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BREEDING FOR IMPROVING THE SEED YIELD AND YIELD CONTRIBUTING TRAITS IN *BRASSICA NAPUS* L. BY USING LINE × TESTER ANALYSIS

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A B S T R A C T

The study was conducted to estimate genetic variation, GCA and SCA in *Brassica napus* genotypes {Star, Golarchi, Hybripol, UAF 2, BA 0714 (lines) and Range, DGL, Ayub2000 (testers)} for seed yield and yield components. These genotypes were crossed in 5×3 line×tester crossing fashion (2010-2011). Data of F_1 and their parents were recorded (2011-2012) for days taken to maturity, plant height, secondary branches/plant, number of siliqua/plant, number of seeds/siliqua, 1000-seed weight, seed yield/plant, protein and oil content. The results of analysis of variance showed significant differences in different parents for all the traits. Analysis of variance for combining ability for different traits showed that mean sum of squares due to lines were significant for all the traits except 1000-seed weight and protein content whereas for testers, the mean sum of squares were non-significant for seed yield/plant. Highly significant results were found in line×tester interaction for all above mentioned traits. The estimates of SCA variance was noticed higher than GCA variance in all traits. The contributions of lines as compared to testers were greater for all traits except 1000-seed weight and protein content.

Keywords: Genetic variation, combining ability, seed yield, *Brassica napus*.

Abbreviations: DTM_days taken to maturity; PH_plant height; SBPP_secondary branches per plant; NSPP_number of siliqua per plant; NSPS_number of seeds per siliqua; SW_1000-Seed weight; SYPP_seed yield per plant; PC_protein content; OC_oil content; GCA_general combining ability effects; SCA_specific combining ability effects

INTRODUCTION

Although Pakistan has made a splendid progress in agriculture, serious shortage of edible oil is persisting. The total available quantity of oil used for edible purposes was 2.9 million tons during 2009-10. Out of which domestic productivity of cooking oil was only 0.662 million tons that contributed about 23% of total available quantity in Pakistan, whereas the rest of 77% was imported from other countries. In nine months from July-March, 2010-2011, a huge quantity of 1.7 million tons cooking oil which is equal to 1.65 billion US$ was ensured through imports. In Pakistan, *Brassica napus* was cultivated on a land of 272 thousand hectares which gross annual productivity of edible oil was 100 thousand tons (Anonymous, 2010-11).

Brassica napus has attracted the attention of many people in recent years. This plant has been given a great importance in the plan for "oil seed import reduction". *Brassica napus* plant has high percentage of oil and protein, is ranked third and second, respectively among the oil seeds. *Brassica napus* seed contains 40-45% oil from its weight. Therefore, it is rich in oil content than other oil crops such as: Cotton (25 %), Soya been (20 %), maize (15 %) and it is close to sunflower (40%). The high percentage of oil in *Brassica napus* makes it the leading oil crop in the world. For that reason, it is cultivated in large areas in many countries. *Brassica napus* seed also contains at least 46.5% protein and 0.35% phosphorus in the meal, is a valuable oil crop in oil industry and animal feed.

The current study is therefore, planned with the aim to find out suitable parents and their crosses for seed yield and yield components. For this purpose general (GCA) and specific combining abilities (SCA) of different genotypes will be determined using line × tester

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analysis. In breeding programs of *Brassica napus* for the improvement and development of open pollinated varieties and F_1 crosses, both GCA and SCA effects are vital initiator of inbred lines potential in varietal combinations. The analysis conducted in line × tester design is an effective way to evaluate a huge number of inbred lines and providing correct information on the relative importance of general combining ability and specific combining ability effects for determining the genetic basis of plan traits of economic importance (Singh and Chaudhury, 1977).

Many studies have reported general and specific combining ability effects for different characters in *Brassica napus* (Sharief *et al*., 2002; Gupta *et al.,* 2006; Nassimi *et al.,* 2006a; Nassimi *et al.,* 2006b; Raziuddin *et al.,* 2006; Akbar *et al.,* 2008; Huang *et al.,* 2009; Rameeh 2011; Singh *et al.,* 2011; Rameeh 2012; Turi *et al.,* 2011). In this research study, The estimates of SCA variance was noticed higher than GCA variance in all traits.

