Colegio de Postgraduados

Profitability of the Production of Sotol (*Dasylirion* spp.) Seedlings Grown under Greenhouse Conditions

Marta-Corral, Dora J.[1]; Olivas-Garcia, Jesus M.[1*]; Anchondo-Paez, Julio Cesar[4]; Castruita-Esparza, Luis U.[1]; Baray-Guerrero, Ma. del Rosario[1]; Ortega-Montes, Fabiola Iveth[1]; Rubio-Arias, Héctor Osbaldo[2]; Clemente-Sánchez, Fernando[3]

[1] Universidad Autónoma de Chihuahua, Facultad de Ciencias Agrícolas y Forestales, Delicias, Chihuahua, Mexico, C. P.33000.
[2] Universidad Autónoma de Chihuahua, Facultad de Zootecnia y Ecología de la Chihuahua, Chihuahua, Mexico.
[3] Profesor Investigador del Colegio de Posgraduados.
[4] Centro de Investigación en Alimentación y Desarrollo A.C. Ave 4ta Sur 3820, Fracc. Vencedores del Desierto. Cd. Delicias, Chihuahua. Mexico C.P. 33089.
* Correspondence: dora22marta@gmail.com

Citation: Marta-Corral, D. J., Olivas- Garcia, J. M., Anchondo-Paez, J. C., Castruita-Esparza, L. U., Baray- Guerrero, Ma. del R., Ortega-Montes,F. I., Rubio-Arias, H. O., & Clemente- Sánchez, F. (2024). Profitability of the Production of Sotol (*Dasylirion* spp.) Seedlings Grown under Greenhouse Conditions. *Agro Productividad*. https:// doi.org/10.32854/agrop.v17i8.2988

Academic Editor: Jorge Cadena Iñiguez
Guest Editor: Juan Francisco Aguirre Medina

Received: April 16, 2024.
Accepted: July 29, 2024.
Published on-line: September 04, 2024.

Agro Productividad, 17(8). August. 2024. pp: 189-194.

ABSTRACT

Objective: Sotol (*Dasylirion* spp.) is a native plant of the Chihuahuan desert, used in the production of alcoholic beverages. The Mexican Council of Sotol (CMS) and the Certification Council of Sotol (CCS) supervise the compliance with the NOM-159-SCFI-2004 official Mexican standard; these organizations also fulfil other functions. The objective was to carry out an economic and financial feasibility analysis of the greenhouse production of sotol seedlings grown under seedbed conditions.
Design/Methodology/Approach: The production cost data were obtained from a module established in the municipality of Meoqui, Chihuahua, Mexico.
Results: Producers registered in the CMS and in the CCS —and who are interested in establishing commercial sotol plantations— provided direct empirical information. In addition, the Net Present Value (NPV), Internal Rate of Return (IRR), and the Benefit-Cost Ratio (B/C) financial variables were determined. The investment project is feasible, because it recorded a 1,483,396.12 NPV, a 59% IRR, and 1.55 B/C ratio.
Findings/Conclusions: A potential demand and a profitable production of sotol seedlings grown under greenhouse conditions in Chihuahua.

Keywords: plant, alcoholic beverage, sereque, financial evaluation.

INTRODUCTION

Mexico is a major producer of plant-based alcoholic beverages: tequila (*Agave tequilana* L.), mezcal (*Agave angustifolia* L.), and bacanora (*Agave angustifolia*). In addition, *Dasylirion* spp. is used to produce an alcoholic beverage known as sotol. Therefore, *Agave* and *Dasylirion* plants are highly appreciated, as a result of the economic benefits they generate for the country. In 2023, 359.9 million tequila liters were produced, out of which, 214.9 million were exported (Forbes staff, 2023).

Image by Selma K at Pixabay

Sotol belongs to the Asparagus family (Asparagaceae) and is native to the Chihuahuan desert, located in northern Mexico and the southeastern USA. The most common genus *Dasylirion* used for sotol production is *D. wheeleri*; however, species such as *D. cedrosanum*, *D. leiophyllum*, and *D. texanum* are also used for this purpose. Sotol plants grow in arid and semi-arid ecosystems, where the annual precipitation rate ranges from 300 to 500 mm. Bogler (1994) mentions that the genus *Dasylirion* was an important part of the diet of the original peoples that inhabited the northern desert of the Americas, while other authors report that it was used in adornments or buildings. Spaniards introduced the distillation process to the Americas. This technique was first applied to Agaves and the result was mezcal. Subsequently —and as a consequence of the similarities between *Agave* and *Dasylirion*—, sotol plants were also subjected to this process.

