NOTAS TÉCNICAS

Evaluation of different substrates in the cultivation of two varieties of Capsicum chinense Jacq. "chile habanero" Mexican chili, in a controlled environment

Evaluación de diferentes sustratos en el cultivo de dos variedades de Capsicum chinense Jacq. "chile habanero" ají mexicano, en ambiente controlado

Romero-Viacava, Marta; Tenorio-Bautista, Saturnino Martin

Romero-Viacava, Marta
National University of San Cristobal de Huamanga. Faculty of Biological Sciences. Research and Innovation Unit of the Faculty of Biological Sciences. Botany Laboratory. Portal Independencia N° 57. Ramón Castilla Av. N° 152. Huamanga - Ayacucho, Perú

Tenorio-Bautista, Saturnino Martin *
saturnino.tenorio@unsch.edu.pe
National University of San Cristobal de Huamanga. Faculty of Biological Sciences. Research and Innovation Unit of the Faculty of Biological Sciences. Basic Sciences Research Center (CICB). Portal Independencia N° 57. Jr. Mariano Bellido N° 355. Huamanga - Ayacucho, Perú

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Abstract: In order to demonstrate the importance of nutrients, the present research work was carried out with the following objectives: to determine the production of the orange (V_1) and red (V_2) varieties using different organic substrates, to identify the most appropriate substrate for the cultivation of the two varieties and to compare the quantity of fruits of V_1 and V_2 of Capsicum chinense Jacq. "habanero chili" using the different substrates. The statistical results show that when observing the main effects for plant size, the effect of the variety-substrate and variety interaction were not significant, while the substrate effect is significant, with better growth and development of plants in S_4 and S_3. Another effect of study is the effect of average leaf size (cm), in the S_4 and S_3 were recorded better average leaf size. In the number of flowers in the variety-substrate interaction and the variety effect were not significant, the best flowering occurred in S_4. In number of fruits, V_1 presented a higher number of fruits compared to V_2 in S_4 and S_3. In the evaluation of average fruit weight (g), in the interaction and variety effects there were no significant differences, the substrate effect is significant where the best results were obtained in S_4. Finally, the average fruit size (g), in V_1 is significantly greater than V_2, while in S_4, S_3 and S_2 the plants presented greater average fruit size without significant differences among the three substrates.

Keywords: *Capsicum chinense*-Ayacucho, adaptation of two varieties, Huamanga, organic management.

Resumen: Los ajíes son los principales insumos en la gastronomía, en la mayoría de los casos su producción es extensiva, sin tener en cuenta la fertilización de los suelos de cultivo, con la finalidad de demostrar la importancia de los nutrientes se realizó el presente trabajo de investigación con los siguientes objetivos: determinar la producción, de las variedades anaranjada (V_1) y roja (V_2) empleando diferentes sustratos orgánicos, identificar el sustrato más apropiado para el cultivo de las 2 variedades y comparar la cantidad de frutos de las V_1 y V_2 de *Capsicum chinense* Jacq. "chile habanero" utilizando los diferentes sustratos. Los resultados estadísticos señalan al observar efectos principales para tamaño de plantas, el efecto de la interacción variedad-sustrato y variedad no fueron significativos, mientras el efecto sustrato es significativo alcanzando mejor crecimiento y desarrollo las plantas en S_4 y S_3. Otro efecto de estudio es el efecto tamaño promedio de hojas (cm), en los S_4 y S_3 se registraron mejor tamaño promedio de hojas. En el número de flores en la interacción variedad-sustrato y el efecto variedad resultaron no significativos, el mejor florecimiento ocurrió en el S_4. En cantidad de frutos la V_1 presentó mayor cantidad de frutos en comparación con la V_2 en S_4 y S_3. En la evaluación de peso promedio de frutos (g), en los efectos de interacción y variedad no hubo diferencias significativas, el efecto sustrato es significativo donde los mejores resultados se obtuvieron en el S_4. Finalmente, el tamaño promedio de frutos (g), en V_1 es significativamente mayor a V_2, mientras en S_4, S_3 y S_2 las plantas presentaron mayor tamaño promedio de frutos sin que exista diferencia significativa entre los tres sustratos.

Palabras clave: *Capsicum chinense*-Ayacucho, adaptación de dos variedades, Huamanga, manejo orgánico.

