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Field Performance and Genetic Analysis in Some Advanced Lines of Mustard (*Brassica rapa* L.)

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Abstract

Twenty four genotypes including four check varieties of mustard (*Brassica rapa* L.) were collected for estimating the genetic variability, heritability, genetic advance of different characters related to the yield and yield components. The experiment was conducted at the Sher-e-Bangla Agricultural University research farm, Dhaka during 2013-2014. Days to 50% flowering and days to 80% maturity showed moderate difference between the phenotypic and genotypic variance whereas, minimum differences were found in number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of seeds siliqua^{-1}, siliqua length and thousand seed weight and yield plant^{-1}. Number of secondary branches plant^{-1} showed high heritability coupled with high genetic advance in percentage of mean. On the other hand, days to 50% flowering, no. of siliqua plant^{-1}, yield plant^{-1} showed high heritability with moderate genetic advance in percentage of mean. Days to 80% maturity, no. of primary branches plant^{-1}, no. of seeds siliqua^{-1} showed high heritability coupled with low genetic advance in percentage of mean. The study showed that variations in the extent of genetic variability, heritability and genetic advance in traits under study which can facilitate selection for further improvement of important traits of *Brassica rapa* L.

Keywords: Variability, heritability, genetic advance, *Brassica rapa* L.

1. Introduction

Brassica rapa L., commonly known as field mustard or turnip mustard is a plant widely cultivated as an oil seed. Rapeseed is a major oilseed crop in Bangladesh. It contributes a lion share to the total edible oil production in Bangladesh. It occupies the 1st position in respect of area and production among the oil crops grown in Bangladesh. Though the local cultivars of *Brassica juncea* and *Brassica napus* are high yielding, they are not short durable. That's why *Brassica rapa* L. is grown widely in the country (Islam, 2013). Development of high-yielding cultivars requires a thorough knowledge of the existing genetic variations for yield and yield components. The observed variability is a combined estimate of both genetic and environmental causes, of which only the former one is heritable. However, estimates of heritability alone do not provide an idea about the expected gain in the next generation, but have to be considered in conjunction with estimates of genetic advance, the change in mean value among successive generations (Shukla *et al*., 2006). The present study was undertaken to find out the genetic variability, heritability, genetic advance and relationship between different traits related to the yield in the advanced lines of *B. rapa* L.

2. Materials and Methods

2.1. Experimental site and experimental materials

The present experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during November, 2013 to March, 2014. A total of twenty four materials were used in this experiment where four were check varieties. All the Materials were collected from the Department of Genetics and Pant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The materials used in that experiment is shown in Table 1.

2.2. Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot size was 20 m × 3.5 m, and the distance between replication to replication was 1m. The spacing between lines was 30cm. Seeds were sown in lines in the experimental plots. The seeds were placed at about 1.5 cm depth in the soil. After sowing the seeds were covered with soil carefully so that no clods were on the seeds.

Table 1. Materials used for the experiment

Sl. No.	Genotypes	Pedigree of the genotypes
01	G1	SAUSR-03
02	G2	BARI-9×BARI-6(F_{12}) LINE-1
03	G3	BARI-6 ×TORI-7(F_{12}) LINE-1
04	G4	BARI-6×TORI-7 LINE-2
05	G5	BARI-9×BARRI-6 LINE-2
06	G6	SAU-1×SAU-2(F_4)
07	G7	SAU-1×BARI-15(F_4)
08	G8	SAUSR 17
09	G9	BARI-9×BARI-6(F_{12}) LINE-3
10	G10	F_6×BARI-9 LINE-1
11	G11	F_6× BARI-9 LINE-2
12	G12	BARI-6× TORI-7 (F_{12}) LINE-3
13	G13	BARI-6× TORI-7 LINE-4
14	G14	F_6× BARI-9 LINE-3
15	G15	F_6× BARI-9 LINE-4
16	G16	BARI-9× BARI-6 LINE-4
17	G17	(BARI-6×BARI-15) ×(F_1×BARI-15)
18	G18	P_5×P_{10} (F_7)
19	G19	P_7×P_{10} (F_7)
20	G20	(SAU-1×SAU-2) ×(F_1×SAU-2)
21	G21	BARI-15 (Check variety)
22	G22	BARI-6 (Check variety)
23	G23	SAU-2 (Check variety)
24	G24	TORI-7 (Check variety)

SAU- Sher-e-Bangla Agricultural University, BARI- Bangladesh Agricultural Research Institute, G= Genotype. All lines were advanced line

2.3. Data collection

For studying different genetic parameters and inter-relationships ten characters were taken into consideration days to 50% flowering, days to 80% maturity, plant height (cm), number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of siliqua plant^{-1}, siliqua length (cm), thousand seed wt (g), seed plant^{-1} (g).

