Evaluación agronómica de accesiones de *Capsicum* del banco de germoplasma de la Universidad Nacional de Colombia Sede Palmira

Agronomic evaluation of *Capsicum* accessions from the germplasm bank of National University of Colombia, Palmira campus

Catherine Pardey Rodríguez; Mario Augusto García Dávila; Franco Alirio Vallejo Cabrera
Facultad de Ciencias Agropecuarias, Universidad Nacional de Colombia Sede Palmira. A.A. 237 Palmira, Valle del Cauca, Colombia. Author for correspondence: magarciad@palmira.unal.edu.co

REC.: 17-10-08 ACEPT.: 05-02-09

RESUMEN

En un diseño de bloques incompletos 10 x 10 con tres repeticiones se estudiaron descriptores cuantitativos relacionados con producción por planta, contenido de capsaicina y presencia de virus en 100 accesiones de *Capsicum* pertenecientes a la Universidad Nacional de Colombia. Las diferencias entre las accesiones fueron explicadas por el contenido de capsaicina, características asociadas con la producción por planta y características del fruto. Se encontró correlación inversa entre el contenido de capsaicina y producción; número de frutos por planta con peso de fruto. La dispersión de las accesiones en el plano cartesiano situó las variedades comerciales Cayenne, Tabasco y Habanero, en función de producción, peso y cantidad de frutos, en posiciones desventajosas con respecto a los promedios generales de las características de las otras accesiones. Cuatro accesiones superaron a Tabasco en contenido de capsaicina. Cuatro tipos de virus (potyvirus, geminivirus y cucumovirus y virus del mosaico del tabaco TMV) se presentaron en el lote de evaluación. Los virus actuaron en forma conjunta; los potyvirus con los cucumovirus y TMV; los geminivirus con TMV.

Palabras claves: Pimentón; ají; producción; capsaicina, virus.

ABSTRACT

100 accessions from the *Capsicum* genebank of the National University of Colombia, Palmira campus were studied under field conditions of the experimental station at Candelaria, Cauca Valley. In a design of incomplete 10 x 10 blocks, with three repetitions, 20 quantitative descriptors, related to plant architecture, flowering and fruiting, were evaluated. Differences between accessions were explained by capsaicin content, and yield-related traits, such fruits, flowers and plants. An inverse correlation was seen between capsaicin content and production; quantity of fruits per plant and

weight; early flowering with large sized fruits; production with cotyledon leaf length. The dispersion of the accessions in the Cartesian axis placed the commercial varieties, Cayenne, Tabasco and Habanero in unfavorable positions in terms of yield, weight and number of fruits with regard to the general averages across all accessions as well as trait stability. The same was observed for the stability of the characteristics above mentioned. There were four accessions with higher capsaicin content than Tabasco. Four virus types affecting the plants were evaluated: potyvirus, geminivirus, cucumovirus and tobacco mosaic virus (TMV). The viruses were acting together; the potyvirus with the cucumovirus and TMV; and geminivirus with TMV.

Key word: *Capsicum*; Pepper; chili; yield; capsaicin.

INTRODUCTION

Agronomic evaluation is an activity aimed at evaluating the quantitative traits of accessions conforming a working collection with the objective of starting a genetic improvement program. The National University of Colombia (UNAL), Palmira campus, possesses a collection of 770 accessions that need to be evaluated to promote their sustainable use.

The objective of the current study was the agronomic evaluation of 100 accessions of *Capsicum* from the germplasm collection of the UNAL, with the aim of identifying traits of agronomic interest associated with plant yield, capsaicin content and presence or absence of different virus types.

MATERIALS AND METHODS

The agronomic evaluation was carried out at the experimental center of the UNAL in Candelaria, Cauca Valley department (3º 6' N and 65 º 3' W, 995 M.A.S.L., 24^{o}C, 60% relative humidity and 1028mm annual precipitation). The 100 samples constituted a random sample from the UNAL *Capsicum* collection. Sowing as conducted using an experimental design of incomplete 10 x 10 blocks, with three repetitions; the experimental unit was comprised of ten plants.