MATERIALS AND METHODS

The research was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the year 2010-2011 and 2011-2012. Eight genotypes were sown namely Star, Golarchi, Hybripol, UAF 2, BA 0714 (lines) and Range, DGL, Ayub2000 (testers) during rabi season of 2010 and were crossed in Line × Tester fashion. Seed obtained by these crosses and the parents were sown next year in randomized complete block design in three replications. Plant to plant distances was 30cm and row to row 60cm in a plot size of 3m x 9m. All the agronomic practices recommended for *Brassica napus* were followed throughout growing season. At the maturity, data of fifteen F_1 crosses and their parents were recorded for various plant parameters, i.e. days taken to maturity, plant height, secondary branches/ plant, number of siliqua/plant, number of seeds/siliqua, 1000-seed weight, seed yield/plant, protein content and oil content. The data were subjected to analysis of variance according to (Steel *et al*., 1997). Since the expected mean sum of squares are not available for the modified line x tester analysis, the mean of each replication for the eleven characters recorded for the hybrids alone were subjected to analysis and the fresh mean sum of squares, along with the variance of general combining ability (GCA) of the parents and specific combining ability (SCA) of the hybrids were worked out based on the procedure developed by Kempthorne (1957).

RESULTS AND DISCUSSIONS

The present study was designed with the aim to find out suitable combining parents for different characters in eight genotypes and to select superior crosses with respect to their good specific combining effects for seed yield and yield components. The analysis of variance for various traits is explained in table 1. Significant (p ≥ 0.01 – 0.05) differences were determine among entries for all traits studied as shown in table 2. The analysis of variance for combining ability for different traits in a line × tester design (5×3). The mean sum of squares due to lines (female) were significant (p ≥ 0.01 – 0.05) for all traits except 1000-seed weight and protein content whereas for testers (male) the mean sum of squares were non-significant for the trait of seed yield/plant and other traits exhibited highly significant results. Highly significant results were found in line × tester interaction for all traits. The estimates of SCA variance was noticed higher than GCA variance in all traits.

Table 1. Mean squares from analysis of variance of various traits in *Brassica napus* L.

Parameters	Replications	Genotypes	Error
Degree of Freedom	2	22	44
Days taken to maturity	3.17	86.96**	12.07
Plant height (cm)	12.45	284.01**	22.62
Secondary branches per plant	0.18	8.78**	0.68
Number of siliqua per plant	3793	71720**	1176
Number of seeds per siliqua	0.48	16.22**	0.20
1000-seed weight (g)	0.05	0.35**	0.03
Seed yield per plant (g)	77.93	399.19**	22.16
Oil content	0.71	13.25**	1.56
Protein content	1.36	12.17**	1.07

* Significant (α=0.05) ** Highly significant (α=0.01).

The contributions of lines as compared to testers were greater for all parameters except 1000-seed weight and protein content. While the involvement of lines × testers were noted higher in case of days taken to maturity, number of seeds/siliqua,1000-seed weight, seed yield/plant, protein content and oil content.

Days taken to maturity: Out of 5 lines, the female parents Hybripol and UAF 2 showed significant results for positive and negative GCA effects respectively. The cultivar Hybripol (3.40) was good general combiner in the female genotypes. Among the 3 testers, Ayub 2000 (-3.40) exhibited highly significant results in relation to negative GCA effects whereas the genotype Range (2.33) showed positive GCA effects as shown in table 3. Table 4 shows that among the fifteen cross combinations, UAF 2 × Ayub 2000 expressed highly significant results for negative SCA effects for this trait. The hybrid UAF 2 × Ayub 2000 (-9.71) was identified as the best specific combiner for this character. Whereas other crosses expressed non-significant results for this plant parameter. Sharief *et al*. (2002); Nassimi *et al*. (2006) and Huang *et al*. (2009) reported significant results for this character.

Plant height (cm): Table 3 shows that the he lines Hybripol, Golarchi, BA 0714 and Star observed to be good general combiner as seen highly significant results for GCA effects in positive and negative direction. In three testers Range and DGL exhibited significant results in relation positive and negative GCA effects correspondingly (Table 4). In case of specific combining ability out of fifteen hybrids, the only F_1 cross UAF 2 × DGL expressed highly significant results in direction of negative specific combining ability effects and identified as best specific combiner. Sharief *et al*. (2002); Rameeh *et al*. (2011); Turi *et al*. (2011) and Rameeh (2012) were calculated both general combining ability and specific combining ability significant effects in *Brassica*.

