



Influence of different planting frames on the development of the hybrid pepper (*Capsicum annuum* L.) 'Carleza' under protected cultivation

Influencia de diferentes marcos de siembra en el desarrollo del pimiento (*Capsicum annuum* L.) híbrido 'Carleza' bajo cultivo protegido

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ABSTRACT: The work was developed with the objective of evaluating the influence of three planting frames in the development of the hybrid pepper (*Capsicum annuum* L.) 'Carleza', under protected cultivation, in a Basic Business Unit of Protected and Semi-protected Crops of the Company "Paquito Rosales Benítez" from Yara municipality, Granma, Cuba. It was used a random block design with three treatments: planting frame 15 cm away (T1), planting frame 40 cm away (T2) and planting frame at 20 cm (T3) and 3 replications. All this, to study the morphological and agronomic parameters of the crop: plant height, stem thickness, fruit length and diameter, number of fruits per plant and agricultural yield after transplanting pepper crop. All of them were compared by means of a double classification analysis of variance (ANOVA) with the statistical package STATISTICA and when there were significant differences, the Fisher's LSD multiple comparison test for a probability $p < 0.95$. The results allowed determining that the T2 planting frame provided an agricultural yield of 19.00 t ha⁻¹; plants reached a stem 15.33 mm thick by 140.00 cm high and fruits with an average length of 7.98 cm by 8.75 cm in diameter.

Key words: fruits, agricultural yield, stem thickness, length and diameter.

RESUMEN: El trabajo se desarrolló con el objetivo de evaluar la influencia de tres marcos de siembra en el desarrollo del pimiento (*Capsicum annuum* L.) híbrido 'Carleza', bajo cultivo protegido, en una Unidad Empresarial Básica de Cultivos Protegidos y Semiprotegidos de la Empresa "Paquito Rosales Benítez" del municipio Yara, Granma, Cuba, mediante un diseño de bloques al azar con tres tratamientos: marco de siembra a 15 cm de distancia (T1), marco de siembra a 40 cm de distancia (T2) y marco de siembra a 20 cm (T3) y tres réplicas, para estudiar los parámetros morfológicos y agronómicos del cultivo: altura de la planta, grosor del tallo, longitud y diámetro de los frutos, número de frutos por planta y el rendimiento agrícola después del trasplante del cultivo del pimiento. Todos ellos comparados mediante un análisis de varianza (ANOVA) de clasificación doble con el paquete estadístico STATISTICA y cuando existieron diferencias significativas, la prueba de comparación múltiple de LSD de Fisher para una probabilidad $p < 0,95$. Los resultados permitieron determinar que el marco de siembra T2 proporcionó un rendimiento agrícola de 19,00 t ha⁻¹, las plantas alcanzaron un tallo de 15,33 mm de grosor por 140,00 cm de altura y frutos con una longitud media de 7,98 cm por 8,75 cm de diámetro.

Palabras clave: frutos, grosor del tallo, longitud y diámetro, rendimiento agrícola.

INTRODUCTION

The pepper (*Capsicum annuum* L.) is one of the most consumed vegetables worldwide, due to the combination of its flavor, nutritional and economic value (1,2). It is

cultivated in most of the countries of the world where environmental conditions are favorable for its development (3). In Cuba, it is one of the main vegetables, given its wide consumption by the population, as well as its level of export (4,5).

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At present, pepper production under protected conditions is limited, due to the use of a 15 cm planting frame between plants, which brings with it a good growth of crop, but with very small fruits. For this reason, efforts are aimed at achieving a sustained increase in pepper production (6), for which resources are allocated, as well as cultivars with short cycles and high yields, which allow guaranteeing the demand for the product. This is a challenge for the production units, which apply current methods and procedures to respond to the population's food requirements (7).