Introduction

In the highlands of Peru, there is a region rich in gastronomy, history and culture, the chili peppers characterize the cuisine of Ayacucho, with traditional dishes that are a delight for domestic and foreign tourists, being the chili bell pepper the main ingredient of this, giving it the special organoleptic characteristics of the fruits of "habanero chili" (CH) with aroma, flavor, heat, sparkle, color, texture and heat, conquering its primordial role in world cuisine[1,2]. This variety of resources should be added to the culinary art, such as the incorporation of CH, after studies of adaptation, acclimatization, planting substrates and fertilization under the conditions of Ayacucho.

It is necessary to introduce new varieties of chili peppers, with the intention of contributing more options to gastronomy, with a species well known in Mexico (*C. chinense*) whose importance is vital to enhance the exquisiteness of the stews, currently Peruvian gastronomy has received contributions from Japanese, African, Italian and Chinese migrants[3,4]. The study of new species is relevant, knowing their germination, growth and development of (*C. chinense*), which is widely used in gastronomy. There are several studies of variability, production, characterization and molecular studies of the *Capsicum* genus, none of the introduction and cultivation in other areas, as well as its adaptation to organic fertilization[5]. In order to achieve the desired results, cultivation materials (potting soil, black soil and sand) were requested from INIA - Ayacucho, which carries out different types of research and has material for different species or varieties of plants and guinea pig manure from a breeding farm. In *C. annuum* L variety glabriusculum, under experimental conditions, germination varies according to different physicochemical parameters (temperature, humidity, light and phytohormones). In *C. annuum* L variety glabriusculum, under experimental conditions, germination varies according to the different physical-chemical parameters (temperature, humidity, light and phytohormones), the phytohormone (gibberellic acid) is used to overcome seed dormancy, for which effect 2000 seeds were

Author notes

* **Dirección de contacto:** Saturnino Martin Tenorio-Bautista.

immersed in a solution of 400 ppm for 20 h, the seeds were dried under shade, sown and after 3 weeks germinated in 90%.

In Venezuela (Monagas), trials were carried out with transplants of *C. chinense* Jacq. at 35, 40, 45 and 50 days after seedling, in definitive soil, the highest yield (16066 t/ha) was produced when the transplant was carried out using 50-day-old seedlings. Successful transplanting was performed 40 days after germination, once the plants reached heights between 15 to 18 cm, they were transplanted into black polyethylene bags 600 caliber of 45 x 50. After 45 days, the seeds were transplanted to the definitive field[6-9]

Although Mexico is the country with the greatest genetic diversity of Capsicum, the CH is almost synonymous with Mexican nationality and its cuisine, there is little research on this species. On the contrary, in other countries there are public and private institutions that dedicate research programs on this plant in order to obtain improved varieties, adapted to the climatic conditions of the place of cultivation and organic cultivation. The use of this resource requires expanding its genetic diversity, of the varieties of chili, many are not hot, used in soft drinks and dyes, it is also used to produce many other products. A main characteristic that made it attractive is the pungency that is due to capsaicin, or more precisely, to a group of substances of alkaloid nature called capsaicinoides called capsaicinoids. Because of its healing properties that CH possesses, it increases the production of endorphins, which cause a pleasant sensation, can help relieve migraines and headaches, has antibacterial properties that prevent and attack sinusitis, helps raise metabolic activity, helping the body to burn fat and calories indicates that in Yucatecan gastronomy CH is the main ingredient of one of the hottest sauces that are served[10-15]. The CH is not only consumed for its nutritional value but involves a persistent cultural characteristic, they consume chili because they learned from their parents, but also for its flavor and spiciness[10].

Organic fertilization provides nutrients to the plants, restoring the biological properties of the soil, improving a dynamic interaction with microorganisms, making it possible to achieve good results, reducing production costs in planting, avoiding environmental pollution and soil deterioration[1,16]. Taking into account the importance of CH for the Ayacucho region, with the intention of carrying out genetic improvement to obtain new varieties adapted and acclimatized to our region, its biological and cultural factors and organic production with management strategies and genetic improvement, this research was carried out to allow new alternatives in the kitchen[17,18]. The indiscriminate use of chemical fertilization in agricultural production has caused considerable damage to the environment, which is why we are looking for organic production alternatives that have positive effects on crop yield and quality[19]. With the desire to enrich the Ayacucho and Peruvian gastronomy, and the purpose of carrying out genetic improvement and organic production, we proposed to carry out the research work, with the objectives were i) To determine the production of V_1 and V_2 of *C. chinense* Jacq. with different substrates. ii) To identify the most appropriate substrate for the cultivation of V_1 and V2. iii) To compare the amount of fruit of V_1 and V_2.

