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ASSESSMENT OF MUSTARD GENOTYPES FOR THERMO TOLERANCE AT SEED DEVELOPMENT STAGE

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SUMMARY

In the present study thirty six mustard (*Brassica juncea* (L.) Czern & Coss) genotypes were assessed for thermotolerance at seed development stage. Seeds were sown in October (normal sowing) and November (late sowing) of *rabi* 2007-08. November sowing caused significant reduction in plant height, dry matter accumulation, branching behaviour, harvest index, yield and yield attributes. Delay one month in sowing of mustard leads to the loss of 40.6 % in seed yield over normal sowing. Genotypes BPR-541-4, NPJ-112, RGN-145 and RH-0119 were identified thermotolerant at terminal stage as these showed minimum (< 20%) reduction in the number of branches, siliquae number, dry matter at post flowering, seed yield and produced bold seeds. Heat susceptibility index values were $\leq$ 0.5 and yield stability ratio was > 80.0%. Number of branches per plant (r=0.946) and number of siliquae per plant (r=0.982) showed positive correlation with seed yield in November sown crop.

***Key words*: Dry matter accumulation, mustard, seed yield, thermotolerance.**

INTRODUCTION

In India, rapeseed mustard is commonly cultivated in arid and semi-arid zones, where abiotic stresses pose serious threat to the productivity. Plants are often subjected to temperature extreme limiting growth and development (Bhattacharjee and Mukherjee 2006). High temperature has deleterious effect on growth, photosynthesis, respiration, reproduction and also change the crop phenology. The adverse effects of high temperature on grain growth and seed yield have been well recognized in wheat (Prakash *et al.* 2004, Sharma-Natu *et al.* 2006) in pea (Guilioni *et al.* 1997) and in mustard (Singh *et al*. 2001, Tripathi *et al*. 2008). Temperature greater than 27 ºC resulted in floral sterility and yield loss in *Brassica napus* (Morrison and Stewart, 2002). In entire north eastern plain zone of the country, the recommended sowing time of mustard is the middle of October. Delay in sowing results drastic reduction in the potential yield as it results in exposure of post anthesis phase to high temperature (Chakravarty *et al.* 2006). With the introduction of late maturing varieties of paddy, sowing of mustard is generally delayed. This shortens vegetative phase, advances flowering time, accerelates senescence, reduces seed development duration and dry matter accumulation (Thurling and Das 1980, Srivastava and Balkrishna 2003, Panda *et al*. 2004, Dhaliwal *et al*. 2007). Late sowing exposes vegetative phase to low temperature, resulting in poor and slow vegetative growth. During reproductive phase high temperature results in flower abortion and poor biomass production. Therefore, only post anthesis thermotolerant varieties may not be successful under late sown conditions. Considerable genotypic variability for thermo tolerance in newly developed promising mustard genotypes exist. Hence, there is a need to screen such genotypes that

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can yield better under high temperature condition. Present study was an attempt to assess the variability in growth and yield behaviour of new promising mustard genotypes and to identify varieties suitable for late sown conditions.

MATERIALS AND METHODS

Thirty six genotypes of mustard (*Brassica juncea* (L) Czern & Coss) viz. BPR-549-9, BPR-543-2, BPR-542-14, BPR-541-5, BPR-537, BPR-541-4, BPR-541-2, BPR-549-2, BPR-542-6, BPR-540-6, BPR-541-3, NPJ-92, NPJ-119, NPJ-112, NPJ-113, NPJ-118, NPJ-116, RGN-145, RGN-152, RGN-73, NRCDR-02, NRCDR-601, RB-50, RH-0305, SKM-531, RH-0204, RH-0115, JMM-0702, RH-0119, CS-5000-1-1-1-4, RH-0116, RH-0446, CS-3000-1-1-1-5, HUJM-05-5, CS-54 and ONK-1 were sown in field under normal (27^{th} October) and late (29^{th} November) sown conditions during *rabi* 2007-08 in randomized block design with three replications at Oilseed Research Farm, Kalyanpur of the C.S. Azad University of Agriculture & Technology, Kanpur. Late sowing was done to expose the crop to face high temperature at seed filling stage. The distance between rows and plant to plant were at 45 cm and 15 cm, respectively, within rows per plot. Basal dose of 60 kg each of N, P_2O_5 and K_2O ha^{-1} was applied in the form of urea, DAP and muriate of potash, respectively. N @ 60 kg/ha was applied 35 days after sowing. Two irrigations were given i.e. 30^{th} November and 26^{th} December, 2007 in normal sown plots and on 30^{th} December, 2007 and 25^{th} January, 2008, in late sown plots. The average minimum and maximum temperature during these stages were 10.9, 26.2 ^{0}C under normal sown and 15.2 and 31.6 ºC under late sown condition, respectively. At maturity three plants were randomly harvested from each plot and used for recording number of branches, yield and yield contributory characters. The harvest index was calculated using the formula of Donald and Hambline (1976). Heat susceptibility index (S) was calculated as Fisher and Maurer (1978),

