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INTER-SPECIFIC (*CAPSICUM CHACOENSE* HUNZ. AND *CAPSICUM ANNUUM* L.) INHERITANCE OF FRUIT DETACHMENT FORCE TRAIT IN HOT PEPPER

Bekir Bülent ARPACI, Faika YARALI KARAKAN

Kilis 7 Aralık University, Faculty of Agriculture, Department of Horticulture,
Mehmet Sanlı Mah. Doğan Güreş Paşa Bul. No:134, KİLİS, Turkey

Corresponding author email: bbarpaci@kilis.edu.tr

Abstract

In red pepper cultivation for spice production, harvesting the fruits is time consuming and high cost requiring process. Also all the cultivated pepper (Capsicum spp.) fruits for processing have to be separated from the pedicel after or before drying. The pedicel is tightly attached with the calyx to the fruit pod in most pepper cultivar. For this reason fruit detachment force (FDF) is an important trait to improve pepper cultivars suitable for mechanical harvesting. Gene action for FDF was calculated using inter-specific crosses between four C. annuum L. (3.860 to 7.340 N FDF) genotypes and C. chacoense Hunz. (0.199 N FDF), C. annuum variety 'Totolapa' (0.173 N FDF). FDF values obtained from parents and F1 generation indicated that gene effects for this trait were mostly displayed dominance and additive. No differences were calculated with respect to heterosis both Capsicum species related FDF. Parents could generate hybrids with high degree of negative heterosis varying between 86.56% and 94.50% related with FDF. Except K7 x CC hybrid easily detached from the fruit with 0.153 N, all the hybrids have fruit detachment force over 'Totolapa'.

Key words: *Fruit detachment force, heterosis, gene effect, pepper.*

INTRODUCTION

Chilies (dried red pepper) is one of the most important crops in South East Anatolian Region where produced 95% of 228,531 tons total chili production of Turkey.

Harvesting of chilies requires high labor and cost due to pick the fruits by hand. Harvest machines for dried chilies have been developed but cultivars suitable for mechanically harvesting needs some improvements (Palau and Torregrosa, 1996; Akay et al., 2009).

Fruit detachment force (FDF) is the most important trait related with either hand or mechanically harvesting.

Inheritance of detachment trait firstly reported with single dominant gene (Smith, 1951) and softening of fruit considered another gene controlling to soft fruited trait. Gersch et al. (1998) correlated FDF with cell size and cell wall thickness in fruit and calyx.

Finally Rao and Paran (2003) detachment or deciduous fruit and soft fruited traits were revealed by pleiotropic effect of endo-polygalacturonase (PG) gene. With this article the gene action of FDF was calculated with line × tester parental design using interspecific crossing in pepper.

MATERIALS AND METHODS

Capsicum annuum (Totolapa) and *Capsicum chacoense* (C. cha.) exhibited easy fruit detaching traits were used as male and *Capsicum annuum* (Dila, Sena, K7 and K8) exhibited hard genotypes were used as female parents. FDF was measured at red mature stage using with two different interval (0.001-5 and 0.1-500 N) digital push and pull force gauge as Newton (Geratech Inc. SH-5 and SH-50) (Figure 1). Variance of general and specific combining ability effects and heterosis were calculated by TNAUSTAT-Statistical package (Manivannan, 2014) with line × tester mating design (Singh and Chaudhry, 1985) using testers as male (Totolapa and C. cha.) and lines female (Dila, Sena, K7 and K8). Experiment was designed completely randomized blocks with 15 replicates. Mean differences among hybrids and parents related with FDF were compared LS Means Differences Tukey HSD. Two hybrid population of *Capsicum chacoense*

and *Capsicum annuum* species matched by paired sample t-test. JMP 5.0.1 software was used for statistical analysis.

RESULTS AND DISCUSSIONS

The fruit detachment trait which is wild characteristic (Paran and Knapp, 2009; Mao and Motsenbocker, 2001) decrease in population with the domestication of pepper. Fruits of many pepper cultivars using fresh or processed tightly adhere to the calyx (Motsenbocker, 1996). Due to time consuming and great effort requirements both harvesting and post-harvest process detachment trait come into prominence for harvest technology so that to eliminate the pedicel from the pepper fruit.

