Heterosis study of agronomic characters of *Brassica napus* L.

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Abstract: The present research was conducted to find out genetic basis and heritability estimates of yield contributing traits of *Brassica napus* L. Seven lines ZM-R-10, OSCAR, ZM-R-30, ZM-R-16, ZM-R-17, ZM-R-5, ZM-R-21 and three testers Hyola-401 and Winer of Brassica napus were crossed in Line x Tester scheme. Twenty one crosses and their parents were evaluated in field by following randomized complete block design with three replications. Data were recorded on quantitative traits i.e. plant height, number of silique per plant, number of seeds per siliqua and 1000 seed weight. The recorded data were subjected to analysis of variance. Data for the traits showing significant genotypic difference were subjected to Line x Tester analysis for estimation of heterosis effects. Analysis of variance showed significant differences for all the traits in crosses parent, lines, and testers. It indicated the existence of considerable genetic variability in breeding material. Plant height ranged from 251cm to 142cm, number of silique per plant from 235cm to 61cm, number of seeds per silique 30 to 16 and seed weight from 7.04g to 4.04g. Narrow sense heritability estimates ranged from 0.01 to 0.45. Plant height, and 1000 seed weight had low heritability. Number of siliquae per plant, number of seeds per silique showed medium heritability. Phenological traits were also showed variation in growth habit, leaf shape, siliqua shape, siliqua colour and seed colors.

[Hafiza Hadiqa Anum, H.M. Waseem, Muhammad Awais, Javaria Tabusam, Barira Shoukat Hafiza, M. Asim Raza, Muhammad Hadi Abba. **Heterosis study of agronomic characters of *Brassica napus* L.** *Nat Sci* 2019;17(8):71-78]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 10. doi:10.7537/marsnsj170819.10.

Key words: Heritability, heterosis, *Brassica napus L.*

Introduction

Rapeseed (*Brassica rapa* and *napus*) is important as vegetable oil and protein meals all over the world (Azizinia, 2012, Iqbal et al., 2017). The nutritive value of rapeseed is very good. It has 40-46% oil percentage approximately. Along with oil it also have good quantity of protein which is 18-22% approximately (Shaukat *et al.,* 2014, Mustafa *et al.,* 2015). Canada, China, India and Germany are major rapeseed producing countries. It is cultivated on large area in Pakistan covering almost 2.11 million hectares with production of 1.94 million tonnes during 2015-16.

The population of Pakistan is rising rapidly therefore the total requirement of edible oil is also increasing swiftly. Pakistan is spending a large amount of foreign exchange on the import of huge quantity of edible oil which is snowballing every year due to increase in demand and population (Mustafa *et al.,* 2017). The production of edible oil is very low in Pakistan as compared with total requirement. The local production fulfill only 16-20% of total requirement so Pakistan is one of the largest edible oil importer in the world. To reduce the edible oil import bill, Pakistan must have to increase the cultivation of oilseed crops by providing good yielding varieties to the farmers.

The exploitation of genetic variation present in the breeding material is very important to obtain high yielding and early maturing varieties. The production of rapeseed can be boosted at commercial level by using hybrid seeds effectively. Efficient use of genetic variability can be possible in the breeding program if the basic knowledge about the genetic effects is available. Combining ability is very important in hybrid formation process because it helps in the selection of superior lines.

For developing improved genotypes through hybridization, the choice of suitable parents is a matter of great concern. Heritability tells us about the transfer of parental characters into the next generation. For crop improvement particular traits can be used which have good variability and high heritability (Aytac and Kinaci, 2009). Another powerful tool is heterosis which provides information about valuable hybrid combination. Line × tester is very helpful in the breeding program because it helps to estimate the different genetic variation among the population. The present research is planned to discover the genetic variability and heritability for seed yield and different characters related to yield. To identify potential parents and the evaluation of cross combinations different test will be performed and the values of heterosis effects will be estimated.

