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Assessment of Variability for Floral Characteristics and Out-Crossing Rate in CMS Lines of Hybrid Rice

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ABSTRACT

The present investigation was aimed to clarify the interrelationship among various floral traits and out crossing rates. High mean value, range of variability and genotypic variance were observed for all the traits except anther length and breadth, stigma length and breadth. Close differences between genotypic and phenotypic variances and genotypic and phenotypic coefficient of variations were observed for all the traits. Considering all genetic parameters, selection based on panicle exertion rate, angle of florate opening, duration of florate opening, anther length, stigma exertion rate and out crossing rate seemed to be effective for the improvement of CMS lines. Out crossing rate had significant positive correlation with panicle exertion rate, angle of florate opening, duration of florate opening, filament length, stigma length, breadth and exertion rate exhibited interesting results, indicating selection with these traits might be possible without compromising seed yield loss. On the basis of direct selection through panicle exertion rate, angle and duration of florate opening, filament length and stigma exertion rate would significantly improve seed yield of CMS lines. Based on mean, range, genetic parameters, correlation coefficient and path coefficient values, direct selection of eight CMS lines IR79156A, BRRI7A, IR75608A, BRRI13A, BRRI35A, BRRI48A, BRRI50A and BRRI53A might be fruitful as good floral characteristics with high out crossing rate of CMS lines.

Key words: Variability, heritability, correlation coefficient, stigma exertion rate

INTRODUCTION

Rice is a major source of livelihood in terms of providing food, income and employment in Bangladesh. It covers about 77 percent of the total cropped area in the country. Rice production in Bangladesh remains almost stagnant in the 2016 at around 34.18 MMT (rough rice or paddy) from 11.6 million hectares of land (Wallace, 2017). But the population growth rate accelerated, so this burgeoning population needs more food. Rice breeder have therefore, been trying to evolve input-efficient high yielding varieties (HYV) to increase the yield through limited land, labour, water etc. One innovation has been the development of hybrid rice varieties for the tropics, which is expected to shift the yield potential of rice plant by 15-20 percent or more. The technology has attracted the attention of research leaders and policy-makers in many Asian countries who see it as an opportunity to overcome the yield ceilings. The discovery of CMS in rice suggested that breeding could develop a commercially viable F_1 hybrid (Athwal and Virmani, 1972). The most promising hybrids yielded 20-30% (Lin and Yuan, 1980) and l5-20% (Yuan, 1998) higher than the best conventional rice varieties. Therefore, to break through the present yield ceiling of semi dwarf modern varieties, hybrid rice seems to be an attractive viable alternative. It is urgently needed to develop parental lines viz. A lines, B lines and R lines for developing hybrid rice varieties, with resistance to disease or environmental

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changes this situation could be reduced by developing CMS lines having diverse cytoplasmic source with stable male sterility, high out crossing rate, good resistance to diseases and other stresses. A plant breeding programme can be divided into three stages, viz. building up a gene pool of variable germplasm, selection of individuals from the gene pool and utilization of selected individuals to evolve a superior variety (Kempthorne, 1957). The available variability in a population can be partitioned into heritable and non heritable parts with the aid of genetic parameters such as genetic coefficient of variation, heritability and genetic advance (Miller *et al.*, 1958). Correlation coefficient helps to identify the relative contribution of component characters towards yield (Panse, 1957). The correlation between yield and a component character may sometimes be misleading. Thus splitting of total correlation into direct and indirect effects would provide a more meaningful interpretation of such association.

Path coefficient, usually a standard partial regression coefficient, specifies the cause and effect relationship and measures the relative importance of each variable. Therefore, correlation in combination with path coefficient analysis will be an important tool to find out the association and quantify the direct and indirect influence of one character upon another (Dewey and Lu, 1959). Improvement of out crossing rate of CMS lines with high panicle exertion rate and stigma exertion rate through the knowledge of variability, association among various floral traits along with direct and indirect influence of these component traits on seed yield has so far been lacking. Therefore, objectives of the present study were to i) analyze variability in genetic parameters, association among different floral traits on out crossing rate of 30 promising CMS lines available in Bangladesh; ii) determine contribution of the component traits towards seed yield potential; and finally iii) find out appropriate selection parameters for the improvement of CMS lines.

