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A Comparative Trial of Papaya Cultivars

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Abstract

Context: Papaya (*Carica papaya* L.) is one of the most important and widely spread fruit trees in tropical and subtropical countries. The single variety exploitation based on Maradol roja cultivar, in Cuba, has exposed this crop to serious risks. Hence, the introduction, characterization, and maintenance of new germplasm of this species is a critical factor when identifying and obtaining new genotypes.
Aim: To evaluate these cultivars, in order to broaden the genetic diversity of this plant, and continue with the genetic breeding program for this species.
Methods: This research study was done at the Tropical Crop Vegetable Research Institute (INIVIT), on mulled brown soil with carbonates. Different parameters were analyzed, such as, plant height (cm), base perimeter (cm), number of active leaves, height of first inflorescence (cm), and average weight of the fruit (kg), number of fruit per plant, flesh thickness (cm), and yield ($t.ha^{-1}$) at the end of the plant cycle. Information was processed through an object-oriented programing language named R 3.6.1 (R Development Core Team).
Results: This study demonstrated a broad variability in growth and productivity of different cultivars.
Conclusions: Cultivars Enana and Criolla grew smaller, which makes them suitable as genotypes to genetically contribute to a reduction in plant size, and cultivars INIVIT fb-4 and INIVIT fb-17 showed acceptable agronomic features suitable for the large papaya consuming market internationally.

Key words: characterization, Carica papaya L., genetic breeding.

Introduction

Family Caricaceae has six genuses and 35 species (Fuentes & Santamaría, 2014), of which *Carica papaya* L. is the most important species due to the commercial value and fruit sales volume. This species is original from the north of Central America, and the south of Mexico, with cultivated and wild populations that have high morphological variations in shape, size, epidermal color, taste, total fruit soluble flavors, and plant size (Singh & Kumar, 2010). Morpho-agronomic characterization is a widely used traditional and efficient method to know the morphological diversity of populations (Rodríguez et al., 2013). In Cuba, papaya is one of the main fruit crops, with approximately 4.994 ha across the country. However, due to the single-variety exploitation based on Maradol variety, this crop is exposed to serious risks mostly related to pests and diseases (Pérez et al., 2012). Therefore, the introduction and characterization of traditional varieties (Aikpokpodion, 2012; Asudi et al., 2010), improved varieties (Singh & Kumar 2010), and both (Sompak et al., 2014), whith a broad commercial interest, is important. Coppens d'Eeckenbrugge et al. (2007) have contributed to strategies for planning handling, genetic breeding, germplasm bank preservation, and sustainable utilization of diversity (Ara et al., 2016).

The aim of this paper is to evaluate and characterize these cultivars, in order to broaden the genetic diversity of this crop, and to continue with the genetic breeding program for this species at INIVIT.

Materials and Methods

The study was done at the Tropical Crop Vegetable Research Institute (INIVIT), located on 22º35' NL, and 80º18' WL, 44.56 meters above sea level, in the municipality of Santo Domingo, province of Villa Clara, on mulled brown soil with carbonates, based on the genetic classification of Cuban soils (Hernández, Ascanio, Morales & Cabrera, 2005). It comprised the March 2018-May 2019 period. The local annual temperature throughout the trial was 22.8 °C, with minimum temperatures of 21 °C, and maximum temperatures of 27.5 °C. The mean annual precipitation value was 141.4 mm, and mean annual relative humidity was higher than 79.2%, according to the agro-weather station.

The plant material used for morphoagronomic characterization included the following cultivars: INIVIT fb-17, Criolla, Gigante guantanamera, NARAN, Red Ladys, Cartagena roja, NIKA 3, INIVIT fb-4, Scarlet princess, Tainung 1, Tainung 5, Sunrise solo, Cartagena amarilla, Maradol amarilla, Gigante matancera, HG X MA, Enana, and Maradol roja, as control. One of them was native, the other were introduced. A randomized block design with three repetitions of 20 plants per plot was used, with plant spacing of 4 x 1.5 m. The plantation was semi-protected with natural maize barriers (*Zea mays* L.). The seedlings (15 cm high) were transplanted at 28 days.