Materials and methods

The experiment was conducted in the field area of institute of horticultural sciences, University of Agriculture, Faisalabad. Seven accessions (ZM-R-10, OSCAR, ZM-R-30, ZM-R-16, ZM-R-17, ZM-R-5 and ZM-R-21) were used as lines or female parents while three accessions (Glarchi, Hyola-401 and Winer) were used as testers or male parents. The lines and testers were crossed in line × tester mating design through controlled artificial pollination. The seed of each cross were harvested at maturity and stored for the next season. In the next season the seed collected from crosses along with parents were sown under randomized complete block design (RCBD) with three replication under field conditions. For all experimental units recommended agronomic practices were used equally. The data on the following parameters were recorded like no. of silique/ plant, number of seed per silique, plant height, 1000 seed weight. The recorded data was subjected to analysis of variance (Steel et al.,1997) in order to determine the genotypic differences for selected traits. Traits showing significant differences were further analyzed for heterosis as proposed by (Falconer and Mackay (1996) and combining ability effects by (Kempthorne, 1957).

Results and discussion

Plant height (cm)

The analysis of variance results for plant height are presented in Table No.1. There is so much variation for plant height in these lines of *Brassica napus* L. The observations for this trait are varying from 251cm to 142cm (Fig.1). Among all the parents Glarchi has maximum plant height followed by ZM-R-10 and ZM-R-5 while ZM-R-30 has minimum height (Fig.1). In the all crosses ZM-R-21 × Hyola-401 shows maximum height followed by ZM-R-21 × Winer while ZM-R-16 × Glarchi shows minimum height (Fig.1). The plant height varying from 69.5 – 206 was also observed by Akbar et al. (2008). Hence the material is found within the range reported in the literature.

Table No. 1 Mean square values from ANOVA for studied traits

SOV	DF	PH	NSPP	NSPS	SYPP	SW
Replication	2	11.0645	3.6237	0.0753	0.0014	0.0033
Treatments	30	6642.0774	5605.8208	28.5262	78.0452	2.4573
Parents	9	1789.8852	1881.2741	22.8000	22.9571	0.2618
Parents vs Crosses	1	118321.6099	109925.2205	300.3627	515.4102	48.7011
Crosses	20	3241.5873	2065.8968	17.5111	80.9666	1.1331
Lines	6	2138.5238	2064.9683	16.7778	15.3926	0.2374
Testers	2	918.1111	733.0000	8.3333	36.7430	0.3954
L × T	1	1441.6016	3075.6571	25.2000	40.7722	0.1409
Error	60	1.5978	1.2014	0.2864	0.0017	0.0005

