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# NEW HYBRID COMBINATIONS OF PEPPER FOR CULTIVATION SYSTEM PROTECTED IN CUBA

## Nuevas combinaciones híbridas de pimiento para el sistema de cultivo protegido en Cuba

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**ABSTRACT**. The investigation was carried out in the Institute of Horticultural Investigations "Liliana Dimitrova" (IIHLD, according its acronyms in Spanish)during the winter campaign 2014-2015, with the objective of studying the behavior of new hybrid combinations of pepper under the system of protected cultivation with good behavior agronomic and high yields, in Cuba. For this, 16 hybrid combinations of pepper were evaluated with regard to the morph agronomic behavior, comparing them with the commercial witness 'LPD-5 $F_1$' and 'LPD-1 $F_1$' of the Program of Genetic Improvement of the IIHLD and the 'FAR-3 $F_1$', of the signature Hazera. Eleven hybrid combinations of pepper, had a behavior more precocious phonologic (22 dat) that the rest of the combinations and of the rehearsed witness. All they are of the habit of growth erect and of the Lamuyo fruit type. Nine hybrid combinations, obtained the biggest values of number of fruits for plant (20 to 25 fruits) and half mass of the fruits (+ 155 g) and eight combinations reached superior values to the 2,5 kg pl. The hybrid combinations F9xBM29 $F_1$, F6xLB $F_1$, 056xLB $F_1$, F7xBM29 $F_1$, 057xLB $F_1$, 057xNv $F_1$, F7xLB $F_1$ and F7x330 have the 70 t $ha^{-1}$ under this production system.

*Key words*: *Capsicum annuum* L., morphagronomic behavior, yield

**RESUMEN**. La investigación se llevó a cabo en el Instituto de Investigaciones Hortícolas "Liliana Dimitrova" (IIHLD) durante la campaña de invierno 2014-2015, con el objetivo de estudiar el comportamiento de nuevas combinaciones híbridas de pimiento bajo el sistema de cultivo protegido con buen comportamiento agronómico y altos rendimientos, en Cuba. Para ello se evaluaron 16 combinaciones híbridas de pimiento con respecto al comportamiento morfoagronómico, comparándolas con los testigos comerciales 'LPD-5 $F_1$' y 'LPD-1 $F_1$' del Programa de Mejoramiento Genético del IIHLD y el 'FAR-3 $F_1$', de la firma Hazera. Once combinaciones híbridas de pimiento, tuvieron un comportamiento fenológico más precoz (22 ddt) que el resto de las combinaciones y de los testigos ensayados. Todas son del hábito de crecimiento erecto y del tipo de fruto Lamuyo. Nueve combinaciones híbridas, obtuvieron los mayores valores de número de frutos por planta (20 a 25 frutos) y masa media de los frutos (+ 155 g) y ocho combinaciones, alcanzaron valores superiores a los 2,5 kg pl. Las combinaciones híbridas F9xBM29 $F_1$, F6xLB $F_1$, 056xLB $F_1$, F7xBM29 $F_1$, 057xLB $F_1$, 057xNv $F_1$, F7xLB $F_1$ y F7x330 sobrepasan las 70 t $ha^{-1}$ bajo este sistema de producción.

*Palabras clave*: *Capsicum annuum* L., comportamiento morfoagronómico, rendimiento

## INTRODUCTION

The pepper (*Capsicum annuum* L.), occupies a prominent place in horticultural production for its preference in the population, due to its exquisite flavor and high nutritional level. Currently, statistics in Cuba indicate in 2016, a decrease in production and average yield for both planting seasons, under protected conditions (1,2).

The dependence on imports and the high costs of the seeds of the pepper hybrids necessary to be used in protected crop technology, the influence of pests, the difficulty of obtaining the inputs and the high temperatures generated in this technology, are some of the causes that influence the low productivity in this system in Cuba; hence the need for the development of Cuban hybrids with greater tolerance to biotic factors, such as the *Potyvirus* (3), and abiotic factors such as high temperatures; high yield potential and seed quality (4,5).

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Viral diseases (tobacco etch virus (TEV), peppery mottle virus (PepMoV), tobacco mosaic virus (TMV), potato virus Y (PVY) and cucumber mosaic virus (CMV), they cause considerable economic losses, causing more than 30% of losses in our country, especially when the infection occurs in the early stages of growth (6,7) .Therefore, a constant and competitive varietal creation is necessary to achieve new cultivars that satisfy different commercial purposes, that present high yield potential and resistance to the main pests in this crop (8-10).

Genetic control is widely used by plant breeders, as it is one of the most efficient crop management alternatives used to achieve their development, by achieving multi-resistant pepper lines to the main diseases to be used as progenitors of more competitive F1 hybrids (11). Through the improvement, a saving is achieved in the substitution of imports for the purchase of seeds, by having hybrids of national origin with good yields, resistant to pests, with adaptation to the tropical climate, more precocious, with plant protection and allowing lengthen your harvest period (12).

