; *Tierra agrícola* = Soil.

*Bars with a different letter indicate significant statistical differences (P≤0.05).

Figure 2. Number of leaves developed with different substrates six months after transplant.

Evaluation at 18 months after the transplant

The variance analysis performed 18 months after the transplant exhibited significant differences for the variables aerial biomass and total biomass, while the significant differences for the variables root biomass and number of leaves were null (Table 1).

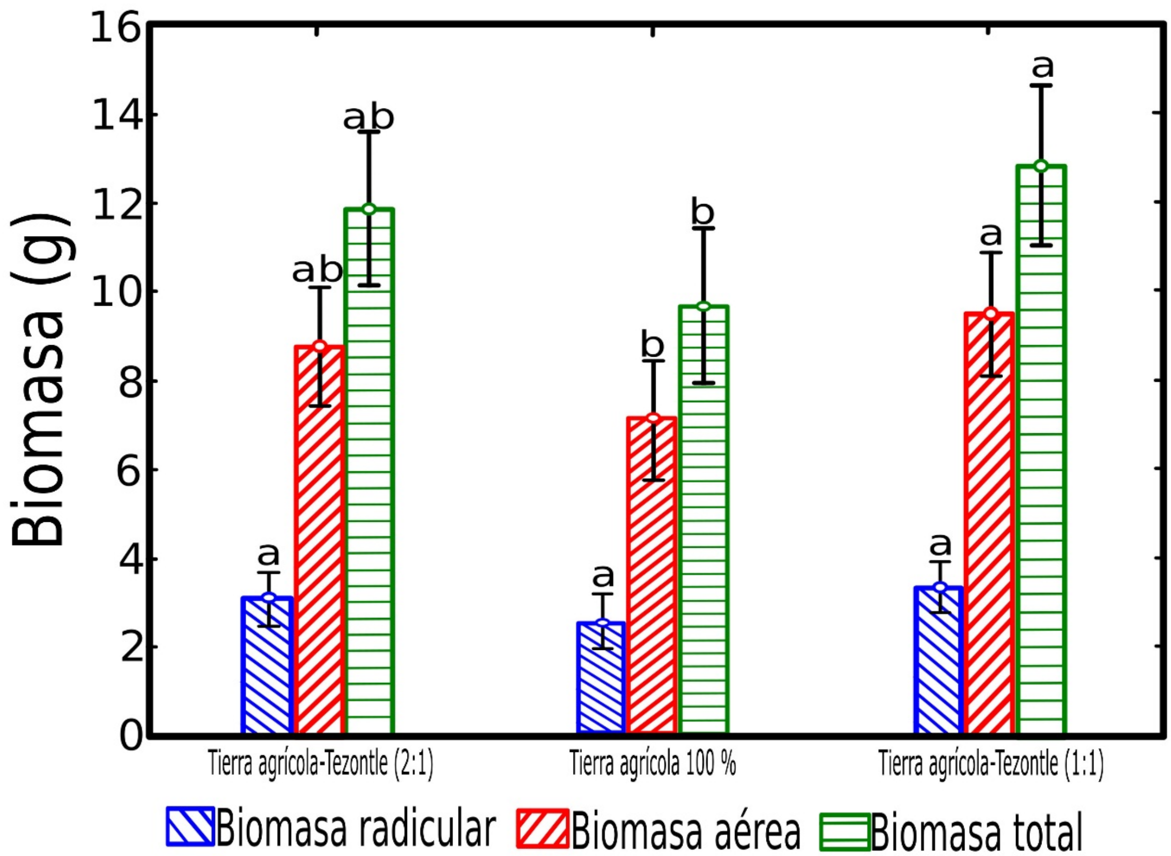
Table 1. Variance analysis of the biomass 18 months after the transplant of *Dasylirion acrotrichum* (Schiede) Zucc.

Variable	Mean squares		Pr>F
	Treatment (2)[a]	Error (41)	
Root biomass	2.1660	1.4076	0.226502
Aerial biomass	23.080	6.671	0.040663
Total biomass	39.384	11.430	0.041153
Number of leaves	52.42	25.57	0.141352

[a]The degrees of freedom corresponding to each source of variation are shown between parentheses.

Tukey's mean comparison test evidenced that, for the variables aerial biomass and total biomass, plants sown in soil and *tezontle* (1:1) exhibited a larger increase than those grown in 100 % soil. For aerial biomass, plants grown in soil and *tezontle* (1:1) obtained 9.54 g (25.5 % more than those grown in 100 % soil), and for total biomass, they reached 12.84 g (24.6 % more than those produced in soil).