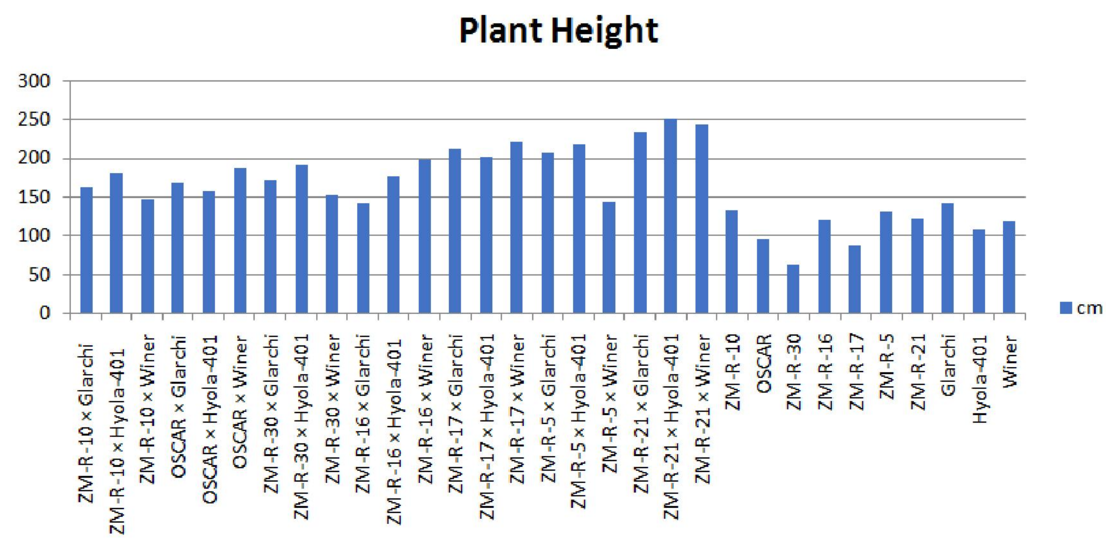

Fig.1 Mean Performance of lines, testers and their crosses for plant height

Number of siliques per plant

The analysis of variance results for number of siliques per plant are presented in Table No.1. There is so much variation for number of siliques per plant in these accessions of *Brassica napus* L. The observations for this trait are varying from 235cm to 61cm (Fig. 2). Among all the crosses ZM-R-21 × Hyola-401 has maximum number of siliques per plant followed by ZM-R-10 × Hyola-401 and ZM-R-17 × Winer while OSCAR × Glarchi has minimum number of siliques per plant (Fig. 3). In all parents winner shows maximum number of siliques per plant followed by ZM-R-5 while ZM-R-16 shows minimum number of siliques per plant (Fig. 3). Ayatac and Kinaci (2009) and Abideen et al. (2013) reported mean values of number of siliquae/plant ranged from 55 to 649. Our observations exhibit less number of siliquae per plant, than the result found in literature. This contradiction may be due to the diverse breeding population or environmental conditions.

Number of seeds per silique

The analysis of variance results for number of seeds per silique are presented in Table No.1. The observations for this trait was varied from 30 to 16 (Fig. 4). Among all the crosses OSCAR × Winer has maximum number of seeds per silique followed by ZM-R-30 × Hyola-401, ZM-R-16 × Hyola-401, ZM-R-5 × Hyola-401 and OSCAR × Hyola-401 while ZM-R-5 × Winer has minimum number of seeds per silique (Fig. 3). In all parents ZM-R-16 and Hyola-401 exhibit maximum number of seeds per silique followed by ZM-R-21 while ZM-R-10 shows minimum number of seeds per silique (Fig. 4). Dar et al. (2011); Abideen et al. (2013) report the range of number of seeds/silique from 12 to 23. Our observations exhibit more number of seeds per silique than the result found in literature. Different environmental effects or diverse breeding population may be the cause of this contradiction.

1000 seed weight

The analysis of variance results for 1000 seed weight are presented in Table No. 1. The observations for 1000 seed weight were varied from 7.04g to 4.04g (Fig.6). Among all the crosses ZM-R-21 × Winer has maximum 1000 seed weight followed by ZM-R-5 × Winer and ZM-R-5 × Glarchi while ZM-R-21 × Hyola-401 has minimum 1000 seed weight (Fig. 4). In all parents OSCAR exhibit maximum 1000 seed weight followed by ZM-R-17 while winner shows minimum 1000 seed weight (Fig. 6). The range of 1000 seed weight which was reported in the literature is 2.4g to 5.79g by Tuncturk and Ciftci (2007) and Abideen et al. (2013). Our observations exhibit more 1000 seed weight than the result found in literature. Different environmental effects or diverse breeding population may be the cause of this contradiction.

