



Performance of Indian mustard (*Brassica Juncea* L. Czern and coss.) genotypes under rainfed agriculture system

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Abstract

Droughts that are severe and last for a long time are being caused by climate change, which will have an important effect on crop growth and output. To ascertain the effect of drought on various characteristics of 73 Indian mustard genotypes, the current study was carried out in both irrigated and rainfed conditions. The RH 0749 was reported to have the highest seed yield under irrigation, while Pusa Bold had the highest seed yield under rainfed conditions. Membrane stability index (37.78%), seed yield per plant (28.62%), seed yield per hectare (28.62%), number of secondary branches (28.13%), and number of primary branches (28.08%) showed the major percent reduction (>25%) while traits like number of siliquae per plant, number of seeds per siliqua, test weight, number of siliquae on main raceme, and SPAD chlorophyll metre reading had more than twenty but less than 25 percent reduction. The range of the yield reduction in percentage was 7.25 to 57.78. In a rainfed situation, the genotypes RB-50 and Pusa Bold showed a minimum percent yield loss which can be exploited as parents in mustard breeding for rainfed condition.

Keywords: Indian mustard, drought, genotypes, percent reduction, screening, yield

Introduction

Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. In India, oilseed *Brassica* is the second most important edible oilseed crop after soybean which contributes 28.6% in the total production of oilseeds. In the world 85.07 million tonnes oilseed mustard has been produced from 40.59 million hectares cultivated area with the productivity 2100 kg per hectare (UASD-Foreign Agriculture Services, 2021-22) whereas In India, rapeseed-mustard covered an area of 13.26 million ha with productivity of 1444 kg ha⁻¹ with four major producing states are Rajasthan, Haryana, Uttar Pradesh and Madhya Pradesh (Sharma *et al.*, 2026). India is the fourth largest oil seed-producing country in the world after USA, China and Brazil and in terms of acreage India ranks third (19.29%) after Canada (24.55%) and China (20.58%). Nearly 37% of the total rapeseed mustard area is rain-fed, where the crop is severely affected by drought resulting in acute yield losses particularly in the drought-prone areas of Eastern and Western India which are

populated largely by resource poor farmers with small land holdings. Lack of precipitation during the winter, particularly in the month of February in North-West India, exposes the crop to moisture stress in rainfed condition. In rainfed condition drought is one of the main limiting factors for the growth and sustainable yield of crops (Fageria *et al.*, 2006). Even a relatively short period of water stress during the reproductive stage significantly reduces the seed yield (Ahmadi and Bahrani 2009) and leads to reduction in oil content and oil yield of oilseed crops. The grain production of mustard is most affected by the lack of water during the flowering and pollination stages (Fernandez 1992). In Indian mustard, moisture stress decrease in yield ranged from 17 and 94 per cent (Mohamed Ali *et al.*, 1990 and Chauhan *et al.*, 2007).

Due to scarcity of water resources, deficit irrigation is used as an efficient option for increasing productivity under water shortage. Another strategy is using plant genetic engineering and breeding to develop drought-tolerant genotypes. Clarke *et al.* (1984) opined that selection for yield under dry condition should alone be

more productive avenue for improvement of drought resistance until more rapid and effective screening procedures could be developed. Mustard genotypes with drought tolerance trait(s) yielded better than those without such trait(s) under water stress conditions (Singh *et al.*, 1988). Therefore, investigating the effects of drought on yield and yield components in Indian mustard is very important for identifying drought-tolerant traits that can be incorporated into high-yielding varieties. This study is aimed at investigating the effects of drought on a wide range of genotypes of Indian mustard and identifying suitable selection criteria for drought tolerance.

Material and Methods

The present investigation consisting seventy-three genotypes of Indian mustard were evaluated in a RBD with three replications during *Rabi* season of 2017-18 at the Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Trial plots consisted of five rows, each 5 m long. Distances between rows and plants within each row were maintained at 30 and 10 cm, respectively. All recommended agronomic package of practices were followed to raise a healthy crop in both the condition (Irrigated and Rainfed) except the irrigation in rainfed condition where only lifesaving irrigation was given. Pre-sowing irrigation was given in both the conditions to ensure the germination. Furthermore, irrigated trials received two irrigations at 40 and 80 days after sowing. Five random plants from each replication were selected from each entry and tagged for recording the observations for various morphological and physiological characters viz., plant height, number of primary branches, number of secondary branches, length of main raceme, number of siliques on main raceme, silique length, number of seed per silique, number of siliques per plant, biological yield, test weight, seed yield per plant, seed yield per hectare), membrane stability index, SCMR (SPAD chlorophyll meter reading), Canopy temperature, harvest Index and oil content whereas days to flowering and days to maturity which were recorded on plot basis. The replication wise mean values were finally subjected to statistical analysis.

Results and Discussion

Growth attributes

The study involved 73 genotypes *Brassica juncea* L. (Indian mustard), to examine the effects of drought on 19 different characters. This makes it easier to identify genotypes with desirable attributes for use in future crop improvement programmes. The results of the analysis of variance for the irrigated and rainfed conditions showed that genotypes had very significant differences for all

Table 1: ANOVA for mustard genotypes for nineteen traits in irrigated and rainfed condition during *rabi* 2017-2018

Source	DF	DM	PH	NPB	NSB	LMR	SMR	SL	SPS	SPP	BY	TW	YP	Y/ha	OC(%)	MSI	SCMR	CT	HI (%)
<i>Irrigated condition</i>																			
Replication	36.66	4.33	661.82	0.46	4.48	27.66	70.63	0.19	2.08	3523.32	27.90	1.14	1.76	3.87	1.60	36.12	18.64	2.04	0.61
Genotypes	29.36**	97.44**	940.98**	4.25**	23.44**	164.80**	58.30**	0.68**	74.44**	17860.23**	294.79**	1.11**	19.96**	43.80**	4.84**	122.88**	28.07**	4.62**	
Error	48.61**																		
Total	17.75	21.49	341.34	0.86	3.16	50.50	24.10	0.24	3.19	4580.63	53.89	0.46	2.99	6.56	1.38	20.12	12.44	0.77	24.76
	83.77	123.26	1944.14	5.57	31.08	242.96	153.03	1.11	79.71	25964.18	376.58	2.71	24.71	54.23	7.82	179.12	59.15	7.43	73.98
<i>Rainfed condition</i>																			
Replication	11.73	12.18	614.75	1.13	0.99	51.01	25.89	0.16	0.34	915.16	10.79	0.06	0.39	0.86	1.18	28.48	3.94	1.18	0.47
Genotypes	47.66**	73.27**	903.93**	1.67**	17.64**	199.69**	66.24**	0.78**	23.66**	13402.41**	283.86**	1.33**	18.21**	39.96**	6.91**	154.39**	24.11**	4.35**	44.05**
Error	12.46	20.37	226.94	0.79	1.04	30.91	22.63	0.11	4.42	1303.69	8.24	0.15	1.13	24.48	1.88	11.25	13.61	1.42	9.94
Total	71.84	105.82	1745.62	3.59	19.68	281.61	114.77	1.05	28.42	15621.26	302.89	1.54	19.73	65.31	9.96	194.11	41.66	6.95	54.46