Table 1. Analysis of variance for Line × Tester and Combining ability analysis for FDF traits

Line × Tester (Including parents)				
SOURCE	DF	SS	MSS	F ratio
Replicates	14	2.40	0.1715	0.24
Genotypes	13	1443.06	111.0049	157.85
Cross	7	0.19	0.0278	0.03
Line (c)	3	0.09	0.0320	0.04
Test (c)	1	0.04	0.0488	0.06
L x T (c)	3	0.04	0.0165	0.02
Parent	5	705.15	141.0307	200.55
Line (p)	3	98.82	32.9429	46.84
Test (p)	1	0.92	0.9289	1.32
L (p) vt (p)	1	605.39	605.3961	860.89
CrovsPAR	1	737.71	737.7152	1049.05
Error	182	127.98	0.7032	
Total	209	1573.44		
Combining ability analysis				
Replicates	14	0.10	0.0075	2.01
Cross	7	0.19	0.0278	7.43
Line (c)	3	0.09	0.0320	8.57
Test (c)	1	0.04	0.0488	13.07
L x T (c)	3	0.04	0.0165	4.42
Error	98	0.36	0.0037	
Total	119	0.66		
Proportional contribution of lines, testers and their interactions to total variance				
Contribution of lines				49.39
Contribution of testers				25.10
Contribution of L × T				25.51

According to analysis of variance for line × tester analysis cross and lines significantly ($p<0.05$) important contribution of FDF traits. Percentage of contribution related with FDF 49.39, 25.10 and 25.51 for lines, testers and lines × testers, respectively (Table 1).

Figure 1.Measuring of FDF using push-pull digital gauge

Variance of general combining (σ^2_{GCA}) and of lines (σ^2_{SCA}) related crosses in respect to FDF were shown in Table 2. General combining ability of Dila and Sena varieties was found non-significant on account of FDF while K7 and K8 has significant ($p<0.01$) general combining ability among the lines using as female plants. GCA effects of both testers were significant for FDF trait. Variance of specific combining ability (σ^2_{SCA}) was non-significant for all of the crosses. Variance of general combining ability was found greater than that of specific combination ability. This situation indicated that additive genes could be effect on FDF traits. Werner and Honma (1980) explained fruit detachment at the fruit receptacle controlling by additive gene effects and pointed out no differences between reciprocal crosses. However mid, low, better parent and standard heterosis percentage of hybrids for FDF were found significantly and negatively. The lowest FDF values are important for easy pick by hand and harvest for the fruits (Werner and Honma, 1980; Motsenbocker, 1996; Gersch et al., 1998).

Therefore negative heterosis is expected from the hybrids for this trait. The highest negative mid parent heterosis percentage was observed K7 x Totolapa with -95.12%. Low parent heterosis was -97.03% at Dila x C. cha. and better and standard heterosis percentage same at this hybrid because of using Dila variety as standard to calculate standard heterosis. But the highest negative standard heterosis percentage was obtained from K7 x Totolapa hybrid with-97.82% (Table 2). All of the hybrids have deciduous fruit and soft fruit flesh. For this reason deciduous fruit trait was expressed along with soft fruit flesh dominantly. Nevertheless fruit detachment force associated with deciduous trait was impressed on additive gene effects combination with dominance. Rao and Paran (2003) determined deciduous fruit and soft fruited trait under control pleiotropic effect of PG gene.

This study exhibited that expression of PG gene could be diversified of phenotype. Gersch et al. (1998) emphasized that FDF related with genotype, maturity and plant growth regulator and also was affected by changing environment such as greenhouse and field.