Taking into account the above, it is necessary to evaluate the morphoagronomic behavior of new hybrid combinations of peppers, with high productive potential, in areas of the module of protected cultivation houses of the Institute of Horticultural Research “Liliana Dimitrova” of Quivicán municipality, Mayabeque province.

## MATERIALS AND METHODS

The present work was carried out in the IIHLD belonging to the Ministry of Agriculture, located in the municipality of Quivicán, in the south of the Mayabeque province, at 22º52’ of North latitude and 82º23 ‘of West longitude according to Lambert North Cuba System coordinates and at an altitude above sea level of 68 m.

The experiment was developed during the 2014-2015 winter season in the months of November to March, on a typical Red Ferralitic soil, corresponding to the genetic classification of Cuban soils (13). The soil has a neutral pH, high contents of $P_2O_5$ and $K_2O$ and low in organic matter.

The genetic material used is described in Table 1.

**Table 1. Plant material used in research under protected cultivation**

| Nº | Hybrid combinations | Nº | Hybrid combinations |
|---|---|---|---|
| 1 | 1X3 $F_1$ | 11 | 'LPD-1 $F_1$' (T) |
| 2 | 1X4 $F_1$ | 12 | 056xLB $F_1$ |
| 3 | 2X3 $F_1$ | 13 | F7x BM29 $F_1$ |
| 4 | 2X4 $F_1$ | 14 | F9x330 $F_1$ |
| 5 | Ch/13 $F_1$ | 15 | 057xLB $F_1$ |
| 6 | F6xBM29 $F_1$ | 16 | F6x330 $F_1$ |
| 7 | 'LPD-5 $F_1$' (T) | 17 | 057xNv $F_1$ |
| 8 | 'FAR-3 $F_1$' (T) | 18 | F7xLB $F_1$ |
| 9 | F9xBM29 $F_1$ | 19 | F7x330 $F_1$ |
| 10 | F6xLB $F_1$ | | |

16 hybrid combinations of the IIHLD Genetic Improvement Program three commercial witnesses 'LPD-5 F1' T and 'LPD-1 F1' T (IIHLD) and 'FAR-3 F1' T Hazera, Israel

Seedling production was carried out using the root ball method (14), in a Tropical T-12 model installation, with an area of 180 $m^2$ and total enclosure with anti-insect mesh, in expanded polystyrene cubic trays with 247 alveoli of 32,50 $cm^3$ of volume. A mixture of 90 % earthworm humus + 10 % lithonite was used as substrate. Irrigation was carried out twice a day for five minutes, with an aerial micro-sprinkler system and a dropper delivery of 36 L/h.

The transplant was performed 35 days after planting the seeds, in a house of culture model A-12 of 540 $m^2$, in beds of 1,80 m wide and 15 cm high, the distance between plants was 0,30 m. The total number of plants was 720. The harvest started 75 days after the transplant, when the fruits reached their physiological maturity. The cultural care of the crop under the protected cultivation system was according to the manual of protected cultivation of vegetables (14). The treatments were arranged in a completely randomized experimental design with three repetitions, for their analysis based on individual plants (method of improvement by individual selection). The variety descriptor proposed by the IBPGRI (15) was used to carry out the evaluations.

Phenological characters: from the moment of the transplant until the culmination of the productive cycle of the crop.

- Transplant to the initial flowering (days)
- Transplant to mass flowering (days)
- Transplant to initial fruiting (days)
- Transplantation to mass fructification (days)

- Transplantation at the beginning of physiological maturity (days)
- Transplantation at the beginning of technical maturity (days)

Evaluations of growth variables: a sample of five plants was measured by treatment and replication.

- Height of the AP plant (cm)
- Width of the AP plant (cm)
- Stem diameter DT (mm)

Productive evaluations: a total of four harvests were made to each variety, with an interval of seven days between them. Performance and its components were determined:

- Length of the fruit LF (cm)
- Fruit width AF (cm)
- Thickness of pericarp GP (mm)
- Average number of fruits per plant NFP (No.pl)
- Average mass of fruits MMF (g)
- Performance (t $ha^{-1}$)

The *potyvirus* resistance was checked to see the improvement progress, by visual evaluation of the general symptomatology of the plant, according to scale 0 (no symptoms), 1 (light mosaic), 2 (intermediate mosaic) and 3 (strong mosaic) (16).

The fulfillment of the basic assumptions of the variance analysis was assessed; normality by log1/y, the asymmetry and kurtosis statisticians for which the variables that did not meet these assumptions were transformed: average fruit mass and yield, taking into account the recommendations given in the statistical package Statgraphics version 5.0 (17).

For the analysis of the data, a simple classification analysis of variance (ANOVA) was performed using the automated program Statgraphics Plus 5.0. The means were obtained based on the 95 % Tukey HSD multiple range test for all variables analyzed (18). In all cases, the normal distribution (Kolmogorov-Smirnov) and homogeneity of variance (Bartlett) were previously checked (19).

