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GENETIC ANALYSIS AND INHERITANCE PATTERN FOR YIELD AND YIELD CONTRIBUTING TRAITS OF *BRASSICA NAPUS*

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ABSTRACT

In *Brassica napus*; genetic variability, combining ability variances and traits associations (General and specific) were studied in a research during the crop season 2015-16. Data were recorded on days taken to flowering, days to 50% flowering, No. of primary branches/plant, No. of secondary branches/plant, No. of siliques/plant, No. of seeds/silique, seed yield/plant (g) and 1000-grain weight (g). Significant ($p \geq 0.01$-0.05) variations were witnessed for all characters under critical analysis. Correlations for all the traits were highly significant except 1000-grain weight (significant). Parent, Zn-M-9 outperformed others with best GCA effects for day to flowers (-1.82**), day to 50 % flowering (-2.91**) and seed yield/plant (0.77**). While, 01816 × ZMR-3 had best SCA results of days to flowering (-3.14**), days to 50 % flowering (1.99**) and 1000-grain weight (0.41**). The results suggested that the selection of genotypes may be helpful to improve crop plant yield and production of brassica. The higher GCA effects indicated that the fixing of relative traits may be helpful to develop synthetic varieties while higher SCA helps to select genotypes to develop higher yield hybrids.

Keywords: Trait association, Genetic variability, *Brassica napus* and Combining ability

INTRODUCTION

Agriculture is playing a significant role in the progress of Pakistan since its independence. GDP contributed by the agriculture sector is 19.8%. It is engaging 42.3% people of Pakistan and also provides the raw material to the other industries having agriculture base. During 1947-60 edible oil production was sufficient for meeting the requirement of Pakistan. In 1960 Pakistan started import of oil. Import of edible oil during 1979-80 was 0.35 million tons and import reached 1.4 million tons during 1994-95. During the year 2014-15 contribution of the local oilseed crops was 0.556 million tons while 2.967 was imported from other countries to meet the requirement of the country [1]. *Brassica napus* L. (AACC=38) belongs to rapeseed group of oilseed crops. *Brassica napus* is locally called as Ghobi sarsoon. Family of *Brassica napus* is Brassicaseae; family includes 375 genera and species are 3200 [2]. Genus of *B. napus* is Brassica that has 100 species. This genus includes the agricultural and horticultural crops so it has great importance. About 200 years ago it was cultivated in india and its oil was used mostly for purpose of burning instead of edible purposes. Its height ranges from 1.2m to 1.5 m. Terminal receme has bisexual flowers with 4 sepals and 4 petals. Six stamens, single pistils have two carpels and single superior ovary. Chances of both selfing and crossing exist because mode of pollination is Entomophilous. Length of the siliqua is 6-9 cm and 15-40 seeds are present in single silique. Colour of the seeds is mostly dark brown to black in nature [3].

Pakistan imports a major proportion of required edible oil. Import can be minimized by increasing production of locally cultivated varieties of the oilseed crops [4]. *Brassica napus* L. is considered an important oilseed crop in Pakistan and almost in the whole world. It contains 35-45% oil in this crop. Oil is used for the purpose of the cooking and margarine [5]. It can be used for feeding poultry and animals because it has high amount of protein 38-40% [6] Lysine, cysteine and methionine are present in amino acid profile of the oilseed [2,6]. Instead of considering the importance of oilseed crops for health of human being, oilseed crops are cultivated as minor crops due to the ignorance of the Govt. and limited research conducted. The present position of oilseed crops production and demand in Pakistan there is need of improvement of the crops by using conventional breeding and biotechnological tools.