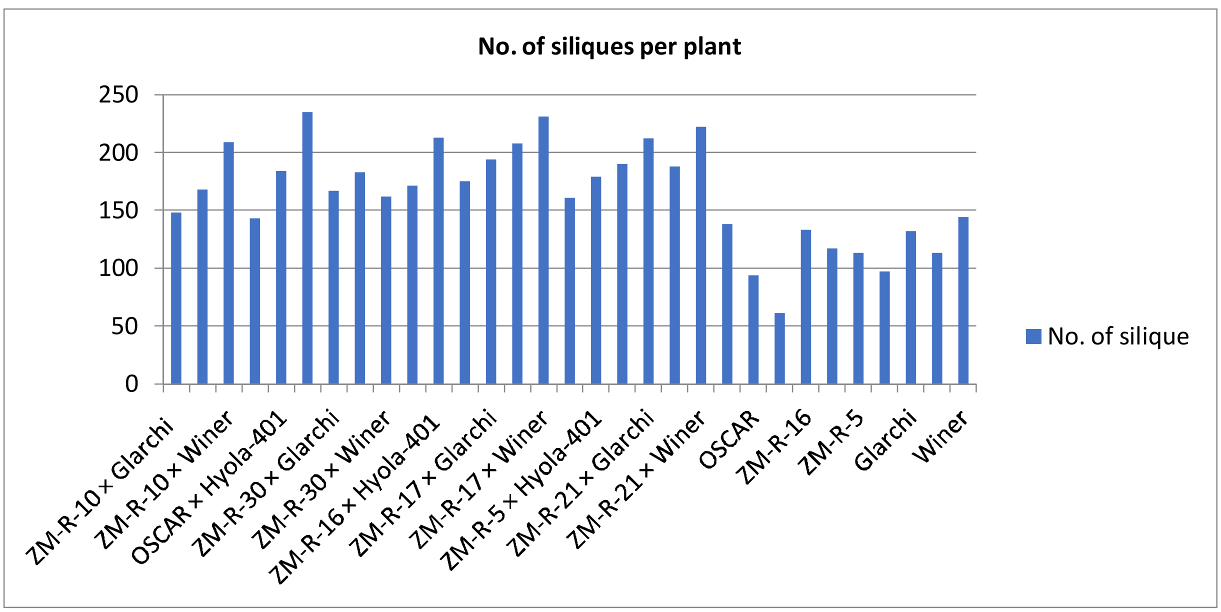

Fig 2 Mean Performance of lines, testers and their crosses for number of siliques per plant

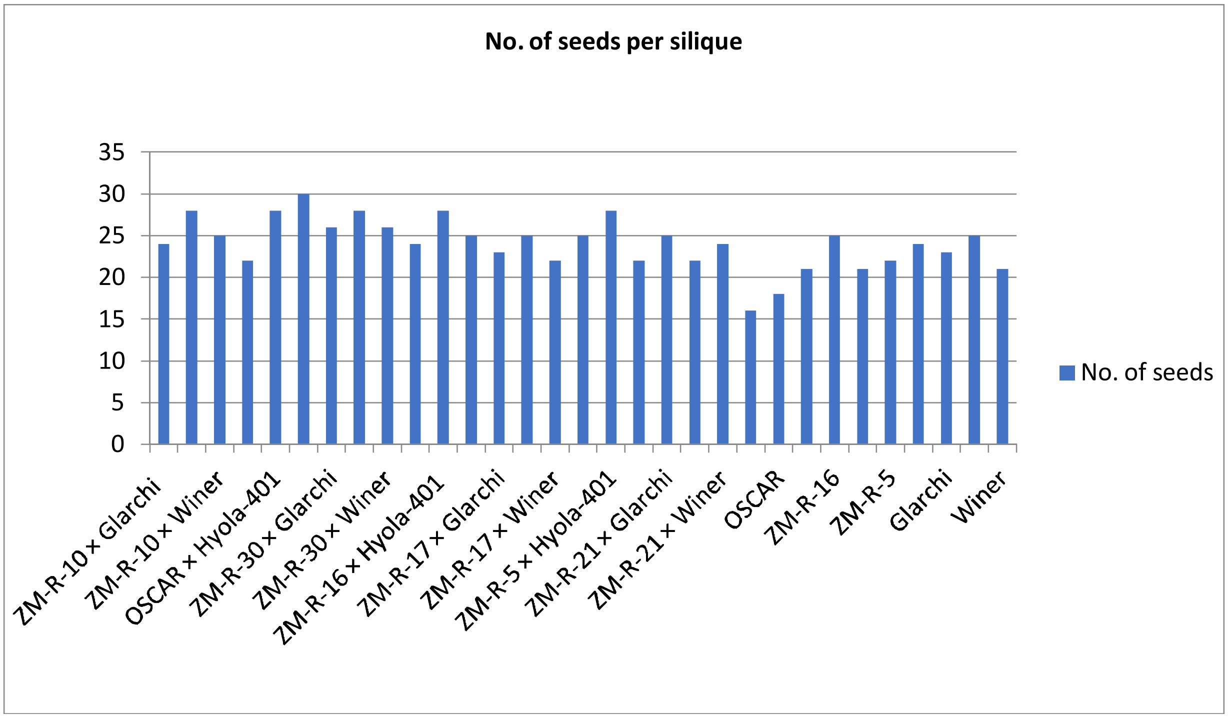

Fig 3 Mean Performance of lines, testers and their crosses for number of seeds per silique