The plants of the Agavaceae family are still widely used and they have been the subject of many studies (Espinoza-Andrews *et al.*, 2021). For example, it is well documented that the genus *Agave* reaches its maximum sugar and fructose concentration at 2-4 years old. However, in the case of *Agave tequilana*, Arrizon *et al.* (2010) proved that 4.5-32.5 kg agave hearts can reach their maximum sugar and fructose concentration after 4 years. Although Mexico obtained a designation of origin (DO) in 2002 —specified in the NOM-159-SCFI-2004 official Mexican standard (DOF, 2004)—, the information about the whole sotol cycle is very scarce. This standard has doubtlessly favored the production, commercialization, and industrialization of this species.

Unlike tequila and mezcal (which are produced with cultivated plants), sotol is produced with wild plants —*i.e.*, no domesticated species are used for this process (Michael, 2023). Consequently, the production, commercialization, and industrialization of sotol is no match for tequila and mezcal. Nevertheless, the production of sotol is increasing and, therefore, further research is required to domesticate this species. Seedling production is the first stage in the development of a technological package for the sotol plant. Some producers are already growing seedlings. Consequently, the objective of this research was to analyze the profitability of the sotol (*Dasylirion* spp.) seedling production, under greenhouse conditions. This information could be useful for those producers interested in growing sotol seedlings as the first stage of the process, before planting them in the fields.

MATERIALS AND METHODS

This study was carried out with the support of producers from the Nuevo San Lucas community, municipality of Meoqui, Chihuahua, Mexico. The following financial variables were used for the profitability analysis: Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost Ratio (B/C). The NPV is used to determine how to invest; it is supported by the actual comparison of the payments and collection of a given investment or project. This process determines the profits and the loses of an investment. The IRR is a profitability indicator of projects or investments: if the IRR is high, the profits will also be high. Therefore, this indicator supports the decision-making process regarding the investment. Finally, the B/C Ratio is the global ratio between the costs and the benefits during a given period (Baca-Urbina, 2013).

The total cost of the production was based on the calculation of the fixed costs and the variable costs (Atheam *et al.*, 2021; Bragg, 2020) of the following seven activities: 1) soil preparation; 2) sowing; 3) irrigation and fertilization; 4) nutritional analysis; 5) pest and disease control; 6) weed control; and 7) harvest and packaging. Soil preparation included the inherent expenditures of the conditioning, which facilitates germination or the establishment of the seedling and the subsequent development of the plant. In addition, other soil preparation expenditures must be taken into account: soil identification; weed removal; aeration and loosening of the soil; soil levelling; furrows and placement of wood and stakes; soil fertilization and enrichment (substrates); and equipment rental (bobcat). Sowing included the selection of the type of plants and the time of planting, the organization of the sowing, and the inspection of the seed. Irrigation and fertilization took into account the application of fertilizers and amendments and the purchase of soluble monopotassium phosphate, liquid vermicompost, potassium nitrate, calcium nitrate, magnesium nitrate, and urea. The nutritional analysis diagnosed the problems and recommended a fertilization treatment. In addition, soil preparation was taken into account. Pest and disease control was carried out using natural enemies. Micronutrient chelate and fungicides were purchased. A bi-weekly manual weeding was quoted. Finally, the production at the moment of the harvest and the moment when the seedling was ready for delivery were estimated for the harvest and packaging variable, during the final stage. A one-year cost forecast was based on the monthly work activities, starting in January. In addition, a five-year cost forecast was carried out, considering a 12% annual inflation.

RESULTS AND DISCUSSION

Table 1 shows the main variable costs: irrigation labor (MXN \$22,125.00), sowing (MXN \$17,755.00), and soil preparation (MXN \$15,500.00). According to the recommendations of BTC Bank (2023), variable costs increase or diminish depending on production. Meanwhile, fixed costs do not change depending on production —*i.e.*, they do not change based on production level. The highest fixed costs for this activity included: administrative fees (MXN \$105,792.00) and electricity (MXN \$36,000.00).

Likewise, Table 1 shows that the biggest expenses were recorded during the first two months of the activity: MXN \$59,451.00 (first month) and MXN \$29,253.33 (second month). For reference purposes, the total cost of the production of sotol seedlings is MXN \$263,723.99. If a total of 240,000 seedlings were produced, the resulting unit cost would be MXN \$1.10. BTC Bank (2023) clearly specifies that some agricultural production elements (*e.g.*, soil, sunlight, heat, and rain) are provided by the environment and consequently do not require financial management.

Figure 1 shows the five-year cost forecast for the production of sotol seedlings (annual inflation: 12%). On the fifth year, the approximate cost would be MXN \$414,994.00. Since today's Mexican peso or American dollar has a greater purchasing power, a given investor understands that a current investment will generate more money than the amount that could be received a year from now. This situation exemplifies the relationship between money at different points in time.

