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Cause and Effect Relationship in Yield and Its Attributing Traits in Early Segregating Generations of Mustard Crosses under Terai Agro-Climatic Zone of West Bengal, India

Suvendu Kumar Roy[1*], Lakshmi Hijam[1], Moumita Chakraborty[1], Nagnathwar Vishal Ashokappa[1], Sanghamitra Rout[1], Vinod Ashok Kale[1], Bijaya Sur[1], Bilin Maying[1], Aparajita Das[1], Abhijit Kundu[2], Rupsanatan Mandal[3] and Hossain Ali Mondal[3]

[1]Department of Genetics and Plant Breeding, Faculty of Agriculture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India
[2]All India Network Project on Jute and Allied Fibres, Directorate of Research, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India
[3]Regional Research Station (Terai Zone), *Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India*

**Corresponding author*

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A B S T R A C T

In F_3 population except seeds per siliqua and 100 seed weight the 15 crosses differed significantly for all the other nine characters, however in F_4 population the 15 crosses differed significantly for all the characters. Pusa Bahar × Rajasthan local selection -1 (13.62) was the highest performer in F_3 generation and in F_4 Rajasthan local selection1 × Pusa Barani (12.53) was the highest yielder. High h^2 and GA were found for height upto first fruiting branch and seed yield per plant in both F_3 and F_4 and GA were found for height upto first fruiting branch and seed yield per plant in both F_3 and F_4 generations. At genotypic level seed yield per plant was positively associated with the plant height, days to physiological maturity, secondary branches per plant and 100 seed weight in F_3 generation and primary branches per plant in F_4 generation. At phenotypic level, seed yield per plant was positively associated with plant height, days to physiological maturity and secondary branches per plant and positive association and high direct effect on seed yield per plant was exhibited by plant height and secondary branches per plant in F_3 generation and in F_4 generation primary branches per plant was positively associated with seed yield per plant although it had negative direct effect on seed yield, due to its better performance through days to physiological maturity, secondary branches per plant and total chlorophyll content and indirect selection for seed yield improvement in F_4 generation is possible for the present set of mustard crosses.

Introduction

Rapeseed-mustard contributes 27 % of the total oilseed production in India accounting for about 14% of world production and 22.5% of world area under rapeseed mustard. The genus *Brassica* comprises of six species (*B. campestris*, *B. oleraceae*, *B. juncea*, *B. nigra*,

B. napus and *B. carinata).* Among them the first three species are elementary and diploids with 2n=16, 18 and 20 and the other three are tetraploids with chromosome members 2n=34, 36 and 38. The edible oil is obtained from *B. napus*, *B. juncea* and *B. campestris*. Oleiferous *Brassicas* cultivated in India are divided into three groups: rai (mustard), sarson (colza) and toria (rape). Information on the nature and magnitude of variability present in the existing material and association among the various morphological characters is a pre-requisite for any breeding programme to be initiated by the breeder for higher yields. However, seed yield, a complex character is usually controlled by non-additive gene actions and it is not only influenced by number of other morphological characters which are governed by a large number of genes, but also by environment to a great extent. Thereby, the heritable variation creates difficulty in a selection programme. Therefore, it is necessary to partition the overall variability into heritable and non-heritable components, which enables the breeders to adopt suitable breeding procedure for further improvement of genetic stocks. Mutual association of plant characters which is determined by correlation coefficient is useful for indirect selection. This further permits evaluation of relative influence of various components of yield. The path coefficient analysis proposed by Wright (1921), is helpful in partitioning the correlation coefficient into direct and indirect effects and in the assessment of relative contribution of each component to the yield. The present study was envisaged with the objective to study the character association in early segregating populations of mustard crosses.