Materials and methods

The work was carried out in the city of Huamanga (Ayacucho), whose geographical coordinates are: 13°08' South latitude, 74°13' West longitude, and 2724 meters above sea level. The average annual temperature is 16.2° C, with an average annual maximum of 24.0° C, an annual minimum temperature of 8.4° C and a rainfall of 572.9 mm, with the hottest months of summer and the coldest months of June and July, with winter frosts. It is characterized by a temperate climate due to the effect of the height above sea level, with seasonal rains between the months of October and March, with rainy summer and dry winter, with an average annual humidity of 65%. An atmospheric pressure of 590 mmHg. Ecologically, according to Holdridge's world life zone classification system, it is subtropical low mountainous thorny steppe (ee-MBS)[20,21], and according to Pulgar Vidal[22] it is located in the Quechua region.

The experiments were carried out in a nursery of 2 x 3 m, with a height of 2 m covered with rastel mesh for nursery, on the roof was placed plastic over the mesh because of the rain, located on the terrace of the house because of the pandemic. In the present research work, the methodology used in the production of potato seed[23] was used. In the statistical processing of the results, the Completely Randomized Design (CRD) with a factorial arrangement of 5V x 5S was used. Two varieties of CH V_1 and V_2 were used, 4 types of substrates, and the type of research was Basic Descriptive Experimental, taking into account the variables and indicators. *Variables and indicators*. Black soil (proportions), guinea pig manure (proportions), cultivated soil (proportions), sand (proportions)[24]. In order to meet the objectives of the work, the cultivated soil, black soil and sand came from the experimental fields of INIA - Ayacucho and the guinea pig manure came from a guinea pig farm. Special care was taken in the preparation of the 4 levels of growing substrates for each experimental unit (EU), first they were prepared in the indicated proportions and then distributed in equal parts, then the seedlings were placed in a designated location.

The experiments began the first week of January 2021 with the installation of seedling beds, followed by the first and second transplanting, followed by the different phenological phases until the harvesting of the fruits and obtaining the seeds, which took place the first week of April 2022.

Varieties of C. chinense Jacq CH. V_1 and V_2 were considered. In the experimental production of the varieties, the following were estimated: number of emerged seedlings (NPE), plant size (TP), average leaf size (TPH), number of flowers (NF), number of fruits (CF), average fruit weight (PPF), average fruit size (TPF)[9,18,25].

Seed collection. Two varieties of fruits of C. chinense Jacq. CH (V_1 and V_2) were collected in Mexico City (2019), transferred to the city of Ayacucho. The seeds were sown obtaining fruits (2020), the seeds of the 2 varieties duly selected, were used in the present work.

Preparation of seedbed. The seedbed was prepared in 6 technopor buckets, using black soil and sand in a 3:1 ratio. In each of the first 3 containers 40 seeds of V_1 were sown and in each of the remaining 3 containers an equal amount of seeds of V_2[26,27] were grown.

Treatment design. It was completely randomized (DCA), the substrate factor and the variety factor[28] were studied. The substrate factor was examined at four levels: S_1 arable soil, S_2 arable soil + black soil + sand (3:2:1), S_3 arable soil + guinea pig manure (3:1), S_4 arable soil + black soil + sand + guinea pig manure (3:2:1:1:1). In the variety factor of *C. chinense* Jacq. CH, 2 levels were analyzed: V_1, V_2. The substrates were prepared in proportions (1:0, 3:2:1, 3:1, 3:2:1:1:1) that received the seedlings from the seedbed, with 3 replicates each.

Transplanting to 7 x 10 cm polyethylene bags. The seeds germinated in seedling beds were transplanted to polyethylene bags, the substrates were placed in equal parts in each of the 3 replications, the average height of the seedlings at the time of transplanting was 5 cm on average.

Transplanting to 25 x 48 cm polyethylene bags. Once the plants gained height, foliage and began to form the first flower buds, they were transplanted to larger polyethylene bags of 25 x 48 cm, to complete the growth and development in each of the experiments. Sampling. Sampling was carried out according to the growth and development of the plants, every 15 days for the dependent variables. Sampling began 15 days after transplanting, using a tape measure to measure plant height (PA) (from the base of the substrate to the apex of the highest branch), and a vernier to measure stem diameter (SD) (at 5 cm height of the plant stem)[18,25].

