

Research Article

Determination of Characteristics of Dry Bean Lines Hybridized by Line x Tester Method and the Effect of Heredity[§]

Şemsi TAMÜKSEK*, Ercan CEYHAN

Department of Field Crops, Faculty of Agriculture, Selcuk University, Konya, Turkey

*Corresponding author: demircan.semsi18@gmail.com

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Abstract

In this study, two dry beans (*Phaseolus vulgaris* L.) (Great Northern 59 and Alberto) and a bombay bean (*Phaseolus coccineus* L.) (testers) were crossed with five bean genotypes (*Phaseolus vulgaris* L. PV04001, PV05023, PV04042, PV04026 and PV04032) (lines). F₁ hybrids obtained by the line x tester method (5x3). This experiment were established in a randomized block design with three replicates in the fully controlled Selcuk University Plant Breeding Greenhouse. The effects of non-additive gene and heritability were found to be low. The heterosis and heterobeltiosis values of the F₁ generations were positive for seed yield.

Key words: Bean, seed yield, line x tester method, combining ability, heterosis.

Line x Tester Metoduyla Islah Edilen Kuru Fasulye Hatlarının Özelliklerinin Belirlenmesi ve Kalıtımın Etkisi

Özet

Araştırmada, tester olarak iki adet kuru fasulye (*Phaseolus vulgaris* L.) (Great Northern 59 ve Alberto) çeşidi ve bir adet bombay fasulyesi (*Phaseolus coccineus* L.) ve ana olarak ise 5 fasulye (PV04001, PV05023, PV04042, PV04026 ve PV04032) hattı arasında melezleme yapılmıştır. Bu çalışma Line x Tester metoduna göre F₁ melezleri elde edilmiştir. Bu araştırma Tesadüf Blokları Deneme desenine göre üç tekerrürlü olarak tam kontrollü Selçuk Üniversitesi Deneme serasında kurulmuştur. F₁ generasyonunda tane verimi için eklemeli olmayan gen etkileri ve dar anlamda kalıtım dereceleri düşük olarak tespit edilmiştir. F₁ generasyonunda heterosis ve heterobeltiosis değerleri tane verimi için pozitif olmuştur.

Anahtar kelimeler: Fasulye, tane verimi, line x tester analizi, kombinasyon yeteneği, heterosis.

Introduction

The bean *Phaseolus vulgaris* L. belongs to the Leguminosae family, members of which produce dry edible legumes that are grown and consumed worldwide. Legumes are a very important source of protein, starch, cellulose and minerals for human nutrition (Aykroyd et al., 1982) and contribute to nitrogen fixation, thus increasing the efficiency of production systems with positive effects on environmental sustainability (Şehirli, 1988).

Breeding studies of beans are generally carried out via selection. However, other approaches are needed to increase genetic

variation in beans (Ceyhan, 2003), such as hybridization. This approach can be used to improve productivity, quality and resistance to diseases. The generation of gene resources that can be used to address these factors is the main subject of breeding studies (Ceyhan, 2003). Line x tester analysis has been used in many crossbreeding programmes, because the breeders present genetic characteristics about quantitative properties (Ceyhan, 2003). Line x tester analysis provides information to breeders about heterosis and the general combination ability (GCA) and specific combination ability of parents (SCA) (Ceyhan et al., 2008). The effects of hybridization

on heritability can also be estimated (Ceyhan, 2003). Previous breeding studies have found that seed yield and harvest index in beans are under the influence of additive genes (Zimmermann et al., 1985; Singh and Urrea, 1994), while the number of ovaries per pod is a single gene allele and under the effect of additive gene (Al-Mukhtar and Coyne, 1981). In contrast, pod properties and plant height are under the influence of non-additive genes (Rodrigues et al., 1998).

The aim of this study was to determine the general and special combination capabilities, heterosis and heterobeltiosis values, and the degree of heritability in the broad and narrow sense in the F1 generations of beans using the line

x tester method, and then to find high-adapt, efficient and high-quality genotypes for the development of new lines.

Materials and Methods

In this study, two dry beans (*Phaseolus vulgaris* L.) (Great Northern 59 and Alberto) and a bombay bean (*Phaseolus coccineus* L.) were used as testers and five bean genotypes (*Phaseolus vulgaris* L.) were used as lines. The characteristics of the parents are shown in Table 1. The Alberto and Great Northern 59 varieties used in this study are the most cultivated and earliest varieties grown in the region (GTHB, 2018).