Materials and Methods

The materials used were developed and maintained by Regional Research Station Programme on Mustard, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The field experiments were conducted at Instructional Farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India, during rabi seasons of two consecutive years (2010-11 and 2011-12). The materials used were developed and maintained by Regional Research Station Programme on Mustard, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The materials represented the seeds of segregating mustard crosses which were advanced by bulk method of breeding for the individual crosses (Table 1). The experimental site belongs to the sub-tropical humid climate, being situated just south of the tropic of cancer (Table 2). The mustard crosses in their F_3 generation, was sown on 30th November 2010-11 in the first year and the F_4 generation was sown on 29th November 2011-12 in the second year, for experimental trials. Randomized Block Design was followed for the two experiments, where segregating populations of mustard were sown with 10 cm plant to plant and 30 cm row to row spacing in 20 m^2 plots, in three replications. Observations were recorded for the following characters for both the experimental trials in 2010-11 and 2011-12 i.e., plant height, height upto first branching, days to 50% flowering, days to physiological maturity, primary branches per plant, secondary branches per plant, siliquae per plant seeds per siliqua, total Chlorophyll Content, 100-seed weight and seed yield per plant.

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability in broad sense (h^2), GA as % of mean, correlation coefficient at genotypic and phenotypic level and path coefficient analysis were computed using standard statistical methods. Heritability (BS) was estimated according to Hanson *et al.,* (1956). Phenotypic and genotypic coefficient of variation were

estimated as per Burton (1952). GA as % of mean was estimated according to Johnson *et al.,* (1995). Correlations were worked out according to the procedure of Weber and Moorthy (1952). The partitioning of genotypic correlation coefficient of traits into direct and indirect effect was carried out using procedure suggested by Dewey and Lu (1959).

Statistical analysis

The statistical analysis was carried out using the software Windowstat (earlier Indostat).

Results and Discussion

Analysis of variance (ANOVA) was done with respect to each of the eleven yield attributing characters in segregating F_3 population in the first year (2010-11) and F_4 population in the second year (2011-12). The ANOVA (Table 3) revealed that the fifteen crosses in F_3 population in the first year except seeds per siliqua and 100 seed weight in the F_3 population in first year and F_4 population in the second year, differed significantly for all the characters. Similar findings were reported by Prasad *et al.,* (2010) and Singh *et al.,* (2010).

The mean performance of the F_3 and F_4 generations of mustard crosses revealed a lot of variability for the different yield attributing characters (Table 4). The estimates of various genetic parameters exhibited wide range of variability for all the characters (Table 5). The degree of variability shown by the different characters can be judged by the values of genotypic coefficient of variation and phenotypic coefficient of variation. The GCV and PCV were comparatively high for the character seeds per siliqua in F_3 generation and height up to first fruiting branch in F_4 generation which indicated the presence of high amount of both genotypic as well as phenotypic variability for these characters in the genetic material. Similar result was obtained by Uddin *et al.,* (1995), Meena *et al.,* (2000), Verma *et al.,* (2001), Sudan *et al.,* (2004), Nigam *et al.,* (2009), Singh *et al.,* (2011), Shazia *et al.,* (2011), Yadav *et al.,* (2012) Shekhawat *et al.,* (2014) and Meena *et al.,* (2017). The estimates of GCV and PCV were low for days to 50% flowering, days to physiological maturity and 100 seed weight in both F_3 and F_4 generation (Yadav *et al.,* 2012). A close proximity in PCV and GCV was observed in plant height, height up to first fruiting branch, days to 50% flowering, days to physiological maturity and siliquae per plant in both the generations except siliquae per plant in F_3 generation indicating little influence of the environment in the expression of these yield attributing characters studied. Similar results were obtained by Singh *et al.,* (2015) and Srivastava *et al.,* (2016).

The high estimate of h^2 was observed in plant height, height up to first fruiting branch, days to 50% flowering, days to physiological maturity, and seed yield per plant, in both F_3 and F_4 generations, but secondary branches per plant and siliquae per plant only in F_4 generation showed high heritability.

The heritability estimates for different characters depend on genetic makeup of the breeding material studied. High heritability will be effective being less influenced by environmental useful in indicating the relative value of selection based on phenotypic expression of different characters.

Thus, these characters indicated that simple selection on the basis of phenotypic performance of the genotype would be more efficient in further improvement of these characters. High heritability estimates for most of the characters studied have been reported earlier also by Diwakar and Singh (1993),Sangwan *et al.,* (1994), Singh *et al.,* (2013) and Vermai *et al.,* (2016).