MATERIALS AND METHODS

Thirty CMS lines, some developed by BRRI and some collected from IRRI were grown in November 2015, consecutively in a randomized complete block design (RCBD) with three replications in BRRI experimental fields, Gazipur. Thirty-day-old seedlings were transplanted in 4.6 m^2 areas using single seedling per hill. Fertilizer doses were 80: 60: 40 kg N P K and 70 kg gypsum per hectare. Except N all other fertilizers were used as basal dose and N fertilizer was top dressed in three equal splits at 15, 30 and 45 days after transplanting. Standard crop management practice was done as and when necessary. Data were collected at flowering time of ten randomly selected plants were considered from each replication for measuring panicle exertion rate (PER), angle of floret opening (AFO), duration of floret opening (DFO), filament length (FL), anther length (AL), and breadth (AB), stigma length (SL), breadth (SB), exertion rate (SER) and out crossing rate (OCR).

The raw data were compiled by taking the means of all the plants taken for each treatment and replication for different traits. The mean data were averaged and the average mean values were statistically analyzed. Analysis of variance was done according to Panse and Sukhatme (1978) for each character. Genotypic and phenotypic variances, phenotypic (PCV) and genotypic coefficient of variation (GCV), heritability in broad sense (h^2b) and expected genetic advance (GA %) were estimated according to Johnson et al. (1955a). Correlation coefficient was analyzed following Hayes *et al.* (1955). Path coefficient analysis was calculated according to the formula given by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the ten traits, which was the indication of the validity of further statistical analysis due to the presence of a wide range of variability among the 30 CMS lines. Mean performance, % CV and CD for floral character and out crossing rate in 30 CMS lines (Table 1).

Floral traits

Panicle exertion rate. Among the 10 traits investigated, the highest panicle exertion rate was observed in IR79156A (78.26%) followed by BRRI7A (77.44%) and IR75608A (75.59%). Rajkumar and Ibrahim (2015) reported that the highest panicle exertion rate was recorded in CMS line IR58025A and the lowest was in IR79156A. The mean panicle exertion rate was 64% and 0.56% coefficient of variation.

Table 1. Mean performance, coefficient of variation (CV) and critical difference (CD) values of floral attributes of 30 CMS lines.

