

Ex situ morphological characterization of the native chili Cha'hua (*Capsicum annuum* L.) cv. Chahua

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Citation: Castillo-Aguilar, C. De La C., Reyes-Ek, J. M., Chiquini-Medina, R. A., Piña-Betancourt, E., Sauri-Duch, E., & Palma-Cancino, D. J. (2024). *Ex situ* morphological characterization of the native chili Cha'hua (*Capsicum annuum* L.) cv. Chahua. *Agro Productividad*. <https://doi.org/10.32854/agrop.v18i2.3056>

Academic Editor: Jorge Cadena Iñiguez

Associate Editor: Dra. Lucero del Mar Ruiz Posadas

Guest Editor: Daniel Alejandro Cadena Zamudio

Received: October 07, 2024.

Accepted: January 29, 2025.

Published on-line: February XX, 2025.

Agro Productividad, 18(2). February. 2025. pp: 59-65.

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ABSTRACT

Objective: To morphologically characterize Cha'hua chili (*Capsicum annuum* L.), a native variety from the Yucatán Peninsula.

Design/methodology/approach: Seeds collected from Cha'hua chili in the state of Yucatán were sown in 200-cavity polystyrene trays. After transplanting, the plants were placed in hydroponic bags and morphologically characterized using the descriptor for the genus *Capsicum* from the International Plant Genetic Resources Institute (IPGRI).

Results: The plant reached a height of 118 cm and a width of 34.8 cm, with white flowers and light green fruits at the early stage, turning red at maturity. The fruits measured 7.42 cm in length and 2.32 cm in width. The plant exhibited tolerance to viral infections caused by whiteflies. Capsaicin and dihydrocapsaicin contents were determined at 10.10 mg g⁻¹ and 3.03 mg g⁻¹, respectively.

Study limitations/implications: The morphological characterization of the Cha'hua variety will generate valuable knowledge to enhance its adaptation to large-scale production systems.

Findings/conclusions: This plant possesses morphological characteristics suitable for genetic improvement aimed at commercial exploitation, given its market acceptance both as fresh and dried fruit, supported by competitive market prices.

Keywords: capsaicin, horticulture, *Capsicum annuum*, native crop, hydroponics.

INTRODUCTION

The diversity of genetic resources forms the foundation of agriculture and food production. Their conservation is essential for ensuring their continuity, which in turn provides products to humanity and supports food and nutritional security (Becerril, 2013).



Mexico possesses a vast array of *Capsicum* spp. phylogenetic resources. Chili peppers are among the most widely used plants worldwide, holding significant culinary, economic, and sociocultural importance in Mexico (Ramírez *et al.*, 2000). In particular, the Yucatán Peninsula hosts a great diversification of landrace chili peppers from the species *C. annuum*, *C. chinense*, and *C. frutescens*, yet comprehensive knowledge of the native germplasm remains limited (Latournerie *et al.*, 2002; Pardey *et al.*, 2006; Castillo-Aguilar *et al.*, 2023). In the Yucatán Peninsula, chili cultivation (*Capsicum* spp.) occurs both in open fields and controlled environments such as greenhouses and shade houses, as seen with habanero chili (*Capsicum chinense* Jacq). However, native landrace varieties are also cultivated in traditional milpa systems and backyard gardens, with the most frequently grown varieties being Ixcat Ik, Dulce, Maax, Yaax Ik, and Cha'huá, all belonging to *Capsicum annuum*, as well as Pico Paloma (*Capsicum frutescens*). These varieties are cultivated regionally for local consumption and are integral to the peninsula's gastronomy (González-Estrada *et al.*, 2012; Castillo-Aguilar *et al.*, 2023). In Maya communities, 70% of Cha'huá chili (*C. annuum* cv. Chahua) plants are managed in small plots, cultivated under rainfed conditions in milpa systems due to their drought tolerance (Molina Suárez *et al.*, 2021).

Cha'huá chili, also known as Chawa (González-Estrada *et al.*, 2012), is a native landrace from the Yucatán Peninsula resistant to drought, with fruit size varying but averaging 4.4 cm in length and 2.1 cm in diameter. It is commercially distributed at the regional level and primarily used for condiment production. This type of chili can be marketed both fresh and dried (Aguilar-Rincón *et al.*, 2010). Given the importance of Cha'huá chili for Maya communities in the Yucatán Peninsula and its potential for genetic improvement, this study aimed to conduct an *ex situ* morphological characterization to optimize its management and enhance its production scale in regional agriculture.

