

OUTLOOK FOR CULTIVATION OF SAYA (*Amoreuxia* spp.) IN NORTHWEST MEXICO, AS A NEW AGRONOMIC PRODUCT

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ABSTRACT

In the past, the inhabitants of northwestern Mexico benefited from the saya plant (several species from the *Amoreuxia* genus), taking advantage of it for both food and medicinal purposes, and subsequently European colonizers utilized it as food, when faced with famine. Currently, some of these species have shown a decline in populations, so they are now considered to be in the NOM 059, 2010 risk category of the Ministry of the Environment and Natural Resources. Recent endeavors have provided knowledge concerning how to propagate this plant under agricultural conditions. In this work, cultivation of saya (*A. palmatifida*) crop was evaluated over two consecutive years, in order to compare productivity during the first year with plants obtained from direct germination of seeds under agricultural conditions, with those produced the second year from tuberous root regrowth. Greater plant productivity was found in the second year evaluation ($p < 0.0001$), in terms of plant growth, seed production and weight of tuberous roots. In the future, it may be possible for some species from the *Amoreuxia* genus to have very positive social impact, if multiplication techniques for this species, as described in this work are applied, in order to rehabilitate this plant in grazing lands of northwestern Mexico and even to generate new plants.

Keywords: biodiversity, Sonoran desert, edible plants.

INTRODUCTION

Today, humanity faces important challenges such as global climate change, land degradation, loss of biodiversity, population growth, and increasing needs in terms of food requirements and natural resources for the population (Blaikie and Brookfield, 2015). Modifications to productive systems are tending towards sustainable management, conservation and recovery of degraded ecosystems and their biodiversity, as a way of mitigating these problems, so that ecosystems provide benefits (Geijzendorffer *et al.*, 2017), including food and water, as well as regulating processes that are crucial for society. Ecosystems have provided humanity with various types of services, including sustenance, provision, and also regulatory and cultural aspects (Millennium Ecosystem Assessment MEA, 2005), where plant biodiversity stands out as a provider of food, timber resources, plants with medicinal properties, reservoir of genetic resources, in addition to plant species from which new species have been propagated to help guarantee the supply of food from agriculture, by maximizing crop productivity (Cecon and Perez, 2016).

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The *Amoreuxia* genus belongs to the Bixaceae family, with a number of species in different regions of Mexico, such as *A. palmatifida*, *A. gonzalezii*, *A. wrightii*, and *A. malvifolia*, known by their common names as saya, zaya, saiya, sai, or temaqui. (León de la Luz and Coria, 1992; Hodgson, 2001; Celaya-Michel *et al.*, 2020). These vary from region to region; in some cases they are used interchangeably with any species from the genus (Van Devender and Reina-Guerrero, 2013). These species grow in 20 states of Mexico (Cedano and Villaseñor, 2004). Their distribution is varied and differs according to each species, with their presence recorded throughout the Baja California peninsula, Sonora, Chihuahua, Durango, Coahuila, Nuevo León, Tamaulipas, Jalisco, Oaxaca, Campeche, Veracruz, Chiapas and Yucatán in the Mexican Republic, and Arizona and Texas in the USA, as well as countries in Central and South America (Pío-León and Ortega-Rubio, 2014).

Species from the *Amoreuxia* genus are termed as perennials, with elongated tuberous roots, and green stems that sprout newly every year during the summer rains (Felger *et al.*, 2013). They have green and palm-shaped leaves, flowers with orange petals and fruit in the form of an ovoid capsule, with black seeds of different shapes, depending on the species (Hodgson, 2001). Plants are small, measuring 50 centimeters or less in height, and the diameter of the plant which depends on the growing conditions of the area, is variable, influenced by seasonal rainfall during each summer season (Celaya-Michel *et al.*, 2020). All parts of the saya (*Amoreuxia* spp.) are edible, including its tuberous roots, leaves, flowers, fruits, stems and seeds (Hodgson, 1989). Saya once served as food, and also as a medicinal plant for North American ethnic groups (Palmer, 1878; Hodgson, 1989). For food purposes, it was mainly the tuberous root that was consumed; both fresh or also cooked together with deer meat or sea turtle, as reported in Sonora, Mexico and Arizona, USA (Palmer, 1878). There is also mention of drying slices of the tuberous roots of saya, as sustenance to take on desert walks, and ethnic groups processed seeds to make tea (Gentry, 1963). Some reported medicinal applications include as a cure for constipation, black widow spider bites, and diabetes (Poppendieck, 2003; Van Devender and Reina-Guerrero, 2013).

