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Combining ability and breeding potential of oilseed rape advanced lines for some of important quantitative traits

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ABSTRACT

Information on estimates of combining ability of the promising lines of breeding material is important for evolving higher yielding varieties of oilseed rape (*Brassica napus* L.). An experiment was conducted to quantitatively examine the genetic parameters of phenological traits, plant height, pods on main raceme, pods per plant and seed yield for eight oilseed rape genotypes using a half-diallel crosses. The result of the diallel analysis revealed significant mean squares of general and specific combining abilities (GCA and SCA) for all studied traits, indicating the importance of additive and non-additive genetic effects for these traits. On the other hand estimation of high narrow-sense heritability estimates for days to flowering, duration of flowering and pods on main raceme, indicated the prime importance of additive genetic effects for these traits. L420 and L401 with significant negative GCA effects for days to flowering and days to maturity were suitable for yielding early maturity combinations. L41, Zafar and L22 with significant positive GCA effects for seed yield were superior parents for increasing seed yield. The crosses with significant positive SCA effects for seed yield had at least one parent with significant positive GCA effects for this trait. The crosses including L41×L22, L41×LF2, Zafar×L22 and Zafar×L420 with seed yield of 3421.7, 3400, 3348.1 and 3311.3 kg ha^{-1} could be promising for determination of superior recombinants for high seed yield coupled with other growth characters in advanced generations of segregation.

Key words: Additive genetic effects, Brassica napus, degree of dominance, combining ability, heritability, oilseed rape, yield.

INTRODUCTION

Oilseed rape or canola (*Brassica napus* L.) is an important oil seed crop of the world (Downey and Rimer 1993) and due to its autumn cultivation in Iran and therefore low need of irrigation, it plays a major role in catering edible oil. Hence it is necessary to develop the new ideotype varieties or hybrids of oilseed rape with high yield components. Seed yield of canola (B. napus) is a quantitative trait, which is largely influenced by the different environmental effects and thus in most of the cases it has low heritability (Habekotte 1997; Diepenbrock 2000; Rameeh 2010; Rameeh 2015; Amiri-Oghana et al. 2016). Exploitation of genetic variability in any crop species is considered to be critical for making further genetic improvement in seed yield as well as other economically important traits (Mahmood et al. 2003; Ishaq et al. 2016). Inter- and intraspecies crosses of Brassica are suitable way to make genetic variations and develop new varieties (Brandle and McVetty 1990; Enqvist and Becker 1991; Qian et al. 2007; Rameeh 2011). Heterosis is commercially exploited in oilseed rape and its potential use has been demonstrated in turnip rape (B. rapa L.) and Indian mustard (B. juncea L.) for most agronomic traits (Teklwold and Becker 2005; Zhang and Zhu 2006). In oilseed rape breeding program for hybrid and open pollinated varieties, general and specific combining ability effects (GCA and SCA) are important indicators of the

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potential of inbred lines in hybrid combinations. By using diallel crosses manners, and other genetic designs significant GCA and SCA effects of phenological traits, seed yield and other yield associated traits were reported in oilseed rape (Shen et al. 2002; Nassimi, et al. 2006b; Wang et al. 2007). Flowering is the most critical developmental stage influencing the yield of this crop (Faraj et al. 2008). The unset of flower initiation can have strong influence on flower, pod and seed number (Diepenbrock 2000; Downey and Rimer 1993; Yasari and Patwardhan 2006; Rameeh 2017). Habekotte (1997) used a sensitivity analysis within a crop growth model to study options for increasing seed yield in winter oilseed rape. The most promising crop type for high seed yield combined late maturity with early flowering (Downey and Rimer 1993). Early flowering in Brassica can provide adequate time for seed formation process and can certainly cause early maturity and higher yields, therefore negative combining ability and heterosis are desirable for days to flowering. In earlier studies on spring cultivars of oilseed rape (Huang et al. 2010; Rameeh 2011; Liton et al. 2017) were stressed the important role of GCA and SCA effects for days to flowering but due to high heritability estimates for this trait in these reports, the prime importance of GCA effects were emphasized. Likewise, studies with winter cultivars of this species (Amiri-Oghana et al. 2009; Sabaghnia et al. 2010) showed both additive and dominance gene effects to have a significant role in the inheritance of flowering time. Significant negative GCA and SCA effects were reported for days to flowering and plant height. Significant GCA and SCA effects were reported for seed yield in oilseed rape (Rameeh, 2010) and other Brassica species (Teklwold and Becker 2005; Singh et al. 2010).