Table.1 List of 15 mustard crosses evaluated over two years (F_3 during 2010-11 and F_4 during 2011-12)

Cross No.	Name of Cross
1	Varuna × Bhagirathi
2	PusaBahar × Rajasthan Local Sel-2
3	Varuna × Pusa Barani
4	Raj Local Sel1 × Pusa Jaikissan
5	Varuna × Raj Local sel-2
6	Pusa Bahar × Chaita Local
7	Seeta (B-85) × Kranti
8	Pusa Bold × Rajasthan Local Sel -1
9	Pusa Bahar × Rajasthan Local Sel-1
10	Pusa Bold × Seeta (B- 85)
11	Seeta (B- 85) × Rajasthan Local Sel-1
12	Raj Local sel- 2 × Kranti
13	Raj Local sel2 × Kranti
14	Raj Local sel2 × Pusa Barani
15	Seeta (B-85) × Rajasthan Local Sel-2

Table.2 Average monthly records of meteorological parameters at the experimental site *i.e.*, instructional farm, Uttar Banga Krishi Viswavidyalaya, during rabi season of 2010-11 and 2011-12

Year	Months	Temperature (°C)		Total rainfall (mm)	Relative humidity (%)	
		Max.	Min.		Max.	**Min.**
2010	November	31.75	22.41	0.027	76.57	**79.87**
	December	26.45	15.54	1.07	79.16	**76.55**
2011	January	24.48	10.65	0.05	90.29	**70.71**
	February	28.18	12.29	0.031	82.04	**58.89**
2011	November	29.03	14.73	0.017	79.57	**80.43**
	December	26.88	12.21	0.01	90.71	**82.42**
2012	January	22.39	9.32	0.11	-99.00	**-99.00**
	February	**26.41**	**11.48**	**0.52**	**-99.00**	**-99.00**

Source: Department of Agronomy, Uttar Banga Krishi Viswavidyalaya, Pundibari, CoochBehar, West Bengal.

Table.3 Analysis of variance for different characters of segregating populations of 15 mustard crosses

Year	Sources of variation	d.f.	Mean Sum of Square (MS)										
			Plant height (cm)	Height upto first fruiting branch (cm)	Days to 50% flowering	Days to physiological maturity	Primary Branches per plant	Secondary Branches per plant	Siliquae per plant	Seeds per siliqua	Total Chlorophyll content (spad502)	100 seed weight (g)	Seed yield per plant (g)
F_3 (2010-11)	Replication	2	46.56*	5.83	0.27	0.56	0.40	1.65	801.92	890.13	70.06*	0.001	0.36
	Genotypes	14	693.72**	232.66**	14.61**	39.70**	0.96*	5.59**	2347.86**	1004.12	52.44**	0.003	15.40**
	Error	28	10.47	11.45	1.65	1.19	0.45	1.95	670.67	866.87	17.74	0.002	2.47
F_4 (2011-12)	Replication	2	0.42	2.76	8.02*	0.42	0.28	0.05	4.39	1.17	8.94	0.002	0.096
	Genotypes	14	1404.84**	664.95**	20.02**	38.12**	0.83**	8.69**	3245.36**	4.57**	31.51**	0.003*	15.12**
	Error	28	5.11	3.92	2.38	1.71	0.24	0.78	5.73	1.17	8.93	0.001	0.30

*, ** = Significant at 5% and 1% levels, respectively

Table.4 Mean table for different characters of segregating population of 15 mustard crosses over two years