One of the alternatives to increase agricultural production is through the planting of protected crops. This allows extending the production calendars of vegetables, with high and stable yields throughout the year. In addition to their fresh supply to the national and international market, with high quality, even in the periods in which the supply of horticultural production grown in the open field is limited, as in the summer, a better option is protected systems, since in these it is possible to obtain pepper productions all year round (5,8,9).

The peppers planted in protected cultivation houses achieve an increase in yields between 10 and 20 t ha⁻¹ compared to the traditional methods applied in open field Cuban agriculture, which is why it presents a great advantage (10). However, pepper productions under protected conditions still do not reach equatorial and polar diameters, as well as surprising agricultural yields to meet current demand (2). Due to the aforementioned, this work aims to evaluate the influence of three planting frames in the development of hybrid pepper (*Capsicum annuum* L.) 'Carleza', under protected cultivation in a Basic Business Unit of Protected and Semi-protected Crops of the Company "Paquito Rosales Benítez" from Yara municipality, Granma, Cuba.

MATERIALS AND METHODS

The investigative work was carried out in protected crop houses "La Veguita" of the Company of Various Crops "Paquito Rosales" of Yara municipality in Granma province, Cuba, on a Fluvisol soil (11), of medium consistency, deep, flat, without the presence of obstacles, with a pH 7. Inside the grow house the average temperature was 26 °C, with a relative humidity of 72 % (12).

The cultivation studied was the pepper, hybrid 'Carleza', marketed by the Granma Seed Company, planted in a

cultivation house with an experimental design in random blocks, with three treatments and three replications, for nine beds of 38×0.80 m in dimension, 0.60 m apart from each other. A seedbed was established in germination trays and the transplant was carried out 37 days after seeds germinated, when the seedlings had four true leaves and a height of 16 cm: at a planting frame 15 cm apart (traditional treatment, T1); planting frame 40 cm apart (treatment, T2); planting frame at 20 cm (treatment, T3).

At 15, 55 and 120 days after transplantation (DAT), morphological parameters were evaluated such as plant height (cm), stem thickness (mm) at 10 cm from the ground. At 60, 90 and 120 days after transplantation (DAT) the agronomic characters were evaluated: length and diameter of fruits both in cm, number of fruits per plant and agricultural yield (t ha⁻¹). The cultural attentions were carried out according to technical instructions (13).

Once the data were collected, a double classification analysis of variance (ANOVA) was performed with the statistical package STATISTICA (14) and when there were significant differences between the treatments, the Fisher's LSD multiple comparison test was used for a probability $p < 0.95$.

RESULTS AND DISCUSSION

Height of pepper plants (cm)

Table 1 shows the height of the pepper plants in each of treatments during three observation dates, where significant differences were found between treatments, according to Fisher's LSD test performed for $p < 0.95$. T1 showed plants with an average height of 123.10 cm, 38 and 14 % higher than the average height of plants reached by T2 and T3, respectively.

At 15 days after planting the crop, the first observation date, the pepper plants in T2 with 24.67 cm in height, showed significant differences, in relation to the plants evaluated in T1 and T3 with 27.70 and 27.65 cm height, respectively. The heights of the plants reached in T1 and T3 exceeded the 25.75 cm height determined by other authors (15).

55 days after planting the crop, the second observation date, there is an increase in the size of plants of 67, 61 and 64 % in T1, T2 and T3, where T1 maintains the taller plants, with values of 83.26 cm in relation to T3 and T2.

Table 1. Plant height (cm) of pepper (*Capsicum annuum* L.) hybrid 'Carleza', in different planting frames, under protected conditions.

| Observation date* | Treatments** | | | | | | Mean | Standard deviation |
|--------------------|--------------|---|----------|---|----------|---|--------|--------------------|
| | T1 | | T2 | | T3 | | | |
| 1 | 27,70 a | C | 24,67 b | C | 27,65 a | C | 26,67 | 1,74 |
| 2 | 83,26 a | B | 64,07 c | B | 77,83 b | B | 75,05 | 9,89 |
| 3 | 258,33 a | A | 140,00 c | A | 213,33 b | A | 203,89 | 59,73 |
| Mean | 123,10 a | | 76,24 c | | 106,27 b | | 101,87 | |
| Standard deviation | 120,36 | | 58,62 | | 96,05 | | | |

*Observation date: 1, 15 days after planting the crop, 2, 55 days after planting the crop, 3, 120 days after planting the crop

** T1, transplant frame 15 cm away, T2, transplant frame 40 cm away, T3, transplant frame 20 cm away

In each row figures followed by the same lowercase letter are not significantly different for ($p < 0.95$) according to Fisher's LSD test.