The objectives of the present study were to identify general and specific combining abilities and narrow-sense heritability for phenological traits, plant height and seed yield in adapted spring oilseed rape advanced lines.

MATERIALS AND METHODS

Eight diverse spring oilseed rape (B. napus) advanced lines including L41, Zafar, L56, L31, L22, LF2, L420 and L401 were crossed in half-diallel scheme during 2010-11 (Table 1). Twenty eight F1s along with their parents were grown in a randomized complete block design with three replications at Biekol Agriculture Research Station, located in Neka, Iran (53°, 13′ E longitude and 36° 43′ N latitude, 15 m above sea

level) during winter 2011-12. Each plot consisted of four rows 5 m long and 40 cm apart. The distance between plants on each row was 5 cm resulting in approximately 300 plants per plot, which were sufficient for F1 genetic analysis. The soil was classified as a deep loam soil (Typic Xerofluents, USDA classification) which contained an average of 280 g clay kg^{-1}, 560 g silt kg^{-1}, 160 g sand kg^{-1}, and 22.4 g organic matter kg^{-1} with a pH of 7.3. Soil samples were found to have 45 kg ha^{-1} (mineral N in the upper 30-cm profile). Fertilizers were applied at the rates of 100: 50: 90 kg ha^{-1} of N: P: K, respectively. All the plant protection measures were adopted to make the crop free from insects. Seed yield (adjusted to kg ha^{-1}) was recorded based on three middle rows of each plot. The data were recorded on ten randomly selected plants of each entry of each replication for days to flowering, duration of flowering and days to maturity and plant height, pods on main raceme and pods per plant. The combining ability analysis was performed using mean values their F1 generations along with parents by using Griffing's method 2 with mixed B model (Griffing 1956). The statistical t-student test was applied to examine the effects of general combining ability (GCA) and specific combining ability (SCA). All the analyses were performed using MS-Excel and SAS soft wares (Zhang and Kang 1997).

RESULTS AND DISCUSSIONS

Analysis of variance

Significant mean squares of genotypes for number of days to flowering, duration of flowering, number of days to maturity, plant height, number of pods on main raceme, number of pods per plant and seed yield indicated a sufficient genetic variation among the parents and their crosses for the studied traits and thus enabling the genetic analysis (Table 2). Significant mean squares of general and specific combining ability (GCA and SCA) mean squares for all the traits are indicating the importance of additive and non-additive genetic effects for controlling the traits. However. Significant ratio of GCA to SCA mean square and high narrow-sense heritability estimates for days to flowering, duration of flowering and number of pods on main raceme implied that inheritances these traits are strongly associated with additive gene actions. Similarly, earlier researchers (Huang et al. 2010; Sabaghnia et al. 2010; Rameeh 2011) reported the important

Table 1: Name and origin of oilseed rape genotypes.

