Development, quality, and yield of two habanero pepper hybrids (*Capsicum chinense* Jacq.) in three greenhouse cultivation systems

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ABSTRACT

Objective: To evaluate the plant development, fruit quality, and yield of two habanero pepper hybrids (*Capsicum chinense* Jacq.) in three cultivation systems under greenhouse conditions.

Design/methodology/approach: Plant height, stem diameter, chlorophyll index, fruit length, width and weight as well as the yield (fruits per plant, kg plant^{-1} and kg ha^{-1}) of the Chichen Itza and Megalodon hybrids grown on plastic mulch, coconut coir growth bags (CCGB) and soil under greenhouse conditions were evaluated. The data obtained were subjected to analysis of variance (ANOVA) under a completely randomized design with a factorial arrangement.

Results: The best vegetative development and highest chlorophyll index were observed in Megalodon hybrid grown on plastic mulch and CCGB. Chichen Itza hybrid produced the longest fruits, while Megalodon the widest ones; however, fruit weight was similar in both hybrids. Chichen Itza showed the highest number of fruits per plant, kg plant^{-1} and kg ha^{-1}.

Limitations on study/implications: The study was conducted during the winter-spring period; therefore, the results might vary in the summer-autumn period under the greenhouse conditions of the experimental site.

Findings/conclusions: The Chichen Itza hybrid showed the best productive performance. Similarly, the highest yield was recorded for both hybrids when directly sown in soil, with or without the use of plastic mulch.

Keywords: Plastic mulch, coconut coir, Chichen Itza, greenhouse, Megalodon.

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INTRODUCTION

Mexico is one of the main producers of several species of peppers (*Capsicum* spp.) worldwide, among which the habanero chili (*C. chinense* Jacq.) is widely cultivated in the Yucatan peninsula. This region is recognized as a center of genetic diversity of *C. chinense*, and its edaphoclimatic conditions have favored the existence of numerous landrace germplasm whose flavor, aroma, and spiciness distinguish them from habanero peppers grown in other parts of the world (Castillo-Aguilar *et al.*, 2019; Muñoz-Ramírez *et al.*, 2020). Paradoxically, these germplasms have small and heterogeneous fruits and low yields (Muñoz-Ramírez *et al.*, 2020), and although they are widely accepted in the local market (Flores-López & Sánchez-Osorio, 2020) they do not meet the quality standards of the national and international markets, making it necessary to develop and evaluate

new varieties and hybrids with better agronomic characteristics and higher yields (Tapia-Vargas *et al.*, 2016; Ramírez *et al.*, 2018).

On the other hand, to increase the yield of both native varieties and improved genotypes, various cultivation systems have been assessed. Thus, some authors have evaluated the direct sowing of this species into the soil (Castillo-Aguilar *et al.*, 2019), the use of plastic mulch (Torres-Bojórquez *et al.*, 2017) or growth bags (Muñoz-Ramírez *et al.*, 2020; Llamas *et al.*, 2024) under greenhouse conditions. Others have sown it under shade mesh using black polyethylene bags as containers (Ontiveros-Sajuan *et al.*, 2024). Likewise, some studies have evaluated the physicochemical characteristics of different types of soils as natural substrates for its cultivation (Borges-Gómez *et al.*, 2014) while others have focused on evaluating the use of alternative substrates such as coconut fiber (Muñoz-Ramírez *et al.*, 2020; Llamas *et al.*, 2024) mixtures of gravel and tezontle (López *et al.*, 2020), tezontle and coconut fiber (Meneses-Lazo *et al.*, 2020) and mixtures of vermicompost, gravel and river sand (Javier-López *et al.*, 2022) with variable results.

Under this context, the present study aimed to evaluate plant development, fruit quality and yield of two habanero pepper hybrids in three cultivation systems under greenhouse conditions.

