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Patterns of Genetic Variation, Correlations under Irrigated and Rainfed Conditions in Indian Mustard [*Brassica juncea* (L.) Czern. & Coss.]

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An experiment was conducted on 77 advanced progenies (F_6) of Indian mustard in augmented block design under irrigated (E_1) and water stressed (E_2) conditions to know the patterns of genetic variability and correlations under irrigated and rainfed conditions. Observations were recorded on 12 morphological characters. The estimates of heritability under irrigated conditions were of higher magnitude (>50%) for main shoot length, siliquae on main shoot, siliquae length, seed yield/plant and 1000 seed weight, whereas under rainfed conditions, secondary branches/plant, siliquae on main shoot, siliquae length and 1000 seed weight recorded higher estimates of heritability. For other characters (siliquae/plant, main shoot length and seed yield/plant) moderate estimates of heritability were observed. Under irrigated conditions, seed yield/plant was positively and significantly correlated with plant height (0.241), primary branches/plant (0.381), secondary branches/plant (0.493), fruiting zone length (0.295), siliquae/plant (0.562), biological yield (0.852) and harvest index (0.613) while under rainfed conditions, seed yield/plant was significantly and positively correlated with plant height (0.445), primary branches/plant (0.443), secondary branches/plant (0.611), fruiting zone length (0.505), siliqua/plant (0.729), main shoot length (0.410), seeds/siliqua (0.283), biological yield (0.774) and harvest index (0.482).

Key Words: Correlations, Heritability, Indian mustard, Rainfed

Introduction

Indian mustard [*Brassica juncea* (L) Czern. & Coss. 2n=4x=36] is a natural amphidiploids between *Brassica campestris* (2n=20) and *Brassica nigra* (2n=16). In India, *Brassica juncea* is a predominant species which accounts for nearly 80% of the oilseed brassicas. Central Asia- Himalayas is a primary center of diversity for this species with migration to China, India and Caucasus (Hemingway, 1976). The crop is mainly grown for its oil which is largely used in cooking and for frying purposes. Oilseed cake or meal which is a byproduct during the extraction of oil from the seeds, is an important source of protein feed for animals while the leaves of the plant are used as vegetable as well as fodder for cattle. In spite of all the efforts made over past decades, the productivity has remained almost constant, may be due to lack of high yielding genotypes with stable performance over the environment. There is lack of adequate genetic variability for morphological traits and high degree of genotype x environment interaction.

Concerted breeding efforts are required to bring out favorable change in yielding ability of this crop. The low yield and stability are ascribed to lack of genetic variability for some important yield components, non-availability of short duration, disease and pest resistant genotypes, even the limited world germplasm collections have been attributed to the limited success achieved so far.

The knowledge of the magnitude of genetic parameters of seed yield and its component traits for different conditions is essential for an effective breeding programme. Moreover, association and interaction of different component characters with seed yield may help in selection of superior lines under different environments. Considering the above facts, present study reports the pattern of variability and character association in advanced lines of Indian mustard under irrigated and rainfed conditions.

Materials and Methods

The material for present investigation consisted of 77 advanced progenies (F_6) of Indian mustard (Table 1) selected on the basis of high yield under rainfed conditions in previous generation. These progenies were derived from 49 different crosses involving Exotic × Indian and Indian × Indian genotypes. The experiment was carried out at research farm of Directorate of Rapeseed Mustard Research, Sewar, Bharatpur during 2011-12.

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Table 1. Details of progenies used in experimentation along with their mean values

