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WHICH IS CRUCIAL FOR HETEROSIS? TRAITS, GENETIC OR CHARACTERISTIC DIVERSITY: PUNGENCY PARADIGM

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Abstract

Commercially plant breeding and crop improvement is possible to know heterotic behavior of plant species and heredity of the traits. It is commonly accepted that heterosis has been positively correlated with distance between traits of the parents. Two pepper variety belongs different Capsicum species, non-pungent Santos Flame (Capsicum annuum L.) and Biquinho (Capsicum chinense Jacq.) which had very low capsaicinoid content were crossed to estimate mid parent heterosis, heterobeltiosis and standard heterosis. In this study extraordinary heterosis rates were calculated F_1 progeny of two different Capsicum species close to pungency trait but definitely divergent genetically. The capsaicin content of Santos Flame, Biquinho and F_1 progeny were 0 mg kg^{-1}, 2.1 mg kg^{-1} and 217.4 mg kg^{-1}, respectively. The highest mid parent heterosis was estimated from capsaicin content with 20605%. Similarly uncommonly heterobeltiosis and standard heterosis rate was estimated for capsaicin content with 10252% and 237%, respectively. Correlatively extreme heterosis rates were calculated for SHU pungency level, dihydrocapsaicin and total capsaicinoids content.

Key words*: pungency, heterosis, heterobeltiosis, pepper.*

INTRODUCTION

The importance of heterosis in agriculture is to improve high yielded varieties. Heterosis is not a trait expressed by specific genes or alleles therefore distinction is important for heterosis (Lippman and Zamir, 2007). Genetic diversity could be as great value as combining ability or greater than it (Hayes and Immer, 1942). Allard (1999) indicated that single-cross hybrids diverged maximally in allelic frequencies produce most heterozygoty in most loci in F_1 hybrids.

The most important quality characteristics in pepper are color, pungency, dry/fresh yield ratio and flesh thickness (Abak, 1995). Capsaicinoids are colorless, odorless and flavorless substances only found in pepper. They have burning feature and no nutrition value. Cause of heat feeling substances are capsaicinoids consist of the most important seven different substances structurally similar pungent compounds including capsaicin, dihydrocapsaicin, nordihydrocapsaicin, norcapsaicin, homocapsacin, nornorcapsaicin and homodihydrocapsaicin (Greenleaf, 1986; Collins and Bosland, 1994).

The capsaicinoid content of the pepper cultivars varies greatly and related with maturity. A subjective assessment Scoville Heat Unit (SHU) based on panel evaluation also is used to determine pungency of peppers. ASTA (American Spice Trade Association) prefers Scoville Heat Unit determining of pungency (Scoville, 1912; ASTA, 1985).

With this study two different *Capsicum* species distinct from genetically but close to pungency trait were crossed and inheritance of pungency component calculated.

MATERIALS AND METHODS

Two pepper cultivars 'Santos Flame', PanAmerican Seed Illinois USA (*Capsicum annuum* L.), as female, and 'Biquinho' (*C. chinense* Jacq.), as male, were crossed and capsaicinoid contents of parents, F_1 48 F_2, progenies and check variety Jalapeño were measured by high pressure liquid chromatography.

Extraction of capsaicin and dihydrocapsaicin

The whole fruits dried at 50°C for 2 days and ground to fine powder. One gram of dried and ground fruit stirred in 10 ml sodium acetate saturated ethanol during 3 hours in 60°C. The mixture was filtrated and analyzed.

Determination of capsaicin and dihydrocapsaicin contents

HPLC: was (Model LC-20 Shimadzu, Kyoto, Japan) consisting of a high-pressure pumps, column (C18 100-5 250 × 4.6 mm), oven (35°C) and UV-VIS detector (at 280 nm). Isocratic mode (methanol 48.4%, water 30.2% dioxan 13.3%, acetonitrile 7.9% and perchloric acid 0.2% [% 2]) was performed at 1.5 ml min^{-1} of flow rate with 20 µL sample volume (ASTA, 1985).

Standards of capsaicin and dihydrocapsaicin were purchased from Sigma-Aldrich Co. Pungency values were converted to SHU (Scoville Heat Unit) multiplying total capsaicinoids by 15 (Mathur et al., 2002).

The plants of parents and progenies were grown in field conditions during the 2015 pepper growing season in EMTZARI (East Mediterranean Transitional Zone Agricultural Research of Institute Kahramanmaraş, Turkey).