MATERIALS AND METHODS

Experimental site

This study was carried out from February to September 2021 in a Gothic-type greenhouse at the Faculty of Biological and Agricultural Sciences of the University of Colima, located at the geographic coordinates 18° 57' 10" N and 103° 53' 46" W, at an altitude of 33 masl. The climate is warm semi-dry with summer rains, corresponding to the formula BS1 (h')w(w) with an average annual temperature and precipitation of 27.4 °C and 882.5 mm, respectively. The experimental soil was sandy loam (clay 17%, sand 77% and silt 6%) with an EC and pH of 2.5 mS cm^{-1} and 6.88, respectively.

Genetic material, plantlet production and trasplant

Seeds of two commercial habanero pepper (*C. chinense*) hybrids were used: Megalodon (Lark Seeds Company®, USA) and Chichen Itza (Bayer®, USA). They were sown at a depth of 0.5-1 cm in previously disinfected 200-cavity white polyethylene trays (Hortiblock®, Mexico) filled with Peat Moss substrate (BM8®, Canada). After sowing, the trays were covered with black bags for five days to induce germination. Once the seedlings emerged, they were uncovered and placed on tables to be watered and fertilized until transplanting, which was carried out after 49 days. The following fertilizers were applied for plant production: Triple 19 (Polyfeed® Haifa, 1 to 2.5 g L^{-1}), 12-42-12 (Polyfeed® Haifa, 1 to 2.5 g L^{-1}), Root factor (Agroscience®, 1.5 mL L-1), Startrak (Abonomex®, 1 to 2.5 g L^{-1}) and Maxirad (Coda®, 1.5 mL L^{-1}).

Greenhouse preparation, growing systems and topological arrangement

Sowing in soil with and without mulch. Manual weeding was performed, and the top 30 cm of soil was removed with a pick and hoe to form the seedbeds. Seedlings were transplanted at 30 cm from each other, with a row spacing of 1.5 m, resulting in a planting density of 21,978 plants ha^{-1}. Black and white plastic mulch was manually placed on the beds, and the edges were covered with soil. Fourteen growth bags (100×16×18 cm and 28.8 cm^3) were filled with fiber and coconut coir at a ratio of 70:30 and placed on partitions to insulate them from the soil. Three holes were made in each bag, spaced 30 cm from each other, and a seedling was placed inside. The distance between rows was 1.5 m resulting in a plant density like that used in direct sowing.

Nutrition and phytosanitary management

Nutrition was carried out through fertigation in four stages according to crop phenology. In stage one (adaptation), six fertigation treatments were applied in 21 days. The sources were: 272.7 g of phosphonitrate, 80.5 g of MKP, and 50.6 g of Nitro K Sulfur. During this stage, 200 mL of Root Factor and 150 g of Pow Humus were also applied to promote rooting. In stage two (development), 12 fertigation applications were made over 30 days, using the following sources: 220.2 g of phosphonitrate, 26 g of MKP, and 81 g of Nitro K Sulfur. In stage three (fruiting), 10 fertigation applications were made over 30 days with 170 g of phosphonitrate, 162.5 g of MKP, and 8.92 g of Nitro K Sulfur. In stage four (production), 28 fertigation applications were made over 60 days with 45 g of phosphonitrate, 28.2 g of MKP, and 108.2 g of Nitro K Sulfur. Throughout all stages, 50 g of micronutrients (Tradecorp A-Z®, Fe, Mn, Zn, B, and Mo) and 150 mL of calcium (Turgent Ca®, Agroscience) were applied weekly. The fertilizer quantities corresponded to a population of 400 plants.

