Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 521-526
Received: 18-01-2020
Accepted: 22-02-2020

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Terminal heat stress on account of late sowing influences growth and development of mustard (B*rassica juncea* L.) genotypes

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Abstract
Investigation entitled "Physiological and biochemical responses associated with terminal heat stress tolerance in Indian mustard (*Brassica juncea* (L.) Czern & Coss.) genotypes" was carried out during *rabi* 2017-18 to investigate the effect of delay in sowing on morphological, physiological, and phenological parameters of mustard affecting yield and yield attributes. Five genotypes of mustard *viz*. Pusa mustard 25 (V_1), Pusa mustard 26 (V_2), BPR-541-4 (V_3), RH-406 (V_4) and Urvashi (V_5) were sown in field on October 30 (normal sown; S_1), November 18 (late sown; S_2) and November 30 (very late sown; S_3) conditions under recommended package of practices. Data pertaining to different parameters were collected at regular intervals. It was observed that leaf number plant^{-1}, leaf area plant^{-1} and leaf dry weight plant^{-1} of mustard genotypes was the maximum when sown on November 15 (S_2). These parameters decreased significantly when sowing was done on November 30 (S_3). These parameters, though as compared to S_2 were lower in S_1, but differences in normal (S_1) and late (S_2) sowings were marginal. Specific leaf area (SLA), specific leaf weight (SLW), leaf area index (LAI) and leaf area ratio (LAR)) indicated that specific leaf area (SLA) and leaf area ration (LAR) at 30 DAS was the maximum and gradually declined till maturity, specific leaf weight (SLW) was the maximum at 90 DAS while leaf area index (LAI) was the maximum in at 60 DAS.

Keywords: Phenological parameters, specific leaf area, specific leaf weight, leaf weight ratio

Introduction
Mustard is cultivated mostly in temperate regions and grown in certain subtropical and tropical regions as a cool season crop. It is widely grown in India, Canada, Australia, China and Russia. India stands at third position in both area and production of rapeseed-mustard after the Canada and China. India contributed 93.39 million tonnes of rapeseed-mustard during 2018-19, from an area of 6.63 million ha with the productivity of 1,281 kg ha^{-1}. (Directorate of Economics and Statistics, DAC&FW, 2018-19). In India rapeseed-mustard is the third important oilseed crop after soybean (*Glycine max*) and groundnut (*Arachis hypogeal*). Contribution of rapeseed-mustard in the total oilseeds production is 28.6% and ranks second after the groundnut sharing 27.8% in India's oilseed economy. Genus *Brassica* represents more than 100 species of rapeseed (*Brassica napus* L.), mustard (*Brassica juncea* L.), cabbage (*Brassica oleracea* L.) and turnip rape (*Brassica rapa* L.), which are mainly grown for oil, condiments, vegetables or fodder purposes (Ashraf and McNeilly, 2004; Hosaini *et al*., 2009) [3, 8]. Generally, the, genetic makeup of Indian mustard is (AABB, 2n = 36), and originated from a cross between *B. rapa* (AA, 2n = 20) and *B. nigra* (BB, 2n = 16).
High temperatures during growth and developmental phases can cause substantial yield losses in *Brassica* species (Angadi *et al*. 2000; Morrison and Stewart, 2002) [2, 10]. Likewise, the seasonal temperature and rainfall patterns indicate that a combined temperature and water stress usually occurs in spring seeded annual crops during their reproductive stages. Moreover, it is expected that the frequency these events will increase in future mainly in the semi-arid regions and arid region and can cause a substantial loss in yield of *rabi* crops (Cutforth *et al*. 1999; Cutforth, 2000) [2, 5, 6]. Indian mustard is grown in regions with annual precipitation of 500 to 4200 mm, the annual temperature varied from 6 °C to 27 °C and soil pH of 4.3 to 8.3 (Singh, 2013) as rain-fed or irrigated crop planted through September (early), October (timely) to November (late). Early sowing prevents the plant from diseases, aphid attack and fruit shattering; however, the heat stress severely affects germination, seedling establishment and finally the yield. The inter or/ mixed cropping with wheat as well as late sowing after rice or cotton exposes this crop to high temperature stress during reproductive stage (Chauhan *et al*. 2009) [4].

2. Methods and Material
The field experiment conducted at the Agriculture Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (India), during *rabi* (winter season) 2017-18. The lab experiments and laboratory analyses of plant and seeds samples were done in the Department of Plant Physiology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (UP), India and investigation was carried out taking five genotypes of Indian mustard, i.e. Pusa mustard 25 (V_1), Pusa mustard 26 (V_2), BPR-541-4 (V_3), RH-406 (V_4) and Urvashi (V_5). The above mentioned five genotypes of Indian mustard were sown in field on the three dates, i.e., October 30, November 15 and November 30 during 2017 in factorial randomized block design with three replications under normal fertility conditions.

2.1 Leaf number
Leaves were counted at 30, 60 and 90 DAS on three randomly selected plants in each plot and mean values were calculated.