S. No.	Progeny	Characters																							
		PH (cm)		PB		SB		FZL (cm)		S/P		MSL (cm)		S/MS		SL (cm)		BY(g)		SY (g)		HI (%)		1000 SW (g)	
		IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF
1	BPR-583-1	177.7	168.6	4.6	4.1	6.0	2.8	81.5	72.4	140.4	129.3	77.8	71.4	43.6	43.0	4.2	4.8	45.8	33.7	10.6	9.4	21.0	28.7	5.7	5.6
2	BPR-577-2	187.7	181.0	5.0	4.1	5.4	2.2	77.7	87.4	142.6	104.9	59.0	77.2	49.0	41.6	3.9	4.3	28.3	36.2	5.6	8.0	20.2	21.0	5.6	5.7
3	BPR-686-3	177.1	171.2	3.8	4.5	1.8	3.6	71.7	78.8	100.6	127.9	70.4	78.0	41.0	42.8	3.9	4.1	23.3	38.7	4.6	8.3	21.0	20.1	5.4	6.3
4	BPR-674-4	174.9	175.2	5.6	3.9	8.2	2.4	67.7	67.4	186.0	49.3	59.0	68.8	27.0	36.6	3.7	4.7	38.3	31.2	9.6	6.6	23.3	19.5	5.0	5.4
5	BPR-694-6	164.5	169.8	5.4	4.1	8.4	3.6	71.7	73.0	229.8	166.3	67.6	71.6	41.4	44.6	4.1	4.6	40.8	33.7	7.1	8.4	16.1	24.7	6.3	5.8
6	BPR-682-7	181.1	175.4	4.8	3.9	3.8	3.2	71.3	74.2	158.2	116.1	57.0	72.6	32.4	38.8	3.9	4.5	40.8	23.7	8.7	8.3	19.8	40.5	4.9	5.6
7	BPR-667-8	164.5	165.6	4.4	4.3	6.4	15.0	68.3	72.2	100.8	128.9	67.8	65.4	33.2	40.2	3.9	4.5	35.8	33.7	7.7	8.4	20.4	24.8	6.2	6.3
8	BPR-639-9	178.5	165.0	4.4	3.1	5.4	1.2	77.9	68.4	135.2	88.1	69.0	69.8	40.6	36.4	4.1	4.5	35.8	38.7	7.0	7.6	18.6	17.7	5.1	5.8
9	BPR-691-10	166.3	176.4	4.0	3.3	4.2	2.4	74.5	75.6	157.8	120.7	187.2	84.0	45.4	39.2	4.3	5.0	35.8	36.2	7.9	7.4	21.0	19.0	5.0	6.2
10	BPR-669-12	174.7	163.8	4.8	4.1	4.4	3.8	73.1	74.2	161.0	178.3	63.8	69.8	42.0	38.2	4.0	5.0	35.8	48.7	6.9	8.5	18.4	15.5	4.0	6.9
11	BPR-1299-18	159.9	156.4	4.8	3.9	4.0	2.0	53.1	62.0	105.2	107.1	55.6	57.6	31.8	31.2	3.7	4.3	35.8	38.7	10.2	8.0	26.7	19.3	5.0	6.7
12	BPR-1292-22	167.2	141.2	3.5	3.4	1.7	2.2	62.2	63.6	166.8	120.5	65.2	62.8	37.6	39.2	4.6	4.4	33.8	19.4	9.3	3.3	26.8	17.9	6.8	5.4
13	BPR-1307-250	188.0	148.8	5.7	4.0	2.1	1.6	69.8	68.4	276.0	104.3	88.0	73.6	47.2	44.0	4.4	4.2	38.8	19.4	10.2	5.5	25.7	30.4	6.2	5.7
14	BPR583-26	174.4	143.0	5.3	3.6	3.3	2.2	71.6	65.8	214.2	81.7	65.4	63.2	45.0	35.6	4.2	4.9	41.3	19.4	11.8	4.1	27.9	21.9	6.7	6.4
15	BPR-645-30	185.6	156.0	2.9	3.6	3.5	0.8	88.6	69.4	183.0	114.3	93.8	67.6	35.6	35.4	4.6	4.1	38.8	11.4	9.0	4.4	22.9	37.5	5.7	6.1
16	BPR-669-31	196.8	158.0	3.9	5.4	4.5	2.0	77.8	77.8	214.4	109.1	81.6	64.4	46.6	39.4	4.3	4.7	43.8	24.4	11.2	5.3	25.2	22.0	5.6	5.4
17	BPR-1293-32	202.2	145.2	3.5	3.4	2.3	2.6	77.4	70.6	170.8	95.1	86.6	73.6	48.6	35.8	3.8	4.7	38.8	29.4	9.7	5.7	24.5	19.9	5.1	6.8
18	BPR-1293-33	178.8	158.4	5.3	3.0	2.3	2.2	73.6	69.6	186.6	104.7	128.0	73.0	49.8	35.6	3.9	3.8	41.3	29.4	9.9	9.4	23.5	38.8	5.9	6.0
19	BPR-1300-35	177.6	150.2	3.5	4.6	0.7	0.8	81.2	69.2	135.4	125.1	78.8	73.0	41.6	35.2	3.7	3.9	28.8	20.9	5.0	4.4	17.6	21.9	5.7	6.3
20	BPR-625-36	162.8	156.8	3.5	4.0	3.5	3.8	71.2	82.6	154.2	134.3	84.8	73.8	42.8	42.6	4.4	4.0	31.3	24.4	4.9	4.2	16.1	18.0	5.5	6.1
21	BPR-625-36	176.2	153.8	3.7	3.8	1.7	2.2	88.0	71.8	169.2	106.1	89.2	72.6	47.2	36.4	4.8	3.7	43.8	24.4	9.0	3.7	20.0	15.9	5.9	5.2
22	BPR-625-39	183.0	151.0	4.1	4.4	0.8	1.6	72.4	66.4	156.6	103.9	65.8	64.0	43.0	39.4	4.1	4.1	31.3	16.9	7.5	3.8	23.7	23.3	5.9	5.5