Processing and analysis of results. These were carried out through descriptive statistical analysis; completely randomised design (CRD), analysis of variance with factorial with factorial arrangement A x B, Tukey's mean comparison test[28].

Resultados

FIGURE 1
Production process of *C. chinense* from adapted seeds
to fruit harvesting and new seed production new seeds

TABLE 1
Analysis of variance and Tukey's test of plant size cm vs variety*substrate

Source	GL	SC Adjusted	MC Adjusted	Value F	Value p
Variety	1	3.38	3.375	.32	.579
Substrate	3	2395.46	798.486	76.05	.000
Variety*Substrate	3	16.79	5.597	.53	.666
Error	16	168.00	10.500		
Total	23	2583.62			

TABLE 2
Analysis of Variance and Tukey's test for mean leaf size (cm) vs. variety*substrate

Source	GL	SC Adjusted	MC Adjusted	Value F	Value p
Variety	1	2.667	2.6667	3.56	.078
Substrate	3	110.833	36.9444	49.26	.000
Variety*Substrate	3	.333	.1111	.15	.929
Error	16	12.000	.7500		
Total	23	125.833			

TABLE 3
Analysis of variance and Tukey's test for number of flowers vs. variety*substrate

Source	GL	SC Adjusted	MC Adjusted	Value F	Value p
Variety	1	10.7	10.67	.22	.645
Substrate	3	12605.8	4201.94	87.01	.000
Variety*Substrate	3	19.3	6.44	.13	.939
Error	16	772.7	48.29		
Total	23	13408.5			

TABLE 4
Analysis of variance and Tukey's test for number of fruits vs variety*substrate

Source	GL	SC Adjusted	MC Adjusted	Value F	Value p
Variety	1	145.0	145.04	6.11	.025
Substrate	3	520.5	173.49	7.30	.003
Variety*Substrate	3	172.5	57.49	2.42	.104
Error	16	380.0	23.75		
Total	23	1218.0			

TABLE 5
Analysis of variance and Tukey's test for mean fruit weight (g) vs. variety*substrate

Source	GL	SC Adjusted	MC Adjusted	Value F	Value p
Variety	1	.2204	.2204	.25	.623
Substrate	3	35.9346	11.9782	13.64	.000
Variety*Substrate	3	2.8379	.9460	1.08	.387
Error	16	14.0533	.8783		
Total	23	53.0463			

TABLE 6
Analysis of variance and Tukey's test for mean fruit size cm vs variety*substrate

Source	GL	SC Adjusted	MC Adjusted	Value F	Value p
Variety	1	1.550	1.5504	7.74	.013
Substrate	3	8.875	2.9582	14.76	.000
Variety*Substrate	3	1.468	.4893	2.44	.102
Error	16	3.207	.2004		
Total	23	15.100			

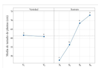

FIGURE 2
Main effects for plant size (cm) with the two varieties of C. chinense Jacq. In 4 different substrate types

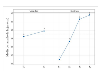

FIGURE 3
Main effects for average leaf size (cm) (cm) with two cultivars of C. chinense Jacq. 4 types of substrates

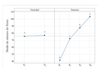

FIGURE 4
Main effects for flower number with two varieties of C. chinense Jacq. On four types of substrates

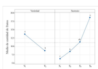

FIGURE 5
Main effects for fruit quantity with two varieties of C. chinense Jacq. On 4 types of substrates substrates

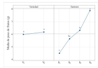

FIGURE 6
Main effects for average fruit weight (g) with two varieties of C. chinense Jacq. On 4 different types of substrates

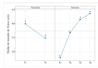

FIGURE 7
Main effects for average fruit size (cm) with two varieties of C. chinense Jacq. 4 types of substrates

Discussion

The seeds of the seedlings germinated 58 V_2 and 54 % V_1 in 21 days, under the environmental conditions of the city of Huamanga. Rangel Campos[29] reports germination in 14 days after sowing (dds). Buenfil Ocampo[30], the first seeds germinated 6 dds under greenhouse conditions using commercial substrate "Cosmopeat". Our results do not coincide, with differences of 7 and 15 days in seed germination, probably due to temperature variations during the day; our experience was in the open air.