For the interpretation of the relationships between characters and the distance between the groups of combinations, a multivariate analysis of clusters was used (17) using Ward's method of hierarchical analysis and, as a measure of dissimilarity, the Euclidean Distance squared of the automated program Statgraphics Plus 5.0. In the resulting dendrogram, by setting a distance threshold of 30, the cluster groups were determined for the established cutting distance, for the productive data in each combination.

## RESULTS AND DISCUSSION

In the occurrence of the different phenological phases evaluated (Table 2), it can be seen that there is a group of hybrid combinations that initiate flowering at 22 dat (days after the transplant) (1x3 F1, 2x3 F1, Ch / 13 F1, F6xBM29 F1, F6xLB F1, 056xLB F1, F7xBM29 F1, F9x330 F1, F6x330 F1, F7xLB F1 and F7x330 F1) and others at 30 dat ('LPD-5 F1' T, 'FAR-3 F1' T, F9xBM29 F1, 'LPD-1 F1' T, 057xNv F1).

**Table 2. Occurrence of the different phenological phases (DAT) in the new hybrid combinations of pepper**

| No | Genotipes | Flowering | | Fructification | | Maturity | |
|---|---|---|---|---|---|---|---|
| | | Initial | Massive | Initial | Massive | Physiological | Technical |
| 1 | 1x3 $F_1$ | 22 | 52 | 57 | 80 | 87 | 98 |
| 2 | 1x4 $F_1$ | 26 | 56 | 61 | 83 | 91 | 106 |
| 3 | 2x3 $F_1$ | 22 | 52 | 57 | 80 | 87 | 98 |
| 4 | 2x4 $F_1$ | 26 | 56 | 61 | 83 | 91 | 106 |
| 5 | Ch/13 $F_1$ | 22 | 52 | 60 | 82 | 87 | 98 |
| 6 | F6xBM29 $F_1$ | 22 | 52 | 62 | 84 | 87 | 98 |
| 7 | 'LPD-5 $F_1$' (T) | 30 | 60 | 62 | 84 | 95 | 106 |
| 8 | 'FAR-3 $F_1$' (T) | 30 | 60 | 62 | 84 | 95 | 106 |
| 9 | F9xBm29 $F_1$ | 30 | 60 | 61 | 83 | 95 | 106 |
| 10 | F6xLB $F_1$ | 22 | 52 | 57 | 80 | 87 | 98 |
| 11 | 'LPD-1 $F_1$' (T) | 30 | 60 | 62 | 84 | 95 | 106 |
| 12 | 056xLB $F_1$ | 22 | 52 | 57 | 80 | 87 | 98 |
| 13 | F7xBM29 $F_1$ | 22 | 52 | 59 | 81 | 87 | 98 |
| 14 | F9x330 $F_1$ | 22 | 52 | 55 | 78 | 87 | 98 |
| 15 | 057xLB $F_1$ | 26 | 56 | 58 | 80 | 91 | 106 |
| 16 | F6x330 $F_1$ | 22 | 52 | 57 | 80 | 87 | 98 |
| 17 | 057xNv $F_1$ | 30 | 60 | 62 | 84 | 95 | 106 |
| 18 | F7xLB $F_1$ | 22 | 52 | 57 | 80 | 87 | 98 |
| 19 | F7x330 $F_1$ | 22 | 52 | 57 | 80 | 87 | 98 |
| Average | | 25 | 55 | 53 | 82 | 94 | 101 |

T: control

Similar behavior was observed in the same groups, for the initial fructification at 57 and 62 dat respectively. They reach their physiological maturity, that are the green fruits made between 87 to 95 dat and their technical maturity begins at 98 and 106 dat respectively. The three witnesses were later than the first group (22 dat).

It is important to note that this phenological behavior of the crop is dependent on climatic factors (temperature), varietals and the agronomic management that is carried out; all of which can influence, advancing or delaying it, according to the date in which the same is planted (20,21).

The study of the phenological phases, allows us to recommend how to establish a stepped sowing from the results obtained. In this case, it is proposed to start the campaign with the group of 22 dat (1x3 F1, 2x3 F1, Ch / 13 F1, F6xBM29 F1, F6xLB F1, 056xLB F1, F7xBM29 F1, F9x330 F1, F6x330 F1, F7xLB F1 and F7x330 F1), because they are the earliest among the combinations tested and the average of the experiment. Continue later with any of the genotypes that start flowering at 26 dat (1x4 F1, 2x4 F1, 057xLB F1) and close the campaign, with those of the group that bloom at 30 dat (057xNv F1, F9xBM29 F1, 'LPD-1 'F1,' LPD-5 'F1 and' FAR-3 'F1), it is known that the cultivation cycle of these cultivars is 165 days. This is done, with the aim that the producer always has product in the field and the market does not become depleted of this important vegetable. As a measure of adaptation to the tropics and to protect the fruits of high solar radiation and exposure to heavy rains, cultivars with good foliage cover are needed to avoid scalds and sunburn that devalue them in the market. Selection by adaptation to tropical conditions must take into account the specific requirements of each region (22,23).