For the phytosanitary management of the insects pest that were present (cryptic complex *Bemisia tabaci*, *Scirtothrips dorsalis*, *Liriomyza* spp., *Tetranichus urticae*, *Polyphagotarsonemus latus*) biorational products [Trilogy® (2.5 mL L^{-1}) and Ajick® (2.5 mL L^{-1})], biological [Bassi-Hit®, 2.5 g L^{-1}) and chemical [Imidacloprid (Imiland®, 1.5 mL L^{-1}), thiamethoxam + lambdacyhalothrin (Engeo®, 1.5 mL L^{-1}), Etoxazole (Tetrasan®, 1.0 mL L^{-1}) and Fenpyroximate (Avolant®, 1.5 mL L^{-1}) were used. For fungal diseases, biological fungicides (Magni-Root®, 2.5 g L^{-1}), biorational fungicides (Castell®, 2.5 mL L^{-1}) and chemical fungicides [Fosetyl-Al (Alleato®, 2.0 g L^{-1}), Azoxystronin + Metalaxyl (Uniform®, 1.5 mL L^{-1}) and Propamocarb + Fosetyl-Al (Previcur®, 1.5 g L^{-1})] were applied.

Treatments

Six treatments were evaluated, resulting from the combination of the two hybrids (Chichen Itza and Megalodon) and three cultivation systems (mulch, bag, and soil). Each plant was considered an experimental unit (replicate), and 12 plants were evaluated per treatment, for a total of 72 replicates.

Response variables

Agronomics. Beginning one week after transplanting, plant height, stem diameter, and chlorophyll index were assessed every two weeks. Plant height was measured using a telescopic aluminum rod from the ground to the apex. Stem diameter was measured with a digital vernier caliper, and chlorophyll index was measured with a CM1000 spectroradiometer (Field Scout®, USA).

Fruit quality. At harvest, 112 fruits were randomly selected per treatment. Their length and diameter were measured with a digital vernier caliper, and their weight was determined using an SF-400 digital scale.

Production and yield. The total number and weight of fruits harvested per plant were recorded during the 13 harvests made over a 99-day period. To calculate the yield in t ha^{-1}, the weight of all crops was added and multiplied by 21,978 plants ha^{-1}.

Statistical analysis

Data were analyzed using a completely randomized analysis of variance (ANOVA) with a factorial arrangement, and means were compared using the Tukey test ($p<0.05$). Statistical analyses were conducted using Statgraphics V.8 for Windows.

RESULTS AND DISCUSSION

Chichen Itza hybrid showed greater plant height at 35- and 49-days post-transplant (DPT). Plants sown in plastic mulch and growth bags had greater height at 35 DPT, whereas at 49 and 63 DPT this was greater only in plants planted in plastic mulch (Table 1). An interaction effect between hybrid and growing system was observed for plant height at 7 and 84 DPT. At 7 DPT, the height of Megalodon plants grown in plastic mulch and soil was greater than that of Chichen Itza, but similar to that of plants grown in growth bag. At 84 DPT, the height of Megalodon plants cultivated in plastic mulch and growth

Table 1. Plant height of two habanero pepper hybrids in three greenhouse cultivation systems.

Factor	Days post-transplant					
	7	21	35	49	63	84
Hybrid						
Chichen Itza	13.40 b	19.12 a	36.24 a	63.53 a	87.22 a	120.44 b
Megalodon	16.56 a	19.36 a	34.81 a	48.42 b	81.39 b	138.25 a
SEM	0.34	0.39	0.77	1.09	1.31	2.81
MSD	0.97	1.10	2.19	3.08	3.68	7.92
p (α=0.05)	0.00001	0.6630	0.1963	0.00001	0.0010	0.00001
Cultivation system						
Plastic mulch	15.23 ab	19.85 a	38.00 a	61.15 a	93.46 a	144.29 a
Coconut coir growth bag	13.88 b	18.72 a	35.15 ab	54.67 b	78.79 b	125.50 b
Soil	15.83 a	19.14 a	33.42 b	52.10 b	81.42 b	118.25 b
SEM	0.42	0.48	0.95	1.33	1.60	3.44
MSD	1.42	1.62	3.22	4.53	5.42	11.66
p (α=0.05)	0.0053	0.2480	0.0042	0.00001	0.00001	0.00001
Hybrid×Cultivation system						
p (α=0.05)	0.0024	0.0869	0.9437	0.1454	0.4819	0.00001

[a,b] Means with different letters are significantly different according to Tukey's test (p=0.05). SEM: standard error of the mean; MSD: minimum significance difference.

bags was greater than that of Chichen Itza, but similar when cultivated in soil. Likewise, Megalodon plants were taller when planted in plastic mulch compared to soil and growth bag, while Chichen Itza was similar in all three cultivation systems.