$$S = (1 - Y/Yp) / (1 - X/Xp)$$

Where Y = mean seed yield of a genotype in a stress environment (late), Yp = mean seed yield of a genotype in a stress free environment (normal), X = mean Y (seed yield) of all genotypes in late, Xp= mean Yp (seed yield) of all genotypes in normal. S is the relative heat stress tolerant ($S \leq 0.5$ stress tolerant, S > 0.5 – 1.0 moderately stress tolerant and S > 1.0 susceptible). Yield stability ratio (YS) was calculated as per Lewis (1954).

$$YS = (\text{Seed yield under late/seed yield under normal}) \times 100$$

RESULTS AND DISCUSSION

Mean minimum and maximum temperature was 4.3 - 5.4^{0}C higher during post anthesis in late sown plants as compared to normal sown. Late sowing reduced plant height, dry matter accumulation at both post flowering and at harvest and the reduction was observed 34.2, 26.0 and 25.3 % respectively, as compared to normal sown plants (Table 1). Genotypic variation in plant height, dry matter production at post flowering among genotypes was recorded in the range of 104.7 (BPR-541-2) to 187.7cm (BPR-541-5), 14.6 (BPR-542-14) to 25.3g (HUJM-05-5) in control plants. In late sown plants above characters varied 70.0 (BPR-542-14) to 118.5cm (RGN-145) and 7.5 (BPR-542-14) to 19.2g (RGN-145), respectively. Harvest index ranged in between 18.1 (BPR-542-14) to 28.6 (NPJ-112) and 8.0 (ONK-1) to 24.7 (NPJ-112), respectively, in control and late sown plants. Reduction in harvest index was noted in late sown as compared to normal sown. Reduction in height and dry matter accumulation was reported in *Brassica* species (Thurling and Das 1980, Singh *et al.* 2002, Panda *et al.* 2004).

Genotypic differences were observed in the number of primary, secondary & tertiary and total branches per plant. The number of above branches varied from 5.0 (BPR-542-14) to 10.3 (ONK-1), 13.3 (NPJ-116) to 39.4 (NRCDR-02), 18.6 (BPR-542-4) to 46.1 (NRCDR-02), 3.3 (ONK-1) to 8.8 (RGN-145), 8.4 (ONK-1) to 24.0 (RGN-145) and 11.7 (ONK-1) to 32.8 (RGN-145), respectively, in normal and late sown plants (Table 2). Reduction in number of different branches was recorded in November sown plants and it was maximum (35.0%) in secondary & tertiary branches $plant^{-1}$. Test weight among genotypes varied in the range of 3.8 (NPJ-113)

Table 1. Plant height, dry matter production and harvest index among mustard genotypes under normal and late sown conditions.

