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EVALUATION OF *Brassica rapa* GENOTYPES SUITABLE FOR RICE BASED CROPPING PATTERN IN BANGLADESH

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Abstract

The field experiment was conducted with 15 *Brassica rapa* genotypes to estimate the genetic variability and correlation of yield contributing traits. The results indicated that the phenotypic variance for all the characters was considerably higher than the genotypic variance denoting little influence of environmental factors. Low genotypic and phenotypic coefficient of variation showed in plant height (6.36, 8.20) and thousand seed weight (4.58, 11.63). While moderate genotypic and phenotypic coefficient of variation was observed in seed yield (12.68, 18.09), number of branches per plant (13.71, 25.18), number of seeds per siliqua (20.20, 28.86). High genotypic (40.65) and phenotypic coefficient of variation (52.85) was observed for number of siliquae per plant. Low heritability with high genetic advance showed in plant height (0.60%, 8.85), number of branches per plant (0.29%, 0.54) and number of seeds per siliqua (0.48%, 6.75) indicating the possibility of non-additive gene action. High heritability with high genetic advance and high genetic advance in percentage of mean were observed in plant height (0.60%, 8.85, 10.16), number of siliquae per plant (0.59%, 31.93, 64.42), number of seeds per siliqua (0.48%, 6.75, 29.12) and seed yield (0.49%, 260.64, 18.32) which revealed the possibility of predominance of additive gene effects. Number of branches per plant had showed significant positive association with number of siliquae per plant (rg= 0.850**, rp= 0.795**) and number of seeds per siliqua (rg= 0.821**). On the other hand, it had significant negative association with thousand seed weight (rg= -0.912**) and non-significant positive and negative association showed with others characters. The results of the path analysis revealed that plant height (0.818) had the maximum direct effect and maximum negative direct effect was observed for number of seeds per siliqua (-2.558). However, the results suggested that some yield related traits such as plant height and thousand seed weight could be used in breeding program for the development of high yielding short duration *B. rapa* variety development in Bangladesh.

Keywords: Correlation coefficient, Genetic variability, Germplasm, Path coefficient

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Introduction

Oilseed Brassicas have been ranked after soybean and palm oil in edible oil production. Brassica species have played an important role in agriculture and contributed to the economy and health in the world. The family Brassicaceae, containing about 350 genera and 3500 species, is one of the ten most economically important plant families with a wide range of agronomic traits. The Brassica genus generally has been categorized into three categories *viz;* Mustard, Rapeseed, and Cole. The Brassicaceae is distinguished on the basis of the presence of conduplicate cotyledons (i.e., the cotyledons are longitudinally folded around the radical) and two segmented fruits (siliquae), which contain seeds in one or both segments with simple hairs if present. These characteristics separate the mustard family from all other plant families. *B. rapa*. is an important widely cultivated crop comprised of a genome n=10 with various forms or morphotypes such as leafy vegetables, turnips, and oilseed rape. At a present large number of commercial varieties are available, and their characterization, differentiation and plant varieties were made by a set of descriptors/ characters.

In Bangladesh rapeseed and mustard is the first leading oil crops in respect of productivity land coverage of oilseed (BBS, 2021). Rapeseed is the most important sources of edible oil in Bangladesh. *B .rapa*, *B. napus* and *B. juncea* are three major cultivated species of Bangladesh. Rapeseed is the most important sources of edible oil in Bangladesh. Rapeseed oil used for both culinary and industrial purpose. The mustard cake contains high protein (37%) rich feed which is highly palatable to livestock (Anil Kumar *et al.*, 2002). Now Bangladesh is facing shortage of edible oil. At present, production of oilseed is about 0.99 million tons (BBS, 2021), which covers only 10% of the domestic need. About 90% of requirement of oil has been imported every year by spending huge amount of foreign currency (BBS, 2021). In Bangladesh, the national grain yield of mustard/rapeseed is about 950 kg/ha which is very low in comparison to other developed countries (2400 kg/ha) (Food and Agriculture Organization of the United Nations, 2020). On the other hand, the area of cultivation of mustard in Bangladesh is lower due to rice based cropping system which is very challenging for increasing overall production of mustard. Henceforth, for a sustainable food security the thrust is to develop short duration high yielding rapeseed variety in between the Transplanted Aman and Boro Rice, for a sustainable food security.

