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Yield of habanero pepper (*Capsicum chinense* Jacq.) under different NPK levels in Campeche, Mexico

Rendimiento de chile habanero (*Capsicum chinense* Jacq.) con el uso de diferentes niveles de NPK en Campeche, México

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ABSTRACT

In the Yucatan Peninsula, the habanero pepper (*Capsicum chinense* Jacq.) Is one of the most in-demand and valuable agricultural products. Improving field productivity implies fostering the development of regional producers. This research aimed to evaluate different NPK (Nitrogen, Phosphorus, and Potassium) fertilization formulas in open-field cultivation of habanero peppers. The experiment was conducted at the Xamantún Experimental Field of the Chiná Institute of Technology, Campeche, Mexico. Five fertilization formulas were assessed: 150-50-200, 200-100-240, 250-150-280, 300-200-320, and 350-250-360, using a fertigation system for habanero pepper plants. The study variables evaluated were the number of flowers per plant (NFP), number of fruits per plant (NFRP), fruit length (FL), fruit diameter (ED), and fresh fruit yield per plant (FFY). The results indicate that the 350-250-360 formula was the best treatment for NFRP, FL, ED, and FFY, obtaining an average yield of 41,259 kg ha^{-1}. The findings suggest that using higher doses than recommended increases fruit production per plant.

KEY WORDS: Yield productivity, Capsicum spp., plant nutrition, fertilization, fertigation system.

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RESUMEN

En la península de Yucatán, el chile habanero (*Capsicum chinense* Jacq.) es uno de los productos agrícolas de mayor demanda y valor. Mejorar los rendimientos productivos en campo supone incrementar el desarrollo de los productores regionales. El objetivo de la presente investigación fue evaluar diferentes fórmulas de fertilización NPK (Nitrógeno, Fósforo y Potasio), en el cultivo de chile habanero en condiciones de cielo abierto. El experimento se llevó a cabo en el Campo experimental Xamantún del Instituto Tecnológico de Chiná, Campeche, México. Se evaluaron cinco fórmulas de fertilización: 150-50-200, 200-100-240, 250-150-280, 300-200-320 y 350-250-360, en un sistema de fertirriego para plantas de chile habanero. Las variables de estudio evaluadas fueron: número de flores por planta (NFP), número de frutos por planta (NFRP), longitud de fruto (FL), diámetro de fruto (FD), y rendimiento de frutos en fresco por planta (FFY). Los resultados señalan como mejor tratamiento la fórmula 350-250-360 para las variables NFRP, FL, FD y FFY, obteniéndose un rendimiento promedio de 41259 kg ha^{-1}. Los resultados sugieren que usar dosis más elevadas a las recomendadas incrementan la producción de frutos por plantas.

PALABRAS CLAVE: Rendimiento de campo, *Capsicum* spp., nutrición vegetal, fertilización, sistema de fertirriego.

Introduction

Habanero pepper (*Capsicum chinense* Jacq.) is characterized by its flavor, aroma and spiciness, holds significant economic importance due to its demand in the national market for both fresh consumption and processing. Additionally, it serves as a source of natural colorants and other compounds such as capsaicinoids (Avilés-Baeza *et al.,* 2021); the latter can be widely used in medicine, cosmetics, paints, tear gas, among others (Chan *et al.,* 2011). Of the total national production, 75% is for fresh consumption, 12% for sauce production, and the remaining 13% for seed production (SIAP, 2022). In 2022, 645 ha were cultivated, yielding a total production of 14,128.81 t of fresh fruit in the states of Campeche, Yucatan, and Quintana Roo, of which 4,737.37 t were produced in Campeche (SIAP, 2022). Typically grown in open fields, the habanero pepper is exposed to various environmental factors that impact the quantity and quality of the product, as well as the profitability of cultivation (Lugo-Jiménez *et al.,* 2010).