DF: days to flowering, DM: days to maturity, PH: plant height, NPB: number of primary branches, NSB: number of secondary branches, LMR: length of main raceme, SMR: silique on main raceme SL: silique length, SPS: seeds per silique, SPP: siliques per plant, BY: biological yield, TW: test weight, YP: seed yield per plant, Y/ha: seed yield per hectare, OC: oil content, MSI: membrane stability index, SCMR: SPAD chlorophyll meter reading, CT: canopy temperature, HI: harvest index

Table 2a: Mean performance of Indian mustard genotypes under irrigated and rainfed condition

Genotypes	DF		DM		PH		NPB		NSB		LMR		SMR		SL		SPS	
	I*	R*	I*	R*	I*	R*	I*	R*	I*	R*	I*	R*	I*	R*	I*	R*	I*	R*
GIRIRAJ	50.67	49.00	129.33	122.00	227.00	192.33	8.33	4.49	14.33	8.33	68.00	50.09	50.73	33.58	6.17	5.57	15.00	11.49
URVASHI	48.67	45.00	125.67	120.33	192.67	169.78	7.17	4.76	13.67	8.13	70.33	61.11	50.67	38.91	5.47	4.96	11.67	9.03
PM 30	49.00	43.33	121.67	119.00	171.00	149.82	4.67	3.42	9.67	5.67	61.67	46.09	41.33	30.58	5.27	5.13	12.00	9.01
KRANTI	52.33	41.33	120.33	118.67	145.00	130.13	8.83	3.50	16.00	10.33	56.33	44.91	44.33	27.82	5.17	4.46	14.00	11.17
RH 406	50.67	49.67	131.67	130.67	175.67	163.67	6.33	4.97	11.33	9.67	60.00	52.67	42.33	41.67	5.37	5.13	14.67	13.60
VARDAN	54.67	53.33	105.33	103.33	197.00	188.83	6.00	5.14	9.67	8.33	58.67	54.58	41.00	38.11	4.77	4.59	14.33	13.33
PBR 541-4	54.33	45.33	120.00	115.00	211.00	190.47	5.83	3.49	9.33	7.67	55.00	53.29	50.67	31.13	4.87	4.68	13.33	10.00
PUSA BOLD	52.00	51.33	126.67	126.33	186.67	182.00	7.83	4.00	12.44	11.33	60.33	57.91	43.33	40.38	6.20	4.47	13.33	12.33
PM 26	47.00	41.00	124.67	117.00	156.33	132.07	5.67	5.04	12.00	8.67	59.67	48.36	32.00	27.53	5.87	5.31	13.33	10.47
SEJ-2	47.67	41.00	106.67	102.67	173.67	143.00	5.33	3.58	7.33	5.00	54.33	51.51	44.00	34.33	5.13	4.26	10.33	7.94
NRCBH-101	50.00	48.00	113.00	112.00	173.67	158.71	6.00	5.51	9.33	8.33	55.67	54.02	46.67	42.31	5.17	4.97	11.67	10.52
JMM-08-01	54.00	43.00	120.67	115.67	140.00	121.89	4.33	3.82	8.00	5.33	59.00	49.18	38.33	29.82	5.47	5.03	13.00	8.17
RGN 236	52.33	41.67	124.67	120.33	190.67	171.60	5.67	4.60	9.67	6.67	59.33	46.98	40.67	31.00	4.70	4.09	16.00	10.03
PM 28	54.33	53.67	108.33	108.00	165.67	161.33	4.00	3.36	10.33	9.50	64.00	58.29	43.67	36.80	5.43	5.39	12.67	11.47
RLM 1359	53.00	43.00	124.33	117.67	215.00	183.36	6.33	4.57	10.33	7.00	65.00	35.83	47.67	35.49	5.33	5.19	12.33	8.72
PBR 91	52.67	45.33	126.00	119.67	175.00	153.33	5.67	3.71	6.67	5.00	54.67	44.82	44.00	36.44	4.67	3.86	13.33	10.00
NDR-8	51.33	44.67	118.67	113.33	176.67	152.67	5.67	3.83	7.33	5.00	45.33	37.30	42.67	32.88	4.83	4.56	15.67	7.61
PAB 9511	52.67	43.00	123.00	119.33	160.33	142.67	4.67	4.13	7.67	5.00	41.33	32.42	45.33	25.78	4.67	3.50	12.67	9.83
RLC-2	57.67	46.33	125.67	120.33	173.33	154.67	4.67	3.33	13.67	10.00	55.00	39.83	39.00	30.03	5.67	5.37	13.00	12.94
HUJM-07-06	54.00	41.67	129.00	123.00	186.00	174.67	5.00	4.13	12.33	12.10	64.67	40.67	32.67	25.33	5.63	5.45	15.33	10.83
PAB 9534	51.00	42.67	124.33	119.00	153.67	134.00	6.00	4.23	10.00	7.00	56.00	32.60	42.67	35.57	5.30	5.03	13.67	10.23
JD-6	51.33	46.33	121.00	114.67	179.00	160.67	5.00	4.58	10.00	7.67	62.00	43.06	40.33	34.42	4.93	4.40	9.00	7.70
NDR-8	50.67	40.67	121.67	117.67	161.33	135.67	6.00	5.09	12.33	9.33	57.33	47.67	45.33	35.42	5.50	5.05	11.00	9.22
JMM-915	51.33	44.33	128.00	122.00	175.00	169.87	6.00	4.16	10.67	7.33	63.33	52.97	40.33	31.47	5.00	4.54	14.00	10.00
SWARN JYOTI	49.00	42.00	120.00	115.33	181.67	159.33	6.33	5.31	10.67	7.33	60.67	50.13	41.67	36.04	4.97	4.86	15.00	11.07
CS-54	54.67	43.67	124.00	118.67	186.00	162.33	6.33	4.53	13.33	8.67	56.67	47.34	40.67	35.24	5.60	5.18	12.67	11.67
JMM 914	51.00	44.33	123.33	118.00	192.33	169.83	6.33	4.11	12.33	9.33	62.33	42.48	48.33	31.60	5.17	4.99	13.00	9.80
ASHIRWAD	46.67	40.33	128.00	122.33	170.00	149.67	5.17	4.98	12.00	8.33	78.00	62.62	43.67	38.21	7.00	5.13	20.67	11.33
RLM 619	45.33	39.00	124.67	118.67	210.00	185.00	6.00	5.18	13.33	9.67	55.33	44.38	44.33	37.58	4.90	4.65	12.67	10.17
RGN 229	56.67	54.00	116.67	115.67	199.33	176.33	5.33	4.49	11.33	9.33	72.67	67.60	45.33	43.00	5.07	4.78	13.33	11.89
DRMR-150-35	55.67	54.67	107.00	106.33	179.67	176.00	5.33	4.40	12.00	9.67	71.33	68.27	49.00	45.38	5.00	4.67	14.33	13.11
DIBYA	48.67	41.33	127.33	122.00	164.00	142.27	5.33	4.00	5.83	3.67	66.00	43.33	44.00	32.04	5.23	4.98	14.00	10.76
MAYA	52.00	43.67	131.00	125.33	206.00	182.67	9.00	4.57	10.33	7.33	51.67	46.59	49.00	43.60	4.77	4.69	12.00	8.88
PRO-19	48.33	41.67	122.33	116.33	168.00	144.80	6.33	4.18	5.83	4.00	66.33	56.51	43.33	26.16	5.47	5.17	13.67	10.20
JAGANNATH	52.33	43.00	129.00	123.67	190.00	169.12	5.33	3.77	9.00	5.33	41.33	41.07	45.00	26.96	4.53	4.07	13.33	9.69
HUJM-9903	50.00	43.33	127.00	122.00	209.00	181.60	5.17	3.09	10.67	5.33	61.67	59.24	48.00	35.82	6.17	5.51	13.00	9.33
KANTI	53.67	46.33	122.00	117.00	179.00	160.13	3.17	2.16	8.33	5.33	55.67	44.13	47.67	34.36	5.33	4.56	13.67	10.33
BASANTI	54.67	44.00	123.33	115.67	186.67	164.33	6.00	2.69	11.33	6.67	56.33	46.78	42.00	30.58	5.10	4.87	14.00	13.00
VARUNA	51.33	44.00	127.67	122.00	167.00	143.22	4.33	3.56	8.33	5.00	52.33	45.87	32.67	24.49	5.57	4.32	15.33	10.56
RH 8813	55.33	45.00	129.67	124.33	184.33	161.83	6.33	3.04	7.67	4.56	50.33	44.82	40.00	29.27	5.17	5.04	10.67	9.51
JM-3	49.33	42.67	124.00	118.67	155.33	127.80	4.67	3.16	6.33	4.07	56.67	39.27	44.67	28.18	5.30	4.69	15.67	8.99
RH 8814	51.00	44.33	127.00	122.00	195.00	168.40	5.33	3.78	12.00	7.87	46.67	40.32	39.33	27.07	4.70	4.32	14.33	12.98
PM-27	53.00	51.33	117.33	116.33	175.00	166.17	4.67	4.45	9.83	9.00	49.67	48.49	39.00	34.53	4.80	4.44	13.67	12.27
RH 781	55.00	47.67	124.33	119.33	188.00	173.03	5.33	4.84	10.00	7.07	61.67	59.82	40.67	31.98	4.80	4.37	13.00	9.33