CMS lines	PER	AFO	DFO	FL	AL	AB	SL	SB	SER	OCR
BRRI10A	58.43	20.57	130.9	5.50	1.57	0.46	1.22	0.35	55.31	22.38
BRRI11A	58.35	20.40	128.8	5.43	1.53	0.45	1.22	0.31	54.75	21.99
GuiA	56.43	20.14	125.1	5.33	1.47	0.44	1.21	0.29	54.22	21.60
BRRI28A	54.92	20.13	122.9	5.27	1.52	0.44	1.20	0.29	51.36	20.70
BRRI30A	54.93	19.68	115.8	5.17	1.45	0.43	1.10	0.28	50.97	20.33
BRRI32A	54.69	19.30	111.8	5.07	1.41	0.43	1.09	0.27	48.84	20.01
You1A	54.52	19.10	106.6	4.97	1.36	0.38	0.95	0.27	48.44	18.46
BRRI4A	53.91	18.83	97.45	4.77	1.08	0.41	0.98	0.23	48.18	18.14
BRRI6A	53.31	18.03	87.42	4.53	1.14	0.40	0.97	0.25	46.21	16.89
BRRI8A	52.45	17.71	79.13	4.67	1.21	0.43	1.08	0.26	46.78	15.37
IR79156A	78.26	26.11	182.8	6.77	2.47	0.55	1.52	0.58	79.28	35.78
D ShanA	62.16	21.06	137.6	5.70	1.67	0.48	1.30	0.40	58.14	23.19
IR58025A	60.00	20.86	136.3	5.63	1.63	0.48	1.28	0.40	55.84	22.81
BRRI1A	59.33	20.64	131.7	5.57	1.60	0.47	1.26	0.38	55.59	22.54
BRRI7A	77.44	25.38	185.3	6.80	2.77	0.58	1.66	0.58	80.31	35.41
BRRI50A	72.19	23.86	169.8	6.37	2.30	0.54	1.51	0.56	72.63	30.68
BRRI53A	70.54	23.49	165.7	6.33	2.23	0.53	1.50	0.56	72.20	30.28
BRRI72A	70.18	23.34	164.2	6.30	2.17	0.52	1.49	0.55	68.69	29.98
IR68886A	69.51	23.03	163.6	6.27	2.10	0.52	1.45	0.55	68.23	28.31
IR68888A	69.13	22.77	160.5	6.20	2.07	0.52	1.45	0.54	67.58	27.85
IR68897A	67.12	22.45	159.2	6.19	2.03	0.51	1.44	0.54	64.69	25.79
II32A	66.46	22.13	157.6	6.17	2.00	0.51	1.44	0.53	64.16	25.49
Jin23A	65.46	21.66	152.6	6.10	1.87	0.51	1.34	0.42	61.76	25.20
V20A	63.54	21.50	149.2	5.99	1.80	0.50	1.33	0.42	61.24	24.99
IR75608A	75.59	24.53	178.8	7.27	2.60	0.57	1.65	0.61	78.91	33.76
BRRI13A	74.47	24.14	176.7	6.63	2.87	0.56	1.62	0.57	76.57	33.35
BRRI35A	74.19	24.19	176.0	6.53	2.40	0.58	1.53	0.57	75.87	32.65
BRRI48A	73.58	23.95	173.7	6.47	2.33	0.54	1.67	0.56	74.63	32.35
2597A	63.31	21.38	144.7	5.93	1.73	0.49	1.33	0.42	59.23	23.78
Gan46A	62.51	21.12	142.0	5.77	1.70	0.48	1.32	0.41	58.23	23.46
Mean	64.23	21.72	143.79	5.86	1.87	0.49	1.34	0.43	61.96	25.45
CV(%)	0.56	1.40	0.34	2.36	4.06	1.98	3.76	2.48	0.42	0.94
CD	0.599	0.509	0.811	0.230	0.129	0.053	0.091	0.052	0.439	0.399

Legend: PER = Panicle exertion rate (%), AFO = Angle of florat opening (0°), DFO = Duration of florate opening (min), FL = Filament length (mm), AL = Anther length (mm), AB = Anther breadth (mm), SL = Stigma length (mm), SB = Stigma breadth (mm), SER = Stigma exertion rate (%) and OCR = Out crossing rate (%).

Angle of floret opening. This trait varied from 17.71° (BRRI8A) to 26.11° (IR79156A) with a mean value 21.72°. Vagolu (2010) also observed mean value of CMS line was 22.90°. The coefficient of variation for this trait was 1.40%.

Duration of floret opening. The variation for this character ranged from 79.13 to 185.3 minute with a mean value 143.79 minute. BRRI7A and IR79156A also recorded higher duration of floret opening.

Filament length. The trait filament length was varied from 4.53 mm (BRRI6A) to 7.27 mm (IR75608A) with an overall mean value of 5.86mm. The highest filament length was observed in the CMS line IR75608A followed by CMS line BRRI7A (6.80 mm) and IR79156A (6.77 mm). Among 30 CMS lines studied 16 CMS lines had higher filament length than the mean value. The coefficient of variability was 2.36% for filament length.

Anther length. The variations of the anther length were highly pronounced among the CMS lines which ranged from 1.08 mm in the CMS line BRRI4A to 2.87 mm in the CMS line BRRI13A. The average mean of the anther length was 1.87 mm, 13 CMS line showed above average performance for anther length. The coefficient of variation for this trait was 4.06%.

Anther breadth. The anther breadth among the CMS lines studied ranged from 0.38 mm (You1A) to 0.58 mm (BRRI35A) with a mean value of 0.49 mm. The CMS lines BRRI35A and BRRI7A also recorded higher anther breadth. The coefficient of variation was 1.98.

