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Study on genetic variability in some agro-morphological traits of *Brassica rapa* L. (Brown sarson) germplasm characterized under rainfed conditions of Kashmir, India

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Abstract: 36 *Brassica rapa* L. (Brown sarson) genotypes were characterized during two successive seasons of 2013/14 and 2014/15 along with two national checks (Puas Kalyani and GSL-2) and one local check variety (Shalimar-1) to assess the extent of variability and amount of variation in agro-morphological traits of plant height, number of primary branches/plant, days to 50% flowering, number of seeds/siliqua, seed yield/plant and 1000-seed weight. Important traits of plant height varied from 58.35 cm - 95.36 cm, seed yield/plant from 3.840 g - 18.470 g and 1000-seed weight from 2.746 g - 4.377 g. Analysis of variance revealed significant differences at 0.05 level of probability among different genotypes for these characters during a particular year while differences were non-significant in all the traits excepting days to 50% flowering when data of the two years was compared. Highest variability, phenotypic coefficient of variation (33.89%) and genotypic coefficient of variation (30.99%) were recorded for the trait seed yield/plant. High heritability coupled with high to moderate per cent genetic advance was recorded for seed yield/plant and 1000-seed weight indicating that these traits can be improved through simple selection. Moderate heritability with low genetic advance was observed in all other traits suggesting greater influence of environment. Promising donor genotypes for all these traits have been identified for possible utilization in breeding programmes in the region.

Keywords: *Brassica rapa* L. (Brown sarson), Genetic advance, Genetic variability, Germplasm, Heritability

INTRODUCTION

Oil seed *Brassica* commonly known as rapeseed and mustard occupies an important position in the rainfed agriculture of India being the third most important edible oilseed crop of the world after soybean and oil palm. In India, during the year 2014-2015 it was grown on an area of 6.6 million hectares with production of more than 8.3 metric tons and productivity of 125 kilograms per hectare; the states of Rajasthan, Haryana, Madhya Pradesh, Uttar Pradesh, West Bengal and Gujarat are the major producers of the crop in that order (DRMR, 2015). Rapeseed is among most important oil and protein rich annual crops in the world and *Brassica rapa* L. (Brown sarson) is one of the most important oleiferous Brassicas cultivated in the North Western regions of India (Singh *et al.*, 2007). In the North Western Indian Himalayan state of Jammu and Kashmir it is a popular and only edible oil seed crop cultivated during *rabi* season under temperate conditions in Kashmir valley and in some high altitude regions of Jammu province. The oil seed crop in the state is grown on an area of 66,700 hectares with total production of 58,000 tones and productivity of 885 kilograms per hectare (Ministry of Agriculture and Cooperation GOI, 2015). However, during last few years area under cultivation of this crop in the entire state has shown a declining trend. Irrespective of this fact, however its production and productivity has increased over these years. Still the state of Jammu and Kashmir lags very much behind in oil seed production and productivity. In Kashmir valley Brown sarson is grown under harsh winter conditions covering an area of more than 47 thousand hectares generally sown during the months of September/October and harvested in May/June followed by paddy cultivation in crop rotation. The yields are disappointingly low and there is a dire need of developing high yielding genotypes of brown sarson to make its cultivation profitable in the state (Dar *et al*., 2013).Thus there is a tremendous scope for genetic improvement of brown sarson to develop high yielding varieties with stability in performance over a range of environments.

Genetic diversity is a prerequisite in crop improvement programmes. It aids in choosing parental materials to get maximum recombination in hybridization process (Arunachalam, 1981). Diversity in germplasm is fundamental in selecting superior genotypes having advantageous traits for utilization in hybridization in developing varieties with increased yield (Joshi and Dhawan, 1966) and wider adaptation, desirable quality,

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pest and disease resistance (Nevo *et al*., 1982).Besides genetic variability in the germplasm, the effectiveness of selection for a particular trait depends on degree of association that exists between different traits as well. Analysis of variability among the traits and the association of a particular character in relation to other traits contributing to yield of a crop would be of great importance in planning a successful breeding program (Mary and Gopalan, 2006).Genetic variation can be evaluated by morphological, biochemical and molecular markers techniques (Marjanovic-Jeromela *et al*., 2009). Morphological characterization continues to be the first step in the description and classification of germplasm.