Saya was also used as food by the Spanish settlers in the states of Baja California, Sonora, Chihuahua and Sinaloa (Havard, 1895; Gentry, 1963). And recently, the consumption of saya has been documented in the northern region of Sinaloa, Mexico, where roots are collected and sold in traditional markets, as food and for medicinal purposes (Castro *et al.*, 2012). Despite its past and present consumption, there is no published information concerning the nutritional content of different parts of the saya plant for human consumption.

Various species of saya in the ecosystems of several states of Mexico constitute part of their biodiversity (Van Devender and Reina-Guerrero, 2013). A number of animal species including iguanas, turtles, wild boars, deer and domestic cattle, are known to readily consume saya (Yetman and Van Devender, 2002), as the plant lacks thorns and grows to a low height, making its biomass accessible at ground level, which facilitates its consumption by fauna and domestic animals. The fragmentation of ecosystems, overgrazing and clearing

(Búrquez *et al.*, 2002), have contributed to a decline in natural populations of several species from the *Amoreuxia* genus.

Saya was described by several authors as a plant with the potential to be used as a new crop, based on its nutritional properties for humans (Hodgson, 2001; Yetman and Van Devender, 2002; Tull, 2013). Despite several decades having elapsed, since the first reports recommended that it should be studied as a possible new crop, to date these detailed studies have not been accomplished; likewise a limitation reported in the literature refers to the problem for germinating seeds for propagation (Hodgson, 2001).

Little by little, livestock farming has gone from being an extensive activity to becoming an intensive activity in northwestern Mexico, with more economic investment, an increase in cattle per hectare, and the use of technological resources focused on greater biomass extraction from plants on the ranch (Búrquez *et al.*, 2002). These changes have not yet been fully studied, in terms of their effect on the natural biodiversity of plants, such as saya. Today *A. palmatifida* saya registers within the official Mexican standard 059, with the status of “subject to special protection”, due to the decrease in its natural populations, similar to *A. wrightii* which is “in danger of extinction” (SEMARNAT, 2010; Van Devender *et al.*, 2010). This contrasts with the fact that in the United States of America, only *A. gonzalezii* has protected status (Tull, 2013).

In 2015, a review of uses and common names for *Cochlospermaceae* from Mexico was published, which includes saya (Maldonado and Ibarra, 2015). For *Amoreuxia wrightii*, another species also known as saya, and also with endangered status according to NOM-059 (SEMARNAT, 2010); a characterization of natural populations, their edaphic preferences, and associated vegetation was published (Soto-Mata *et al.*, 2018).

A. gonzalezii has also been newly documented in the Baja California peninsula (Pío-León and Ortega-Rubio, 2014). In addition, *A. palmatifida* appears as an anecdotal species in various study articles, where it is mentioned due to its protected status, although not the central theme of the work in question (Vega-Mares, *et al.*, 2014; Ramírez-García *et al.*, 2015; Wurl *et al.*, 2017).

There is little recent information on *A. palmatifida*; however, the positive results from sanding seeds as a technique to improve their germination are notable (Celaya-Michel *et al.*, 2017). This offers an opportunity to obtain propagules that complement possible recovery programs for the species in natural ecosystems, in addition to giving credence to its study as an agronomic crop.

The objectives of this work were to evaluate the productive behavior of saya under agricultural conditions and with drip irrigation for two years, comparing the first year when seedlings were grown from seeds to the second year, when the tuberous roots from the previous year's plant, sprouted.

