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Potential areas for taro (*Colocasia esculenta* (L.) Schott) cultivation in Tabasco, Mexico

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ABSTRACT

Objective: To analyze the productive potential of taro in the state of Tabasco, Mexico, in order to suggest the edaphoclimatic zones with the best conditions for its use.

Design/Methodology/Approach: The analysis was carried out using geographic information systems QGIS 3.16.1 and Arc GIS 10.2.2, to generate spatial interpolations of edaphic and climatic variables. The edaphoclimatic zoning for this crop in the state was generated through map algebra.

Results: The results indicate that the edaphoclimatic conditions allow the establishment of this crop in 1 608, 565 hectares, which is equivalent to 67% of the territory of Tabasco, although the optimal surface is only 655, 632 hectares (27%).

Study Limitations/Implications: The main limitations for cultivation are mainly edaphic, rather than climatic.

Findings/Conclusions: From the edaphic point of view, the most suitable soils are flat, deep, with loamy or clayey textures, with slightly acidic or neutral pH. The physiographic areas of the alluvial plain, river valley and hills are the optimal ones for the cultivation of taro. The unsuitable areas are those with permanent flooding and close to the coast, as well as in the highest areas of the Sierra de Tabasco.

Keywords: Tuber crop, taro, edaphoclimatic zoning, tropical climate, tropical soils.

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INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott) is a vegetable originally from Asia, which was introduced to America by black slaves; it is considered that the area of greatest variability of this genus is in the Antilles, where it is the oldest crop inherited from the indigenous Arawak people in Puerto Rico. It was introduced from Africa in 1843 and its species are cultivated in many islands of the Pacific, including New Guinea, Fiji and New Caledonia (Zapata, 2013; Mazariegos *et al.*, 2017; Barrera *et al.*, 2004). In Mexico, it has been

cultivated commercially in the states of Veracruz, Oaxaca, Puebla, Nayarit and Sinaloa, primarily for exports to the United States and Canada. Just for the farming year in Veracruz, principal national producer, 482 hectares cultivated are reported, with a production of 36,128 tons; the production value reached 158.28 million pesos (SIAP, 2019). Likewise, a variant adapted in wild form in tropical zones is produced on the edges of rivers, streams or lagoons (Rodríguez *et al.*, 2011). It is framed within exotic or non-traditional products, whose global consumption has seen an important rise, taking advantage of the interest from growing sectors of consumers that use it in human and animal diet and for different industrial uses (Eleazu, 2016; Caicedo, 2013). It is an alternative and exotic crop, also known as taro, dashen or ñame, with great potential for tropical zones (Rodríguez *et al.*, 2011).

Taro is an annual herbaceous plant, whose cycle consists of nine months. It prospers in warm-humid climates, with temperatures that range between 25 and 35 °C and at altitudes of 0-1000 masl. It prefers lose silt soils (with high content of organic matter and a pH of 5.5 to 6.5) and clayey soils, although if there is no availability of water for the harvest the activity is made difficult. In addition, it tolerates flooding, surviving up to three days under water, since it is a plant that has high water demand (López *et al.*, 2020). Currently taro is a crop that has not been exploited in Tabasco, it is produced naturally, and it is only consumed traditionally cooked, fried and in *atole*. Producing taro is a profitable business, as the market is increasingly larger, although more production is required to supply the list of clients that is increasing. Taro is a tuber full of benefits and properties, ideal within a balanced diet due to its wealth in essential nutrients and healing and preventive qualities (Figure 1).

The usable parts are tuberous underground stalks that contain between 6.87 and 10% of moisture, 1.1-7% of protein, 1.2 to 2.5% of lipids, 2.0 to 4.0% of ash, and starch content higher than 60% (Madrigal *et al.*, 2018).

The territory in Tabasco has high edaphoclimatic potential to cultivate taro, since there is favorable temperature and precipitation for the good development and growth of the

Figure 1. Commercial taro (*Colocasia esculenta* (L.) Schott) plantation in the municipality of Cunduacán, Tabasco, Mexico. Source: Dr. Rutilo López-López.

taro crop, average temperatures of 28 °C to 35°C, which is not a limitation for production of the crop. This makes it a product with high potential for its implementation in the country, participating actively in the reconversion of crops that need it (Figure 2).