Stigma length. The trait varied from o.95 mm (You1A) to 1.67 mm (BRRI48A) with mean value of 1.34 mm. Among the 30 CMS lines BRRI48A and BRRI7A recorded higher stigma length. Vagolu (2010) also assessed the similar result in CMS lines. The coefficient of variation was 1.34.

Stigma breath. Although the stigma breadth had significant variations among the CMS lines, the range of variations of the lines weren't pronounced (0.23 mm to 0.61 mm). The highest stigma breadth was found in IR75608A followed by BRRI7A (0.58 mm) and IR79156A (0.58 mm). The coefficient of variation for this trait was 2.48.

Stigma exsertion rate. The variations of the stigma exertion rate were highly pronounced among the genotypes which ranged from 46.21% in the CMS lines BRRI6A to 80.31% in the CMS lines BRRI7A. The average mean of the stigma exertion rate was 61.96%. Thirteen CMS lines showed above average performance for stigma exertion rate, of which 6 CMS lines viz BRRI7A, IR79156A, IR75608A, BRRI13A, BRRI35A and BRRI48A showed outstanding stigma exertion rate 80.31%, 79.28%, 78.91%, 76.57%, 75.87% and 74.63% respectively. The CV for this trait was 0.42%.

Out crossing rate. Enormous out crossing rate was obtained from 30 CMS lines investigated that ranged from 15.37% (BRRI8A) to 35.78% (IR79156A) with an average value of 25.45%. The highest OCR was obtaining from the CMS line IR79156A, followed by CMS lines BRRI7A (35.41%), IR75608A (33.76%), BRRI13A (33.35%), BRRI35A (32.65%) and BRRI48A (32.35%). Out of 30 CMS lines studied eight had OCR>30% while four CMS lines (BRRI8A, BRRI6A, BRRI4A and You1A) had lower OCR. From this investigation it was revealed that when out crossing rates high it is associated with high rates in other floral traits. The investigation also showed that eight CMS lines IR79156A, BRRI7A, IR75608A, BRRI13A, BRRI35A, BRRI48A, BRRI50A and BRRI53A were out yielded over their corresponding means.

Variability studies

Variability plays a vital role in the selection of superior genotypes in crop improvement programme. Pronounced variation in the breeding materials is a prerequisite for development of varieties to fulfill the existing demand. Economically important traits are generally quantitative in nature that interacts with the environment where it is grown. This is why breeder should calculate the variability by partitioning into genotypic, phenotypic, and environmental effects. Creation of variability is prerequisite for crop breeders. Floral traits are quantitative in nature, and interact with the environment under study, so partitioning the traits into genotypic, phenotypic, and environmental effects is essential to find out the additive or heritable portion of variability. Table 2 presents the mean, range, genotypic and phenotypic variance (V_g, V_p) and coefficient of variation (GCV, PCV), h^2b, GA and GA in percent of mean. In the present investigation, the range of variation was much prominent for all the traits except anther breadth and stigma breadth indicating a wide range of variability among the CMS lines studied. High genotypic and phenotypic variances were observed for panicle exertion rate, angle of floret opening, duration of florate opening, filament length, stigma exertion rate and out crossing rate showing the presence of the wide range of variability among the traits in CMS lines. In contrast anther length, anther breadth, stigma length and breadth had showed low genotypic and phenotypic variances that indicate no scope of selection on the basis of these traits for improvement of CMS lines. Panicle exertion rate, angle of florate opening, duration of florate opening, filament length, stigma exertion rate and out crossing rate had close differences in genotypic and phenotypic variances along with genotypic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV) values, indicating preponderance of additive gene effects for these traits. Less environmental influence in the expression of these traits or the major portion of the phenotypic variance was genetic in nature and greater scope of improvement of CMS line through selection. Hossain *et al.* (2016) reported similar findings. Variability alone is not of much help in determining the heritable portion of variation. The amount of gain expected from a selection depends on heritability and genetic advance in a trait.