The following features were evaluated in the three repetitions with 20 plants each:

- Evaluations were made at 10 months of age, of growth features: plant height (cm), base perimeter (cm), number of leaves, and height of first inflorescence (cm).
- The productivity, average fruit weight (kg), number of fruits/plant, fruit flesh thickness (cm), and yield (t/ha^{-1}) were evaluated at 8 months following planting.

The Shapiro-Wilk (Shapiro & Wilk 1965) normality test from the stats package was used in this research. Single-factor ANOVA was performed. The aov function described in the package Stats (Y~X) was used, where Y is the response variable, which is the quantitative variable associated to the experiment, and X is the factor, the condition established to measure the response variable.

The Tukey test was used for multiple comparisons, to estimate the differences among treatments, comparing all the possible means two by two. The R Tukey test used the HSD Tukey function, implemented in the package {Stats}. Information was processed through an object-oriented programing language named R 3.6.1 (R Development Core Team).

Results and discussion

The variability observed in plant height, stem diameter, and leaf and fruit number may have been influenced by the environmental conditions. This aspect influenced the different phenological phases of plants at the time of evaluation. Accordingly, temperature is the factor that determines the duration of phenological phases from seed germination to fruit maturity (Hernández & Soto., 2012 and Maqueira et al., 2016).

Table 1 shows the features of growth and productivity in the cultivars studied. The genetic richness is being used to generate new more productive papaya varieties, and smaller plants (Vázquez et al., 2014). The results of this parameter permit to suggest cultivars Enana (82.45 cm) and Criolla (88.50 cm) as genotypes for breeding programs, and can be used to genetically contribute to a reduction in plant size. The stem base perimeter showed a significant difference, with cultivars Sunrise solo, Tainung 1, and Gigante guantanamera having the highest values (26.73 cm, 26.24 cm, and 26.00 cm, respectively), with no significant differences between them, but with the other cultivars evaluated. According to Rodríguez & Rosell (2005), this parameter somehow indicates plant vigor, which is considered a positive value when selection. The comparison referred to as the number of leaves produced indicates that cultivars NIKA 3, Scarlet princess, Tainung 1, and Red Ladys produced the greatest number of leaves, with no significant differences from cultivars INIVIT fb-17, Tainung 5, and Gigante matancera. These results correspond to the reports of Muñozcano & Martínez, (2009), considering 100 or more leaves produced every year as a basis, when choosing the best vegetative growing cultivars, and it is also an indicator of productivity, considering that the axillary buds of each leaf produces one fruit, at least. Likewise, the reduction of the insertion height of the first flower in papaya has an economic relevance, since it allows for greater duration of the harvest, which along with early fruiting and plant vigorousness, are attractive features in terms of papaya breeding (Marin et al., 2006), being considered as very positive, since it facilitates collection and reduces labor costs. The best results were observed in NARAN, Cartagena roja, and Maradol roja.

Table 1. Evaluation of papaya cultivars in relation to growth and productivity parameters

Cultivars	Height (cm)	Base P. (cm)	No. of leaves	Flowering height (cm)
INIVIT fb-17	166.60 c	24.80 e	32.60 f	47.30 i
Criolla	88.50 q	23.67 h	24.30 p	34.15 l
Gigante Guantanamera	104.00 p	26.00 c	26.00 m	44.21 j
NARAN	123.40 m	24.40 f	30.10 h	28.46 p
Red Ladys	133.10 k	23.00 l	33.50 d	32.30 n
Cartagena roja	108.40 o	22.00 q	26.00 m	28.42 q
NIKA 3	158.66 e	22.43 o	34.50 a	39.44 k
INIVIT fb-4	122.00 n	23.50 j	25.20 o	47.30 i
Scarlet princess	142.78 j	22.48 n	34.45 b	52.14 g
Tamung 1	164.25 d	26.24 b	34.00 c	61.74 b
Tamung 5	176.37 a	22.58 m	32.47 g	55.91 e
Sunrise solo	172.39 b	26.73 a	22.45 q	71.82 a
Cartagena amarilla	124.68 l	23.43 k	27.00 l	47.72 h
Maradol amarilla	145.93 h	23.57 i	29.58 i	56.94 d
Gigante matancera	148.79 f	25.76 d	32.78 e	59.24 c
HG X MA	147.83 g	24.31 g	28.92 j	52.41 f
Enana	82.45 r	14.74 r	25.31 n	31.68 o
Maradol roja	145.38 i	22.36 p	27.32 k	32.46 m
SE ±	3.20	0.30	0.45	1.47
VC (%)	19.94	10.90	13.15	27.30