23	BPR-1294-42	181.2	174.4	5.5	3.4	10.8	1.5	86.4	71.6	219.6	184.6	90.9	75.7	48.0	39.4	3.9	4.4	55.2	22.9	13.5	4.7	26.6	21.2	4.6	5.4
24	BPR-625-37	194.6	182.4	5.1	4.2	9.0	0.5	80.0	76.0	166.8	119.8	76.7	68.9	47.4	37.4	4.0	4.6	50.2	30.4	12.4	6.2	26.5	20.5	3.9	6.6
25	BPR-669-1	194.8	153.8	4.5	3.6	8.2	3.9	85.4	67.2	242.8	124.0	84.7	70.3	43.0	39.4	5.1	4.7	65.2	22.9	15.5	4.1	26.3	18.4	5.0	5.3
26	BPR-669-2	172.8	156.4	4.3	3.2	11.2	2.7	85.2	65.2	130.6	106.2	85.7	66.5	39.4	35.0	4.0	4.8	47.7	20.4	10.7	3.8	23.9	19.5	4.9	6.1
27	BPR-694-4	168.0	164.4	5.7	3.8	12.4	2.9	70.4	70.8	235.0	127.2	67.3	68.3	40.2	35.8	4.0	4.6	57.7	25.4	14.2	5.3	26.9	21.3	4.6	5.6
28	BPR-694-5	184.6	155.8	6.5	3.0	15.4	2.1	90.8	59.0	251.2	87.6	75.5	65.1	45.6	30.6	3.6	4.8	75.2	25.4	18.6	5.0	27.6	20.1	4.0	6.2
29	BPR-1304-6	179.8	173.2	3.5	3.4	13.2	4.5	84.4	80.8	218.4	182.4	81.3	87.1	37.0	50.2	4.1	4.5	67.7	40.4	17.3	10.1	28.3	24.6	4.0	6.0
30	BPR-139-7	178.8	172.4	4.5	3.8	10.2	5.7	83.2	75.2	245.8	193.0	76.7	77.5	40.0	39.4	3.8	3.7	62.7	32.9	13.5	11.7	23.7	35.8	3.4	5.0
31	BPR-606-11	178.0	170.0	5.9	4.4	13.0	5.5	78.5	76.8	226.0	191.2	75.1	74.7	44.0	47.2	3.8	4.4	55.2	45.4	15.3	10.8	30.1	23.4	3.4	5.3
32	BPR-639-16	171.0	178.0	5.1	4.6	8.4	7.3	73.2	80.4	199.0	214.8	65.9	81.5	35.8	40.4	3.9	4.2	41.7	57.9	11.9	15.0	30.2	25.2	5.2	6.6
33	BPR-639-18	180.4	177.8	4.7	3.4	12.8	5.1	73.6	78.4	204.2	139.6	79.1	80.1	49.4	30.4	4.1	4.2	52.7	37.9	14.9	9.6	30.6	25.1	5.1	7.0
34	BPR-1298-26	167.0	157.2	5.3	3.5	11.0	5.6	74.4	71.2	232.4	167.8	58.3	64.1	36.8	40.8	3.8	3.5	64.2	45.7	17.4	5.9	29.9	15.4	4.5	4.8
35	BPR-141-36	166.6	143.4	4.5	2.9	8.8	0.6	72.0	55.2	194.6	80.0	72.3	58.5	41.8	38.4	3.4	4.1	40.2	20.7	10.4	4.9	27.2	24.7	4.8	5.7
36	BPR-578-43	166.6	158.0	3.7	2.5	10.2	2.8	63.4	68.2	111.2	125.6	43.5	73.3	37.8	36.2	3.9	3.5	37.7	38.2	9.0	7.7	24.5	21.4	4.1	4.8
37	BPR-675-44	171.6	155.4	3.9	2.9	7.4	3.6	78.0	70.2	206.0	131.0	79.9	65.5	39.8	44.0	3.9	3.1	45.2	38.2	12.0	10.3	28.3	26.7	4.0	4.1
38	BPR-683-45	170.4	149.0	4.5	2.9	5.8	0.4	67.4	64.6	164.6	51.4	70.7	68.1	43.4	39.8	3.9	5.0	47.7	14.2	13.0	4.3	29.3	28.3	5.6	6.1
39	BPR-675-46	167.0	155.6	4.3	3.7	6.8	1.0	62.4	64.0	158.6	59.2	63.1	58.7	42.0	36.8	3.7	3.7	39.2	20.7	11.5	5.2	31.0	25.6	4.2	6.0
40	BPR-656-47	176.0	141.4	2.5	2.5	7.0	3.0	77.0	62.2	177.4	94.0	71.1	64.7	40.8	40.6	4.1	3.8	40.2	22.2	12.6	6.1	33.2	26.9	4.4	4.9
41	BPR-670-48	175.4	164.4	2.9	3.3	4.8	0.8	75.8	63.0	146.4	104.2	79.1	60.1	39.4	40	3.3	3.4	29.7	18.2	7.7	5.1	25.6	27.4	4.4	4.6
42	BPR-156-52	140.4	163.2	4.1	3.9	7.4	6.0	71.6	66.6	188.2	145.8	69.7	64.9	44.8	42.2	5.7	3.5	37.7	23.2	10.5	8.4	29.1	32.7	4.8	5.1
43	BPR-172-53	187.6	153.8	4.5	3.9	10.4	7.8	76.4	72.8	221.0	265.4	71.7	61.7	42.6	48.4	3.8	3.66	42.7	40.7	12.5	12.7	31.2	30.0	4.4	4.3
44	BPR-181-54	110.2	152.6	4.1	3.3	5.4	2.4	80.2	66.0	206.0	64.6	65.5	61.9	47.0	35.2	4.0	4.1	39.2	20.7	11.1	1.8	29.8	15.0	3.7	4.3
45	BPR-150-58	169.8	149.5	4.5	3.1	5.6	1.0	72.7	57.0	196.8	106.7	64.4	65.7	37.0	40.1	4.6	3.8	30.0	35.0	7.5	10.3	24.7	29.4	4.8	5.4