Heritability has been widely used to assess the degree to which a character may be transmitted from parent to offspring. Knowledge of heritability of a character is important as it indicates the possibility and extent to which improvement is possible through selection. However, high heritability alone is not enough to make sufficient improvement through selection generally in advance generations unless accompanied by a substantial amount of genetic advance (Johnson *et al.*, 1955b). The expected genetic advance is a function of selection intensity, phenotypic variance, and heritability and measures the differences between the mean genotypic values of the original population from which the progeny is selected. It has been emphasized that genetic gain should be considered along with heritability in coherent selection breeding programme (Sarker *et al.*, 2015). It is considered that if a trait is governed by non-additive gene action it may give high heritability but low genetic advance, which limits the scope for improvement through selection, whereas if it is governed by additive gene action, heritability and genetic advance would be high, consequently substantial gain can be achieved through selection. The heritability was high for all the traits indicated the preponderance of additive gene action for these traits. High heritability coupled with high GA in percent of mean was observed for all the traits indicated that were governed to a great extent by additive gene. So selection based on these traits would be effective for the improvement of CMS lines. High heritability (84.9) and high genetic advance as percent of mean (23.54) were recorded for stigma exertion rate by Vagolu (2010).

Table 2. Genetic parameter for floral attributes of 30 CMS lines.

Character	Range	MS	σ^2g	σ^2e	σ^2p	GCV	PCV	h^2_b	GA	GAPM
PER	52.45-78.26	196.53**	65.47	0.13	65.60	12.60	12.67	99.80	12.77	19.88
AFO	17.71-26.11	14.19**	4.70	0.09	4.79	9.98	10.08	98.06	3.39	15.62
DFO	79.13-185.3	2522.59**	840.79	0.23	841.02	20.16	20.17	99.97	45.81	31.86
FL	4.53-7.27	1.42**	0.47	0.02	0.49	11.68	11.91	96.10	1.06	18.09
AL	1.08-2.87	0.69**	0.23	0.01	0.24	25.57	25.90	97.44	0.75	39.87
AB	0.38-0.58	0.009**	0.01	0.01	0.02	10.52	12.33	72.73	0.07	14.17
SL	0.95-1.67	0.13**	0.04	0.01	0.05	15.44	15.97	93.43	0.32	23.58
SB	0.23-0.61	0.05**	0.02	0.01	0.03	29.21	30.11	94.12	0.19	44.78
SER	46.21-80.31	348.22**	116.05	0.07	116.12	17.39	17.39	99.94	17.02	27.46
OCR	15.37-35.78	97.41**	32.45	0.06	32.51	22.38	22.40	99.82	8.99	35.33

** = Significant at the 1% level, σ^2g = Genotypic variance, σ^2e = Environmental variance, σ^2p = Phenotypic variance, GCV = Genotypic coefficients of variations, PCV = Phenotypic coefficients of variations, h^2_b = Heritability in broad sense, GA = Genetic advance, GAPM = Genetic advance percent of mean. PER = Panicle exertion rate(%), AFO = Angle of florat opening (0°), DFO = Duration of florate opening (min), FL = Filament length (mm), AL = Anther length (mm), AB = Anther breadth (mm), SL = Stigma length (mm), SB = Stigma breadth (mm), SER = Stigma exertion rate (%) and OCR = Out crossing rate (%).

Correlation studies

Table 3 presents the phenotypic and genotypic correlations between the various characters. In the present investigation, the genotypic correlation coefficients were very much close to the corresponding phenotypic values for all the traits indicating additive type of gene action i.e., less environmental influence on the expression of the traits.

From Table 3 it was revealed that out crossing rate had a significant positive correlation with panicle exertion rate (0.986**), angle of florate opening (0.895**), duration of florate opening (0.865**), filament length (0.777**), stigma length (0.884**), stigma breadth (0.746**) and stigma exertion rate (o.993**) indicating selection for high panicle exertion rate, angle of florate opening, duration of florate opening, filament length, stigma length, breadth and exertion rate were closely

Table 3. Genotypic (r_g) and phenotypic (r_p) correlation coefficient for floral attributes of 30 CMS lines.