Type	Origin	Pedigree	Genotype	Genotype no.
Spring-open-pollinated	Iran-Mazandaran	RGS003 × 308	L41	1
Spring-open-pollinated	Iran-Mazandaran	19H × Sarigol	Zafar	2
Spring-open-pollinated	Iran-Mazandaran	RW × RGS003	L56	3
Spring-open-pollinated	Iran-Mazandaran	SLM046 × 308	L31	4
Spring-open-pollinated	Iran-Mazandaran	Zarfam × 401	L22	5
Spring-open-pollinated	Iran-Mazandaran	Zarfam × 308	LF2	6
Spring-open-pollinated	Iran-Mazandaran	RGS003 × 420	L420	7
Spring-open-pollinated	Iran-Mazandaran	RGS003 × 420	L401	8

Table 2: Half-diallel analysis for phenological traits, yield components and seed yield in eight oilseed rape genotypes.

	df	(M.S)						
		No. days to flowering	Duration of flowering	No. days to maturity	Plant height	No. pods on main raceme	No. pods per plant	Seed yield
Rep	2	16.0 ns	10.5 ns	4.7 ns	275.3*	79.9 ns	78.7ns	1571000**
Crosses	35	913.3**	648.0**	424.8**	593.7**	359.4**	1417.3**	387481**
GCA	7	3979.2**	2581.1**	798.8**	1526.9**	1181.7**	1610.2**	975122**
SCA	28	146.8**	164.7**	331.3**	360.4**	153.9**	1369.1**	240570**
Error	70	7.6	13.5	2.7	151.1	27.5	103.8	64580
MS(GCA)/MS(SCA)		27.11**	15.67**	2.41*	4.24**	7.68**	1.18 ns	1.18 ns
.h²N		0.84	0.76	0.32	0.43	0.60	0.32	0.32

ns,* and **: Not- significant, significant at 5% and 1% levels of probability, respectively.

role of additive genetic effects for phenological traits and also the importance of non-additive effects for seed yield.

General combining ability and performance means of the parents

Considering the negative GCA values for days to flowering, the genotypes L420 and L401 could be distinguished for its significantly different value. These parents had also a significant positive GCA effects for duration of flowering (Table 3). The mean values of the number days to flowering varied from 83 to 113 days in L420 and L22, respectively and the parents L420 and L401 with 83 and 84 days exhibited low mean values of this trait (Table 4). Significant positive correlation GCA effects of parents for the number of days to flowering with days to maturity and pods on main raceme (Table 5), concluded that, GCA effect of days to flowering is good criterion for improving GCA effect of days to maturity and pods on main raceme. Due to important positive effect of duration of flowering on pod formation, L420 and L401 with high mean values and also significant positive GCA effect of this trait will be preferred. Significant negative correlation was detected between GCA effect of parents for days to flowering

and duration of flowering The parents with significant negative GCA effects for the number of days to flowering had also significant negative GCA effects of the number of days to maturity. Having studied several quantitative and qualitative traits of oilseed rape lines, cultivars and hybrids, Marjanović – Jeromela et al. (2007) reported different values of plant height. The parents L31, LF2 and L401 with significant negative GCA effects for plant height were suitable for the decreasing this trait and their mean performances for this trait were 149, 153 and 155 cm, respectively. The number of pods on main raceme ranged from 42 in L401 and 56 in L41 and Zafar and these parents had also significant positive GCA effects for this trait. The number of pods per plant as prime important yield component had considerable effect on seed yield, therefore the parents L41, Zafar and L22 with significant positive GCA effects of this trait were preferred. Among the parents, L41, Zafar and L22 had significant GCA effect for seed yield and most of parents with positive GCA effects of the number of pods per plant had positive GCA effect of this trait. This finding is in agreement with the results of Rameeh (2010) and Sabaghnia et al. (2009) reports for significant positive GCA effects of parents for seed yield in oilseed rape.

Table 3: General combining ability effects of half-diallel analysis for phenological traits, yield components and seed yield in eight oilseed rape genotypes.