Genotype	Plant height (cm) at harvest		Dry matter (g)/plant at post flowering		Dry matter (g)/plant at harvest		Harvest index (%)	
	Normal	Late	Normal	Late	Normal	Late	Normal	Late
BPR-549-9	110.0	74.7	15.2	9.9	83.3	50.0	23.5	17.8
BPR-543-2	128.0	79.7	18.3	8.9	55.0	50.0	23.2	15.8
BPR-542-14	117.7	70.0	14.6	7.5	45.3	43.3	18.1	12.2
BPR-541-5	187.7	95.0	20.3	7.9	100.0	50.0	22.2	14.0
BPR-537	155.3	103.0	18.7	9.6	75.0	55.0	21.1	17.3
BPR-541-2	104.7	100.3	20.3	8.3	100.0	83.3	25.1	17.1
BPR-541-4	174.3	111.7	20.0	17.8	85.3	73.3	22.3	21.1
BPR-549-2	153.7	98.0	16.0	15.5	83.3	69.7	24.0	18.3
BPR-542-6	144.0	101.7	19.2	15.9	70.0	60.0	21.1	19.0
BPR-540-6	147.7	100.7	15.0	12.9	83.3	50.0	21.0	11.1
BPR-541-3	126.3	99.3	20.6	10.1	56.7	50.0	21.9	18.8
NPJ-92	134.3	100.7	19.8	10.5	103.3	60.0	22.5	17.2
NPJ-119	161.0	106.0	20.1	15.9	66.7	60.0	21.1	18.5
NPJ-112	125.0	112.3	20.1	18.4	66.7	62.7	28.6	24.7
NPJ-113	124.3	88.7	23.4	15.7	63.3	53.3	21.6	18.8
NPJ-118	152.7	106.3	18.2	15.3	83.3	70.0	20.4	19.3
NPJ-116	116.0	95.3	16.5	12.1	53.3	50.0	20.0	15.4
RGN-145	180.0	118.5	23.5	19.2	90.0	80.7	25.8	23.9
RGN-152	184.7	102.3	22.0	16.6	93.3	60.0	24.3	19.5
RGN-73	156.7	104.0	20.2	16.4	103.3	83.3	25.1	18.1
NRCDR-02	167.3	105.0	20.8	15.5	129.1	83.3	23.4	16.5
NRCDR-601	153.0	100.0	18.4	13.6	73.3	55.3	23.7	20.3
RB-50	158.3	91.0	23.5	15.8	100.0	83.3	24.3	16.7
RH-0305	147.3	95.7	16.0	13.3	103.3	60.0	28.4	17.3
SKM-531	155.7	102.3	20.1	16.0	73.3	60.0	21.6	19.7
RH-0204	163.0	101.0	20.8	16.0	83.3	60.0	19.4	17.3
RH-0115	176.3	105.0	20.6	16.0	133.3	73.3	21.2	20.1
JMM-0702	155.7	105.0	17.1	14.3	83.3	46.7	19.9	16.3
RH-0119	157.7	115.5	22.0	18.9	67.5	64.7	26.6	23.2
CS-5000-1-1-1-4	184.0	105.7	16.1	14.7	100.0	53.3	26.6	20.9
RH-0116	166.7	102.2	15.7	14.6	133.3	83.3	20.7	12.7
RH-0446	155.3	102.5	20.3	16.0	85.3	83.3	25.3	19.9
CS-3000-1-1-1-5	169.7	103.3	22.1	15.9	83.3	73.0	24.4	21.6
HUJM-05-5	180.7	105.0	25.3	17.1	106.7	83.3	22.7	21.2
CS-54	159.7	105.0	17.0	15.5	90.0	83.3	20.4	17.2
ONK-1	174.0	99.5	15.2	13.6	83.3	50.0	23.9	8.0
Mean	152.8	100.5 (34.2)	19.2	14.2 (26.0)	85.8	64.1 (25.3)	22.9	17.9
CD (0.05)	* **	* x **	* **	* x **	* **	* x **	* **	* x **
	7.5 1.8	10.6	1.2 0.3	1.7	4.2 1.0	6.0	1.5 0.4	2.2

* G = Genotype, ** S = Sowing date

Data in parenthesis indicates % reduction in late over normal.

Table 2. Number of branches per plant and test weight among mustard genotypes under normal and late sown conditions.