METHODOLOGY

This study was carried out in the experimental section of the Department of Agriculture and Livestock at the University of Sonora (29°00'55" North latitude and 110°07'59" West

longitude), in a very dry climate, at very warm and warm temperatures; an average annual temperature of 25.2 °C, and average annual rainfall of 378 mm (Figure 1) (National Institute of Statistics and Geography INEGI, 2014). Prior to carrying out this work, permission to collect saya (*Amoreuxia palmatifida*) seeds was processed and granted by SEMARNAT.

Saya seeds were sown directly on agricultural soil with drip irrigation and perimeter cyclone mesh, over a two year period. The performance of the plant was evaluated during the first year and compared to the second year. The seed was scarified manually by sanding (Celaya-Michel *et al.*, 2017), it was then sown during June 2020, at a depth twice its size and a distance between seeds of 50 cm, in furrows 20 meters long, with a total of 20 established furrows. The growth and productivity of saya were evaluated during the year of sowing and the following year when regrowth of tuberous roots was evaluated to assess their productivity during the second year of cultivation.

We evaluated variables including the height of the plant, the width of the leaf canopy, the weight of the tuberous roots and the weight of the seeds, produced per plant per cycle. For this, 15 plants were randomly collected to evaluate their parameters during the first year and likewise 15 plants for evaluation during the second year. The height of plants and the width of the canopy were measured using a metric tape at the end of each production cycle that for both years began in June and ended in October. From the sampled plants being studied, the main tuberous roots were extracted at the end of the cycle for weighing. Mature seed capsules were collected when the thick green outer layer became separated from the seed capsule, leaving the thin white inner layer exposed (Kearney and Peebles, 1942). Principal tuberous roots were weighed using a 3 kg capacity Rhino® brand balance, and the seeds produced per plant were weighed using an Ohaus® brand 110 g capacity Analytical Balance.



Figure 1. Location of the study site, 21 km from the city of Hermosillo, Sonora, Mexico.

Statistical analyzes were carried out using the JMP program, version 10 (SAS Institute, 2000). Information relating to variables of growth and seed production was compared by applying variance analysis, once data complied with assumption of normality. Separation of means was performed using Tukey's test. In all cases, there was an evident statistical significance of less than or equal to 5%.

RESULTS AND DISCUSSION

Results show significant differences according to year of study, in terms of variables evaluated by crop. Evidently saya plants, grown during the second year, manifested superior characteristics for all variables evaluated, in comparison to those of the first year (Table 1). Plants from the second year, product of regrowth from their tuberous roots, grew to a greater height, and had a wider canopy. However, greatest differences were apparent in tuberous root weight and seed production.

Product results from the first year of saya cultivation concur with previous studies under agricultural conditions, where it was demonstrated that the plant grows better under this system, compared to the cultivation of this species in pots, in a nursery or under shade mesh (Celaya- Michel *et al.*, 2017). However, no productivity reports were found for saya from the second year of cultivation on agricultural soil and with drip irrigation.

Converting the values of this study to values per hectare, a production level of 178 and 625 kg of seed per hectare was found for the first and second year of production, respectively. Previous data mention production of 114.7 kg of seed per hectare for first-year plants, which represents slightly lower production than the results found in this study (Celaya-Michel *et al.*, 2018).

Regarding the production of tuberous roots per hectare, this was 2,993 kg during the first year and 7,953 kg for the second year. However, in the literature there are only

Table 1. Average results for study variables, from the first and second year of saya production, under agricultural conditions with drip irrigation.