Contrary to what was observed in the present study, Llamas *et al.* (2024) reported an inverse behavior in plant height of both hybrids grown in bags with coconut coir substrate, with higher values for the Chichen Itza hybrid. Furthermore, at a similar age, the Megalodon hybrid was shorter (117.2 cm) and the Chichen Itza hybrid taller (136.1 cm) than in the present study (Megalodon 138.75 cm and Chichen Itza 112.25 cm). Regarding cultivation systems, Toscano-Verduzco (2023) observed that the use of shade mesh increased plant height of Megalodon at 60, 75 and 90 DPT by 12.2, 9.5 and 7.4%, respectively. In contrast to the results of this study, he also observed that the use of plastic mulch negatively affected plant growth, and at 90 DPT, plants grown without plastic mulch were 21.8% taller. This author suggested that the use of plastic mulch increases soil temperature and salt concentration, causing abiotic stress in the plants and negatively affects their growth. Another study concluded that plants grown with silver-colored plastic mulch showed greater height and growth index compared to those grown without mulch (Torres *et al.*, 2017).

Other authors have identified various cultural practices that affect the plant height of *C. chinense*. Javier *et al.* (2022) evaluated the use of different fertilization sources and substrates in this crop and observed that, at 199 DPT, plants grown in sand and vermicompost and fertilized with chemical and organic sources, respectively, were taller than those grown in a mixture of vermicompost, soil and gravel fertilized with and an organic source (192.6, 173.4 and 126.43 cm, respectively). Tapia-Vargas *et al.* (2016) evaluated the application of a hormonal compound on the height of chocolate habanero pepper plants and observed greater height in the treated plants due to enhanced cell division and elongation. An advantage of smaller genotypes is the ease and speed with which some agronomic practices such as pruning, defoliation, and harvesting can be performed without the use of stilts, resulting in lower risk and cost for the producer.

At 49 DPT, Megalodon plants showed a greater stem diameter than Chichen Itza plants, while at 49 and 63 DPT, plants grown in plastic mulch and growth bags showed a greater stem diameter than those grown in soil (Table 2). An interaction effect was observed for this variable at 35 and 84 DPT. At 35 days, the stem diameter of both hybrid plants grown in plastic mulch and growth bag was similar, but Megalodon plants had greater stem diameter when grown in soil. At 84 DPT, the stem diameter of Megalodon plants grown in plastic mulch and growth bags were larger than those grown in soil.

At 84 DPT, Megalodon plants grown in growth bags showed a larger stem diameter than Chichen Itza plants (14.54 *vs.* 10.85 mm, respectively). However, Llamas *et al.* (2024) did not observe any difference in stem diameter between the two hybrids. Likewise, these authors reported at 87 DPT a smaller stem diameter for Megalodon plants (12.85 mm) and a larger one for Chichen Itza plants (12.41 mm) than those observed in the present study. According to Toscano-Verduzco (2023), at 90 DPT the use of shade mesh did not affect the stem diameter of Megalodon plants, while at 84 DPT the use of plastic mulch significantly decreased stem diameter, a trend also observed in the present study. As with

Table 2. Stem diameter of two habanero pepper hybrids in three greenhouse cultivation systems.