The present study was therefore, undertaken to determine genetic variability and to find association among yield and some yield related traits in Brown sarson (*Brassica rapa* L.) germplasm which may be helpful in selection of superior genotypes for furthering oilseed crop improvement programmes in the state of Jammu and Kashmir.

MATERIALS AND METHODS

36 accessions of *Brassica rapa* L. (Brown sarson) germplasm collected from different parts of India and supplied by ICAR-National Bureau of Plant Genetic Resources, New Delhi along with one local (Shalimar-1) and two national check varieties (Pusa Kalyani, GSL-2) were used in the present study. Genotypes were characterized during two successive *rabi* seasons of 2013/2014 and 2014/2015 with actual sowing dates of 26-10-2013 and 19-11-2014 respectively. The trials were laid out in a randomized complete block design with two replications each year at the Experimental Field of ICAR-NBPGR Regional Station Srinagar, Jammu and Kashmir (33°59′ N latitude, 74°47′ E longitude, 1639 m above sea level, average monthly rainfall 52mm, soil; clay 33: silt 60: sand 7 and pH 6.23).Each genotype was sown by hand in a single row of 3 m length with spacing of 30 x 10 cms between and within rows respectively. Weeds were removed by hand prior to flowering stage and standard cultural practices were followed for raising the crop.Five plants were randomly selected and marked from each genotype ignoring those on the peripheries for recording data on plant height (cms), number of primary branches per plant, days to 50% flowering, number of seeds per siliqua, seed yield per plant (g) and 1000-seed weight (g).In order to estimate the extent of magnitude of variation among these traits, the data were subjected to analysis of variance for both the years individually as well as pooled data across two years. Components of variance; σ^2 g (genotypic variance), σ^2 p (phenotypic variance) and σ^2 e (error variance) were estimated using the following formulae (Wricke and Weber, 1986):

$\sigma^2 g = (MSG – MSE)/r$

$\sigma^2 p = MSG/r$

$\sigma^2 e = MSE/r$

MSG, MSE and r are the mean square of genotypes, mean square of error and number of replications respectively

Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) were determined using following formulae (Singh and Chaudhary, 1985):

$GCV (\%) = \sqrt{\sigma^2 g} / \bar{X} \times 100$

$PCV (\%) = \sqrt{\sigma^2 p} / \bar{X} \times 100$

$\bar{X}$ is the sample mean value

Broad sense heritability (h^2) was estimated by the formula suggested by Allard (1999) as follows:

Heritability $(h^2) = \sigma^2 g / \sigma^2 p$

Expected Genetic Advance (GA) and percentage of GA was calculated by the following formulae (Allard, 1960; Singh and Chaudhary, 1985):

$GA = K.\sqrt{\sigma^2 p}.\ h^2$

K is the constant with a value of 2.06 at 5% selection intensity

$GA (\%) = GA / \bar{X} \times 100$

RESULTS AND DISCUSSION

The data recorded on different agro-morphological traits of 36 *Brassica rapa* L. genotypes and pooled across two years of 2013/2014 and 2014/2015 are presented in the Table 1.The results showed moderate to high variability for all the traits studied. The variability was highest in the trait seed yield/plant with coefficient of variation value of 33.89% followed by number of seeds/siliqua (13.41%), number of primary branches/ plant (12.12%), plant height (11.31%) and 1000-seed weight (10.51%) in that order (Table 2).The extent of variability in the trait days to 50% flowering was, however not appreciable. Compared to best performing check varieties promising donor genotypes were identified for all the traits studied and are listed in Table 3.Yield components have significant role in the final yield performance of the plant, meaning that the indirect selection for traits that influence yield can be an effective approach in rapeseed breeding program (Sadat *et al*., 2010; Marjanovic-Jeromela *et al*., 2011).The mean values of different traits recorded during two separate years of 2013/2014 and 2014/2015 have been presented in Table 4.It is pertinent to mention here that compared to first year sowing time in second year was delayed by three weeks. The results show that early sowing is advantageous so far as traits of plant height, number of primary branches, number of seeds per siliqua and seed yield per plant are concerned resulting in comparatively higher values.The differences between the years were however not significant in all traits excepting days to 50% flowering. Interestingly 50% flowering occurred 11 days earlier in late sown crop than in the early sown crop; the difference being significant at 0.05 level of probability.