VAIBHAV	55.00	46.00	128.00	122.67	195.00	175.33	7.83	3.18	12.00	8.33	60.00	54.44	43.67	32.55	4.70	4.63	10.00	8.44
DRMR 601	56.00	45.33	126.00	119.33	173.33	150.18	5.67	4.07	11.00	7.73	61.00	47.51	41.67	31.56	5.23	4.39	15.33	11.00
GM-2	57.67	45.00	128.67	123.00	170.00	150.98	5.67	4.07	10.33	7.33	58.33	46.16	38.33	32.83	5.07	4.54	10.67	9.11
RH 8812	53.00	45.33	124.00	118.33	194.00	171.16	5.33	3.11	14.00	10.00	53.00	42.16	41.67	30.53	5.67	3.78	12.33	9.29
HUJM-9504	51.33	44.33	124.33	118.67	185.67	164.83	5.53	3.62	5.17	3.00	62.00	44.80	35.67	28.16	5.17	4.62	12.33	9.02
NRCDR 02	52.67	43.00	122.00	117.00	176.00	152.67	5.33	5.22	8.67	6.00	55.67	50.22	38.00	29.61	6.17	5.44	13.67	11.87
NDRE-4	55.00	43.67	125.00	116.00	172.67	153.50	5.33	5.04	6.00	4.33	53.00	39.97	41.00	32.01	4.90	3.88	13.33	8.95
NPJ 112	47.67	43.00	126.00	119.00	194.00	171.21	4.67	3.36	10.00	7.33	57.33	47.05	38.33	32.89	5.93	5.46	12.00	11.00
MCN-10-11	51.00	42.67	127.33	122.33	176.33	151.40	6.00	3.56	9.67	4.33	54.00	44.92	38.00	27.93	5.77	5.37	11.67	7.97
HUJM-9901	52.00	45.33	124.33	123.00	187.67	166.62	5.67	4.47	12.33	8.60	59.00	52.52	40.00	34.49	4.93	4.54	12.33	9.47
ISH-7-3-2	48.33	40.00	123.00	117.67	190.33	170.53	5.67	4.07	9.00	6.67	61.00	56.92	41.67	30.92	5.50	5.27	11.00	8.07
HUJM-08-12	46.00	37.67	128.67	125.67	178.33	157.67	4.67	4.31	14.33	7.00	63.00	58.20	41.33	32.23	5.33	5.05	13.00	10.00
HUJM-05-03	49.33	39.67	126.67	121.67	188.33	170.96	5.33	3.82	8.33	5.67	57.33	55.40	44.67	33.19	5.03	4.35	11.00	10.47
NDR 8501	54.67	45.00	123.67	118.67	200.00	178.22	5.67	3.89	9.00	6.33	57.00	46.96	52.00	34.22	5.27	5.17	13.00	11.64
HUJM-9804	54.00	47.00	126.67	120.67	187.67	169.11	5.67	5.13	11.33	7.00	64.67	57.33	46.33	37.27	5.50	5.08	11.33	10.56
RGN 73	57.33	55.00	115.33	111.67	169.67	159.83	7.50	4.31	15.00	10.67	63.67	55.13	43.00	34.40	4.33	4.29	14.67	9.73
RGN 298	58.67	55.67	124.00	122.33	192.67	185.89	7.67	5.16	16.33	15.67	49.33	48.89	36.00	35.11	5.20	5.03	15.00	12.10
PUSA BAHAR	52.67	45.33	138.00	117.33	189.67	170.81	5.33	4.29	8.67	6.96	64.67	57.56	43.00	28.27	5.70	5.28	14.00	9.80
PITAMBARI	45.33	41.67	127.33	116.67	120.00	95.37	11.00	6.27	0.00	0.00	31.00	27.00	33.67	22.49	5.70	5.56	53.00	30.53
SHIVANI	52.00	49.00	123.00	118.00	181.00	159.45	6.00	4.98	9.00	7.33	55.33	53.63	37.00	34.87	5.53	4.98	14.00	11.67
RH 119	54.67	48.33	125.00	122.33	197.67	179.12	6.00	5.13	10.00	9.00	70.33	67.94	43.67	42.58	5.23	5.08	16.00	14.40
RH 0749	50.00	46.67	132.00	125.67	202.00	169.33	6.00	4.73	13.67	9.53	60.33	41.19	44.00	38.36	6.20	5.17	17.33	12.33
RB 50	52.00	51.67	128.00	127.00	173.33	170.76	5.00	4.27	8.67	8.00	60.67	55.09	45.00	34.44	5.57	5.48	13.00	9.33
VASUNDHARA	52.67	45.33	127.00	124.67	177.33	160.33	5.33	3.67	10.67	7.00	53.00	42.85	39.00	29.95	4.73	3.81	13.67	9.56
RH 30	49.00	42.33	125.33	120.67	196.00	170.18	5.67	4.00	12.00	9.67	50.00	41.19	44.33	33.00	4.87	4.53	10.00	8.22
RVM-2	50.00	43.00	125.67	120.33	181.00	161.00	5.67	4.42	10.00	7.00	61.00	53.70	39.33	32.09	6.10	5.27	12.67	11.00
PUSA TARAK	50.67	42.33	127.00	121.67	176.33	154.67	5.33	3.42	13.00	10.33	58.33	49.80	39.00	33.44	5.33	5.15	13.00	9.11
PUSA VIJAY	45.33	43.00	126.67	124.00	165.33	145.67	6.00	5.36	8.67	5.67	55.33	44.17	39.33	29.80	5.17	4.94	14.33	10.32
HUJM-08-01	57.67	49.33	119.67	114.67	202.00	176.00	6.67	4.07	16.00	11.60	66.33	50.13	51.67	34.78	5.70	3.26	14.67	10.62
Mean	51.90	45.10	123.90	119.01	181.23	161.55	5.84	4.20	10.38	7.46	58.30	48.87	42.44	33.18	5.30	4.78	13.85	10.63
CV	8.12	7.82	3.74	3.79	10.19	9.32	15.87	21.09	17.13	13.67	12.18	11.37	11.57	14.33	9.27	6.87	12.90	19.78
SE	2.43	2.03	2.67	2.60	10.66	8.69	10.66	0.51	1.02	0.58	4.10	3.20	2.83	2.74	0.28	0.19	1.03	1.21
CD 5%	6.80	5.69	7.48	7.28	29.82	24.31	29.81	1.43	2.87	1.64	11.47	8.97	7.92	7.67	0.79	0.53	2.89	3.39
MAX.	58.67	55.67	138.00	130.67	227.00	192.33	11.00	6.27	16.33	15.67	78.00	68.27	52.00	45.38	7.00	5.57	53.00	30.53
MIN.	45.33	37.67	105.33	102.67	120.00	95.37	3.17	2.16	0.00	0.00	31.00	27.00	32.00	22.49	4.33	3.26	9.00	7.61