This crop is important and representative of the Yucatan Peninsula, prompting efforts to achieve higher yields to meet its high demand. Specifically, for Campeche state, updating the elements comprising technology packages in each production modality, such as fertilization, is

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preferred. Several factors, including cultural, ideological, geographic, and economic aspects, influence the cultivation of habanero peppers in each region, with a focus on technology personalized for each capacity of producers, including nutritional aspects. Each region has used different preparations for supplying nutritional requirements in habanero peppers, using a widely variable formula of fertilization including nitrogen, phosphorus, and potassium (Ayala-Garay *et al.,* 2018). There are several recommendations on the amounts to apply fertilizers among which we can mention those proposed by Soria-Fregoso *et al*. (2002), Noh-Medina *et al*. (2010), Avilés-Baeza *et al*. (2021), and Javier-López *et al*. (2022). However, the results of field fertilization are not entirely satisfactory as this depends on the soil type and its characteristics (Borges-Gómez *et al.,* 2014; Ayala-Garay *et al.,* 2018; Meneses & Garruña, 2020).

The objective of this research was to know the performance of habanero pepper to the application of different levels of nitrogen (N), phosphorus (P), and potassium (K) fertilization, for the increase of fresh fruit yield.

Material and Methods

Study area description

The experiment was established under open-field conditions within the Xamantún experimental field of the Instituto Tecnológico de Chiná, geographically located 19°14' N and 90°28' W, with an average altitude of 44 m.a.s.l. The habanero pepper was planted in September in deep, fine-textured soil of the K'ankab lu'um (KV) according to the Mayan nomenclature (Palma-López & Bautista, 2019), and Ferric Luvisol according to the WRB (IUSS-WRB, 2015). The climate type is characterized as warm sub-humid with summer rainfall and a rainfall range of 1,000 to 1,200 mm (Matos-Pech *et al.,* 2022).

Experimental design

The habanero pepper variety (*Capsicum chinense* Jacq.) used for this project was "Mayapan", known for its good performance in the conditions of the Yucatan Peninsula and for producing fruits in demand by producers and consumers in the region. The experimental design used was a completely randomized block design with three replications. The treatments consisted of the application of five fertilization formulas (NPK) with different levels of nitrogen (N), phosphorus (P), and potassium (K). The experimental unit consisted of four furrows with a distance between them of 1.5 m and a furrow length of 14 m, covering a total area of 84 m^2. The useful plot was taken from the central part of each row, resulting in a surface area of 28 m^2.

The treatments consisted of the application of fertigation with five doses of fertilization with different NPK levels, which are the result of evaluating various nutritional requirements that have been used in some regions of Tabasco and the Yucatan Peninsula by various researchers and producers of habanero peppers (Soria-Fregoso *et al.,* 2002; Ramírez, 2003; Prado, 2006). Additionally, two proposals with higher quantities of NPK than those commonly used were

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employed (Borges-Gómez *et al.,* 2010; Meneses & Garruña, 2020), which are described in Table 1. Fertilization management consisted of the application of a base or background fertilization and fertigation, which were provided in a percentage of 30 % nitrogen, 50 % phosphorus, and 40 % potassium for the base fertilization, and 70 % nitrogen, 50 % phosphorus, and 60 % potassium in each of the fertilization formulas evaluated.

Table 1. Nitrogen, phosphorus, and potassium (NPK) fertilization formulas used as treatment in this study.

Treatments	Bibliographic reference
150-50-200 (**T**)	Based on (Soria-Fregoso *et al*., 2002).
200-100-240	With reference to the dose used by Ramírez, (2003).
250-150-280	
300-200-320	Requirement adjustment with respect to Prado, (2006).
350-250-360	

T=Test treatment

The study variables were the number of flowers per plant (NFP), number of fruits per plant (NFRP), fruit diameter (FD), fruit length (FL), and fresh fruit yield (FFY). Sampling was carried out based on ten plants taken per treatment and replicate. The selected plants were located in the central furrows of the experimental unit, which also formed a useful plot. Sampling was carried out every 8 days for flowering variables and every 15 days for vegetative development variables, starting 60 days after transplanting and continuing with sampling until the end of the crop.