Table 1. Mean performance of 36 *Brassica rapa* L. (Brown sarson) genotypes grown during two seasons of 2013/2014 and 2014/2015 (combined data) under rainfed conditions of Kashmir.

S. No.	Genotype	Plant height (cms)	No. of primary branches	Days to 50% flowering	No of seeds/ siliqua	Seed yield/ plant(g)	1000- Seed weight(g)
1	IC-259339	58.35	2.4	165.7	6.55	5.727	3.792
2	IC- 338496	73.34	2.7	167.7	11.35	11.580	3.157
3	IC- 343127	74.97	2.8	168.0	10.15	15.732	2.943
4	IC- 371886	68.11	2.9	168.5	12.42	13.515	3.428
5	IC- 416883	68.96	2.8	167.7	12.00	9.405	3.670
6	IC- 491555-A	79.72	2.6	168.0	10.70	12.410	3.987
7	EC- 657026	80.51	3.0	167.5	11.62	7.310	3.465
8	IC- 11765	85.50	3.4	166.2	11.35	15.265	3.550
9	IC- 212127	73.68	3.8	166.2	12.20	11.165	3.578
10	IC- 262076	76.54	3.5	166.0	13.55	11.907	3.397
11	IC- 262823	71.54	3.0	166.2	10.05	10.655	3.107
12	IC- 262824	64.52	3.0	165.7	13.30	12.702	3.414
13	IC- 280040	69.84	2.7	167.0	11.20	13.745	3.143
14	IC- 280042	75.28	3.4	167.2	15.45	10.675	3.267
15	IC- 280045	64.45	3.0	167.7	13.35	15.175	3.815
16	IC- 280048	71.92	3.1	167.2	11.85	16.850	3.293
17	IC- 298004	63.75	3.5	167.2	12.30	7.420	3.625
18	IC- 313175	78.06	3.3	167.0	13.45	3.840	3.859
19	IC- 332634	76.79	2.7	167.5	11.97	12.320	3.319
20	IC-363616-A	90.08	3.2	167.5	10.30	9.550	3.727
21	IC- 363710	76.82	3.1	168.5	12.05	14.600	3.403
22	IC- 363713	75.93	2.8	168.2	12.86	10.545	2.746
23	IC- 363731	74.28	3.4	167.5	10.85	6.962	3.200
24	IC- 363733	81.06	4.0	167.0	14.25	11.535	4.156
25	IC- 363735	84.02	3.9	167.0	14.85	18.470	2.928
26	IC- 363739	71.28	3.2	165.7	11.15	15.465	3.389
27	IC- 363751	67.08	2.9	166.2	10.60	7.940	3.075
28	IC- 363752	58.80	2.7	166.0	11.13	6.855	3.188
29	IC-363771	95.36	3.2	166.2	11.60	6.470	3.679
30	IC- 363776	75.01	3.2	168.7	11.62	5.522	3.525
31	IC- 399823	82.57	3.5	167.5	11.00	9.997	4.377
32	IC- 399827	79.82	3.2	167.5	11.70	6.115	3.369
33	IC-538641	90.87	3.6	168.2	13.15	12.700	3.632
34	IC-553083	81.51	3.4	166.2	10.95	8.415	3.325
35	IC-553126	86.54	3.8	165.5	13.00	10.690	4.274
36	IC-223406-A	71.56	3.0	165.7	13.70	6.245	3.469

Table 2. Variability in some agro-morphological traits of 36 *Brassica rapa* L. (Brown sarson) genotypes grown during two seasons of 2013/2014 and 2014/2015 under rainfed conditions of Kashmir.