2.4. Statistical analysis

All the collected data of the study were subject to statistical analysis for each character. Analysis of variance (ANOVA) was performed and mean, range were calculated using MSTATC software program. Phenotypic and genotypic variances were estimated by the formula used by Johnson *et al*. (1955). Heritability and genetic advance were measured using the formula given by Singh and Chaudhary (1985) and Allard (1960).

3. Results and Discussion

The present study was conducted with a view to determine the variability among 24 genotypes of *Brassica rapa* L. and the data were recorded on different characters. The data were statistically analyzed and thus obtained results are described below.

3.1. Variability among the genotypes of Brassica rapa **L.**

Table 2 shows that days to 50% flowering was observed the highest in G21 (44.67 days) and lowest in G13 (34 days). The genotypes G13 showed early flowering than the popular check varieties G24 (40.33), G21 (44.67 days) respectably. Phenotypic and genotypic variance for days to 50% flowering was observed as 13.96 and 9.15 respectively (Table 3), with moderate differences between them, suggested moderate influence of environment on the expression of the genes controlling this trait. The phenotypic coefficient of variation (9.90%) was higher than the genotypic coefficient of variation (8.02%), which suggested that environment has significant role on the expression of this trait. Tak (1977) found these values as 4.5% and 1.8% respectively. The highest days to 80% maturity was observed in G19 and G24 (92.33 days) and the lowest days to maturity was observed in G1 (79.33 days). In present study, G1 showed better performance (early maturity) over the popular check verities (G21, G22, G23, G24) (Figure 1).

Phenotypic and genotypic variance for days to maturity was observed 27.01 and 19.54, respectively (Table 2) with high differences between them, suggested high influence of environment on the expression of the genes controlling this trait. The phenotypic coefficient of variation (PCV) of 5.97% was close to the genotypic coefficient of variation (GCV) (5.08%), which suggested that there was no or little environmental effect (Table 3) for the expression of the character. Naznin (2013) also found low difference between PCV (22.15) and GCV (19.74) in *B. rapa* L.

In this study, the highest plant height was observed in G22 (115.10 cm) whereas, the minimum plant height was observed in G2 and G10 (91.77cm), respectively, (Table 2). Phenotypic variance and genotypic variance were observed as 59.57 and 25.91, respectively (Table 3). The phenotypic variance appeared to be highly differing than the genotypic variance suggested that environmental effect was high on the expression of the genes controlling this trait. The higher PCV (7.76%) than the GCV (5.12%) from the Table 2 gave information that there were much variation among the genotypes in case of plant height. Low phenotypic coefficient of variation and genotypic coefficient of variation was found by Ghosh and Gulati (2001). The highly significant differences were observed among the genotypes for number of primary branches plant^{-1} (111.38).

Among the 24 genotypes the highest number of primary branches plant^{-1} was observed in G3 (7.13) whereas the minimum number of primary branches plant^{-1} was observed in G22 (5.27) in Table 2.

Table 2. Mean performance of ten characters of 24 genotypes of *Brassica rapa* L.