Short duration varieties of oilseed crops like sunflower and rapeseed/mustard can increase yield by intercropping with other crops. Existing rotations of different crops with rapeseed/mustard that are followed in Pakistan are;

- Rice-rapeseed/mustard-sugarcane
- Rapeseed/mustard-groundnut-wheat
- Wheat-guar-rapeseed/mustard-cotton
- Rice-rapeseed/mustard-rice

Desirable parents can be identified by combining ability analysis. Information about polygenic traits can be provided by combining ability analysis [7]. Line × tester analysis gives information about general combining anility and specific combining ability. Researcher and scientists are using Line × Tester analysis for genetic analysis and assessment of combining abilities i.e GCA and SCA in different crops like cotton, wheat, pea, soybean, sunflower and brassica [8]. Correlation analysis provides an opportunity to select genotypes for higher yield [9-14].

MATERIALS AND METHODS

Experimental Conditions

The present study was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Faisalabad is situated at a longitude 73°74 East, latitude 30°31.5 North, with an elevation of 184 meters (604 ft) above sea level. The soil of Faisalabad consists of alluvial deposits mixed with loess having calcareous characteristics, making the soil very fertile. The experimental material consisted of nine genotypes of *Brassica napus* viz. Legend, ZMR-3, Cycalon, Zn-R-18, 01816, Zn-R-1, D-265, B-LBAN and Zn-M-9 obtained from the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan. In nine genotypes, three parents (Zn-R-18, 01816, Zn-R-1, D-265, B-LBAN, Zn-M-9) were used as lines and three genotypes (Legend, ZMR-3, Cycalon) were used as testers for Line × Tester crossing pattern. These genotypes were grown in the field during 2016 and crossed in a complete Line × Tester fashion through controlled pollinations. The seed was harvested and cleaned for next season.

Layout

Seeds of eighteen crosses and their parents were sown in the field following a randomized complete block design with three replications during of October 2016. Plant to Plant distance of 30 cm and row to row 60 cm was maintained. All the agronomic practices recommended for *Brassica napus* L, were followed uniformly for all entries throughout growing season. Crossed seed was sown during the October 2016-2017 in RCBD design along with parents and data of the following traits were recorded, *viz*., days to 50% flowering, days taken to flowering, number of primary branches, number of secondary branches, number of seeds/ silique, number of silique/plant, seed yield/plant (g), 1000 grain weight (g), Oil contents (%), and Protein content (%)

Analysis of variance for parents and hybrids

The mean of three replications calculated for the hybrids and parents for ten traits were subjected to statistical and biometrical analysis [15].

Line × Tester analysis

The collected data for all the traits were subjected to analysis of variance [15] and further evaluated for general & specific combining abilities and contribution of parents.

Combining ability analysis

Since expected mean sum of squares are not reachable for the modified Line x Tester analysis, the mean of each replication for the ten 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 analyzed based on the method developed by Kempthorne [16].

Estimation of GCA effects

I). Lines

$$gi = Xi/mr + X\ldots/mfr$$

Where Xi is total of the i^{th} female parent over all male parent and replications.

II). Testers

$$gt = Xj/fr + X\ldots/mfr$$

Where

l = number of lines

t = number of testers

r = number of replications

x i.. = Total number of F_1 resulting from crossing i^{th} lines with all the testers.

x...= Total of all the crosses.

Estimation of SCA effects

Sij= (Xij/r) – (Xi../mr) – (Xj../fr) – (X…/mfr)

Where;

Xij = Total of F_1 resulting from crossing ith lines with jth tester.

Xi = Total of all the crosses of i^{th} line with all testers.

Xj = Total of all the crosses of j[th] tester with all lines.

Contribution of Lines, Testers, and their interaction to overall Variance

Contribution of lines = (SS $_l$ / SS (Crosses)) × 100

Contribution of testers = (SS $_t$ /SS (Crosses)) × 100

Contribution of (l × t) = (SS $_{l\times t}$/SS (Crosses)) × 100

Where;