Trait	Range	Mean ± SE	CV (%)	Mean value of check varieties		
				Shalimar-1	Pusa Kalyani	GSL-2
Plant height	58.35 – 95.36	75.51 ± 1.42	11.31	76.48	81.00	85.13
No. of primary branches	2.4 – 4.0	3.2 ± 0.06	12.12	2.8	3.3	3.3
Days to 50% flowering	165.5 – 168.7	167.1 ± 0.15	0.55	166.9	167.1	166.6
No. of seeds/ siliqua	6.55 – 15.45	11.93 ± 0.27	13.41	10.97	12.92	13.46
Seed yield/ plant	3.840 – 18.470	10.708 ± 0.605	33.89	7.532	7.094	9.005
1000-Seed weight	2.746 – 4.377	3.479 ± 0.061	10.51	3.918	3.386	3.479

Table 3. Promising accessions identified during characterization of 36 genotypes of *Brassica rapa* L. (Brown sarson) genotypes grown during two seasons of 2013/2014 and 2014/2015 under rainfed conditions of Kashmir.

Trait	Promising genotypes
Plant height	>85.13 : IC-363771, IC-538641, IC-363616-A, IC-553126
No. of primary branches	>3.3 : IC- 363733, IC- 363735, IC- 212127, IC-553126
Days to 50% flowering	<166.6 : IC-553126, IC-259339, IC- 262824, IC- 363739
No. of seeds/siliqua	>13.46 : IC- 280042, IC- 363735, IC- 363733, IC-223406-A
Seed yield/plant	>9.005 : IC- 363735, IC- 280048, IC- 343127, IC- 363739
1000-Seed weight	>3.918 : IC- 399823, IC-553126, IC- 363733, IC- 491555-A

Table 4. Summary Mean and LSD values of different agro-morphological traits of 36 *Brassica rapa* L. (Brown sarson) genotypes grown during two seasons of 2013/2014 and 2014/2015 under rainfed conditions of Kashmir.

Year	Plant height (cms)	No. of primary branches	Days to 50% flowering	No. of seeds/ siliqua	Seed yield/ plant (g)	1000-seed weight(g)
2013/2014	80.90	3.3	172.5	13.8	11.107	3.459
2014/2015	70.12	3.1	161.6	10.1	10.310	3.500
Mean	75.51	3.2	167.1	11.9	10.710	3.479
LSD at 5%	21.56	0.9	2.25	4.2	4.205	0.661

Table 5. Correlation among different agro-morphological traits in 36 *Brassica rapa* L. (Brown sarson) genotypes grown during two seasons of 2013/14 and 2014/15 under rainfed conditions of Kashmir.

Parameter	Plant height	No. of primary branches	Days to 50% flowering	No. of seeds/ siliqua	Seed yield/ plant	1000-Seed weight
Plant height	1.000	0.514	0.145	0.222	0.070	0.262
No. of primary branches		1.000	-0.149	0.552	0.108	0.319
Days to 50% flowering			1.000	0.089	0.146	-0.085
No. of seeds/ siliqua				1.000	0.232	0.009
Seed yield/ plant					1.000	-0.209
1000-Seed weight						1.000

Table 6. Genetic parameters for six quantitative characters in 36 *Brassica rapa* L. (Brown sarson) genotypes grown during two seasons of 2013/2014 and 2014/2015 under rainfed conditions of Kashmir.

S. N.	Trait	σ^2p	σ^2g	σ^2e	PCV (%)	GCV (%)	h^2	GA	GA (%)
1	Plant height	72.95	16.53	56.41	11.31	5.38	0.2266	3.99	5.28
2	No. of primary branches	0.152	0.057	0.095	12.26	7.50	0.3750	0.30	9.47
3	Days to 50% flowering	0.850	0.235	0.615	0.551	0.29	0.2765	0.52	0.31
4	No. of seeds/ siliqua	2.560	0.383	2.177	13.41	5.18	0.1496	0.49	4.14
5	Seed yield/ plant	13.169	11.023	2.146	33.88	30.99	0.8370	6.28	58.63