The state of Tabasco is characterized by high rainfall in the summer, with warm-subhumid climates that favor the development of the taro crop; however, the producers are unaware of the agronomic management of this species (Salgado, 2003).

The crop adapts to the edaphoclimatic conditions of the state of Tabasco; specifically it prefers silty-clayey soils with pH of 5 to 7. Growing taro in Tabasco is practiced with traditional technology, in small surfaces by producers with average yields of 20 t ha^{-1}, in monocrop or interspersed with other crops at the level of family garden. The objective of this study was to analyze the productive potential for the state of Tabasco, to suggest the best edaphoclimatic zones of best conditions for its exploitation.

MATERIALS AND METHODS

Geographic Location

The territory in Tabasco has 17 municipalities and is divided into two economic regions, Grijalva and Usumacinta, of which there are five sub-regions (Centro, Chontalpa, Sierra, Pantanos and Los Ríos). The first two are located in the Grijalva zone and the last three in Usumacinta, and these names are due primarily to the hydrological representation of two large rivers that cross Tabasco. The state has a territorial extension of 24 661 km^2, with the coordinates 18° 39' 03" North, 17° 15' 03" South, 90° 59' 15" East, and 94° 07' 48" West. It borders north with the Gulf of Mexico and Campeche; east with Campeche and Guatemala; south with Chiapas; west with Veracruz de Ignacio de la Llave (INEGI, 2017). Tabasco is a state located in southeastern Mexico, which presents different uses of the soil, although more than half of the territory is used as pasture (mainly livestock producing activities). There are many other activities such as oil production, tourism, forestry and agriculture, where there is still the option of growing taro, since it is a crop with high

Figure 2. Harvest of taro (*Colocasia esculenta* (L.) Schott) corms, ready for their commercialization. Source: Dr. Rutilo López-López.

demand whose offer is not covered by the state production, which is why it has to be imported from neighboring states such as Veracruz. Edaphoclimatic factors were used that limit the cultivation of taro in the state of Tabasco (Table 1).

Interpolation and algebra of taro zoning maps in Tabasco

The geographic information systems used were QGIS 3.16.1 and Arc GIS 10.2.2, where spatial interpolations were generated of the soil and climate variables, in order to relate the entire territory in Tabasco and also to carry out the algebra of maps in order to have different zones and generate edaphoclimatic zones that are more apt for taro cultivation in the state of Tabasco.

RESULTS AND DISCUSSION

Climate zoning

The combination of elements from the climate in the state of Tabasco make practically more than 75% of the territory optimal for taro cultivation and 18% good, particularly in the municipalities of Huimanguillo, Teapa, Tenosique and Balancán; and only a small part of the sierra in Tabasco (7%), specifically in the municipalities of Huimanguillo and Tacotalpa, do not present conditions for the crop (Figure 3).

Because of the climatic requirements of taro, only a small extension of the territory in Tabasco is excluded from the cultivation of this plant. Regarding the water supply from rainfall, the entire territory of Tabasco presents a tropical climate (A), which is characterized by the record of mean annual temperature higher than 18 °C and a precipitation between 800 and 4000 mm per year. This tropical climate is subdivided into three climate regions: Af (tropical with rainfall all year); Aw (tropical with rainfall in the summer) and Am (tropical with monsoon rainfall) (Rivera-Hernández *et al.*, 2012). In every case, the water supply does not represent any limitation. Taro is a plant that grows adequately up to altitudes of 1000 masl, which is why the altitude also does not represent limitations, since the highest part of the state of Tabasco is located at 500 masl (Zavala-Cruz *et al.*, 2016). In the zone known as the Sierra, some restrictions can take place, particularly in what concerns temperatures, which in some seasons of the year can lower the critical threshold that is adequate for the crop, which is 25 °C.