Character		AFO	DFO	FL	AL	AB	SL	SB	SER	OCR
PER	r_g	0.989**	0.964**	0.883**	0.392	0.567	0.785**	0.777**	0.995**	0.986**
	r_p	0.981**	0.963**	0.768**	0.331	0.429	0.765**	0.674*	0.894**	0.884**
AFO	r_g		0.881**	0.898**	0.473	0.596	0.791**	0.863**	0.791**	0.895**
	r_p		0.875**	0.817**	0.442	0.379	0.779**	0.756**	0.684*	0.788**
DFO	r_g			0.628	0.565	0.494	0.698*	0.763**	0.963**	0.865**
	r_p			0.553	0.491	0.435	0.478	0.660*	0.862**	0.764**
FL	r_g				0.629*	0.684*	0.564	0.473	0.778**	0.777**
	r_p				0.587	0.632*	0.504	0.351	0.664*	0.665*
AL	r_g					0.592	0.434	0.454	0.593	0.696
	r_p					0.521	0.364	0.444	0.484	0.646
AB	r_g						0.255	0.372	0.685	0.685
	r_p						0.198	0.259	0.475	0.574
SL	r_g							0.774**	0.784**	0.884**
	r_p							0.650*	0.767**	0.823**
SB	r_g								0.764**	0.746*
	r_p								0.662*	0.643*
SER	r_g									0.993**
	r_p									0.892**

** = Significant at the 1% level and * = Significant at the 5% level, PER = Panicle exsertion rate (%), AFO = Angle of florat opening (0°), DFO = Duration of florate opening (min), FL = Filament length (mm), AL = Anther length (mm), AB = Anther breadth (mm), SL = Stigma length (mm), SB = Stigma breadth (mm), SER = Stigma exsertion rate (%) and OCR = Out crossing rate(%).

associated with high out crossing rate i.e. increase in panicle exertion rate, angle of florate opening, duration of florate opening, filament length, stigma length, breadth and exertion rate could lead to increase the out crossing rate of CMS line. Rajkumar and Ibrahim (2015) revealed that panicle exertion rate had positive association with out-crossing rate. Similarly Roy *et al.* (2015) observed significant positive association between yield and its contributing traits in rice. Stigma exertion rate had the significant positive association with panicle exertion rate (0.995**), angle of florate opening (0.791**), duration of florate opening (0.963**), filament length (0.778**), stigma length (0.784**) and stigma breadth (0.764**) indicating high stigma exertion rate with high out crossing rate. A similar trend was observed by earlier work in CMS line (Hossain *et al.*, 2016). Genotypic correlation was found insignificant between stigma breadth with anther length and breadth. It was also found insignificant between stigma length with anther length and breadth indicated that selection for high anther length and breadth might be possible without compromising seed yield loss. Similarly, no significant association was found between anther breadth and length with panicle exertion rate, angle of florate opening, duration of florate opening. Filament length and duration of florate opening showed significant positive association with panicle exertion rate and angle of florate opening that exhibited a significant positive correlation with panicle exertion rate.

Path coefficient studies

Path coefficient analysis was carried out using genotypic correlation coefficient among ten floral traits to estimate the direct and indirect effect on out crossing rate in CMS line (Table 4). The angle of florate opening (0.821) and stigma exertion rate (0.771) exhibited high positive direct effect on out crossing rate. On the other hand, high negative direct effect was observed in stigma length (-0.407) and moderate negative direct effect was found in anther length (-0.244) and stigma breadth (-0.247). Anther breadth (=0.002) had negligible negative direct effect on out crossing rate. Similarly, Hasan *et al.*, (2015) observed that yield contributing traits had direct positive effect on grain yield in hybrid rice. Hossain *et al.*, (2016) also observed percent stigma exertion had remarkable positive direct effect on out crossing rate. The panicle exertion rate (0.123) showed little positive direct effect on out crossing rate. The duration of florate opening (0.103) and filament length (0.198) exhibited considerable positive direct effect on out crossing rate. It was interesting that path coefficient analysis results confirmed the similarity of the correlation coefficient analysis result. Anther length had considerable negative direct effect and insignificant positive correlation and anther breadth exhibited negligible negative direct effect and insignificant positive correlation. Direct selection based on these two traits (anther length and breadth) would not be effective for the improvement of out crossing rate i.e. seed yield of CMS lines. Concomitant selection based on high panicle exertion rate and high out crossing rate would be effective for the improvement of CMS lines. Panicle exertion rate showed considerable positive direct effect with high positive genotypic correlation on out crossing rate. Vagolu (2010) revealed that panicle exertion rate had positive direct effect and positive correlation with out-crossing percentage. Direct selection on the basis of panicle exertion rate would be effective for improving out crossing rate as well as seed yield of CMS lines.