Seed yield in rape is a complex and highly variable character and is being associated with a number of component characters (Varshney *et al.*, 1986). Yield improvement is one of the major goals in rapeseed breeding. Information related to genetic variability and character association is a prerequisite for initiating a successful breeding program aiming to develop high yielding and short duration varieties. Correlation and path coefficient are used to assess the relative contribution of different components on yield (Sachan and Sharma, 1971 and Jatasra and Paroda, 1978). The path coefficient analysis has been found to give more specific information on the direct and indirect influence of each of the component characters upon seed yield (Behl *et al.*, 1992). Thus, the present study was undertaken to find out suitable genotypes for higher seed yield through study of genetic variability, heritability, genetic advance, correlation among different characters and the direct and indirect effect of these characters towards seed yield with short duration lines for further use in variety development research.

Materials and Methods

The experiments were conducted at the research fields of Oilseed Research Centre of Bangladesh Agricultural Research Institute, Gazipur (latitude: 23°99′N, longitude: 90°41′E), during Rabi season 2020 (winter season in Bangladesh). The area is characterized by subtropical monsoon climate, with average annual rainfall of about 1,898 and 1,895 mm, respectively. The soil characteristics of the experimental field is sandy clay loam and silty clay loam in texture, respectively. The field capacity, permanent wilting point, and bulk density were 0.295 $cm^3\ cm^{-3}$, 0.141 $cm^3\ cm^{-3}$, and 1.50 g cm^{-3}, respectively. Fifteen *B. rapa* genotypes were used in this experiment. The experiment was set up in a RCBD with three replications, following 30 cm × 10 cm spacing. The unit plot size was 5 m × 1.5 m and block to block distance was 1.5 m. The plot was fertilized with 250, 170, 85, 150, 5 Kg/ha Urea, TSP, MOP, Gypsum and Borax respectively. Standard agronomic practices were carried out to raise healthy crop. Harvesting was done when 80% of the plants showed symptoms of maturity i.e. straw colour of siliquae, leaves, stem and desirable seed colour in the matured siliquae. Ten plants were selected at random from all genotypes in each plot and data were recorded on Plant height (cm), Number of branches per plant (no.), Number of siliqua per plant (no.), Number of seeds per siliqua (no.), Thousand seed weight (g), Seed yield (kg/ha). The data were analyzed for different genetic components. Phenotypic and genotypic variance was 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). Genotypic and phenotypic coefficient of variation was calculated by the formula of (Burton, 1952). Simple correlation 17 coefficient was obtained using the formula suggested by (Singh and Chaudhary, 1985) and path co-efficient analysis was done following the method outlined by (Dewey and Lu, 1959).

Results and Discussion

The results of analysis of variance (ANOVA) for all the traits under study are presented in Table 1. According to the table there was a significant difference among the genotypes and replications for the traits suggesting there were significant differences among the genotypes and replications for the characters. It was found that the tallest plant of 97.26 cm was observed in G11 while the shortest plant of 77.30 cm was in G4 (Table 2).

The maximum number of primary branches per plant (4.83) and number of siliqua per plant (92.60) were recorded in G11 and the lowest number of primary branches per plant (2.23), and number of siliqua per plant（26.20）was in G13. On the other hand, number of seed per siliqua was observed the highest in G2 (34.96) and the lowest in G8 (15.20). Maximum thousand seed weight (4.00 g) was recorded in G4, and the minimum 3.00g was in G6 and G10. The highest seed yield (1761.85 kg/ha) was recorded in G5 and the lowest (1137.85 kg/ha) was recorded in G2 in Table 2.

Table 1. Analysis of variances of seven important characters in respect of *Brassica rapa*

Source	df	DM	PH	NBPP	NSPP	NSPS	TSW	SY
Replication	2	16.98	17.64	0.58	259.25	129.87**	2.12***	91720
Genotypes	14	114.2**	112.40***	1.28*	1498.69***	88.70**	0.13	131380**
Error	28	7.88	8.79	0.25	26.48	10.34	1.15	19.29
CV%		25.87	27.84	20.75	33.40	20.42	10.06	13.79

DM, Days to maturity (day); PH, Plant height (cm); NBPP, Number of branches per plant (no.); NSPP, Number of siliqua per plant (no.); NSPS, Number of seed per siliqua (no.); TSW, Thousand seed weight (g): SY, Seed yield (kg/ha)