Parents	No. days to flowering	Duration of flowering	No. days to maturity	Plant height	No. pods on main raceme	No. pods per plant	Seed yield
L41	5.4**	-4.53**	2.25**	6.34**	5.50**	10.72**	184.68**
Zafar	5.1**	-3.93**	1.28**	9.15**	5.93**	9.31**	147.26**
L56	8.6**	-6.33**	1.82**	4.51*	5.12**	-8.78**	27.47ns
L31	4.0**	-6.00**	5.62**	-10.37**	-1.20	0.33ns	-291.27**
L22	9.9**	-5.73**	5.32**	-1.50	5.64**	3.59*	187.30**
LF2	3.9**	-3.27**	-1.92**	-5.97**	-6.95**	-2.85ns	9.99ns
L420	-18.8**	13.77**	-4.98**	4.58*	-5.59**	-6.17**	-44.01ns
L401	-17.9**	16.03**	-9.38**	-6.76**	-8.44**	-6.16**	-221.41**

ns,* and **: Not -significant, significant at 5% and 1% levels of probability, respectively.

Table 4: Mean values of half-diallel analysis for phenological traits, yield components and seed yield in eight oilseed rape genotypes.

Parents	No. days to flowering	Duration of flowering	No. days to maturity	Plant height (cm)	No. pods on main raceme	No. pods per plant	Seed yield (kg ha^{-1})
L41	107	57	208	168	56	140	2929.2
Zafar	107	58	207	170	56	137	2925.0
L56	110	55	207	164	54	130	2866.7
L31	106	55	212	149	48	119	2187.5
L22	113	55	212	158	55	158	3120.8
LF2	106	58	205	153	44	112	2737.5
L420	83	76	199	164	44	130	2612.5
L401	84	78	198	155	42	94	2083.3
LSD(α=0.05)	4.41	5.88	2.63	19.67	8.39	16.64	414.99
LSD(α=0.01)	5.78	7.71	3.45	25.79	11.00	22.13	551.93

Table 5: Pearsons correlation coefficient among GCA effects of parents and SCA effects of crosses for phenological traits, yield components and seed yield.

GCA (n=8)							
	No. days to flowering	Duration of flowering	No. days to maturity	Plant height	No. pods on main raceme	No. pods per plant	Seed yield
No. days to flowering	1						
Duration of flowering	-0.98**	1					
No. days to maturity	0.87**	-0.91**	1				
Plant height	0.12 ^{ns}	0.11 ^{ns}	0.07 ^{ns}	1			
No. pods on main raceme	0.75*	-0.72*	0.76*	0.60 ^{ns}	1		
No. pods per plant	0.48 ^{ns}	-0.48	0.51 ^{ns}	0.37	0.61 ^{ns}	1	
Seed yield	0.51 ^{ns}	-0.43	0.35 ^{ns}	0.73*	0.69 ^{ns}	0.57 ^{ns}	1
SCA (n=28)							
	No. days to flowering	Duration of flowering	No. days to maturity	Plant height	No. pods on main raceme	No. pods per plant	Seed yield
No. days to flowering	1						
Duration of flowering	-0.75**	1					
No. days to maturity	0.59**	0.61**	1				
Plant height	-0.09 ^{ns}	0.38*	0.04 ^{ns}	1			
No. pods on main raceme	-0.15 ^{ns}	0.33 ^{ns}	-0.07 ^{ns}	0.71**	1		
No. pods per plant	-0.14 ^{ns}	0.08 ^{ns}	0.02 ^{ns}	0.56**	0.65**	1	
Seed yield	-0.18 ^{ns}	0.05 ^{ns}	-0.04 ^{ns}	0.27 ^{ns}	0.35 ^{ns}	0.66**	1

* and **: Significant at 5% and 1% levels of probability, respectively.