2.2 Leaf area (cm^2 plant^{-1})
Three plants from each plot were selected at random and uprooted every 30 days interval at 30 60 90 DAS. Shoot were removed and surviving green leaf were separated area of all leaves collected from plant (three plants plots^{-1}) were drawn on white paper seat as early as possible. Paper area, representing leaves area, was cut and their weight (g) was determined on an electrical balance correctly at the fourth place of decimal. Known paper area from the sample same paper seat (5 cm×5 cm) was also removed and weight similarly. Total leaf area of a plants was determining as Leaf area = Paper weight (g) representing leaf area × Known paper area cm^2 / Weight (g) of known area of paper This was further expressed on per plant basis.

2.3 Leaf dry matter (g)
Three plants from each plot were selected at random and uprooted every 30 days interval at 30 60 90 DAS and harvest stage. After sundried, leaves are removed and kept in an oven at 70° C till the constant weight. The average was recorded as leaf dry matter g plant^{-1}.
Weight of the leaf was added to the rest of the shoot weight to obtain total dry matter production (TDMP). This was expressed on per plant basis shoot dry weight and leaf area of plants were utilized to calculate specific leaf area (SLA), specific leaf weight (SLW) Leaf area index (LAI) and leaf area ratio (LAR) at 30, 60 and 90 DAS.

2.4 Specific leaf area (SLA) (cm^2 g^{-1})
Specific leaf area is a ratio indicating how much leaf area a plant builds with a given amount of leaf biomass. It was expressed as cm^2 g^{-1}. SLA was measured at 30, 60 and 90 DAS.

$$SLA = A_L/W_L$$

Where
$A_{L=}$ where A is the area of a given leaves plant^{-1}
$W_{L=}$ W_L is the dry mass of those leaves plant^{-1}

2.5 Specific leaf weight (SLW) (mg cm-^{2})
SLW indicated the leaf thickness and was determined by the formula of Redford (1976). It was expressed as mg cm-^{2}. SLW was measured at 30, 60 and 90 DAS.

SLW=Leaf dry weight (mg)/ Leaf area (cm^2).

2.6 Leaf area index (LAI)
LAI was calculated by dividing the leaf area per plant with the land area occupied per plant (Sestak *et al.*). LAI was measured at 30, 60 and 90 DAS.
LAI = Leaf area/ Land area

2.7 Leaf area ratio (cm-^{2} g-^{1})
Leaf area ratio (LAR) calculated by dividing total leaf area of a plant divided by the dry mass of the entire plant (D.J Watson). It indicates the efficiency with which a plant uses its leaves to produce plant material. Typically measured in cm^2 g^{-1} at 30, 60 and 90 DAS.
LAR= Leaf area/ plant dry weight

3. Experimental finding
3.1 Leaf number plant^{-1}
Leaf number plant^{-1} was determined at 30, 60 and 90 day after sowing (DAS). At all stages differences were significant with respect to sowing date (S) genotype (G) and S×G. During 2017-18 at 30 DAS the average leaf number plant^{-1} was significantly higher in S_1 (5.1 leaves plant^{-1}) than in plants under S_2 (4.7 leaves plant^{-1}) and S_3 (2.8 leaves plant^{-1}) sowings (Table 1). However, mean value for genotypes was the maximum for V_3 (4.7 leaves plant^{-1}) and the minimum for V_5 (3.8 leaves plant^{-1}) and it followed a trends as $V_3>V_2>V_1>V_4>V_5$. The trends for leaf number plant^{-1} under different sowing dates as well as genotypes at 90 DAS indicated that when sowing was done on November 15 (S_2) the leaf number was the maximum (50.2 leaves plant^{-1}), followed by when sowing was done on October 30 (S_1;46.5 leaves plant^{-1}) and the minimum (29.8 leaves plant^{-1}) when crop was sown on November 30. Nevertheless, at 90 DAS mean leaf number plant^{-1} in difference genotype ranged between 50.5 (V_5)-36.1 (V_1) and it followed a trend as $V_3>V_2>V_1>V_4>V_5$, where difference between V_4 and V_5 were not significant. Similarly, differences between V_1 and V_2 were also not significant.

3.2 Leaf area (cm^2 plant^{-1})
Leaf area (cm^2 plant^{-1}) was determined at 30, 60 and 90 day after sowing. At all stages differences were significant with respect to sowing date (S) genotype (G) and S×G. During 2017-18 at 30 DAS stage the average leaf area plant^{-1} was significantly higher in plant under S_2 (551.92 cm^2) than in S_1 (492.99 cm^2) and S_3 (408.00 cm^2) sowings. However, mean value for genotype was the maximum for V_3 (516.62 cm^2 plant^{-1}) and the minimum for V_5 (442.31 cm^2 plant^{-1}) and it followed a trends as $V_3>V_2>V_1>V_4>V_3$.
As compare to 30 DAS, at 60 DAS stage there was about 2 folds increase in leaf area plant^{-1} under respective sowing dates. At this stage also mean leaf area under different sowing dates showed the maximum value for plants under S_1 (960.42 cm^2 plant^{-1}) followed by S_2 (927.81 cm^2 plant^{-1}) and the minimum (834.10 cm^2 plant^{-1}) in plants under S_3 sowing. However, mean value for genotype was the maximum for V_3 (1034.8 cm^2 plant^{-1}) and the minimum for V_5 (725.65 cm^2 plant^{-1}) and followed a trends as $V_3>V_2>V_1>V_4>V_5$. Differences between V_1 and V_2 were not significant; similarly difference between V_4 and V_5 were also not significant (Table 2). The trend for leaf area under different sowing dates as well as genotypes at 90 DAS stage indicated that when sowing was done on October 30 (S1) the leaf area was the maximum