The phenotypic variance was considerably higher than the genotypic variance for all the characters studied indicating less environmental influence of these characters (Table 3). Deshmukh *et al.,* (1986) also reported that phenotypic coefficient of variation was higher than the genotypic coefficient of variation. Least difference between phenotypic variance and genotypic variance were observed in number of branches per plant, number of siliqua per plant, number of seed per siliquae and thousand seed weight which indicated low environmental influence on this character which might be due to their genetic control. Relatively high phenotypic variation was observed in plant height (51.02), number of siliquae per plant (686.41), number of seed per silique (44.81) and Seed yield (66246.8) which indicated large environmental influence on these characters. Characters like plant height (6.36, 8.20) and thousand seed weight (4.58, 11.63) showed low genotypic and phenotypic coefficient of variation indicated that the genotype has considerable variation for these traits. Moderate genotypic and phenotypic coefficient of variation was observed in number of seed per siliqua (20.20, 28.86), number of branches per plant (20.22, 22.16) and seed yield (12.68, 18.09) which indicated moderate variability were present among the genotype for these characters. Number of siliquae per plant showed high genotypic and phenotypic coefficient of variation (40.65) and (52.85) respectively indicated that the genotype were highly variable for this trait (Table 3). Plant height (0.60%, 8.85), number of branches per plant (0.29%, 0.54) and number of seed per siliqua (0.48%, 6.75) showed low heritability with high genetic advance which indicated the possibility of non-additive gene action. The high heritability was due to favorable influence of environment rather than genotype and selection for such traits might not be rewarding. Plant height (0.60%, 8.85, 10.16), number of siliqua per plant (0.59%, 31.93, 64.42), number of seed per siliqua (0.48%, 6.75, 29.12) and seed yield (0.49%, 260.64, 18.32) showed high heritability with high genetic advance and high genetic advance in percentage of mean revealed the possibility of predominance of additive gene effects and selection should lead to a fast genetic improvement of the material.

Table 2. Mean performances of seven important traits in *Brassica rapa*

Codes	Genotype	DM	PH	NBPP	NSPP	NSPS	TSW	SY
G1	BC-2014-Y01	78.00bc	81.10fg	3.76bc	47.80bc	23.96d	3.33b	1267.86bc
G2	BC-2014-Y02	77.00c	86.26cd	3.50cde	41.63cd	34.96a	3.66ab	1137.85cde
G3	BC-214-Y-6	77.33c	91.86bc	4.63ab	108.43a	18.50ef	3.33b	1169.63cd
G4	2014-Y11	77.00c	77.30h	3.73bc	38.76ef	19.16e	4.00a	1496.08b
G5	BC-2014-B08	76.00cd	84.50cde	3.56bcd	38.50ef	21.36e	3.66ab	1761.85a
G6	BC-2014-B10	75.33cd	93.00ab	3.10cde	41.50cd	24.03cd	3.00bc	1282.97bc
G7	BC-2014-B14	73.00d	86.83cd	3.10cde	40.06cde	25.30c	3.33b	1299.00fg
G8	BS-14X BS 15-1	75.33cd	79.83def	3.96b	64.66b	15.20fgh	3.66ab	1269.18bc
G9	BS-14X BS 15-3	80.00bc	82.63de	2.86cdef	46.00bc	17.50fg	3.66ab	1694.45a
G10	BS-14X BS 15-4	80.33b	87.60c	3.86bc	41.80cd	21.96e	3.00bc	1218.89bcd
G11	BS-14X BS 15-1 (NET)	73.00d	97.26a	4.83a	92.60a	18.36g	3.33b	1697.80a
G12	BS-14X BS 15-3 (NET)	75.33cd	96.96a	3.83bcd	41.96c	30.30ab	3.33b	1238.52bcd
G13	BC-2014-Y02 (NET)	83.6a	92.16b	2.23 cdef	26.90efgh	30.43ab	3.30bc	1336.67bc
G14	BC-2014-Y03 (NET)	81.4ab	80.70gh	3.20def	36.00efg	22.00e	3.66ab	1697.78a
G15	BS-14- (CH)	78.66bc	81.66gh	3.36de	36.93ef	24.80def	3.33b	1561.48ab
	F-Test	**	**	**	**	**	**	**
	LSD $_{(0.05)}$	17.77	18.11	0.55	12.36	3.53	0.25	146.54
	Sx/sd	7.10	7.03	0.89	25.82	6.97	0.49	259.62

In a column means having similar letter(s) or without letter is identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability; CV%, Percentage of co-efficient of variation; LSD, Least significant difference; Sx/sd, Standard deviation; DM, Days to maturity (day); PH, Plant height (cm); NBPP, Number of branches per plant (no.); NSPP, Number of siliqua per plant (no.); NSPS, Number of seed per siliqua (no.); TSW, Thousand seed weight (g): SY, Seed yield (kg/ha)