Factor	Days post-transplant					
	7	21	35	49	63	84
Hybrid						
Chichen Itza	2.47 a	3.92 a	6.21 b	6.92 a	8.42 a	10.48 b
Megalodon	2.57 a	3.78 a	6.84 a	6.56 b	8.74 a	13.40 a
SEM	0.05	0.09	0.13	0.10	0.13	0.18
MSD	0.15	0.26	0.36	0.29	0.36	0.51
p (α=0.05)	0.1605	0.2852	0.0008	0.0124	0.0804	0.00001
Cultivation system						
Plastic mulch	2.50 a	3.86 a	6.60 ab	7.01 a	8.90 a	12.72 a
Coconut coir growth bag	2.58 a	4.01 a	6.85 a	7.14 a	8.97 a	12.69 a
Soil	2.88 a	3.68 a	6.13 b	6.07 b	7.88 b	10.40 b
SEM	0.07	0.11	0.16	0.12	0.16	0.22
MSD	0.22	0.39	0.53	0.42	0.53	0.75
p (α=0.05)	0.4465	0.1365	0.0064	0.00001	0.00001	0.00001
Hybrid×Cultivation system						
p (α=0.05)	0.2794	0.5983	0.0074	0.4340	0.0987	0.0006

[a,b] Means with different letters are significantly different according to Tukey's test (p=0.05). SEM: standard error of the mean; MSD: minimum significance difference.

plant height, this author indicated that abiotic stress caused by increased soil temperature and salt concentration negatively affected plant growth.

Other authors have reported that the source of fertilization and the substrate used affect the stem diameter of *C. chinense* plants. In this regard, Javier *et al.* (2022) recorded larger stem diameters at 199 DPT in plants grown in vermicompost with organic fertilization (19.06 mm) compared to those grown in sand with chemical fertilization (15.95 mm), in a mixture of vermicompost, soil, and gravel with organic fertilization (15.72 mm), and in a mixture of vermicompost, sand, and gravel with organic fertilization (13.46 mm).

Regarding the chlorophyll index, it was higher in Megalodon plants and in plants grown in soil at 7 and 35 DPT, respectively (Table 3). An interaction effect was observed at 21, 49, and 84 DPT.

At 21 and 49 DPT, Chichen Itza plants grown in growth bags showed a lower chlorophyll index than Megalodon plants, while plants of both hybrids grown in plastic mulch and soil showed similar values. At 84 DPT, Chichen Itza plants grown in plastic mulch had a lower chlorophyll index than Megalodon plants, with similar values for both hybrids when grown in growth bags and soil.

The relative chlorophyll index is an indicator of the total chlorophyll content in leaves and allows for the evaluation of the plant's nitrogen status, which is essential to produce amino acids and other molecules and tissues required for plant growth. The chlorophyll index recorded in both hybrids during the growth phase was higher than that observed for these same hybrids by Llamas *et al.* (2024). This difference can be explained by the altitude at which the crops were established, since as elevation increases, the diffusion

Table 3. Chlorophyll index of two habanero pepper hybrids in three greenhouse cultivation systems.

Factor	Days post-transplant					
	7	21	35	49	63	84
Hybrid						
Chichen Itza	124.17 a	196.19 a	203.58 b	363.86 a	354.33 a	323.11 b
Megalodon	127.67 a	189.56 a	238.58 a	327.72 b	360.11 a	367.56 a
SEM	2.77	3.08	6.60	8.64	8.80	5.61
MSD	7.81	8.69	18.64	24.37	24.83	15.85
p (α=0.05)	0.3742	0.1322	0.0004	0.0043	0.6439	0.00001
Cultivation system						
Plastic mulch	115.46 b	183.75 b	210.67 a	359.33 a	370.42 a	371.17 a
Coconut coir growth bag	117.33 b	180.33 b	226.29 a	315.08 b	359.21 a	342.42 b
Soil	144.96 a	214.54 a	226.29 a	362.96 a	342.04 a	322.42 b
SEM	3.39	3.77	8.09	10.58	10.78	6.88
MSD	14.76	12.79	27.43	35.87	36.54	23.32
p (α=0.05)	0.00001	0.00001	0.2948	0.0030	0.1801	0.0000
Hybrid×Cultivation system						
p (α=0.05)	0.5920	0.0119	0.1485	0.0000	0.3340	0.0005

