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VARIABILITY AND PATH-COEFFICIENT IN ADVANCED LINES OF RAPESEED (*BRASSICA RAPA* L.)

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ABSTRACT: The research was carried out using eight advanced lines and two check varieties of *Brassica rapa* L. for estimating the magnitude of variations in character, heritability, genetic advance, character associations, direct and indirect effect of different characters on seed yield per plant. Path coefficient analysis was carried out using correlation coefficients to know the yield- contributing traits having true associations with seed yield. Improvement in seed yield could be achieved by selection using the correlation and path analysis data generated in this study. The genotypes were found significantly variable for all the characters. Number of siliquae per plant showed high heritability coupled with high genetic advance and genetic advance in percent of mean. Plant height, number of secondary branches per plant, number of siliquae per plant and length of siliqua showed highly significant positive correlation with yield per plant. Path co-efficient study concluded that the traits number of primary branches per plant, number of siliquae per plant and siliqua length were the most important contributor to the seed yield per plant which could be taken into consideration for selection in future hybridization program.

KEYWORDS: Rapeseed, variability, path co-efficient, Plant breeding etc.

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1.INTRODUCTION

Brassica is a genus under the family Brassicaceae contributes approximately 10% of the world's vegetables and 12% of the worldwide edible oil supply [1]. Rapeseed (*Brassica napus* L.) is an amphidiploid (AACC genome, 2n=38) and is believed to have arisen by inter-specific hybridization between diploid *Brassica rapa* L. (AA genome, 2n=20) and *Brassica oleracea* L. (CC genome, 2n=18) [2]. Among the oilseed crops, mustard and rape seed is in the second position after soybean [3]. The utilization of oil seed in Bangladesh is 1.8 million tons where 1.6 million tons is imported [4]. In Bangladesh, *Brassica rapa* is the main oil yielding species of *Brassica* [5]. The local cultivars of *Brassica juncea* and *Brassica napus* are high yielding, they are not short durable. Although *Brassica rapa* is a low yielding variety but short durable, that's why *Brassica rapa* is grown widely in the country [6]. Development of improved varieties of oil seeds with short duration, better quality; higher yields are the most important issues with high priority [7]. Success of any crop improvement program depends upon the presence of substantial amount of genetic variability and heritability [8], [9], [10], [11] because the ultimate goal is to develop high yielding varieties. Correlation is, therefore, helpful in determining the component characters of a complex trait, like yield [12]. Determination of correlation co-efficient between the characters has a considerable importance in selecting breeding materials. The path co-efficient analysis gives information that is more specific on the direct and indirect of each of the component characters upon seed yield [13]. Therefore, eight advanced lines were produced through inter-varietal crosses which are in F_5, F_8 and F_{14} generations. These lines were grown with two leading checks of mustard and the performance was evaluated to find out varieties that expected to be short durational and high yielding. The present study was conducted to estimate the variability, to study the relation between different traits and the direct and indirect effect of different character on yield in advanced lines of rapeseed which will give an opportunity to find out the desired variety.

2. MATERIALS AND METHODS

The present experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207, during 06 November, 2014 to 10 February, 2015. A total number of 10 materials were used in the experiment where eight were advanced lines produced from continuous selection of segregating generations originated from inter-varietal crosses of *Brassica rapa* namely G1 (BARI Sharisha 6×BARI Sharisha 15, S_1, F_8), G2(BARI Sharisha 6×BARI Sharisha 15, S_2 F_8), G3 (BARI Sharisha 6×BARI Sharisha 15, S_5, F_8), G4 (BARI Sharisha 6×BARI Sharisha 15, S_9, F_8), G5 (SAU Sharisha 1×BARI Sharisha 15, S_1, F_5), G6 (SAU Sharisha 1×BARI Sharisha 15, S_3, F_5), G7 (BARI Sharisha 6×Tori-7, S_5, F_{14}), G8 (BARI Sharisha 6×Tori-7, S_6, F_{14}) .Two check varieties namely V1 (BARI Sharisha-15) and V2 (SAU Sharisha 1) were used to compare the performances of the lines. These genotypes were cultivated in randomized complete block design (RCBD) having three replications. Each replication size was 21m× 4.6m, and the distance between replication to replication was 1m. The spacing between line to line was 30 cm. All recommended agronomic and cultural practices were practiced during the whole tenure of experiment. Ten plants were randomly selected and tagged for data collection of days to 50% flowering, days to 80% maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, Number of siliqua per plant, siliqua length (cm), number of seeds per siliqua, 1000 seed weight (g), seed yield per plant and seed yield (t/ha).