Five quantitative descriptors related to plant yield, capsaicin content and presence or absence of different virus types, were studied (Table 1). To determine the total content of capsaicin and dehydro-capsaicin between three and five fruits from each accession were analyzed in the Biology Laboratory of the UNAL, Bogotá campus, using High Performance Liquid Chromatography - HPLC (Melgarejo *et al*., 2004).

Table 1. Quantitative descriptors evaluated in 100 accessions of ***Capsicum***

Production per plant	Fruit weight (g)
	Number of fruits
	Production per plant (g)
Capsaicin content	Capsaicin content (mg/g of fruit)
Presence of virus in the field	Potyvirus, geminivirus, cucumovirus, Tobacco mosaic virus.

To identify the viruses, samples of apical meristem were taken from each plant and evaluated serologically with a polyclonal antibody for geminivirus, potyvirus y tobacco mosaic virus (TMV) and a monoclonal antibody of the cucumber mosaic virus (CMV).

For data analysis a matrix of rows (accessions) and columns (descriptors) was generated. A descriptive analysis was performed (average, standard deviation, minimum and maximum values, and coefficient of variation). The variables were transformed by $\sqrt{(x+1)}$ to normalize the capsaicin content, average plant yield, average number of fruits per plant, and average fruit weight. Principal Component Analysis was performed to explain the variability between accessions (Nakos y Joyner, 1999), and dispersion diagrams constructed for capsaicin and yield components.

RESULTS AND DISCUSSION

The descriptors: capsaicin content, plant yield, number of fruits per plant, and fruit weight were very variable between accessions.

Principal Component Analysis explained 60% of the variation of the accessions through three synthetic variables: capsaicin content; traits associated with plant yield; and fruit traits (Table 2). These results were similar to those of other characterization studies, which attributed genus variation principally to fruit traits (Correa, 1997; Gómez, 2001; Pardey, García y Vallejo, 2006; García, 2007; Palacios, 2007).

Table 2. Summarized variability according to the Principal Component Analysis with 100 accessions of *Capsicum* from the Germplasm Bank of the National University of Colombia, Palmira campus

Component	Synthetic Variable	Values	Absolute Variance	Accumulated Variance
1	Capsaicin	3.15	0.26	0.26
2	Production per plant	2.43	0.20	0.46
3	Weight and number of fruits	1.74	0.14	0.60

The correlation matrix distinguished associations of agricultural interest. (Table 3). The variable capsaicin content was significantly associated with low fruit production, high number of fruits and low fruit weight, and the high production with low number of fruits and high weight fruits.

Analysis of variance showed significant differences between accessions for variables plant production, weight and number of fruits per plant (Table 4). In *C. annuum, C. frutescens* and *C. chinense*, production showed variability within and between species. In *C. annuum* fruit weight varied most. The most homogenous production and greatest quantity of fruit per plant was in *C. frutescens* (Table 5).

Table 3. Correlation between descriptors of the genus *Capsicum*

	Capsaicin	Production	Fruit number	Fruit weight (g)
cap	**1**	**-0.42** **<.0001**	**0.33** **.0006**	**-0.26** **0.006**
P^n		**1**	**-0.62** **<.0001**	**0.78** **<.0001**
#fr			**1**	**-0.49** **<.0001**
r.fr				**1**

Table 4. Analysis of variance for the variable plant production, fruit weight, and number of fruits per plant in *Capsicum*.

Sources of variation		Production (g)	Fruit weight (g)	Number of fruits
	gl	CM	CM	CM
Group	9	1650.95ns	4.77ns	875.31*
Repetition	2	15981.59*	3.49ns	2960.47**
Accession	99	16657.08**	311.47**	2632.43**
Error	189	2669,37	3,93	536,8

ns not significant
* Significant difference at 5%
** Significant difference at 10%

Table 5. Descriptive statistics for the variables of fruit weight, number of fruits per plant, and yield in *Capsicum.*