Genotype	Branches/plant				Total branches plant^{-1}		1000 seed weight (g)	
	Primary		Secondary & tertiary					
	Normal	Late	Normal	Late	Normal	Late	Normal	Late
BPR-549-9	6.0	5.0	24.3	13.9	30.3	18.9 (37.6)	4.8	3.7
BPR-543-2	6.0	4.3	15.4	15.0	21.4	19.3 (9.8)	4.2	3.8
BPR-542-14	5.0	4.0	13.6	11.0	18.6	15.0 (19.4)	4.4	3.8
BPR-541-5	6.7	4.3	28.7	12.4	35.4	16.7 (52.8)	4.6	3.5
BPR-537	5.7	5.3	18.6	14.0	24.3	19.3 (20.6)	5.9	3.8
BPR-541-2	6.7	6.3	31.4	17.7	38.1	24.0 (37.0)	5.4	4.0
BPR-541-4	7.0	8.0	23.0	18.0	30.0	26.0 (13.3)	5.1	4.1
BPR-549-2	7.7	5.3	25.0	17.7	32.7	22.3 (31.8)	4.3	4.0
BPR-542-6	5.7	5.3	17.7	15.3	23.4	20.6 (12.0)	4.7	2.7
BPR-540-6	6.3	5.0	22.4	12.3	28.7	17.3 (39.7)	5.3	3.0
BPR-541-3	6.3	5.7	14.6	13.7	20.9	19.4 (7.2)	4.5	4.0
NPJ-92	10.0	5.0	27.3	15.0	37.3	20.0 (46.4)	5.2	3.6
NPJ-119	5.3	5.0	20.0	15.7	25.3	20.7 (18.2)	4.8	4.0
NPJ-112	6.0	8.0	24.7	20.3	30.7	25.0 (18.6)	4.8	4.0
NPJ-113	6.3	5.3	14.7	14.4	21.4	19.7 (7.9)	3.8	3.3
NPJ-118	7.0	6.7	20.0	15.4	27.0	22.1 (18.1)	4.2	3.6
NPJ-116	6.7	5.0	13.3	13.3	20.0	18.3 (8.5)	4.5	3.5
RGN-145	7.0	8.8	30.7	24.0	37.7	32.8 (13.0)	5.0	4.1
RGN-152	9.0	5.3	26.7	16.7	35.7	22.0 (38.4)	4.8	2.8
RGN-73	8.3	5.3	31.3	19.0	39.6	24.3 (38.6)	4.9	2.8
NRCDR-02	7.0	6.7	39.4	17.0	46.1	24.0 (47.9)	5.4	3.4
NRCDR-601	6.3	5.7	22.0	15.0	28.3	20.7 (26.9)	4.7	3.4
RB-50	9.3	6.3	28.7	17.4	38.0	23.7 (37.6)	5.7	2.9
RH-0305	9.7	5.3	35.0	14.7	44.7	20.0 (55.3)	4.6	3.4
SKM-531	6.3	5.3	18.7	15.6	24.0	21.9 (8.8)	4.9	3.9
RH-0204	5.7	5.0	18.7	15.0	24.4	20.0 (18.0)	3.9	3.6
RH-0115	7.3	6.3	36.0	18.0	43.3	24.3 (43.9)	6.0	4.0
JMM-0702	5.0	5.0	21.7	12.0	26.7	17.0 (36.3)	4.2	2.8
RH-0119	7.0	8.7	22.0	18.0	29.0	26.7 (7.9)	4.6	4.0
CS-5000-1-1-1-4	8.3	4.7	33.7	16.0	42.0	20.7 (50.7)	5.2	3.7
RH-0116	9.0	5.0	33.3	15.6	42.3	20.6 (51.3)	3.9	3.7
RH-0446	9.7	6.3	25.2	17.7	34.9	24.0 (31.2)	6.0	4.0
CS-3000-1-1-1-5	7.7	6.3	27.0	17.4	34.7	23.7 (31.7)	4.9	3.9
HUJM-05-5	10.0	5.3	28.0	19.0	38.0	24.3 (36.1)	5.6	2.7
CS-54	8.7	5.3	21.0	19.0	29.7	24.3 (18.2)	5.0	4.0
ONK-1	10.3	3.3	21.3	8.4	31.6	11.7 (63.0)	4.4	2.0
Mean	7.3	5.6 (23.2)	24.3	15.8 (35.0)	31.6	21.4 (32.3)	4.8	3.5 (27.1)
CD (0.05)	* **	* x **	* **	* x **	* **	* x **	* **	* x **
	0.6 0.1	0.9	1.4 0.3	1.9	1.8 0.4	2.5	0.4 0.1	0.6

* G = Genotype, ** S = Sowing date

Data in parenthesis indicates % reduction in late over normal.

Table 3. Number of siliquae on different branches and total per plant among mustard genotypes under normal and late sown conditions.