Table 1 Contd.

S. No.	Progeny	PH (cm)		PB		SB		FZL (cm)		S/P		MSL (cm)		S/MS		SL (cm)		BY(g)		SY (g)		HI (%)		1000 SW (g)	
		IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF
46	BPR-783-60	209.2	155.3	4.7	3.9	5.4	3.8	78.5	62.0	150.8	131.7	74.6	61.9	45.6	38.7	3.8	3.9	45.0	25.0	10.3	10.5	23.6	38.8	3.3	5.4
47	BPR-1669-44	177.2	140.9	5.7	3.3	7.2	2.8	72.9	48.4	146.0	123.5	65.2	53.7	37.4	35.9	4.3	4.2	42.5	25.0	11.0	9.7	26.9	36.4	4.9	6.3
48	BPR-671-45	191.8	129.7	4.1	2.9	3.4	1.8	84.3	42.8	155.2	97.1	82.8	57.5	48.8	30.9	4.3	4.5	35.0	25.0	8.6	9.0	24.8	33.9	5.1	5.5
49	BPR-645-50	197.8	156.7	5.3	3.3	7.2	3.4	78.7	67.8	166.4	130.3	69.8	66.9	39.4	35.3	3.9	4.2	50.0	35.0	13.9	12.3	29.2	35.3	5.4	6.4
50	BPR-565-52	191.6	155.1	5.5	4.7	5.8	10.2	77.7	60.4	198.2	230.7	67.0	63.1	46.4	41.5	3.2	3.4	35.0	45.0	7.8	16.1	22.2	35.7	4.1	5.8
51	BPR-587-56	189.8	168.9	4.9	4.3	10.4	5.2	78.5	68.2	243.0	223.5	79.2	77.3	46.2	34.5	4.6	3.8	45.0	50.0	11.9	13.9	27.5	28.6	3.7	6.0
52	BPR-630-62	194.8	153.3	5.1	4.7	3.8	0.4	76.9	60.8	127.0	137.1	65.2	71.1	35.0	31.9	5.0	3.8	40.0	42.5	8.1	10.6	20. 2	25.8	5.0	5.6
53	BPR-583-63	208.6	158.9	4.1	3.3	6.2	4.4	69.9	63.6	171.2	168.7	61.6	75.5	43.0	44.5	3.7	3.6	45.0	45.0	10.3	11.6	23.7	26.7	4.8	5.8
54	BPR-606-62	198.2	147.5	4.1	2.9	5.0	2.8	85.9	60.6	169.2	131.1	82.4	66.7	46.2	35.9	4.0	4.5	37.4	42.5	10.6	12.8	29.4	30.5	5.4	6.8
55	BPR-645-68	172.2	148.1	5.9	3.5	6.4	6.4	66.9	65.4	132.6	212.7	61.2	69.9	32.2	34.7	4.7	4.2	47.5	42.5	11.2	10.0	24.4	24.6	4.6	5.4
56	BPR-648-69	172.7	173.8	3.8	3.3	2.2	6.8	62.1	78.4	130.4	181.7	64.2	87.8	37.0	56.8	3.5	4.3	33.8	43.7	5.7	10.3	16.6	23.1	6.0	5.7
57	BPR-667-70	170.5	172.4	3.0	5.3	0.8	7.0	66.5	84.4	75.0	190.5	66.8	79.0	33.6	44.0	4.1	4.3	23.3	51.2	3.5	11.0	17.3	20.4	5.6	5.9
58	BPR-671-71	163.7	158.2	4.8	4.5	4.0	6.2	71.5	73.2	143.0	177.9	61.0	76.4	39.8	47.4	4.3	4.5	25.8	38.7	4.4	9.9	18.1	25.6	4.6	5.8
59	BPR-671-72	146.1	166.6	4.2	3.6	4.8	5.4	72.3	102.2	104.4	178.9	76.4	90.4	41.6	44.4	3.7	4.6	27.3	56.2	4.7	12.8	17.9	22.1	5.8	6.3
60	BPR-671-73	180.3	147.2	3.2	4.3	2.4	7.4	77.7	75.4	86.6	158.7	72.8	84.6	42.2	45.6	3.8	4.3	25.8	53.7	3.1	8.2	14.1	13.1	5.3	5.6
61	BPR-682-74	179.1	185.2	5.2	4.7	3.4	8.0	83.1	90.2	140.4	232.5	78.2	89.8	40.0	53.0	4.1	5.0	35.8	56.2	6.7	13.3	17.9	23.2	4.1	5.1
62	BPR-1309-75	172.5	182.8	4.6	3.9	7.0	6.0	70.5	90.4	125.0	210.9	67.2	90.6	37.2	56.6	4.3	4.9	35.8	51.2	5.5	12.4	14.7	23.8	4.5	5.3
63	BPR-645-76	160.3	178.2	4.0	3.9	2.4	6.6	72.9	86.4	113.0	166.5	69.6	85.8	32.0	50.6	4.6	5.2	35.8	41.2	7.2	10.3	19.2	24.8	5.6	6.7
64	BPR-565-24	161.1	175.6	3.2	7.3	2.4	7.0	73.7	82.6	69.6	200.1	77.8	84.6	38.4	48.2	4.3	4.4	28.3	45.7	5.1	13.6	18.5	30.5	4.7	5.4
