



Acta Botanica
Mexicana

Distribución potencial de *Abies vejarii* (Pinaceae) y su relación con factores ambientales, topográficos y antropogénicos en el noreste de México

Potential distribution of *Abies vejarii* (Pinaceae) and its relationship with environmental, topographic and anthropogenic factors in northeastern Mexico

Rigoberto González-Cubas¹ , Eduardo J. Treviño-Garza^{1,3} , Oscar A. Aguirre-Calderón¹ , Rahim Foroughbakhch-Pournavab² 

Resumen:

Antecedentes y Objetivos: *Abies vejarii* (oyamel) es una especie endémica del noreste de México, actualmente catalogada como Casi Amenazada por la Unión Internacional para la Conservación de la Naturaleza (IUCN), con poblaciones aisladas. Los objetivos del presente estudio fueron i) buscar áreas en donde se reúnan las condiciones ideales para el desarrollo del oyamel utilizando el algoritmo de máxima entropía en la Sierra Madre Oriental (SMOR), ii) identificar las variables ambientales topográficas asociadas a su distribución actual y iii) evaluar los impactos antropogénicos actuales en la distribución de *A. vejarii*.

Métodos: Mediante un modelo de distribución de especie (MDE), se modeló la idoneidad de su hábitat, utilizando datos bioclimáticos y topográficos. Se identificaron las variables ambientales que influyen en su distribución geográfica mediante análisis cluster (CA) y de componentes principales (PCA). Finalmente, se relacionó el efecto del impacto antropogénico sobre sus áreas de distribución actual.

Resultados clave: El área total que se predice y que es climáticamente adecuada para su presencia es de 67,096 ha. El análisis de las variables ambientales y topográficas mostró que el rango anual de temperatura y la precipitación del mes más seco resultaron ser las más importantes. Se encontró una asociación negativa y significativa con el impacto antropogénico. La Sierra Madre Oriental presenta las condiciones que son el hábitat favorable para la persistencia de *A. vejarii*.

Conclusiones: La cuantificación de las áreas óptimas que permitan el establecimiento y desarrollo de *A. vejarii* hará posible diseñar estrategias y prescribir acciones para la conservación y restauración de las poblaciones de esta especie.

Palabras clave: especie relicto, idoneidad climática, impacto antropogénico, modelo de distribución.

Abstract:

Background and Aims: *Abies vejarii* (oyamel) is an endemic species of northeastern Mexico, currently listed as Near Threatened by the International Union for the Conservation of Nature (IUCN), with isolated populations. The objectives of the present study were i) to look for areas where the ideal conditions for oyamel development meet, using the maximum entropy algorithm in the Sierra Madre Oriental (SMOR), ii) identify the topographic environmental variables associated with its current distribution, and iii) evaluate the current anthropogenic impacts on the distribution of *A. vejarii*.

Methods: Using a species distribution model (MDE), the suitability of its habitat was modeled, with bioclimatic and topographic data. The environmental variables that influence its geographical distribution were identified through cluster (CA) and principal component analyses (PCA). Finally, the effect of the anthropogenic impact was linked with its current distribution areas.

Key results: The total area that is predicted and that is climatically adequate for its presence was 67,096 ha. The analysis of the environmental and topographic variables showed that the annual temperature range and the precipitation of the driest month were the most important. A negative and significant association with the anthropogenic impact was found. The Sierra Madre Oriental presents the conditions that are the favorable habitat for the persistence of *A. vejarii*.

Conclusions: The quantification of the optimal areas that allow the establishment and development of *A. vejarii* will make it possible to design strategies and prescribe actions for the conservation and restoration of populations of this species.

Key words: anthropogenic impact, climate suitability, distribution model, relict species.

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Recibido: 26 de agosto de 2019.

Revisado: 1 de octubre de 2019.

Aceptado por Marie-Stéphanie Samain: 4 de febrero de 2020.

Publicado Primero en línea: 10 de marzo de 2020.

Publicado: Acta Botanica Mexicana 127 (2020).