DF: days to flowering, DM: days to maturity, PH: plant height, NPB: number of primary branches, NSB: number of secondary branches, LMR: length of main raceme, SMR: silique on main raceme SL: silique length, SPS: seeds per silique

the features. It suggests existence of sufficient variability between the genotypes (Table 1). Climate change is leading to severe prolonged drought, which will have a significant impact on crop growth and productivity. In irrigated condition Pitambari took minimum number of days (45.33) whereas RGN 298 taken the maximum number of days (58.67) to achieve 50% flowering. In rainfed condition genotypes HUJM-08-12 took minimum number of days (37.67). Vardan (105.33) had minimum number of days to 75 percent maturity followed by SEJ-2 (106.67 days) in irrigated condition whereas in rainfed condition least number of days (102.67) to attain 75% maturity was found in SEJ-2 (Table 2a).

In irrigated condition Giriraj (227.00 cm) followed by RLM 1359 (215.00 cm) had maximum plant height, Pitambari (11.00) followed by Kranti (8.83) recorded maximum number of primary branches. The highest secondary branches were seen in RGN 298 (16.33) followed by Kranti (16.00) while genotypes Pitambari (0.00) has least number of secondary branches, on contrary in rainfed condition Giriraj has maximum plant height (192.33 cm) followed by PBR 541-4 (190.47 cm) while minimum plant height was seen in the genotype Pitambari (95.37 cm). Maximum number of primary branches was recorded in Pitambari (6.27) whereas number of secondary branches was highest in RGN 298 (15.67) followed by HUJM-07-06 (12.10) and Pitambari (0.00) recorded least number of secondary branches in rainfed condition. According to Ardell *et al.* (2001), the soil moisture regime during the plant growth phase is directly related to the desired number of branches per unit of surface. The highest length of main raceme, number of siliquae on main raceme and siliqua length was observed in Ashirwad (78.00cm), NDR 8501 (52.00) and Ashirwad (7.00) respectively in irrigated condition while in rainfed condition DRMR 150-35 has maximum length of main raceme (68.27 cm). DRMR 150-35 (45.38) followed by RGN 229 (43.00) has highest and Pitambari (22.49) followed by Varuna (24.49) has least number of siliquae on main raceme, Giriraj (5.57) exhibited highest siliqua length under rainfed situation (Table 2a).

Genotype Pitambari showed maximum number of seed per siliqua in both the condition. In irrigated condition RH 749 (527.33) had maximum number of siliquae per plant while Pitambari (145.00) had least number of siliquae per plant. In rainfed condition RH 119 (452.00) had highest and Pitambari (108.85) had least number of siliquae per plant (Table 2b). Sodani *et al.* (2017) found that RH-749 under control conditions and RGN-48 under drought conditions had the maximum number of siliquae per plant. Under irrigated condition maximum seed yield per plant and seed yield per hectare was seen in the genotypes RH

0749 followed by Pusa Bold. The biological yield was maximum in RH 0749 (72.00 g) while Pitambari (21.67 g) recorded minimum values. The genotypes RGN 73 (6.27 g) followed by Giriraj (6.07 g) showed highest test weight, RH 406 (43.22%) followed by Vardan (43.21%) had maximum oil content. In rainfed condition Pusa Bold had maximum seed yield per plant (14.95 g) and seed yield per hectare (22.14 q/ha) followed by RGN 298. The genotypes, RGN 229 (67.73 g) followed by NRCHB 101 (60.20 g) exhibited highest and Pitambari (17.33 g) followed by PAB 9511 (21.40 g) exhibited least biological yield, genotypes RH 119 showed maximum test weight (5.13 g) and Vardan had maximum oil content (42.31%) followed by PM 27 (41.91%) (Table 2b). Like what we found in our study, Sodani *et al.* (2017) reported that RH-406 performed better in irrigated conditions whereas RB-50 and RGN-48 had the characteristic property of maintaining higher seed yield and oil content under water shortage stress like situations. This is because the yield attributes and tolerance mechanism of these two varieties were less affected by these conditions. *Brassica* species genotypes with drought-tolerance features are known to produce the most seeds under droughts (Singh *et al.*, 1988). Several earlier studies have reported similar findings. According to Alipour and Zahedi (2016), consistent watering produced the maximum grain production. Moreover, a shortage of soil moisture during the flowering stage can result in a reduction in photosynthesis and the formation of various plant parts, which can result in a loss of oil yield. According to Singh *et al.* (2014), the average performance of *Brassica* offspring was noticeably better in an irrigated environment for days to 50% flowering, siliques per plant, 1000 seed weight, seed production per plant, and protein content.