Table 1. The characteristics of the parents used in breeding.

Parents	Characteristics of the Parents
PV04001	It is 50-60 cm long. Broad beans are flat, light green, without awn. Seed dermason type and color is white. The average vegetation period is 110-125 days. The average yield per decare is 150-250 kg. Protein content is between 24-26%.
PV04042	The plant is semi-dwarf bean color light green, grain shape round-oval and large. Grain color is white. The average vegetation period is 115-120 days. The average yield per decare is 200 - 280 kg. Protein content is between 19-23%.
PV04026	It is an early and leechy dwarf bean line. The pods are smooth, medium long, green and awned. Seeds are round and white in color. The average vegetation period is 90-100 days. Average yield per decare is 200-300 kg. Protein content is between 19-23%.
PV04032	It has a height of 50 cm, white flower color, broad bean shape, dermason type and white seed color. The average vegetation period is 120-130 days. Average yield per decare is 250-300 kg. Protein content is between 20-23%.
PV05023	It grows upright and grows to 55-60 cm. The flower color is white, pod shape is flat and seed has white color. The average vegetation period is 110-120 days. The average yield per decare is 200 -280 kg. Protein content is between 22-25%.
Alberto	Semi dwarf, plant height 60-70 cm, no pods opening, flower color is white, yield 280-300 kg da ⁻¹ , dermason type, pod shape flat-end curved, resistant to viruses and bacterial diseases. The average vegetation period is 110-120 days.
<i>Phaseolus coccineus</i> L.	It grown as an ornamental plant. Length up to 3 meters. The beans are bright, showy, with white and red flowers. Pods are larger and longer. The bones are hard and thick.
Great Northern 59	Medium-sized, kidney-shaped flat white seed. Its yield is very high and it is an early variety. The average seed yield of this variety is 150-200 kg da ⁻¹ . The average vegetation period is 90-100 days.

Eight bean genotypes were sown on four different dates at 10-day intervals starting from 25 October 2016 in a fully controlled greenhouse in the Department of Field Crops, Faculty of Agriculture, Selcuk University. Ten seeds of each parent were sown in rows 2 m long. The hybridization process was performed as described by Ceyhan (2003) and Ceyhan et al. (2014).

The breeding process was performed using the line x tester method and gave 15 (5x3) hybrid combinations. At least 30 seeds were obtained from each of the 15 hybrid combinations. The obtained hybrid seeds and parents were grown under greenhouse conditions again. The greenhouse experiment was established using a

randomized block design with three replicates in 1 m long plots on 30 March 2017. Harvesting was carried out in August. During the study, 15 kg DAP (Diammonium Phosphate) fertilizer was applied to the whole experimental area in a uniform manner to meet the needs of the hybrids and the parents. Weed control was performed by hand and drip irrigation was given five times depending on the water demand of the plants. During cultivation, the greenhouse was kept constant at a daytime temperature of 25 °C, night temperature of 18 °C, relative humidity 50–55% and wind speed 5 km/h.

Data collected from observation, measurement and analysis on F1 plants were subjected to a preliminary variance analysis using

the MSTAT-C Statistics Program according to the randomized block design. Line x tester analysis was applied to the properties that showed variation among hybrids of between 1% and 5% significance (Kempthorne, 1957; Sing and Chaudhary, 1979). General and special combination ability effect and variance Griffing (1956), heritability Stansfield (1969), in the calculation of the percentage values of heterosis and heterobeltiosis Fonseca and Pattersan (1968), in the determination of the relations between the properties Yurtsever (1984) were utilized.

Results and Discussion

The line x tester analysis of variance of the investigated characteristics in the study revealed

that the squares averages of the hybrids were statistically significant for all traits. Significant differences were found between genotypes in all investigated characteristics (Table 2). In the F₁ generation, the hybrids showed variation in all properties studied, except for the number of seeds per plant, at the 1% significance level. Significant differences were observed between lines for plant height and protein content. Among the tester plants, plant height, seed yield, plant weight, and protein content were significantly different. In the line x tester interaction, significant differences were found for all properties except protein content.

Table 2. The average of squares calculated by line x tester method for seed yield and its components in F₁ hybrids of beans.