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Citar como:

González-Cubas, R., E. J. Treviño-Garza, O. A. Aguirre-Calderón y R. Foroughbakhch-Pournavab. Distribución potencial de *Abies vejarii* (Pinaceae) y su relación con factores ambientales, topográficos y antropogénicos en el noreste de México. Acta Botanica Mexicana 127: e1607. DOI: 10.21829/abm127.2020.1607

e-ISSN: 2448-7589

Article

Elemental Composition and Flue Gas Emissions of Different Components from Five Semi-Arid Woody Species in Pyrolysed and Non-Pyrolysed Material

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Received: 4 February 2019; Accepted: 21 February 2019; Published: 26 February 2019



Abstract: Biofuels are sustainable alternatives to fossil fuels. However, they must comply with energy efficiency requirements and contribute to environmental protection. This study was focused on elemental composition (carbon, hydrogen, nitrogen, sulphur and chlorine) of different plants' components (stems, branches, twigs and leaves) from pyrolysed (charcoal) and non-pyrolysed samples of five semi-arid trees: *Acacia berlandieri*, *A. wrightii*, *Ebenopsis ebano*, *Havardia pallens* and *Helietta parvifolia*. Carbon fluctuated from 80.77% to 89.30% in charcoal and 44.99% to 49.70% in non-pyrolysed biomass, and hydrogen ranged from 2.38% to 2.69% in charcoal and 5.89% to 6.62% in non-pyrolysed biomass. Nitrogen accounted for 0.39%–0.65% (branches) and 0.32%–0.64% (stems) in charcoal, and the ranges for non-pyrolyzed material were 2.33–4.00% (leaves), 1.06%–1.76% (twigs), 0.21%–0.52% (branches) and 0.15%–0.28% (stems). Considerably higher concentrations of sulphur compared to chlorine were found, with increasing values for both elements from the base of trees to the leaves. Non-pyrolysed samples were characterized by 68.05 mg/kg–769.16 mg/kg (stems), 118.02 mg/kg–791.68 mg/kg (branches), 225.11 mg/kg–1742.25 mg/kg (twigs) and 374.73 mg/kg–6811.52 mg/kg (leaves) for sulphur, and 117.86 mg/kg–528.08 mg/kg (stems), 109.18 mg/kg–464.15 mg/kg (branches), 905.47 mg/kg–4205.19 mg/kg (twigs) and 2799.68 mg/kg–5072.76 mg/kg (leaves) for chlorine. In charcoal, the concentration ranges for sulphur were 47.54 mg/kg–376.95 mg/kg (branches) and 42.73–292.20 mg/kg (stems) and 139.34 mg/kg–419.68 mg/kg (branches) and 177.39 mg/kg–479.16 (stems) for chlorine. The study has shown that pyrolysis increased the amount of carbon and decreased the amount of hydrogen. Coincidentally, the amount of nitrogen, chlorine and sulphur could be decreased significantly by pyrolysis which means an improvement of the fuel considering the flue gas emissions. Besides the influence of the type of combustion plant and the influence of the source of biofuel, the treatment has a significant influence on the amount and composition of flue gases emitted in the combustion.

Keywords: biofuels quality; pyrolysis; sulphur and chlorine; elemental analysis; semi-arid woody species

Estructura y diversidad de la vegetación en un matorral espinoso prístino de Tamaulipas, México

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Recibido 25-I-2018. Corregido 18-V-2018. Aceptado 12-IX-2018.

Abstract: Structure and diversity of the vegetation of pristine scrubland in Tamaulipas, Mexico.

Tamaulipan scrubland is a type of shrub vegetation endemic to Northeastern Mexico and Southern Texas in the U.S. The structure of the Tamaulipan scrubland was evaluated in the study, establishing the minimum area with plots of 256 m² by determining the species-area curve, valuing the composition and diversity of the strata of the plant species (arboreal, shrub, low forest, semi shrubby, herbaceous and epiphytes); three sampling sites of 16×16 m were established. Dasometric information such as height, diameter and cup coverage was recorded to determine the structural variables of coverage, density, relative density, dominance, relative dominance, frequency, relative frequency and Importance Value Index, as well as estimation of the Margalef richness index, Shannon-Wiener diversity index, Menhinick, Simpson and Pielou's evenness index. The floristic richness was of 33 species distributed in 30 genera and 19 families, leaving the predominance value of the highest species of Leguminosae (Fabaceae). Six strata were recognized for the studied vegetation from which the highest IVI was *Helietta parvifolia* with 17.68 % for the shrubby stratum with 14 species and within the plant community of the MET the IVI was 8.53 %; for the low forest stratum with 8 species, the one with the highest IVI was *Bernardia myricifolia* with 39.20 %; and within the vegetal community 7.74 % for the semi shrubby there were 7 species where *Lantana canescens* has an IVI of 60.38 % and of 13.09 % inside the community. For the herbaceous stratum with 2 species, *Wissadula* sp. dominates with 54.20 % and 2.06 % for the community. In the arboreal stratum, the species with the highest IVI was *Celtis laevigata* with 100.00 % and when integrated to the plant community, it presented a value of 1.98 %. For the stratum formed by the epiphytes, the species *Adiantum capillus-veneris* had an IVI of 100 % and inside the plant community presented an IVI of 1.55 %. For the MET plant community studied, an H' value of 2.42 and a D_{Mg} value of 4.34 was obtained.