In a column, the figures followed by the same capital letter are not significantly different for ($p < 0.95$) according to Fisher's LSD test

Something similar is observed 120 days after planting the crop, the third observation date, where an increase in plant growth of 68, 54 and 64 % was observed in T1, T2 and T3, respectively, in relation to the height of plants, reached on the second observation date. On this date the plants reached good growth, with height above 100 cm (203.89 cm), in particular T1, with plants with a height of 258.33 cm, 46 and 17 % higher than the plants obtained by T2 (140.00 cm) and T3 (213.33 cm). This result could be because plants being more united in T1 than in T2 and that in T3 they compete with each other in the search for water and sunlight, this favors their growth.

However, the height reached by plants in T1, T2 and T3 is above the height reached by peppers' cultivars of the F6xLB F1 and Nathalie type studied by several authors (2,6), where plants with a height 124.7 and 136.3 cm, respectively, in protected culture systems. This height is considered good, since for the exploitation of peppers, under protected cultivation systems, it requires plants with very long and straight stems that exceed 2 m in height, to facilitate handling tasks and ensure more production per area (6).

Stem thickness of pepper crop (mm)

For the stem thickness, on the first date, treatments did not show significant differences for $p < 0.95$, according to Fisher's LSD test (Table 2), with stems between 4.73 and 5.07 mm thick. On the second date, a small increase was shown, but with no difference between treatments. However, on the third date, the thickness of stems obtained by T2 (15.33 mm), were significantly greater than the obtained ones by T1 (13.67 mm) and T3 (14.00 mm). As in the height of plants, the third date turned out to be the best in relation to the first and the second observation date, with plants 14.33 mm thick, with T2 standing out with the best result. Its value surpasses that achieved by cultivars of peppers of the 2x4 F1 and Nathalie types, studied by several authors (2,6), with stems 12.7 and 14 mm thick, respectively, in protected cultivation systems.

Length and diameter of pepper fruits (cm)

Regarding the dimension of pepper fruits, the treatments showed significant differences between them (Table 3), where T2 reached fruits with a mean length of 7.98 cm, 16 and 7 % higher than the mean length reached by T1 and T3, with

mean values of 6.70 and 7.39 cm, respectively. The length of the fruits obtained by T2, was in correspondence with the average diameter of fruits, where T2, reached fruits with an average diameter of 8.75 cm, greater than the average diameter reached by T1 and T3, with values of 7.98 and 7.76 cm, respectively. The length and diameter of the fruits obtained by T2 are below the values achieved by cultivars of the FAR-3 F1 and F6xLB F1 type studied by several authors (6,16) with fruits of 12.0 and 14.95 cm long by 9.10 and 9.12 cm in diameter, respectively in a protected culture system.

When analyzing the observation dates, for the length and diameter of the fruits, a reduction of 24 and 20 % in the size of the fruits is observed, respectively upon reaching the third date (Table 3), in relation to the first observation date. This result indicates that in T1, T2 and T3 the length of the fruits varied by 2.32; 1.03 and 2.4 cm, respectively, and the diameter of the fruits varied by 2.16; 1.47 and 1.56 cm respectively, both in relation to the first observation date. In this case, the length and diameter of the fruits obtained by T2 and T3 were more stable than in T1, since no significant differences were found between the first and second dates. Fruit size corresponds to the range of 8 cm in length by 9 cm in diameter, established by technical instructions (13), for this type of pepper hybrid. Likewise, it is adjusted to values obtained by the California Wonder type cultivar, studied by several authors (5), with fruits between 4.85 and 6.01 cm in diameter and 8.18 to 9.30 cm in length, respectively. The T2 and T3 guarantee fruits of a good size, since for fresh consumption fruits of good size are required, although other authors point out that the crops differ, not only by color or size, but also by their attitude to achieve a good production (6,17).