Source of variation	DF	Plant height	Number of pods per plant	Number of seeds per pod	Number of seeds per plant
Replication	2	5.058	22.464	0.099	945,255
Treatments	22	1480.808**	76.557**	1.436**	3220,578**
Parents	7	3718.994**	12.995	2.200**	1248,157**
Hybrids	14	466.260**	29.442**	0.757**	890,954
Par vs Hyb	1	17.165	1181.100**	5.593**	49642,260**
Line	4	213.578**	17.105	0.226	128,080
Tester	2	2460.556**	21.848	0.047	564,846
Line vs Tester.	8	94.028**	37.509**	1.200**	1353,918**
Error	44	26.316	9.722	0.109	375,179
Source of variation	DF	Seed yield	100-seed weight	Protein content	
Replication	2	111.862	22.755**	0.088	
Treatments	22	772.198**	375.431**	4.069**	
Parents	7	40.311	571.670**	1.319	
Hybrids	14	572.687**	297.409**	3.895**	
Par vs Hyb	1	8688.559**	94.054**	25.760**	
Line	4	443.272	216.181	8.558**	
Tester	2	1592.219**	1284.078**	3.647*	
Line vs Tester.	8	382.512**	91.356**	1.626	
Error	44	56.419	2.676	0.841	

* : $p < 0.05$; ** : $p < 0.01$

The average seed yield of the parents ranged from 28.04 to 38.80 g, and the 100-seed weight ranged from 30.17 to 70.17 g. Plant height, number of pods per plant, number of seeds per pod, and number of seeds per plant ranged from 49.33 to 153.33 cm, 14.77 to 20.77, 2.67 to 5.23, and 41.29 to 110.14, respectively. Protein content ranged from 23.18% to 25.12%.

The average seed yield of the F₁ hybrids varied from 36.82 to 88.55 g, average plant height from 55.33 to 93.67 cm, average number of pods per plant from 21.37 to 32.20, average number of seeds per pod from 4.53 to 6.10, average number of seeds per plant from 113.95 to 170.84, average

100-seed weight from 29.00 to 61.43 g, and average protein content from 23.53% to 27.20%. Plant height (Genchev, 1995; Ceyhan, 2004; Ulker and Ceyhan, 2008a; Ceyhan et al., 2012), number of pods (Ceyhan, 2004; Varankaya, 2011), the number of seeds per pod (Anlarsal et al., 2000; Ulker and Ceyhan 2008a), the number of seeds per plant (Düzdemir, 1998; Ulker and Ceyhan, 2008a), seed yield (Saraç and Sehirali 1989; Pekşen and Gulumser 2005) and protein content (Duzdemir, 1998; Ulker and Ceyhan 2008b) were similar to the findings of other studies.

In terms of the investigated properties the (H/D)^{1/2} ratio was greater than 1 and the

$\sigma^2\text{GCA}/\sigma^2\text{SCA}$ ratio was less than 1, showing that a non-additive dominant gene effect influences these characteristics (Table 3). This indicates that selection can be started from the next generation on investigated properties. At the same time, the number of pods, number of seeds per pod and number of seeds per plant were found to be influenced by an additive gene effect in the F_1 generation (Table 3). It has been found that

investigated properties are under the effect of additive and non-additive genes. Some investigators (Singh and Urrea, 1994; Oliveira Junior et al., 1997) stated that additive genes influence seed yield in beans, while others (Barelli et al., 2000) reported that non-additive genes influence seed yield. Other researchers obtained similar results (Saraç and Şehirali, 1989; Bozoğlu, 1995; Ceyhan, 2004; Ulker and Ceyhan, 2008a).

Table 3. Estimation of GCA variance, estimation of SCA variance estimation, additive variance, proportional relationship with dominance variance, broad and narrow inheritance in parents and F_1 hybrids of beans.

Features	$\sigma^2\text{GCA}$	$\sigma^2\text{SCA}$	$\sigma^2\text{GCA}/\sigma^2\text{SCA}$	$\sigma^2\text{D}$	$\sigma^2\text{H}$	$(\text{H/D})^{1/2}$	H^2	h^2
Plant height	7.825	298.802	0.026	15.649	22.571	1.201	94.36	33.30
Number of pods per plant	-0.170	5.255	----	-0.339	9.262	----	66.98	-2.79
Number of seeds per pod	-0.009	0.127	----	-0.019	0.364	----	85.64	-4.88
Number of seeds per plant	-9.732	102.368	----	-19.464	326.246	----	57.89	-4.51
Seed yield	3.998	249.860	0.016	7.995	108.697	3.687	90.15	5.90
100-seed weight	4.331	175.954	0.025	8.663	29.560	1.847	78.40	22.15
Protein content	0.048	1.256	0.038	0.095	0.261	1.655	78.40	14.97

Table 4. Means in terms of properties examined in the parents and F_1 hybrids of beans.