Genotypes	Days to 50% flowering	Day to 80% maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of siliqua plant^{-1}	No. of seed siliqua^{-1}	Siliqua length (cm)	1000 seed weight (gm)	Yield plant^{-1} (gm)
G1	39.00	79.33	103.5	6.20	4.83	140.4	18.17	5.12	4.17	8.92
G2	37.00	80.67	91.77	6.00	3.93	130.7	19.90	6.15	4.14	7.87
G3	35.00	82.67	94.53	7.13	6.30	148.0	18.77	5.27	4.09	9.44
G4	35.67	83.00	93.17	6.10	4.13	152.2	18.77	6.27	3.69	8.74
G5	35.00	80.67	99.83	5.93	4.80	135.0	19.00	5.47	3.93	7.91
G6	39.33	82.33	106.8	6.00	4.77	137.1	20.03	5.95	4.34	8.95
G7	41.67	84.67	99.23	5.90	3.60	134.5	17.83	5.68	4.06	8.32
G8	37.67	83.67	92.07	5.97	4.87	131.2	18.50	5.36	4.15	8.09
G9	35.67	89.67	96.30	6.13	4.47	146.1	19.83	6.23	3.86	7.96
G10	34.67	91.67	91.77	5.97	5.87	134.2	19.98	6.29	3.72	8.47
G11	35.67	80.00	91.90	5.86	4.93	140.2	19.00	6.25	3.76	8.62
G12	35.33	90.33	99.77	6.60	5.17	147.9	20.07	6.04	4.15	9.26
G13	34.00	92.00	94.53	5.77	3.87	133.2	21.00	5.54	4.01	7.51
G14	36.00	90.33	101.1	5.63	4.90	137.9	21.53	5.90	3.87	8.02
G15	35.00	90.67	92.57	6.20	4.20	126.2	20.03	6.28	3.64	9.29
G16	37.67	84.67	99.07	6.30	3.53	144.6	17.60	5.54	3.83	8.22
G17	34.33	91.00	106.7	6.83	8.20	187.4	16.83	5.50	4.17	8.40
G18	34.33	91.00	101.7	6.57	6.40	132.5	19.50	6.01	3.60	7.12
G19	39.67	92.33	102.5	6.87	4.30	136.3	21.00	5.69	3.67	8.17
G20	43.33	91.33	108.0	7.07	7.50	150.3	18.20	5.49	3.55	7.24
G21	44.67	83.67	98.97	6.37	1.40	105.0	21.37	5.23	3.59	6.88
G22	43.33	91.00	115.1	5.27	4.60	96.97	20.87	5.97	3.06	6.79
G23	41.67	91.00	102.2	5.93	3.23	131.0	22.00	5.53	3.48	7.32
G24	40.33	92.33	103.0	6.20	4.77	136.3	19.53	5.69	3.82	8.17
Mean	37.75	87.08	99.42	6.20	4.77	137.30	19.55	5.77	3.85	8.15
CV (%)	5.81	3.14	5.84	5.66	9.39	12.05	4.41	5.98	7.80	5.78

Table 3. Estimation of genetic parameters for yield and yield contributing characters of 24 genotypes of *Brassica rapa* L.

Characters	Phenotypic variance (δ^2p)	Genotypic variance (δ^2g)	PCV (%)	GCV (%)
Days to 50% flowering	13.96	9.15	9.90	8.02
Day to 80% maturity	27.01	19.54	5.97	5.08
Plant height(cm)	59.57	25.91	7.76	5.12
Number of primary branches plant^{-1}	0.29	0.16	8.65	6.54
Number of secondary branches plant^{-1}	2.08	1.88	30.25	28.75
Number of siliqua plant^{-1}	454.38	180.84	15.53	9.79
Number of seed siliqua^{-1}	2.28	1.54	7.73	6.35
Siliqua length (cm)	0.22	0.10	8.06	5.41
1000 seed weight(g)	0.15	0.06	9.90	6.11
Yield plant^{-1} (g)	0.71	0.48	10.31	8.54

Table 4. Heritability and genetic advance in percent of means for yield and yield contributing characters of 24 genotypes of *Brassica rapa* L.

Characters	Heritability (%)	GA	GA (%)
Days to 50% flowering	65.58	5.05	13.37
Day to 80% maturity	72.35	7.75	8.89
Plant height(cm)	43.50	6.92	6.96
Number of primary branches plant^{-1}	57.19	0.63	10.19
Number of secondary branches plant^{-1}	90.36	2.69	56.30
Number of siliqua plant^{-1}	39.80	17.48	12.73
Number of seed siliqua^{-1}	67.46	2.10	10.74
Siliqua length (cm)	44.99	0.43	7.47
1000 seed weight(g)	38.07	0.30	7.77
Yield plant^{-1} (g)	68.58	1.19	14.56

The genotype G3 showed better performance than the check varieties. Phenotypic variance and genotypic variance were observed as 0.29 and 0.16 respectively (Table 3). The phenotypic variance (0.29) appeared to be higher than the genotypic variance (0.16) suggested environmental effect present on the expression of the genes controlling this trait. Relatively low difference between PCV (8.65%) and GCV (6.54%) value indicating the apparent variation not only due to genotypes but also due to the influence of environment. Hosen (2008) showed least difference between phenotypic and genotypic variances. Number of secondary branches plant^{-1} showed highly significant differences (Table 2) among the genotypes (5.85). Among the 24 genotypes the highest number of secondary branches plant^{-1} was observed in G17 (8.20) whereas the minimum number of secondary branches plant^{-1} was observed in G21 (1.40).