3. RESULTS AND DISCUSSION

Variability

The study of estimation of variability in the given population in the terms of yield and its heritable parts is essential for any program of breeding, targeting to increase the yield and other specific characters. Among the genotypes almost all characters showed highly significant variation (Table 1) indicating wide scope for selection for these characters. Data revealed substantial variability and thus high possibility of improvement in most of the traits. The phenotypic variance was partitioned into genotypic and environmental variances for clear understanding of the pattern of variations. From table 4, the highest days to 50% flowering (40.33 days), days to 80% flowering and Days to 80% Maturity (89days) was observed in G1 and G2 that was higher than both the check varieties. Maximum number of primary branches/ Plant (6.60) was obtained from G7 that was lower than V2. The maximum number of secondary branches/ Plant (4.03), number of siliquae/ Plant (148.3), Length of siliqua (6.42cm), yield per plant (8.54g) was found in G7 that was higher than both the check varieties. G5 gave higher number of seed per siliqua and thousand seed weight than the other genotypes and check varieties. G8 gave maximum yield/ha that was statistically similar to G6 ,G7 and check variety 2.

Heritability and genetic advance

Phenotypic and genotypic variance for the traits days to 50% flowering, 80% flowering, the number of primary branches per plant, length of siliqua, seeds per siliqua, 1000-seed weight, yield per plant, Yield (ton/ha) showed low differences between them indicated low influence of environment on the expression of the genes controlling the trait. Higher phenotypic variance than genotypic variance for days to 80% maturity and number of siliquae per plant indicated high environmental influence on the expression of the concerned trait. Heritability magnitude indicates the reliability with which the genotype will be recognized by its phenotypic expression [14]. Heritability values are categorized by formula of Johnson [15] as low (< 30%), medium (30 -60%) and high (> 60 %). As a whole, most of the traits showed high heritability and consequent low genetic advance indicated the lower possibility of selecting the genotypes for this trait. Number of siliquae per plant is the only one trait which was found to exhibit high heritability (94.14%) with high genetic advance of 66.15 and genetic advance in percent of mean (84.64%). This result revealed the existence of predominance of additive gene action in the inheritance of this trait. As this trait possessed high variation; it would be high potential for effective selection for further genetic improvement of this trait.

Correlation co-efficient

All possible phenotypic and genotypic correlation coefficients were worked out for all the character combinations under study (Table 5). The seed yield per plant exhibited highly significant and positive correlation with number of siliqua per plant, plant height, the number of secondary branches per plant and length of siliquae followed by number of primary branches per plant. Highly significant negative correlation was found from days to 50% flowering and days to 80% flowering both at genotypic and phenotypic level. Days to 50% flowering showed highly significant positive correlation with days to 80% flowering (0.984) and days to 80% maturity (0.733) where highly significant but negative correlation with plant height (-0.785), the number of secondary branches per plant (-0.814), number of siliqua per plant (-0.863) and siliquae length (-0.820). Days to 80% flowering also showed significant positive correlation with days to 80% maturity (0.787) and highly significant but negative correlation with number of siliqua per plant (-0.800) and siliquae length (-0.776). Days to 80% maturity, siliquae length and number of seed per siliquae showed non- significant correlation with other traits. Plant height showed highly significant positive correlation with the number of secondary branches per plant (0.924), number of siliqua per plant (0.922) and siliquae length (0.867). The number of primary branches per plant showed significant positive correlation with number of siliqua per plant (0.665) and non-significant with other traits. The number of secondary branches per plant showed highly significant positive correlation with number of siliqua per plant (0.964) and siliquae length (0.948) and non-significant negative correlation with number of seed per siliquae length and 1000 seed weight. The number of siliqua per plant had highly significant positive correlation with siliquae length (0.870) and non-significant negative correlation with others.