Key words: Index value of importance; Montemorelos; Margalef; strata.

Valdez M., C. G., Guzmán L., M. A., Valdés G., A., Foroughbakhch P., R., Alvarado V., M. A., & Rocha E., A. (2018). Estructura y diversidad de la vegetación en un matorral espinoso prístino de Tamaulipas, México. *Revista de Biología Tropical*, 66(4), 1674-1682.

El matorral espinoso tamaulipeco (MET) con una superficie de 200 000 km² del noreste de México y al sur de Texas (Estados Unidos de América), se considera un tipo de vegetación semiárido-subtropical localizado dentro de la Provincia de la Planicie Costera del Golfo

Norte (Mora, González, Alanís, Jiménez, & Yerena, 2013b). El MET constituye la vegetación natural que abarca aproximadamente el 80 % de la superficie de los estados de Nuevo León y Tamaulipas (Romero, 1999) y el 1.30 % de la cobertura vegetal de todo el país

Physical, mechanical and energy characterization of wood pellets obtained from three common tropical species

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ABSTRACT

Background. The need for energy sources with low greenhouse gas emissions and sustainable production encourages the search for alternative biomass sources. However, the use of biomass fuels faces the problem of storage, transport and lower energy densities. Low-density values can negatively affect energy density, leading to an increase in transportation and storage costs. Use of pellets as alternative biomass source is a way to reduce the volume of biomass by densification, which improves their energy quality. They are produced by diverse biomass resources and mainly from wood materials. In all cases, it is important to evaluate the fuel characteristics, to determine their suitability on the heating system and handling properties.

Methods. The present study determines and compares data from proximate analysis, calorific values, physical and mechanical properties of wood pellets produced from the common tropical species *Acacia wrightii*, *Ebenopsis ebano* and *Havardia pallens*. Data were obtained from pellets produced from each species chips collected from an experimental plantation and analyzed through ANOVA and Kruskal–Wallis test at 0.05 significance level.

Results. The results of diameter, length and length/diameter ratio didn't show statistical differences ($p > 0.05$) among species. *Acacia wrightii* showed the highest density (1.2 g/cm^3). Values on weight retained and compression test showed statistical differences ($p = 0.05$) among species. *Havardia pallens* was more resistant to compression strength than *A. wrightii* and *Ebenopsis ebano*. Statistical differences ($p < 0.01$) were also observed for the volatile matter and calorific value. *E. ebano* has the lowest volatile matter (72%), highest calorific value (19.6 MJ/kg) as well as the fixed carbon (21%).

Discussion. The pellets of the species studied have a high energy density, which makes them suitable for both commercial and industrial heating applications. A pellet with low compression resistance tends to disintegrate easily, due to moisture adsorption. The percentages obtained for the resistance index were higher than 97.5%, showing that the pellets studied are high-quality biofuels. Proximate analysis values also indicate

Submitted 10 February 2018

Accepted 31 July 2018

Published 4 September 2018

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Academic editor
Andrea Ghermandi

Additional Information and
Declarations can be found on
page 10

DOI 10.7717/peerj.5504

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Foliar biomass production and litterfall pattern of five timber species in forest plantations of semi-arid lands of the northeastern Mexico

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Botanical Sciences
95 (2): 1-11, 2017

DOI: 10.17129/botsci.770

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Author contributions: Ngangyo-Heya, Foroughbahchk and Carrillo-Parra conceived and designed the experiments; Ngangyo-Heya, Carrillo-Parra and Salas-Cruz performed the experiments and contributed materials/analysis tools; Ngangyo-Heya, Foroughbahchk, Carrillo-Parra and Alvarado-Vazquez analyzed the data; Ngangyo-Heya wrote the paper; Foroughbahchk, Carrillo-Parra, Alvarado-Vazquez, Salas-Cruz and Bustamante-Garcia revised the paper.

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Abstract

Background: Fodder shrubs and trees have both economic as well as ecological values in most extensive systems of arid and semiarid regions.

Hypothesis: The litterfall represents an important way in maintaining the productivity of these ecosystems, and we hypothesized that its production pattern is related to the foliar biomass production, associated with seasons and species.