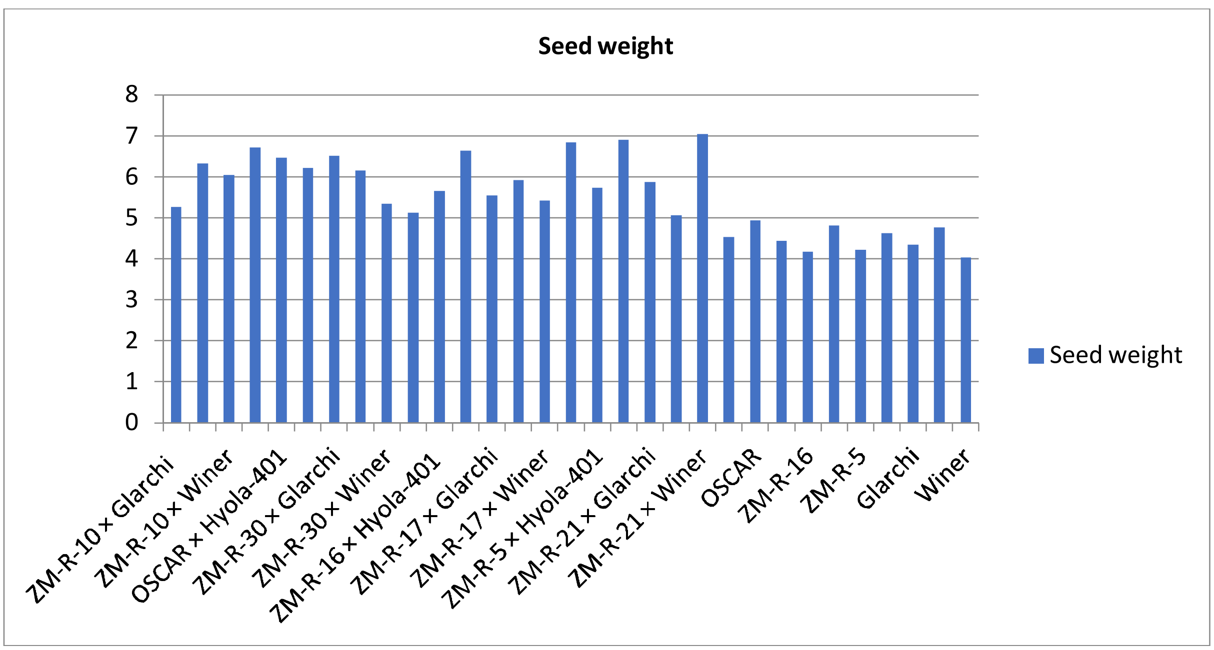

Fig 4 Mean Performance of lines, testers and their crosses for 1000 seed weight

Plant height

Mid parent heterosis and better parent heterosis for plant height are presented in Table 2. Mostly crosses showed positive and significant mid parent heterosis. ZM-R-30 × Hyola-401 had highest positive and significant mid parent heterosis followed by ZM-R-21 × Hyola-401 and ZM-R-17 × Winer. Crosses showed positive and significant better parent heterosis except ZM-R-16 × Glarchi. ZM-R-21 × Hyola-401 had highest positive and significant better parent heterosis followed by ZM-R-21 × Winer, ZM-R-17 × Hyola-401 and ZM-R-17 × Winer. Intermediate plant height is important in Brassica to prevent lodging of plant in different environmental conditions. Positive and significant heterosis over mid and better parents in Brassica is also observed by Ahsan et al. (2013).

Table 2. Heterosis for plant height in Brassica napus L.

