Colegio de Postgraduados

# Sowing of stevia (*Stevia rebaudiana* Bertoni) in the humid tropical climate of Tabasco, México

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**ABSTRACT**

**Objective**: To evaluate *Stevia rebaudiana* under the climatic conditions of the state of Tabasco, Mexico.

**Design/Methodology/Approach**: Three consecutive sowings of stevia plants were carried out for one year, progressively adapting the management and crop establishment according to the results obtained in the previous sowing. The survival percentage at 15 days after transplantation (dat) was calculated. Plant height was measured at 60 days and limitations observed in each crop cycle were recorded, as well as climatic variables.

**Results**: bending problems, soil splashing on the leaves, and foliar fungal diseases were recorded during the December 2019 sowing; however, 71% of the plants survived the transplant. In the April 2020 sowing, 40% of the plants survived the transplant; nevertheless, the plants showed generalized chlorosis and lack of growth, as a consequence of excessive solar radiation. Finally, in August 2020, the survival rate reached 89% and an average plant height of 20.55 cm was recorded.

**Study Limitations/Implications**: the rainfall that caused flooding in June and October 2020 limited the development of this research. Likewise, to determine the steviosides content and establish the quality of the harvest, the cultivation cycle must conclude.

**Findings/Conclusions**: Stevia can be grown in the climatic conditions of Tabasco, as long as the rainy seasons and high temperatures are avoided during the first stage of cultivation. Water is a limiting factor that causes phytopathological problems and the death of the plant.

**Keywords**: non-caloric sweetener, alternative crop, survival.

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## INTRODUCTION

*Stevia rebaudiana* Bertoni or "candy leaf" is native to Brazil and Paraguay (Ferrazzano *et al.*, 2016). It is a perennial plant of the Asteraceae family. Stevia is a major sugar substitute because it is 250 to 300 times sweeter than sucrose (Latarissa *et al.*, 2020). Its leaves contain steviol glycosides, making it suitable for consumption by people with blood sugar concentration and overweight problems (Hossain *et al.*, 2017). It provides other health benefits, such as anticancer, antidepressant, antiviral, and antimicrobial properties and it also helps to control hypertension (Oviedo-Pereira *et al.*, 2015). In

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addition, it can be used in cosmetics, as a soil improver, and as a supplement in animal diets, among other uses (Martínez, 2015). In Mexico, stevia was introduced approximately a decade ago (Ramírez *et al.*, 2011; Herrera *et al.*, 2012). In 2017, the Servicio de Información Agroalimentaria y Pesquera reported that a total of 55.85 hectares of stevia were cultivated in the country, in the states of Nayarit, Chiapas, Michoacán, Oaxaca, Campeche, and Quintana Roo. However, there is no record of the production of this crop in Tabasco. Its establishment in new production areas requires diverse information about its adaptation and management, including density, fertilization, irrigation, etc., which vary according to the following and other factors: climate, relative humidity, luminosity, and soil fertility (Espitia, 2007; Jarma, 2010; Jarma, 2012; Daza, 2015). For México, stevia is an innovative and profitable crop with promising national and international market conditions. It is a labor-intensive crop that generates many rural jobs, making it an option for small producers (Espitia *et al.*, 2009; Ramírez *et al.*, 2011). Additionally, as a result of the accelerated trend expansion towards natural and organic eating habits, the interest in growing backyard plants for food or for their medicinal properties has increased. In view of the health benefits of cultivating stevia and the possible benefits to the economy of family gardens, the response of *Stevia rebaudiana* to the environmental conditions in the state of Tabasco, México, was evaluated.