Treatments with the same script have no significant differences

From table 2, it can be deduced that the productive performance of the cultivars evaluated, which shows that cultivar Sunrise plants were the only ones that produced the greatest number of fruits, differed significantly from the other cultivars. This occurs thanks to the genetic characteristics of this variety that lead to higher flower development, and to the formation of flower-fruit per node, and the presence of double peduncles, a negative feature of selection programs, which coincides with a study done in the conditions of Jagüey Grande (Alonso et al., 2009). In turn, broad variability was observed in the average weight feature of the fruits from cultivars evaluated, which is associated with the demands of the market (De Morais et al., 2008), between 5.60 kg and 1.58 kg, the higher value corresponds to HG X MA, without significant differences from INIVIT fb-4 and INIVIT fb-17. Similar results were achieved in evaluations made to wild papaya collections on five locations of Costa Rica (Brown et al., 2012). Today, the already extensive market of papaya fruits is considerably growing worldwide; hence, these papaya cultivars may be an alternative with a higher potential to meet the consumer demands of this item (Alonso et al., 2008). Regarding the thickness of the flesh, the highest value was observed in cultivar INIVIT fb-4, with 5.41 cm, with no significant differences from INIVIT fb-17 and Enana, which is appealing, since the edible part of the fruit is much better used, and the central cavity is smaller. According to Rugiero (1980), a small seminal cavity is preferable, since it provides more pulp with easily removed seeds, and according to Marin et al. (2006), consumers prefer hermaphrodite papaya plants with a piriform and/or elongated format, which is associated with a smaller ovarian cavity, and thicker pulp. This feature offers greater commercial value to this kind of fruits in the market. The sexual type of *Carica papaya* L. can only be visualized until flowering (after three months following transplantation, approximately), as reported by Ming et al. (2007); Niroshini, et al. (2008); Reddy, Krishna & Reddy (2012). Therefore, the determination of the sex of papaya seedlings is critical for plant breeders, being a complement of traditional selection of plants ready for bearing fruits, depending on the demands of the market, or to introduce them to the genetic selection and breeding program of the species (Sánchez-Betancourt & Nuñez, 2008). Besides, the fruits from hermaphrodite papaya flowers are generally elongated, with sufficient firmness to withstand post-harvest mechanical damage, and with a higher commercial demand, as it uses less space per unit when packing, which means savings in leasing, especially for exports (Muñozcano & Martínez, 2009).

INIVIT fb-4 showed higher yields per plant (146.97 t/ha) without significant differences from INIVIT fb-17 (144.63 t/ha), with significant differences from the other cultivars. The production from this cultivar coincides with studies done by Ruiz et al. (2018), which was around 120.76 kg/plant.

Table 2. Productive performance of evaluated papaya cultivars

Cultivars	No. of fruits	Weight (Kg)	Flesh Thick. (cm)	Yields t.ha^{-1}
INIVIT fb-17	24.80 e	4.58 c	4.43 b	144.63 b
Criolla	12.00 m	3.91 h	3.46 j	65.18 h
Gigante Guantanamera	21.00 f	4.30 e	3.63 h	71.66 e
NARAN	11.80 o	3.96 g	3.13 m	64.31 j
Red Ladys	12.00 m	2.88 n	3.12 n	69.15 f
Cartagena roja	13.00 l	3.70 l	2.71 o	61.66 n
NIKA 3	17.00 j	4.41 d	3.57 i	73.49 d
INIVIT fb-4	28.00 c	5.32 b	5.41 a	146.97 a
Scarlet princess	17.6 i	3.81 j	3.26 k	63.50 k
Tamung 1	29.8 b	2.84 o	2.10 p	14.31 r
Tamung 5	18.40 g	4.08 f	3.82 f	68.20 g
Sunrise solo	36.00 a	1.58 q	0.91 q	26.33
Cartagena amarilla	17.80 h	3.80 k	3.21 l	63.35 m
Maradol amarilla	15.00 k	3.90 i	3.26 k	64.90 i
Gigante matancera	15.00 k	3.70 l	4.32 c	61.60 o
HG X MA	11.81 n	5.60 a	3.92 e	63.49 l
Enana	10,40 p	3,20 m	4,10 d	53,33 p
Maradol roja	26,58 d	2,32 p	3,74 g	82,46 c
SE ±	0.85	0.11	0.11	3.67
VC (%)	38.59	25.29	27.20	44.65

