Phenotypic, genotypic and environmental correlations in eggplant

Correlaciones fenotípicas, ambientales y genéticas en berenjena

Hermes Araméndiz Tatis[1], Carlos Enrique Cardona Ayala[2], Miguel Mariano Espitia Camacho[3]

[1]Universidad de Córdoba, Facultad de Ciencias Agrícolas, AA 354, Montería, Colombia. Author for correspondence: haramendiz@hotmail.com; ccardona@sinu.unicordoba.edu.co, espitia@sinu.unicordoba.edu.co

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Abstract

The phenotypic, genotypic and environmental correlations between six characters of 24 cultivars of eggplant (*Solanum melongena*) were studied in the research centre of Turipaná of Corpoica (Cereté- Córdoba-Colombia – 8° 31' N and 75° 58' W, 13 m.a.s.l.). A completely randomized block design was used with three repetitions and experimental units of 10 m^2. The analyses showed that genetic correlations were of higher or equal magnitude to the phenotypic correlations, while the environmental ones had low effects on the results. The number of fruits and the yield showed a positive and highly significant ($r = 0.56$, $P < 0.01$) genetic correlation. A negative and highly significant ($r = -0.68$, $P < 0.01$) genetic correlation was observed between fruit length and fruit strength. No correlation was detected between yield and fruit weight ($r = 0.04$). Fruit number and fruit weight showed a negative and highly significant genetic correlation ($r =-0.63$, $P < 0.01$). It is suggested that the number of fruits per plant could be used as a selection criterium to obtain high yield eggplant cultivars.

Key words: *Solanum melongena*, solanaceae, plant quality, fruit yield, genetic correlation.

Resumen

En el Centro de Investigaciones Turipaná de la Corporación Colombiana de Investigaciones (Corpoica) (Cereté, Córdoba, Colombia –8° 31' N y 75° 58' O, a 13 m.s.n.m) se estudiaron las correlaciones, ambientales y genéticas entre seis caracteres de 24 cultivares de berenjena (*Solanum melongena*). Para el efecto se utilizó un diseño de bloques completamente al azar con tres repeticiones y unidades experimentales de 10 m^2. Los resultados mostraron que las correlaciones fueron de mayor o igual magnitud que las fenotípicas, mientras que las ambientales fueron de escaso valor. El número de frutos y el rendimiento estuvieron genéticamente correlacionados ($r = 0.56$, $P < 0.01$), la longitud y la resistencia del fruto mostraron correlación genética negativa (r = -0.68, P < 0.01) y entre el rendimiento y peso de fruto la correlación fue muy baja (r = 0.04). El número de frutos y su peso de frutos se correlacionaron de manera negativa (r =-0.63, P < 0.01). El número de frutos por planta puede ser utilizado como criterio de selección para la obtención de cultivares de berenjena de altos rendimientos.

Palabras clave: *Solanum melongena*, solanacea, calidad de la planta, rendimiento de fruto, correlación genética.

Introduction

The eggplant (*Solanum melongena* L.), together with its related species comprises a wide range of species with geopgraphic origin principally in Asia and Africa. The species was domesticated in the region of India and South East China, and is the horticultural species with greatest economic importance (Daunay et al., 2000; Sekara et al., 2007) that is cultivated in subtropical areas of Africa (Stommel & Whitaker, 2003). Within the complex of cultivated forms, varieties exist with a high morphological variability characterized by the presence of spines on the cáliz and leaves, flowers in andromonoicas racemes, fruits of different forms, sizes and brilliant colors, all resulting from mutations at various loci under pleiotropic effects frutos (Sekara et al., 2007). However, improved cultivars are characterized by the absence of spines, large (> 200 g), medium (100 - 200 g) or small (< 100 g) fruits, which may vary in coloration (Prohens et al., 2005; Sekara et al., 2007).