In irrigated condition the physiological parameters like MSI, based on the estimation of solute leakage from tissue under moisture stress condition. The best one leaked out lowest amount of solute from the leaf in stress condition indicating high stability index. In present study high MSI was reported in Jagannath (60.95). Leaf chlorophyll content is another important trait because it helps to improve the seed yield under moisture stress condition. The SPAD chlorophyll meter reading and canopy temperature was highest in Varuna (50.67) and RH 8813 (27.23), respectively. On the other hand in rainfed condition, RGN 298 has maximum membrane stability index (47.01), RB 50 had maximum SCMR value (40.13) and Varuna (30.06) followed by Swarn jyoti (29.33) had maximum canopy temperature while minimum canopy temperature was seen in the genotype JD-6 (24.25) followed by PM28 (24.64). Kranti (34.13) exhibited highest harvest index while NDRE-8 (10.43) recorded lowest

Table 2b: Mean performance of Indian mustard genotypes under irrigated and rainfed condition

Genotypes	SPP		YP (g)		Y/ha (kg.)		BY (g)		TW (g)		OC (%)		MSI		SCMR		CT		HI	
	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺	I ⁻	R ⁺
GIRIRAJ	497.67	311.00	15.27	9.89	22.62	14.65	61.13	50.33	6.07	4.60	41.60	39.60	42.10	31.96	36.70	25.37	24.85	25.83	24.98	20.57
URVASHI	353.67	266.67	9.99	8.56	14.80	12.68	40.67	34.00	3.97	2.37	41.42	39.56	42.73	26.11	37.39	32.30	25.21	27.06	25.26	25.16
PM 30	286.33	213.52	10.85	7.22	16.07	10.70	46.47	37.80	5.07	4.50	41.13	39.38	49.97	29.93	36.27	29.03	24.60	26.27	23.46	19.08
KRANTI	418.67	285.67	15.30	10.33	22.67	15.31	36.67	30.33	3.57	2.87	42.80	40.97	54.92	34.63	35.53	29.20	25.95	28.09	41.50	34.13
RH 406	347.67	292.67	14.80	12.55	21.93	18.60	52.73	50.33	5.17	4.50	43.22	40.59	49.87	40.38	40.27	37.63	26.01	26.66	28.02	25.01
VARDAN	285.67	268.00	10.11	8.67	14.98	12.84	45.73	41.67	4.57	4.20	43.21	42.31	40.82	32.27	39.73	36.63	26.11	27.43	22.05	20.88
PBR 541-4	209.67	165.00	8.87	6.44	13.14	9.55	35.40	29.40	3.97	3.40	41.45	40.08	55.73	30.86	42.00	31.77	24.40	25.71	25.06	21.93
PUSA BOLD	334.33	309.00	16.11	14.95	23.87	22.14	51.27	49.33	5.30	4.87	39.35	38.74	41.67	34.62	39.60	35.64	25.70	26.02	33.25	30.21
PM 26	317.33	241.00	10.44	7.22	15.47	10.70	37.40	30.87	5.33	3.40	41.08	38.42	51.96	26.24	43.43	35.40	25.78	26.58	28.29	23.52
SEJ-2	227.67	165.67	8.91	6.55	13.20	9.71	35.93	27.20	4.17	3.23	39.71	37.36	59.36	26.56	43.00	34.97	23.40	24.92	25.87	24.13
NRCBH-101	344.67	337.48	13.00	11.10	19.26	16.45	60.93	60.20	5.17	4.53	40.18	39.41	38.62	30.96	43.40	39.63	25.80	26.37	21.55	18.49
JMM-08-01	226.00	149.53	8.61	5.67	12.76	8.40	34.13	27.73	5.23	3.93	39.99	38.11	59.28	32.07	39.33	31.20	25.61	28.40	25.25	20.68
RGN 236	340.33	265.33	9.98	7.00	14.78	10.37	53.53	43.80	4.60	3.57	38.62	37.63	54.72	33.80	33.47	30.43	24.34	26.10	19.01	16.02
PM 28	273.33	265.33	12.73	11.78	18.86	17.45	59.47	57.53	4.60	4.53	40.60	40.10	43.28	27.00	43.87	39.67	23.29	24.64	21.73	21.01
RLM 1359	369.67	264.80	11.56	7.09	17.12	10.50	50.13	40.47	5.50	4.13	41.18	36.42	49.97	31.00	41.53	30.80	25.40	27.25	23.85	17.52
PBR 91	198.67	151.84	8.94	5.78	13.25	8.56	36.93	29.00	4.07	3.60	40.60	36.64	51.75	30.54	42.33	31.87	22.74	25.20	24.35	19.81
NDR-8	238.33	175.56	7.24	3.06	10.73	4.53	36.33	29.27	4.33	3.13	39.41	37.78	46.59	29.01	43.00	32.13	24.53	26.11	19.83	10.48
PAB 9511	237.00	193.33	5.62	3.67	8.32	5.43	27.67	21.40	4.87	3.77	40.38	38.65	48.06	24.88	39.07	29.30	25.32	26.92	20.39	17.25
RLC-2	386.33	278.13	12.58	7.78	18.64	11.52	56.87	42.20	4.20	3.17	39.89	37.57	45.86	26.61	39.53	33.03	26.43	28.14	22.04	18.45
HUJM-07-06	446.00	340.37	14.29	12.00	21.17	17.78	62.73	55.67	4.27	3.67	39.98	36.57	50.13	24.70	39.40	31.90	25.56	27.38	23.01	21.91
PAB 9534	400.67	236.26	10.89	6.89	16.13	10.21	60.60	47.67	5.50	4.23	40.31	39.14	60.13	37.98	37.07	32.80	24.66	26.24	18.04	14.46
JD-6	326.33	247.67	8.89	6.33	13.18	9.38	43.93	36.40	5.07	3.63	39.52	38.54	38.46	36.16	40.73	32.40	22.47	24.25	20.99	17.40
NDR-8	363.67	260.52	9.27	6.33	13.74	9.38	39.60	33.00	5.83	3.83	41.11	39.63	47.27	29.06	41.50	33.57	26.61	27.31	23.61	19.17
JMM-915	369.67	269.18	10.20	7.11	15.12	10.54	52.87	43.80	5.27	4.00	40.53	38.99	50.01	30.79	43.50	30.77	26.35	28.74	19.24	16.17
SWARN JYOTI	346.33	281.57	8.35	5.66	12.37	8.39	35.27	28.73	4.87	3.73	39.81	37.26	45.14	27.86	39.07	34.17	26.86	29.33	23.76	19.72
CS-54	369.67	231.24	13.13	8.89	19.45	13.17	43.67	36.13	5.27	3.53	41.03	39.07	55.92	34.32	41.17	34.63	25.41	27.14	30.37	24.69
JMM 914	389.67	292.00	10.18	6.89	15.08	10.21	43.80	35.67	5.23	4.73	40.71	38.29	45.72	44.70	43.90	34.93	24.62	26.56	23.22	19.27
ASHIRWAD	300.33	231.76	9.51	8.00	14.09	11.85	41.20	35.33	3.77	2.60	39.42	37.85	41.40	15.47	39.77	30.37	23.07	25.57	23.07	22.69
RLM 619	388.00	285.13	10.51	6.56	15.57	9.71	48.87	36.33	4.60	2.40	37.16	36.32	48.22	27.06	39.20	29.73	27.00	28.15	21.60	18.00
RGN 229	387.33	374.40	14.24	12.17	21.10	18.02	70.33	67.73	5.07	4.40	41.60	40.45	49.17	40.25	41.47	38.20	26.50	27.11	20.34	17.98
DRMR-150-35	353.00	337.43	13.97	11.67	20.69	17.28	59.13	53.67	5.37	4.83	42.62	40.48	50.55	40.16	40.90	37.03	24.03	25.16	24.01	21.74
DIBYA	160.67	119.33	10.91	6.89	16.16	10.21	47.73	37.13	5.20	4.10	37.72	35.60	57.94	45.65	42.63	31.37	25.07	26.88	23.47	18.55
MAYA	341.33	241.33	9.48	6.28	14.05	9.30	36.33	29.53	5.57	4.83	36.95	34.74	52.97	28.34	39.63	28.67	26.60	27.55	26.12	21.49
PRO-19	189.67	133.24	7.70	4.63	11.41	6.86	37.33	29.33	5.57	4.10	38.75	37.38	44.28	27.87	39.81	29.80	22.75	24.91	20.66	15.83
JAGANNATH	261.33	158.09	9.71	6.33	14.39	9.38	37.73	31.13	4.70	2.90	39.73	37.07	60.95	37.66	44.83	33.90	24.72	26.37	26.69	20.43
HUJM-9903	405.00	304.52	16.06	9.00	23.80	13.33	67.53	53.73	5.37	4.03	40.82	38.68	47.75	29.89	41.27	30.80	25.33	26.97	24.24	16.75
KANTI	256.67	174.39	8.23	5.78	12.20	8.56	41.47	36.27	4.27	3.77	38.99	37.22	49.31	35.15	40.20	27.93	26.07	27.82	19.83	15.99
BASANTI	310.33	244.00	9.60	4.67	14.22	6.91	36.67	27.40	5.50	4.13	39.41	37.02	54.00	33.52	45.43	31.97	22.77	24.98	26.25	17.01
VARUNA	257.00	170.03	11.17	7.78	16.55	11.52	43.20	36.13	4.87	3.60	41.64	39.40	49.05	39.95	50.67	36.20	26.08	30.06	26.94	21.56
RH 8813	258.33	184.67	10.53	7.67	15.60	11.36	46.20	35.53	4.93	2.53	41.07	38.98	56.06	33.23	40.43	31.30	27.23	29.14	25.52	21.56
JM-3	188.33	139.87	6.61	4.55	9.80	6.75	36.93	29.87	4.93	3.53	39.89	36.51	43.47	31.10	43.37	33.40	26.05	27.44	19.28	15.26
RH 8814	346.00	269.15	12.21	8.45	18.09	12.51	53.67	44.67	4.50	3.60	39.89	36.91	51.07	32.14	42.37	32.20	23.77	25.94	22.76	18.98
PM-27	319.33	294.52	10.83	9.78	16.05	14.49	46.47	42.87	5.10	4.97	42.46	41.91	39.89	38.15	36.17	32.00	25.18	27.10	23.49	22.86
RH 781	286.67	232.93	9.93	7.00	14.71	10.37	60.47	53.13	5.07	2.23	40.09	38.92	44.97	28.10	43.30	34.57	26.33	28.08	16.78	13.29