When comparing the individuals in which the soil and *tezontle* (1:1) treatment was used with those grown in soil and *tezontle* (2:1), no significant differences were detected (Figure 3). This may be due, in principle, to the difference in root biomass observed in the first measurement, for, according to Harris (1992) and Di Stéfano and Fouriere (1999), in pot-grown plants, a well-developed root system is crucial for the vigorous growth of the aerial part. This also reinforces the statement of Mata-Balderas *et al.* (2014) that the genus *Dasylirion* grows naturally in areas with porous soils. Furthermore, Robertson *et al.* (2009) cites that the growth and productivity of *Dasylirion* spp. will largely depend on the status and growth of the root system.



Biomasa = Biomass; *Biomasa radicular* = Root biomass; *Biomasa aérea* = Aerial biomass; *Biomasa total* = Total biomass; *Tierra agrícola* = Soil.

***Bars with the same pattern and different letters indicate statistically significant differences (P≤0.05).

Figure 3. Biomass obtained in different substrates 18 months after transplant.

As for the root biomass, a tendency to increase it was observed in the plants in which the soil and *tezontle* (1:1) treatment was used, compared with the other two. The absence of significant differences may be due to the effect of the container on the roots (Santiago *et al*., 2015), since 18 months after the transplant, the available space had already been occupied and, as cited by Matthe-Sears and Larson (1999), the growth is affected by the use of limited spaces.

Again, in relation to the number of leaves, the absence of significant differences between the treatments was noticeable; this is ascribable to the size of the container into which the plants were transplanted, since it may have restrained the growth of the roots, which in turn may have influenced the development of the number of leaves, as suggested by Robertson *et al.* (2009).

Limiting factors for the results obtained in the present assay were the time intervals between measurements, as were the size and shape of the container into which the plants were transplanted. It is worth noting that they may have been affected by these restrictions (Di Stéfano and Fouriere, 1999). Certain studies indicate that the bracts of the seed influence both the germination and the growth (Sierra *et al.*, 2008). It is also important to highlight that the variation in the germination and growth characteristics of the *Dasylirion* spp. seedlings is very wide, and this makes it difficult to define the optimal characteristics and conditions for the production of the seedlings (Vega-Cruz *et al*., 2006). Furthermore, it should be considered that the assays documented in the literature were carried out on species other than *D. acrotrichum*, and, in general, knowledge regarding its physiology is very scarce; therefore, there may be other factors which influence its initial growth that were not included in the present study.

Conclusions

The soil and *tezontle* (1:1) substrate is the best mixture for the production of *D. acrotrichum* at the initial stages of growth, since it favors the increase of root biomass and of the number of leaves, while the less porous substrates limit the growth of the plant in a same time period and under the same environmental conditions.

It is important to follow up on this type of studies by assessing other mixtures and proportions that may modify the porosity of the substrate in order to optimize the production of *D. acrotrichum* plants, given that this species is being increasingly harvested due to its importance in the liquor and ornamental industries.

Conflict of interest

The authors declare that they have no conflict of interests.

Contributions by author

Abraham Palacios-Romero: work at the nursery; Rodrigo Rodríguez-Laguna: responsible for the integral project; Ramón Razo-Zárate: laboratory work; Edith Jiménez-Muñoz: statistical analyses. All authors participated in the drafting and editing of the manuscript.

References

Arias T., A. A., M. T. Valverde V. y J. R. Santiago. 2000. Las plantas de la región de Zapotitlán Salinas, Puebla. Instituto Nacional de Ecología., Red para el Desarrollo Sostenible A.C., Universidad Nacional Autónoma de Puebla. México, DF., México. 80 p.

De Freitas, P. L., R. W. Zobel and V. A. Synder. 1999. Corn Root growth in soil columns with artificially constructed aggregates. Crop Science 39 (3): 725–30. doi:10.2135/cropsci1999.0011183X003900030020x.

Dexter, A. R. 2002. Soil Structure: The key to soil function. *In*: Pagliai, M. and. R. Jones (comp.). Sustainable Land Management-Environmental Protection: A soil physical approach. advances in GeoEcology. Catena Verlag. Reiskirchen, Germany. pp. 57–69.

Di Stéfano, J. F. y L. A. Fournier. 1999. Crecimiento de la parte aérea y radicular de plántulas de *Enterolobium cyclocarpum* (GUANACASTE). Agronomía Costarricense 23(1): 77–87.