Harvesting was carried out when the fruit reached commercial characteristics of color and fruit size (intense bright green). A total of six cuts were made, one every 12 days.

Statistical analysis

After analyzing the obtained data for the evaluated variables, the assumptions of normality (Shapiro-Wilks) and homoscedasticity (Levene's test) were checked and confirmed. The data were ordered and subjected to analysis of variance (ANOVA) using the statistical program SAS (Statistical Analysis System, SAS Institute Inc.), through the general linear model procedure for the completely randomized block experimental design. To determine the best treatments from a statistical standpoint, the treatment means were subjected to the Tukey multiple means comparison test (α=*0.05*).

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Results and Discussion

Number of flowers and number of fruits per plant

The effect of increasing the fertilization dose on habanero pepper for the number of flowers per plant could not be established through the 13 samplings conducted, given the dynamic process of the change from flower to fruit and the loss of unattached flowers, making precise counting challenging. This was reflected in the results of the mean comparison tests throughout the 13 samples taken. However, the formula 350-250-360 was identified as the treatment that induced the highest number of flowers (Tables 2 and 3).

Table 2. Test for comparison of means by sampling for the variable number of flowers per plant until day 111 after planting, with different NPK treatments.

Formula	Sample (day)						
Fertilization	69	76	83	90	97	104	111
150-50-200	114.00 ab	150.00 a	174.33 c	221.33 a	257.67 a	293.00 a	329.33 a
200-100-240	135.33 ab	171.33 a	207.00 abc	242.67 a	278.67 a	314.33 a	350.67 a
250-150-280	166.67 ab	147.67 a	183.33 bc	219.00 a	255.00 a	290.67 a	326.67 a
300-200-320	167.67 a	195.00 a	222.33 ab	248.67 a	277.67 a	303.33 a	317.00 a
350-250-360	166.67 ab	194.00 a	255.33 a	254.33 a	285.67 a	314.67 a	334.67 a
MSD	55.59	51.80	40.17	47.55	48.75	48.50	40.12

MSD= Minimum significant difference; treatments with the same letter are statistically equal (Tukey, $p>0.05$)..

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Table 3. Test for comparison of means by sampling for the variable number of flowers per plant from days 118 – 153 after planting, with different NPK treatments.

Formula	Sample (day)					
Fertilization	118	125	132	139	142	153
150-50-200	295.33 b	261.66 b	228.00 b	194.67 b	161.00 a	127.67 a
200-100-240	317.33 ab	284.33 b	251.00 ab	218.00 ab	185.33 a	152.00 a
250-150-280	297.00 b	267.00 b	237.33 b	207.67 ab	178.00 a	148.67 a
300-200-320	315.00 ab	287.66 b	247.33 b	211.33 ab	169.33 a	126.67 a
350-250-360	340.66 a	325.33 a	286.00 a	239.33 a	189.67 a	119.67 a
MSD	29.98	32.59	35.04	38.83	44.74	46.31

MSD= Minimum significant difference; Treatments with the same letter are statistically equal (Tukey, *p*=0-05).

These results indicate an effect of the nutritional regime on flowering in habanero pepper, increasing the number of flowers per plant (López-Gómez *et al.,* 2017). Regarding fruits number, it was possible to observe more precisely an increase due to the effect of the use of the fertilization formula (NPK) 350-250-360, an effect that was maintained throughout all the samplings. This suggests, under the study conditions, an adequate nutritional state of the habanero pepper plants. These findings can be explained by having habanero pepper plants with sufficient nutrition, as these stages of growth and development are crucial for fruit yield. During flowering, a large number of flowers and fruits are usually aborted due to nutritional deficiencies, resulting into losses for producers. The results found are supported by López-Gómez *et al.* (2017, 2020), who reported that flowering and fruit set are increased by the effect of the amount of nitrogen and phosphorus applied, including the type of soil.