VAIBHAV	317.00	240.19	8.67	6.06	12.84	8.97	56.07	45.93	4.03	3.03	39.93	36.59	60.14	37.29	36.20	31.37	23.40	25.57	17.21	13.20
DRMR 601	346.67	256.91	12.03	8.33	17.83	12.35	52.33	42.93	4.37	3.57	42.26	39.43	38.58	19.84	38.47	32.13	22.83	24.67	23.42	19.40
GM-2	293.67	211.56	7.83	5.40	11.60	8.00	43.87	36.33	4.47	3.13	38.89	36.59	47.20	29.36	43.10	31.71	26.75	26.85	17.84	14.90
RH 8812	336.33	246.25	11.70	8.00	17.33	11.85	46.53	38.33	5.43	3.30	41.11	39.25	46.79	40.36	37.53	29.57	25.24	25.89	25.23	21.02
HUJM-9504	194.33	143.97	9.18	5.94	13.60	8.81	39.13	29.73	4.50	3.87	40.97	38.52	48.91	30.80	41.50	32.70	26.07	28.31	25.08	20.09
NRCDR 02	240.67	170.20	7.76	6.11	11.49	9.05	42.80	38.87	5.00	4.53	39.23	36.35	51.87	32.05	40.63	34.93	26.68	27.71	18.02	15.84
NDRE-4	187.67	139.80	8.16	5.00	12.08	7.41	33.33	26.87	5.10	4.40	40.52	39.10	42.96	26.06	42.50	32.38	23.56	25.59	24.45	18.75
NPJ 112	365.00	267.95	12.68	8.78	18.79	13.00	50.00	42.07	3.73	2.93	39.74	36.94	39.83	17.35	39.70	31.27	25.54	26.21	25.55	20.88
MCN-10-11	276.33	169.35	9.38	6.33	13.90	9.38	44.07	33.67	5.43	4.40	40.18	37.84	57.13	21.02	45.17	33.23	24.71	26.38	22.48	18.79
HUJM-9901	331.67	276.00	10.69	8.89	15.84	13.17	38.73	34.87	4.40	3.63	40.30	38.28	43.88	21.91	42.27	31.37	24.98	26.98	27.78	25.52
ISH-7-3-2	278.00	207.40	8.26	5.56	12.23	8.23	43.33	36.47	5.73	4.13	40.44	38.16	45.01	17.09	41.37	32.70	23.49	25.54	18.90	15.26
HUJM-08-12	358.33	260.71	12.43	8.44	18.42	12.51	50.20	41.87	5.07	3.43	40.80	38.33	51.15	26.72	39.60	28.57	25.52	27.26	24.74	20.18
HUJM-05-03	240.67	176.00	9.91	6.67	14.68	9.88	42.00	33.93	4.13	3.57	41.60	39.27	48.34	14.49	43.00	33.03	24.50	26.57	23.66	19.66
NDR 8501	296.67	217.07	10.91	7.44	16.16	11.03	49.00	40.60	5.60	3.03	39.71	37.42	42.08	35.29	38.07	29.13	23.77	26.30	22.09	18.33
HUJM-9804	332.00	244.67	12.81	7.67	18.98	11.36	45.47	32.33	4.17	3.80	41.34	39.83	49.81	23.37	39.03	29.70	26.61	26.88	28.59	24.19
RGN 73	397.67	371.00	14.37	10.33	21.29	15.31	60.67	47.13	6.27	4.40	39.44	36.97	42.59	20.04	40.97	31.17	26.12	27.74	24.08	21.91
RGN 298	363.00	344.94	15.21	13.65	22.54	20.22	54.00	52.40	4.43	4.07	40.81	40.07	52.21	47.01	37.63	32.80	24.65	24.99	28.26	26.07
PUSA BAHAR	269.00	197.08	9.79	6.67	14.50	9.88	45.67	38.07	4.87	3.77	38.37	36.85	58.28	23.75	41.77	33.00	26.21	27.98	21.45	17.63
PITAMBARI	145.00	108.85	7.02	3.67	10.40	5.43	21.67	17.33	5.53	4.00	39.67	37.33	45.94	23.35	39.53	31.93	26.73	28.67	32.33	21.49
SHIVANI	274.67	206.07	12.58	9.44	18.64	13.99	42.00	38.73	5.20	4.80	41.56	40.70	59.06	25.11	39.87	35.03	24.43	26.27	29.97	24.52
RH 119	508.00	452.00	16.07	13.22	23.80	19.59	65.60	60.13	5.73	5.13	41.83	41.07	42.07	41.75	30.17	28.63	26.64	26.93	24.61	22.04
RH 0749	527.33	356.22	17.92	11.33	26.55	16.79	72.00	56.87	5.03	3.33	41.58	39.22	55.52	32.67	43.43	32.90	23.98	25.71	25.17	19.90
RB 50	272.67	266.88	11.26	10.43	16.67	15.46	48.67	46.67	5.23	4.53	41.61	41.04	44.32	36.55	42.67	40.13	26.46	27.14	23.20	22.36
VASUNDHARA	369.00	273.67	9.65	6.78	14.30	10.04	44.40	37.33	4.93	4.00	38.54	37.78	51.25	26.41	43.97	33.17	25.55	27.35	21.73	18.22
RH 30	269.67	201.89	10.37	7.56	15.36	11.20	44.60	39.07	5.57	4.20	40.36	38.75	35.01	16.01	39.90	30.33	24.65	26.30	23.17	19.24
RVM-2	331.00	238.27	9.83	6.44	14.57	9.55	46.73	37.40	5.53	3.40	40.07	37.10	35.68	21.81	44.27	34.17	23.38	25.34	21.14	17.26
PUSA TARAK	326.33	241.30	8.42	5.72	12.48	8.48	41.07	34.33	4.53	4.00	41.44	38.98	59.14	36.75	42.10	34.10	23.42	24.96	20.40	16.48
PUSA VIJAY	273.00	203.15	7.47	5.11	11.07	7.58	43.87	36.53	3.50	2.97	38.81	37.60	44.07	26.97	41.27	34.17	24.45	26.41	17.09	13.93
HUJM-08-01	342.33	241.64	10.82	7.22	16.03	10.70	45.20	37.07	5.40	4.13	40.41	38.38	45.91	26.76	46.30	36.00	25.35	27.59	24.09	20.14
Mean	314.76	240.87	10.83	7.73	16.04	11.46	46.65	39.22	4.90	3.80	40.39	38.43	48.57	30.22	40.81	32.62	25.09	26.71	23.70	19.78
CV	21.50	14.98	15.96	13.74	15.96	13.74	15.73	7.31	13.80	10.10	2.90	3.56	9.23	11.09	8.64	11.30	3.49	4.45	20.98	15.93
SE	39.07	20.84	0.39	0.61	1.47	0.90	2.68	1.65	0.39	0.22	0.68	0.79	2.58	1.93	0.67	2.12	2.50	0.68	0.99	1.82
CD 5%	109.22	58.27	1.09	1.71	4.13	5.08	7.48	4.63	1.09	0.62	1.89	2.21	7.23	5.41	1.89	5.95	1.41	1.92	8.03	5.08
MAX.	527.33	452.00	17.92	14.95	26.55	22.14	72.00	67.73	6.27	5.13	43.22	42.31	60.95	47.01	50.67	40.13	27.23	30.06	41.50	34.13
MIN.	145.00	108.85	5.62	3.06	8.32	4.53	21.67	17.33	3.50	2.23	36.95	34.74	35.01	14.49	30.17	25.37	22.47	24.25	16.78	10.48