Amount of fruits per plant

The amount of fruits per plant (Figure 1) shows that there are significant differences between the treatments, according to Fisher's LSD test for $p < 0.95$. It is observed that T3 reached the highest number of fruits (28 fruits/plants), 43 and 14 % higher than the amount of fruits obtained by T1 and T2 with 16 and 24 fruits/plants, respectively. Fruit/plant quantity reached by T3 exceeds by 11 % (three fruits) the fruit quantity reported by pepper cultivars of F9xBM29 F1 and F9x330 F1 type studied by several authors (6,18) with 25 fruits/plants, respectively.

Table 2. Plant stem thickness (mm) of hybrid pepper (*Capsicum annuum* L.) 'Carleza' in different planting frames under protected conditions.

| Observation date* | Treatments** | | | | | | Mean | Standard deviation |
|--------------------|--------------|---|--------|---|--------|---|-------|--------------------|
| | T1 | | T2 | | T3 | | | |
| 1 | 5,07a | C | 4,95a | C | 4,73a | C | 4,92 | 0,17 |
| 2 | 7,81a | B | 7,91a | B | 8,28a | B | 8,00 | 0,25 |
| 3 | 13,67b | A | 15,33a | A | 14,00b | A | 14,33 | 0,88 |
| Mean | 8,85b | | 9,40a | | 9,00b | | 9,08 | |
| Standard deviation | 4,39 | | 5,35 | | 4,68 | | | |

* Observation date: 1, 15 days after transplanting the culture, 2, 55 days after transplanting the culture, 3, 120 days after transplanting the culture

** T1, transplant frame 15 cm away, T2, transplant frame 40 cm away, T3, transplant frame 20 cm away

In each row figures followed by the same lowercase letter are not significantly different for ($p < 0.95$) according to Fisher's LSD test.

In a column, figures followed by the same capital letter are not significantly different for ($p < 0.95$) according to Fisher's LSD test

Table 3. Length and diameter of pepper (*Capsicum annuum* L.) fruits hybrid 'Carleza' in different planting frames under protected conditions.

| Observation date* | Treatments** | | | | | | Mean | Standard Deviation | |
|--------------------|--------------|-------|----|-------|----|--------|------|--------------------|------|
| | T1 | | T2 | | T3 | | | | |
| Length | 1 | 7,59b | A | 8,36a | A | 8,23ab | A | 8,06 | 0,41 |
| | 2 | 7,25b | B | 8,26a | A | 8,10a | A | 7,87 | 0,54 |
| | 3 | 5,27c | C | 7,33a | B | 5,83b | B | 6,14 | 1,07 |
| Mean | | 6,70c | | 7,98a | | 7,39b | | 7,36 | |
| Standard deviation | | 1,25 | | 0,57 | | 1,35 | | | |
| Width | 1 | 8,73b | A | 9,34a | A | 8,33b | A | 8,80 | 0,51 |
| | 2 | 8,63b | A | 9,03a | A | 8,13b | A | 8,60 | 0,45 |
| | 3 | 6,57b | B | 7,87a | B | 6,80b | B | 7,08 | 0,69 |
| Mean | | 7,98b | | 8,75a | | 7,76b | | 8,16 | |
| Standard deviation | | 1,22 | | 0,77 | | 1,35 | | | |

Observation date: 1, 15 days after transplanting the culture, 2, 55 days after transplanting the culture, 3, 120 days after transplanting the culture

** T1, transplant frame 15 cm away, T2, transplant frame 40 cm away, T3, transplant frame 20 cm away

In each row the figures followed by the same lowercase letter are not significantly different for ($p < 0.95$) according to Fisher's LSD test.