65	BPR-572-78	167.5	162.8	3.8	4.5	4.2	4.8	67.1	82.8	66.2	148.9	58.4	85.0	30.0	43.0	4.0	4.4	30.8	38.7	3.4	9.1	12.0	22.9	4.5	6.7
66	BPR-575-79	176.1	155.4	4.0	4.1	2.6	3.8	67.9	82.2	111.2	145.3	66.0	76.4	42.2	42.8	4.5	4.3	38.3	45.2	6.8	7.1	16.9	13.2	4.2	5.1
67	BPR-599-80	158.0	160.8	3.1	5.2	1.2	5.8	69.2	76.4	85.0	166.9	72.0	69.6	39.2	40.8	4.5	4.1	23.8	25.4	5.5	6.6	22.9	26.5	6.1	5.9
68	BPR-605-81	179.0	166.0	4.1	4.8	2.9	6.2	57.0	75.6	165.0	195.1	79.0	71.6	44.0	48.4	4.9	3.8	33.8	36.9	4.8	9.5	14.7	25.9	5.3	5.1
69	BPR-611-82	181.0	160.8	4.1	5.0	4.5	5.8	77.2	76.4	183.1	168.0	80.8	68.8	42.8	41.2	5.4	3.9	51.3	39.4	12.6	10.3	24.1	26.3	5.9	5.3
70	BPR-620-83	185.0	173.6	3.7	4.4	4.3	4.8	82.6	80.8	229.4	187.7	86.6	78.0	54.0	56.0	4.9	3.7	48.8	29.4	12.2	7.2	24.5	24.8	5.8	6.2
71	BPR-624-84	178.6	166.0	5.1	5.0	1.7	6.2	85.2	77.2	163.6	157.3	72.6	74.4	41.6	49.8	4.7	3.8	56.3	24.4	14.5	10.4	25.3	42.7	6.3	5.3
72	BPR-659-85	176.4	174.8	3.9	4.2	1.5	5.8	74.8	93.8	144.4	190.3	75.8	91.2	41.8	54.6	4.8	3.7	38.8	23.9	8.3	8.7	21.3	36.7	5.8	6.0
73	BPR-606-12	181.8	184.2	4.1	4.2	4.9	6.8	73.6	87.6	157.4	203.5	74.4	85.6	45.4	61.6	5.0	3.6	36.3	29.4	7.48	8.1	20.5	27.8	6.0	6.0
74	BPR-639-15	173.8	174.4	3.3	4.4	2.9	4.8	71.2	81.4	214.0	187.9	78.2	78.0	51.8	56.6	4.0	4.1	33.8	37.4	9.5	7.4	27.2	20.3	5.7	5.7
75	BPR-639-17	170.0	162.8	4.3	5.6	6.5	6.0	81.0	93.8	182.4	184.7	86.4	76.4	42.0	48.0	3.9	3.9	31.3	41.9	9.5	10.9	27.9	26.2	5.3	6.6
76	BPR-667-21	158.8	167.0	4.5	4.4	6.1	4.8	70.6	84.4	192.6	200.5	70.2	79.0	40.4	53.4	4.3	3.7	41.3	30.9	11.3	9.1	26.7	29.7	5.4	6.3
77	BPR-682-24	159.4	171.8	4.7	4.4	8.9	6.6	73.6	74.2	232.8	160.5	70.6	77.8	48.2	47.6	3.6	4.7	36.3	39.4	8.9	10.4	24.1	26.6	5.6	4.1
Check	RB 50	169.7	167.2	4.7	3.8	6.3	2.3	73.7	71.4	149.4	134.6	73.8	70.4	41.3	39.7	3.8	4.6	37.8	33.5	8.0	9.6	21.0	29.7	4.3	6.3
Check	RH 819	194.2	169.2	4.6	4.4	7.7	1.7	78.5	69.2	218.4	122.2	75.5	61.4	48.4	39.4	3.4	4.1	43.7	33.2	9.6	8.7	22.0	26.6	4.1	5.1
Check	PBR 97	181.7	162.1	5.2	3.6	7.8	2.8	78.8	72.8	186.3	111.6	73.4	73.4	41.1	42.8	3.5	3.9	31.0	29.0	6.7	7.5	21.6	25.5	4.3	5.1
	General mean	177.1	162.8	4.5	3.9	6.0	3.7	75.2	72.3	171.9	140.3	74.5	71.6	42.0	41.5	4.0	4.2	40.0	33.2	9.3	8.4	23.2	25.7	4.9	5.7
	Range	110.2-209.2	129.7-185.2	2.5-6.5	2.5-7.3	0.7-15.4	0.4-15.0	53.1-90.8	55.2-102.2	66.2-276.0	49.3-265.4	43.5-187.2	53.7-90.4	27.0-54.0	30.6-61.6	3.2-5.7	3.1-5.2	23.3-75.2	11.4-56.2	3.1-18.6	1.8-16.1	12.0-33.2	13.1-42.7	3.3-6.8	4.17.0
	CD at 5%	31.6	25.6	1.5	1.8	8.4	3.4	17.2	20.8	139.8	86.8	18.9	14.2	7.0	8.7	0.7	0.5	20.4	12.8	4.4	4.9	14.0	17.7	0.7	0.9
	SEM	12.1	9.8	0.6	0.7	3.2	1.3	6.6	8.0	53.7	33.3	7.2	5.4	2.6	3.3	0.2	0.2	7.6	4.9	1.7	1.9	5.3	6.8	0.3	0.3