Table 1. Factors and variables for the zoning of taro (*Colocasia esculenta* (L.) Schott) in Tabasco, Mexico.

Factors	Variables					
	Slope (%)		**Texture**		**pH**	
Edaphic	0-12	Optimal	Franco arenoso	Good	5.6-7.4	Optimal
	13-25	Good	Clay, clay loam, sandy clay loam; and organic	Not suitable	4.8-5.5	Good
	26-70	No suitable			<4.7	Not suitable
Climatic	**Precipitation**		**Temperature (°C)**		**Climate Type**	
	1500-2500	Optimal	22-28	Optimal	Am	Optimal
	2501-4500	No suitable			Af and Aw	Good

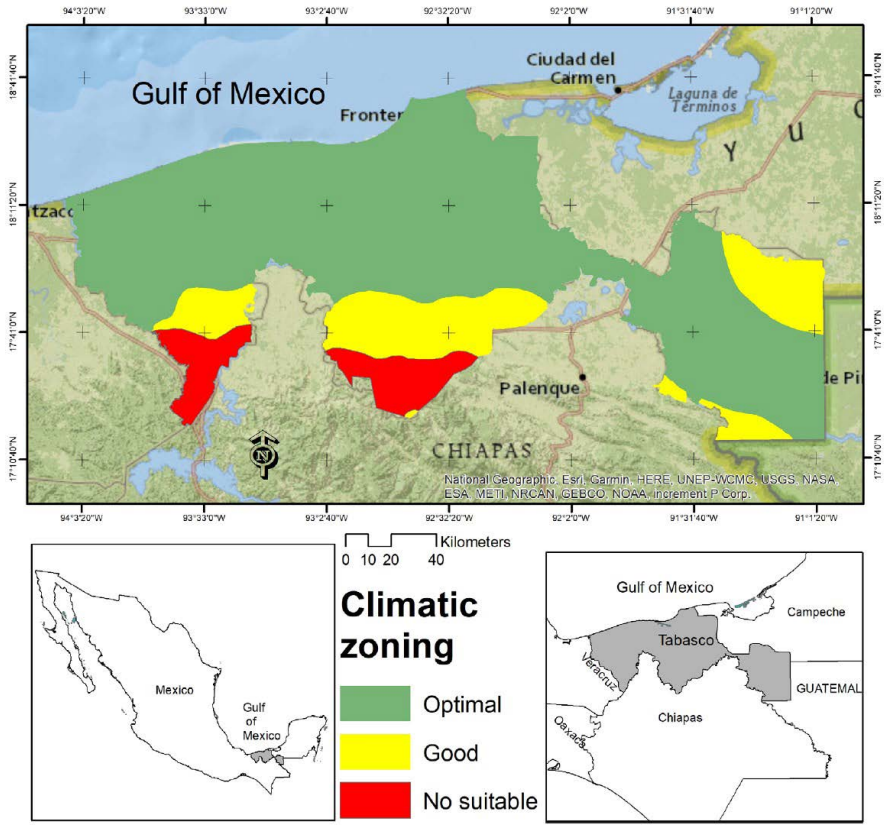

Figure 3. Climate zoning for the taro crop (*Colocasia esculenta* (L.) Schott) in Tabasco, Mexico. Source: prepared by the authors.

Soil zoning

According to the zoning of the soil aptitude for the taro crop, 34% of the surface presents an optimal aptitude; 38% is good and 28% is not apt (Figure 4), which is why it can be clearly seen that the soil is the factor of highest restriction, above the climate factor.

The soils in Tabasco are classified in 81 soil sub-units, distributed in seven physiographic zones: sierra, calcareous, hills, alluvial plain, river valley, flooding plain and coast (Palma *et al.*, 2007). From these physiographic zones, the sierra, calcareous and flooding plain zones are the ones that present most restrictions, and this is due to problems associated with the shallow depth of the soil, stoniness, water excess, permanent flooding or low fertility. Therefore, the concentrations of soil units that are optimal for taro cultivation are grouped into zones of alluvial plain, river valley and hills. Taro cultivation is adapted to low flooded lands due to its capacity to transport oxygen from the leaves to the roots, which is vital for the growth and normal functioning of the roots (Raju and Byju, 2018). However, the crop prefers silty soils that are rich in organic matter, neutral or slightly acid, and although clayey soils can offer conditions for the crop, if they present water deficit during the harvest, this can be problematic, in addition to the clayey soils presenting compacting problems, which makes corm growth difficult.