Variable	Average	Variance	Standard variation	Coef. Variation	Minimum	Maximum
Block	5.5	8.28	2.87	52.33	1	10
Group	2	0.6	0.81	40.89	1	3
Treatment	50	836.03	28.91	57.25	1	100
Fruit weight	6.41	111.45	10.55	164.18	0.1	82.1
C.annuum	9.83	209.07	14.45	147.06	0.18	78.95
C.chinense	6.04	12.66	3.55	58.90	0.78	17.74
C. frutescens	1.88	2.80	1.67	89.00	0.24	8.81
Fruits/plant	45.10	1286.97	35.87	79.52	4.07	217.6
C.annuum	38.59	993.46	31.51	81.67	5.33	156.13
C.chinense	33.07	187.90	13.70	41.44	7.18	70.81
C. frutescens	62.22	826.46	28.74	46.19	5.20	121.01
Production per plant	119.18	7501.33	86.61	72.66	6.73	508.40
C.annuum	137.80	8611.17	92.79	67.33	13.57	403.30
C.chinense	142.86	2110.55	45.94	32.15	33.65	210.77
C. frutescens	78.73	1721.01	41.48	52.68	7.77	191.78

Plant production

Plant production was distributed in quadrants based on the average (119.18 g) and the variance (2756.7) (Figure 1). 53 accessions were placed in the lower quadrants, 46 of which had low variability (quadrant 1). The wild accessions *C. annuum* y *C. frutescens*, the variety Tabasco and other similar accessions in form and size were placed In the quadrants 1 and 2. 47 accessions were placed in the top quadrants of high yield; 25 of stable yield (quadrant 3), predominantly of the jalapeño type. The commercial varieties, *chinense,* from the Atlantic Coast, the Cayenne variety and other commercial sweet pepper varieties were placed in quadrant 4.

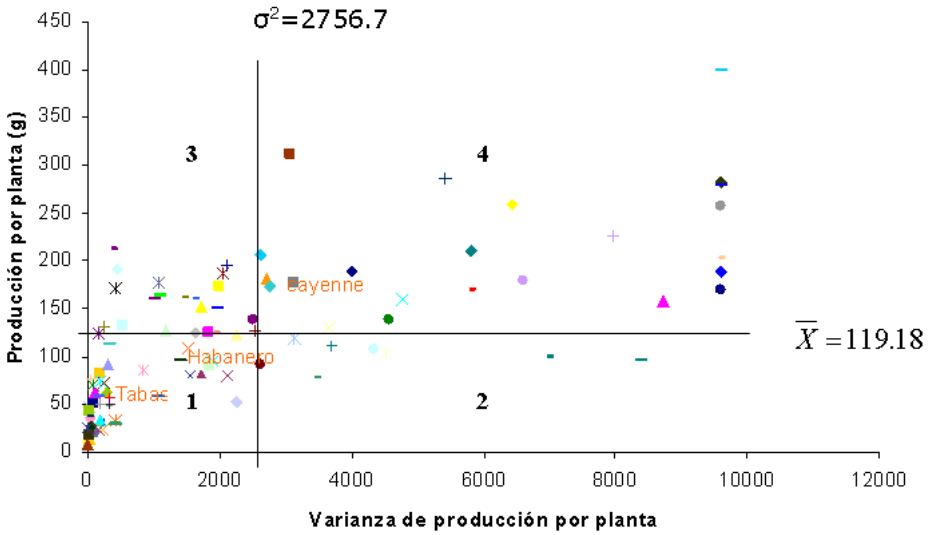

Figure 1 Relationship between production per plant and variance of production per plant in 100 accessions of *Capsicum.*

Fruit weight

Fruit average was dispersed over quadrants based on the medium (6.16 g) and variance (0.59) (Figure 2). The majority of the accessions were placed in the two lower quadrants, 1 and 2; 73 with lower than average weight; 59 with low variability (quadrant 1). The wild species *C. annuum* and *C. frutescens*, and the varieties Tabasco and Habanero were located in quadrant 1. 27 accessions with higher than average weight were placed in the top quadrants. Seven accessions of the jalapeño type and some commercial varieties from the Atlantic Coast that presented a stable weight were placed in quadrant 3. The rest of the commercial varieties, and the sweet pepper types showed high variability in harvested fruit weight (quadrant 4).