## MATERIALS AND METHODS

The experiment consisted of a series of three consecutive sowings, progressively adapting the crop management and establishment, based on the results obtained in the previous sowing. Therefore, *S. rebaudiana* was sown in December 2019 and harvested in March 2020. The crop was established in the nursery and greenhouse area of the División Académica de Ciencias Agropecuarias of the Universidad Juárez Autónoma de Tabasco (DACA UJAT), located in the community of La Huasteca (17° 47' 15" N, 92° 57' 15" W), municipality of Centro, Tabasco, México, at an altitude of 19.7 m.a.s.l. During the cultivation period, temperature and relative humidity were recorded with a HOBO Data Logger. Meanwhile, according to the Comisión Nacional del Agua (CONAGUA, 2019), the monthly rainfall registered was 144.4 mm, 75.3 mm, 137.8 mm, and 18.8 mm, in December 2019 and January, February, and March 2020, respectively. The plants were established in a sandy clay loam texture soil, with an OM of 4.3%, pH of 4.5, and EC of 0.096 dS/cm. In the area, cleaning with a machete, leveling, cleaning, and preparing drains were carried out by hand. Twelve 1×3 meters long and 30 cm high beds were made. Rooted cuttings of the Morita II variety from Akil Yucatán, México were established. The one-month-old plants were grown in vermicompost trays. They were established directly on the previously designed beds with a 20×20 cm density in a square system. Crop management was carried out by manual weeding and watering according to the crop needs (Figure 1).

The second sowing was established in April 2020 at the Instituto Tecnológico de la Zona Olmeca, located in Ocuiltzapotlán in the municipality of Centro, Tabasco (18° 09' 39" N and 92° 50' 55" W). The area has a warm humid climate with abundant rains in summer. The mean monthly temperature was recorded in April, May, and June with a

a) December 2019 b) April 2020 c) August 2020

**Figure 1**. a) Manual preparation of planting beds, irrigation, and manual weeding; b) Soil and mechanized preparation of planting beds, drip irrigation system; and c) manual preparation of planting beds, drip irrigation, silver plastic mulch.

HOBO Data Logger. The monthly precipitation was 36.3 mm, 281.7 mm, and 385.7 mm in the said months, according to the Comisión Nacional del Agua (CONAGUA, 2020). The cultivation area has a soil with a clayey texture, with an OM of 2.3%, pH of 7.9, and an EC of 0.47 dS/cm.

The cultivation area was cleaned by hand with a machete, harrowed twice, and the land was weevilled using mechanized means. We prepared 1.50-m wide, 25-m long, and 30-cm high planting beds, with 50-cm furrows between beds for crop management. Planting was carried out with rooted cuttings of stevia (Morita II variety) from the company "Stevia Huntulchaac" from Yucatán, México. The plants were established with a 20 × 20 cm density between plants in a square system, while a drip irrigation system with tape was installed with 30 cm between rows and outlets every 30 cm (Figure 1).

In August 2020, the third sowing was carried out at the Instituto de la Zona Olmeca de Ocuiltzapotlán Centro, Tabasco. Average and maximum temperatures were recorded with a HOBO Data Logger. According to the Comisión Nacional del Agua (CONAGUA, 2020), the monthly precipitation was 303.1 mm, 461.3 mm, and 550.4 mm in August, September, and October 2020, respectively. The land was cleaned by hand with a machete, it was left to dry in the sun for four days, and the stubble was subsequently burned. We made 25-m long beds with a useful surface of 70 cm wide; the soil was turned over to form a 30-cm tall elevation. A 50-cm furrow was left between beds. An irrigation system with a strip was installed with 40 cm between rows and with outlets every 30 cm in the row. Rooted cuttings of S. rebaudiana (Morita II variety) from Tekax, Yucatán, were established. A 20×20 cm density was used in the square system (Figure 1).

For plant management, a formative pruning was carried out one week after the transplant and a second formative pruning at 30 dat in the three sowings. For nutritional purposes, the dose reported by Casaccia and Álvarez (2006) was used: 162 N, 19 P, 140 K, 40 Ca, 9 Mg kg $ha^{-1}$. Fifty percent of the fertilizer was applied the first week after the transplant and the rest at 45 dat. The variables were: survival percentage at 15 dat

and plant height at 60 d, taking 15 plants at random per sowing. The data obtained were subjected to basic statistics.

## RESULTS AND DISCUSSION

Regarding the *S. rebaudiana* established in the humid tropical conditions of Tabasco, the results show that 71% of the plants sown in December 2019 survived the transplant (Table 1). The norte wind season —a period characterized by heavy rains and winds resulting from the formation of tropical storms and cyclones— caused lodging and the deposit of soil on the leaves, leading to foliar fungal diseases (Arturo *et al.*, 2009; Salazar *et al.*, 2015). The rainfall, the size of the plants at the time of transplantation (10 cm), and the uncovered soil (without vegetation cover) contributed to this problem. Under these conditions, it was necessary to design drains to evacuate excess water and avoid flooding that would affect the crop. In addition, a sanitation cutting of the diseased plants was carried out and a 2.5 ml $L^{-1}$ dose of Metalaxil® was applied to control the fungus. During this period, lepidopteran larvae consumed tender shoots, without causing severe damage to the crop. Individuals were captured by hand to control the larval population.