Parents	Plant height	Number of pods per plant	Number of seeds per pod	Number of seeds per plant	Seed yield	100-seed weight	Protein content
PV04001	54.00	19.57	4.90	97.16	38.80	30.90	30.90
PV04042	55.33	18.80	5.10	98.08	37.88	35.90	35.90
PV04026	52.33	17.83	4.90	88.74	32.73	33.93	33.93
PV04032	54.67	15.40	5.07	79.10	28.04	32.80	32.80
PV05023	49.33	16.47	5.13	86.37	31.17	32.17	32.17
Alberto	55.33	20.77	5.23	110.14	35.86	30.17	30.17
<i>Phaseolus coccineus</i> L.	153.33	14.77	2.67	41.29	36.43	71.17	71.17
Great Northern 59	56.67	16.70	5.13	88.30	32.67	31.37	31.37
F_1 Hybrids							
PV04001 x Alberto	55.67	24.93	5.77	145.65	51.04	34.47	34.47
PV04001 x <i>P. coccineus</i> L.	73.67	25.03	4.53	115.02	69.60	59.37	59.37
PV04001 x Great Northern 59	59.00	29.13	5.33	158.46	61.15	38.00	38.00
PV04042 x Alberto	59.67	24.57	4.87	121.41	36.82	29.00	29.00
PV04042 x <i>P. coccineus</i> L.	70.67	21.37	5.70	125.34	50.40	37.97	37.97
PV04042 x Great Northern 59	58.67	27.57	6.10	170.84	61.22	34.70	34.70
PV04026 x Alberto	59.33	25.63	5.90	152.34	59.45	37.73	37.73
PV04026 x <i>P. coccineus</i> L.	81.33	30.37	4.80	148.44	80.55	53.27	53.27
PV04026 x Great Northern 59	62.33	29.00	4.87	144.80	49.96	33.87	33.87
PV04032 x Alberto	60.33	32.20	5.13	167.68	55.63	32.40	32.40
PV04032 x <i>P. coccineus</i> L.	91.67	23.63	6.00	142.78	58.74	39.93	39.93
PV04032 x Great Northern 59	55.33	21.73	5.13	113.95	38.63	33.10	33.10
PV05023 x Alberto	62.67	25.97	5.33	141.90	50.22	34.53	34.53
PV05023 x <i>P. coccineus</i> L.	93.67	23.90	5.93	145.32	88.55	61.43	61.43
PV05023 x Great Northern 59	67.33	28.33	5.07	143.00	54.37	36.50	36.50

Based on the general combination abilities of the F_1 generation for particular characteristics,

the following pairs were found to be suitable parents: PV05023 and *Phaseolus coccineus* L. for

plant height; PV04026 and *Phaseolus coccineus* L. for the number of pods; PV04042 and *Phaseolus coccineus* L. for number of seeds per pod; PV04026, PV05023 and *Phaseolus coccineus* L. for seed yield; and PV04001 and *Phaseolus coccineus* L. for protein content (Table 5). PV04026, PV05023 and *Phaseolus coccineus* L. genotypes, which are superior in seed yield, can be used in breeding programmes to improve seed yield.

Considering the special combination capabilities of hybrids in F₁ generation, for plant height “PV04032 x *Phaseolus coccineus* L.” hybrid; for the number of pods “PV04032 x Alberto” and “PV04026 x *Phaseolus coccineus* L.” hybrids; for number of seeds per pod “PV04001 x Alberto”, “PV04042 x Great Northern 59”, “PV04026 x Alberto”, “PV04032 x *Phaseolus coccineus* L.” and “PV05023 x *Phaseolus coccineus* L.” hybrids; for

number of seeds per plant “PV04042 x Great Northern 59” and “PV04032 x Alberto” hybrids; for seed yield “PV04042 x Great Northern 59”, “PV04032 x Alberto” and “PV05023 x *Phaseolus coccineus* L.” hybrids; for protein content “PV04032 x Alberto” hybrid were positive (Table 5). The GCA and SCA effects of parents and hybrids on the number of pods per plant were determined by Al-Mukhtar and Coyne (1981), Ceyhan (2003) and Ceyhan et al. (2008). These researchers have obtained similar results to our findings. Many other studies have been done on the effect of GCA and SCA on beans and have determined the combinations of parents and hybrids with different numbers of significant GCA and SCA for seed yield in the investigated generations (Oliveira Junior et al., 1997; Barelli et al., 2000).