Characters / Crosses		Plant height (cm)	Height upto first fruiting branch (cm)	Days to 50% flowering	Days to physiological maturity	Primary Branches per plant	Secondary Branches per plant	Siliquae per plant	Seeds per siliqua	Total Chlorophyll content (spad502)	100 seed weight (g)	Seed Yield per plant (g)
Varuna × Bhagirathi	F_3 (2010-11)	143.53	27.57	52.00	94.33	4.87	7.67	126.07	13.87	37.67	0.47	10.75
	F_4(2011-12)	147.33	44.50	51.67	115.33	4.60	8.10	217.33	14.03	43.33	0.44	7.29
Pusa Bahar× RajLocal Sel -2	F_3 (2010-11)	142.80	25.10	50.33	98.00	5.37	6.50	164.17	13.77	45.93	0.52	11.61
	F_4(2011-12)	152.33	21.83	51.33	105.33	5.30	6.20	284.87	11.17	43.22	0.47	10.85
Varuna × Pusa Barani	F_3 (2010-11)	137.33	19.73	49.33	95.33	5.23	5.43	216.57	13.53	43.27	0.44	10.36
	F_4(2011-12)	174.67	54.27	53.67	110.00	4.60	6.87	227.83	10.63	42.37	0.52	8.54
Raj Local Sel-1× Pusa Jaikissan	F_3 (2010-11)	153.70	17.73	52.33	99.00	5.73	7.23	201.73	13.43	48.17	0.48	8.94
	F_4(2011-12)	177.30	56.83	53.33	110.00	5.70	10.33	234.50	13.10	48.27	0.48	10.27
Varuna × Raj Local sel- 2	F_3 (2010-11)	125.80	22.63	52.33	96.00	5.60	8.27	177.47	12.93	38.67	0.43	6.31
	F_4(2011-12)	187.00	36.30	48.67	107.67	5.07	8.17	195.77	12.77	45.30	0.50	9.66
Pusa Bahar × Chaita Local	F_3 (2010-11)	115.34	17.27	46.67	95.00	4.47	4.10	115.33	19.23	44.70	0.43	5.21
	F_4(2011-12)	142.33	37.40	55.67	114.33	4.30	4.77	172.33	13.83	49.84	0.42	5.17
Seeta (B-85) × Kranti	F_3 (2010-11)	136.80	35.13	47.00	98.33	4.33	8.80	162.93	12.43	39.30	0.44	11.64
	F_4(2011-12)	150.03	29.20	50.00	113.00	5.83	9.08	238.07	13.33	40.20	0.46	8.67
Pusa Bold × Raj Local Sel -1	F_3 (2010-11)	150.37	33.90	50.00	104.67	4.53	7.53	177.90	32.60	44.53	0.45	12.28
	F_4(2011-12)	108.53	20.43	52.00	114.67	4.17	7.10	193.37	13.63	42.90	0.53	9.22
Pusa Bahar × Raj Local Sel- 1	F_3 (2010-11)	164.70	71.03	47.67	103.33	5..50	8.70	203.20	12.90	34.50	0.51	13.62
	F_4(2011-12)	155.07	22.60	53.00	114.00	4.27	8.47	227.20	12.20	43.67	0.48	7.51
Pusa Bold × Seeta (B- 85)	F_3 (2010-11)	165.60	25.37	48.00	97.33	5.67	7.50	157.23	14.10	41.33	0.50	10.50
	F_4(2011-12)	156.16	15.73	51.67	111.67	4.80	9.13	206.00	12.50	37.40	0.46	11.27
Seeta (B- 85)×RajLocal Sel- 1	F_3 (2010-11)	140.30	35.10	53.00	93.33	5.97	6.93	195.63	11.90	38.60	0.44	10.57
	F_4(2011-12)	155.70	25.53	52.33	117.67	5.63	8.70	153.00	15.30	38.43	0.50	12.27
Raj Local sel- 2 × Kranti	F_3 (2010-11)	156.07	52.50	46.33	94.60	4.53	7.00	165.13	11.77	35.73	0.47	9.76
	F_4(2011-12)	132.47	15.20	49.00	115.00	5.03	7.93	222.63	14.15	44.83	0.43	11.29
Raj Local sel- 2 × Pusa Barani	F_3 (2010-11)	125.63	28.10	48.00	98.33	4.27	6.70	159.83	13.20	39.63	0.46	11.43
	F_4(2011-12)	171.83	55.50	53.67	115.00	4.70	3.83	171.83	12.57	42.90	0.48	12.53
Raj Local sel- 1 × Kranti	F_3 (2010-11)	130.60	25.47	50.00	104.33	4.80	8.13	164.33	11.00	47.53	0.49	10.64
	F_4(2011-12)	146.37	35.20	57.00	117.00	4.80	7.70	201.33	13.17	45.30	0.47	6.96
Seeta (B- 85) × Raj Local Sel- 2	F_3 (2010-11)	123.10	29.80	49.00	96.00	4.83	4.80	195.53	12.23	41.70	0.48	7.38
	F_4(2011-12)	115.60	14.57	47.33	109.00	4.63	8.60	236.47	14.60	43.20	0.46	6.22
Mean (F_3)		140.78	28.43	49.47	97.86	5.05	7.02	172.20	19.26	41.42	0.47	10.07
Mean (F_4)		151.51	32.34	52.02	112.64	4.90	7.66	212.17	13.13	43.41	0.47	9.18
CD of F_3 (P= 0.05)		5.41	5.66	2.15	1.83	1.12	2.33	43.31	-	7.04	-	2.62
CD of F_4 (P= 0.05)		3.78	3.31	2.58	2.19	0.82	1.48	4.00	1.81	5.00	0.06	0.92