Studied species: *Acacia berlandieri*, *Acacia wrightii*, *Ebenopsis ebano*, *Havardia pallens* and *Helietta parvifolia*.

Study site and years of study: The foliar biomass was evaluated seasonally, from the dry weight of a representative branch of each species. The litterfall was collected every 15 days through litter traps installed under tree canopies, in experimental plantations of 30 years old, in the semi-arid zone of northeastern Mexico.

Results: The foliar biomass values showed highly significant differences ($P < 0.01$) among species as well as seasons, whereas leaf litter values presented highly significant differences ($P < 0.01$) among seasons but not ($P > 0.05$) among species. The maximum foliar biomass production was registered in summer by *E. ebano* (9,029 kg ha⁻¹), while the lowest value (103 kg ha⁻¹) was recorded in winter by *A. wrightii*. The greatest leaf litter accumulation was observed in winter (296 kg ha⁻¹) by *A. wrightii*, and the lower value was recorded in spring, by *E. ebano* (97 kg ha⁻¹). A significant linear correlation ($R^2 = 68,79\%$) was determined between accumulation of leaf litter and foliar biomass production in autumn.

Conclusions: As conclusion, the leaf litter pattern can be related to the foliar biomass production, depending on the seasons and species. That constitutes a practical tool for the management of the forest ecosystems in semiarid areas.

Key words: Foliar biomass, litterfall, timber species, semi-arid zone.

Producción de biomasa foliar y hojarasca de cinco especies leñosas en plantaciones forestales de la zona semi-árida del noreste de México

Resumen

Antecedentes: Los arbustos y árboles forrajeros constituyen un valor tanto ecológico como económico en la mayoría de los sistemas extensivos de las regiones áridas y semiáridas.

Hipótesis: La caída de hojarasca representa una importante vía para el mantenimiento de la productividad de estos ecosistemas, por lo que se plantea como hipótesis que su patrón de producción está relacionado con la producción de biomasa foliar, en función de las estaciones y de las especies.

Especies en estudio: *Acacia berlandieri*, *Acacia wrightii*, *Ebenopsis ebano*, *Havardia pallens* y *Helietta parvifolia*.

Sitios de estudio y fechas: La biomasa foliar se evaluó estacionalmente a partir del peso seco de una rama representativa de cada especie. La colecta de hojarasca se hizo quincenalmente, a través de trampas de hojarasca, instaladas en la base de los árboles en plantaciones forestales de 30 años de edad, en la zona semi-árida del noreste de México.

Resultados: Se presentaron diferencias altamente significativas ($P < 0.01$) tanto en función de especies como en función de estaciones para la biomasa foliar, mientras que la hojarasca no presentó diferencias significativas entre especies ($P > 0.05$), pero con diferencias altamente significativas por estación del año ($P < 0.01$). La biomasa foliar alcanzó su máximo producción en verano (9,029 kg ha⁻¹) con *E. ebano*, mientras que el valor menor (103 kg ha⁻¹) se registró con *A. wrightii* en invierno. El mayor aporte de hojarasca foliar ocurrió en invierno (296 kg ha⁻¹) con *A. wrightii*, y el menor valor (97 kg ha⁻¹) se registró en primavera con *E. ebano*. Se determinó una correlación lineal significativa ($R^2 = 68,79\%$) entre la acumulación de hojarasca y la producción de biomasa foliar en otoño.

Conclusiones: Como conclusión, el patrón de caída de hojarasca está relacionado con la producción de biomasa foliar, dependiendo de las estaciones y de las especies. Esto constituye una herramienta práctica para el manejo de los ecosistemas forestales de zonas semiáridas.

Palabras clave: Biomasa foliar, hojarasca, especies leñosas, zona semi-árida.

Effect of heating rate and plant species on the size and uniformity of silver nanoparticles synthesized using aromatic plant extracts

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Received: 9 March 2016 / Accepted: 28 April 2016

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Abstract Mixing aqueous silver solutions with aqueous leaf aromatic plant extracts from basil, mint, marjoram and peppermint resulted in the synthesis of quasi-spherical silver nanoparticles in a range of size between 2 and 80 nm in diameter as analyzed by analytical high-resolution electron microscopy. The average size could be controlled by applying heat to the initial reaction system at different rates of heating, and by the specific botanical species employed for the reaction. Increasing the rate of heating resulted in a statistically significant decrease in the size of the nanoparticles produced, regardless of the species employed. This fact was more evident in the case of marjoram, which decreased the average diameter from 27 nm at a slow rate of heating to 8 nm at a high rate of heating. With regard to the species, minimum sizes of

<10 nm were obtained with basil and peppermint, while marjoram and mint yielded an average size between 10 and 25 nm. The results indicate that aromatic plant extracts can be used to achieve the controlled synthesis of metal nanoparticles.