From a certain height of the stem, the pepper emits two or three branches depending on the variety and continues branching in a dichotomous manner until the end of its cycle, the secondary stems bifurcate after sprouting several leaves and so on (22,23 ).

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In Table 3, some growth variables of the hybrid combinations under study are shown, from the variety descriptor proposed by the IBPGRI (15). It can be observed that all the combinations are of indeterminate growth habit, with plant height above 1 m as a measure of their adaptation to the protected culture conditions. In the wide variable of the plant, all the combinations show an adequate development with values that oscillate between 61,20 and 76,20 cm.

However, all combinations have a good stem thickness with values between 10 to 12,5 mm. The hybrid combinations F6xLB F1, 056xLB F1, 057xLB F1 and 057xNv F1, showed greater height with more than 119 cm above the controls used. With regard to the width of the plant and diameter of the stem, most of the combinations under study show good characteristics with respect to these variables. The combinations F6xLB F1, 056xLB F1, 057xLB F1 and 057xNv F1, showed the best results in all the analyzed variables without significant differences with the'LPD-5 F1'T and'FAR-3 F1'T controls, but if they differ with the witness 'LPD-1 F1'T.

The exploitation of the pepper under protected cultivation systems, requires that the cultivars to be exploited in this environment have to have very long stems (up to 2 m) and erect growth, to facilitate the management tasks and look for more production per area, in addition to that the fruits do not touch the ground as a measure of their adaptability to the prevailing environment. Likewise, they have good foliage cover, allowing to protect the fruits from sunburn that cause spots that devalue the product (24,25).

The study of the long and wide varieties of the fruit and thickness of the pericarp (Table 4), it can be said that there are no significant differences in each of the variables analyzed with respect to the different combinations evaluated or with the control tested. The set of combinations revealed values of length of the fruit between 11,32 to 14,95 cm, for the diameter of the fruit of 6,28 to 9,50 cm and thickness of the pericarp of 5 and 6 mm. The measured dimensions correspond to the group of Lamuyo type peppers, referred by several authors (21,26,27) where it expresses a length between 12 to 15 cm, a width between 6 to 10 cm and a thickness of pericarp between 3 to 7 mm.

As for the shape of the fruit, there is a great variability that can be elongated, spherical, heart-shaped, prismatic, cubic, etc. (28). Most of the classifications of the cultivated peppers have been made according to the shape of the fruit or to parameters such as the relation between the length and width of the fruit or the shape of its section. Although the shape of the fruit is not directly related to its chemical composition or its flavor, thick, cubic prismatic and heart-shaped peppers are usually sweet (29,30).

In the character size of the fruit, in the genus *Capsicum* there is a great variability, there are cultivars that barely measure 2 cm while others exceed 20 cm in length. For fresh consumption, large, cubic or prismatic fruits are preferred (28). Likewise, these authors state that crops differ not only in shape, size or color, but also in their ability to achieve a certain phenotype under different production conditions.

**Table 3. Morphological behavior of the new hybrid combinations of pepper for protected cultivation**

| No | Hybrid combinations | Habit of growth | AlP (cm) | AnP (cm) | DT (mm) |
|---|---|---|---|---|---|
| 1 | 1x3 $F_1$ | 1 | 97,0 c | 75,4 ab | 11,9 ab |
| 2 | 1x4 $F_1$ | 1 | 108,7 b | 71,1 bc | 11,0 b |
| 3 | 2x3 $F_1$ | 1 | 92,8 c | 76,2 a | 10,3 c |
| 4 | 2x4 F1 | 1 | 118,4 ab | 63,5 de | 12,7 a |
| 5 | Ch/13 $F_1$ | 1 | 93,6 c | 69,7 cd | 11,6 ab |
| 6 | F6xBM29 F1 | 1 | 103,8 b | 65,7 de | 11,7 ab |
| 7 | 'LPD-5 F1' (T) | 1 | 118,6 ab | 66,4 de | 11,6 ab |
| 8 | 'FAR-3 F1' (T) | 1 | 117,2 ab | 67,4 cd | 11,5 ab |
| 9 | F9xBm29 $F_1$ | 1 | 88,8 c | 66,8 de | 11,5 ab |
| 10 | F6xLB $F_1$ | 1 | 124,7 a | 67,7 cd | 12,5 a |
| 11 | 'LPD-1 F1' (T) | 1 | 81,6 c | 61,2 f | 10,6 c |
| 12 | 056xLB $F_1$ | 1 | 119,8 ab | 73,0 ab | 12,4 a |
| 13 | F7xBM29 $F_1$ | 1 | 98,8 c | 69,7 cd | 11,3 ab |
| 14 | F9x330 $F_1$ | 1 | 112,7 ab | 72,4 bc | 11,5 ab |
| 15 | 057xLB $F_1$ | 1 | 122,8 a | 70,3 bc | 12,2 a |
| 16 | F6x330 $F_1$ | 1 | 108,1 b | 68,7 cd | 11,2 b |
| 17 | 057xNv $F_1$ | 1 | 128,7 a | 73,8 ab | 12,9 a |
| 18 | F7xLB $F_1$ | 1 | 110,2 ab | 70,9 bc | 11,8 ab |
| 19 | F7x330 $F_1$ | 1 | 103,4 b | 75,8 ab | 11,8 ab |
| | C.V. (%) | | 4,59 | 10,58 | 11,43 |
| | Ex | | 0,0456 | 0,7543 | 0,0427 |