Crosses	MPH	BPH
ZM-R-10 × Glarchi	18.36 **	14.75 **
ZM-R-10 × Hyola-401	49.52 **	35.16 **
ZM-R-10 × Winer	17.00 **	10.72 **
OSCAR × Glarchi	40.98 **	18.03 **
OSCAR × Hyola-401	54.58 **	45.99 **
OSCAR × Winer	74.30 **	57.26 **
ZM-R-30 × Glarchi	68.08 **	20.84 **
ZM-R-30 × Hyola-401	125.44 **	77.78 **
ZM-R-30 × Winer	66.97 **	27.09 **
ZM-R-16 × Glarchi	7.71 **	-0.23 ns
ZM-R-16 × Hyola-401	55.23 **	46.70 **
ZM-R-16 × Winer	64.82 **	63.46 **
ZM-R-17 × Glarchi	84.08 **	48.95 **
ZM-R-17 × Hyola-401	105.78 **	86.73 **
ZM-R-17 × Winer	113.18 **	85.20 **
ZM-R-5 × Glarchi	51.15 **	45.67 **
ZM-R-5 × Hyola-401	81.39 **	64.90 **
ZM-R-5 × Winer	13.26 **	7.83 **
ZM-R-21 × Glarchi	75.41 **	63.70 **
ZM-R-21 × Hyola-401	116.71 **	103.24 **
ZM-R-21 × Winer	100.00 **	96.76 **

Number of silique per plant

Mid parent heterosis and better parent heterosis for number of silique per plant are presented in Table 3. Mostly crosses showed positive and significant mid parent heterosis. ZM-R-30 × Hyola-401 had highest positive and significant mid parent heterosis followed by OSCAR × Winer and OSCAR × Hyola-401. Mostly crosses exhibit positive and significant better parent heterosis. ZM-R-17 × Hyola-401 had highest positive and significant better parent heterosis followed by ZM-R-21 × Hyola-401, OSCAR × Winer and OSCAR × Hyola-401. Number of silique per plant is an important yield related trait which contributes effectively in seed yield of the crop.

Table 3. Heterosis for number of silique per plant in Brassica napus L.

Crosses	MPH	BPH
ZM-R-10 × Glarchi	9.63 **	7.25 **
ZM-R-10 × Hyola-401	33.86 **	21.74 **
ZM-R-10 × Winer	47.75 **	44.68 **
OSCAR × Glarchi	26.55 **	8.33 **
OSCAR × Hyola-401	78.10 **	63.13 **
OSCAR × Winer	97.48 **	63.19 **
ZM-R-30 × Glarchi	73.40 **	26.77 **
ZM-R-30 × Hyola-401	109.96 **	61.65 **
ZM-R-30 × Winer	57.40 **	12.04 **
ZM-R-16 × Glarchi	29.06 **	28.57 **
ZM-R-16 × Hyola-401	73.17 **	60.15 **
ZM-R-16 × Winer	26.35 **	21.53 **
ZM-R-17 × Glarchi	55.97 **	46.72 **
ZM-R-17 × Hyola-401	81.98 **	79.37 **
ZM-R-17 × Winer	77.46 **	60.42 **
ZM-R-5 × Glarchi	31.43 **	21.97 **
ZM-R-5 × Hyola-401	58.11 **	58.11 **
ZM-R-5 × Winer	48.38 **	32.41 **
ZM-R-21 × Glarchi	84.62 **	60.61 **
ZM-R-21 × Hyola-401	78.48 **	66.37 **
ZM-R-21 × Winer	83.72 **	54.17 **

Number of seeds per silique

Mid parent heterosis and better parent heterosis for number of seeds per silique are presented in Table 4. Mostly crosses exhibit positive and significant mid parent heterosis except ZM-R-21 × Hyola-401. OSCAR × Winer had highest positive and significant mid parent heterosis followed by ZM-R-10 × Hyola-401, ZM-R-10 × Winer and OSCAR × Hyola-401. Mostly crosses exhibit positive and significant better parent heterosis. OSCAR × Winer had highest positive and significant better parent heterosis followed by ZM-R-30 × Winer and ZM-R-10 × Winer. Number of seeds per silique is an important yield related trait which contributes effectively in seed yield of the crop.

Table 4. Heterosis for number of seeds per silique in Brassica napus L.