Keywords Silver nanoparticles · Synthesis · Green chemistry · Nanotechnology · Plant extracts · Heating rate

Introduction

It is now recognized that nanotechnology has potential applications in diverse fields such as electronics, medicine and other disciplines, due to the unique physical and chemical properties of nanostructured materials (Glomm 2005; Chan 2006; Boisselier and Astruc 2009). Structures that are now routinely synthesized in academic and industrial laboratories include nanotubes, nanoprisms, nanowires and nanoparticles as important constituents in nanoscale technological systems and devices. The geometry, composition, and average size are key determinants in the properties of the resulting nanostructures, i.e., the inhibitory effect of silver nanoparticles (AgNPs) in the growth of bacteria (Sukdeb et al. 2007). Thus, one of the fundamental aspects in the development of nanotechnology is to control the synthesis of these basic structural units. Metal nanoparticles are generally made up of atomic aggregations that grow as spherical or quasi-spherical structures with dimensions between 1 and 100 nm in diameter. Various physical and chemical methods of nanoparticle synthesis have been developed in recent history. However, despite improvements in the efficiency of synthetic methods to increase the amounts and quality of the nanoparticles produced, these methods largely still

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REVISIÓN / REVIEW

**PRODUCED WATERS OF THE OIL INDUSTRY AS AN ALTERNATIVE WATER SOURCE
FOR FOOD PRODUCTION**

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(Recibido marzo 2015; aceptado febrero 2016)

Key words: connate waters, formation waters, irrigation

ABSTRACT

Increased water demand for crop irrigation requires new water sources in the short term. One alternative may be unconventional ground water sources, such as produced waters that are pumped to the surface mixed with hydrocarbons in the process of drilling when extracted gas or oil. Such produced waters are confined to unproductive wells or used to maintain pressure in petroleum deposits. However, previous studies have highlighted the possibility of using these waters within the industrial sector as well as in the farming or forestry sectors. The objective of this review was to compile information about the origin, composition, actual and potential uses of produced waters from the oil industry, which might be useful in future research on this natural resource.

Palabras clave: aguas congénitas, aguas de formación, irrigación

RESUMEN

El incremento en la demanda de agua para irrigación de cultivos requiere nuevas fuentes del recurso hídrico en el corto plazo. Una alternativa pueden ser las aguas subterráneas no convencionales, tal es el caso de las aguas producidas que son bombeadas a la superficie mezcladas con hidrocarburos en el proceso de perforación para la extracción de gas o petróleo. Por lo común, las aguas producidas generadas de esta manera se confinan en pozos no productivos o se utilizan para mantener la presión en los yacimientos de petróleo. Sin embargo, diversos estudios indican la posibilidad de utilizar dichas aguas en el sector industrial así como en los sectores agropecuario y forestal. El objetivo de la presente revisión fue recopilar información acerca del origen, composición, usos actuales y potenciales de las aguas producidas generadas por la industria extractora de petróleo, de utilidad en futuras investigaciones acerca de este recurso natural.

Article

Calorific Value and Chemical Composition of Five Semi-Arid Mexican Tree Species

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Academic Editors: Jarmo Holopainen and Timothy A. Martin

Received: 1 December 2015; Accepted: 22 February 2016; Published: 4 March 2016

Abstract: The current global energy crisis has generated growing interest in looking for alternatives to traditional fossil fuels, presenting lignocellulosic materials as a promising resource for sustainable energy production. In this paper, the calorific values and chemical composition of the trunks, branches, twigs and leaves of five timber species of the semi-arid land of Mexico (*Helietta parvifolia* (Gray) Benth., *Ebenopsis ebano* (Berl.) Barneby, *Acacia berlandieri* (Benth.), *Havardia pallens* (Benth.) Britton & Rose and *Acacia wrightii* (Benth.)) were determined according to international standards. The results highlighted the calorific value ranges of 17.56 to 18.61 MJ kg⁻¹ in trunks, 17.15 to 18.45 MJ kg⁻¹ in branches, 17.29 to 17.92 MJ kg⁻¹ in twigs, and 17.35 to 19.36 MJ kg⁻¹ in leaves. The pH presented an acidic trend (3.95–5.64). The content of mineral elements varied in trunks (1.09%–2.29%), branches (0.86%–2.75%), twigs (4.26%–6.76%) and leaves (5.77%–11.79%), showing the higher proportion in Ca (57.03%–95.53%), followed by K (0.95%–19.21%) and Mg (0.88%–13.47%). The highest amount of extractives was obtained in the methanolic solvent (3.96%–17.03%). The lignin recorded values of 28.78%–35.84% for trunks, 17.14%–31.39% for branches and 20.61%–29.92% for twigs. Lignin showed a moderately strong correlation ($r = 0.66$) with calorific value, but the best mathematical model was registered with the calorific value depending on the pH and lignin ($R^2 = 58.86\%$).