Table 1. Analysis of variance for different morphological plant characters of 10 genotypes

Characters	df	Days to 50% Flowering (DAS)	Days to 80% flowering (DAS)	Days to 80% Maturity (DAS)	Plant height (cm)	No. of primary branches/ Plant	No. of secondary branches/ Plant	No. of siliquae/ Plant	Length of siliqua (cm)	No. of seed/ siliqua	1000 seed weight (g)	Yield/ plant (g)	Yield (ton/ha)
Replication	2	3.70	2.43	2.633	23.01	0.562	0.003	102.97	0.197	0.625	0.007	0.008	0.061
Genotypes	9	37.68**	32.60**	4.67*	82.47*	3.557**	5.858**	3354.57**	1.254**	5.165**	0.072**	11.378**	0.483**
Error	18	1.92	1.84	1.893	28.98	0.172	0.004	68.20	0.132	0.862	0.013	0.220	0.055

** indicates significant at 0.01 probability level. * indicates significant at 0.05 probability level

Table 2. Mean performance of 10 rapeseed genotypes based on different morphological traits related to yield

Genotypes with the different letter (s) are significantly different

Genotypes	Days to 50% Flowering (DAS)	Days to 80% flowering (DAS)	Days to 80% Maturity (DAS)	Plant height (cm)	No. of primary branches/ Plant	No. of secondary branches/ Plant	No. of siliqua / Plant	Length of siliquae (cm)	No. of seed/ siliquae	1000 seed weight (g)	Yield/plant (g)	Yield (ton/ha)
G1	**40.33 a**	**43.33 a**	**89.00 a**	103.6 b	4.60 cde	0.00 d	59.60 de	4.38 c	21.67 ab	3.187 cd	3.003 de	2.047 b
G2	**40.33 a**	**43.67 a**	**89.00 a**	103.5 b	3.70 f	0.00 d	54.53 e	4.59 c	20.83 b	3.36 bc	2.850 e	1.893 b
G3	36.67 bc	38.67 bc	87.33 ab	99.82 b	5.33 bc	0.133 c	71.67 cd	4.43 c	18.50 d	3.44 ab	3.853cd	1.977 b
G4	37.33 b	39.67 b	87.67 ab	103.0 b	4.63 cde	0.00 d	56.00 e	4.56 c	18.90 cd	3.32 bc	3.260 de	1.703 b
G5	38.33 ab	40.67 b	87.67 ab	104.7 b	3.97 ef	0.133 c	55.70 e	4.80 c	**22.80 a**	**3.64 a**	3.650 de	2.083 b
G6	37.33 b	39.33 bc	87.67 ab	104.4 b	4.77 bcd	0.00 d	67.43cde	4.72 c	21.33 ab	3.44 ab	4.680 c	2.570 a
G7	31.33 d	34.67 d	85.67 b	115.3 a	**6.60 a**	**4.03 a**	**148.3 a**	**6.42 a**	19.90 bcd	3.30 bc	**8.540 a**	2.753 a
G8	29.67 d	33.67 d	86.67 ab	115.0 a	5.500 b	2.40 b	130.7 b	5.50 b	21.10 ab	3.33 bc	7.427 b	**2.833 a**
V1	34.67 c	37.00 c	85.33 b	102.1 b	4.367 def	0.00 d	59.97 de	4.987 bc	20.30 bc	3.08 d	3.253 de	2.040 b
V2	38.00 ab	40.67 b	86.33 ab	104.4 b	**7.067 a**	0.00 d	77.30 c	4.327 c	21.53 ab	3.46 ab	4.650 c	2.623 a
$LSD_{(0.05)}$	2.38	2.33	2.36	9.24	0.711	0.109	14.17	0.623	1.59	0.196	0.805	0.402
Mean	36.4	39.13	87.23	105.58	5.05	0.67	78.12	4.87	20.69	3.36	4.52	2.25
SE (±)	1.12	1.04	0.395	1.66	0.344	0.442	10.57	0.204	0.415	0.049	0.616	0.127
CV (%)	3.81	3.47	1.58	5.10	8.21	8.86	10.57	7.47	4.49	3.36	10.38	10.45

Table 3. Estimation of genetic parameters for morphological characters related to yield

SL. No.	Characters	Phenotypic variance (δ^2p)	Genotypic variance (δ^2g)	PCV (%)	GCV (%)
1	Days to 50% flowering (DAS)	13.84	11.92	10.22	9.49
2	Days to 80% flowering (DAS)	12.10	10.26	8.89	8.18
3	Days to 80% maturity (DAS)	2.82	0.93	1.92	1.10
4	Plant height (cm)	46.81	17.83	6.48	4.00
5	No. of primary branches/plant	1.30	1.13	22.57	21.02
6	No. of secondary branches/plant	1.96	1.95	208.71	208.49
7	No. of siliquae/plant	1163.66	1095.46	43.67	42.37
8	Length of siliqua (cm)	0.506	0.374	14.59	12.55
9	No. of seed/siliqua	2.296	1.43	7.33	5.79
10	1000-seed weight (g)	0.033	0.020	5.38	4.18
11	Yield/plant (g)	3.94	3.72	43.95	42.71
12	Yield (ton/ha)	0.198	0.143	19.74	16.77