Table 5. GCA values in parents of beans and SCA values in F₁ hybrids of beans.

Parents	Plant height	Number of pods per plant	Number of seeds per pod	Number of seeds per plant	Seed yield	100-seed weight	Protein content
PV04001	-4.644**	0.141	-0.153	-2.752	2.841	4.194**	1.375**
PV04042	-4.422**	-1.724	0.191*	-3.266	-8.274**	-5.862**	-0.111
PV04026	0.244	2.109*	-0.176	6.067	5.564**	1.871**	-0.581*
PV04032	1.689	-0.369	0.058	-0.992	-6.755**	-4.607**	0.474
PV05023	7.133**	-0.158	0.080	0.944	6.625**	4.404**	-1.157**
Alberto	-7.889**	0.436	0.036	3.334	-7.122**	-6.125**	-0.228
<i>Phaseolus coccineus</i> L.	14.778**	-1.364	0.029	-7.082	11.814**	10.643**	0.566**
Great Northern 59	-6.889**	0.928	-0.064	3.748	-4.691**	-4.519**	-0.338
F₁ Hybrids							
PV04001 x Alberto	0.778	-1.868	0.520**	2.605	-2.432	-3.354**	-0.207
PV04001 x <i>P. coccineus</i> L.	-3.889	0.032	-0.707**	-17.606	-2.811	4.784**	-0.147
PV04001 x Great Northern 59	3.111	1.836	0.187	15.001	5.243	-1.430	0.354
PV04042 x Alberto	4.556	-0.369	-0.724**	-21.124*	-5.540	1.236	0.299
PV04042 x <i>P. coccineus</i> L.	-7.111**	-1.769	0.116	-6.775	-10.892**	-6.566**	-0.088
PV04042 x Great Northern 59	2.556	2.138	0.609**	27.899**	16.432**	5.330**	-0.211
PV04026 x Alberto	-0.444	-3.136*	0.676**	0.479	3.256	2.236**	-0.401
PV04026 x <i>P. coccineus</i> L.	-1.111	3.398*	-0.418**	6.995	5.416	1.001	0.519
PV04026 x Great Northern 59	1.556	-0.262	-0.258	-7.474	-8.672*	-3.237**	-0.117
PV04032 x Alberto	-0.889	5.909**	-0.324	22.878*	11.751**	3.380**	-0.906
PV04032 x <i>P. coccineus</i> L.	7.778**	-0.858	0.549**	8.391	-4.071	-5.854**	0.544
PV04032 x Great Northern 59	-6.889**	-5.051**	-0.224	-31.269**	-7.680*	2.474**	0.362
PV05023 x Alberto	-4.000	-0.536	-0.147	-4.838	-7.035	-3.498**	1.215**
PV05023 x <i>P. coccineus</i> L.	4.333	-0.802	0.460**	8.995	12.359**	6.634**	-0.828
PV05023 x Great Northern 59	-0.333	1.338	-0.313	-4.158	-5.323	-3.137**	-0.387

* : $p < 0.05$; ** : $p < 0.01$

Conclusions

The estimates of heterosis and heterobeltiosis were calculated as the percentage increase and decrease over values for all traits studied. The heterosis of the 15 F₁ hybrids ranged from -32.27% to 27.04% for plant height, from -5.81% to 55.17% for number of seeds per pod, from -0.13% to 162.02% for seed yield, from -

29.08% to 22.04% for 100-seed weight, and from -2.13% to 12.14% for protein content. The heterobeltiosis of the 15 F₁ hybrids ranged from -53.91% to 18.82% for plant height, from -7.48% to 18.83% for number of seeds per pod, from -2.79% to 143.10% for seed yield, from -46.65% to 21.14% for 100-seed weight, and from -3.91% to 10.52% for protein content. Ceyhan (2003) and Ceyhan et

al. (2008) reported high or low heterosis and heterobeltiosis levels. The fact that the average heterosis and heterobeltiosis values were negative in the F_1 generation indicates that the effects of

non-additive genes are important for investigated properties.

As a result, selection in future generations may produce promising genotypes that can be used in different breeding programmes.

Table 6. Heterosis (%) values of the properties examined in F_1 generation.