The lowest survival percentage among the plants sown in April 2020 was the result of the extreme environmental factors recorded in May of the same year, such as the high solar intensity (9,974.56 lux), as well as the highest temperature (52 °C) and the lowest relative humidity (34.52%) of the year (Table 1 and 2). Consequently, the plants stopped growing and showed general chlorosis and leaf thickening. This physiological response

**Table 1**. Survival of rooted cuttings of *Stevia rebaudiana* (Morita II variety), established in Tabasco on three different dates.

| Sowing | Survival (%) | Temperature* 30 ddt (°C) | Precipitation* 30 ddt (mm) |
|---|---|---|---|
| December 2019 | 71 | 24.4 | 144.4 |
| April 2020 | 40 | 30.8 | 36.3 |
| August 2020 | 89 | 28.8 | 303.1 |

*Average for Tabasco (CONAGUA, 2021 and 2022); dat (ddt): days after transplant.

**Table 2**. Temperature (T), relative humidity (RH), and light intensity, recorded in the cultivation areas of *Stevia rebaudiana* (Morita II variety), in Tabasco, Mexico.

| Date | Average | | | Maximum | | Minimum | |
|---|---|---|---|---|---|---|---|
| | T (°C) | HR (%) | Intensity (lux) | T (°C) | HR (%) | T (°C) | HR (%) |
| December 2019 | 27.06 | 79.57 | - | 45.42 | 87.44 | 20.71 | 58.18 |
| January 2020 | 25.40 | 87.10 | - | 40.99 | 96.03 | 19.87 | 65.54 |
| February 2020 | 25.83 | 85.75 | - | 41.34 | 95.50 | 19.31 | 63.42 |
| April 2020 | 29.50 | 73.97 | 698.41 | 38.38 | 86.17 | 23.05 | 56.87 |
| May 2020 | 32.66 | 70.44 | 9974.56 | 52.07 | 92.60 | 23.93 | 34.52 |
| June 2020 | 29.95 | 78.96 | 4393.89 | 45.09 | 93.19 | 25.14 | 50.24 |
| August 2020 | 31.14 | 76.00 | 6459.02 | 47.93 | 97.82 | 23.24 | 34.93 |
| September 2020 | 30.36 | 79.55 | 4677.49 | 45.8 | 98.3 | 23.5 | 40.9 |

was caused by the stress resulting from light radiation which increases water and nutrient consumption (Canovas, 1995). High solar radiation can lead to photo-oxidation, causing the decomposition of photosynthetic pigments, which results in chlorosis (Tadeo and Gómez, 2008). For his part, Gómez (2012) mentions that high radiation, high temperatures, and water stress increase photorespiration, affecting productivity, because of the consumption of the carbohydrates produced in the photosynthetic process.

Finally, all the plants of this crop cycle were impacted by the tropical storm "Cristobal", which recorded 611 mm to 635 mm rainfalls (CONAGUA, 2020), flooding of the land and causing the death of the plants in three days. In relation to excess water in the crop, Bentancour-Ancona and Segura-Campos (2015) mention that stevia requires 1,000 to 1,400 mm rainfall per year and the state of Tabasco exceeds the rainfall required by the crop with an annual average of 2,550 mm; the area of the mountains has recorded the most copious rainfall in the state (INEGI, 2017). Therefore, the local precipitation must be taken into consideration and the rainy season should be avoided in the early stages of the crop, in order to prevent soil saturation, fungal diseases, and root anoxia (Salisbury and Ross, 1992).

The highest survival percentage was recorded among the plants sown in August 2020 (Table 1). Turgid plants without sanitary problems or transplant stress were observed in this cycle. The climatic conditions during this season were favorable (Figure 2): the average temperature was 31 °C, slightly higher than the optimal range (24-28 °C) reported for stevia by Cruz (2016). There were no significant rains and the use of plastic mulch prevented soil splashing on the leaves and the presence of fungal diseases; it also helped with weed control and soil moisture conservation (Bériot, 2022).