PCV (%) = Percent of Phenotypic Coefficient of Variation, GCV (%) = Percent of Genotypic Coefficient of Variation

Table 4: Estimation of genetic parameters for morphological characters related to yield

SL. No.	Characters	Heritability (%)	GA	GA (%)
1	Days to 50% flowering (DAS)	86.12	6.6	18.13
2	Days to 80% flowering (DAS)	84.78	6.07	15.52
3	Days to 80% maturity (DAS)	32.84	1.14	1.3
4	Plant height (cm)	38.09	5.37	5.08
5	No. of primary branches/ plant	86.77	2.04	40.34
6	No. of secondary branches/ plant	90.8	2.87	29.06
7	No. of siliquae/ plant	94.14	66.15	84.68
8	Length of siliqua (cm)	73.91	1.08	22.22
9	No. of seeds/ siliqua	62.46	1.95	9.43
10	1000 seed wt (g)	60.2	0.224	6.68
11	Yield/ plant (g)	94.42	3.86	85.48
12	Yield/ha (ton)	72.18	0.661	29.35

Table 5. Coefficients of genotypic (g) and phenotypic(p) correlation among different yield components

Characters		DF80 %	DM80 %	PH (cm)	NPB/P	NSB/P	NS/P	SL (cm)	NS/S	TSW (g)	Y/P (g)
DF 50% (DAS)	g	0.963**	0.747*	-0.781**	-0.476	-0.821**	-0.865**	-0.841**	0.239	0.237	**-0.852****
	p	0.984**	0.733*	-0.785**	-0.467	-0.814**	-0.863**	-0.820**	0.241	0.215	**-0.852****
DF80%DAS)	g		0.760*	-0.696*	-0.466	-0.755*	-0.798**	-0.800**	0.289	0.182	**-0.811****
	p		0.787**	-0.690*	-0.462	-0.748*	-0.800**	-0.776**	0.298	0.181	**-0.806****
DM80% (DAS)	g			-0.373	-0.632*	-0.521	-0.547	-0.643*	0.172	0.190	**-0.601**
	p			-0.384	-0.583	-0.485	-0.542	-0.571	0.215	0.221	**-0.558**
PH (cm)	g				0.453	0.983**	0.958**	0.918**	0.111	-0.126	**0.952****
	p				0.461	0.924**	0.922**	0.867**	0.145	-0.051	**0.924****
NPB/P	g					0.531	0.665*	0.340	-0.189	0.080	**0.669***
	p					0.526	0.665*	0.352	-0.159	0.057	**0.673***
NSB/P	g						0.968**	0.961**	-0.136	-0.130	**0.943****
	p						0.964**	0.948**	-0.133	-0.126	**0.939****
NS/P	g							0.900**	-0.140	-0.095	**0.976****
	p							0.870**	-0.125	-0.095	**0.981****
SL (cm)	g								-0.119	-0.201	**0.890****
	p								-0.093	-0.191	**0.865****

NS/S	g									0.359	**-0.057**
	p									0.325	**-0.049**
TSW (g)	g										**0.004**
	p										**0.025**

Path co- efficient analysis of seed yield with other characters

Path coefficient analysis provides more effective means of separating direct and indirect factors to produce a given correlation and measuring the relative importance of the causal factors. Days to 50% flowering had positive direct effect (3.89) on yield per plant. This trait showed indirect positive effect on yield per plant through days to 80% maturity, plant height, number of secondary branches per plant (5.68), number of seeds per siliqua and showed indirect negative effect via days to 80% flowering, number of primary branches per plant, number of

Table 6. Path coefficient analysis showing direct and indirect effects of different characters on yield of *Brassica rapa* L (boled number = direct effect)