Variable		Medium	SD		Av Value
Height of plant (centimeters)	1 st Year	35.52	6.41	B	0.0001
	2 nd Year	47.28	7.70	A	
Width of canopy (centimeters)	1 st Year	37.42	9.64	B	0.0003
	2 nd Year	49.67	5.78	A	
Root weight (grams)	1 st Year	149.68	28.33	B	0.0001
	2 nd Year	397.66	86.03	A	
Seeds produced (grams)	1 st Year	8.94	2.49	B	0.0001
	2 nd Year	31.26	11.51	A	

SD: standard deviation. Different letters indicate significant difference for each variable, compared by applying variance analysis and Tukey's post hoc test with $p \leq 0.05$.

reports of 2,573 kg for the first year (Celaya-Michel *et al.*, 2018). In the near future, a comparison should be made with other tuberous root crops, in addition to including to results following the application of different amounts of fertilizer, in order to define the maximum production potential of this species.

Evidently, the entire plant is edible and dried seeds have been used to make a tea-type drink (Gentry, 1963; Hodgson, 1989), thus, we recommend that a study of the nutritional properties of saya should be undertaken, in order to encourage greater consumption in society.

Future potential social impact on the part of species from the *Amoreuxia* genus could be widespread and auspicious, with ongoing research offering the possibility of converting it into a new crop for food purposes (Hodgson, 2001; Yetman and Van Devender, 2002; Tull, 2013), and with the creation of programs to recover their populations on land grazed by livestock. In both instances, it is necessary to investigate more aspects of agronomic management of saya and repeat these investigations for other species in the genus. It may be possible to promote saya growth in cattle ranches and abandoned agricultural areas, by means of propagule multiplication programs, which can be established on degraded lands to reduce desertification risk (Celaya-Michel *et al.*, 2018).

It is necessary to continue researching agronomic, nutritional and even medicinal aspects of species from the *Amoreuxia* genus (Poppendieck, 2003; Van Devender and Reina-Guerrero, 2013) in order to progress with recovery of degraded land, while introducing this as a new crop and discovering more about its medicinal properties, as attributed by ethnic groups who consume it.

Importantly, if the recovery of degraded soils were achieved through the implementation of saya cultivation programs, the possibility of removing it from the protected species list exists (Celaya-Michel *et al.*, 2018). Saya could be part of future research, taking an agroecological approach, due to its interaction with insects, such as bees or ants, with fauna such as wild boars, turtles, and for domestic livestock. An advantage of saya is its capacity to accumulate resources in the tuberous roots, enabling it to tolerate the dry periods that occur during the growing season, unlike annual species which are more dependent on rainy years to produce biomass for foraging (Yetman and Van Devender, 2002).

Saya has the potential for ornamental use in arid and semi-arid areas of Mexico, given the beauty of its flower and its tolerance to arid and semi-arid conditions (Van Devender and Reina-Guerrero, 2013), in addition to providing a corridor for pollinators during the summer season.

CONCLUSIONS

Production of saya (*Amoreuxia palmatifida*), cultivated under agricultural conditions and with drip irrigation on the coast of Hermosillo, increases the second year when tuberous roots regrow, compared to the first when the plant grows as a result of seed germination. This agronomic behavior identifies it as a potential resource that requires research concerning other aspects of this plant and other species from this genus. In future studies,

the most propitious topics for research include agronomic and nutritional potential for human consumption, as well as agroecological aspects, in order to generate new crops from the genus or to recover these species in degraded ecosystems. in the arid zones of northwestern Mexico.