Genotype	Siliquae on different branches				Secondary & tertiary		Total plant^{-1}	
	Main		Primary					
	Normal	Late	Normal	Late	Normal	Late	Normal	Late
BPR-549-9	35.7	24.7	175.0	107.0	361.0	193.7	571.7	325.4(43.1)
BPR-543-2	28.3	19.7	118.7	109.0	244.7	197.7	391.7	326.4(16.7)
BPR-542-14	23.7	15.0	113.0	84.3	171.7	152.6	308.4	251.9(18.3)
BPR-541-5	42.0	18.3	163.3	96.7	423.6	175.6	628.9	290.6(53.8)
BPR-537	38.7	22.7	147.7	80.0	291.0	232.6	477.4	335.3(29.8)
BPR-541-2	36.0	30.3	230.3	148.0	486.3	288.3	752.6	466.6(38.0)
BPR-541-4	41.7	43.7	188.7	204.3	339.0	305.4	569.4	553.4 (2.9)
BPR-549-2	32.0	20.7	188.7	122.3	396.4	278.4	617.1	421.4(31.7)
BPR-542-6	36.7	21.0	163.0	113.7	267.0	256.0	466.7	390.7(16.3)
BPR-540-6	39.0	18.0	150.7	88.0	314.3	178.0	504.0	284.0(45.7)
BPR-541-3	28.7	20.3	131.0	128.0	227.7	181.4	387.4	329.7(14.9)
NPJ-92	36.0	22.7	196.3	110.0	429.0	216.0	661.3	349.0(47.2)
NPJ-119	38.3	35.3	164.0	100.0	237.3	239.7	439.6	375.0(14.7)
NPJ-112	41.0	43.5	179.3	201.2	329.0	274.4	549.3	519.1(5.5)
NPJ-113	34.3	26.7	121.7	101.7	245.4	218.0	401.4	346.41(3.7)
NPJ-118	26.7	21.3	139.0	128.3	338.7	292.0	504.4	441.6(12.5)
NPJ-116	34.0	26.0	112.3	93.3	222.7	201.0	369.0	320.3(13.2)
RGN-145	41.3	43.7	176.3	225.0	474.6	347.3	692.2	616.0(11.0)
RGN-152	32.0	29.3	189.0	114.7	412.6	274.3	633.6	418.3(34.0)
RGN-73	33.7	32.3	217.0	164.7	539.3	292.7	790.0	489.7(38.0)
NRCDR-02	44.3	21.7	227.7	127.0	582.0	308.7	854.0	457.4(46.4)
NRCDR-601	38.3	26.0	155.7	135.7	317.0	235.3	511.0	397.0(22.3)
RB-50	38.7	27.3	199.3	163.7	507.4	260.7	745.4	451.7(39.4)
RH-0305	34.7	23.7	228.3	111.7	577.3	228.3	840.3	363.7(56.7)
SKM-531	29.7	26.0	132.3	117.0	319.6	272.0	481.6	415.0(13.8)
RH-0204	33.3	23.0	152.7	118.7	296.7	220.0	482.7	361.7(25.1)
RH-0115	40.7	30.3	313.7	134.0	466.0	298.0	820.4	462.3(43.6)
JMM-0702	39.3	30.0	132.0	115.3	325.3	156.3	496.6	301.6(39.3)
RH-0119	40.3	43.3	164.7	201.7	324.3	267.4	529.3	512.4 (3.2)
CS-5000-1-1-1-4	43.7	31.7	244.0	117.3	509.6	226.7	797.3	375.7(52.9)
RH-0116	36.3	27.7	244.3	124.7	538.4	217.7	819.0	370.1(54.8)
RH-0446	35.7	28.0	188.7	163.0	398.3	379.4	622.7	570.4(8.4)
CS-3000-1-1-1-5	35.3	33.0	195.3	186.0	391.3	345.4	621.9	564.4(9.2)
HUJM-05-5	38.3	34.3	197.3	160.3	454.7	397.0	690.3	591.6(14.3)
CS-54	32.3	30.7	150.0	122.7	349.3	319.6	531.6	473.0(11.0)
ONK-1	27.3	21.3	183.3	63.7	403.0	112.0	613.6	197.0(67.9)
Mean	35.8	27.6 (22.9)	177.3	130.0 (26.7)	375.3	253.9 (32.3)	588.1	408.8(30.5)
CD (0.05)	* **	* x **	* **	* x **	* **	* x **	* **	* x **
	2.4 0.6	3.4	11.3 2.7	16.0	28.4 6.7	40.1	58.6 13.8	82.9

* G = Genotype, ** S = Sowing date

Data in parenthesis indicates % reduction in late over normal.

Table 4. Seed yield, heat susceptibility index(S) and yield stability ratio (YS) among mustard genotypes under normal and late sown conditions.