1: Habit of growth, AlP: Height of the plant, AnP: Width of the plant, DT: Diameter of the stem. Stocks with the same letters do not differ significantly for p≤0.05

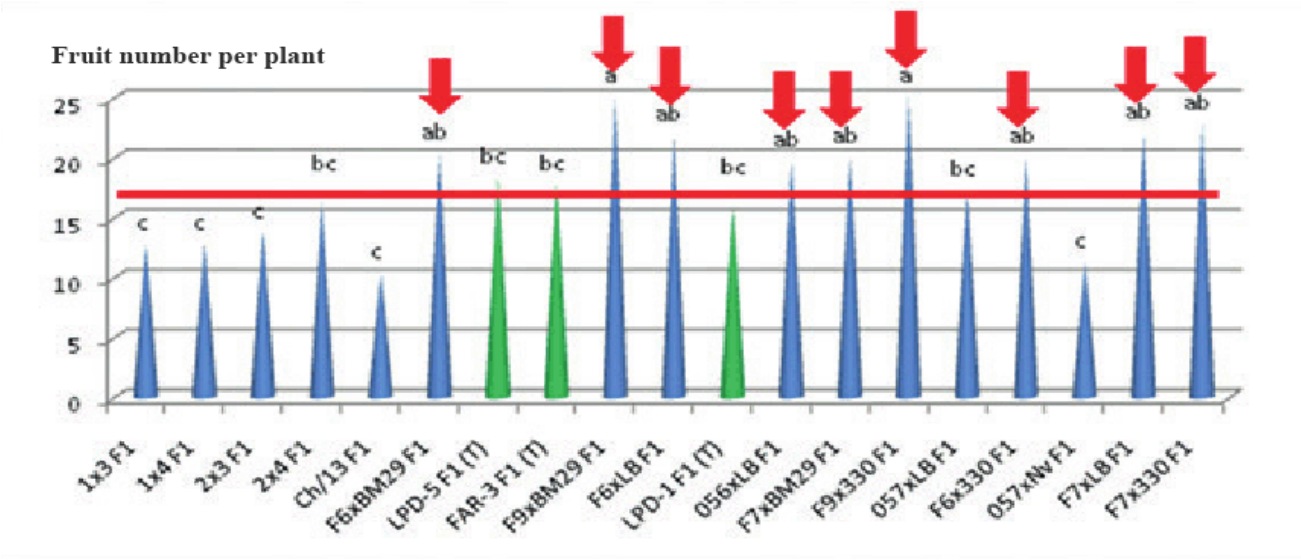
**Table 4. Agronomic behavior of pepper genotypes for open field**

| No | Hybrid combinations | LF (cm) | AF (cm) | GP (mm) |
|---|---|---|---|---|
| 1 | 1x3 $F_1$ | 12,03 | 8,50 | 5 |
| 2 | 1x4 $F_1$ | 11,95 | 8,12 | 5 |
| 3 | 2x3 $F_1$ | 12,52 | 8,70 | 5 |
| 4 | 2x4 $F_1$ | 11,83 | 8,09 | 5 |
| 5 | Ch/13 $F_1$ | 11,50 | 8,02 | 5 |
| 6 | F6xBM29 $F_1$ | 14,12 | 7,62 | 6 |
| 7 | 'LPD-5 $F_1$ ' (T) | 13,0 | 9,12 | 5 |
| 8 | 'FAR-3 $F_1$' (T) | 12,0 | 9,10 | 6 |
| 9 | F9xBm29 $F_1$ | 13,95 | 9,50 | 6 |
| 10 | F6xLB $F_1$ | 14,95 | 9,12 | 6 |
| 11 | 'LPD-1 $F_1$' (T) | 12,75 | 9,05 | 5 |
| 12 | 056xLB $F_1$ | 14,30 | 9,40 | 6 |
| 13 | F7xBM29 $F_1$ | 14,02 | 6,28 | 6 |
| 14 | F9x330 $F_1$ | 12,7 | 8,42 | 5 |
| 15 | 057xLB $F_1$ | 14,02 | 6,82 | 6 |
| 16 | F6x330 $F_1$ | 14,40 | 9,50 | 6 |
| 17 | 057xNv $F_1$ | 13,06 | 7,72 | 6 |
| 18 | F7xLB $F_1$ | 11,32 | 8,54 | 5 |
| 19 | F7x330 $F_1$ | 12,44 | 7,72 | 5 |
| | C.V. (%) | 14,97 | 25,05 | 13,26 |
| | Ex | 0,9870 ns | 0,5632 ns | 0,8693 ns |