Crosses	MPH	BPH
ZM-R-10 × Glarchi	20.34 **	2.90 ns
ZM-R-10 × Hyola-401	34.96 **	12.16 **
ZM-R-10 × Winer	34.51 **	18.75 **
OSCAR × Glarchi	8.94 **	-2.90 ns
OSCAR × Hyola-401	32.81 **	14.86 **
OSCAR × Winer	54.24 **	42.19 **
ZM-R-30 × Glarchi	17.29 **	13.04 **
ZM-R-30 × Hyola-401	23.19 **	14.86 **
ZM-R-30 × Winer	23.44 **	23.44 **
ZM-R-16 × Glarchi	2.10 ns	-1.35 ns
ZM-R-16 × Hyola-401	14.86 **	14.86 **
ZM-R-16 × Winer	10.14 **	2.70 ns
ZM-R-17 × Glarchi	5.34 **	0.00 ns
ZM-R-17 × Hyola-401	11.76 **	2.70 ns
ZM-R-17 × Winer	6.35 **	4.69 *
ZM-R-5 × Glarchi	12.59 **	10.14 **
ZM-R-5 × Hyola-401	21.43 **	14.86 **
ZM-R-5 × Winer	3.08 ns	1.52 ns
ZM-R-21 × Glarchi	7.80 **	5.56 **
ZM-R-21 × Hyola-401	-9.59 **	-10.81 **
ZM-R-21 × Winer	5.88 **	0.00 ns

1000 seed weight

Mid parent heterosis and better parent heterosis for 1000 seed weight are presented in Table 5. Mostly crosses showed positive and significant mid parent heterosis. ZM-R-5 × Winer had highest positive and significant mid parent heterosis followed by ZM-R-21 × Winer, ZM-R-16 × Winer and ZM-R-5 × Glarchi. Mostly crosses exhibit positive and significant better parent heterosis also. ZM-R-5 × Winer had highest positive and significant better parent heterosis followed by ZM-R-16 × Winer, ZM-R-5 × Glarchi and ZM-R-21 × Winer. 1000 seed weight is an important yield related trait which contributes effectively in seed yield of the crop.

Table 5 Heterosis for 1000 seed weight in Brassica napus L.

Crosses	MPH	BPH
ZM-R-10 × Glarchi	18.57 **	16.18 **
ZM-R-10 × Hyola-401	36.20 **	32.87 **
ZM-R-10 × Winer	40.85 **	33.24 **
OSCAR × Glarchi	44.59 **	36.13 **
OSCAR × Hyola-401	33.49 **	31.33 **
OSCAR × Winer	38.68 **	26.25 **
ZM-R-30 × Glarchi	48.16 **	46.55 **
ZM-R-30 × Hyola-401	33.65 **	29.16 **
ZM-R-30 × Winer	25.87 **	20.16 **
ZM-R-16 × Glarchi	20.20 **	17.85 **
ZM-R-16 × Hyola-401	26.68 **	18.88 **
ZM-R-16 × Winer	61.33 **	58.69 **
ZM-R-17 × Glarchi	21.16 **	15.29 **
ZM-R-17 × Hyola-401	23.55 **	22.91 **
ZM-R-17 × Winer	22.27 **	12.46 **
ZM-R-5 × Glarchi	59.78 **	57.39 **
ZM-R-5 × Hyola-401	27.45 **	20.14 **
ZM-R-5 × Winer	67.41 **	63.90 **
ZM-R-21 × Glarchi	30.96 **	27.00 **
ZM-R-21 × Hyola-401	7.48 **	5.94 **
ZM-R-21 × Winer	62.26 **	51.98 **

Positive and significant mid parent heterosis and better parent heterosis for number of silique per plant is also observed by Sinicik (2011) and Ahsan *et al.* (2013).

Conclusion:

Keeping in view all these findings it is revealed that there is genetic variability in the experimental material that may be used in further breeding programs. Crosses OSCAR × Winer, ZM-R-16 × Hyola-401, ZM-R-5 × Glarchi, ZM-R-5 × Hyola-401 and ZM-R-21 × Glarchi should be used in breeding program for hybrid development. Lines ZM-R-5, ZM-R-30 and ZM-R-30 may be used as potential parents for hybridization program. Testers Hyola-401 and Winer may be used as potential parents for hybridization program also.

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5/18/2019