SS $_{(l)}$ = Sum of square due to lines

SS$_{(t)}$ = Sum of square due to testers

SS $_{l\times t}$ = Sum of square due to lines × testers

SS$_c$ = Sum of square due to crosses

RESULT AND DISCUSSION

Analysis of variance

In the experiment different genotypes of *Brassica napus* were crossed in Line × Tester crossing pattern to get the high yielding and good quality lines for further breeding. Recorded data was subjected to analyze the differences among the genotypes of *Brassica napus* L. The results of analysis of variance (ANOVA) for different traits are listed in **Table 1**. All the genotypes had significant (p≥ 0.01-0.05) differences for all the traits under observation. Variability was recorded among the genotypes for different morphological, physiological, yield and quality contributing traits. Various researchers found significant difference for majority of the characters in Brassica species [2, 4, 5, 8, 17-19]. Yield and quality contributing traits had significant mean square values. Infact, improvement in yield contributing traits is an improvement is yield itself. Highly significant variability in oilseed Brassicas for yield and yield related traits was observed [20-22].

Table 1: Mean sum of square of analysis of variance for different traits in *Brassica napus* L

SOV/Traits	Df	Days to flowering	Days to 50% flowering	No. of primary branches /plant	No. of secondary branches/ plant	No. of siliquaes/ plant	No. of seeds/silique	1000 seed weight	Seed yield/plant
Replication	2	0.2091ns	18.3374*	0.1529ns	0.5346ns	18.4114*	0.1353ns	0.0145ns	0.1059ns
Genotypes	26	48.6363**	82.1547**	2.5727*	25.7248**	7791.25**	10.9331**	***0.3701*** *	22.9388**
Parents	8	13.0648**	96.692**	2.6282*	11.034*	7679.66**	6.9133*	0.1401*	67.9732**
Crosses	17	66.9401**	69.0489**	2.6565*	33.4049**	4650.78**	11.574**	0.2976*	3.0793**
Parents vs Cros	1	22.0448**	188.655**	0.7054*	12.6896**	62072.1**	32.1959**	3.4439**	0.2763
Lines	5	46.4931**	98.1963**	2.1204*	51.0964**	4857.64**	8.2946**	0.2251*	1.7441**
Testers	2	0.3147ns	14.2816**	3.4475*	17.4544**	1168.47**	7.8058**	0.3335*	3.0711*
LxT	10	90.4886**	65.4287**	2.7663*	27.7493**	5243.81**	13.9673	0.3267	3.7485*

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

Analysis of variance for combining ability

The concept of combining ability, general and specific has become increasingly important to plant breeders because of the extensive use of hybrid cultivars in many crop plants. General combining ability provides information for each parental inbred whereas; specific combining ability provides information for hybrids. Thus performance of specific genotypes can be evaluated. The data of each plant trait was subjected to analysis of variance. Significant differences were observed among the accessions for all characters studied. The **Table 2** showed the analysis of variance for combining ability of different quantitative and qualitative traits in *Brassica napus* by using the line × tester crossing pattern. The mean sums of squares due to lines (female) were significant for all the traits included in study. Mean sum of square due to testers were highly significant for days taken to 50% flowering, number of primary branches per plant, number of secondary branches per plant, number of siliquae per plant, number of seeds per siliquae, 1000-seed weight and seed yield per plant while exhibited non-significant results due to testers for days taken to flowering in Brassica [8,22]. The highly significant results were found in line × tester interaction for days taken to flowering, days taken to 50% flowering, number of primary branches per plant, number of secondary branches per plant, number of siliqae per plant, number of seeds per siliqua, seed yield per plant while interaction was significant for 1000-seed weight. Contribution of lines was more as compared to the contribution of testers [10,18].

Table 2: Analysis of variance for combining ability

SOV/Traits	Df	Days to flowering	Days to 50% flowering	No. of primary branches /plant	No. of secondary branches/ plant	No. of siliquaes/ plant	No. of seeds/sili que	1000 seed weight	Seed yield/plant
Replication	2	0.0589	5.1047	0.1816	0.1406	166.085	0.0174	0.0388	0.0626
Cross	17	66.9401	69.0489	2.6565	33.4049	4650.78	11.574	0.2976	3.0793
LINE	5	46.4931	98.1963	2.1204	51.0964	4857.64	8.2946	0.2251	1.7441
Tester	2	0.3147	14.2816	3.4475	17.4544	1168.47	7.8058	0.3335	3.0711
LxT	10	90.4886	65.4287	2.7663	27.7493	5243.81	13.9673	0.3267	3.7485