In the Departments of Córdoba, Sucre and Bolívar (Colombia) approximately 374 ha of eggplant are planted, representing 72% of the national production. Yield from these regional crops reaches 16 t/ha, with crops planted between 1000 and 2500 m^2, by small scale producers, landless peasants, and workers in agricultural activities (Araméndiz et al., 1999; DNP, 2005; Agronet, 2008). In contrast, the yield of the improved hybrids is frequently greater than 40 - 50 t/ha, with the crop characterized by being early, of a uniform nature at harvest, and with better characteristics for storage (Sekara et al., 2007).

Producers in the Colombian Caribbean region plant cultivars with a high genetic variability, using seeds from their own crops, which were introduced by Arab migrants after the Spanish conquest. As a result of the processes of mutation, natural selection and natural hybridization a high variability in agronomic characteristics of interest has been generated, yielding an excellent source of germplasm for the development of cultivars adapted to the tropical conditions in the region (Araméndiz et al., 2006; Araméndiz et al., 2008a).

Yield is a trait with a complex nature that depends on the interactions of a high number of factors. The statistical tool that allows the crop breeder to estimate the grade and the nature of such associations is the correlation coefficient (r). The phenotypic correlation is estimated from values measured in the field; the genotypic correlation corresponds to the genetic portion of the phenotypic correlation (Ceballos, 2003).

The correlation between traits is important when simultaneous selection of traits is required, or when the trait of interest presents a low heritability, or measuring and identification problems. In this case, by selecting for another trait with high variability and easy identification and measuring, and with a high correlation to the desired trait, the breeder may obtain more rapid progress compared with direct selection (De Carvalho et al., 1999).

In eggplant, a genetic correlation exists between yield and the number of fruits per plant, and the index and weight of fruits; equally, there is evidence that the former is the variable with the most direct effect on yield, followed by the diameter of fruits (Dhameliya & Dobariya, 2007; Bansal & Metha, 2008; Lohakare et al., 2008).

The program for genetic improvement of eggplant at the University of Córdoba, Colombia is developing tropical cultivars with high yields and good fruit quality to satisfy the demands of farmers, the agro-industry and consumers. The objective of the present study was to estimate the magnitude and the direction of the phenotypic, genetic and environmental correlations between fruit yield, its components and resistance, traits of economic importance in eggplant, with the aim of obtaining greater efficiency in the selection process.

Materials and methods

The study was carried out in the first semester of 2008 in the Research Center of Turipaná of the Colombian Corporation for Agricultural Research (Corpoica) located in Cereté-Córdoba, Colombia. The center is located in the humid Caribbean region of Colombia (8° 31' N & 75° 58' O, at 13 m.a.s.l.). The soil of the experimental area is Fluvaquentic endoaquept franco with means of 2.2% organic material and a pH of 5.9, apparent density of 1.12 g/cm^3 and moderately stable structure (Palencia et al., 2006).

24 genotypes of eggplant were evaluated. These genotypes originated from Brazil, Colombia, Japan, Taiwan and the USA (Box 1). A completely randomized block design was used with three repetitions was used. Each plot was comprised of a furrow of 10m, with the distance between plants and furrows of 1m.

Box 1. Origin of the eggplant genotypes used in the study. * the first two characters of the code refer to the origin of the genotype. CC – commercial enterprise, Colombia.

Cuadro 1. Procedencia de los genotipos de berenjena utilizados en el estudio.

Código*	Genotipos	Procedencia (casa comercial o país)
BR01	Broxa	Topseed-Brasil
BR02	Berenjena cica	Embrapa –Brasil
BR03	Linea tradicional	Feltrin – Brasil
CC01	B. Long purple	Fercon - Colombia
CC02	Black Bell	Miguel Saen y Cia. – Colombia
CC03	Berenjena Barcelona	Impulsemillas – Colombia
CC04	Berenjena N° 5	Impulsemillas - Colombia
CC06	B. Long purple	Arroyave – Colombia
CC08	B. roxa	Semicol – Colombia
JP01	B. Japonesa Senryo	Japón
TW01	S. Chaoyan Taiwan	Taiwan
TW03	Brinjal Mebh-11	Taiwán
TW04	Mandhari Seeds	Taiwán
TW06	Shuangfeeng G.13	Taiwán
EU01	Black beauty	Estados Unidos
EU02	Long purple	Estados Unidos
C002	Lila	Cereté, Córdoba, Colombia
C003	Lila pompa	Cereté, Córdoba, Colombia
C009	Morada	San Carlos, Córdoba, Colombia
C016	Lila	Cereté, Córdoba, Colombia
C023	Berenjena Palanca	Cereté, Córdoba, Colombia
C025	Roja calabaza	Cereté, Córdoba, Colombia
C033	Morada con espina	Lorica; Córdoba, Colombia
C043	Negra larga	Montería, Córdoba, Colombia