Fruit length and diameter

The increase in fruit length and diameter was attributed to the effect of NPK fertilization, with 350-250-360 being the best fertilization formula across the samples, followed by 300-200-320 (Table 4 and Table 5). As nitrogen, phosphorus, and potassium levels increased, there was a noticeable increase in fruit size, attributed to their combined effects on plant growth, protein component (N), energy production (P) (López-Gómez *et al.,* 2017) and promotion of fruit quality (K) (Berrios et al., 2007). The results found are in agreement with what was referred by (López-Gómez *et al.,* 2017) in the sense that nutrient supply has an impact on plant development, yield,

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and fruit quality of habanero chili, including the soil and environmental conditions present during crop development.

Table 4. Test for comparison of means by sampling for the fruit length variable in mm.

Fertilization	Day of sampling					
N-P-K	93	105	117	129	142	153
150-50-200	50.33^{ab}	54.30^{a}	53.46^{abc}	55.40^{a}	55.30^{a}	54.86^{ab}
200-100-240	50.33^{ab}	53.06^{a}	54.50^{ab}	55.63^{a}	55.60^{a}	55.10^{ab}
250-150-280	46.53^{bc}	48.33^{b}	49.73^{bc}	50.87^{a}	50.83^{a}	50.33^{b}
300-200-320	45.66^{c}	47.86^{b}	49.30^{c}	50.47^{a}	50.36^{a}	49.90^{b}
350-250-360	51.63^{a}	53.73^{a}	55.13^{a}	39.33^{a}	55.23^{a}	55.76^{a}
MSD	3.67	4.15	4.79	35.69	5.90	5.24

MSD = Minimum significant difference; treatments with the same letter are statistically equal (Tukey, $p > 0.05$).

Table 5. Test for comparison of means by sampling for the fruit diameter variable in mm.

Fertilization	Day of sampling					
N-P-K	93	105	117	129	142	153
150-50-200	31.03^{ab}	32.36^{ab}	34.86^{ab}	35.73^{ab}	35.70^{ab}	35.13^{ab}
200-100-240	33.20^{a}	35.36^{a}	36.70^{a}	37.60^{a}	37.50^{a}	36.96^{a}
250-150-280	32.50^{ab}	33.86^{ab}	35.26^{ab}	36.10^{ab}	36.03^{ab}	35.46^{ab}
300-200-320	29.80^{b}	31.16^{b}	32.56^{b}	33.36^{b}	33.33^{b}	32.76^{b}
350-250-360	31.76^{ab}	32.50^{ab}	33.86^{ab}	34.76^{ab}	34.70^{ab}	34.13^{ab}
MSD	2.85	3.69	3.73	3.70	3.69	3.71

MSD = Minimum significant difference; treatments with the same letter are statistically equal (Tukey, $p > 0.05$).

Under the study conditions the Luvisol soil is a clayey soil considered suitable for vegetable cultivation. However, the study site is frequently intensively used for growing various crops, making a high dose of NPK suitable for habanero pepper cultivation. The type of soil has been shown to have a direct relationship with the growth and development of chili fruits (Borges-Gomez *et al.,*

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2010; Medina-Lara *et al.,* 2019). However, it can be argued that when plants are cultivated, the variety of factors that affect growth cannot simply be reduced to the presence or absence of a nutrient or lack of water; soil structure must be taken into account since it is complex and variable.

These results can be explained by considering the role of the evaluated macronutrients, while still considering soil conditions and other parameters, such as climatic factors (Ayala-Garay *et al.,* 2018). Obtained data are interesting since traditionally the fertilization formulas proposed are low ranging in an average order of 150-120-200 (Avilés-Baeza, 2021). Authors such as Borges-Gómez (2014), suggest that the productive potential of habanero pepper under irrigated conditions is mainly determined by soil class and mean annual temperature. If good production conditions are crucial for achieving high habanero pepper yields, the productive potential of the genotype used is equally important (López-Espinoza *et al.,* 2018). Under protected agriculture conditions several researchers report yields of up to 80 t ha^{-1} which is mainly attributed to management practices (Meneses & Garruña, 2020).