Table 1. Variable and Fixed Costs (1st year).

Concept	Cost
Variable	mexican pesos ($)
Land preparation	15,500.00
Nutritional analysis	2,200.00
Sowing	17,775.00
Fertilization	8,340.00
Fungicides	2,199.99
Water	2,592.00
Labour - Risks (3 dairy risks from $1.50 to $50.00 p/ho	22,125.00
Labour - Gas charge and discharge	3,400.00
Labour - Weeding and fallow	6,000.00
Labour - Fertilization	8,000.00
Subtotal	88,131.99
Fixed	
Module Instalations	11,500.00
Labour - sowing	2,500.00
Greenhouses and bleaches structures manteinment	8,800.00
Greenhouses belts manteinment	6,000.00
Electric energy	36,000.00
Use of pump, nebulizer, tank	4,000.00
Others	1,000.00
Administrator fees	105,792.00
Subtotal	175,592.00
Total	263,723.99

Elaboración propia (2023).

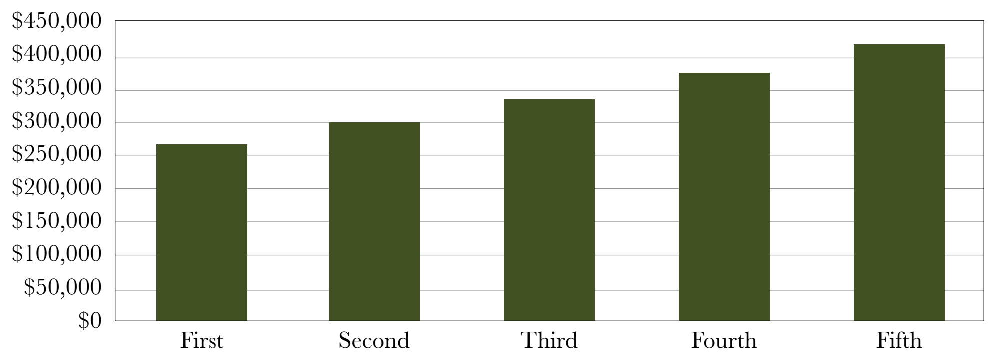

Figure 1. Five-year cost forecast to produce sotol seedlings.

In December, production amounted to 240,000 seedlings. The sale price per seedling amounted to MXN $1.70, resulting in an income of MXN $408,000. Fisher *et al.* (2014) mentioned that seedling production is the easiest stage of a greenhouse business, although they specified that the main objective is to guarantee a profitable production within a highly competitive industry.

The NPV, IRR, and B/C ratio were the financial variables used to determine the result of the profitability analysis (Table 2). The five-year forecast was determined based on the initial investment, income, and costs, using a readjustment rate. Table 2 shows the NPV value (1,483,396.12); the NPV parameter is one of the traditional methods for the evaluation of investment projects (Brotons, 2017). López-Marín *et al.* (2020) studied the greenhouse production of chili peppers and reported a NPV of €178,394 —a higher figure than the normal or traditional NPV. As a rule, a given investment with a positive NPV should be accepted, while a negative NPV should be rejected (Cruz and Singerman, 2019). In other words, a positive NPV guarantees that income levels will be higher than production costs. Consequently, this study recommends investing in the production of sotol seedlings.

Meanwhile, IRR is also an advantageous method used to evaluate a given investment project. This method does not require a discount rate, since the internal rate of return is intrinsic to the investment under evaluation (Ross *et al.*, 2005). Table 2 specifies the IRR value for this study (59%); therefore, the average annual return of this sotol seedling production project will be MXN $59 for every MXN $100 invested. This percentage is like the 53% IRR reported by Sengar and Kothari (2008), who concluded that cultivating roses was a highly attractive project from the financial point of view. Overall, a >20% TAS is acceptable for any investment project, while any investment project with a <5% TAS should be reconsidered. Finally, Miller *et al.* (2017) and other researchers proved the financial advantages of calculating the NPV and TAS values for the greenhouse production of hydroponic lettuce and tomato.

This study reported a 1.55 B/C ratio, which can be considered acceptable for this kind of investment project. Nevertheless, some greenhouse crops can have a higher B/C ratio. For example, Sengar and Kothari (2008) reported a very high B/C ratio (4.5) for the cultivation of roses, owing to the price of roses in the market.

Table 2. Results of the profitability analysis, using the NPV, IRR, and B/C ratio financial variables.