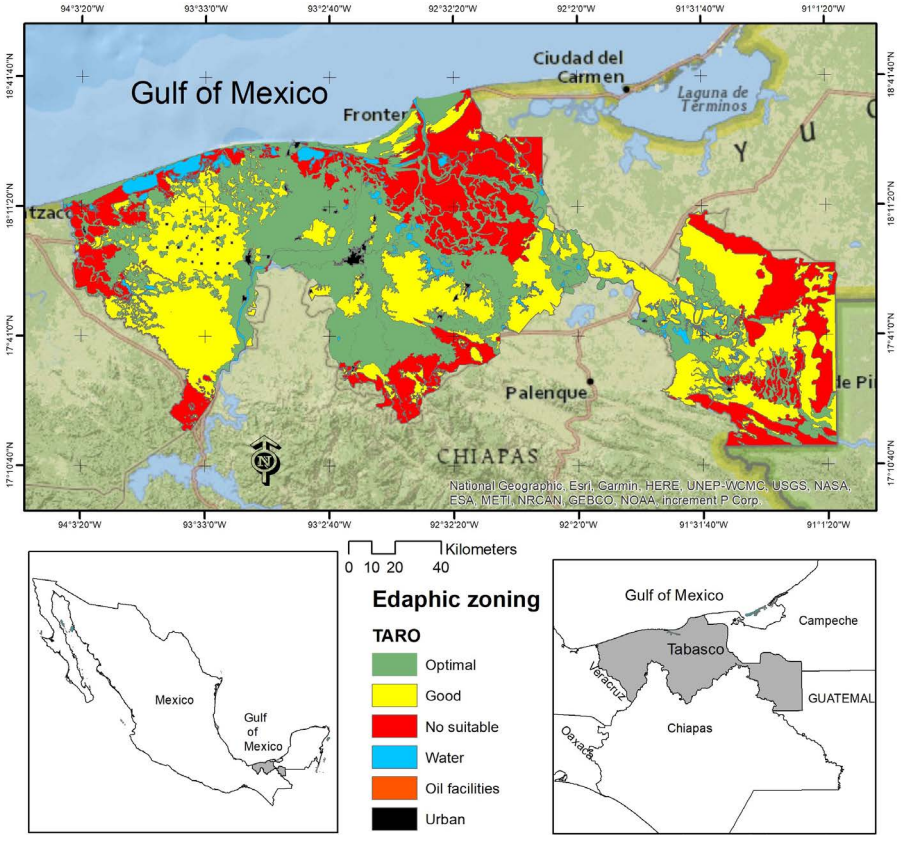

Figure 4. Soil zoning for the taro crop (*Colocasia esculenta* (L.) Schott) in Tabasco, Mexico. Source: prepared by authors.

Edaphoclimatic zoning

When combining the layers of soil and the climate, the edaphoclimatic zoning is generated for the taro crop in Tabasco (Figure 5). In this image it can be seen that 67% of the surface of the territory in Tabasco presents conditions for the crop; however, only 27% is optimal, 40% is good, while 33% of the surface is not apt for production of the crop. These areas of greater vocation are distributed in the zones of the alluvial plain, river valley and hills, where the following soils predominate: Fluvisol, Cambisol, Regosol, Vertisol, Gleysols, Luvisol, and Acrisol (Palma *et al.*, 2007).

Taro can withstand prolonged periods of flooding, frequent in the clayey soils of Tabasco; however, the type of clay and the degree of compacting must be taken into account to select the cultivation areas (Mazariegos *et al.*, 2017).