Keywords: calorific value; chemical components; timber species

1. Introduction

Wood is one of the main commercial product from the forest [1], and one of the energy sources most used before the industrial revolution [2]. Facing the current crisis in the global energy model, caused by the excessive use of fossil fuels that cause sometimes irreparable damages to the terrestrial biosphere and the environment [3], the interest in finding substitutes for fossil fuels grows daily, proposing alternatives for strengthening a transition to a more sustainable energy model. In this approach, biofuels are the most immediate substitute, since its energy density (energy per unit mass) is similar to that of gasoline (only 20% less) [4]. These biofuels derived from agricultural and/or forestry systems, which are major producers of biomass.

Mexico has a privileged position to generate this kind of energy, since it has a forest area of 126.6 million hectares, equivalent to 64.4% of the national territory [5], of which 25.8 million hectares

Effect of Selenium on Elemental Concentration and Antioxidant Enzymatic Activity of Tomato Plants

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ABSTRACT

Selenium is an essential element for humans, therefore, adding it to plants is convenient for biofortification. Thus, the aim of this work was to analyze experimentally the ability of sodium selenite to increase the concentration of Se and modify the antioxidant activity in tomato plants. We used plants of the Toro hybrid variety and applied three treatments: 0, 2 and 5 mg L⁻¹ of selenium as sodium selenite (Na₂SeO₃) using an irrigation system. Three samplings 40, 80, and 120 days after transplantation and a quantification of the accumulation of selenium and macronutrients in leaves, stems, and fruits were carried out. Plant height, stem diameter, firmness, and total solids of fruits and total dry matter were measured. The enzyme activity of catalase, glutathione peroxidase, and superoxide dismutase was quantified. The results indicated positive effects of Se on agronomic variables of the plants and fruit quality; however, fruit production showed no significant differences. Se had no effect on the concentration of the macro and micronutrients. The addition of 5 mg L⁻¹ of Se resulted in significant increases in the concentration of selenium on a dry basis, reaching 20.4 µg g⁻¹ in leaves, 52.3 µg g⁻¹ in stems, and 35.8 µg g⁻¹ in fruits. The increase in enzyme activity in the fruits was enhanced by the application of 5 mg L⁻¹ of Se: There was up to 352.7% more catalase activity, 312.2% more glutathione peroxidase activity, and 200.8% more superoxide dismutase activity compared with the control.

Keywords: Biofortification, Catalase, Glutathione peroxidase, Sodium selenite, Superoxide dismutase.

INTRODUCTION

Eating healthy foods high in antioxidant nutrients contributes to the protection of cells from oxidative damage and to the prevention of various diseases (Broadley *et al.*, 2006). Free radicals cause oxidative chain reactions that are eliminated by the action of defensive antioxidant systems, including enzymes such as SuperOxide Dismutase (SOD), Catalase (CAT) and Glutathione Peroxidase (GSH-Px) according to Sahnoun *et al.* (1997). Antioxidant enzymes generally use trace elements such as Selenium (Se) as cofactors, as in the case of GSH-Px (Arthur, 2003). Selenium is

thought to be associated with antioxidant metabolism (Lin *et al.*, 2012; Feng *et al.*, 2013) through its role as a cofactor of selenoenzymes (Combs, 2001); its deficiency could induce changes in cellular redox balance. In humans, the average reference intake of Se is 60 to 75 µg per day, according to 1980 data from the U.S. Food and Nutrition Board (Broadley *et al.*, 2006); however, these values are well below the consumption levels cited by Combs (2001) and Broadley *et al.* (2006), indicating up to 300 µg per day for reducing the risk of cancer. Generally, cultivated plants that grow in non-seleniferous soils have low concentrations of Se, ranging from 0.01 to 1 mg kg⁻¹ dry weight. Thus, in some countries

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GA4 AND tZR QUANTIFICATION IN PISTILLATE AND STAMINATE PLANTS OF *DASYLIRION CEDROSANUM*