F1 hybrids	Plant height	Number of pods per plant	Number of seeds per pod	Number of seeds per plant	Seed yield	100-seed weight	Protein content
PV04001 x Alberto	1.83	23.64	13.82**	40.53	36.74	12.88**	8.87**
PV04001 x <i>P. coccineus</i> L.	-28.94**	45.83**	19.82**	66.16	85.04**	16.34**	10.55**
PV04001 x Great Northern 59	6.63	60.64**	6.31**	70.89	71.12	22.04**	11.96**
PV04042 x Alberto	7.83	24.18**	-5.81**	16.62	-0.13	-12.21**	6.11**
PV04042 x <i>P. coccineus</i> L.	-32.27**	27.31	46.78**	79.87	35.67	-29.08**	6.01**
PV04042 x Great Northern 59	4.76	55.31**	19.22**	83.33	73.57	3.17	4.68**
PV04026 x Alberto	10.22	32.82**	16.45**	53.20	73.36	17.73**	-1.77*
PV04026 x <i>P. coccineus</i> L.	-20.91**	86.30**	26.87**	128.32	132.94**	1.36	3.48**
PV04026 x Great Northern 59	14.37	67.95**	-2.99**	63.59	52.76	3.73	0.01
PV04032 x Alberto	9.70	78.06**	-0.32	77.22	74.13	2.91	4.58**
PV04032 x <i>P. coccineus</i> L.	-11.86	56.69**	55.17**	137.20	82.25	-23.18**	12.14**
PV04032 x Great Northern 59	-0.60	35.41**	0.65	36.15	27.27	3.17	10.71**
PV05023 x Alberto	19.75	39.48**	2.89**	44.42	49.87	10.80**	4.69**
PV05023 x <i>P. coccineus</i> L.	-7.57	53.04**	52.14**	127.66	162.02**	18.90**	-2.13**
PV05023 x Great Northern 59	27.04**	70.85**	-1.30**	40.53	36.74	12.88**	8.87**
Average	-0.12	48.92	15.73	69.89	66.01	3.37	4.65
LSD₅	8.687	5.280	0.558	32.801	12.720	2.770	1.553
LSD₁	7.192	4.371	0.462	27.155	10.530	2.293	1.286

* : $p < 0.05$; ** : $p < 0.01$

Table 7. Heterobeltiosis (%) values of the properties examined in F_1 generation.

F1 hybrids	Plant height	Number of pods per plant	Number of seeds per pod	Number of seeds per plant	Seed yield	100-seed weight	Protein content
PV04001 x Alberto	0.60	20.06	10.19**	32.24**	31.55**	11.54**	8.66**
PV04001 x <i>P. coccineus</i> L.	-51.96**	27.94**	-7.48	18.39	79.38**	-16.57**	8.96**
PV04001 x Great Northern 59	4.12	48.88**	3.90	63.10**	57.60**	21.14**	10.52**
PV04042 x Alberto	7.83	18.30	-7.01	10.23	-2.79	-19.22**	5.02
PV04042 x <i>P. coccineus</i> L.	-53.91**	13.65	11.76**	27.79**	33.07**	-46.65**	3.24
PV04042 x Great Northern 59	3.53	46.63**	18.83**	74.19**	61.64**	-3.34	4.59
PV04026 x Alberto	7.23	23.43**	12.74**	38.32**	65.81**	11.20**	-3.65
PV04026 x <i>P. coccineus</i> L.	-46.96**	70.28**	-2.04	67.28**	121.13**	-25.15**	3.17
PV04026 x Great Northern 59	10.00	62.62**	-5.19	63.18**	52.62**	-0.20	-2.96
PV04032 x Alberto	9.04	55.06**	-1.91	52.25**	55.15**	-1.22	2.46
PV04032 x <i>P. coccineus</i> L.	-40.22**	53.46**	18.42**	80.51**	61.26**	-43.89**	8.12**
PV04032 x Great Northern 59	-2.35	30.14**	0.00	29.05	18.24	0.91	9.67**
PV05023 x Alberto	13.25**	25.04**	1.91	28.84**	40.07**	7.36**	4.48
PV05023 x <i>P. coccineus</i> L.	-38.91**	45.14**	15.58**	68.25**	143.10**	-13.68**	-3.91
PV05023 x Great Northern 59	18.82**	69.66**	-1.30	61.95**	66.41**	13.47**	-2.22
Average	-10.70	39.95	3.88	45.56	56.85	-7.72	3.17

* : $p < 0.05$; ** : $p < 0.01$

§: This article is summarized from Şemsi TAMÜKSEK's Master Thesis.

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