Treatments with the same scripts have no significant differences

Conclusions

The cultivars studied showed proper adaptation to the cultivating conditions, depending on the descriptive characteristics of plants, representing a great advance to develop further breeding programs in papaya for commercial purposes.

Cultivars Enana and Criolla were the smallest, which suggests that they can be used as genotypes for breeding programs, and can contribute genetically to a reduction in plant size.

Cultivars INIVIT fb-4 and INIVIT fb-17 were the largest producers, demonstrating acceptable agronomic characteristics for the consuming market of large papaya fruits, nationally and internationally.

Author contribution

Elianet Ruiz Díaz: research implementation, morphological description of cultivars, analysis of results, redaction of the manuscript, final review.

Yuniel Rodríguez García: analysis of the results and review of the manuscript.

José Armando Herrera: data collection and analysis of the results.

Conflicts of interest

Not declared.

References

Aikpokpodion, P. O. (2012) Assessment of genetic diversity in horticultural and morphological traits among papaya (*Carica papaya* L.) accessions in Nigeria. *Fruits*, *67*, 173-187, doi: https://doi.org/10.1051/fruits/2012011

Alonso Esquivel, M., Tornet Quintana, Y., Ramos Ramírez, R., Farrés Armenteros, E., Aranguren González, M., & Rodríguez Martínez, D. (2008). Caracterización y evaluación de dos híbridos de papaya en Cuba. *Agricultura técnica en México*, *34*(3), 333-339. Retrieved on February 18, 2020, from: http://www.scielo.org.mx/pdf/agritm/v34n3/v34n3a8.pdf

Alonso, M., Tornet, Y., Ramos, R., Farrés, E., & Rodríguez, D. (2009). Evaluación de dos híbridos de papaya introducidos en Cuba. *Agronomía Costarricense*, *33*(2), 267-274. Retrieved on February 18, 2020, from: https://revistas.ucr.ac.cr/index.php/agrocost/article/view/6725/6413

Ara, N., Moniruzzaman, M., Begum, F., Moniruzzaman, M., & Khatoon, R. (2016). Genetic divergence analysis in papaya (*Carica papaya* L.) genotypes. *Bangladesh Journal of Agricultural Research*, *41*(4), 647-656, doi: https://doi.org/10.3329/bjar.v41i4.30697

Asudi, G. O., Ombwara, F. K., Rimberia, F. K., Nyende, A. B., Ateka, E. M., Wamocho, L. S., … Onyango, A. (2010). Morphological diversity of Kenyan papaya germplasm. *African Journal of Biotechnology*, *9*(51), 8754-8762. Retrieved on February 18, 2020, from: https://www.ajol.info/index.php/ajb/article/download/125888/115425

Brown, J. E., Bauman, J. M., Lawrie, J. F., Rocha, O. J., & Moore, R. C. (2012). The structure of morphological and genetic diversity in natural populations of Carica papaya (caricaceae) in Costa Rica. *Biotropica*, *44*(2), 179-88, doi: http://doi:10.1111/j.1744-7429.2011.00779.x

Coppens d'Eeckenbrugge G., Restrepo, M. T., Jiménez, D., & Mora, E. (2007). Morphological and isozyme characterization of common papaya in Costa Rica. *Acta Horticulturae*, *740*, 109-120, doi: https://doi.org/10.17660/ActaHortic.2007.740.11