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

Estimates of general and specific combining abilities for various traits of *Brassica napus*

General combining ability effects for different traits of *Brassica napus* are explained in **table 3**

Days taken to flowering Early flowering is desirable for developing early maturing varieties therefore negative GCA effects were favorable in Brassica. Out of six lines, 01816, B-LBAN and Zn-M-9 showed highly significant but Zn-R-1 showed significant GCA effects in negative direction and D-265 showed highly significant GCA effects in positive direction. Among the testers all exhibited non-significant GCA effects. The hybrids Zn-R-18 × ZMR-3, 01816 × ZMR-3, Zn-R-1 × Cycalon, D-265 × Legend, B-LBAN × Cycalon, Zn-M-9 × Legend and Zn-M-9 × Cycalon showed highly significant results for SCA effects in negative direction and verified as good specific combiner for days taken to flowering. Hybrids Zn-R-18 × Cycalon, 01816 × Legend, 01816 × Cycalon, Zn-R-1 × Legend, Zn-R-1 × ZMR-3, D-265 × Cycalon, B-LBAN × Legend, B-LBAN × ZMR-3 and Zn-M-9 × ZMR-3 displayed significant results for SCA effect in positive direction. Zn-R-18 × Legend and D-265 × ZMR-3 were two hybrids that showed non-significant heterosis for days taken to flowering. Various exhibited highly significant results for both GCA and SCA effects for days to flowering in Brassica [23-25].

Days taken to 50% flowering

Zn-R-1 and Zn-M-9 showed highly significant GCA effects in negative direction that was deliberated as good general combiner for the development of early maturing varieties in Brassica. D-265 exhibited significant and positive GCA effects. Zn-R-18, 01816 and B-LBAN showed non-significant GCA effects in positive direction. Among testers Legend revealed significant GCA effects in negative direction while ZMR-3 and Cycalon indicated significant positive GCA effects. Among the crosses 01816 × ZMR-3, Zn-R-1 × Cycalon, D-265 × Legend, B-LBAN × Legend and Zn-M-9 × Cycalon showed highly significant SCA effects in negative direction that proved as specific combiner for the development of early maturing varieties. So these above mentioned crosses can be used for development of short duration varieties. Crosses, Zn-R-18 × ZMR-3, 01816 × Legend, 01816 × Cycalon, Zn-R-1 × Legend, D-265 × Cycalon, B-LBAN × Cycalon and Zn-M-9 × ZMR-3 had significant results for SCA in positive direction. Out of eighteen crosses, Zn-R-18 × Legend, Zn-R-18 × Cycalon, Zn-R-1 × ZMR-3, D-265 × ZMR-3, B-LBAN × ZMR-3 and Zn-M-9 × Legend showed non-significant SCA effects in positive direction for days taken to 50% flowering. Comparable significant positive and negative GCA and SCA effects were assessed [10,20,26].

Number of primary branches per plant

Lines Zn-R-1 and D-265 exhibited significant results for GCA effects in positive direction and Zn-R-18, 01816 and B-LBAN showed significant GCA in negative direction. Only one line Zn-M-9 had non-significant GCA effects in positive direction. Among the testers ZMR-3 showed negative and significant GCA effects. Cycalon was a tester that had significant GCA effects in negative direction. Only Legend showed non-significant GCA effects in positive direction. Crosses, Zn-R-18 × Legend, Zn-R-18 × ZMR-3, 01816 × Cycalon, Zn-R-1 × Cycalon, D-265 × Cycalon, B-LBAN × Legend, B-LBAN × ZMR-3, Zn-M-9 × ZMR-3 revealed significant positive GCA effects and Zn-R-18 × Cycalon, 01816 × ZMR-3, Zn-R-1 × Legend, Zn-R-1 × ZMR-3, D-265 × Legend, D-265 × ZMR-3, B-LBAN × Cycalon and Zn-M-9 × Cycalon showed significant GCA effects in negative direction. Combinations, Zn-R-18 × ZMR-3, 01816 × Legend, 01816 × Cycalon and Zn-M-9 × ZMR-3 had non-significant GCA effects for number of primary branches. Various researchers studied significant general and specific combining abilities effects for number of primary branches [20,25].