MATERIALS AND METHODS

The morphological characterization of Cha'huá chili was part of the research project "Collection, Morphological Characterization, Molecular Typification, Conservation, and Sustainable Utilization of the Capsicum Genus in the State of Campeche." The study was conducted at the Lol'ic (Chili Flower) nursery, located along the former Mérida-Motul highway, in front of Hacienda San Antonio Holactún, in the community of Conkal, Yucatán. Sowing took place on August 22, 2023, in 200-cavity polystyrene trays, using peat moss (Peat Moss Sunshine 3[®]) as the substrate. The seeds of *Capsicum annuum* cv. Chahua were collected in the community of Conkal, Yucatán. Transplanting occurred 50 days after sowing, when the plants had reached an average height of 20 cm. They were transferred to hydroponic plastic bags (600-gauge), measuring 50 cm in width and 40 cm in length. The substrate used consisted of 40% Nitisol soil, 40% Rendzina soil, and 10% agricultural perlite (Multiperl[®]). The plants remained in a protected system for three months before being moved to open-field conditions. An integrated management approach was applied for fertilization and pest and disease control, following the recommendations of Soria *et al.* (1999). Morphological characterization was performed on 10 randomly selected plants with three replications. The evaluation included seedling, plant, flower, and fruit characteristics, using the *Capsicum* descriptor from the International Plant Genetic Resources Institute

(IPGRI, 1995). Additionally, spiciness level was determined using high-performance liquid chromatography (HPLC). The morphological characterization of quantitative variables was analyzed through descriptive statistics, including mean, standard deviation, and coefficient of variation.

RESULTS AND DISCUSSION

Seedling

Cha'huá chili exhibited a 50% seedling emergence rate at 8 ± 2 days after sowing (DAS), with full plant emergence at 10 ± 12 DAS. The seedlings had a white coleoptile, scarce hypocotyl pubescence, green cotyledon leaves, and oval-shaped cotyledon leaves with an average length of 10.12 ± 2.57 mm and a width of 1.72 ± 0.28 mm. Leaf width was the trait with the lowest coefficient of variation (CV) at 16.27%.

These results are important considering that there is no existing morphological description of the seedling stage of Cha'huá chili. Therefore, the observed values represent a valuable contribution to morphological knowledge. This nursery growth stage is crucial, as nursery managers must be well aware of the morphological characteristics of the variety or ecotype they are working with to ensure varietal purity, leading to the expected field results.

Plant

The Cha'huá chili plant was characterized by an erect and rustic growth habit, a stem with no anthocyanins, lanceolate leaves with wavy margins (Figure 1). Additional characteristics related to the plant's growth stage are shown in Table 1.

The qualitative and quantitative characteristics observed in Cha'huá chili allowed for a morphological definition of the plant during its vegetative growth stage. Some of these findings align with the descriptions provided by Aguilar-Rincón *et al.* (2010) and Escalera-Ordaz *et al.* (2019), although their morphological characterizations are limited. Based on field observations, the qualitative traits that contributed most to the morphological



Figure 1. From left to right: Leaf shape and color of Cha'huá chili; stem shape, color, and pubescence of Cha'huá chili. Photographs taken in the field by the authors.

Table 1. Qualitative and quantitative characteristics of the plant growth stage of the Cha'huá chili (*Capsicum annuum* cv. Chahua).

Feature	Value	Feature	Value
Stem color	green	tillering	dense
Anthocyanins at the node	absent	Leaf density	dense
Stem shape	angular	Leaf color	green
Pubescence on the stem	scarce	Leaf shape	lanceous
Plant growth habit	erect	Leaf margin	wavy
Plant height (cm)	58.6±8.51	Leaf pubescence	medium
Plant width (cm)	53.6±0.51	Leaf length (cm)	8.72±1.13
Branching density	high	Leaf width (cm)	3.48±0.66

description were leaf shape, leaf margin, and pubescence level. These results partially agree with those reported by Latournerie *et al.* (2002), who identified leaf shape as a key element in chili characterization.

Regarding the quantitative traits, the coefficients of variation for the evaluated characteristics ranged between 10% and 20%, similar to those reported by Escalera-Ordaz *et al.* (2019). These coefficients indicate a low to moderate variation in plant characteristics. Based on this, it was determined that the Cha'huá landrace variety has lost certain wild-type chili traits over time, particularly in terms of growth habit and plant stature. Unlike wild chilis, which exhibit a determinate growth pattern and are highly dependent on environmental conditions for crop management, Cha'huá chili has begun to show increased susceptibility to pests and diseases (Castillo-Aguilar *et al.*, 2023).

Flower

The flowers of Cha'huá chili were characterized as solitary and pendulous, with a white, round corolla, white filaments, blue anthers, and an exerted stigma. These traits align with the descriptions provided by Aguilar-Rincón *et al.* (2010) in his morphological study of Mexican chili varieties. Additional characteristics can be observed in Figure 2 and Table 2.

**Figure 2.** Flower of the Cha'huá chili (*Capsicum annuum* L.) cv. Chahua, showing its shape, color, position, anthers, and exposed style. Photographs were taken in the field by the authors.