Calculating heterosis

Mid parent, better parent also known as heterobeltiosis and standard also called as economic heterosis (Sharma et al., 2013) calculated by using formula.

$$\text{Mid Parent} = \frac{F_1 - MP}{MP} \times 100$$

$$\text{Better Parent} = \frac{F_1 - BP}{BP} \times 100$$

$$\text{Standard} = \frac{F_1 - \text{Check (Jalapeño)}}{\text{Check (Jalapeño)}} \times 100$$

Where: F_1 was mean of F_1; MP was mean of two parents; BP was mean of better parents and Jalapeño was used for control variety.

RESULTS AND DISCUSSIONS

The chromatogram peaks for capsaicin and dihydrocapsaicin of parents, F_1, Acc. 97, Acc. 103 and 270) were exhibited in Figure 1. The mean of retention time was 5.56 min. for capsaicin and 7.47 min. for dihydrocapsaicin.

Cultivar Biquinho which had a little amount (2.10 mg kg^{-1}) capsaicin content crossed non-pungent Santos Flame and hybrid exhibited 217 mg kg^{-1} capsaicin. An extraordinary heterosis over mid parent, better parent and standard check (Jalapeño 64.60 mg kg^{-1}) was observed in F_1 generation for capsaicinoid content and pungency level from interspecific crosses of *Capsicum*. The magnitudes of heterosis, better parent and standard check for capsaicin were 20605, 10252 and 237%, respectively (Table 1.)

Mid parent heterosis and heterobeltiosis was 3877 and 1889%, respectively while the economic heterosis was 228% over standard check Jalapeño cultivar on account of dihydrocapsaicin.

The percentage of mid parent heterosis related sum of the capsaicin and dihydrocapsaicin contents was 7855%. Heterobeltiosis and standard heterosis was 3877 and 233%, respectively. Correlatively pungency level had similarities with sum of the capsaicin and dihydrocapsaicin concerning mid parent, better parent and economic heterosis were found same.

The capsaicin contents ranged between 0.00 - 1279 mg kg^{-1} and the dihydrocapsaicin contents ranged from 0.00 - 912 mg kg^{-1}. The Accession 97 had the highest capsaicin content with 1279 mg kg^{-1} while the highest dihydrocapsaicin was obtained from Accession 103 with 912 mg kg^{-1}. Ten accessions from F_2 progeny of Santos Flame × Biquinho had no capsaicin content. Dihydrocapsaicin was not detected from 11 accessions of F_2 progeny of Santos Flame × Biquinho. Despite low level capsaicin content than Acc. 97, Acc. 103 was the most pungent genotype with 30793 SHU because of its high amount of dihydrocapsaicin. Segregation of all of the pungency components transgressively in F_2 progeny demonstrated that pungency was expressed dominantly (Figures 2 and 3).

Biquinho exhibited 140 SHU pungency level while it was 0 in Santos Flame. The interspecific hybrid of these two cultivars produced 349.61 mg kg^{-1} sum of capsaicin and dihydrocapsaicin content and exposed 5594 SHU pungency level. Pungency mean of parents was 70 SHU and the check variety Jalapeño had 1678 SHU level.

Table 1. Capsaicinoid content of hybrid, parental and check varieties and heterosis percentage of pungency components

	Capsaicin (mg kg^{-1})	Dihydrocapsaicin (mg kg^{-1})	Capsaicin + Dihydrocapsaicin (mg kg^{-1})	Pungency (SHU)
Biquinho	2.10	6.65	8.79	140
Santos Flame	0.00	0.00	0.00	0
Mean	1.05	3.33	4.40	70
F_1	217.40	132.25	349.61	5594
Jalapeño	64.60	40.26	104.85	1678
		Heterosis (%)		
Mid Parent	20605	3877	7855	7855
Better Parent	10252	1889	3877	3877
Standard	237	228	233	233

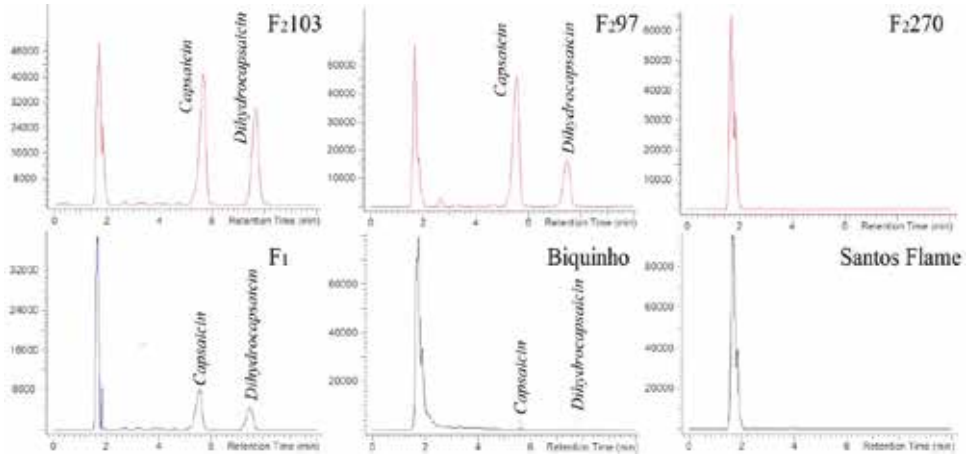

Figure 1. Capsaicin and dihydrocapsaicin HPLC chromatogram of Biquinho, Santos Flame and their F_1 and 103, 97,270 lines from F_2 progenies