SPP: siliquae per plant, BY: biological yield, TW: test weight, YP: seed yield per plant, Y/ha: seed yield per hectare, OC: oil content, MSI: membrane stability index, SCMR: SPAD chlorophyll meter reading, CT: canopy temperature, HI: harvest index

harvest index under rainfed condition (Table 2b). Ahmed *et al.* (2013) reported reduction in chlorophyll a and carotenoid content, membrane stability index, 1000 seed weight, seed yield and total biomass decrease under drought condition.

Effect of drought stress on morpho-physiological and biochemical characters

Moisture stress had a negative impact on both quantitative and qualitative aspects of the yield (as reduction in the oil content of the seeds was observed as well) (Choudhary *et al.*, 2021; Singh *et al.*, 2019). Among the all traits membrane stability index (37.78%), seed yield per plant (28.62 g), seed yield per hectare (28.55 q/ha), number of secondary branches (28.13) and number of primary branches (28.03) showed the major per cent reduction (>20) whereas it have been reported that traits like number of siliquae per plant (23.48), number of seeds per siliqua (23.08), test weight (22.45), number of siliquae on main raceme (21.82) and SPAD chlorophyll meter

reading (20.07) had more than 20 per cent and less than 25 per cent reduction. All the remaining traits show less than 20 per cent reduction in rainfed condition as compare to irrigated condition (Table 3). The reduction in siliqua per plant and seed yield observed in our study is comparable to that reported by Mirzaei *et al.* (2013), who found that drought stress significantly affected oil content, test weight, plant height, seed yield, number of seeds per siliqua, and siliqua per plant of cultivars (Hyola-401, Hyola-308, Zarfam, and PF) in Iran. Akanksha *et al.* (2020) found a decrease in yield and its allies. The possible cause of this decline in the entire set of traits under drought stress is reduced cell division, particularly during critical stages such as flowering, which results in both yield and test weight reduction (Pandey *et al.*, 2001). In general, reduction in most of the characteristics under rainfed conditions could be attributed to decreased translocation of assimilated and growth substance, impairing nitrogen metabolism, loss of turgidity and consequently reduced sink (Kumawat *et al.*, 1997).