Table 2. Qualitative and quantitative characteristics of the Cha'huá chili flower (*Capsicum annuum* L.) cv. Chahua.

Feature	Value	Feature	Value
Number of flowers per axil	1	Filament color	white
Position of the flower	earring	Style length (mm)	1.75 ± 0.21
Color of the corolla	white	Corolla size (mm)	21.47 ± 1.10
Corolla shape	round	Exsertion (stigma)	exserted
Corolla length	1.5 a 2.5	Calyx pigmentation	absent
Anther color	blue	Calyx margin	dentate
Anther length (mm)	3.22 ± 0.50	Calyx construction	absent

A differential morphological characterization of the Cha'huá chili flower must consider both qualitative and quantitative traits, as several floral morphological characteristics are identical to those of other chili types, such as Ixcat Ik and Yaax Ik chili (Castillo-Aguilar *et al.*, 2023).

Fruit

Qualitatively, the fruit was observed to be light green in its immature stage, orange at the intermediate stage, and red when fully mature, with slight transverse wrinkling (Figure 3). It is an elongated fruit with an average length of 9.9 cm and a width of 1.1 cm, values that fall within the ranges reported by González-Estrada (2000) and Aguilar-Rincón *et al.* (2010). The fruit had an average weight of 4.39 g and a pericarp thickness of 1.35 cm (Table 3).

A more detailed description than the one provided in this study is not available, as this chili is considered a native landrace variety of the Yucatán Peninsula, cultivated on a small scale for regional culinary purposes. The qualitative characteristics that best described the Cha'huá chili fruit were its slight transverse wrinkling and its pale green coloration, which

**Figure 3.** Cha'huá chili plants (*Capsicum annuum* L.) cv. Chahua with fruits at different stages of maturity. Photographs taken in the field by the authors.

Table 3. Qualitative and quantitative characteristics of the fruit of the Cha'huá chili (*Capsicum annuum* L.) cv. Chahua.

Feature	Value	Feature	Value
Anthocyanin spot	absent	Fruit weight (g)	4.39±1.66
Fruiting period (days)	60 days	Pedicle length (cm)	28.16±3.85
Fruit color stage I	Light green	Fruit wall thickness (cm)	1.35±0.27
Fruit color intermediate stage II	orange	Shape of fruit at junction with pedicel	obtuse
Fruit color mature III	red	Neck at base of fruit	absent
Fruit shape	elongated	Shape at apex of fruit	pointed
Fruit length (cm)	9.91±2.01	Flowering vestige	absent
Fruit width (cm)	1.10±0.20	Transverse wrinkling of fruit	mild

producers refer to as white. The fruit gradually transitions through two additional color shades before reaching its final red hue (Figure 3).

The morphological characteristics of the fruit exhibited moderate to high variability. Based on the obtained coefficient of variation (CV) values, the variation was greater than that reported by Escalera-Ordaz *et al.* (2019) in their morphological characterization of cultivated varieties of *Capsicum pubescens*. Among the quantitative traits, the pedicel length showed the lowest CV at 13.67%, while fruit weight was the most variable trait, with a CV of 37.81%, a value considered high. This variability is partially explained by the fact that Cha'huá chili is a landrace variety (Castillo-Aguilar *et al.*, 2023). In addition to the morphological characterization of the Cha'huá chili landrace, its pungency was determined, yielding values of $10.1057 \pm 0.922 \text{ mg g}^{-1}$ of capsaicin per gram of dry matter and $3.0317 \pm 0.2766 \text{ mg g}^{-1}$ of dihydrocapsaicin per gram of dry matter, equivalent to a total of 211,520.289 Scoville Heat Units (SHU). These values can be considered high, taking as a reference habanero chili (*Capsicum chinense* Jacq.), which has an average total Scoville rating of 250,000 SHU (Castillo-Aguilar *et al.*, 2023).

CONCLUSIONS

The most distinctive morphological traits of Cha'huá chili included the absence of anthocyanins in the seedling stage, coleoptile coloration, and leaf shape. During vegetative growth, the most notable characteristics were stem shape and pubescence, as well as leaf morphology. In the flowering stage, flower position stood out as a defining trait. Regarding the fruit, its sequential coloration throughout development was particularly distinctive, especially its light green hue in the early stages. The obtained morphological data should be considered preliminary due to the variation among Cha'huá chili ecotypes and potential environmental influences that may affect the expression of different morphological traits. The capsaicinoid content of Cha'huá chili proved to be significant when compared to values reported for other chili varieties in the Yucatán Peninsula, reinforcing its versatility for use in fresh, mature, and dried forms.

ACKNOWLEDGEMENTS

We thank the Colegio de Postgraduados for the financial support provided for this research through the internal projects funding scheme.

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