Table.5 Genetic parameters for different characters of segregating population of 15 mustard crosses over two years

Characters		Plant height (cm)	Height upto first fruiting branch (cm)	Days to 50% flowering	Days to physiological maturity	Primary Branches per plant	Secondary Branches per plant	Siliquae per plant	Seeds per siliqua	Total Chlorophyll content (spad502)	100 seed weight (g)	Seed Yield per plant (g)
Mean	F_3 (2010-11)	140.78	28.43	49.47	97.86	5.05	7.02	172.20	19.26	41.42	0.47	10.07
	F_4(2011-12)	151.51	32.34	52.02	112.64	4.90	7.67	212.17	13.13	43.41	0.47	9.18
Range	F_3 (2010-11)	112.23-169.70	13.70-55.50	44.00 - 53.00	92.00-107.00	3.20-6.80	3.60-10.90	114.0-283.20	8.90 - 210.90	29.80-52.30	0.35-0.61	4.75-14.33
	F_4(2011-12)	107.60-189.00	13.10-58.00	45.00-58.00	104.00-119.00	3.90-7.00	3.10-11.90	152.00-289.00	10.00 - 17.10	34.30- 52.30	0.34- 0.54	4.900-13.43
CV (%)	F_3 (2010-11)	2.30	11.90	2.59	1.12	13.30	19.89	15.04	152.87	10.17	9.05	15.61
	F_4(2011-12)	1.49	6.12	2.96	1.16	10.03	11.52	1.13	8.25	6.88	7.32	9.10
PCV	F_3 (2010-11)	10.96	32.47	4.94	3.83	15.60	25.34	20.36	156.85	13.07	9.79	25.86
	F_4(2011-12)	14.33	46.31	5.52	3.30	13.50	24.11	15.53	11.56	9.34	8.64	24.94
GCV	F_3 (2010-11)	10.72	30.20	4.20	3.66	8.15	15.70	13.73	35.12	8.21	3.74	20.62
	F_4(2011-12)	14.26	45.90	4.66	3.09	9.04	21.18	15.49	8.10	6.32	4.59	24.21
h^2 (B.S)	F_3 (2010-11)	95.6	86.6	72.4	91.5	27.3	38.4	45.5	5.00	39.5	14.6	63.6
	F_4(2011-12)	98.9	98.3	71.2	87.7	44.8	77.2	99.5	49.1	45.7	28.2	94.2
GA as % of mean	F_3 (2010-11)	21.59	57.89	7.36	7.21	8.77	20.03	19.07	16.20	10.63	2.95	33.88
	F_4(2011-12)	29.21	93.72	8.10	5.96	12.46	38.33	31.82	11.69	8.80	5.02	48.40

Table.6 Genotypic association between yield and its attributing traits in segregating population of 15 mustard crosses over two years