Genotype	Seed yield (g) per plant on different branches						Total/plant		Heat susceptibility index (S)	Yield stability ratio (YS)
	Main		Primary		Secondary & tertiary					
	Normal	Late	Normal	Late	Normal	Late	Normal	Late		
BPR-549-9	2.1	0.6	5.7	2.6	11.8	5.7	19.6	8.9(54.6)	1.334	45.4
BPR-543-2	1.6	0.6	4.5	1.8	6.7	5.5	12.8	7.9(38.3)	0.935	61.7
BPR-542-14	0.9	0.2	3.2	1.7	4.1	3.4	8.2	5.3(35.4)	0.864	64.6
BPR-541-5	2.4	0.3	6.1	1.5	13.7	5.2	22.2	7.0(68.5)	1.673	31.5
BPR-537	1.9	0.7	5.4	3.0	8.5	5.8	15.8	9.5(39.9)	0.974	60.1
BPR-541-2	1.7	1.0	8.4	4.6	15.0	8.6	25.1	14.2(43.4)	1.061	56.5
BPR-541-4	1.7	1.9	5.4	6.6	11.9	7.0	19.0	15.5(18.4)	0.450·	81.5·
BPR-549-2	1.9	0.4	6.6	3.4	11.5	8.9	20.0	12.7(36.5)	0.892	63.5
BPR-542-6	1.4	0.4	5.5	3.5	7.9	7.5	14.8	11.4(23.0)	0.561	77.0
BPR-540-6	1.4	0.3	5.2	1.6	10.9	3.7	17.5	5.6(68.0)	1.662	32.0
BPR-541-3	1.2	0.6	4.0	3.1	7.2	5.7	12.4	9.4(24.2)	0.591	75.8
NPJ-92	1.7	1.0	7.1	2.8	14.4	6.5	23.2	10.3(55.6)	1.359	44.3
NPJ-119	1.5	0.8	5.7	2.9	6.9	7.4	14.1	11.1(21.3)	0.520	78.7
NPJ-112	1.6	2.0	4.1	5.4	13.4	8.1	19.1	15.5(18.8)	0.460·	81.1·
NPJ-113	1.1	0.8	4.4	2.6	8.2	6.6	13.7	10.0(27.0)	0.660	72.9
NPJ-118	0.9	0.7	5.0	4.4	11.1	8.4	17.0	13.5(20.6)	0.503	79.4
NPJ-116	1.0	0.6	3.7	2.0	6.0	5.1	10.7	7.7(28.0)	0.685	71.9
RGN-145	2.0	2.3	7.4	8.3	13.9	8.7	23.3	19.3(17.2)	0.419·	82.8·
RGN-152	1.5	1.0	6.8	2.5	14.4	8.2	22.7	11.7(48.5)	1.184	51.5
RGN-73	1.6	1.0	7.9	4.9	16.4	9.2	25.9	15.1(41.7)	1.019	58.3
NRCDR-02	3.7	0.4	8.4	3.2	18.2	10.2	30.3	13.8(54.5)	1.3.31	45.5
NRCDR-601	2.4	0.6	5.1	3.0	9.9	7.6	17.4	11.2(35.6)	0.870	64.3
RB-50	2.0	0.8	7.6	5.3	14.7	7.8	24.3	13.9(42.8)	1.046	57.2
RH-0305	1.6	0.5	8.2	2.6	19.5	7.3	29.3	10.4(64.5)	1.576	35.4
SKM-531	1.1	0.9	5.1	3.7	9.6	7.2	15.8	11.8(25.3)	0.618	74.6
RH-0204	1.1	0.5	5.6	2.7	9.5	7.2	16.2	10.4(35.8)	0.875	64.1
RH-0115	2.5	0.9	10.8	3.7	14.9	10.1	28.2	14.7(47.9)	1.170	52.1
JMM-0702	1.7	1.0	4.8	3.6	10.1	3.0	16.6	7.6(54.2)	1.325	45.7
RH-0119	1.7	2.0	4.7	5.6	11.6	7.4	18.0	15.0(16.7)	0.407*	83.3*
CS-5000-1-1-1-4	2.5	1.0	7.9	4.1	16.2	6.0	26.6	11.1(58.3)	1.424	41.7
RH-0116	1.5	0.7	7.9	2.6	18.2	7.3	27.6	10.6(61.6)	1.505	38.4
RH-0446	1.2	1.0	7.5	5.0	12.9	10.6	21.6	16.6(23.1)	0.565	76.8
CS-3000-1-1-1-5	1.1	1.0	7.2	4.4	12.0	10.4	20.3	15.8(22.2)	0.541	77.8
HUJM-05-5	1.6	1.0	7.6	5.0	14.6	11.7	23.8	17.7(25.6)	0.626	74.3
CS-54	1.4	1.0	4.8	4.3	12.2	9.1	18.4	14.4(21.7)	0.531	78.2
ONK-1	2.1	0.4	5.5	1.6	12.3	2.0	19.9	4.0 (79.9)	1.953	20.1
Mean	1.7	0.8 (52.9)	6.1	3.6(41.0)	11.9	7.2(39.5)	19.7	11.7(40.6)		
CD (0.05)	* **	* x **	* **	* x **	* **	* x **	* **	* x **		
	0.2 0.1	0.2	0.4 0.1	0.6	0.6 0.1	0.8	0.9 0.2	1.9		