Specific combining ability effects of the crosses

Out of 28 crosses, 13 crosses had significant negative SCA effects of No. days days to flowering (Table6). Most of the crosses with significant negative SCA effect of No. days days to flowering had at least one parent with significant negative GCA effect for this trait. The crosses L420×L401, Zafar×L401, L41×L420, L56×L420, L31×L420 and L31×L401 with 66, 78, 84, 84, 83 and 81 days to flowering had low mean values of this trait (Table 7), were also good combinations. SCA effects of combinations for No. days to flowering was significant negative correlated to No. days to maturity, therefore SCA effect of No. days to flowering is good selection criterion for improving No. days to maturity. The crosses L41×L401, Zafar×L401, L56×L401, L31× L420, L22

× L420, LF2×L401 and L420×L401 with 79, 90, 78, 77, 76, 78 and 88 days of flowering had also significant positive SCA effects for this trait were considered as merit combinations. The crossesincluding L41×L420, Zafar×L420, Zafar×L401, L56×L420 and LF2×L401 with low mean values of days to maturity (188, 188, 184, 189 and 178 days, respectively) also high significant negative SCA effect of No. days to maturity (-16.03, -14.39, -14.66, -13.93 and -17.13, respectively) were suitable combinations for improving this trait. The genotypes with low mean values of plant height will have high tolerance to lodging, therefore the crosses including L41×L31, L56×L401 and LF2×L401 with significant negative SCA effect for plant height were valuable combinations for improving this trait. The knowledge of yield components helps breeders to select genotypes and methods suitable for achieving specific objectives in rapeseed breeding. It is also desirable to know other traits and the genetic rules regulating their inheritance since these traits are associated with yield components (Teklwold and Becker, 2005; Zhang and Zhu, 2006). High positive SCA values of No of pods on main raceme, which were significantly different from the other values, were registered in L41×LF2, L41×L420, Zafar×L401 and L31×L401. Significant negative correlation

exhibited between SCA effects of combinations for No. of pods per plant and seed yield (Table 5), therefore SCA effect of combinations for the No. of pods per plant is good selection criterion for improving seed yield of combinations. Seed yield per plant is a highly variable trait, mainly because it depends on all other yield components. This complex trait is controlled by a large number of genes, whose expression is strongly affected by environmental conditions. In this study, different values of seed yield per plant were registered, from 2196.7 kg ha^{-1} in L56×L420 to 3400 kg ha^{-1}L41×LF2. The crosses L41×LF2, Zafar×L22, Zafar×L420 and L56 ×L22 with seed yield of 3400, 3348.1, 3311.3 and 3278.4 kg ha^{-1} were high potential combinations for seed yield. Hybrid combinations L41×LF2, Zafar×L420, L56×L22, L31×L401and LF2×L420 had highest SCA values, which were highly significant in relation to the SCA values of the other hybrid combinations. The crosses L41 × LF2, Zafar × L420, L56 ×L22, L31×L401 and LF2×L420 with significant positive SCA effects for seed yield were suitable combinations for improving this trait. It had been observed before that crossing a parent with high GCA values with a parent with low GCA values may produce a hybrid combination with high SCA values (Marjanović – Jeromela, et al., 2007).

Table 6: Mean values of half-diallel analysis for phenological traits, yield components and seed yield of eight oilseed rape genotypes.