Number of secondary branches per plant

Table 3 shows that four lines (01816, Zn-R-1, D-265 and B-LBAN) exhibited significant and negative GCA effects; one line (Zn-M-9) in positive direction and remaining showed non-significant GCA effects for number of secondary branches. Zn-M-9 proved as best general combiner for this trait. Among the testers, ZMR-3 had positive and significant results for GCA effects and proved as a good general combiner. Legend and Cycalon were testers that showed significant results for GCA effects in negative direction. In case of specific combining ability, cross combinations; Zn-R-18 × Legend, Zn-R-18 × ZMR-3, 01816 × Cycalon, Zn-R-1 × Cycalon, D-265 × Legend, D-265 × ZMR-3, B-LBAN × Cycalon and Zn-M-9 × Legend were the crosses that revealed significant specific combining abilities in positive direction and crosses Zn-R-18 × Cycalon, 01816 × Legend, Zn-R-1 × Legend, D-265 × Cycalon, B-LBAN × Legend, B-LBAN × ZMR-3, Zn-M-9 × ZMR-3 revealed significant SCA in negative direction. The crosses proved as best specific combiner for number of primary branches were Zn-R-18 × Legend and 01816 × Cycalon. Whereas, crosses; 01816 × ZMR-3, Zn-R-1 × ZMR-3 and Zn-M-9 × Cycalon indicated non-significant SCA for number of secondary branches per plant. Researchers have explained both GCA and SCA significant effects in *Brassica napus* [6,11,27,28].

Number of siliquae per plant

Out of six lines, Zn-R-18, D-265 and B-LBAN displayed highly significant results for GCA effects in positive direction. D-265 proved as best general combiner with highest GCA effects. Whereas, 01816 and Zn-M-9 were lines that had significant GCA effects in negative direction and Zn-R-1 indicated non-significant GCA results in positive direction. Among the testers, Legend had significant GCA effects in positive direction and proved a best general combiner for number of siliquae per plant, Cycalon shown significant GCA effects in negative direction and ZMR-3 exhibited non-significant results for GCA effects in positive direction. In case of SCA, out of eighteen crosses, Zn-R-18 × Legend, 01816 × ZMR-3, D-265 × ZMR-3, B-LBAN × Cycalon and Zn-M-9 × Cycalon displayed highly significant results for SCA effects. While, Zn-R-18 × ZMR-3, 01816 × Cycalon, Zn-R-1 × Cycalon, D-265 × Cycalon, B-LBAN × Legend and Zn-M-9 × ZMR-3 revealed significant SCA effects in negative direction. B-LBAN × Cycalon was a cross combination that proved as a good specific combiner followed by Zn-R-18 × Legend for number of siliquae per plant. Cross combination like Zn-R-18 × Cycalon, 01816 × Legend, Zn-R-1 × Legend, Zn-R-1 × ZMR-3, D-265 × Legend, B-LBAN × ZMR-3 and Zn-M-9 × Legend had non-significant SCA effects both in positive and negative direction. Various researchers have also estimated alike significant GCA and SCA effects for number of siliquae per plant [21,29-31].