[a,b] Means with different letters are significantly different according to Tukey's test (p=0.05). SEM: standard error of the mean; MSD: minimum significance difference.

of solar radiation decreases, which negatively affects the photosynthetic rate (Montero-Torres, 2022). In this sense, the present study was carried out at an altitude of 33 m.a.s.l., while Llamas *et al.* (2024) established their cultivation at 645 m.a.s.l. Toscano-Verduzco (2023) reported a chlorophyll index of 651.6 at 90 DPT in the Megalodon hybrid grown in a greenhouse under shade mesh. Previous studies have indicated that the use of shading can improve the photosynthetic capacity of pepper leaves (Zhu *et al.*, 2012), as they tend to have a greater number of light-harvesting complexes per unit area to capture as much light as possible (Griffin *et al.*, 2004).

Fruit width of Megalodon was greater than that of Chichen Itza and similar across the three cultivation systems, while an interaction effect was observed for fruit length and weight (Table 4). Fruit length of Chichen Itza was greater than that of Megalodon and did not differ among cultivation systems, whereas Megalodon fruit length was greater when plants were grown in soil. Fruit weight of Megalodon was higher when grown in soil, while that of Chichen Itza was higher when grown in soil and under plastic mulch.

Fruit size and weight of *C. chinense* show great variability and both are key characteristics that determine its quality. Borges-Gómez *et al.* (2010) indicate that the fruit can be classified according to its weight as first grade fruit, when it is greater than 6.5 g, second grade fruit, when it is between 5.5 and 6.4 g, and third grade fruit when it is less than 5.4 g. In the present study, the width and length of the Megalodon fruit were larger and smaller than those of Chichen Itza respectively, and based on their weight, they were classified as first-grade fruits. Average fruit width of both hybrids was greater than that reported by Ramírez *et al.* (2018) and Meneses-Lazo *et al.* (2020), for Jaguar (25-30 mm)

Table 4. Fruit width, length, and weight of two habanero pepper hybrids in three greenhouse cultivation systems.

Factor	Fruit width (mm)	Fruit length (mm)	Fruit weight (g)
Hybrid			
Chichen Itza	32.47 b	45.03 a	10.31 a
Megalodon	35.68 a	34.65 b	9.93 a
SEM	0.39	0.46	0.17
MSD	1.09	1.28	0.48
p (α=0.05)	0.0000	0.0000	0.1160
Cultivation system			
Plastic mulch	34.79 a	39.07 b	10.27 b
Coconut coir growth bag	33.43 a	38.59 b	9.09 c
Soil	34.01 a	41.87 a	11.00 a
SEM	0.48	0.57	0.21
MSD	1.59	1.88	0.70
p (α=0.05)	0.1329	0.0001	0.00001
Hybrid×Cultivation system			
p (α=0.05)	0.1734	0.0215	0.0430

[a,b] Means with different letters are significantly different according to Tukey's test (p=0.05).
SEM: standard error of the mean; MSD: minimum significance difference.

and Naranja (29 mm) varieties, but was smaller than that reported by Castillo-Aguilar *et al.* (2019) for Rosita variety (51.20 mm). Regarding fruit length, Chichen Itza was longer than the Rosita (44.10 mm) and Naranja (40.00 mm) varieties (Castillo-Aguilar *et al.*, 2019; Meneses-Lazo *et al.*, 2020), while the length of these varieties was greater than that of Megalodon. Similarly, Ramírez *et al.* (2018) reported a fruit length of 38 to 55 mm for the Jaguar variety, which is also greater than that observed here for Megalodon. The average weight (21.79 g) of the fruit of Rosita variety (Castillo-Aguilar *et al.*, 2019) far exceeded that recorded here for both hybrids, while that reported by Meneses-Lazo *et al.* (2020) for Naranja variety (8 g) was lower. For its part, Jaguar variety has a fruit weight ranging from 6.5 to 10 g (Ramírez *et al.*, 2018), which is lower than that observed for Chichen Itza in the present study.