In a column, the figures followed by the same capital letter are not significantly different for ($p < 0.95$) according to Fisher's LSD test

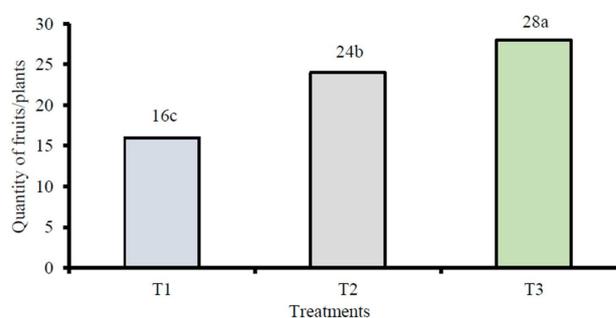
Plants in T3 presented better flowering and fruiting, which allowed reaching a greater number of fruits per plant than in T1 and T2. Due to the temperature that occurs inside the grow house at noon, many of the flowers are approached by plants, producing negative effects on the crop yield. However, results in T1, T2 and T3 exceed those reported by other authors with 6.7 fruits/plant in greenhouses (2).

Agricultural yield of the pepper crop (t ha⁻¹)

When evaluating the agricultural yield achieved, it is observed that there are significant differences between treatments, according to Fisher's LSD test for $p < 0.95$ (Figure 2). Where T2, showed the highest value 19.00 t ha⁻¹, 30 and 14.5 % higher than the yield reached by T1 (13.38 t ha⁻¹) and T3 (16.25 t ha⁻¹), respectively. This T2 result corresponds to the yield of 19.7 t ha⁻¹, achieved by the California Wonder pepper cultivar, studied by several authors (5). However, it is below the agricultural yield of 115 and 105 t ha⁻¹ reached by pepper cultivars of the Vargas and Tejas type studied by other authors (19). Under protected cultivation conditions and in the same way to the yield of 120 at 140 t ha⁻¹ year⁻¹, reported by the LPD-5'F pepper cultivar studied by various authors of Cuban origin (18). However, it exceeds the yield values obtained by other authors, in the open field, between 11 and 13 t ha⁻¹ (9). The variation of the traditional planting frame, by one of 40 cm (T2) between plants, favored a better size of the fruits, to obtain a yield above the other planting frames T1 and T3.

CONCLUSIONS

- The highest agricultural yield of crop, the best size of the fruits and the thickness of the stem of pepper plants was achieved with the application of the planting frame at 40 cm distance between plants.
- The sowing frame at 40 cm distance between plants is feasible for peppers under protected cultivation house.



Figures with the same letters do not differ significantly for ($p < 0.95$)

Figure 1. Quantity of fruits per pepper plants (*Capsicum annuum* L.) hybrid 'Carleza' in different planting frames under protected conditions.

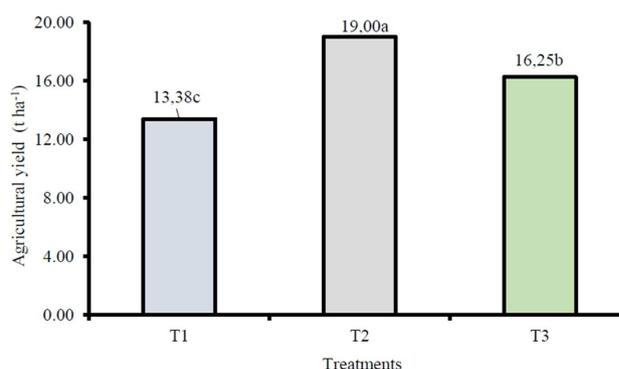


Figure 2. Yield of the hybrid pepper (*Capsicum annuum* L.) 'Carleza' crop in different planting frames under protected conditions.

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