LF: Length of the fruit, DF: Diameter of the fruit, GP: Thickness of the pericarp, T: Control

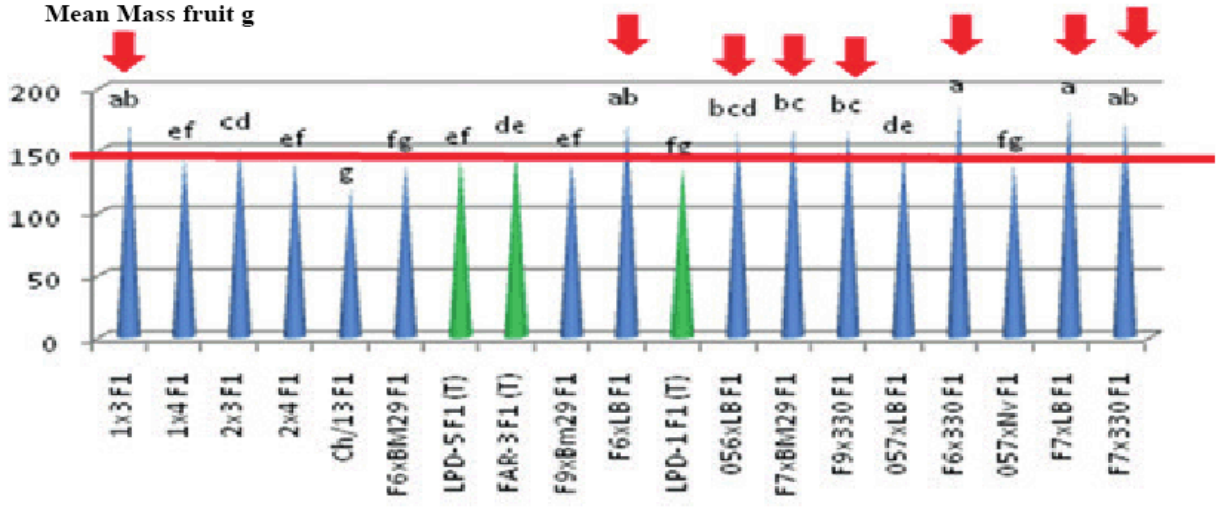
The components number of fruits per plant and average mass of the fruit (Figure 1 and 2), show that there are significant differences between all hybrid combinations. Regarding the number of fruits per plant (NFP), it is observed that many hybrid combinations have 20 to 25 fruits superior to the controls (above the red line), with 18 fruits. The rest of the combinations are below the values of the witnesses used. The combinations F9xBM29 F1 and F9x330 F1 offer 25 fruits per plant, respectively. In the average mass of the fruits (MMF) there are also significant differences between the hybrid combinations tested, the values oscillate between 120 to 190 g. The highest value combinations were 1x3 F1, F6xLB F1, 056xLB F1, F7xBM29 F1, F9x330 F1, F6x330 F1, F7xLB F1 and F7x330 F1 with more than 155 g higher than the controls.

From the point of view of performance behavior (Figure 3), it could be observed that there are significant differences between all the combinations, where the range oscillates between 75 to 82 t $ha^{-1}$, that is, above the red line. In this test, it is shown that in the winter season the new combinations showed a good yield potential superior to the controls used.




ESx NFP= 0,0282xxx
Means with equal letters do not differ significantly for p≤ 0.05 Red line indicates the highest value with respect to the witnesses. Above this line are the best hybrids

**Figure 1. Behavior of the number of fruits per plant, in the new hybrid combinations of pepper for protected cultivation**