Number of seeds per siliquae

Among the lines B-LBAN and Zn-M-9 revealed significant results for GCA in positive direction while Zn-R-18, Zn-R-1 and D-265 showed significant GCA effects in negative direction. 01816 was only line that had non-significant GCA effects in positive direction. In the lines B-LBAN proved as a best general combiner for number of seeds/siliquae. All the testers showed significant results for GCA in both positive and negative direction. Legend and ZMR-3 were testers that showed positive significant GCA effects while Cycalon exhibited significant GCA effects in negative direction. Out of 18 crosses, Zn-R-18 × Legend, Zn-R-18 × ZMR-3, 01816 × Cycalon, Zn-R-1 × ZMR-3, D-265 × Legend, D-265 × Cycalon, B-LBAN × Cycalon and Zn-M-9 × Cycalon displayed significant SCA effects in positive direction. While, Zn-R-18 × Cycalon, 01816 × Legend, Zn-R-1 × Legend, Zn-R-1 × Cycalon, D-265 × ZMR-3, B-LBAN × Legend, B-LBAN × ZMR-3 and Zn-M-9 × Legend showed significant SCA effects in negative direction. D-265 × Cycalon was a combination that proved as best combiner for number of seeds per siliquae. The crosses that showed non-significant SCA effects were 01816 × ZMR-3 and Zn-M-9 × ZMR-3. Significant GCA and SCA results were reported [6, 30-32].

1000-seed weight

Among lines, D-265 showed significant GCA effects in negative direction and all remaining five lines had non-significant GCA effects in both positive and negative direction. Legend was the only tester that had significant GCA results in positive direction and proved as a good general combiner for 1000-seed weight. Cycalon exhibited significant results in negative direction and ZMR-3 had non-significant GCA effects. In case of SCA effects, D-265 × Legend, Zn-R-18 × Cycalon and 01816 × ZMR-3 revealed significant results in positive direction. 01816 × ZMR-3 (0.41*) proved as good specific combiner followed by Zn-R-18 × Cycalon (0.37*) out of 18 cross combination for 1000-seed weight. The crosses, Zn-R-18 × ZMR-3, 01816 × Cycalon and D-265 × Cycalon that had significant SCA results in negative direction whereas, all remaining crosses showed non-significant SCA results in both positive and negative direction. Various researchers have explained significant GCA and SCA effects for 1000-seed weight in Brassica [25, 26, 32, 33].

Seed yield per plant (g)

Zn-M-9 was a line that had significant GCA effects in positive effects while Zn-R-18 and D-265 showed significant GCA effects in negative direction. Among the lines Zn-M-9 proved as good general combiner for seed yield per plant. ZMR-3 was a tester that exhibited positive and significant GCA effects for this traits whereas Cycalon showed significant GCA effects in negative direction. Out of total cross combinations, Zn-R-18 × Legend, Zn-R-18 × ZMR-3, 01816 × ZMR-3, Zn-R-1 × Cycalon, D-265 × ZMR-3, B-LBAN × ZMR-3, Zn-M-9 × Legend and Zn-M-9 × Cycalon showed significant SCA effects in positive direction. While, Zn-R-18 × Cycalon, 01816 × Legend, Zn-R-1 × ZMR-3, D-265 × Cycalon, B-LBAN × Legend and Zn-M-9 × ZMR-3 revealed significant SCA effects in negative direction. Zn-R-1 × Cycalon was a good cross combination that proved as good specific combiner for seed yield per plant. Remaining cross combinations showed non-significant SCA effects in both positive and negative directions. Various researchers have calculated significant results for general and specific combining abilities effects for seed yield per plant [24, 28, 31, 33].

Table 3: Estimates of general combining ability for various traits in *Brassica napus* L.

Traits	Days to flowering	Days to 50% flowering	No. of primary branches/ plant	No. of secondary branches/ plant	No. of siliquaes/ plant	No. of seeds/silique	1000 seed weight	Seed yield/plant
LINES								
Zn-R-18	0.22ns	0.82ns	-0.61**	0.16ns	15.58**	-0.56**	0.17ns	-0.53**
1816	-0.72**	-0.84ns	-0.23**	-2.11**	-33.49**	0.05ns	-0.13ns	-0.07ns
Zn-R-1	-0.6*	-1.77**	0.6**	-0.48**	1.56ns	-1.1**	0.14ns	-0.07ns
D-265	4.4**	4.89**	0.53**	-1.71**	19.86**	-0.58**	-0.23*	-0.25*
B-LBAN	-1.49**	-0.19ns	-0.35**	-0.41*	19.83**	1.52**	0.07ns	0.16ns
Zn-M-9	-1.82**	-2.91**	0.06ns	4.54**	-23.33**	0.66**	-0.02ns	0.77**
TESTERS								
Legend	0.08ns	-2.38**	-0.05ns	-0.47**	7.72*	0.45**	0.14*	-0.13ns
ZMR-3	0.07ns	1.07**	-0.41**	1.13**	0.64ns	0.31**	0.03ns	0.46**
Cycalon	-0.15ns	1.31**	0.46**	-0.66**	-8.36*	-0.76**	-0.14*	-0.33**