* Los dos primeros caracteres del código hacen referencia al origen de los genotipos. CC: casa comercial Colombia; BR: Brasil; EU: Estados Unidos; JP: Japón; TW: Taiwán; C0: Córdoba-Colombia.

The measured variables were fruit length (cm), number of fruits per plant (cm), fruit weight (g) resistance of fruit to penetration (newtons), plant height (cm) and fruit yield (kg/ha) in three plants randomly chosen for each repetition, with the exception of yield which was measured in the eleven plants in each furrow.

Agronomic management in the nursery and in the field was conducted according to recommendations for the crop in the Sinú valley (Aramendiz et al., 2008b). Analysis of variance and covariance for the six traits studied, as well as the phenotypic environmental and genotypic correlations were performed using the program Genes version Windows (Cruz, 2004). Once the correlation coefficients wer estimated, the statistical significance of each was confirmed, using the null hypothesis: Ho: r = 0, versus the alternative hypothesis: Ha: r ¹ 0, with the ‘t’ test, using the following formula:

$$t_c = \frac{r\sqrt{(n-2)}}{\sqrt{(1-r^2)}}$$

The calculated ‘t’ (t_c) was compared with a table ‘t’ (t_t) at the selected significance level between 0.05 & 0.01 with n = 2 degrees of freedom. The decision rule was: if $t_c \geq t_t$, then the value of ‘r’ is statistically different to zero.

Results and discussion

The values for the genotypic correlations were greater or of equal magnitude to the phenotypic correlations (Box 2), indicating that the relationship between the variables depends on additive genetic factors present in the study material, and not on the existence of environmental effects, which is in accordance with the findings of Martínez & Torregroza (1988), Yadav et al. (1997), Leggese et al. (1999), Ferreira et al. (2003), Espitia et al. (2005, 2008a, 2008b), with coincidence between coefficient pairs. These results can be explained by the reduction in experimental error in the Analysis of Variance, as when this is close to a value of zero (0), both the phenotypic and the genotypic correlations tend to be identical (Legesse et al., 1999).

Box 2. Phenotypic (r_F) genetic (r_G) and environmental (r_E) correlations for six traits in eggplant, Sinú valley, Colombia. LONFRU - fruit length; NUFRUPTA – no. of fruits per plant; PEFRU – fruit weight; RENFRU – fruit yield; RESFRU – fruit resistance; ALPTA – plant height. *, ** = significant at 5% and 1% respectively.

Cuadro 2. Correlaciones fenotípicas (r_F), genéticas (r_G) y ambientales (r_E) para seis caracteres de berenjena. Valle del Sinú, Colombia.

	Correlaciones	NUFRUPTA	PEFRU	RENFRU	RESFRU	ALPTA
LONFRU	r_F	-0.33	0.39	0.00	-0.67**	0.52**
	r_G	-0.35	0.31	0.00	-0.68**	0.53**
	r_E	0.22	-0.07	0.10	0.04	0.14
NUFRUPTA	r_F	–	-0.63**	0.56**	-0.02	-0.47*
	r_G	–	-0.64**	0.56**	-0.02	-0.46*
	r_E	–	0.04	0.23	-0.04	-0.02
PEFRU	r_F	–	–	0.04	-0.06	0.74**
	r_G	–	–	0.04	-0.06	0.75**
	r_E	–	–	0.17	-0.08	-0.17
RENFRU	r_F	–	–	–	-0.03	0.03
	r_G	–	–	–	-0.03	0.04
	r_E	–	–	–	0.12	-0.20
RESFRU	r_F	–	–	–	–	-0.14
	r_G	–	–	–	–	-0.14
	r_E	–	–	–	–	-0.09
ALPTA	–	–	–	–	–	–