IR=Irrigated, RF=Rainfed

PH = Plant height, PB= Primary branches/plant, SB=Secondary branches/plant, FZL= Fruiting zone length, S/P= Siliquae/plant, MSL= Main shoot length, S/MS= Siliquae on main shoot, SL= Siliqua length, BY= Biological yield/plant, SY= Seed yield/plant, HI=Harvest index (%), 1000 SW= 1000 seed weight.

Experimentation was done in an augmented block design (Fedrer, 1956)] under normal (E_1) and water-stressed (E_2) conditions. The material was divided into seven blocks consisting of 11 progenies and three check varieties in each block, namely, PBR 97, RB 50 and RH 819. In each block, progenies and check varieties were sown in three row plots of five meter length, spaced 30 cm apart with plant-to-plant spacing of 10 cm achieved by thinning after 15-20 days of sowing. Border effect was removed by taking observations on middle plants in a row. Recommended package of practices were followed to raise a healthy crop. Water-stressed (E_2) was grown as rainfed experiment and only pre-sowing irrigation was given, while normal (E_1) environment was irrigated twice during cropping season, one at 35 days after sowing and another at 70 days after sowing. Initial moisture content of experimental area (water-stressed E_2) at sowing time was 7.93% at 0-15 cm depth, 7.75% at 15-30 cm depth and 11.06% at 30-60 cm depth. After 50 days, moisture content was reduced up to 5.53% at 0-15 depth, 7.0% at 15-30 cm depth and 9.93% at 30-60 cm depth. However, 24.3 mm rain was received in a day in January during the cropping season. Observations were recorded on 12 morphological characters *viz.,* plant height, primary branches/plant, secondary branches/plant, fruiting zone length, siliquae/plant, main shoot length, siliqua length, seeds/siliqua, biological yield, seed yield/plant, harvest index and 1000-seed weight.

The mean data were subjected to analysis of variance (Fedrer, 1956) using SPAD (Abhishek *et al.,* 2004) software. Genetic parameters and simple correlations in all possible combinations were worked out as per standard procedure (Burton, 1952; Johnson *et al.,* 1955).