Granados-Sánchez D., A. Sánchez-González, R. L. Granados Victorino y A. Borja de la Rosa. 2011. Ecología de la vegetación del desierto chihuahuense. Revista Chapingo Serie Ciencias Forestales y del Ambiente 17: 111-130. http://dx.doi.org/10.5154/r.rchscfa.2010.10.102.

Haeckel, I. B. 2008. Notes on economic plants The “Arco Floral”: Ethnobotany of *Tillandsia* and *Dasylirion* spp. in a mexican religious adornment. Economic Botany. 62: 90-95. https://doi.org/10.1007/s12231-008-9009-8.

Harris, R. W. 1992. Arboriculture: Integrated management of landscape trees, shrubs, and vines. Prentice-Hall International. Davis, CA USA. 674 p.

Instituto Nacional de Estadística y Geografía (INEGI). 2015. Anuario Estadístico y Geográfico de Hidalgo 2014. Aguascalientes, Ags., México. 606 p.

López, C., S. Chanfón y G. Segura. 2005. La riqueza de los bosques mexicanos más allá de la madera. Secretaría de Medio Ambiente y Recursos Naturales. México, D.F., México. 200 p.

López-Gutiérrez, B. N. 2010. Etnobotánica de *Dasylirion acrotriche* (Schiede) Zucc. (Nolinaceae), en áreas del centro y sur del Estado de Hidalgo, México. Tesis de Maestría. Universidad Autónoma del Estado de Hidalgo. Pachuca, Hgo., México. 89 p.

Mata-Balderas, J. M., E. J. Treviño-Garza, J. Jiménez-Pérez, O. A. Aguirre-Calderón, E. Alanís-Rodríguez y R. Foroughbakhch-Pournavab. 2014. Prácticas de rehabilitación en un ecosistema semiárido, afectado por el establecimiento de un banco de material, en el noreste de México. CienciaUAT 8(2): 32–43. https://doi.org/10.29059/cienciauat.v8i2.291.

Matthes-Sears, U. and D. W. Larson. 1999. Limitations to seedling growth and survival by the quantity and quality of rooting space: Implications for the establishment of *Thuja occidentalis* on cliff faces. International Journal of Plant Sciences 160 (1): 122–28. https://doi.org/10.1086/314105.

Reyes-Valdés, M. H., A. Benavides-Mendoza, H. Ramírez-Rodríguez y J. A. Villarreal-Quintanilla. 2012. Biología e importancia del sotol (*Dasylirion* spp). Parte I: sistemática, genética y reproducción. Planta 14(7): 11-13.

Robertson, T. R., C. W. Bell, J. C. Zak and David T Tissue. 2009. Precipitation timing and magnitude differentially affect aboveground annual net primary productivity in three perennial species in a Chihuahuan desert grassland. New Phytologist 181 (1): 230–42. https://doi.org/10.1111/j.1469-8137.2008.02643.x.

Santiago T., O., J. J. Vargas H., A. Aldrete, J. López U y A. M. Fierros G. 2015. Sustratos y tamaños de contenedor en el desarrollo de Müll. Arg. en Vivero. Revista Mexicana de Ciencias Forestales 6 (31): 94–113. https://doi.org/10.29298/rmcf.v6i31.199.

Schlegel, B., J. Gayoso y J. Guerra. 2000. Manual de procedimientos muestreos de biomasa forestal. Medición de la capacidad de captura de carbono en bosques de Chile y promoción en el mercado mundial. Valdivia: Universidad Austral de Chile. http://www.uach.cl/procarbono/pdf/manuales/guia_destructivo.pdf
(10 de junio de 2016).

Sierra T., J. S., C. R. Lara M., R. R. Carrillo, A. C. Mendoza, C. N. Morales y M. H. Royo M. 2008. Los Sotoles (*Dasylirion* SPP) de Chihuahua. Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias. Folleto técnico Núm. 20. Chihuahua, Chih., México. 58 p.

Torres M., G. 2016. Manejo Tradicional de *Dasylirion Acrotrichum* (Schiede) Zucc. (Asparagaceae) para la elaboración de arcos florales en el centro de Veracruz y la evaluación del impacto en sus poblaciones naturales. Tesis de Maestría. Universidad Veracruzana. Xalapa, Ver., México. 89 p.

Vega-Cruz J., A. Melgoza-Castillo y J. S. Sierra-Tristán. 2006. Caracterización del crecimiento de dos especies de sotol (*Dasylirion leiophyllum* Engelm. ex Trelease y *D. sereke* Bogler) fertilizadas con nitrógeno y fosforo. Ciencia Forestal en México 31 (99): 55-71.