Table 3: Effect of drought stress on morpho-physiological and biochemical characters in Indian mustard genotypes

Traits	Range						% reduction
	Min.		Max.		Mean		
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	
DF	45.33	37.67	58.67	55.67	51.90	45.10	13.10
DM	105.33	102.67	138.00	130.67	123.90	119.01	13.95
PH	120.00	95.37	227.00	19233.00	181.23	161.55	10.86
NPB	3.17	2.16	11.00	6.27	5.84	4.20	28.08
NSB	0.00	0.00	16.33	15.67	10.38	7.46	28.13
LMR	31.00	27.00	78.00	68.27	58.30	48.87	16.17
SMR	32.00	22.49	52.00	45.38	42.44	33.18	21.82
SL	4.33	3.26	7.00	5.57	5.30	4.78	9.81
SPS	9.00	7.61	53.00	30.53	13.82	10.63	23.08
SPP	145.00	108.85	527.33	452.00	314.76	240.87	23.48
YP	5.62	3.06	17.92	14.95	10.83	7.73	28.62
Y/hac.	8.32	4.53	26.55	22.14	16.04	11.46	28.55
BY	21.67	17.33	72.00	67.73	46.65	39.22	15.93
TW	3.50	2.23	6.27	5.13	4.90	3.80	22.45
OIL (%)	36.95	34.74	43.22	42.31	40.39	38.43	4.85
MSI	35.01	14.49	60.95	47.01	48.57	30.22	37.78
SCMR	30.17	25.37	50.67	40.13	40.81	32.62	20.07
CT	22.47	24.25	27.23	30.06	25.09	26.71	-6.46
HI (%)	16.78	10.48	41.50	34.13	23.70	19.78	16.54

Per cent yield reduction

Because of emerging diseases, pests, and abiotic factors such as drought and heat, mustard productivity is being harnessed. Drought and heat are the two most significant environmental stresses affecting Indian mustard growth and

yield globally. The effects of drought stress include reductions in seed yield, leaf area, plant height, and the number of lateral stems. Even so, plants have evolved a natural defence mechanism that allows them to withstand a certain amount of stress and continue to carry out all cellular functions in a variety of water and temperature conditions.

Table 4: Per cent yield reduction in the yield of 73 genotypes of Indian mustard (*Brassica juncea* L.) under drought condition

Genotypes	Yield (kg/ha)			Genotypes	Yield (kg/ha)		
	I*	R ⁺	% Reduction		I*	R ⁺	% Reduction
GIRIRAJ	2262	1465	35.24	KANTI	1220	856	29.82
URVASHI	1480	1268	14.38	BASANTI	1422	691	51.39
PM 30	1607	1070	33.41	VARUNA	1655	1152	30.40
KRANTI	2267	1531	32.46	RH 8813	1560	1136	27.22
RH 406	2193	1860	15.18	JM-3	980	675	31.13
VARDAN	1498	1284	14.29	RH 8814	1809	1251	30.83
PBR 541-4	1314	955	27.35	PM-27	1605	1449	9.74
PUSA BOLD	2387	2214	7.22	RH 781	1471	1037	29.52
PM 26	1547	1070	30.85	VAIBHAV	1284	897	30.12
SEJ-2	1320	971	26.44	DRMR 601	1783	1235	30.75
NRCHB-101	1926	1645	14.61	GM-2	1160	800	31.05
JMM-08-01	1276	840	34.19	RH 8812	1733	1185	31.63
RGN 236	1478	1037	29.84	HUJM-9504	1360	881	35.23
PM 28	1886	1745	7.51	NRCDR 02	1149	905	21.22
RLM 1359	1712	1050	38.68	NDRE-4	1208	741	38.70
PBR 91	1325	856	35.37	NPJ 112	1879	1300	30.79
NDRE-8	1073	453	57.80	MCN-10-11	1390	938	32.48
PAB 9511	832	543	34.72	HUJM-9901	1584	1317	16.84
RLC-2	1864	1152	38.20	ISH-7-3-2	1223	823	32.69
HUJM-07-06	2117	1778	16.03	HUJM-08-12	1842	1251	32.09
PAB 9534	1613	1021	36.73	HUJM-05-03	1468	988	32.74
JD-6	1318	938	28.80	NDR 8501	1616	1103	31.74
NDR-8	1374	938	31.71	HUJM-9804	1898	1136	40.15
JMM-915	1512	1054	30.29	RGN 73	2129	1531	28.09
SWARN JYOTI	1237	839	32.19	RGN 298	2254	2022	10.27
CS-54	1945	1317	32.29	PUSA BAHAR	1450	988	31.90
JMM 914	1508	1021	32.33	PITAMBARI	1040	543	47.78
ASHIRWAD	1409	1185	15.89	SHIVANI	1864	1399	24.92
RLM 619	1557	971	37.62	RH 119	2380	1959	17.72
RGN 229	2110	1802	14.58	RH 0749	2655	1679	36.77
DRMR-150-35	2069	1728	16.47	RB 50	1667	1546	7.31
DIBYA	1616	1021	36.86	VASUNDHARA	1430	1004	29.77
MAYA	1405	930	33.78	RH 30	1536	1120	27.11
PRO-19	1141	686	39.86	RVM-2	1457	955	34.46
JAGANNATH	1439	938	34.79	PUSA TARAK	1248	848	32.06
HUJM-9903	2380	1333	43.97	PUSA VIJAY	1107	758	31.58
				HUJM-08-01	1603	1070	33.24

But as climate change progresses, there are increasingly frequent weather anomalies, which ultimately harm mustard crop. The most effective and secure way for plant breeders to address these losses in mustard productivity is to create a resistant variety. So, in order to develop tolerant varieties, plant breeders must have some screening indices available to differentiate the tolerant genotypes from all the lines used in the experiment. The average reduction of all cultivars under consideration can aid in the selection of

tolerant genotypes. In rainfed condition genotypes viz., Urvashi, RH 406, Vardan, Pusa Bold, NRCHB 101, PM 28, HUJM-07-06, Ashirwad, RGN 229, DRMR 150-35, PM-27, HUJM-9901, RGN 298, RH 119 and RB 50 had less than 20 per cent yield reduction (Table 4).

The per cent yield reduction was ranged from 7.25 to 57.78%. The maximum per cent reduction was reported in NDRE-8 (57.78%) whereas minimum showed by the Pusa

bold (7.25%) followed by RB-50 (7.26%). Chauhan *et al.* (2007) reported that drought stress can reduce the yield of Indian mustard by 17-94%.

Conclusion

Based on the per cent yield reduction Pusa Bold, PM-28, PM-27 and RB-50 had less yield reduction (<10%) because they had good average performance. Results showed that under stress, all the cultivars attributes were negatively impacted significantly. However, due to lower yield reduction and tolerance mechanisms, genotypes RB-50 and RGN-48 maintained higher seed yield and oil quantity in drought conditions. These genotypes also found to drought tolerant. As a result, the genotypes with the lowest per cent yield reduction could be used for breeding purposes.

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