Secondary branches per plant: The female parents Hybripol observed to be good general combiner as seen highly significant results for GCA effects in negative direction (Table 3). In three male parents Range and DGL exhibited significant results for GCA effects in negative and positive relation. in case of specific combining ability out of fifteen hybrids, only 2 hybrids i.e. BA 0714 × DGL and UAF 2 × Range expressed highly significant results in direction of positive and negative specific combining ability effects while the other cross

combinations exhibited non-significant results for Secondary branches/plant (Table 4). Sharief *et al*. (2002); Turi *et al*. (2011) was also explained both GCA and SCA significant effects in *Brassica napus*.

Number of siliqua/plant: Among the lines, Golarchi, UAF 2, Star and Hybripol showed highly significant results for positive and negative GCA effects. Out of three testers, DGL and Range exhibited highly significant positive and negative general combining ability effects as shown in table 3. Table 4 depicts that out of 15 hybrids, these crosses Golarchi × DGL, BA 0714 × Range, Hybripol × DGL showed highly significant results for positive SCA effects but the hybrids viz., BA 0714 × DGL, Hybripol × Range and Golarchi × Range revealed highly significant results in negative direction of SCA effect for number of siliqua/plant. The cross combination Golarchi × DGL (119.24) was the best specific combiner. Sharief *et al*. (2002); Huang *et al*. (2009) studied the both GCA and SCA effects for the trait number of siliqua per plant in mustard.

Number of seeds/siliqua: Out of five female parents, three lines i.e. Star, Hybripol and UAF 2 expressed highly significant results for GCA effects in negative and positive direction respectively (Table 3). In three male parents, only one tester exhibited Ayub 2000 significant results for GCA effects in positive relation. Table 4 shows that in case of specific combining ability out of fifteen hybrids, the F_1 crosses viz., BA 0714 × Ayub 2000, UAF 2 × Range, Hybripol × Range, Star × DGL and BA 0714 × Range, Hybripol × Ayub 2000, Star × Ayub 2000, BA 0714 × DGL, UAF 2 × Ayub 2000 expressed highly significant results in direction of positive and negative specific combining ability effects. The hybrid BA 0714 × Ayub 2000 (3.77) was the best specific combiner. Sharief *et al*. (2002); Nassimi *et al*. (2006) and Akbar *et al.* (2008) were also explained both GCA and SCA significant effects for number of seed per siliqua in *Brassica napus*.

1000-seed weight (g): Among the lines, all female indicated non-significant results for good general combiner GCA effects while in male parents only Ayub 2000 revealed significant results in direction of positive GCA effects (Table 3). In case of specific combining ability out of fifteen hybrids, the crosses i.e. BA 0714 × Range, Golarchi × Ayub 2000 and Hybripol × Range, BA 0714 × Ayub 2000 expressed significant results in direction of positive and negative specific combining ability effects while the other cross combinations exhibited non-significant reults for the trait of 1000-seed weight as shown in table 3.

Table 2. Analysis of variance for combining ability analysis of varioustraits in *Brassica napus* L.

Traits	d.f	DTM	PH	SBPP	NSPP	NSPS	SW	SYPP	PC	OC
Replication	2	3.17	12.44	0.18	3793	0.48	0.35	77.92	0.71	1.36
Lines (L)	4	75.14**	690.05**	7.31**	198231**	25.83**	3.57	482.87**	2.47	20.89**
Testers (T)	2	136.06**	101.40*	6.86**	16959**	1.29**	14.64**	7.92	17.82**	5.99**
L × T	8	102.42**	122.20**	1.74*	28907**	14.39**	10.78**	464.74**	11.45**	10.63**
Error	44	12.068	22.616	0.68	1176	0.20	1.93	22.16	1.56	1.07
S^2 GCA		0.10	5.38	0.07	1578.3	0.04	0.05	2.03	0.05	0.07
S^2 SCA		30.12	33.19	0.35	9243.4	4.73	2.94	147.52	3.29	3.18
S^2gca/S^2sca		0.003	0.162	0.20	0.170	0.008	0.017	0.013	0.015	0.022
Contribution (%) of										
Lines		21.59	70.04	51.37	74.9	46.74	11.01	34.09	7.21	46.26
Testers		19.54	5.14	24.08	3.2	1.17	22.56	0.28	25.98	6.64
Lines × Testers		58.86	24.80	24.53	21.9	52.08	66.42	65.62	66.80	47.08

* Significant (α=0.05) ** Highly significant (α=0.01).

Table 3. Estimates of GCA effects of female and male parents for various traits in *Brassica napus* L.