Table 3. Estimation of some genetic parameters in *Brassica rapa*

Parameters	DM	PH	NBPP	NSPP	NSPS	TSW	SY
σ^2g	29.80	30.68	0.23	406.13	21.94	0.02	32566.6
σ^2p	49.70	51.02	0.80	686.41	44.81	0.15	66246.8
GCV	6.03	6.36	13.71	40.65	20.20	4.58	12.68
PCV	7.90	8.20	25.18	52.85	28.86	11.63	18.09
h^2b (%)	0.55	0.60	0.29	0.59	0.48	0.15	0.49
GA	8.12	8.85	0.54	31.93	6.75	0.12	260.64
GA (%)	9.87	10.16	15.38	64.42	29.12	3.72	18.32

σ^2g, Genotypic variance; σ^2p, Phenotypic variance; GCV, Genotypic coefficient of variation; PCV, Phenotypic coefficient of variation; h^2b, Broad sense heritability; GA, Genetic advance; GA (%), Genetic advance in percent of mean; DM, Days to maturity (day); PH, Plant height (cm); NBPP, Number of branches per plant (no.); NSPP, Number of siliqua per plant (no.); NSPS, Number of seed per siliqua (no.); TSW, Thousand seed weight (g): SY, Seed yield (kg/ha)

Table 4. Correlation co-efficient among different characters of the *Brassica rapa*

Characters	Correlation	PH	NBPP	NSPP	NSPS	TSW	SY
DM	r_g	0.039	0.287	0.298	0.26	0.12	0.15
	r_p	0.399	0.422*	0.325	0.34	0.23	0.21
PH	r_g		0.037	0.291	0.310	-1.284**	-0.418
	r_p		0.421**	0.435**	0.352*	-0.308*	-0.085
NBPP	r_g			0.850**	0.821**	-0.912**	-0.131
	r_p			0.795**	-0.122	0.001	0.146
NSPP	r_g				-0.696**	-0.583*	0.037
	r_p				-0.295*	-0.037	0.142
NSPS	r_g					-0199	-0.809
	r_p					-0.213	-0.200
TSW	r_g						0.076
	r_p						0.182

**, Significant at the 0.01 level of probability; *, Significant at the 0.05 level of probability; DM, Days to maturity (day); PH, Plant height (cm); NBPP, Number of branches per plant (no.); NSPP, Number of siliqua per plant (no.); NSPS, Number of seed per siliqua (no.); TSW, Thousand seed weight (g): SY, Seed yield (kg/ha)

Plant height showed phenotypic level highly significant positive association with number of branches per plant, number of siliquae per plant and number of seeds per siliqua found significantly positive. On the other hand, plant height showed highly significant negative association with thousand seed weight and seed yield found non-significant negative correlation with genotypic and phenotypic level. Singh *et al.,* (1987) also found a similar result. The result revealed that the tallest plant initiated with an increase of number of primary branches per plant. Number of branches per plant had showed significant positive association with number of siliquae per plant (r_g= 0.850**, r_p= 0.795**) and number of seeds per siliqua (r_g= 0.821**). On the other hand, it had significant negative association with thousand seed weight (r_g= -0.912**) and non-significant positive and negative association found with others characters. This result is disagreement with Singh *et al.*, (1969) who got negative association between numbers of branches per plant. Number of siliquae per plant had significant negative association both genotypic and phenotypic level with number of seeds per siliqua (r_g= -0.696**; r_p= -0.295*) and thousand seed weight (r_g= -0.583*). Number of seeds per siliqua showed non-significant negative association with thousand seed weight (r_g= -0199; r_p= -0.213) and seed yield (r_g= -0.809; r_p= -0.200) indicated that as the 1000 seed weight and seed yield would decrease. Thousand seed weight had non-significant positive association with seed yield (kg/ha) both genotypic and phenotypic level (0.076; 0.182) indicated that as the thousand seed weight increases, the seed yield (kg/ha) would increase.