Data in parenthesis indicates % reduction in late over normal.
* G = Genotype, ** S = Sowing date
· = Temperature tolerant genotypes showing low(S) high (YS).

to 6.0g (RH-0115, RH-0446) and 2.0 (ONK-1) to 4.1g (BPR-541-4, RGN-145) under normal and late sown condition, respectively. Similar results have been reported by Sardana *et al.* (2008).

Significant reduction was noted in siliquae number (Table 3) borne on different branches and maximum reduction (32.3%) occured on secondary & tertiary branches. Among genotypes ONK-1 faced maximum (67.9%) reduction in siliquae number plant^{-1} in late over normal plants. Genotypic variation occurred in number of siliquae borne on main raceme, primary branches, secondary & tertiary branches and also total plant^{-1}. Maximum number of siliquae plant^{-1} was recorded in RGN-145 (616.0) in late and in NRCDR-02 (854.0) under normal sown plant. Late sowing caused 30.5% reduction in number of siliquae plant^{-1} over normal sowing. The reduction in production of siliquae may be due to floral sterility caused due to high temperature exposure at terminal stage. Such observations have also been reported by (Talwar *et al.* 1999, Kurmi 2002, Morrison and Stewart 2002).

Significant reduction occured in seed yield in plants under late sown conditions as compared to normal sown plants. The magnitude of reduction in yield of main, primary, secondary & tertiary and plant^{-1} was observed 52.9, 41.0, 39.5 and 40.6 %, respectively, per plant (Table 4). Among genotypes ONK-1 experienced highest (79.9 %) reduction while minimum reduction (16.7%) in seed yield plant^{-1} was observed in RH-0119 in late environment. Maximum (19.3 g) seed yield plant^{-1} was recorded in RGN-145 in November sown plants whereas, in October sown plants maximum (30.3g) seed yield plant^{-1} was observed in NRCDR-02. The reduction in seed yield might be attributed to similar reduction in biomass accumulation and yield attributes of late sown plants. Similar reduction in yield, yield attributes and genotypic differences in late sowing have also been reported in Brassica species (Srivastava & Balkrishna 2003, Gan *et al.* 2004, Tripathi *et al.* 2008).

Genotypes BPR-541-4, NPJ-112, RGN-145 and RH-0119 were identified thermotolerant at seed filling stage as in these value of heat susceptibility index was $\leq$ 0.5 and yield stability ratio was > 80.0% (Table 4). The seed yield per plant has significant positive correlation (Table 5) with number of branches per plant (r=0.946), number of siliquae per plant (r = 0.982) under late sown while dry matter at harvest (r=0.924), number of siliquae per plant (r=0.992) and number of branches per plant (r=0.989) under normal sown. Similar correlation between seed yield and yield attributes had also been reported by Tripathi *et al.* (2008) in mustard.

Table 5. Relationship between seed yield and other characters in mustard sown under normal and late sown conditions.

Characters	Correlation coefficient (r) with seed yield	
	Normal sown	Late sown
Yield vs dry matter at post flowering	-0.174	0.675**
Yield vs dry matter at harvest	0.924**	0.827**
Yield vs number of branches/plant	0.989**	0.946**
Yield vs number of siliquae on main raceme	0.503**	0.711**
Yield vs number of siliquae on primary branches	0.893**	0.581**
Yield vs number of siliquae on secondary & tertiary branches	0.978**	0.941**
Yield vs number of siliquae /plant	0.992**	0.982**
Yield vs harvest index	0.535**	0.792**
Yield vs seed yield on main raceme	0.604**	0.684**
Yield vs seed yield on primary branches	0.912**	0.875**
Yield vs seed yield on secondary and tertiary branches	0.864**	0.887**

** significant at P = 0.01 (r=>0.302)

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