Table 1 and Figure 2 present effects for TP (cm), the effect of the interaction between the variables is not significant, while the effect of substrate is significant, the plants reached greater size in substrates S_3 and S_4, both not differing significantly. The figure clearly shows that as nutrient concentration increases, growth and development is upward. The interaction effects and the variety are not significant, while the effect of the substrate is significant, the plants reached greater size in S_4 and S_3, both do not differ significantly. López Arcos et al.[31], supplied organic fertilizer, with significant differences between treatments for the PA variable. Plants treated with manure infusion (T_3) reached the greatest height 52 cm, surpassing the rest. The treatment that reached the lowest height was the experimental control of 17 cm. Tucuch-Haas et al.[32] observed the variation in PA through statistical analysis, the differences observed in the treatments were mainly due to the effect of substrates and, to a lesser extent, of nutrient solutions. Quintal Ortiz et al.[33] reported that PA and leaf size were greater with T_1 ($P \leq 0.05$), due to greater moisture content and availability in the substrate, while growth was low in treatments with less irrigation. Rangel Campos[29], a slow growth until 63 days after transplanting (ddt) this behavior may be related to the stress caused by the change from transplanting to open field and the consequent recovery, since during the first 4 weeks the plants develop their root and foliar system. Lopez Puc et al[1]. point out that the use of fertilizers in crops allows obtaining higher yields, reducing crop production costs and avoiding environmental contamination. Medina Gámez[8] observed significant differences between treatments for the PA variable. T_1, T_3, T_7 and T_{16}, with organ mineral nutrient solution, achieved higher yields. The present work is corroborated by the aforementioned works, because greater heights were reported in treatments with higher proportions of guinea pig manure. It is known that organic matter contains NPK and other nutrients necessary for plant growth and development. It is also necessary to mention that roots absorb water and along with this vital element, nutrients are absorbed when they are dissolved in water.

Table 2 and Figure 3, show the interaction effect of the varieties are not significant, while the effect of the substrate is significant, S_4 and S_3 presented greater size (cm) of leaves, both do not present significant difference, when we observe the mean line of the TPH the 2 varieties do not differ statistically, while when verifying the behavior of S_1, S_2 and S_3 they differ statistically, S_3 and S_4 do not, but the TPH are statistically greater than the first 3 treatments. About TPH (cm), Quintal Ortiz et al.[33], observed that leaf water potential is important in treatments, with high substrate moisture values PA and leaf area were higher with T_1 ($P \leq 0.05$). These results fit with those pointed out by López Arcos et al.[31], when evaluating the DT, they observed vermicompost (T_4) with 0.859 cm, surpassing the others, manure infusion (T_3), bokashi (T_1) and compost (T_2) with respect to the experimental control (T_0), they mention plants with a DT should possess leaf size. Fernando Peña & Zenner de Polanía[34], affirm that high percentages of dry matter in the aerial part of *C. annuum* plants indicate a greater number of leaves, source and production of photo-assimilates for the filling of demanding organs. In addition, Peil & Gálvez[35], show that, under the conditions of cultivation in artificial substrates under greenhouse, with a water and nutrient supply close to the optimum, it is possible to achieve maximum plant growth with a reduced root system that achieves foliage production. David-Santoya[36], when evaluating PA, leaf area and number of leaves, the combination of vermicompost and soil (1:1) significantly increased ($p \leq 0.05$) the height and leaf area of CH seedlings when compared to the control. With the results that we had in our work, they mean, when the substrate is increased the foliage increases, however, as soon as it is too much manure increased the results are similar between S_3 and S_4, statistically, the leaves are important for being the places where photosynthesis takes place taking advantage of sunlight, CO_2, water and nutrients (guinea pig manure) containing the substances.