Sl. No.	Characters		Height upto first fruiting branch (cm)	Days to 50% flowering	Days to physiological maturity	Primary Branches per plant	Secondary Branches per plant	Siliquae per plant	Seeds per siliqua	Total Chlorophyll content (spad,502)	100 seed weight (g)	Seed Yield per plant (g)
1	Plant height (cm)	F_3 (2010-11)	0.354	-0.173	0.275	0.560*	0.617**	0.317	-0.975**	-0.302	0.913**	0.669**
		F_4(2011-12)	0.661**	0.005	-0.277	0.460*	0.027	-0.053	-0.580*	0.066	0.264	0.355
2	Height upto first fruiting branch (cm)	F_3 (2010-11)		-0.356	-0.037	-0.354	0.377	0.045	-0.823**	-0.746**	0.056	0.399
		F_4(2011-12)		0.529*	0.037	0.108	-0.266	-0.169	-0.383	0.474*	0.245	0.007
3	Days to 50% flowering	F_3 (2010-11)			-0.014	0.985**	0.124	0.341	-0.908**	0.359	-0.049	-0.141
		F_4(2011-12)			0.489*	-0.313	-0.425	-0.365	-0.227	0.380	0.122	-0.191
4	Days to physiological maturity	F_3 (2010-11)			-0.093	-0.226	0.629**	0.213	-0.012	0.350	0.587*	0.560*
		F_4(2011-12)				-0.252	-0.102	-0.688**	0.660**	-0.120	-0.009	-0.012
5	Primary Branches per plant	F_3 (2010-11)					0.397	0.624**	-0.914**	-0.052	0.485*	0.150
		F_4(2011-12)					0.511*	0.259	0.091	-0.239	-0.009	0.603**
6	Secondary Branches per plant	F_3 (2010-11)						0.100	-0.935**	-0.502*	0.362	0.688**
		F_4(2011-12)						0.291	0.313	-0.297	0.042	0.016
7	Siliquae per plant	F_3 (2010-11)							-0.949**	-0.010	-0.046	0.235
		F_4(2011-12)							-0.564*	0.050	-0.205	-0.121
8	Seeds per siliqua	F_3 (2010-11)								0.811**	-0.997**	**-0.939****
		F_4(2011-12)								0.090	-0.524*	-0.138
9	Total Chlorophyll content (spad	F_3 (2010-11)									0.025	-0.252
		F_4(2011-12)									-0.473*	-0.560*
10	100 seed weight (g)	F_3 (2010-11)										0.819**
		F_4(2011-12)										0.388

*, ** = Significant at 5% and 1% levels, respectively

Table.7 Phenotypic association between yield and its attributing traits in segregating population of 15 mustard crosses over two years

Sl. No.	Characters		Height upto first fruiting branch (cm)	Days to 50% flowering	Days to physiological maturity	Primary Branches per plant	Secondary Branches per plant	Siliquae per plant	Seeds per siliqua	Total Chlorophyll content (spad,502)	100 seed weight (g)	Seed Yield per plant (g)
1	Plant height (cm)	F_3 (2010-11)	0.320	-0.054	0.258	0.288	0.400	0.234	-0.195	-0.187	0.392	0.536*
		F_4(2011-12)	0.655**	0.175	-0.262	0.293	0.011	-0.054	-0.402	0.029	0.141	0.338
2	Height upto first fruiting branch (cm)	F_3 (2010-11)		-0.266	-0.054	-0.258	0.197	0.017	-0.141	-0.451*	0.092	0.303
		F_4(2011-12)		0.432	0.015	0.052	-0.241	-0.167	-0.224	0.272	0.116	0.007
3	Days to 50% flowering	F_3 (2010-11)			-0.113	0.317	0.252	0.182	-0.139	0.094	0.002	0.030
		F_4(2011-12)			0.371	-0.162	-0.290	-0.306	-0.246	0.201	0.033	-0.165
4	Days to physiological maturity	F_3 (2010-11)				-0.073	0.311	0.158	0.013	0.261	0.205	0.460*
		F_4(2011-12)				-0.097	-0.079	-0.655**	0.412	-0.092	-0.158	-0.042
5	Primary Branches per plant	F_3 (2010-11)					0.027	0.418	-0.114	0.061	0.176	-0.105
		F_4(2011-12)					0.429	0.162	0.150	-0.189	-0.049	0.352
6	Secondary Branches per plant	F_3 (2010-11)						0.108	-0.153	-0.188	0.167	0.463*
		F_4(2011-12)						0.260	0.176	-0.203	0.055	0.026
7	Siliquae per plant	F_3 (2010-11)							-0.209	0.004	0.098	0.273
		F_4(2011-12)							-0.385	0.032	-0.095	-0.102
8	Seeds per siliqua	F_3 (2010-11)								0.182	-0.008	-0.251
		F_4(2011-12)								-0.088	-0.161	-0.043
9	Total Chlorophyll content (spad	F_3 (2010-11)									0.040	-0.184
		F_4(2011-12)									-0.158	-0.374
10	100 seed weight (g)	F_3 (2010-11)										0.278
		F_4(2011-12)										0.205