Results and Discussion

Mean of different progenies in irrigated and rainfed conditions for morphological traits are presented in Table 1. The overall mean performance of progenies was comparatively higher in irrigated environment as compared to drought condition for secondary branches/plant, siliquae/plant, main shoot length, siliquae on main shoot, and seed yield/plant. Drought appeared to have reduced the overall mean performance of these traits by 38.51%, 18.33%, 3.94%, 1.33%, 9.21%, respectively. For siliquae length and 1000 seed weight, mean performance was slightly higher in drought environment. The reduction in mean performance of progenies under drought situations for most of the traits may be ascribed to decreased translocation of assimilates and growth substances, impairing nitrogen metabolism, loss of turgidity and consequently reduced sink size (Kumawat *et al.,* 1997). The more or less similar observations were made by Singh and Choudhary (2003) and Chauhan *et al.* (2007) in *Brassica juncea* where they reported up to 60% yield reductions under rainfed environments. Analysis of variance showed that the progenies differed significantly for secondary branches/plant, siliquae/plant, main shoot length, siliquae on main shoot, siliquae length, seed yield/plant and 1000 seed weight under rainfed conditions while progenies showed significant differences for main shoot length, siliquae on main shoot, siliquae length, 1000 seed weight, seed yield/plant under irrigated conditions. For rest of the traits there were non-significant differences in both the conditions. This indicates that material has sufficient variability for these traits and response to selection may be expected in the breeding programme for irrigated as well as rainfed conditions.

The variances of various characters were compared on the basis of coefficient of variation. It was observed that main shoot length closely followed by seed yield/plant in irrigated environment, and secondary branches/plant followed by seed yield/plant in rainfed conditions exhibited comparatively higher estimates of genotypic as well as phenotypic coefficient of variation (Table 2). It indicated that simple selection for these characters might be advantageous in particular condition. The estimates of heritability in the present investigation were of higher magnitude (>50%) for main shoot length, siliquae on main shoot, siliquae length, seed yield/plant and 1000 seed weight, whereas, under rainfed conditions, secondary branches/plant, siliquae on main shoot, siliquae length and 1000 seed weight recorded higher estimates of heritability. For other characters (siliquae/plant, main shoot length and seed yield/plant) moderate estimates of heritability were observed. Similar reports were made by Meena *et al.* (2008) and Singh *et al.* (2009).

The genetic advance was highest for main shoot length followed by seed yield/plant and 1000 seed weight under irrigated conditions, whereas, secondary branches/plant followed by seed yield/ plant and siliquae/plant showed higher estimates of genetic advance under rainfed conditions (Table 2). These findings indicate that there is good scope for development of genotypes having more main shoot length and increased seed weight which would perform better under favorable conditions.

Table 2. Mean, range, genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance in advanced progenies of Indian mustard

Genotype	Mean		Range		GCV		PCV		h2		GA	
	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF	IR	RF
Secondary branches/ plant	6.05	3.72	0.70-15.4	0.43-15.03	*	49.19	*	60.48	*	66.14	*	82.31
Siliquae/plant	171.90	140.39	66.2-276.0	49.38-265.4	*	14.77	*	27.96	*	27.89	*	16.07
Main shoot length (cm)	74.55	71.61	43.55-187.22	53.79-91.26	19.92	5.12	22.18	9.20	80.67	30.97	36.86	5.88
Siliquae on main shoot	42.09	41.53	27.09-54.09	30.48-61.61	9.53	9.51	11.45	12.47	68.90	58.11	16.26	14.92
Siliquae length (cm)	4.07	4.26	3.28-5.70	3.14-5.22	8.11	7.04	10.81	8.68	57.89	64.29	12.77	11.63
Seed yield/plant (g)	9.34	8.48	3.19-18.65	1.85-16.18	19.16	17.80	26.66	28.76	52.10	38.65	28.57	22.50
1000 seed weight (g)	4.93	5.73	3.31-6.8	4.11-7.06	11.16	8.02	12.58	10.12	76.92	61.76	20.07	12.95

*Mean sum of squares were non – significant,
IR=Irrigated, RF=Rainfed, GCV=Genotypic coefficient of variation, PCV=Phenotypic coefficient of variation, h2=Heritability, GA=Genetic advance expressed as % of mean

Similarly, under rainfed conditions there is enough scope for development of promising genotypes having more number of siliquae/plant. High heritability values accompanied with high genetic advance were observed for main shoot length followed by seed yield/plant under irrigated conditions. Similar reports of high heritability with high genetic advance for these characters were made by Patel *et al.* (2006). This indicates that selection will be more effective for these characters in comparison to other.