Years	Income (mexican pesos $)	Cost (mexican pesos $)	Cash Flow (mexican pesos $)	Interest rate 1/(1+t) N	Updated income (mexican pesos $)	Update expenses (mexican pesos $)
0		253,800.00	253,800.00	1.00		
1	408,000.00	263,723.99	109,523.99	0.79	323,809.52	209,304.75
2	456,960.00	295,370.87	52,065.14	0.63	$611,640.21	395,353.42
3	511,795.20	330,815.37	894,675.71	0.50	$867,489.71	560,730.02
4	573,210.62	370,513.22	1,838,370.26	0.40	1,094,911.49	707,731.44
5	641,995.90	414,974.80	2,895,370.26		1,297,064.18	838,399.37
Total	2,591,961.72	1,929,192.25	824,786.68		4,194,915.11	2,711,519.00

Financial indicators	
NPV	1,483,396.12
ROI	59%
B/C	1.55

NPV: net present value, ROI: internal rate of return, B/C: benefit/cost.

CONCLUSIONS

There is economic and financial viability of sotol seedling production under greenhouse seedbed conditions. Economic profitability indicators, such as NPV of 1,483,396.12, IRR of 59% and a B/C ratio of 1.55 confirm that the project is acceptable and profitable. Given the demonstrated economic potential, it is suggested to promote and expand sotol seedling production in greenhouses. It is crucial that regulatory agencies, CMS and CCS, continue to support producers by implementing training programs and providing resources for the establishment of new commercial plantations.

REFERENCES

Arrizon, J., Morel, S., Gschaedler, A., Monsan, P. 2010. Comparision of the water-soluble carbohydrate composition and fructan structurs of *Agave tequilana* plants of different ages. *Food Chemistry* 122: 130.

Atheam, K., Yarick, M., Parks, N. 2021. Knowing your product costs: A primer for farmers and food entrepreneurs. IFAS Extension University of Florida. https://edis.ifas.ufl.edu/publication/FE1103

Bogler, D.J. 1994. Sotol [Greek dasy- thick- or dense-, and lirion, white lily, alluding to the compact arrangement of flowers in the inflorescence] *Flora of North America* 26: 413-422. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=109344.

Bragg, S. 2020. Cost of revenue definition. Accounting Tools. Available at https://www.accountingtools.com

Brotons, J.M. Supuestos de Valoración de Inversiones: Métodos Clásicos y Opciones Reales; Universidad Miguel Hernández: Elche, Spain, 2017.

BTC Bank, 2023. Community minded... Just like you. Fixed and Variable Inputs for Commercial Farms. https://btcbank.bank/about/fixed-vs-variable-inputs-for-commercial-farms

Cruz, J., Singerman, A. 2019. Understanding Investment Analysis for Farm Manager. IFAS Extension. https://edis.ifas.ufl.edu/publication/FE1060

DOF, 2004. Diario Oficial de la Federación. 2004. Norma Oficial Mexicana nom-159-scfi-2004, bebidas alcohólicas-sotol-especificaciones y métodos de prueba. Junio, 2004

Espinoza-Andrews, H., Urías-Silvas, J.E., Morales-Hernández, N. 2021. The role of agave fructans in health and food applications: A review. *Trends in Food Science and Technology* 114: 585-5986.

Fisher, P., Hodges, A., Swanekamp, B., Kube-Pak Corp., Hall, Ch. 2014. The new economics of greenhouse production. *Floriculture Research Alliance*. https://ellisonchair.tamu.edu/files/2013/09/Combined-costing-series.pdf

Forbes staff, 2023, Producción del Tequila beneficia a más de 100 mil familias mexicanas. Portada/Negocios 2023. Julio 2023. https://www.forbes.com.mx/la-produccion-del-tequila-beneficia-a-mas-de-100-mil-familias-mexicanas/.

López-Marín, J., Gálvez, A., M. del Amor, F., Brotons, J.M. 2020. The Financial Valuation Risk in Pepper Production: The Use of Decoupled Net Present Value. *Mathematics 9*(1): 13. https://doi.org/10.3390/math9010013

Michael, 2023. Sotol-the other, Mexican Spirit. January 24, 2023. https://spiritedagave.com/sotol/.

Miller, J., Boumtje, P., Johnson, R. 2017. Investment Analysis for Commercial Greenhouse Hydroponically Produced Lettuce and Tomato. Published By: American Society of Farm Managers and Rural Appraisers (ASFMRA). *Journal of ASFMRA* 1-10.

Ross, S. A., R.W. Westerfield, and J. Jaffe. 2005. Corporate Finance, 7th ed. McGraw-Hill/Irwin, New York, NY

Sengar, A.H., y Kothari, S. 2008. Economic evaluation of greenhouse for cultivation of rose nursery. *African Journal of Agricultural Research Vol. 3*(6), pp. 435-439. Available online at http://www.academicjournals.org/AJAR