De Morais, P. L., Da Silva, G. G., Menezes, J. B., Maia, F. E., Dantas, D. J., & Júnior, R. S. (2007). Pós-colheita de mamão híbrido UENF/CALIMAN 01 cultivado no Rio Grande do Norte. *Rev. Brás. Frutic.*, *29*(3), 666-670. Retrieved on February 12, 2019, from: http://www.scielo.br/pdf/rbf/v29n3/a46v29n3.pdf

Fuentes, G., & Santamaría, J. M. (2014). Papaya (*Carica papaya* L.): Origin, Domestication, and Production. En R. Ming, & P. Moore (eds.) *Genetics and Genomics of Papaya. Plant Genetics and Genomics: Crops and Models*. (vol. 10, Pt. 1, pp. 3-15). New York, NY.: Springer, doi: https://doi.org/10.1007/978-1-4614-8087-7_1

Hernández, A., Ascanio, M.O., Morales, M., & Cabrera, A. (2005). *Correlación de la nueva versión de clasificación génetica de los suelos de Cuba con las clasificaciones internacionales y nacionales: una herramienta útil para la investigación, docencia y producción agropecuaria.* La Habana, Cuba: Instituto Nacional de Ciencias Agrícolas (INCA) Retrieved on January 15, from: http://bida.uclv.edu.cu/bitstream/handle/123456789/7195/Correlaci%25F3n%2520de%2520la%2520nueva%2520versi%25F3n%2520de%2520clasificaci%25F3n%2520gen%25E9tica%2520de%2520los%2520suelos%2520de%2520Cuba.pdf?sequence=1&isAllowed=y

Hernández Córdova, N., & Soto Carreño, F. (2012). Influencia de tres fechas de siembra en el crecimiento y rendimiento de especies de cereales cultivadas en condiciones tropicales. Parte II. Cultivo del sorgo (Sorghum bicolor I. Moench var. Isiap Dorado). *Cultivos Tropicales*, *33*(2), 50-55. Retrieved on January 23, 2020,

from: http://scielo.sld.cu/pdf/ctr/v33n2/ctr07212.pdf

Maqueira López L. A., Torres de la Nova, W., Pérez Mesa, S.A., Díaz Paez, D., & Roján Herrera, O. (2016). Influencia de la temperatura ambiental y la fecha de siembra sobre la duración de las fases fenológicas en cuatro cultivares de arroz (Oryza sativa L.). *Cultivos Tropicales*, *37*(1), 65-70. Retrieved on December 20, 2019, from: http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S0258-

Marin, S. L. D., Pereira, M. G., do Amaral Junior, A.T., Martelleto, L. A. P., & Ide, C. D. (2006). Heterosis in papaya hybrids from partial diallel of 'Solo' and 'Formosa' parents.*Crop Breeding and Applied Biotechnology*, *6*, 24-29. Retrieved on January 23, 2020, from: http://www.sbmp.org.br/cbab/siscbab/uploads/c8eb9792-79e5-5f23.pdf

Ming, R., Yu, Q., & Moore, P. H. (2007). Sex determination in papaya. *Seminers in cell and developmental biology*, *18*(3), 401-408. Retrieved on February 25, 2020, from: https://pubag.nal.usda.gov/download/2783/PDF

Muñozcano Ruiz, M., & Martínez Alvarado, C. O. (2009). *Paquete tecnológico para la producción de papaya en Sinaloa.* Sinaloa, Mexico: Fundación Produce Sinaloa A.C. Retrieved on January 23, 2020, from: https://www.fps.org.mx/portal/index.php/component/phocadownload/category/29-frutales?download=24:paquete-tecnologico-para-la-produccion-de-papaya-en-sinaloa

Niroshini, E., Everard, J. M. D. T., Karunanayake, E. H., & Tirimanne, T. L. S. (2008). Detection of sequence characterized amplified region (SCAR) markers linked to sex expression in *Carica papaya* L. *J. Nat. Sci. Foundation Sri Lanka*, *36*(2), 145-150. Retrieved on March 5, 2020, from: https://pdfs.semanticscholar.org/2187/1b1563aef41357a7911c292a9e0e8dde3ea3.pdf

Pérez, O. (2012). *Caracterización biológica del Virus de la mancha anular de la papaya en Carica papaya L. var. Maradol roja en Cuba.* (Tesis de Diploma) Facultad de Ciencias Agropecuarias, Universidad Central "Marta Abreu" de Las Villas, Santa Clara. Retrieved on January 23, 2020, from: http://dspace.uclv.edu.cu/bitstream/handle/123456789/1865/Odleny%20P%C3%A9rez%20BatistaPAPAYA.pdf?sequence=1&isAllowed=y

Reddy, S. R., Krishna, R. B., & Reddy, K. J. (2012). Sex determination of Papaya (*Carica papaya* L.) at seedling stage through RAPD markers. *Research in. Biotechnol.*, *3*(1): 21-28.