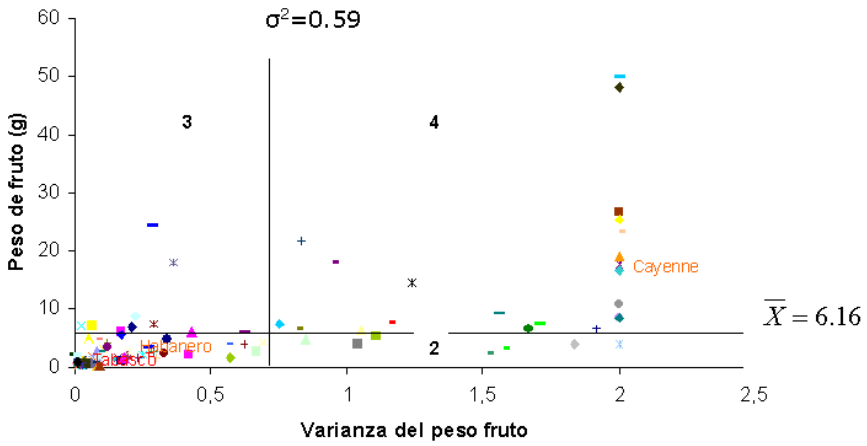

Figure 2 Relationship between fruit weight and variance of fruit weight in 100 accessions of *Capsicum.*

Number of fruits per plant

Accessions with low and high numbers of fruits were identified according to the medium (45 fruits / plant), distributed according to the trait stability expressed below or above the variance (576.3). 64 accessions with large fruits, but lower quantity (commercial varieties of the sweet pepper, and the jalapeño types) were placed in quadrants 1 and 2. Among the four accessions in quadrant 2 was the Cayenne variety. The variety Habanero was placed near the border between quadrants 2 and 3. 36 accessions with numerous small fruits were placed in quadrants 3 and 4, including Tabasco in quadrant 3, and the wild species in quadrant 4 (Figure 3)

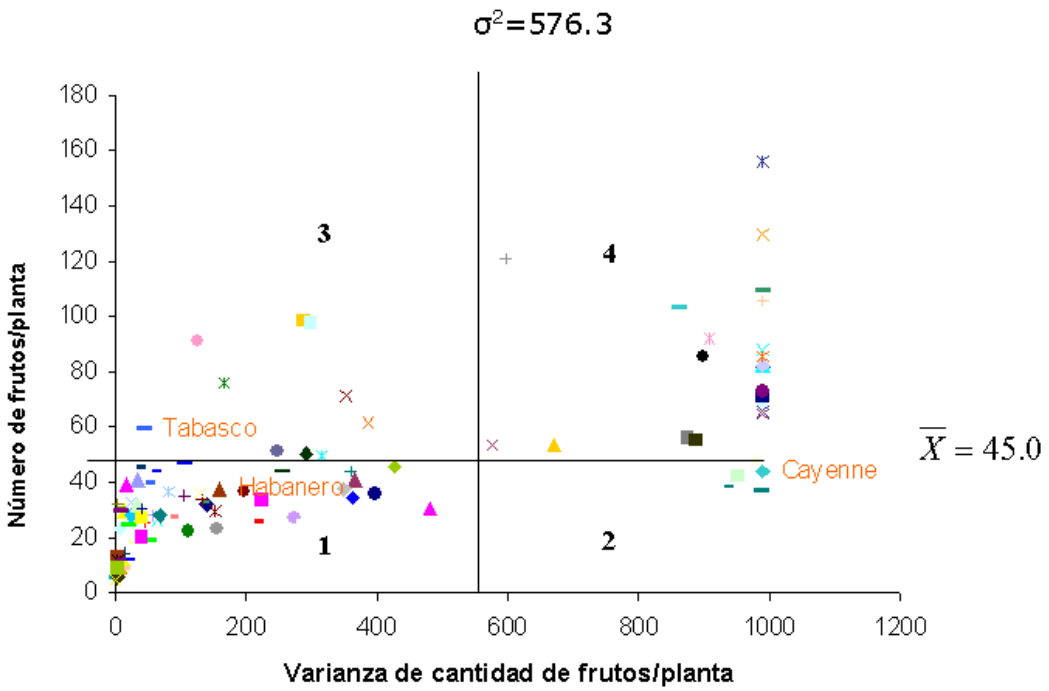

Figure 3. Relationship between number of fruits per plant and variance of number of fruits per plant in 100 accessions of *Capsicum.*