Difference between phenotypic variance (2.08) and genotypic variance (1.88) were low, that means less environmental effect involved in this character (Table 3). PCV (30.25%) was higher than GCV (28.75%) which indicate presence of high variability among the genotypes for such trait (Table 3). Lekh *et al.* (1998) found highest genotypic coefficient of variation for number of secondary branches while working on 24 genotypes of *Brassica napus*. The highest number of siliqua plant^{-1} was observed the highest in G17 (187.4) and the lowest in G22 (96.97). Advanced line G17 showed better performance than the check varieties (G21, G22, G23 and G24) for this trait. Number of siliqua per plant showed highly difference between phenotypic variance (454.38) and genotypic variance (180.84) (Figure 2). The highest phenotypic variance and genotypic variance indicating large environmental influence, high genotypic variance indicating the better transmissibility of the character from parent to their offspring and the difference between the PCV (15.53%) and GCV (9.79%) was moderate, which indicates that existence of adequate variation among the genotypes.

High genetic variation was also found by Kudla (1993). Low GCV (20.19) and high PCV (33.81) was found by Khan *et al*. (2013). Length of siliqua was observed the highest in G10 (6.29 cm) and the minimum length of pod was observed in G1 (5.12 cm). In this study check verities showed smaller siliqua length than the advanced lines. Length of siliqua showed phenotypic variance (0.22) and genotypic variance (0.10) with little difference between them indicating that they were less responsive to environmental factors for their phenotypic expression and relatively medium PCV (8.06%) and GCV (5.41%) indicating that the genotype has moderate variation for this trait (Table 3). Difference between PCV and GCV indicated high possibility of selecting this trait. High co-efficient of variation for this trait for both genotypic and phenotypic variability was recorded by Masood *et al.* (1999). The number of seeds per siliqua was observed highest in G 23 (22). The minimum number of seeds per siliqua was observed in G17 (16.83). The phenotypic and genotypic variances for this trait were 2.28 and 1.54 respectively (Table 3).

The phenotypic variance appeared to be higher than the genotypic variance indicated influence of environment on the expression of the genes controlling this trait. The value of PCV and GCV were 7.73% and 6.35% respectively for number of seeds siliqua^{-1} which indicating less environmental effect exists among different genotypes. Due to less difference between GCV and PCV this trait can be improved through the selection. Similar variability was also recorded by Kumar and Singh (1994). Thousand seed weight was found maximum in G6 (4.35 g) whereas the minimum thousand seed weight was found in G22 (3.06g). The important yield contributing character thousand seed weight of advanced line G6 was higher than the popular check varieties in this experiment. Thousand seed weight showed very low phenotypic variance (0.15) and genotypic variance (0.06) with little differences indicating that they were low responsive to environmental factors (Table 3). The phenotypic coefficient of variation (9.90%) and genotypic coefficient of variation (6.11%) were close to each other, it indicated these traits are controlled by the same genes and selection based on this would be effective.

There was moderate difference between phenotypic and genotypic co-efficient of variation, indicating environmental influence on this character was moderate. Khan *et al*. (2013) found large difference between GCV (3.67) and PCV (18.09) while Naznin (2013) found very low difference (PCV=9.85 and GCV=8.13) in *B. rapa.* in this trait. Yield per plant was found maximum in G3 (9.44 g) when it was the minimum yield per plant was found in G22 (6.79 g) advanced line. Advanced line G3 showed better performance than the popular check varieties. The phenotypic variances and genotypic variances for this trait were 0.71 and 0.48 respectively (Table 3). The values are close to each other indicated less environmental influences on this trait. The values of PCV and GCV were 10.31% and 8.54% indicating that the genotype has minimum environmental variation for this trait. Naznin (2013) and Akter (2010) found more PC value for the trait.