Table 5. Partitioning of genotypic correlation with seed yield (kg/ha) into direct (bold) and indirect components of *Brassica rapa*

Character	DM	PH	NBPP	NSPP	NSPS	TSW	SY
DM	**0.831**						
PH	0.054	**0.818**	-0.007	-0.484	-0.794	-0.949	-0.418
NBPP	0.498	0.067	**-0.212**	-1.413	2.101	-0.674	-0.131
NSPP	0.52	0.530	-0.181	**-1.661**	1.780	-0.431	0.037
NSPS	0.531	0.564	0.174	1.156	**-2.558**	-0.147	-0.809
TSW	0.12	-2.336	0.194	0.968	0.510	**0.739**	0.076
SY							-0.332

DM, Days to maturity (day); PH, Plant height (cm); NBPP, Number of branches per plant (no.); NSPP, Number of siliquae per plant (no.); NSPS, Number of seeds per siliqua (no.); TSW, Thousand seed weight (g): SY, Seed yield (kg/ha)

The results of the path analysis revealed that plant height (0.818) had the maximum direct effect followed by thousand seed weight (0.739). Maximum negative direct effect was observed for number of seeds per siliqua (-2.558) followed by number of branches per plant (-0.212) and number of siliquae per plant (-1.661). Number of seed per siliqua had negative direct effect as well as negative and non-significant genotypic correlation with yield (-0.809). The contributions of yield components like plant height and thousand seed weight were higher in the present study. Singh (1985) observed high positive direct effect on 50% flowering, plant height, numbers of branching, number of siliquae per plant, number of seeds per siliquae on yield. Varshney (1986) working with several strains of *B. rapa* found the negative direct effect of plant height, siliquae per plant, seeds per siliqua and 1000 seed weight on yield. The residual effect was (-0.332) indicated that about 72% of the variability was contributed by six quantitative characters studied in path analysis. This low residual effect might be due to characters not studied, environmental factors, sampling error etc. The results revealed that the germplasm possesses expected variations in the examined traits. Variation among the genotypes are desirable for breeding works toward developing target oriented varieties. Present investigation depicts that a wide variation existed among the *B. rapa* genotypes which are potential resources to develop short duration (all the studied genotypes are short durated) and high yielding varieties from further experimentations. In addition, there was correlation of different yield components with the yield of *B. rapa*.

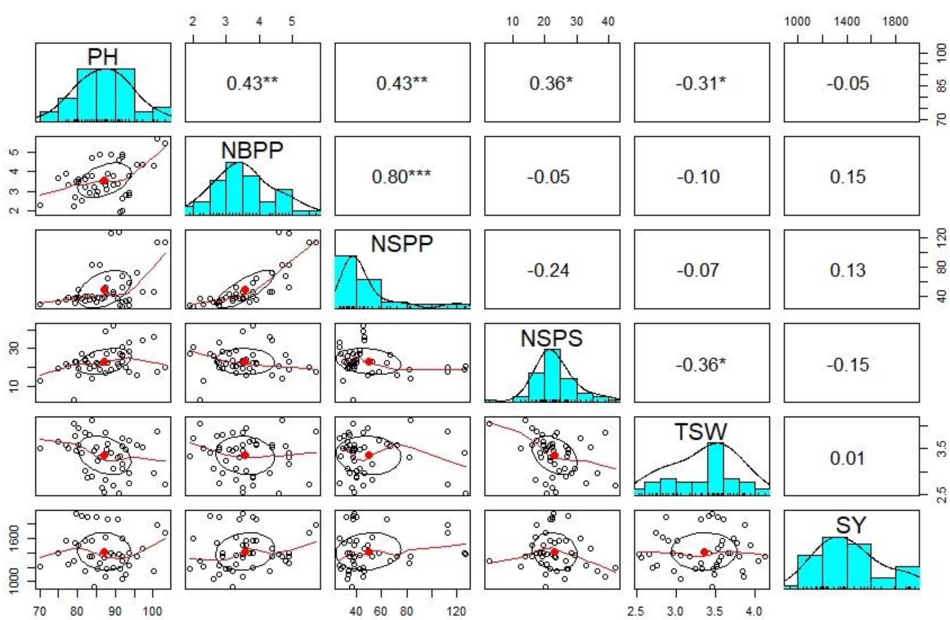

Fig. 1. Pearson correlation with p values among six characters of the *B. rapa*

Conclusion

This present study revealed that the agronomic and yield contributing traits has potential for developing short and high yielding varieties. Generally *B. rapa* varieties cultivated throughout the country in T. aman rice-Fallow-Boro rice based cropping patterns. From the combined analysis we found significant variations among the traits in the germplasm. From the mean performance of yield and other related contributing characters, genetic parameters, G5. G14, G11 and G9 found promising genotypes and these could be brought to the breeding programs in future. They will be able to release new varieties after further experimentation, evaluation and adaptive experiments.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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