Table 2. General and specific combining ability effects and heterosis percentage of lines testers and crosses for FDF

Lines	σ^2_{GCA}	Cross	σ^2_{SCA}	Heterosis (%)			
				Mid Parent	Low Parent	Better Parent	Standard
Dila	0.01 ns	Dila x C. cha.	-0.02ns	-94.50**	-97.03**	-97.03**	-97.03**
Sena	0.01 ns	Sena x C. cha.	0.02ns	-92.12**	-95.96**	-95.96**	-95.96**
K7	0.04**	K7 x C. cha.	0.03ns	-93.83**	-96.69**	-96.69**	-96.39**
K8	-0.04**	K8 x C. cha.	-0.03ns	-93.89**	-96.87**	-96.87**	-96.58**
Testers		Dila x Totolapa	0.01ns	-88.32**	-93.38**	-93.38**	-96.09**
Totolapa	-0.02*	Sena x Totolapa	-0.01ns	-86.56**	-92.98**	-92.98**	-95.86**
C.chacoense	0.02*	K7 x Totolapa	-0.02ns	-95.12**	-97.33**	-97.33**	-97.82**
		K8 x Totolapa	0.02ns	-91.74**	-95.74**	-95.74**	-96.52**

*Significant differences at p<0.05 ** p<0.01 and ns: non-significant

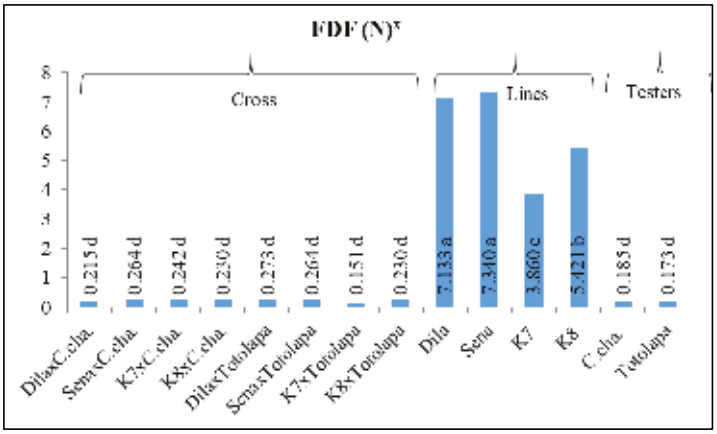

Figure 2. Fruit Detachment Force (FDF) of lines tester and crosses.
[x]Mean separation within the columns by LSMeans Differences Tukey HSD multiple range test at p≤ 0.05

Fruit detachment force of lines, testers and crosses were demonstrated in Figure 2. The highest FDF was 7.340 N at Sena variety. K7 was the less adhere to the receptacle genotypes in the lines with 3.860 N FDF. The testers Totolapa and C. cha. displayed 0.173 and 0.185 N FDF, respectively. K7 x Totolapa hybrid exhibited the lowest FDF among all the lines, testers and crosses. However all of the crosses and testers placed same statistically group (Figure 2.). Motsenbocker (1996) determined the lowest FDF value with 2.5 N at red mature stage "McIlhenny Select" tabasco (*Capsicum frutescens*) pepper variety in field study while it was 0.6 N in greenhouse condition. Mao and Motsenbocker (2002) observed 2.9 N FDF

from McIlhenny Select and no differences find between ethephon applied and control treatment on account of FDF. With this study two F1 populations of *Capsicum chacoense* and *Capsicum annuum* species were compared. No differences observed on these two population concerning FDF according to t-test. The mean of *Capsicum chacoense* population was 0.237 N and Totolapa (*C. annuum*) was 0.229 N (data not shown).

CONCLUSIONS

The fruit detachment force of pepper fruits from peduncle is under control additive gene effect with dominance. No differences inter or intra specific crossing were found for FDF traits. Fruit flesh softness and deciduous fruit trait were complete dominant and inherited jointly. Nevertheless the FDF can be affected by female genotypes adhered calyx tightly and differentiated phenotypically.

High percentage of mid, low, better parent and standard heterosis was calculated for FDF traits. Quite low FDF was observed on crosses from two different Capsicum species. These FDF values are promising to improve pepper varieties for mechanical harvesting.

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