Large amount of variability in respect of panicle exertion rate, floral characteristics and stigma exertion rate were observed among the CMS lines while analyzing genetic parameters, correlation and path coefficient values and interpretation of these results. Breeder may utilize the present findings for developing

Table 4. Partitioning of genotypic correlation into direct (bold) and indirect effect for floral attributes of 30 CMS lines.

Character	Effect through									OCR
	PER	AFO	DFO	FL	AL	AB	SL	SB	SER	
PER	**0.123**	0.812	0.099	0.194	-0.241	-0.003	-0.400	-0.240	0.766	0.986**
AFO	0.002	**0.821**	0.101	0.197	-0.244	-0.002	-0.403	-0.237	0.763	0.895**
DFO	0.002	0.806	**0.103**	0.196	-0.235	-0.001	-0.406	-0.237	0.741	0.865**
FL	0.002	0.820	0.103	**0.198**	-0.241	-0.001	-0.412	-0.239	0.754	0.777**
AL	0.002	0.821	0.099	0.196	**-0.244**	-0.002	-0.403	-0.235	0.764	0.696
AB	0.003	0.817	0.102	0.200	-0.242	**-0.002**	-0.408	-0.239	0.759	0.685
SL	0.002	0.813	0.103	0.200	0.241	-0.001	**-0.407**	-0.240	0.759	0.884**
SB	0.002	0.790	0.099	0.192	-0.232	-0.001	-0.396	**-0.247**	0.743	0.746*
SER	0.002	0.813	0.099	0.193	-0242	-0.002	-0.400	-0.238	**0.771**	0.993**

Residual effect – 0.067. ** = Significant at the 1% level and * = Significant at the 5% level. PER = Panicle exertion rate(%), AFO = Angle of florate opening (0°), DFO = Duration of florate opening (min), FL = Filament length (mm), AL = Anther length (mm), AB = Anther breadth (mm), SL = Stigma length (mm), SB = Stigma breadth (mm), SER = Stigma exsertion rate (%) and OCR = Out crossing rate (%).

high seed producing CMS line with good floral characteristics in future. Further investigation may be carried out to confirm the study in different locations of Bangladesh for their stability analysis.

CONCLUSION

Considering high genotypic and phenotypic variance along with genotypic coefficient of variability and phenotypic coefficient of variability values, high heritability coupled with high genetic advance and genetic advance in percent of mean of six traits i.e. panicle exertion rate, angle of florate opening, duration of florate opening, anther length, stigma exertion rate and out crossing rate would be selected for the improvement of 30 CMS lines under study. However, correlation study revealed that strong positive association of panicle exertion rate, angle of florate opening, duration of florate opening, filament length, stigma length, breadth and exertion rate with out-crossing rate. Selection based on panicle exertion rate, angle of florate opening, duration of florate opening, filament length, stigma length, breadth and exertion rate could lead to increase the seed yield of CMS line. Based on direct selection through panicle exertion rate, angle of florate opening, duration of florate opening, filament length and stigma exertion rate would significantly improve seed yield of CMS lines. On the basis of mean, genetic parameters, correlation coefficient value and direct selection of eight CMS lines IR79156A, BRRI7A, IR75608A, BRRI13A, BRRI35A, BRRI48A, BRRI50A and BRRI53A might be selected as good floral characteristics with high out-crossing rate of CMS lines.

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