Capsaicin content

Capsaicin content, which determines the pungency of chilies, varied from zero to 5 mg/g, a greater range than that reported by Melgarejo *et al*. (2004) for 6 accessions from Amazonas (1.6 mg/g). Pungency is a response affected by the environment-genotype interaction, sometimes with a predominance of environmental factors, such as sowing location (Harvell y Bosland, 1997) and other times by genetic differences and the position of the fruits on the plant (Zewdie y Bosland, 2002). Chili hotness is associated with small fruits, and the inverse correlation between capsaicin and fruit weight conforms this. Spatial localization of the accessions by capsaicin values associated with fruit weight (Figure 4) was dispersed, with extreme values in accession 126 collected in the Cauca Valley. The appearance of this fruit was similar to Tabasco. The pungency of the commercial varieties in decreasing order was Tabasco, Habanero and Cayenne. Only four accession of *C. frutescens* were greater than Tabasco (126, 357, 997 and 73), and their weights were greater.

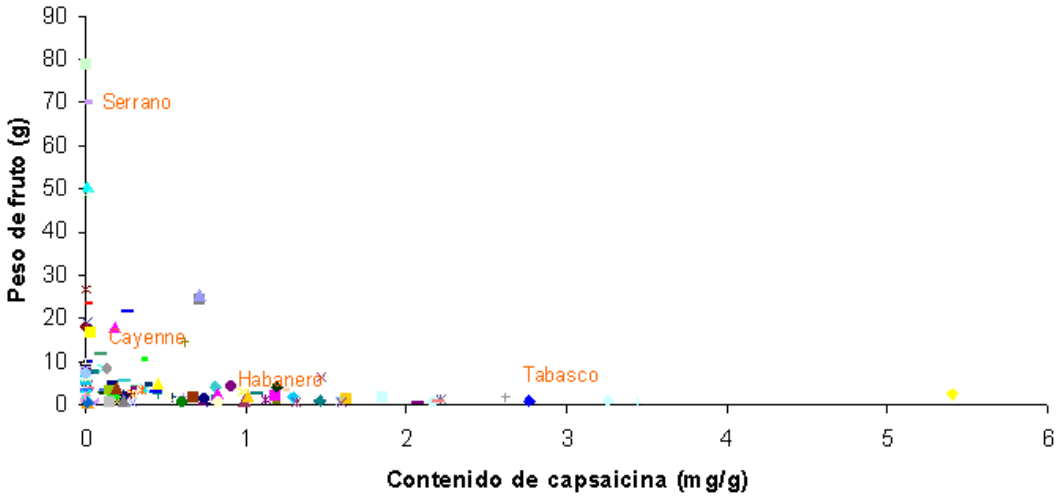

Figure 4. Capsaicin content associated with fruit weight in 100 accessions of *Capsicum.*

Evaluation of the presence in the field of potyvirus, cucumber mosaic virus (CMV), geminivirus and tobacco mosaic virus (TMV)

TMV was the virus with the greatest incidence in the field (12 accessions), followed by potyvirus (nine accessions); CMV and Geminivirus were found once. The viruses occurred in combinations: Potyvirus was associated with CMV and TMV; Geminivirus with TMV (Table 6). Virus distribution in the field was not homogenous and was detected in isolated plants.

The presence of four types of virus was probably due to the presence of white fly and trips in the neighboring tomato cultivations. The low presence of the virus is explained as the experimental center is surrounded by sugar cane plantations, pastureland, and chicken farms.

The future of the chili crop in Colombia requires the development of cultivars with high yields, high content of capsaicin and resistance to the main insect pests, in order to increase competition in the international markets.

In the germplasm bank of the UNAL material was detected with potential for improving capsaicin content, and resistance to various viruses, with useful fruit traits for the food, pharmaceutical and colorant industries. The accessions present novel traits for the production of sauces, powders, repellents, medicinal substances and nutra-ceuticals for their high antioxidant content.

Tabasco, a principal variety for export, showed stable behaviors in fruit production, but the study revealed better material, which should undergo further study and selection.

Table 6. Virus incidence evaluation of *Capsicum* germplasm from the Experimental Center of the National University of Colombia, Palmira campus, CEUNP.