Rodríguez, D., Alonso, M., Tornet, Y., Valero, L., Lorenzetti, E. R., & Pérez, R., (2013). Evaluación de accesiones cubanas de papaya (*Carica papaya* L.) ante la mancha anular. *Summa Phytopathologica*, *39*(1), 24-27, doi: Retrieved on February 25, 2020, from: https://doi.org/10.1590/S0100-54052013000100004

Rodríguez Pastor, M. C., & Rosellp, P. (2005). Productividad y características fenológicas de los cultivares de papaya Sunrise y Baixinho de Santa Amalia en invernadero de malla en la zona suroeste de la isla de Tenerife. En *V Congresso Ibérico de Ciências Hortícolas; IV Congresso Iberoamericano de Ciências Hortícolas: [comunicaçoes]*. (Vol. 2, pp. 245-249). Portugal: Associação Portuguesa de Horticultura.

R Development Core Team. (2019). *R: A Language and Environment for Statistical Computing* (version 3.6.1). Viena, Austria: R Foundation for Statistical Computing.. Retrieved on October 7, 2019, from: http://www.r-project.org/

Ruiz Díaz, E., Caballero Álvarez, M. W., Rodríguez Morales, S. J., & Rodríguez García, Y. (2018). "INIVIT fb-4", nuevo cultivar de papaya (Carica papaya L.) Para la agricultura cubana. *Cultivos Tropicales*, *39*(4), 91. Retrieved on February 18, 2020, from: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0258-59362018000400013&lng=es&tlng=es

Rugiero, C. (1980). Situação da cultura no Brasil. En *Simposio Brasileiro sobre a cultura do mamoeiro*. (pp. 3-13). Jaboticabal, Brasil: SP, FCAV/UNESP.

Sánchez Betancourt, E., & Núñez, V. M. (2008). Evaluación de marcadores moleculares tipo SCAR para determinar sexo en plantas de papaya (*Carica papaya* L.). *Rev. Corpoica-Ciencia y Tecnología Agropecuaria.*, *9*(2), 31-36. Retrieved on February 25, 2020, from: http://revistacta.agrosavia.co/index.php/revista/article/download/115/116/

Sevilla Guzmán, E., & Woodgate, G. (2013). Agroecology: Foundations in Agrarian Social Thought and Sociological Theory. *Agroecoiogy and Sustainable Food Systems*, *37*(1), 32-44, doi: 10.1080/10440046.2012.695763

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance for normality (complete samples). *Biometrika*, *52*(3-4), 591-611, doi: https://doi.org/10.1093/biomet/52.3-4.591

Singh, K., & A. Kumar (2010). Genetic variability and correlation studies in papaya under Bihar conditions. *Acta Horticulturae*, (851-20), 145-150, doi: https://doi.org/10.17660/ActaHortic.2010.851.20

Sompak S., Siriyan, R., Nimkingrat, T., Chaikiattiyos S., & Khumcha, U. (2014). Papaya (*Carica papaya* L.) germplasm collection at Si Sa Ket Horticultural Research Center. *Acta Horticulturae: III International Symposium on*

Papaya 1022, 63-68, doi: https://doi.org/10.17660/ActaHortic.2014.1022.6

Vázquez, M., Zavala, M. J., Contreras, F. A., Espadas, F., Navarrete, A., Sánchez, L. F., & Santamaría, J. M. (2014). *New cultivars derived from crosses between commercial cultivar and a wild population of papaya*. *Journal of Botany*, *2014*, 1-10, doi: http://dx.doi.org/10.1155/2014/829354