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REFETENCES

- Blaikie P, Brookfield H. 2015. Land degradation and society. Routledge. New York. <https://doi.org/10.4324/9781315685366>. 296 p.
- Búrquez MA, Miller ME, Martínez YA. 2002. Mexican grasslands, thornscrub and the transformation of the Sonoran desert by invasive exotic buffelgrass (*Pennisetum ciliare*). In: B. Tellman (ed), Invasive Species in Sonoran desert Communities. University of Arizona Press. pp: 126-146.
- Castro JA, Zayas RA, Sainz P, Romero M, Bojórquez FR, Bojórquez O. 2012. El consumo de la zaya (*Amoreuxia* spp) una tradición cultural de la región del Évora en el estado de Sinaloa, México. Revista Mexicana de Agronegocios, Quinta Época. Año XVI. 30: 898-907. Recuperado de <https://www.redalyc.org/articulo.oa?id=14123097011>.
- Ceccon E, Pérez DR (coord). 2016. Más allá de la ecología de la restauración: perspectivas sociales en América Latina y el Caribe. Buenos Aires, Argentina: Vázquez Mazzini (eds). 384 p.
- Cedano M, Villaseñor L. 2004. Usos y Nombres Comunes de las Especies de Cochlospermaceae en México. Etnobiología, 4, 73-88. Recuperado de <https://revistaetnobiologia.mx/index.php/etno/article/view/247>
- Celaya-Michel H, Ochoa-Meza A, López-Eliás J, Barrera-Silva MÁ. 2017. Germinación y Crecimiento en Vivero y en Campo de Zaya (*Amoreuxia palmatifida* DC.), Una Especie Nativa Amenazada en México. European Scientific Journal, ESJ, 13(24). Recuperado de <https://doi.org/10.19044/esj.2017.v13n24p66>
- Celaya-Michel H, Valdez-Domínguez RD, Sosa-Castañeda J, Morales-Munguía JC, Barrera-Silva MA, Rueda-Puente E O. 2018. Usos y posibilidad de cultivo de la saya (*Amoreuxia* spp.) en el noroeste de México. Agro Productividad, 11(7), 137-143. Recuperado de <https://revista-agroproductividad.org/index.php/agroproductividad/article/view/928>.
- Celaya-Michel H, Hinojo-Hinojo C, Celaya-Rosas M, Valdez-Zamudio D, Rueda Puente EO. 2020. Plantas nativas más comunes de las zonas áridas de Sonora. Universidad de Sonora. Colección de Textos académicos. Hermosillo Sonora. <https://doi.org/10.47807/UNISON.41>. 255 p.
- Felger RS, Wilder BT, Romero-Morales H. 2013. Plant life of a Desert Archipelago: Flora of the Sonoran Islands in the Gulf of California. University of Arizona Press. Tucson. Recuperado de <https://uapress.arizona.edu/book/plant-life-of-a-desert-archipelago>.
- Geijzendorffer IR, Cohen-Shacham E, Cord AF, Cramer W, Guerra C, Martín-López B. 2017. Ecosystem services in global sustainability policies. Environmental Science & Policy, 74, 40-48. <https://doi.org/10.1016/j.envsci.2017.04.017>.
- Gentry HS. 1963. The Warihio Indians of Sonora-Chihuahua: An ethnographic survey. Bureau of American Ethnology. Bulletin 186. U.S. Government Printing Office. Washington. Anthropological Papers 65, (186), 61.
- Havard V. 1895. Food plants of the North American Indians. Bulletin of the Torrey Botanical Society, 22, 98-123.
- Hodgson WC. 1989. A tale of two saiyas: conserving plant lore and gene pools. Agave. 3, 12-14.
- Hodgson WC. 2001. Food plants of the Sonoran Desert. University of Arizona Press. Arizona. Recuperado de <https://uapress.arizona.edu/book/food-plants-of-the-sonoran-desert>
- INEGI. 2014. Anuario estadístico y geográfico de Sonora 2014. Instituto Nacional de Estadística y Geografía. México. Recuperado de www.inegi.org.mx.
- Kearney TH, Peebles RH. 1942. The flowering plants and ferns of Arizona. U.S.D.A. Misc. Publ. 423, U.S. Govt. Printing Office, Washington, D.C.
- León de la Luz JL, Coria R. 1992. Flora Iconográfica de Baja California Sur. La Paz, BCS, México. Recupera-