CONCLUSIONS

The taro crop (*Colocasia esculenta* [L.] Schott) is adapted to the edaphoclimatic conditions in 67% of the territory of Tabasco (1,657,446 hectares), although with some limitations, primarily of the soil, and to a lesser degree from climate conditions, which is why the optimal areas for the crop are reduced to 677,926 hectares (27%). From the point of view of the soil, the deepest soils with good internal drainage, silt or clay textures, rich in organic

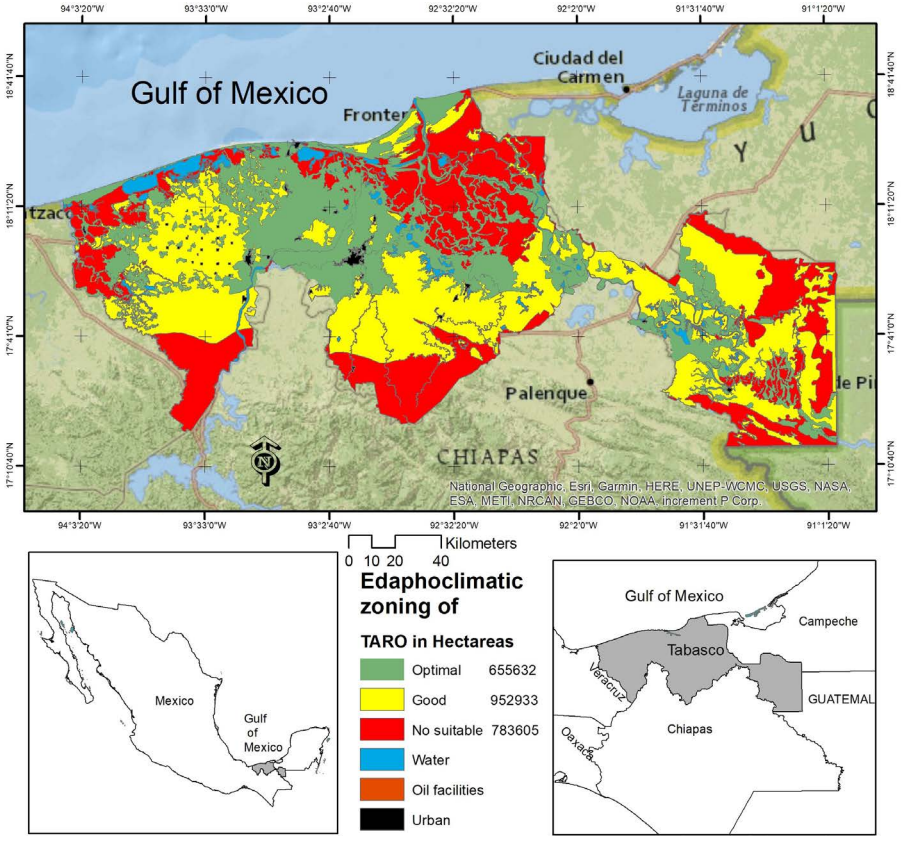

Figure 5. Edaphoclimatic zoning for the taro crop (*Colocasia esculenta* (L.) Schott) in Tabasco, Mexico. Source: prepared by authors.

matter and with slightly acidic or neutral pH are the most adequate for the crop. The climate factor does not represent an important obstacle for the development of the plant, except in a small area of the sierra, where the temperatures in some seasons of the year can decrease under the adequate threshold for the crop. The physiographic zones of the alluvial plain, river valley and hills are optimal for the growth, development and production of the taro crop.

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REFERENCES

Barrera, V., Tapia C., & Monteros, A. (2004). Caracterización Fisicoquímica, Nutricional y Funcional de Raíces y Tubérculos Andinos, In: Raíces y Tubérculos Andinos: Alternativas para la conservación y uso sostenible en el Ecuador. Instituto Nacional Autónomo de Investigaciones Agropecuarias, Quito, Ecuador & Lima, Perú. pp. 91-116.

Caicedo, W.O. (2013). Tubérculos de papa china (*Colocasia esculenta* (L.) Schott) como una fuente energética tropical para alimentar cerdos, una reseña corta sobre las características de la composición química y de los factores antinutricionales. *Revista Computarizada de Producción Porcina* 20: 278-282.