Characters	DF 50%	DF80%	DM80%	PH (cm)	NPB/P	NSB/P	NS/P	SL (cm)	NS/S	TSW (g)	Y/P (g)
DF 50% (DAS)	**3.89**	-1.97	0.453	0.443	-0.109	5.68	-5.72	-3.49	0.037	-0.061	-0.852**
DF80% (DAS)	3.74	**-2.04**	0.461	0.395	-0.107	5.22	-5.16	-3.33	0.045	-0.047	-0.811**
DM80% (DAS)	2.9	-1.55	**0.605**	0.212	-0.144	3.61	-3.54	-2.67	0.025	-0.049	-0.601
PH (cm)	-3.03	1.42	-0.226	**-0.567**	0.104	-6.8	6.19	3.82	0.017	0.032	0.952**
NPB/P	-1.86	0.951	-0.382	-0.257	**0.228**	-3.68	4.29	1.41	-0.029	-0.021	0.669*
NSB/P	-3.19	1.54	-0.315	-0.558	0.121	**-6.922**	6.26	3.99	-0.021	0.033	0.943**
NS/P	-3.44	1.63	-0.331	-0.543	0.152	-6.7	**6.46**	3.74	-0.022	0.024	0.976**
SL (cm)	-3.27	1.63	-0.389	-0.521	0.077	-6.65	5.82	**4.16**	-0.019	0.052	0.890**
NS/S	0.929	-0.59	0.104	-0.063	-0.043	0.941	-0.905	-0.495	**0.157**	-0.092	-0.057
TSW (g)	0.921	-0.372	0.115	0.071	0.018	0.899	-0.614	-0.836	0.056	**-0.256**	0.004
Residual effect = 0.0664											

* and ** indicate significant at 5% and 1% level of probability, respectability.

DF 50%=Days to 50%, DF80%= Flowering Days to 80% flowering, DM80%=Days to 80% Maturity, PH=Plant height, NPB/P=No. of primary branches/ Plant, NSB/P= No. of secondary branches/ Plant, NS/P= No. of siliquae/ Plant, SL=Length of siliqua, NS/S=No. of seed/ siliqua, TSW=1000 seed weight, Y/P= Yield/ plant.

siliquae per plant, siliqua length and thousand seed weight. Days to 80% flowering had negative direct effect (-2.04) on yield per plant but exerted positive indirect effect via number of secondary branch per plant (5.22) followed by days to 50% flowering, days to 80% maturity, plant height and number of seed per siliqua. days to 80% maturity had exerted direct positive effect (0.605) on yield per plant and indirect positive effect on yield via number of secondary branch per plant (3.61) followed by days to 50% flowering, plant height and number of seed per siliqua. It had indirect negative effect on days to 80% flowering, number of primary branches per plant, number of siliquae per plant length of siliqua and thousand seed weight. Plant height exhibited direct negative effect (-0.567) on seed yield but indirectly positive effect on yield via days to 80% flowering, number of primary branches per plant, number of siliquae per plant, length of siliqua, number ofseed per siliqua and thousand seed weight.

Number of primary branches per plant exerted direct positive effect (0.228) on yield per plant and indirect positive effect via days to 80% flowering, number of siliquae per plant (4.29) and length of siliqua. Number of secondary branches per plant had negative direct effect (-6.922) on yield per plant and Number of siliquae per plant had a positive direct effect (6.46). Length of siliqua had a direct positive effect (4.16) on yield per plant. Number of seeds per siliqua had exerted direct positive effect (0.157) on yield per plant and thousand seed weight exerted direct negative effect on yield (-0.256).

4. CONCLUSION

A wide range of variations were observed in most of the characters studied among the eight advanced lines and two check varieties. Almost all the characters had higher phenotypic variance than the genotypic variance indicating the greater influence of environment to express the characters. The correlation study revealed that yield per plant had significant positive association with plant height (r_p= 0.924, r_g= 0.952), number of primary branches per plant (r_p= 0.673, r_g= 0.669), number of secondary branches per plant (r_p= 0.939, r_g= 0.943), number of siliquae per plant (r_p= 0.981, r_g= 0.976), length of siliqua (r_p= 0.865, r_g= 0.890) while significant negative correlation was found with days to 50% flowering and days to 80% flowering in both genotypic & phenotypic level. From Path co-efficient analysis it was revealed that days to 50% flowering, days to 80% maturity, number of primary branches per plant, number of siliquae per plant, length of siliqua and number of seeds per siliqua had the positive direct effect on yield per plant whereas days to 80% flowering, plant height, number of secondary branches per plant and thousand seed weight had negative direct effect on yield per plant. The genotypic correlation of plant height, number of secondary branches per plant, number of siliquae per plant and length of siliqua with seed yield was positive and considerably higher in magnitude. This was mainly due to high positive direct and positive indirect effects of other characters. Selection would be effective for these traits and finally beneficial for the crop improvement. From the path co-efficient study it could be concluded that number of primary branches per plant, number of siliquae per plant and siliqua length were the most important contributors to seed yield per plant which could be taken into consideration for future hybridization program.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The authors confirm that the data supporting the findings of this research are available within the article.

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CONFLICT OF INTEREST

Authors have declared that there is no conflict of interest.

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