	ELISA							
	Potyvirus		CMV		Geminivirus		TMV- fruit	
	Atc. m. de Agdía		Atc.m. 10-1D10-1G1-3C5		Atc. m. $C1-3F7		Specific Atc.	
Accession	Absorbence	Reaction	Absorbence	Reaction	Absorbence	Reaction	Absorbence	Reaction
2	0.0540	-	0.020	-	0.0030	-	2.0490	+
16	0.3790	+	o.2020	+	0.0170	-	0.0130	-
19mc	0.0150	-	0.0020	-	0.6460	+	1.0554	+
67	2.1130	+	0.0040	-	0.0125	-	2.9670	+
69	0.0250	-	0.0040	-	0.0260	-	1.0970	+
70	0.0220	-	0.0020	-	0.0190	-	1.6410	+
73	0.0150	-	0.0040	-	0.0020	-	3.0100	+
95y	0.1820	+	0.0010	-	0.0180	-	0.0300	-
244y	0.7640	+	o.0030	-	0.0020	-	0.0180	-
283a	0.8510	+	0.0040	-	0.0170	-	0.0000	-
315	0.0450	-	0.0050	-	0.0040	-	1.9900	+
317	1.2280	+	0.0010	-	0.0050	-	2.3510	+
336y	3.0290	+	0.0010	-	0.0230	-	1.1390	+
615	2.2410	+	0.0030	-	0.0090	-	0.0060	-
631	0.3020	+	0.0000	-	0.0060	-	0.0090	-
655	0.0050	-	0.0040	-	0.0160	-	0.7030	+
707	0.0500	-	0.0060	-	0.0230	-	4.0000	+
981	0.0100	-	0.0000	-	0.0260	-	0.6580	+

CONCLUSIONS

1. Variation between *Capsicum* genotypes is associated with pungency, plant production and fruit traits.
2. Accessions were identified with superior traits of yield, fruit number, average fruit weight and capsaicin content than the commercial varieties of chili, Cayenne, Habanero and Tabasco.
3. Some *Capsicum* plants were infected with four types of virus, potyvirus, geminivirus and cucumovirus and tobacco mosaic virus (TMV).

ACKOWLEDGEMENTS

To COLCIENCIAS for financial support for the doctoral thesis of C. Pardey, from which was derived this article.

BIBLIOGRAPHY

1. Correa R., R. D. 1997. caracterización de ají y pasifloras. Pasantía. Corporación Colombiana de Investigaciones agropecuarias, CORPOICA Rionegro 53p.

2. García D., M. A. 2007 Diversidad genética de *Capsicum* en Colombia. Tesis doctoral. Universidad Nacional de Colombia Sede Palmira Facultad de Ciencias Agropecuarias. 86p.

3. Gómez C., A. F. 2001. Caracterización morfoagronomica de diferentes accesiones del género *Capsicum* sp. Pasantía. Corporación Colombiana de Investigaciones agropecuarias, CORPOICA Rionegro 110p.

4. Harvell, K.; Bosland, P. 1997 The environment produces a significant effect on pungency of chiles. *HortScience* 32(7):1292.

5. Melgarejo, L. M.; Hernández, M. S.; Barrera, J. A.; Bardales, X. 2004. Caracterización y usos potenciales del banco de germoplasma de ají amazónico. Bogotá, Colombia: Instituto Amazónico de Investigaciones Científicas SINCHI, Universidad Nacional de Colombia, 108p.

6. Nakos, G.; Joyner, D. 1999. Eigenvalores y eigenvectores. *En*: Álgebra lineal con aplicaciones. México: Editorial Internacional Thomson. 666p.

7. Palacios C., S; García D., M. A. 2007. Caracterización morfológica de accesiones de *Capsicum* spp. Trabajo de Maestría. Palmira: Universidad Nacional de Colombia. 74p.

8. Pardey R., C.; García D., M. A.; Vallejo C., F. A. 2006. Caracterización morfológica de cien accesiones de *Capsicum* del Banco de germoplasma de la Universidad Nacional de Colombia Sede Palmira. *Acta Agron* (Palmira) 55(3): 1-9.

9. Zewdie, Y.; Bosland, P. 2002. Pungency of Chile (*Capsicum annuum* L) fruits is affected by node position. *HortScience* 35(6): 1174.