Traits	DTM	PH	SBPP	NSPP	NSPS	SW	SYPP	PC	OC
GCA for Lines									
Star	1.95	-6.66**	0.86*	73.77**	-1.94**	0.72	-1.67	0.40	0.20
Golarchi	0.28	7.66**	0.04	99.55**	0.36*	0.52	-8.10**	-0.04	-2.04**
Hybripol	3.40*	9.33**	-1.45**	-255.33**	-1.12**	-0.33	-5.45*	-0.04	-0.09
UAF 2	-3.82*	0.44	0.61*	86.77**	2.50**	-0.08	7.94**	-0.82*	2.23**
BA 0714	-1.82	-10.77**	-0.07	-4.77	0.20	-0.82	7.29**	0.51	-0.29
GCA for Testers									
Range	2.33*	2.6*	-0.21	-34.33**	-0.12	0.34	-0.28	-0.26	-0.48
DGL	1.06	-2.6*	-0.54*	32.86**	-0.21	0.77*	-0.54	-0.93*	-0.22
Ayub 2000	-3.40**	0.0	0.75*	1.46	0.33*	-1.11*	0.82	1.19*	0.71*

* Significant (α=0.05) ** Highly significant (α=0.01).

The hybrid BA 0714 × Range was good specific combiner for this character. Akbar *et al.* (2008) was estimated significant results for both GCA and SCA effects.

Seed yield/plant (g): Out of five female parents, 3 lines (UAF 2, BA 0714 and Golarchi) expressed highly significant results for GCA effects in negative and positive direction respectively. In three testers there was no good general combiner present (Table 3). In case of specific combining ability out of fifteen hybrids, the F_1 viz., Hybripol × Range and Star × DGL expressed highly significant results in direction of positive specific combining ability effects while the hybrids Star × Range and Hybripol × Ayub 2000 showed highly significant results in negative direction. The hybrid Hybripol × Range (16.12) was the best specific combiner (Table 4). Rameeh *et al*. (2011) and Turi *et al*. (2011) also found both GCA and SCA significant effects for seed yield per plant in *B. napus* L.

Table 4. Estimates of SCA effects of Hybrids for all the parameters in *Brassica napus* L.

Hybrids	DTM	PH	SBPP	NSPP	NSPS	SW	SYPP	PC	OC
Star × Range	-4.88*	-2.60	0.37	53.55*	0.24	-0.49	-18.02**	0.26	2.39**
Golarchi × Range	1.77	5.06	0.22	-93.88**	-0.88*	-0.69	2.84	1.37	-2.90**
Hybripol × Range	-5.00*	-4.93	0.56	-106.00**	1.30**	-1.67*	16.12**	-1.28	-0.26
UAF 2 × Range	7.55*	5.28	-1.00*	41.55*	1.66**	-0.05	3.35	1.82*	0.24
BA 0714 × Range	0.55	-2.81	-0.15	104.77**	-2.33**	2.91*	-4.29	-2.17*	0.52
Star × DGL	1.37	3.26	-0.40	-43.64*	1.50**	1.07	15.29**	1.26	-1.61*
Golarchi × DGL	-4.62*	-1.40	-0.48	119.24**	0.23	-1.26	-7.13*	-1.62*	1.80*
Hybripol × DGL	3.26	4.60	-0.28	86.13**	0.62*	0.16	-2.86	-0.28	0.27
UAF 2 × DGL	2.15	-11.17**	0.15	-39.64*	-0.91*	1.28	-8.86*	0.48	1.04
BA 0714 × DGL	-2.17	4.71	1.00*	-122.08**	-1.44**	-1.25	3.56	0.15	-1.51*
Star × Ayub 2000	3.51	-0.66	0.03	-9.91	-1.74**	-0.57	2.72	-1.52*	-0.77
Golarchi × Ayub 2000	2.84	-3.66	0.25	-25.35	0.65*	1.95*	4.29	0.24	1.10
Hybripol × Ayub 2000	1.73	0.33	-0.28	19.86	-1.92**	1.51	-13.20**	1.57*	-0.01
UAF 2 × Ayub 2000	-9.71**	5.88*	0.85	-1.91	-0.75**	-1.23	5.50*	-2.31*	-1.29*
BA 0714 × Ayub 2000	1.62	-1.88	-0.85	17.31	3.77**	-1.66*	0.72	2.01*	0.98

* Significant (α=0.05) ** Highly significant (α=0.01).