Table 3 and Figure 4, examined the interaction effect and variety effect are not significant, in the 2 varieties used, however the substrate effect is significant, the plants of the S_4 substrate presented more flowers ($p < 0.05$, $\alpha=0.05$), the 4 substrates are statistically different, which means that S_1 produces less number of flowers, while in S_4 the production is higher number of flowers. It is clearly observed that the number increases as the nutrient concentration is higher in each of the treatments. These results are corroborated by Lopez Arcos et al.[31], the application of vermicompost and other organic fertilizers (bokashi, compost, manure infusion) at the beginning of flowering in vegetables, because it can present precocity in production and benefit the producer specially to calendar the harvests. Lopez Puc et al[1]., in agronomic management and the factors that influence the growth and development of CH crop plants, flowers appeared 1 week after the first flower buds, flowers that formed between 27 and 47 days after transplanting (DPT) did not become fruits, while flowers that were produced at 63 DPT became fruits, considering the total quantity of flowers, significant differences in plants developed in different types of soil. Ramírez-Luna et al.[37], using growth regulators on flowering and fruit setting in CH, reported an increase in NF per plant, compared to the control treatment, possibly because these products contain gibberellins, chemical substances capable of promoting flower formation under certain environmental conditions of temperature and light.

Table 3 and Figure 4, examined the interaction effect and variety effect are not significant. And variety effect is not significant, in the 2 varieties used, while the effect of substrate is significant, the plants of substrate S_4 showed a greater number of flowers ($p < 0.05$, $\alpha=0.05$), the 4 substrates are statistically different, which means that S_1 produces less flowers, while in S_4 the flowers, while in S_4 the production is higher quantity of flowers. Of flowers. It is clearly observed that the number increases as the nutrient concentration is higher in each of the treatments. Is higher in each of the treatments. These results are corroborated by López Arcos et al.[31], the application of vermicomposting and other organic fertilizers organic fertilizers (bookish, compost, manure infusion) in early flowering at the beginning of flowering in vegetables, is based on the fact that that early production can occur and can benefit the producer benefit the grower, especially for the timing of harvesting. The harvests. Lopez Puc et al[1]., on agronomic management and the factors that influence the growth and development of CH crop plants, flowers appeared 1 week after the first flowers buds, the flowers that formed between 27 and 47 days after transplanting (DPT) did not develop into fruit, while flowers that formed between 27 and 47 days after did not develop into fruit, while flowers produced at 63 DPT developed into fruit. At 63 DPT became fruit, considering the total number of flowers, the significant the total number of flowers, the significant differences in the plants developed in different types of transplanting in the plants developed in different soil type's soil. Ramirez-Luna et al.[37], using growth regulators on flowering and fruit set growth regulators on flowering and fruit setting in CH, reported an increase in NF per plant, compared to the control treatment, possibly because these products contain gibberellins, substances possibly because these products contain gibberellins, chemical substances capable of promoting flower formation under certain environmental conditions of temperature and under certain environmental conditions of temperature and light.

Table 4 and Figure 5, represent the main effects of fruits, the varieties differ in fruit production, V_1, produced higher CF fruits under the conditions of the present experiment, when we observe the effects of the substrates are statistically significant, in S_4 and S_3 the plants had higher CF, both did not present significant difference, that is, the mentioned substrates produce statistically equal amount of fruits. According to Peil & Gálvez[35], the number of young fruits growing on the plant depends considerably on the source/sink ratio, which can be defined as the ratio between the photosynthetic rate and the sum of the sink powers of all plant organs, a low source/sink ratio produces small fruits and abortion of young fruits. Lopez Puc et al[1]., the fruits depend on NF produced by the plants, when comparing the production of CH by soil type, they observed that in the red soil they obtained better results, when performing the analysis of variance, there was a significant difference in CF by the interaction of the factors soil type and DPT, obtaining plants developed in black soil, had few fruits 24 %, while in red and brown soils they produced 40 and 36 % respectively. Rangel Campos[29], when studying the growth of CH under different spacing between rows in the Comarca Lagunera, reported fruit production per plant, there was no statistical difference between treatments. Borges-Gómez et al.[38], the yield of CH was statistically similar when 120 and 240 kg N ha^{-1} were applied, however, the yields with these doses of N were higher than the treatment where N was not applied. Haro Hernández & Valarezo Olivo[9], in two harvests carried out, T. presented the highest CF with a total of 43.70 fruits per plot, followed by T_1 and T_4 with values of 36.40 and 35.70 fruits per plot respectively, while T_3 reached 33.00 fruits. The results of the experiments carried out were ratified by the authors cited above, as the proportion of matter increases the amount of fruit is greater, the results of which are corroborated by the results of the experiments carried out on T_1 and T_4, the results are corroborated by the cited authors.