On the other hand 1000-seed weight remained almost unaffected by the time of sowing. The results corroborate with a recent study conducted during *rabi* 2011-2012 under temperate conditions of Kashmir in which early sowing of *Brassica rapa* L. on 1st October has taken more number of days to reach maturity as almost 80% plants started flowering almost two weeks earlier in late sown (31st October) than in earlier sown seeds (Akhter *et al*., 2015). Rapeseed-Mustard has been found to be highly sensitive to changes in weather conditions as evidenced by variations in growth and yield components to different dates of sowing (Kumar *et al*., 2007). Mondal *et al*. (1999) have reported time of sowing to be very important in mustard production.Sowing at proper time provides optimum conditions for growth such as temperature, light, humidity and rainfall, thus being crucial in fully exploiting the genetic potential of a variety (Iraddi, 2008). Higher seed yields have been reported in 5th October sowing than late sowing by about a month in *Brassica juncea* L. (Chahal *et al*., 2009).In different canola varieties a one month delay in sowing has been reported to decrease seed yield by 10 to 50% (Shargi *et al*., 2011).

Correlation between traits is of interest to understand whether selection for one trait will have an effect on another. Simple correlation coefficients from the combined data across two years of 2013/2014 and 2014/2015 are shown in Table 5.Interestingly we have found a moderate negative correlation (-0.209) between seed yield/plant and 1000-seed weight indicating more the yield/plant lighter the seeds size and *vice versa*.

The pooled estimates of genetic parameters of variability; Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), Heritability in broad sense (h^2), Genetic advance (GA) and Genetic advance as percentage of mean (GA **%**) worked out to have a better understanding of the nature of the gene action for various traits are presented in Table 6.High range of variability, heritability, genetic advance and positive correlation coefficient among traits could be an excellent tool for selection of genotypes (Akbar *et al*., 2003).Studies of character association may supply more reliable information on the nature and level of interrelationships of yield with yield components (Jankulovska *et al*., 2014). Estimated values of PCV were higher than corresponding values of GCV for all characters because of variation due to environment as well as due to interactions; the magnitude of difference was comparatively lesser in the traits of seed yield/ plant and 1000-seed weight indicating lesser environmental influence on the expression of these traits. Higher PCV and corresponding GCV was recorded for the trait seed yield/plant implying enormous variability for this trait.On the other hand number of days to 50% flowering showed lowest PCV and GCV values indicating limited scope for selection of this trait. Heritability of an attribute provides an idea about its transmissibility from parents to off springs but it is the percentage of genetic advance that is more important to the breeder and together both are more reliable in selection (Shukla *et al*., 2006).The traits having high heritability with high genetic advance are considered under control of additive genes, whereas high heritability with low genetic advance are under control of non-additive (dominant and/or epistatic) genes which limits the scope for improvement through selection (Akbar *et al.*, 2003). In the present study high heritability coupled with high to moderate genetic advance as per cent of mean was recorded for seed yield/plant and 1000-seed weight indicating preponderance of additive gene action; the traits can thus be improved through simple selection. On the other hand moderate heritability with low genetic advance as per cent of mean was observed in all other traits viz., plant height, number of primary branches, days to 50% flowering and number of seeds/ siliqua indicating greater influence of environment; the selection thus would be ineffective. Characters showing high heritability along with moderate or low genetic advance could be improved by inter-mating superior genotypes of segregating population developed from combination breeding (Samadia, 2005).The intermating between selected segregates in advanced generations would help to accumulate favorable, desirable alleles for further improvement in seed yield and its component traits in Brown sarson.

Conclusion

Oil seed crop *Brassica rapa* L. (Brown sarson) has lot of scope for improvement in the state of Jammu and Kashmir in general and Kashmir valley in particular. The present study on 36 brown sarson genotypes has revealed maximum variability for seed yield/plant (CV 33.88%) ranging from 3.840 g - 18.470 g. This trait also exhibited high heritability and genetic advance (%).High heritability coupled with moderate genetic advance (%) was also recorded for 1000-seed weight indicating that both these traits can be improved through simple selection and that these characters could be used as selection criteria for improving overall yield of the crop. Promising genotypes identified based on these and other traits especially number of seeds/siliqua can be utilized directly in breeding programmes for genetic enhancement of this crop in the region.

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