- do de <http://dspace.cibnor.mx:8080/handle/123456789/2131>.
- Maldonado MC, Ibarra LV. 2015. Usos y nombres comunes de las especies de Cochlospermaceae en México. *Etnobiología*, 4(1), 73-88. Recuperado de <https://revistaetnobiologia.mx/index.php/etno/article/view/247>.
- MEA. 2005. Ecosystems and Human Well-Being: Desertification Synthesis. Millennium Ecosystem Assessment. World Resources Institute, Washington, D.C. Island Press. Recuperado de <https://www.millenniumassessment.org/documents/document.356.aspx.pdf>.
- Palmer E. 1878. Plants used by the Indians of the United States. *The American Naturalist*, 12, 593-606, 646-655. <https://doi.org/10.1086/272200>.
- Pío-León JF, Ortega-Rubio A. 2014. Nuevo registro de *Amoreuxia gonzalezii* (Bixaceae) para la península de Baja California, México. *Revista mexicana de biodiversidad*, 85(4), 1269-1272. <https://doi.org/10.7550/rmb.44212>.
- Poppendieck HH. 2003. Cochlospermaceae. In: Kubitzki K, & Bayer C (eds), Flowering plants, dicotyledons: Malvales, Capparales and Non-betain Caryophyllales. Springer Berlin Heidelberg. Vol. 5. Recuperado de <https://link.springer.com/book/10.1007/978-3-662-07255-4>. pp: 71-74.
- Ramírez-García AG, Sánchez-García P, Cruz-León A. 2015. Diagnóstico participativo para desarrollar un proyecto de turismo alternativo en la comunidad de Agiabampo, Huatabampo, Sonora, México. *Ra Ximhai*, 11(5), 159-182. Recuperado de <https://www.redalyc.org/articulo.oa?id=46142593009>.
- SAS Institute. 2000. SAS statistical software. Version 5. SAS Institute. Cary, NC, USA. 254 p.
- SEMARNAT. 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010. Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio- Lista de especies en riesgo. Secretaría del Medio Ambiente y Recursos Naturales. Diario Oficial de la Federación. Cd. Mx., México. Recuperado de http://dof.gob.mx/nota_detalle.php?codigo=5173091&fecha=30/12/2010.
- Soto-Mata B, Alanís-Rodríguez E, Jurado E, Pando-Moreno M, Molina-Guerra V, Alcalá-Rojas A, Marroquín-Castillo JJ. 2018. Caracterización del hábitat de *Amoreuxia wrightii* (Bixaceae), una especie en peligro de extinción en el noreste de México. *Acta Botanica Mexicana* 122:21-31. <http://dx.doi.org/10.21829/abm122.2018.1196>.
- Tull D. 2013. Edible and Useful Plants of the Southwest: Texas, New Mexico, and Arizona. University of Texas Press, Austin. Recuperado de <https://utpress.utexas.edu/9780292748279/>
- Van Devender TR, Felger RS, Fishbein M, Molina-Freaner FE, Sánchez-Escalante JJ, Reina-Guerrero AL. 2010. Biodiversidad de las plantas vasculares. In: FE Molina-Freaner, & TR Van Devender (eds), *Diversidad biológica de Sonora*. UNAM, México. pp: 229-262.
- Van Devender TR, Reina-Guerrero AL. 2013. In Search of *Amoreuxia* and *Echinocactus* in Sonora. *The Plant Press*. The Arizona Native Plant Society, 36, 1-3. Recuperado de <http://www.aznps.com/documents/2013.12.PP.pdf>.
- Vega-Mares JH, Estrada-Castillón AE, Villarreal-Quintanilla JÁ, Martínez GQ. 2014. Flora of the *Halophytic grasslands* in the Valle de Janos, Chihuahua, Mexico. *Journal of the Botanical Research Institute of Texas*, 8(1), 151-163. Recuperado de <https://www.jstor.org/stable/26549351>.
- Wurl J, Martínez García CN, Imaz Lamadrid MÁ. 2017. Respuesta hidrológica al cambio climático en regiones áridas: caso de estudio en los Comondú, Baja California Sur, México. *Hidrobiológica*, 27(1). Recuperado de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-88972017000100013&lng=es&tlng=es.
- Yetman D, Van Devender TR. 2002. Mayo ethnobotany: land, history, and traditional knowledge in north-west Mexico. Univ. of California Press. Berkeley, USA. Recuperado de <https://www.ucpress.edu/book/9780520227217/mayo-ethnobotany>.