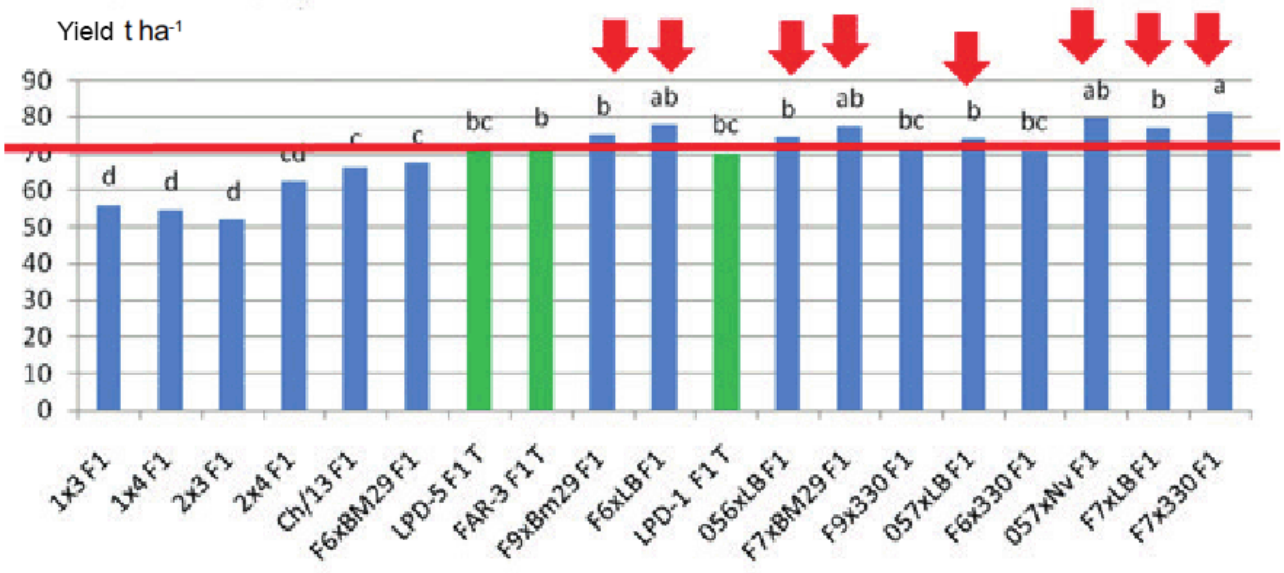



ESx MMF g= 0,0119xxx
Means with equal letters do not differ significantly for p≤ 0.05 Red line indicates the highest value with respect to the witnesses. Above this line are the best hybrids

**Figure 2. Behavior of the average mass of the fruits (g), in the new hybrid combinations of pepper for protected cultivation**

Starting from the grouping of the genotypes shown in the cluster analysis (Figure 4), it was possible to determine that the groups of similarity between the combinations according to the phenological, morphological and productive parameters obtained in protected culture conditions were four groups. It was observed, at a cutting distance of thirty (marked by the red line), a first group comprising five combinations, a second group with most of them (seven), a third group with three combinations and a fourth group that the witnesses are used plus a combination.

Groups II and III were characterized by having the combinations that had the highest productive values such as number of fruits per plant, average mass of fruits and yield (kg plant$^{-1}$ and t ha$^{-1}$).




ESx t ha$^{-1}$=+- 0,3456xxx
Means with equal letters do not differ significantly for p≤ 0.05 Red line indicates the highest value with respect to the witnesses. Above this line are the best hybrids