The growth of the stevia plants varied in each growing cycle. Average plant heights ranged from 9.8 cm to 20.55 cm at 60 dat. The April sowing was the most affected in terms of growth, due to extreme weather factors coupled with a silt loam soil that limited the movement of water. Table 3 shows that the plants sown in August 2020 had

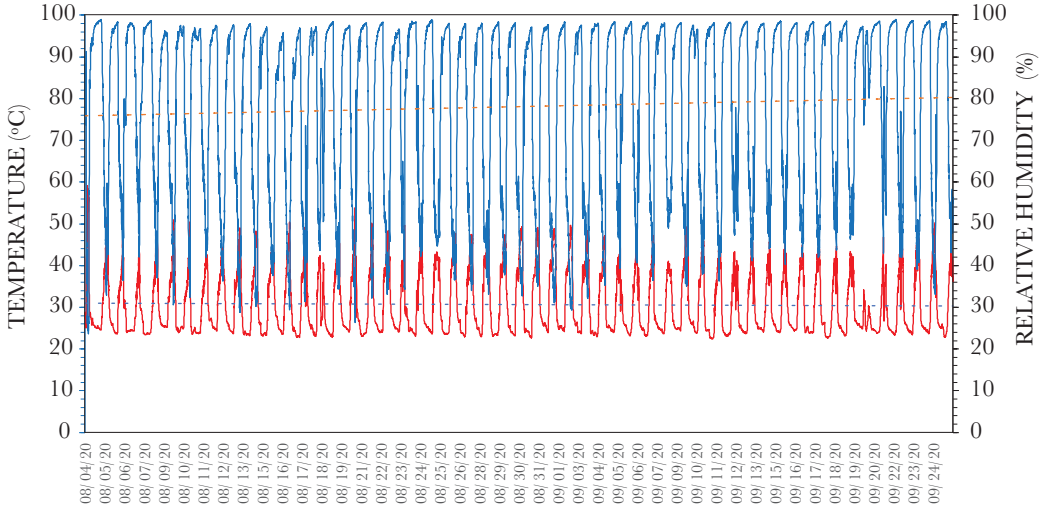


**Figure 2**. Temperature and relative humidity in August and September 2020, in the *Stevia rebaudiana* cultivation area in Tabasco.

**Table 3**. Average height of *Stevia rebaudiana* (Morita II variety) plants, established under different climatic conditions and infrastructures in Tabasco.

| Sowing date | Height 60 ddt (cm) | Planting conditions | Observations |
|---|---|---|---|
| December 2019 | 12.5 | Bedding, weeding and manual irrigation | Bending by splash and presence of leaf spots |
| April 2020 | 9.86 | Mechanized soil and drip irrigation system | leaf thickening, general chlorosis, no growth |
| August 2020 | 20.55 | Manual bedding, drip irrigation, plastic mulching | Turgid and healthy plants |

a higher growth (20.55 cm, in average) than those reported by Herrera *et al.* (2012) in Nayarit (14 cm).

Several authors mention that the development of the stevia plant is affected by such factors as sowing density (Espitia, 2007), solar radiation (Jarma, 2012), irrigation (Daza, 2015), nutrition (Jarma, 2010), and crop management (Ramírez *et al.*, 2011). However, the limiting factor observed during this study was the water-soil ratio. Soil texture defines the movement of water and determines drainage and water retention and consequently root development (Gayosso *et al.*, 2021). Stevia plants did not tolerate soil saturation for more than three days, resulting in the total loss of the crop; therefore, the water factor (rainfall or irrigation) and the type of soil are important in the selection of the cultivation area. Regarding the soil, Ramírez *et al.* (2011) mention deep soils (20-50 cm), loamy and sandy soils, luvisols, regosols, and fluvisols, with a 5-7 pH.

## CONCLUSIONS

A determining factor for the cultivation of stevia in Tabasco is excess water; therefore, areas with less rainfall and sandy loam soils should be selected. High temperatures and low relative humidity are critical during the first stage of cultivation. The transplant of stevia to soil in the month of August in Tabasco has a similar survival and growth percentage than the average of other states. However, the cultivation of stevia can be an option in Tabasco, if the quality of the harvest is valued by determining the steviosides content and the cost-benefit ratio.

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