Protein content: Among the lines, only UAF 2 showed significant results for negative GCA effects. Out of three testers, Ayub 2000 and DGL exhibited significant positive and negative general combining ability effects (Table 3). Out of 15 hybrids, these crosses BA 0714 × Ayub 2000, UAF 2 × Range and Hybripol × Ayub 2000 showed significant results for positive SCA effects but the hybrids viz., UAF 2 × Ayub 2000, BA 0714 × Range and Golarchi × DGL and Star × Ayub 2000 revealed significant results in negative direction of SCA effect for the trait of oil content (Table 4). The cross combination BA 0714 × Ayub 2000 (2.01) followed by UAF 2 × Range (1.82) was the best specific combiner. Huang *et al*. (2009) studied the both GCA and SCA effects for the trait number of siliqua per plant in mustard.

Oil content: The female parents UAF 2 and Golarchi observed to be good general combiner as seen highly significant results for GCA effects in positive and negative direction. In three male parents Ayub 2000 exhibited significant results for GCA effects in positive relation (Table 3). In case of specific combining ability out of fifteen hybrids, only 2 hybrids i.e. Star × Range and Golarchi × Range expressed highly significant results in direction of positive and negative specific combining ability effects (Table 4). While the other cross combinations viz., Golarchi × DGL and Star × DGL, BA 0714 × DGL, UAF 2 × Ayub 2000 exhibited significant positive and negative SCA effects. Huang *et al*. (2009) and Turi *et al*. (2011) also found both GCA and SCA significant effects in *Brassica napus* L.

REFERENCES

Akbar, M., Tahira, B.M. Atta and M. Hussain. 2008. Combining Ability Studies in Rapeseed (Brassica napus). Int. J. Agric. Biol. 10(2): 205-208.

Anonymous. 2010-11. Economic survey of Pakistan. Government of Pakistan, Finance Division, Economic Advisor's wing, Islamabad, Pakistan.

Gupta, S.K., N. Karuna and T. Dey. 2006. Heterosis and combining ability in rapeseed (*Brassica napus* L.). J. Res. Skuast. 5(1): 42–47.

Huang, Z., P. Laosuwan, T. Machikowa and Z. Chen. 2009. Combining ability for seed yield and other characters in rapeseed. Suranaree J. Sci. Technol. 17(1):39-47.

Nassimi, A.W., Raziuddin, N. Ali, S. Ali and J. Bakht. 2006a. Analysis of combining ability in *Brassica napus* L. lines for yield associated traits. Pak. J. Biol. Sci. 9(12): 2333-2337.

Nassimi, A.W., Raziuddin, S. Ali, G. Hassan and N. Ali. 2006b. Combining ability analysis for maturity and other traits in rapeseed (*Brassica napus* L.). Agron. J. 5(3): 523-526.

Rameeh, V. 2011. Combining ability analysis of rapeseed genotypes under restricted nitrogen application. J. Oilseed Brassica. 2(1): 7-12.

Rameeh, V. 2012. Combining ability analysis of plant height and yield components in spring type of rapeseed varieties (*Brassica napus* L.) using line × tester analysis. Int. J. Agric & Forestry. 2(1): 58-62.

Raziuddin, D., A.W. Nassimi, N. Ali, S. Ali and J. Bakht. 2006. Combining ability analysis for maturity and other traits in rapeseed (*Brassica napus* L.). Agron. J. 5(3): 523–526.

Sharief, A.E., A.M. Salama, M.M. Keshta, and M.A.A. Mohammed. 2002. Combining ability of some canola (*Brassica napus* L.) inbred lines and their hybrids under different plant population density. J. Agric. Sci. Mansoura Univ. 27(11): 7225–7235.

Singh, M., L. Singh and S.B.L. Srivastava. 2011. Combining ability analysis in Indian mustard (*Brassica juncea* L. Czern & Coss). J. Oilseed Brassica. 1(1): 23-27.

Singh, R.K., and B.D. Chaudhury. 1977. Biometrical techniques in breeding and genetics. Scholarly Pubns, Delhi, India. PP: 350. ISBN: 0880651938.

Turi, N.A., Raziuddin, Farhatullah, N.U. Khan, G. Hassan, J. Bakht, S. Khan and M. Shafi. 2011. Combining ability for yield related traits in *Brassica juncea.* Pak. J. Bot. 43(2): 1241-1248.

Kempthorne, O. 1957. Introduction to genetic statistics John Willey and Sons, Inc. New York, USA.

Steel, R.G.D., G.H. Torrie and D.A. Dicky. 1997. Principles and procedures of statistics. A biometrical approach (3rd Ed.). McGraw Hill Book International CO. New York.