Crosses	No. days to flowering	Duration of flowering	No. days to maturity	Plant height (cm)	No. pods on main raceme	No. pods per plant	Seed yield (kg ha^{-1})
L41 × Zafar	114	46	214	167.2	55	145	2839.2
L41 ×L56	118	49	214	173.7	62	136	3180.8
L41 ×L31	111	47	213	141.1	48	138	2315.9
L41 ×L22	113	53	211	164.3	63	156	3412.7
L41 ×LF2	104	65	206	169.5	62	172	3400.0
L41 ×L420	84	73	188	188.1	57	162	3000.0
L41 ×L401	98	79	207	173.7	47	154	2908.3
Zafar × L56	121	46	213	183.6	62	139	3031.1
Zafar × L31	113	49	217	155.8	49	129	2673.8
Zafar × L22	113	56	212	162.4	62	145	3348.1
Zafar × LF2	114	57	211	165.6	54	146	2512.5
Zafar × L420	84	74	188	163.9	45	173	3311.3
Zafar × L401	78	90	184	192.5	65	177	2975.0
L56 × L31	119	48	215	156.2	56	139	2302.5
L56 × L22	117	51	212	171.4	61	148	3287.4
L56 × LF2	114	51	206	153.6	48	124	2915.4
L56 × L420	84	74	189	151.8	46	105	2695.8
L56 × L401	86	78	194	147.7	36	96	2196.7
L31 × L22	112	56	215	150.9	52	145	2626.9
L31 × LF2	112	49	215	149.8	44	172	2511.7
L31 × L420	83	77	189	147.6	34	112	2537.5
L31 × L401	81	68	214	144.5	47	166	2812.5
L22 × LF2	117	49	217	147.2	37	112	2727.7
L22 × L420	98	76	202	166.2	55	106	2413.7
L22 × L401	117	49	214	144.3	47	143	2883.3
LF2 × L420	94	66	207	151.9	39	131	3079.6
LF2 × L401	83	78	178	134.4	38	125	2546.4
L420 × L401	66	88	213	160.7	34	125	2365.4
LSD(α=0.05)	4.41	5.88	2.63	19.67	8.39	16.64	414.99
LSD(α=0.01)	5.78	7.71	3.45	25.79	11.00	22.13	551.93

CONCLUSIONS

In general pods Significant ratio of GCA to SCA mean square and high narrow-sense heritability estimates for days to flowering, duration of flowering and number of pods on main raceme implied that inheritances these traits are strongly associated with additive gene actions. Among the parents, L41, Zafar and L22 with significant positive GCA effects for seed yield were superior combiners for improving this trait. The crosses with significant positive SCA effects for seed yield had at least one parent with significant positive GCA effects for this trait. The crosses including L41×L22, L41×LF2, Zafar×L22 and Zafar×L420 with seed yield of

3421.7, 3400, 3348.1 and 3311.3 kg ha^{-1} could be promising for determination of superior recombinants for high seed yield coupled with other growth characters in advanced generations of segregation.

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Table 7: Specific combining ability effects of half-diallel analysis for phenological traits, yield components and seed yield in eight oilseed rape genotypes.

Crosses	No. days to flowering	Duration of flowering	No. days to maturity	Plant height	No. pods on main raceme	No. pods per plant	Seed yield
L41 × Zafar	1.36	-7.35**	4.04**	-8.70	-6.25**	-12.08*	-278.1*
L41 ×L56	2.16	-1.95	3.84**	2.41	1.48	-3.36ns	183.2 ns
L41 ×L31	-0.54	-4.28*	-1.29	-15.28*	-6.36**	-9.84ns	-362.9**
L41 ×L22	-4.47**	1.79	-2.99**	-0.98	2.30	4.51 ns	255.3 ns
L41 ×LF2	-7.11**	11.65**	-0.43	8.69	13.43**	26.51**	420.0**
L41 ×L420	-5.17**	2.62	-16.03**	16.74*	7.90**	20.23**	74.0 ns
L41 ×L401	8.33**	5.69**	8.04**	13.71*	0.55	11.79*	159.7 ns
Zafar × L56	5.46**	-5.21**	3.47**	9.56	1.45	0.84 ns	71.0 ns
Zafar × L31	2.09	-2.88	3.34**	-3.43	-5.29*	-17.80**	32.4 ns
Zafar × L22	-3.84**	3.85*	-1.36	-5.63	0.81	-4.69 ns	228.1 ns
Zafar × LF2	2.86*	3.05	4.87**	2.01	5.83*	2.35 ns	-430.1**
Zafar × L420	-4.87**	2.69	-14.39**	-10.21	-5.13*	32.37**	422.7**
Zafar × L401	-11.71**	16.42**	-14.66**	29.70**	17.69**	36.22**	263.8 ns
L56 × L31	3.89**	-0.81	1.14	1.65	2.88	10.22 ns	-219.1 ns
L56 × L22	-3.71**	1.92	-1.89	7.94	0.24	16.13**	287.3*
L56 × LF2	-0.67	-0.88	0.01	-5.39	0.30	-1.39 ns	92.6 ns
L56 × L420	-8.41**	4.75*	-13.93**	-17.67**	-3.43	-17.27**	-73.0 ns
L56 × L401	-7.24**	7.15**	-5.19**	-10.50	-10.71**	-26.12**	-394.8**
L31 × L22	-4.41**	5.92**	-2.36**	2.36	-1.70	3.96 ns	-54.5 ns
L31 × LF2	2.29	-3.21	4.54**	5.76	2.52	36.93**	7.6 ns
L31 × L420	-4.11**	7.75**	-18.06**	-7.05	-9.00**	-19.75**	87.4 ns
L31 × L401	-6.94**	-3.51	11.34**	1.22	6.75**	34.30**	539.8**
L22 × LF2	1.03	-3.81*	6.84**	-5.78	-11.75**	-26.29**	-255.0 ns
L22 × L420	4.63**	6.82**	-4.76**	2.71	5.03*	-28.14**	-515.0**
L22 × L401	22.79**	-22.45**	11.97**	-7.85	-0.12	8.11 ns	132.1 ns
LF2 × L420	6.66**	-6.31**	7.14**	-7.15	1.95	3.20 ns	328.2*
LF2 × L401	-5.17**	3.42	-17.13**	-13.32*	3.77	-2.68 ns	-27.5 ns
L420 × L401	0.76	-3.61	20.94**	2.50	-1.29	-0.23 ns	-154.6 ns