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Abstract

'Sotol', a protected designation of origin alcoholic beverage, is obtained from *Dasyllirion cedrosanum* spp. plants. There is little knowledge concerning the sexual differentiation mechanisms of this species, which leads to a lack of proposals for not only its conservation and reforestation but also mechanisms to account for the dioecious nature of the plant. Phytohormones have been associated with sexual differentiation in dioecious plants because, individually or in combination, these hormones promote masculinization or feminization of their sexual structures. The objective of this study was to quantify gibberellin A4 (GA4) and trans-zeatin riboside (tZR) levels in samples of different organs of staminate and pistillate plants of *D. cedrosanum*, which were collected at different stages of floral development. The plant material was obtained at three locations in Coahuila at North Mexico. Gibberellin A4 (GA4) and trans-zeatin riboside (tZR) were quantified by HPLC-UV at 205 nm and 268 nm, respectively. During the later appearance of pollen and seeds, the GA4 levels in the crown and leaves were the same but exceeded those in the inflorescence. There were no differences in tZR levels between the plants of different sexes. Among organs, differences were only found during inflorescence emergence and death, stages during which the crown presented the highest levels of tZR. The results for the GA4/tZR ratio were similar to those reported for GA4. GA4 most likely plays a role in sexual determination in *D. cedrosanum* because its presence is associated with the appearance of staminate flowers.

Key words: Cytokinins, Gibberellins, Phytohormones, Sexual differentiation, Sotol.

Introduction

Most flowering plants in the world are hermaphroditic. However, a minority of hermaphroditic flowering plants evolved toward two different sexual forms, that is, toward dioecy. Approximately three-quarters of the flowering plant families include dioecious plant species. Dioecy occurs in the *Asparagaceae* family but is not especially prevalent (Ainsworth, 2000).

Dasyllirion cedrosanum is a dioecious plant belonging to the *Asparagaceae* family, *Nolinaceae* subfamily. This subfamily is distributed in Northern Mexico and the Southwestern United States at elevations of 950-2000 meters above sea level (MASL) (Bogler, 1994). Certain species of the genus, such as *D. duranguense*, *D. wheeleri*, and *D. cedrosanum*, have economic significance because they are used regardless of their sex to obtain extracts with high sugar content. Those extracts are obtained from ground, boiled, and fermented crown tissues and are used to create an alcoholic beverage common in regions where the plant grows (De la Garza, 2008). Local populations refer to this beverage by several names, such as "sotol," "zotol," or "sereque." In 2002, "Sotol," as it is known in Mexico (Anon., 2004), obtained a protected designation of origin. For the inhabitants of the arid regions where different species of *Dasyllirion* are found, the artisanal production of the sotol beverage is one of the most significant sources of income. Nevertheless, little information concerning the biology of these plants is available, especially concerning their reproductive characteristics. This lack of knowledge has contributed to the poor management of natural populations and an

overexploitation of this natural resource. This overexploitation could be alleviated by establishing nursery specimens of *D. cedrosanum* to be used in reforestation programs. However, this activity requires techniques for the early determination of the sex of plants. Unfortunately, there is currently no information on this topic because of a poor understanding of the factors involved in sex determination in the *Dasyllirion* genus.

Certain determinants of sexual differentiation in dioecious plants are based upon the presence of sex-linked genes, homomorphic X and Y chromosomes, or the presence of compounds such as phytohormones that induce the masculinization or feminization of sex organs (Durand & Durand, 1984; Ming *et al.*, 2007; Soldatova & Khryanin, 2010). Gibberellins and cytokinins are among the phytohormones that play a key role in sexual differentiation because these hormones induce masculinization and feminization, respectively, in different species, such as *Cucumis sativus* (Yin & Quinn, 1995b), *Mercurialis annua* (Boissay *et al.*, 1996), *Zea mays* L. (Zhao *et al.*, 1999), *Buchloe dactyloides* (Yin & Quinn, 1995a), and *Cannabis sativa* L. (Soldatova & Khryanin, 2010). However, note that sex organ masculinization or feminization is not always induced by these hormones. For example, sex determination in male and female asparagus (*Asparagus officinalis*) flowers depends on endogenous levels of auxin and cytokinins, respectively (Bracale *et al.*, 1991).