Fresh fruit yield

It is essential to consider that open-field habanero pepper production depends on genotype, soil type, environmental conditions, and crop management, including fertilization, factors that condition the crop yield potential. For the study conditions, the application of the 350-250-360 formula showed a considerable effect on fruit yield in the field, estimated in the order of 41,250 kg ha^{-1} (Fig. 1), taking into account the quality of the fruit. Considering the soil quality as good, this yield is higher than what is typically obtained under similar cultivation conditions in the state of Campeche, which is around 20,000 kg-ha^{-1}. Additionally, considering that five harvests are common in open-field conditions, producing habanero pepper fruits with commercial quality, the production is profitable (Castillo-Aguilar *et al.,* 2015).

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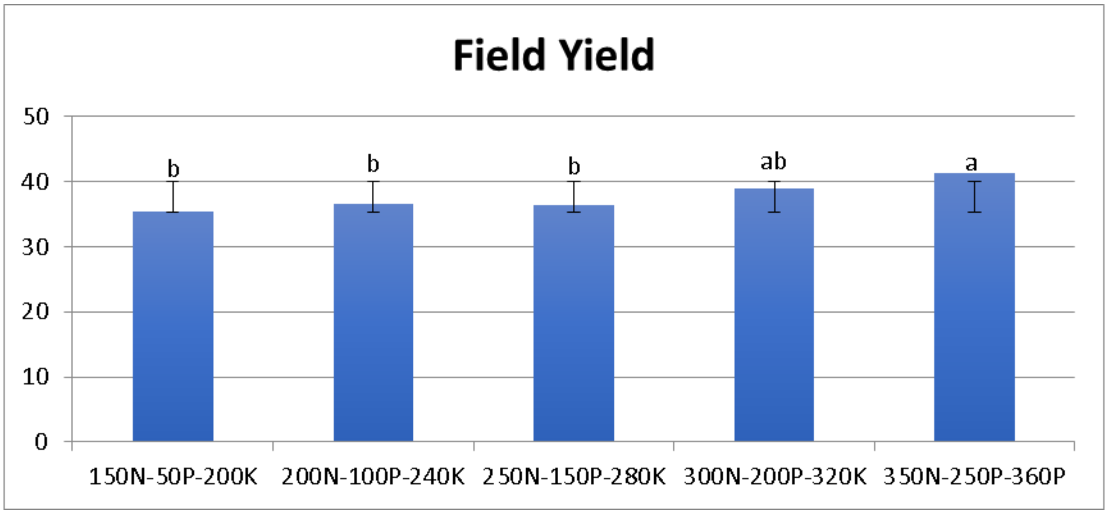

Figure 1. Habanero pepper fruit field yield (t ha^{-1}) by fertilization formula.

Treatments with the same letter are statistically equal (Tukey, *p =0.05*). MSD= 3985.8.
Source: Own elaboration based on the data obtained during this research.

The average fresh fruit yield obtained is comparable with other research works such as that of Rangel-Campos (2016), who obtained in his evaluations a yield of 42.56 t ha^{-1}. The results reveal a difference of 21,250 kg of fresh habanero pepper fruit, more than double the typically produced amount in open-field conditions. This could potentially translate into greater economic benefits for rural and industrial habanero pepper producers in the state of Campeche.

Conclusions

Higher levels of nitrogen, phosphorus, and potassium (NPK) resulted in a yield increase exceeding 100% compared to conventional methodology suggested for open-field habanero pepper cultivation (*Capsicum chinense* Jacq.). The fertilization formula that induced the highest habanero pepper fruit yield was 350-250-360, (NPK), with an average yield of 41,259 kg ha^{-1}. The application of the 350-250-360 formula is recommended for Luvisol soil conditions; however, results may diverge with changes in soil type, soil fertility, and production techniques. Lastly, it is advisable to direct future research efforts towards assessing the cost-benefit generated by the increased fertilization doses in local and regional production systems.