Chichen Itza hybrid showed a higher number of fruits, production per plant and yield than Megalodon, while the highest number of fruits, production per plant and yield were obtained when both hybrids were grown in plastic mulch and soil (Table 5).

The superior productive performance of the Chichen Itza hybrid compared to Megalodon, contrasts with the results of Llamas *et al.* (2024), who cultivated these two hybrids under greenhouse conditions, in growth bags using a semi-hydroponic system and found no differences in the number fruits and production per plant and yield in t ha^{-1}.

In addition to genotype, the production and yield of *C. chinense* depend on several factors, including the cultivation system and agronomic management. In the present

Table 5. Number of fruits, production per plant and yield of two habanero pepper hybrids in three greenhouse cultivation systems.

Factor	Fruits per plant	Production (kg plant^{-1})	Yield (t ha^{-1})
Hybrid			
Chichen Itza	126.50 a	0.94 a	20.53 a
Megalodon	69.08 b	0.60 b	13.17 b
SEM	3.72	0.03	0.60
MSD	10.50	0.08	1.70
p (α=0.05)	0.00001	0.00001	0.00001
Cultivation system			
Plastic mulch	114.92 a	0.91 a	19.96 a
Coconut coir growth bag	74.67 b	0.55 b	12.15 b
Soil	103.79 a	0.84 a	18.44 a
SEM	4.56	0.03	0.74
MSD	15.45	0.11	2.51
p (α=0.05)	0.00001	0.00001	0.00001
Hybrid×Cultivation system			
p (α=0.05)	0.4906	0.8755	0.8809

[a,b] Means with different letters are significantly different according to Tukey's test (p=0.05). SEM: standard error of the mean; MSD: minimum significance difference.

study, production per plant and yield per hectare were similar when both hybrids were grown in soil with or without plastic mulch, and in both cases higher than when grown in growth bags. These results differ from those reported by Torres *et al.* (2017), who found that the production of *C. chinense* using transparent, silver, and white mulch was 996.9, 824.7, and 725.2 g m^{-2}, respectively, while plants grown without mulch yielded only 353.4 g m^{-2}. Ramírez *et al.* (2018) reported that the Jaguar variety produces around 15 t ha^{-1} when established in irrigated production systems or under favorable rainfed conditions in the south-central regions of Veracruz, Chiapas, and Campeche, reaching yields of 30 t ha^{-1} under drip irrigation and fertigation systems, and up to 43 t ha^{-1} under protected agriculture conditions. Javier-López *et al.* (2022) evaluated the production of the Chichen Itza hybrid in a greenhouse using four substrates and two fertilization sources and observed that cumulative yield per plant was 52.14% higher when grown in vermicompost with organic fertilization than in sand with chemical fertilization (616.41 g *vs.* 405.14 g). One of the factors that most influences yield is fertilization. In this study, a formula of 180-200-220 kg ha^{-1} of N-P-K was applied according to each phenological stage of the crop using a fertigation system. However, Llamas *et al.* (2024), using a semi-hydroponic system in bags with coconut fiber, reported yields of 65.8 and 59.6 t ha^{-1} for Megalodon and Chichen Itza hybrids over 28 harvests, applying nutrient solutions with conductivities of 0.8 to 1.6 mS cm^{-1}, which could explain the lower performance observed with stage-based fertigation.

CONCLUSION

The Megalodon habanero pepper hybrid showed greater plant height and stem diameter, with wider but similarly weighted fruits compared to the Chichen Itza hybrid. The Chichen Itza hybrid produced a higher number of fruits, resulting in greater production per plant and yield per hectare. Regardless of the hybrid, the highest fruit number and total fruit weight per plant and per hectare were obtained with direct sowing in soil, both with and without the use of plastic mulch.

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