Simple correlations were estimated between seed yield and component traits in irrigated as well as rainfed conditions (Table 3). Under irrigated conditions, seed yield/plant was positively and significantly correlated with plant height (0.241), primary branches/plant (0.381), secondary branches/plant (0.493), fruiting zone length (0.295), siliquae/plant (0.562), biological yield (0.852) and harvest index (0.613), while, under rainfed conditions, seed yield/plant was significantly and positively correlated with plant height (0.445), primary branches/plant (0.443), secondary branches/ plant (0.611), fruiting zone length (0.505), siliquae/plant (0.729), main shoot length (0.410), seeds/siliqua (0.283), biological yield (0.774) and harvest index (0.482). These results were in agreement with the earlier reports of Kardam and Singh (2005), Meena *et al.* (2008) and Singh *et al.* (2011). Among other important positive and significant associations noted, the association of plant height with primary branches/plant, secondary branches/plant, fruiting zone length and biological yield/ plant was observed under both the conditions which is in accordance with the report of Meena *et al.* (2008) and Singh *et al.* (2011). Significant positive association of primary branches/plant with secondary branches (rainfed and irrigated), fruiting zone length (only rainfed), siliquae/plant (rainfed and irrigated) and biological yield/plant (rainfed and irrigated) was observed. This result of present investigation is in accordance with the report of Kardam and Singh (2005). Significant positive association of secondary branches/plant with fruiting zone length, siliquae/plant, main shoot length and biological yield/plant was observed under both the conditions. Association of fruiting zone length with siliquae/plant, main shoot length, and biological yield/ plant was found significant and positive under both the conditions. Singh *et al.* (2010) also made similar observations. Association of siliquae/plant with main shoot length (only rainfed), seeds/siliquae (only rainfed) and biological yield was observed to be positive and significant (Kardam and Singh, 2005 and Singh *et al*., 2010). Seeds/siliquae and 1000 seed weight were found to be positivity and significantly associated with siliquae/ length under both the conditions (Singh *et al.,* 2011)

On the basis of this study it can be concluded that plant height, primary and secondary branches/plant, fruiting zone length, siliquae/plant and biological yield/ plant are important traits for constructing selection index under both irrigated and rainfed situations which should be considered in selection programme.

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Table 3. Correlation coefficients between different characters in advanced progenies of Indian mustard under irrigated and rainfed conditions

Characters	Situation	PH	PB	SB	FZL	SLP	MSL	SMS	SL	SS	BY	SY	HI	1000 SW
PH	I	1												
	RF	1												
PB	I	0.156	1											
	RF	0.375	1											
SB	I	0.218*	0.527**	1										
	RF	0.292**	0.484**	1										
FZL	I	0.415**	0.138	0.328**	1									
	RF	0.624**	0.469**	0.518**	1									
SLP	I	0.362**	0.496**	0.634**	0.415**	1								
	RF	0.476**	0.563	0.764**	0.673**	1								
MSL	I	0.144	-0.038	0.438**	0.368**	0.196	1							
	RF	0.485**	0.183	0.450**	0.774**	0.556**	1							
SMS	I	0.334**	0.083	0.188	0.394**	0.459**	0.35**	1						
	RF	0.548**	0.353**	0.554**	0.675**	0.681**	0.63**	1						
SL	I	-0.233	-0.221	-0.288**	-0.078	-0.201	0.066	-0.166	1					
	RF	-0.062	-0.115	-0.165	-0.114	-0.211	-0.031	-0.176	1					
SS	I	-0.018	-0.158	0.0125	0.087	0.091	0.113	0.526**	0.525**	1				
	RF	0.052	0.161	0.33	0.031	0.291**	0.078	0.202	0.253*	1				
BY	I	0.318**	0.370**	0.531**	0.342**	0.502**	0.118	0.155	0.097	0.233*	1			
	RF	0.415**	0.433**	0.609**	0.598**	0.732**	0.519**	0.454**	-0.096	0.191	1			
SY	I	0.214	0.381**	0.493**	0.295**	0.562**	0.128	0.132	0.105	0.175	0.851**	1		
	RF	0.445**	0.443**	0.611**	0.505**	0.729**	0.410**	0.499**	-0.202	0.283**	0.774**	1		
HI	I	0.004	0.156	0.182	0.097	0.352**	0.086	0.049	0.060	0.006	0.121	0.613**	1	
	RF	0.134	0.085	0.112	-0.005	0.137	-0.039	0.154	-0.195	0.132	-0.145	0.482**	1	
1000SW	I	-0.112	-0.131	-0.376	-0.159	-0.174	0.021	-0.152	0.338**	-0.077	-0.106	0.037	0.189	1
	RF	-0.169	-0.202	-0.159	-0.053	-0.203	0.019	-0.280	0.295**	-0.127	-0.163	-0.150	-0.002	1

I=Irrigated, RF=Rainfed, PH= Plant height, PB = Primary branches/plant, SB= Secondary branches/plant, FZL=Fruiting zone length, SLP=Siliquae/plant, MSL=Main shoot length, SMS=Siliquae on main shoot, SL= Siliquae length, SS=Seeds/siliqua, BY=Biological yield, SY = Seed yield/plant, HI=Harvest index, SW=1000 seed weight

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