LONFRU: Longitud de fruto, NUFRUPTA: Número de fruto por planta, PEFRU: Peso de fruto, RENFRU: Rendimiento de frutos, RESFRU: Resistencia de frutos, ALPTA: Altura de planta.
*, ** = significativo al 5 y 1%, respectivamente.

The phenotypic and genetic coefficients of correlation between yield and measured characters, as well as the associations between these, indicate that yield is not correlated with fruit length, fruit weight, fruit resistance, nor plant height. However, it was revealed that there was a positive and highly significant correlation with respect to the number of fruits per plant ($r = 0.56$, $P < 0.01$). Kruiteva (1985) did not find a correlation between yield and plant height, noe fruit length, but a correlation was found between the number of fruits and the fruit weight, in agreement with Damnjanovic et al. (2002) and Rodríguez et al. (2008), due to the high heritability that these two variable possess, being little affected by the environment nor additive genetic variation.

Ingale and Patil (1995), Bansal and Metha (2008), and Lohakare et al. (2008) found a positive correlation between yield and the number of fruits, and the absence of a correlation with fruit weight. Gutiérrez del Río et al. (2004) and Zorzoli et al. (2000) found that the correlation between yield and fruit weight in eggplant varied as a function of the size of the fruits of the evaluated genotypes. In this way, those cultivars with small fruits may produce a greater quantity of these per floral raceme, which favors yield. Additionally, the genotypes of large fruits present frequent fruit abortions, again favoring yield.

The results of the present study indicate that the improvement of fruit yield of eggplant cultivars may be obtained through increasing the number of fruits. Vadivel and Bapu (1988a, 1988b, 1989a) considered the number of productive branches as an important trait in yield breeding programs, as it possesses a high coheritability and moderate heritability, allowing genetic advances due to the predominance of additive genetic action.

The number of fruits per plant presented a negative, highly significant genetic correlation with respect to fruit weight ($r = -0.63$, $P < 0.01$), results which coincide with those seen by Wessel-Beauver (1992) in tomato; Tavares et al. (1999) in chili, Monpara and Kamani (2007) in eggplant, Ferreira et al.(2003) in watermelon and Pimentel et al.(2008) in passionfruit; and a significant correlation with a negative tendency for plant height ($r = -0.47$, $P < 0.05$). These results indicate that the improvement through a greater quantity of fruits coincides with a progressive reduction in the fruit weight, compromising yield and quality when large fruits are required, as highlighted by Bertin et al. (1998), Antonini et al. (2002) and Scarpare Filho et al.(2000). If the objective is to obtain cultivars with small fruits with few seeds, selection for weight must be emphasized. However, at the moment of selection between these traits, a balance must be made, so as to not compromise yield and fruit quality, as a negative correlation exists between the number of fruits and fruit weight that retards genetic improvement.

Fruit weight presented a low correlation with length, indicating that the size of the fruit is a function of width, in agreement with the findings of Ben-Chaim & Poran (2000) in chili. Fruit resistance to damage also presented a negative correlation with length ($r = -0.68$, $P < 0.01$), but did not show a relationship with the other traits considered in the study. This suggests that the longest fruits are more sensitive to transport, possibly presenting a lower accumulation of potassium (Ruiz- Sánchez, 2006).

Conclusions

- The number of fruits per plant in the yield component with greatest importance in genetic improvement in eggplant.
- The existence of a significant negative correlation between fruit number and fruit weight suggests the existence of a physiological limit between these two traits.
- The genetic components of the correlations were more important than the environmental, as the phenotype is a reflection of the genotype.

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1-2 Agronomic Engineer, M. Sc. Ph.D.
3 Agronomic Engineer, M. Sc. In Agricultural Sciences.