ns,* and **: Not- significant, significant at 5% and 1% levels of probability, respectively.

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Potencial razmnoževanja selekcioniranih linij oljne repice na nekatere pomembne kvantitativne lastnosti

IZVLEČEK

Informacije o ocenah združevanja lastnosti potencialnih linij plemenskega materiala so pomembne za razvoj boljših sort oljne repice (Brassica napus L.). S preiskavo smo proučevali kvantitativne genetske lastnosti fenološko pomembnih lastnosti (višina rastlin, št. strokov na socvetju/rastlino in pridelek semena za osem genotipov polovično dialelnih križancev oljne repice. Rezultat dielektrične analize je pokazal značilne srednje kvadratne odklone splošnih (SPLO) in specifičnih (SPEC) lastnosti za vse proučevane lastnosti. To kaže na pomembnost delovanja aditivnega in ne-aditivnega učinka na proučevane lastnosti.

V ozkem smislu je pokazala heritabiliteta za število dni do cvetenja, trajanja cvetenja in strokov na glavnem socvetju, da je glavni aditivni učinek na proučevane lastnosti. Liniji L420 in L401 sta z značilnimi negativnimi učinki na SPLO lastnosti za število dni do cvetenja, starosti ko rastline doseže zrelost sta bili primerni za tvorjenje zgodaj zrelih kombinacij oljne repice.

Linije L41, Zafar in L22 z značilno pozitivnimi učinki na SPLO lastnosti za količino semena so bili primerni za starševsko linijo za povečanje količine semen. Križanci s statistično značilnim pozitivnim SPEC lastnostmi imajo vsaj enega starša z značilno pozitivno lastnostjo za to SPLO lastnost. Možne najboljše kombinacije križanj so se pokazali križanci L41×L22, L41×LF2, Zafar×L22 in Zafar×L420, ki so imeli pridelek semena 3421,7, 3400, 3348,1 in 3311,3 kg ha-1.

Omenjeni križanci so najboljši rekombinanti za visok pridelek semena in druge rastne lastnosti v naslednjih generacijah segregacijske selekcije.

Ključne besede: oljna repica, križanci, aditivni učinki, stopnja dominantnosti, sposobnost združevanja lastnosti, heritabiliteta, pridelek