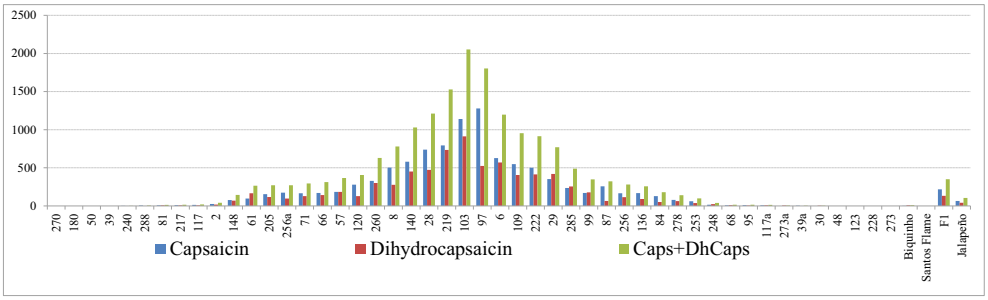

Figure 2. Capsaicin, dihydrocapsaicin (mg kg^{-1}) content of Biquinho, Santos Flame and their F_1 and F_2 progenies

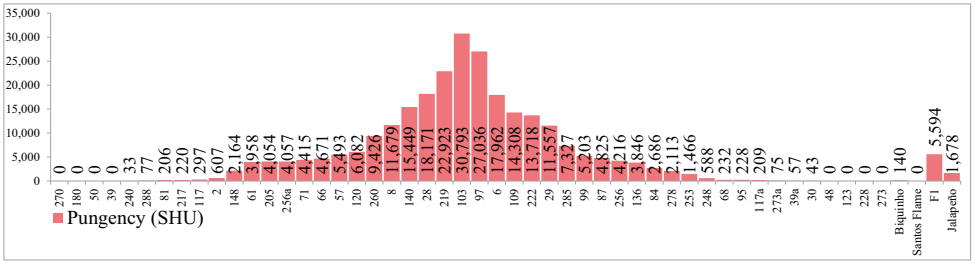

Figure 3. Pungency level (SHU) of Biquinho, Santos Flame and their F_1 and F_2 progenies

The pungency components in pepper were first extracted by Thresh (1846) and named as capsaicin. Substances of pungency in peppers are highly influenced by environmental conditions such as high temperatures and water stress (Lindsey and Bosland, 1996). Ahmed et al. (1982) emphasized that the pungency is a dominant character and additive gene effect was very important in their inheritance. According to our results transgressive segregation of pungency indicated capsaicin, dihydrocapsaicin content and pungency was inherited dominantly.

Biquinho (*Capsicum chinense* Jacq.) is known as non-pungent sweet pepper cultivar (Alves et al., 2014; Sganzerla et al., 2014). Nevertheless de Aguiar et al. extracted (2014) low concentration of capsaicinoids in Biquinho pepper. We found a low concentration of capsaicin and dihydrocapsaicin in Biquinho. These two compounds were not detected from Santos Flame. The main objective of the research was to manifest that genotypes close to concerned trait could be exhibited heterotic behavior if they were distinct from genetically. Prasad and Singh (1986) indicated that extremely divergent parents create high magnitude of heterosis harmonizing by alleles. Genetic diversity is important related with heterosis and inbred lines from different origin show greater heterosis (Hayes and Immers, 1942). Pearson (1983) reported that Peter and Singh (1976) declared 494% heterosis related with yield in eggplant and Shifriss and Rylski (1973) notified 195% for exported quality in bell pepper. Tu et al. (2007) find 672.7% better parent heterosis for kernel yield in rice. However there is no extraordinary heterosis and heterobeltiosis percentage as we found in our experiment for the literally we know.

CONCLUSIONS

The extreme heterosis and heterobeltiosis percentages were observed from hybrid of two species *Capsicum chinense* Jacq. and *Capsicum annuum* L. distinct from genetically but closed to pungency trait and its component. Therefore genetic diversity was found important related with heterosis. However it is believed that quality traits such as pungency could be more heterotic compared yield and yield component.

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