*, ** = Significant at 5% and 1% levels, respectively

Table.8 Genotypic direct (diagonal) and indirect (off-diagonal) effects of different attributing triaits on seed yield in segregating population of 15 mustard crosses over two years

Sl. No.	Characters		Plant height (cm)	Height upto first fruiting branch (cm)	Days to 50% flowering	Days to physiological maturity	Primary Branches per plant	Secondary Branches per plant	Siliquae per plant	Seeds per siliqua	Total Chlorophyll content (spad502)	100 seed weight (g)	Correlation with Seed Yield per plant (g)
1	Plant height (cm)	F_3 (2010-11)	**1.04**	0.17	0.01	-0.02	-0.07	0.50	-0.01	-0.08	-0.34	-0.53	0.67*
		F_4(2011-12)	**-0.28**	4.70	1.34	2.89	-0.13	0.08	0.31	-0.11	-0.61	-1.83	0.36
2	Height upto first fruiting branch (cm)	F_3 (2010-11)	0.37	**0.47**	0.12	0.00	0.05	0.31	0.00	-0.04	-0.83	-0.04	0.40
		F_4(2011-12)	-4.15	**7.11**	3.15	-0.14	-0.03	-0.77	0.99	-0.07	-4.38	-1.70	0.01
3	Days to 50% flowering	F_3 (2010-11)	-0.02	-0.17	**-0.33**	0.01	-0.13	0.10	-0.01	-0.03	0.40	0.03	-0.14
		F_4(2011-12)	-1.42	3.77	**5.95**	-5.10	0.09	-1.22	2.14	-0.04	-3.51	-0.85	-0.19
4	Days to physiological maturity	F_3 (2010-11)	0.29	-0.02	0.03	**-0.08**	0.03	0.51	0.00	-0.25	0.39	-0.34	0.56*
		F_4(2011-12)	1.74	0.10	2.91	**-10.41**	0.07	-0.29	4.03	0.12	1.11	0.61	-0.01
5	Primary Branches per plant	F_3 (2010-11)	0.58	-0.17	-0.33	0.02	**-0.13**	0.32	-0.01	0.20	-0.06	-0.28	0.15
		F_4(2011-12)	-2.89	0.77	-1.86	2.63	**-0.29**	1.47	-1.52	0.02	2.21	0.07	0.60**
6	Secondary Branches per plant	F_3 (2010-11)	0.64	0.18	-0.04	-0.05	-0.05	**0.81**	0.00	-0.03	-0.56	-0.21	0.69**
		F_4(2011-12)	-0.17	-1.89	-1.53	1.06	-0.15	**2.88**	-1.70	0.06	2.74	-0.29	0.02
7	Siliquae per plant	F_3 (2010-11)	0.33	0.02	-0.11	-0.02	-0.08	0.08	**-0.02**	0.01	-0.01	0.03	0.24
		F_4(2011-12)	0.33	-1.20	-2.17	7.16	-0.07	0.84	**-5.85**	-0.10	-0.46	1.42	-0.12
8	Seeds per siliqua	F_3 (2010-11)	0.16	0.04	-0.02	-0.26	0.05	0.04	-0.67	**-0.51**	0.02	0.21	**-0.94****
		F_4(2011-12)	3.64	-2.72	-1.35	-6.87	-0.03	0.90	3.30	**0.19**	-0.83	3.63	-0.14
9	Total Chlorophyll content (spad	F_3 (2010-11)	-0.32	-0.35	-0.12	-0.03	0.01	-0.41	0.00	-0.14	**1.12**	-0.02	-0.25
		F_4(2011-12)	-0.41	3.37	2.26	1.25	0.07	-0.86	-0.93	0.02	**-9.25**	3.28	-0.56*
10	100 seed weight (g)	F_3 (2010-11)	0.95	0.03	0.02	-0.05	-0.06	0.29	0.00	0.19	0.03	**-0.58**	0.82**
		F_4(2011-12)	-1.66	1.75	0.73	0.91	0.00	0.12	1.20	-0.10	4.37	**-6.93**	0.39