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Authors' contribution

Work conceptualization: C.C.C.C.A., S.G.B.P.; methodology development, C.C.C.A., R.A.C.C.M.; supervision and fieldwork: C.G.W.P., G.M.P., R.A.C.M.; software management, E.R.L.; experimental validation: C.C.C.A., E.R.L.; analysis of results: C.C.C.A., R.A.C.M., D.J.P.C.; data management: E.R.L., R.A.C.M.; manuscript writing and preparation: C.C.C.A., D.J.P.C.; drafting, revising and editing: C.C.C.A., D.J.P.C.; project manager: C.C.C.A., R.A.C.M., D.J.P.C.; fund acquisition: E.R.L., R.A.C.M.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Referencias

Avilés-Baeza, W.I., Lozano-Contreras, M.G., & Ramírez-Silva, J.H. (2021). Evaluation of habanero pepper (*Capsicum chinense* Jacq.) varieties under shade house conditions in Yucatan, Mexico. *Open Access Library Journal*, 8, 1-10. https://doi.org.10.4236/oalib.1107515

Ayala-Garay, O.J., Pinzón-López, L.L., Latournerie-Moreno, L., Ayala-Garay, A.V., & Tovar-Carvajal, S. (2018). Adaptaciones metodológicas para evaluar la calidad fisiológica en semillas de chile habanero (*Capsicum chinense* Jacq.). *AgroProductividad*, 11(9), 9-14. https://doi.org/10.32854/agrop.v11i9.1208

Berrios, U.M.E., Arredondo, B.C., & Tjalling, H.H. (2007). Guía de manejo de nutrición vegetal de especialidad pimiento. SQM SA.

Borges-Gómez, L., Cervantes, C.L., Ruiz, N.J., Soria-Fregoso, M., Reyes, O.V., & Villanueva, C.E. (2010). Capsaicinoides en chile habanero (*Capsicum chinense* Jacq.) bajo diferentes condiciones de humedad y nutrición. *Terra Latinoamericana*, 28(1), 35-41.

Borges-Gómez, L., Moo-Kauil, C., Ruíz-Novelo, J., Osalde-Balam, M., González-Valencia, C., Yam-Chimal, C., & Can-Puc, F. (2014). Suelos destinados a la producción de chile habanero en Yucatán: características físicas y químicas predominantes. *Agrociencia,* 48(4), 347-359.

Castillo-Aguilar, C.C., Quej-Chi, V., Coh-Méndez, D., Carrillo-Ávila, E., & Monsalvo-Espinoza, A. (2015). Producción de planta de chile habanero (*Capsicum chinense* Jacq.). *AgroProductividad,* 8(4), 73-78.

Chan, C.N., Sauri, D.E., Olivera, C.L., & Rivas, B.J.I. (2011). Evaluación de la calidad en la industrialización del chile habanero (*Capsicum chinense*). *Revista Iberoamericana de Tecnología Postcosecha*, 12(2), 222-226.

IUSS-WRB [International Union for Soil Sciences Working Group World Base for Soil Resources]. (2015). Base referencial mundial del recurso suelo 2014, Sistema Internacional de clasificación de suelos para la nomenclatura de suelos y la creación de leyendas de mapas de suelos. Food and Agriculture Organization of the United Nations (FAO).

Javier-López, L., Palacios-Torres, R.E., Ramírez-Seañez, A.R., Hernández-Hernández, H., Antonio-Luis, M.C., Yam-Tzec, J.A., & Chaires-Grijalva, M.P. (2022). Producción de chile habanero (Capsicum chinense Jacq.) en lombricomposta con fertilización orgánica. *Ecosistemas y Recursos Agropecuarios*, 9(3), e3348. https://doi.org/10.19136/era.a9n3.3348

López-Espinoza, S.T., Latournerie-Moreno, L., Castañón-Nájera, G., Ruiz-Sánchez, E., Gómez-Leyva, J.F., Andueza-Noh, R.H., & Mijangos-Cortés, J.O. (2018). Genetic diversity of habanero pepper (*Capsicum chinense* Jacq.) using ISSR. *Revista Fitotecnia Mexicana*, 41(3), 227-236. https://doi.org/10.35196/rfm.2018.3.227-236