Eleazu, C. O. (2016). Characterization of the natural products in cocoyam (*Colocasia esculenta*) using GC–MS. *Pharmaceutical Biology* 54: 2880-2885,

Instituto Nacional de Estadística y Geografía (INEGI). (2017). Anuario estadístico y geográfico de Tabasco 2017. 440 p. Consultado en línea en octubre de 2021 en: https://tabasco.gob.mx/sites/default/files/users/planeacion_spf/ANUARIO%20ESTADISTICO%20WEB%2B%2B.pdf

López, J. M., Martínez-Herrera, J., Arguello, G.E. (2020). La malanga (*Colocasia esculenta* Schott) un cultivo alternativo paraTabasco. Villahermosa, Tabasco. *Revista Agroregión* 102: 16-21.

Madrigal-Ambriz, L.V., Hernández-Madrigal, J.V., Carranco-Jáuregui, M.E., Calvo-Carrillo, M.C., Casas-Rosado, R.G. (2018). Caracterización física y nutricional de harina del tubérculo de "Malanga" *Colocasia esculenta* (L.) Schott de Actopan, Veracruz, México. *Archivos Latinoamericanos de Nutrición* 68: 175-183.

Mazariegos, A., Águila, J., Milla, A., Espinoza, S., Martínez, J., López, C. (2017). Cultivo de Malanga (*Colocasia esculenta* Schott). *Agroproductividad* 10 (3): 75-80.

Palma-López, D. J.; Cisneros, D. E.; Moreno, C. E. y Rincón-Ramírez, J. A. (2007). Suelos de Tabasco: Su uso y manejo sustentable. Colegio de Postgraduados-ISPROTAB-FUPROTAB. Villahermosa, Tabasco, México. 194 p.

Raju, J., & Byju, G. (2018). Quantitative determination of NPK uptake requirements of taro (*Colocasia esculenta* (L.) Schott). *Journal of Plant Nutrition* 42 (3): 203-217.

Rivera-Hernández, B.; Aceves-Navarro, L. A.; Juárez-López, J.; Palma-López, D. J.; González Mancillas, R.; González-Jiménez, V. (2012). Zonificación agroecológica y estimación del rendimiento potencial del cultivo de la yuca (*Manihot esculenta* Crantz) en el estado de Tabasco, México. *Avances en Investigación Agropecuaria* 16: 29-47.

Rodríguez-Miranda J., J.M. Rivadeneyra-Rodríguez, E.J. Ramírez-Rivera, J.M. Juárez-Barrientos, E. Herrera-Torres, R.O. Navarro-Cortéz, B. Hernández-Santos (2011). Caracterización fisicoquímica, funcional y contenido fenólico de harina de malanga (*Colocasia esculenta*) cultivada en la región de Tuxtepec, Oaxaca, México. *Ciencia y Mar* 43: 37-47.

Salgado G., S., Núñez E., R. Bucio A., L. (2003). Determinación de la dosis óptima económica de fertilización en caña de azúcar. *Terra Latinoamericana* 21(2): 267-272.

Servicio de Información Agropecuaria y Pesquera (SIAP). (2019). Atlas Agroalimentario 2018. Consultado en línea en Octubre 2021 en: https://nube.siap.gob.mx/gobmx_publicaciones_siap/pag/2019/Atlas-Agroalimentario-2019

Zapata Martínez, J., & Velásquez Escandón, C. (2013). Estudio de la producción y la comercialización de la malanga: Estrategias de incentivos para la producción en el país y consumo en la ciudad de Guayaquil, Colombia. Tesis de Maestría en Ciencias. Universidad Politécnica Salesiana Ecuador. 12 p.

Zavala-Cruz, J., Jiménez-Ramírez, R., Palma-López D. J., Bautista Zúñiga F., Gavi-Reyes, F. (2016). Paisajes geomorfológicos: base para el levantamiento de suelos en Tabasco, México. *Ecosistemas y Recursos Agropecuarios* 3: 161-171.