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

Table 4: Estimates of specific combining ability for various traits in *Brassica napus* L.

Hybrids	Days to flowering	Days to 50% flowering	No. of primary branches/ plant	No. of secondary branches/ plant	No. of siliquaes/ plant	No. of seeds/silique	1000 seed weight	Seed yield/plant
Zn-R-18 × Legend	0.02ns	-1.23ns	0.48**	3.06**	43.57**	1.56**	0.12ns	0.6**
Zn-R-18 ×ZMR-3	-3.14**	1.99**	0.26ns	1.01**	-50.93**	1.71**	-0.49**	0.84**
Zn-R-18 ×Cycalon	3.11**	-0.76ns	-0.74**	-4.07**	7.36ns	-3.27**	0.37*	-1.44**
01816× Legend	3.41**	4.83**	0.19ns	-2.93**	-14.31ns	-1.02**	-0.11ns	-0.6**
01816× ZMR-3	-9.13**	-8.74**	-0.34*	-0.13ns	39.79**	-0.04ns	0.41**	0.84**
01816× Cycalon	5.72**	3.91**	0.15ns	3.06**	-25.47**	1.06**	-0.3*	-0.24ns
Zn-R-1× Legend	1.03*	2.52**	-0.77**	-2.37**	15.15ns	-0.87**	0.04ns	-0.3ns
Zn-R-1× ZMR-3	1.37**	1.32ns	-0.36*	0.49ns	8.01ns	2.14**	-0.12ns	-1.27**
Zn-R-1×Cycalon	-2.4**	-3.84**	1.13**	1.89**	-23.15*	-1.27**	0.08ns	1.57**
D-265×Legend	-3.3**	-3.09**	-0.64**	0.7*	17.05ns	1.56**	0.32*	-0.06ns
D-265×ZMR-3	-0.29ns	0.33ns	-0.72**	2.36**	21.98*	-3.56**	0.09ns	0.6**
D-265×Cycalon	3.6**	2.76**	1.35**	-3.07**	-39.03**	2**	-0.41**	-0.54**
B-LBAN×Legend	0.92*	-3.15**	0.37*	-1.24**	-56.22**	-0.42*	-0.12ns	-0.52**
B-LBAN×ZMR-3	4.26**	0.74ns	1**	-0.88**	8.99ns	-0.52*	0.06ns	0.39*
B-LBAN×Cycalon	-5.18**	2.41**	-1.37**	2.12**	47.23**	0.95**	0.07ns	0.13ns
Zn-M-9×Legend	-2.08**	0.12ns	0.36*	2.78**	-5.23ns	-0.81**	-0.25ns	0.87**
Zn-M-9×ZMR-3	6.93**	4.35**	0.16ns	-2.85**	-27.84**	0.27ns	0.06ns	-1.39**
Zn-M-9×Cycalon	-4.85**	-4.48**	-0.52**	0.07ns	33.07**	0.54*	0.19ns	0.52**

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

CONCLUSIONS

Keeping in view all these findings it is revealed that there is genetic variability in the accessions that could be used in breeding programs and may be exploited through selection. The superior hybrids having the best specific combining ability may be further evaluated for the development of improved hybrids with higher yield potential in *Brassica napus* L. The number of siliquae per plant, seed yield per plant and secondary branches/plant can be used as selection criteria for high yield production in *Brassica napus* L. (Gobhi Sarson).

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