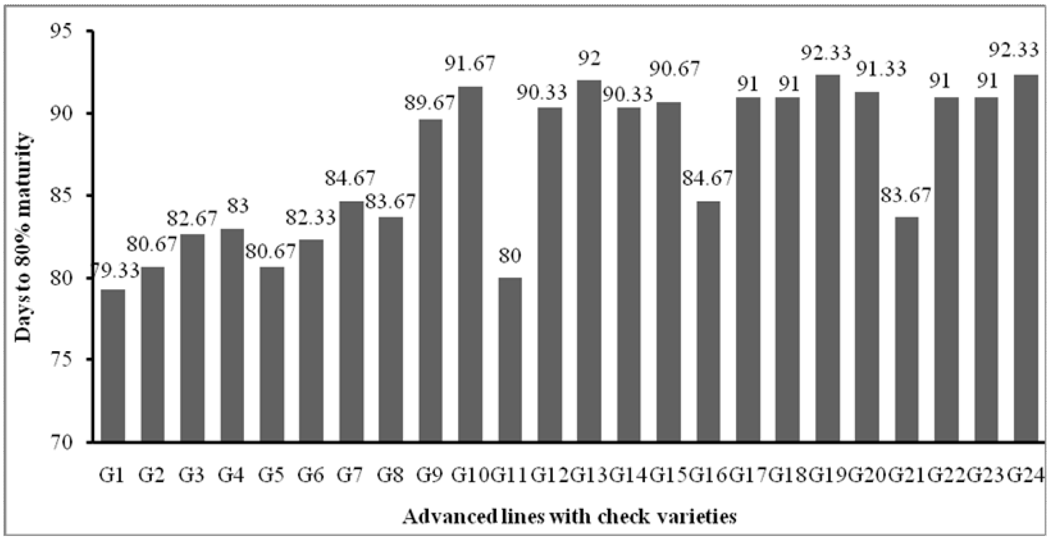

Figure 1. Mean performance of days to 80% maturity of the 24 genotypes (G21 to G24 are check varieties)

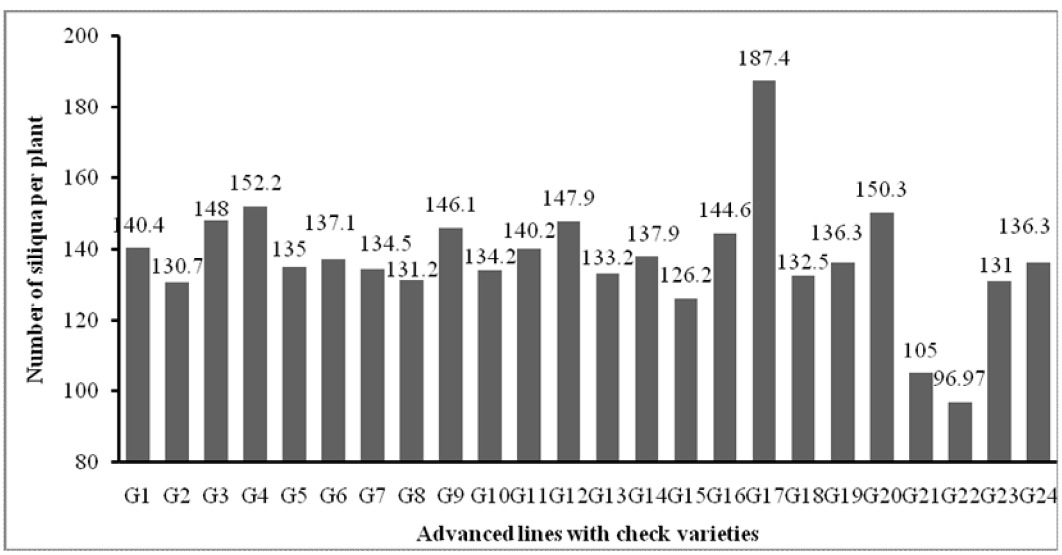

Figure 2. Mean performance of number of siliqua plant^{-1} of 24 genotypes (G21 to G24 are check varieties)

3.2. Heritability and genetic advance

In present study, days to 50% flowering exhibited high heritability (65.58%), low genetic advance (5.05) with moderate genetic advance in percent of mean (13.37%) which revealed that the character was governed by additive gene action and high heritability indicates that this character is least influenced by the environmental effect. It showed moderate possibility for the selection of this trait (Table 4). Saifullah (2010) also found high heritability (88.86%) and low genetic advance (2.06%). Aktar (2010) and Khan *et al.,* (2012) supported the result. Days to 80% maturity showed high heritability (72.35%) with low genetic advance (7.75) and genetic advance in percentage of mean (8.89%) indicated that this trait was controlled by non-additive gene action and selection for such trait might not be rewarding (Table 4). Naznin (2013) found high heritability (89.14%) with low genetic advance (8.69%) for the trait. The magnitude of heritability of plant height was moderate heritability (43.50%) with low genetic advance (6.92) and low genetic advance in percent of mean (6.96%).