Table 5 and Figure 6, the interaction and variety effects for PPF are not significant, while the substrate effect is significant, the S_4 plants presented higher PPF ($p < 0.05$, $\alpha=0.05$), the results obtained are validated by the following authors. Borges-Gómez et al.[13], the yields achieved indicate the importance of applying high doses of N, P_2O_5 and K_2O to the soil and sufficient water availability in the soil solution for this species. López Arcos et al.[31], applying organic fertilizers, PPF 9.49 g per fruit using vermicompost, also observed significant differences between treatments for CH fresh fruit yield; plants treated with vermicompost (T_4) and manure infusion (T_3) obtained yields of 949 g/plant and 863 g/plant, respectively. With compost, bokashi and the experimental control obtained yields of 687, 679 and 325 g/plant. It is also mentioned that organic fertilizers provide nutrients to the plants, increasing the physical, chemical and biological properties of the soil, increasing the unit production of chili, and improving the quality of the fruit. On the other hand, Tucuch-Haas et al.[32] reported CH yields of 302 g/plant in 3 fruit cuts, supplying the Steiner solution with a NH_4^+/NO_3^- ratio of 10/90 %, respectively, in combination with a mixture of tezontle-coconut fiber substrate (75-25 % respectively), with tezontle granulometry of 10-20 mm. Ramirez-Luna et al.[37], when observing their results of the effect of regulating products in greenhouse conditions of CH, small fruit sizes, explaining this result to the fact that they received a lower intensity of light, since the type of plastic used in the greenhouse was the 600 caliber, which has 90 % transparency, reducing by 10 % the intensity of sunlight entering the greenhouse, which favored the development of larger plants, with thinner stems, but small fruits. According to Haro Hernandez & Valarezo Olivo[9], the fruit weights with the highest results in T_2 and T_1 with values of 810.00 and 753.40 g respectively per plot. The results in our work are supported by the different authors mentioned.

Table 6 and Figure 7, the interaction effect is not significant, but the effect of variety is significant, the average fruit size of V_1 is significant to V_2, while the effect of substrate is significant. In substrates S_4, S_3 and S_2 the plants showed higher average fruit size, and there is no significant difference between the 3 substrates. These results found in the present work are in accordance with those generated by the researchers. Haro Hernández & Valarezo Olivo[9] reported that T_2 with 9.10 cm was outstanding in terms of fruit length, while T_1, T_3, T_4 and the control were 8.02, 7.02, 7.30 and 6.80 cm, respectively. Huez López et al.[39], when carrying out productivity studies of CH under greenhouse conditions, obtained large fruits (> 4.0 cm). Ebel et al.[15] reported higher fruit weights in treatments without pitahaya, whose fruits were of first quality. The length in all treatments ranged between 3.5 to 4.5 cm per chile bell pepper and the width between 2.5 and 3.5 cm. López Arcos et al.[31], using organic fertilizers on CH crops claim to have a positive and significant effect, since the nutrients are dispensed in the soil when the plants require them, since their release is slow and gradual, and there are significant differences between treatments for CH fruit yield. Tucuch-Haas et al.[32], when analyzing the yield and fruit quality variables (weight, length and diameter), the effects obtained from the nutrient solution independently of the substrate showed that the best treatment was the ammonium/nitrate ratio of 20/80 %. Ugas & Mendoza[27] mentioned that chili peppers are demanding plants and when grown commercially require attention and nutrition, they need cattle manure or guano of 20 t/ha, in addition to foliar fertilizers and irrigation for production. Our results indicate that the more organic matter the substrates have, the larger the fruit size, which corroborates the aforementioned autores. In addition, we agree with López Arcos et al.[31], who mention that there are few or almost no studies focused on the use of organic fertilizers in CH, being an alternative its integral use of available natural resources (manure, plant residues) of low cost for production. Its use allows obtaining higher crop yields, protecting the soil without contaminating it, and making its handling safer. The use of chemical fertilizers in crop fertilization is currently causing the soil to suffer an accelerated depletion of organic matter and a nutritional imbalance, and over time it loses its fertility and productive capacity.

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Authors' contribution:*Marta Romero Viacava*, development of the research project, selection and research, selection and acquisition of seeds of Capsicum chinense Jacq "chile habanero"; responsible for the development for the development, execution and final report of the project. *Saturnino Martín Tenorio Bautista*, review of the literature for the project literature review for the project, sampling, preparation of the final report, discussion of results and final report, discussion of results and statistical analysis.

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