López-Gómez, J.D., Villegas-Torres, O.G., Sotelo, N.H., Andrade R.M., Juárez, L.P., & Martínez, F.E. (2017). Rendimiento y calidad del chile habanero (*Capsicum chinense* Jacq.) por efecto del régimen nutrimental. *Revista Mexicana de Ciencias Agrícolas*, 8(8), 1747-1758. http://dx.doi.org/10.29312/remexca.v11i2.1777

López-Gómez, J.D., Sotelo, N.H., Villegas-Torres, O.G., & Andrade, R.M. (2020). Rendimiento y calidad del chile habanero en respuesta a la poda de conducción y régimen nutrimental. *Revista Mexicana de Ciencias Agrícolas*, 11(2), 315-325. https://doi.org/10.29312/remexca.v11i2.1777

Lugo-Jiménez, N., Carballo, B.M., Sauri, D.E., Centurión, Y.A., & Tamayo, C.E. (2010). Efecto del sistema de cultivo sobre la calidad microbiológica del chile habanero (*Capsicum chinense* Jacq.) después de su cosecha. *Revista Iberoamericana de Tecnología Postcosecha*, 11(2), 171-179.

Matos-Pech, G., Arcocha-Gómez, E., López-Hernández, M.B., Garma-Quen, P., González-Valdivia, N.A., & Echavarría-Góngora, E.J. (2022). Efectos de abonos verdes inoculados en las propiedades químicas de un luvisol férrio de Campeche, México. *Terra Latinoamericana,* 40, e993 1-9. http://dx.doi.org/10.28940/terra.v40i0.933

Medina-Lara, F., Souza-Perera, R., Martínez-Estévez, M., Ramírez-Sucre, M.O., Rodríguez-Buenfil, I.M., & Echevarría-Machado, I. (2019). Red and brown soils increase the development and content of nutrients in habanero pepper subjected to irrigation water with high electrical conductivity. *HortScience,* 54(11), 2039-2049. https://doi.org/10.21273/HORTSCI14157-19

Meneses, L.R., & Garruña, R. (2020). The habanero pepper (*Capsicum chinense* JACQ.) as a study plant model in Mexico. *Tropical and Subtropical Agroecosystems*, 23, 1-17.

Noh-Medina, J., Borges-Gómez, L., & Soria-Fregozo, M. (2010). Composición nutrimental de biomasa y tejidos conductores de chile habanero (*Capsicum chinense* Jacq). *Tropical and Subtropical Agroecosystems*, 12(2), 219-228.

Palma-López, D.J., & Bautista, F. (2019). Technology and local wisdom: the Maya soil classification app. *Boletín de la Sociedad Geológica Mexicana*, 71(2), 249-260. http://dx.doi.org/10.18268/BSGM2019v71n2a2

Prado, U.G. (2006). Tecnología de producción comercial de chile habanero (*Capsicum chinense* Jacq). Gobierno del estado de Tabasco – ISPROATAB.

Ramírez, L.E. (2003). Efecto de reguladores del crecimiento sobre la floración y amarre de fruto en chile habanero en campo e invernadero. [Tesis de Maestría, Colegio de Postgraduados, Campus Campeche].

Rangel-Campos, L. (2016). Crecimiento de chile habanero (*Capsicum chinense* Jacq.) bajo diferente espaciamiento entre hileras en la comarca lagunera. [Tesis de Maestría, Universidad Autónoma Agraria Antonio Narro].

Servicio de Información Agroalimentaria y Pesquera [SIAP]. (2022). Anuario estadístico de producción agrícola., https://nube.siap.gob.mx/cierreagricola/

Soria-Fregoso, M., Tun, S.J., Trejo, R.A., & Terán, S.R. (2002). Paquete tecnológico para la producción de chile habanero (*Capsicum chinense* Jacq.). SEP-DGTA ITA-2.