**Figure 3. Performance behavior in the new hybrid combinations of pepper for protected crop**

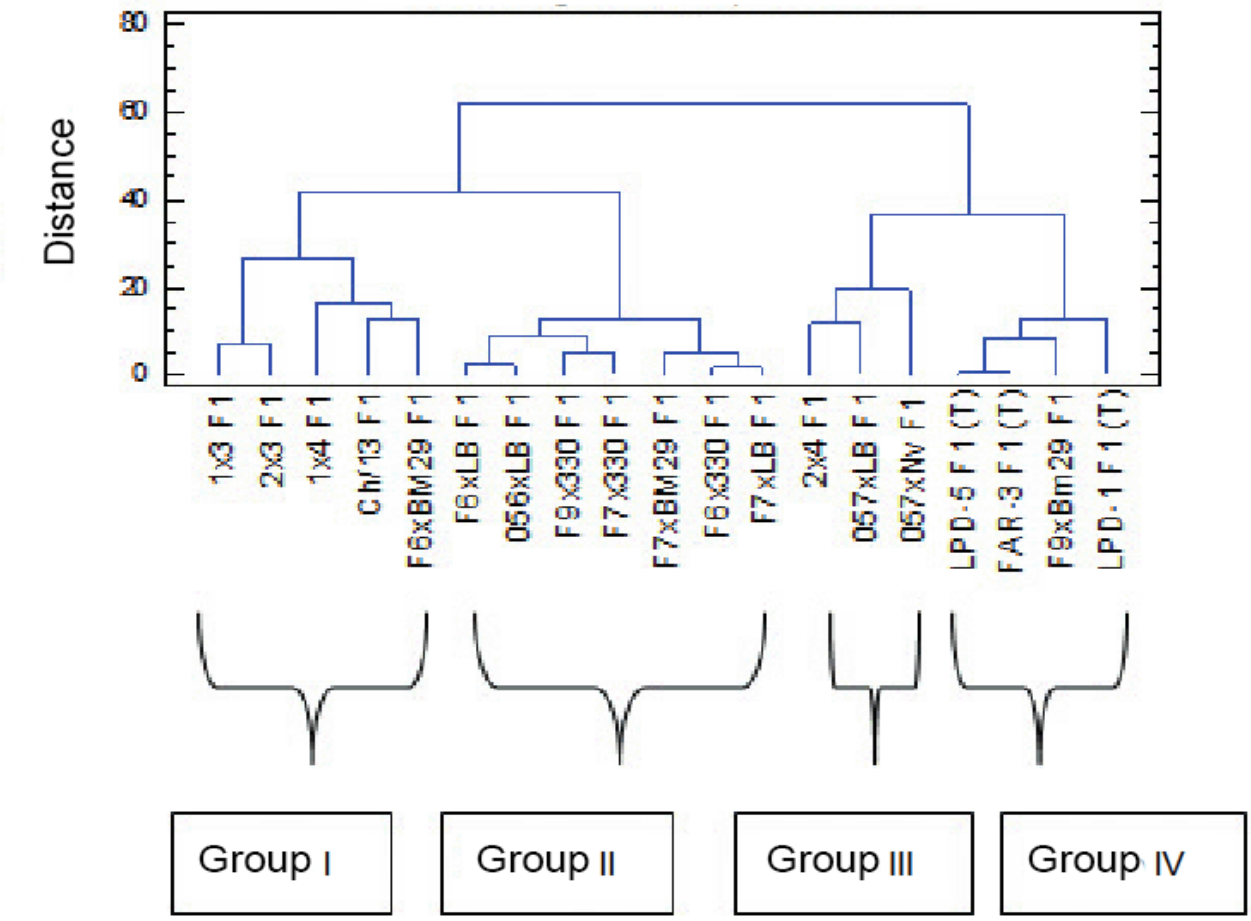



**Figure 4. Dendrogram resulting from the Conglomerate Analysis of the new hybrid combinations**

Several authors state that the greatest impact on the success achieved by the protected pepper culture system in the region of Almeria, Spain (21), has been given by the use of hybrids of undetermined growth, earlier, with lengthening of the period of harvest, fruit quality and superior production, which have not yet been extracted their full productive potential; they can be renewable, as a result of the strong varietal creation existing in said species. These approaches support the validity of the previous study of new hybrid combinations taking into account the integrality of their productive characteristics.

The hybrids obtained for the first time in Cuba, were evaluated in two sowing periods (2011-2012) standing out for their performance the hybrid No 5 in the spring - summer period with 3,73 kg plant$^{-1}$ and 8,44 kg m$^2$ and the No 2 hybrid in the winter period with 1,6 kg plant$^{-1}$ and 4,0 kg m$^2$ respectively (31).

The potential yield of the pepper under the protected culture system in Cuba in previous years has been around 140 t ha$^{-1}$ year$^{-1}$, with introduced foreign hybrids (32). Méndez (2), reported that in 2016 the hybrid 'LPD-5' F1 of national origin (IIHLD) had a performance of 120 t ha$^{-1}$-year$^{-1}$ to 140 t ha$^{-1}$ year$^{-1}$. Other authors suggest that the variety in any crop that is selected must have the potential to produce a commercial fruit yield equal to or greater than that obtained with the variety already used by the farmer (33).

It is important to accelerate genotypic stabilization work in Cuba, in order to facilitate more productive materials, so the Program for the Genetic Improvement of this crop should be continued. According to the scale for potyvirus (16) the results showed that the hybrid combinations 'F9xBM29', 'F6xLB', '056xLB', 'F7xBM29', '057xLB', '057xNv', 'F7xLB' and 'F7x330', showed 100% of resistance by not presenting symptoms of disease in conditions of natural infection. Similar results were reported by different authors in different species of *Capsicum* since they did not show any symptoms after inoculating with pot virus (32,34) (Table 5).

**Table 5. Percentage of resistance to natural infection against potyviruses under the protected culture system**

| No | Hybrid combinations | % R | No | Hybrid combinations | % R |
|---|---|---|---|---|---|
| 1 | 1x3 $F_1$ | 83 | 10 | F6xLB $F_1$ | 100 |
| 2 | 1x4 $F_1$ | 86 | 11 | 'LPD-1 $F_1$' (T) | 32,7 |
| 3 | 2x3 $F_1$ | 90 | 12 | 056xLB $F_1$ | 100 |
| 4 | 2x4 $F_1$ | 94 | 13 | F7xBM29 $F_1$ | 100 |
| 5 | Ch/13 $F_1$ | 20 | 14 | F9x330 $F_1$ | 96,3 |
| 6 | F6xBM29 $F_1$ | 95,6 | 15 | 057xLB $F_1$ | 93 |
| 7 | 'LPD-5 $F_1$' (T) | 98,3 | 16 | F6x330 $F_1$ | 95,7 |
| 8 | 'FAR-3 $F_1$' (T) | 54,6 | 17 | 057xNv $F_1$ | 100 |
| 9 | F9xBm29 $F_1$ | 100 | 18 | F7xLB $F_1$ | 100 |
| | | | 19 | F7x330 $F_1$ | 100 |

**CONCLUSIONS**

- There are morphological differences between the different hybrid combinations that make it possible to establish a stepped planting under this cultivation system.
- All are from the habit of erect growth and the Lamuyo fruit type.
- The hybrid combinations 'F9xBM29', 'F6xLB', '056xLB', 'F7xBM29', '057xLB', '057xNv', 'F7xLB' and 'F7x330' exceed 70 t ha$^{-1}$ for the protected culture system.

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