These findings were the indication of non-additive gene action and selection for such trait not be effective (Table 4). High heritability (92.48%) with moderate genetic advance (18.87) was found by Saifullah (2010) for the trait, where Naznin (2013) found high heritability (71.01%) with low genetic advance in percent of mean (9.49%) for this trait. Number of primary branches plant^{-1} exhibited high heritability (57.19%) and very low genetic advance (0.63) and genetic advance in percent of mean (10.19%) that determined the presence of non-additive gene effect on the character and for this reason, improvement through selection might not be so wise (Table 4). Khan *et al.* (2012) found high heritability (60.17%) and high genetic advance (17.89%) for the trait. In this experiment number of secondary branches per plant exhibited high heritability (90.36%) with low genetic advance (2.69) and high genetic advance in percentage of mean (56.30%). These findings discovered that the action of additive gene involved on the expression of this character as well as a scope of improvement through selection must be rewarding (Table 4). Akter (2010) supported the result as he also found high heritability (89.65%) and low genetic advance (3.50%). Moderately high heritability coupled with low genetic advance was also found by Singh *et al.* (1987).

Number of siliqua per plant exhibited moderate heritability (39.80%) with moderate genetic advance (17.48) and genetic advance in percentage of mean (12.73%). These results implied the possibility of predominance of additive gene action in the inheritance of this trait. There was both environmental and genotypic influence on the character (Table 4). This trait possessed moderate variation; it is moderate potential for effective selection for further genetic improvement of this character. Khan *et al.* (2013) also found moderate heritability (35.65%) with high genetic advance (48.78%) which supports the trait. Number of seeds per siliquae showed high heritability (67.46%) with low genetic advance (2.10) and genetic advance in percent of mean (10.74%). The character was governed by non-additive genes and high heritability was being exhibited due to favorable environment rather than genotypes and selection for this trait may not be rewarding (Table 4). Saifullah (2010) also found high heritability (88.86%) and low genetic advance (2.06). Aktar (2010) and Khan *et al.,* (2012) supported the result. Siliqua length showed moderate heritability (44.99%) with very low genetic advance (0.43) and genetic advance in percent of mean (7.47%) that indicated that environmental effect was more than the genotypic effect and due to non-additive gene action selection for further improvement of the trait might not be effective (Table 4). Saifullah (2010) found the similar result for this trait.

The magnitude heritability of thousand seed weight (g) was moderate heritability (38.07%) and low genetic advance (0.30) and low genetic advance in percent of mean (7.77%). These result indicated non-additive genes involvement in the expression of the trait and this with limited scope of improvement by direct selection (Table 4). Low heritability (16.09%) with low genetic advance (0.16) was found by Akter (2010) and high heritability (65.03%) with low genetic advance (0.31%) was stated by Saifullah (2010) for the trait. In case of Yield plant^{-1} (g) it showed high heritability (68.58%) coupled with low genetic advance (1.19) with moderate genetic advance in percent of mean (14.56%) indicated that low influence of genotypic materials and additive gene effect was present (Table 4). Moderately possibility showed for the selection of this trait. Naznin (2013) found high heritability (57.05%) with low genetic advance (0.99%) for the trait.

4. Conclusions

All the 24 genotypes varied significantly with each other for all the characters which indicated the presence of considerable variations among the genotypes. The highest amount of yield per plant was observed in G3. However, the phenotypic variance and phenotypic coefficient of variations were higher than the corresponding genotypic variance and genotypic coefficient of variation for all the characters under study. Considering all the characters related to yield and early maturity, the genotypes G3 and G17 have the potentiality toward the development of improved variety that might be a trademark in *Brassica rapa* L. It may be concluded that there is a scope for further work with G1 (SAUSR-03) that was the earliest matured genotypes with moderate yield.

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