*, ** = Significant at 5% and 1% levels, respectively

The GA is also useful indicator of the progress that can be expected as a result of exercising selection on the population. The high estimates of GA expressed as percentage of mean were recorded for height up to first fruiting branch and seed yield per plant in both F_3 and F_4 generations. Johnson *et al.*, (1995) impressed that heritability values along with estimates of GA were more useful than heritability alone. The h^2 along with GA were higher for height up to first fruiting branch and seed yield per plant in both F_3 and F_4 generations indicating that these characters can be improved by simple phenotypic selection as they are more likely to be controlled by additive gene action. Similar result was reported by Sangwan *et al.*, (1994), Uddin *et al.*, (1995) and Akabari *et al.*, (2015).

In the present study, the genotypic correlation coefficient was higher in magnitude than their respective phenotype correlation coefficient for most of the traits indicating depression of phenotypic expression by the environmental influence (Table 6). In F_3 generation seed yield was found to be positively associated with plant height, days to physiological maturity, secondary branches per plant and 100 seed weight, on the other hand seeds per siliqua was found to be negatively associated with seed yield per plant. Plant height was positively associated with primary branches per plant, secondary branches and 100 seed weight and negatively associated with seeds per siliqua. Days to physiological maturity were positively associated with secondary branches per plant and 100 seed weight. Secondary branches per plant was however, negatively associated with total chlorophyll content. In F_4 generation seed yield per plant was positively associated with primary branches per plant and negatively associated with total chlorophyll content (spad). Primary branches per plant was positively associated with only secondary branches per plant. Similar results were reported by Arunachalam and Katiyar (1991), Zehra *et al.*, (2009), Doddabhimappa *et al.*, (2009), Bind *et al.*, (2014), Bhuiyan *et al.*, (2015), Vermai *et al.*, (2016) and Meena *et al.*, (2017).

In phenotypic correlation, F_3 generations showed positive association of seed yield per plant with plant height, days to physiological maturity and secondary branches per plant (Table 7). These three component characters however had no positive association with other yield attributing characters. In F_4 none of the yield attributing characters was positively associated with seed yield per plant which indicated that selection for these characters would be fruitless to improve seed yield.

In F_3 generation the high positive direct effect (Table 8) on seed yield per plant was recorded by plant height, secondary branches per plant and total chlorophyll content (spad) and among these three characters only plant height and secondary branches per plant were positively associated with seed yield, whereas total chlorophyll content (spad) was not associated with seed yield (Table 8). Similar results were reported by Behl *et al.*, (1992), Gosh and Mukhopadhyay (1994), Kumar and Shrivastava (2000) and Bind *et al.*, (2014). Among the other traits which were positively associated with seed yield are days to physiological maturity, secondary branches per plant and 100 seed weight. Days to physiological maturity was positively associated with seed yield because of its superior performance through plant height, secondary branches per plant and total chlorophyll content. Positive association between 100 seed weight and seed yield was due to superior performance of 100 seed weight through plant height and secondary branches per plant. In F_4 generation high direct effect on seed yield per plant was exhibited by height up to first fruiting branch,

days to 50% flowering and secondary branches per plant but direct selection through these three component characters would be fruitless as none of them are positively associated with seed yield. However primary branches per plant which had negative direct effect on seed yield but had positive association with seed yield due to its superior performance, through days to physiological maturity, secondary branches per plant and total chlorophyll content.

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