According to the above studies, sex determination in many species showing either monoecy or dioecy is believed to be driven by more than one of the genetic or biochemical mechanisms mentioned above (Soldatova & Khryanin, 2010). Many related phytohormones regulates

Effect of iodine application on antioxidants in tomato seedlings

Efecto de la aplicación de yodo sobre antioxidantes en plántulas de jitomate

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Abstract

Iodine is a beneficial micronutrient, but its metabolic function is still unknown. The aim of this study was to evaluate the effect of iodine application on biomass and antioxidant concentration in tomato seedlings. Iodine was applied in the form of iodide (I⁻) and potassium iodate (IO₃⁻), at concentrations of 1 µM daily and 100 µM biweekly, directly to the substrate or by foliar application to tomato var. Río Grande seedlings under greenhouse conditions. The effect of iodine on enzymatic antioxidants (superoxide dismutase, catalase, ascorbate peroxidase, and glutathione peroxidase), as well as the concentration of non-enzymatic antioxidants (ascorbate, glutathione, and total phenols) was analyzed. No treatment with I⁻ or IO₃⁻ had a negative effect on seedling biomass. In addition, the biweekly I⁻ treatments both by foliar and substrate application, as well as the daily IO₃⁻ and I⁻ treatments via foliar application showed a 54 to 86 % decrease in superoxide dismutase enzymatic activity, without showing changes in the other enzymes. On the other hand, in both cases with daily I⁻ foliar application, the non-enzymatic antioxidant concentrations for ascorbate and glutathione increased by 22 and 85 %, respectively. Phenolic compounds showed no changes in the different treatments.

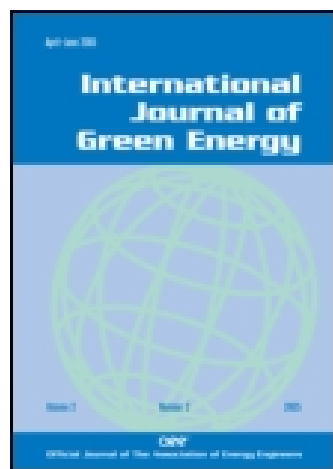
Keywords: biofortification, oxidative stress, enzymes, ascorbate, glutathione.

Resumen

El yodo es un micronutriente benéfico; sin embargo, aún se desconoce su función metabólica. El objetivo de este trabajo fue evaluar el efecto de la aplicación de yodo sobre la biomasa y la concentración de antioxidantes en plántulas de jitomate. Se hicieron aplicaciones de yodo en forma de yoduro (I⁻) y yodato de potasio (IO₃⁻), a concentraciones de 1 µM diariamente y 100 µM cada dos semanas, directo al sustrato o por aspersión foliar a plántulas de jitomate var. Río Grande, bajo condiciones de invernadero. Se analizó el efecto del yodo sobre los antioxidantes enzimáticos: superóxido dismutasa, catalasa, ascorbato peroxidasa y glutatión peroxidasa, así como la concentración de antioxidantes no enzimáticos: ascorbato, glutatión y fenoles totales. Ningún tratamiento con I⁻ o IO₃⁻ tuvo efecto negativo sobre la biomasa de las plántulas. Además, se encontró que los tratamientos de I⁻ aplicado cada dos semanas, tanto vía foliar como al sustrato, así como IO₃⁻ y I⁻ empleados vía foliar diariamente, mostraron disminución de 54 al 86 % en la actividad enzimática de superóxido dismutasa, sin evidenciar cambios en las enzimas restantes. Por otro lado, en la concentración de los antioxidantes no enzimáticos, el ascorbato y glutatión presentaron un aumento de 22 y 85 %, respectivamente; en ambos casos con aplicación diaria de I⁻ por aspersión foliar. Los fenoles no mostraron cambios en los diferentes tratamientos.

Palabras clave: biofortificación, estrés oxidativo, enzimas, ascorbato, glutatión.





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International Journal of Green Energy

Publication details, including instructions for authors and subscription information:

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Firewood Production, Yield and Quality of Charcoal From *Eucalyptus camaldulensis* and *E. microtheca* Planted in the Semiarid Land of Northeast Mexico

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Accepted author version posted online: 13 Oct 2014.

To cite this article: Karina C. Briseño-Urbe, Artemio Carrillo-Parra, Verónica Bustamante-García, Humberto González-Rodríguez & Rahim Foroughbachk (2015) Firewood Production, Yield and Quality of Charcoal From *Eucalyptus camaldulensis* and *E. microtheca* Planted in the Semiarid Land of Northeast Mexico, International Journal of Green Energy, 12:9, 961-969, DOI: [10.1080/15435075.2014.891121](https://doi.org/10.1080/15435075.2014.891121)

To link to this article: <http://dx.doi.org/10.1080/15435075.2014.891121>

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