(383.50 cm^2 $plant^{-1}$), followed by when sowing was done on November 15 (S2; 367.79 cm^2 $plant^{-1}$) and the minimum when crop was sown on November 30 (333.64 cm^2 $plant^{-1}$). Nevertheless, at 90 DAS stage mean leaf area in different genotype ranged between 413.95 (V_3) to 283.59 cm^2 $plant^{-1}$ (V_5) and followed a trend as V_3>V_2>V_1>V_4>V_5. Difference between V_1 and V_3 were not significant; similarly difference between V_2 and V_4 were significant (Table 2).

3.3 Leaf dry weight (g $plant^{-1}$)

Leaf dry weight was determined at 30, 60 and 90 day after sowing (DAS). At all stages differences were significant with respect to sowing date (S) genotype (G) and S×G. During 2017-18 at 30 DAS the average leaf dry weight did not differ significantly between plants under S_1 (1.56 g $plant^{-1}$) and S_2 (1.60 g $plant^{-1}$) sowings and average leaf dry weight of S_3 (0.31g $plant^{-1}$) was significantly lower than that of S_1 and S_2 (Table 3). Average values for genotypes V_1 (1.09 g $plant^{-1}$), V_2 (1.39 g $plant^{-1}$) and V_4 (0.95 g $plant^{-1}$) also differed significantly. Mean leaf weight $plant^{-1}$ was the maximum for V_3 (1.55 g $plant^{-1}$) and the minimum for V_5 (0.81 g $plant^{-1}$) and followed a trends as: V_3>V_2>V_1>V_5>V_4. At 60 DAS also mean leaf dry weight under different sowing dates showed the maximum value for plants under S_2 (6.16 g $plant^{-1}$) followed by S_1 (5.08 g $plant^{-1}$) sowing and the minimum (3.02 g $plant^{-1}$) for plants under S_3 sowing. Mean value for different genotypes ranged between 3.96-5.50 g $plant^{-1}$ and a trend as: V_3>V_2>V_1>V_4>V_5. Differences were not significant between V_1 (4.80 g $plant^{-1}$) and V_2 (5.11 g $plant^{-1}$) as well as between V_4 (4.39 g $plant^{-1}$) and V_5 (3.96 g $plant^{-1}$), however it was the minimum for V_5 and the maximum for V_3. At 90 DAS average leaf dry weight was the maximum (7.55 g $plant^{-1}$) in plants under S_2 sowing followed by S_1 (7.15 g $plant^{-1}$) and the minimum (5.45 g $plant^{-1}$) in S_3. Mean values of genotype V_3 (7.28 g $plant^{-1}$) and V_2 (7.35 g $plant^{1}$) differ significantly. Mean values of different genotype also follow similar trends as observed at 90 DAS with the maximum (7.35 g $plant^{-1}$) in V_2 and the minimum (5.65 g $plant^{-1}$) in V_5 and followed a trend as: V_2>V_3>V_1>V_4>V_5 (Table 3).

3.4 Specific leaf area (cm^2 g^{-1})

Specific leaf area (SLA) was determined at 30, 60 and 90 day after sowing (DAS). Values were calculated as cm^2 g^{-1} dry matter production.

During 2017-18 significant difference were observed with respect to sowing date (S), genotype (G) and S×G (Table 4). The mean SLA was maximum at 30 DAS and for genotypes it ranged from 467.28 cm^2 g^{-1} (V_3) to 1232.96 cm^2 g^{-1} (V_5) and for sowing dates is ranged between 327.21 cm^2 g^{-1} (S_1) to 1693.05 cm^2 g^{-1} (S_3). Differences between S_1, S_2 did not differed significantly but value under S_3 sowing was significantly higher than those for S_1, S_2 sowings. Mean values for sowing dates though decrease at 60 DAS to a greater magnitude than 30 DAS and the patterns for different genotypes and sowing dates were comparable. Mean values for different genotypes register the maximum for V_1 (227.67 cm^2 g^{-1}) and the minimum for V_4 (187.01 cm^2 g^{-1}) and followed a pattern as: V_1>V_3>V_2>V_5>V_4. Differences between V_2 and V_4 were significant while in rest of the genotypes it was significantly higher for V_1. Value between S_1,S_2 and S_3 indicated significantly lower SLA when sowing was done on November 15 (S_2; 154.45 cm^2 g^{-1}) as compared to that when sowing was done on October 30 (S_1; 190.53 cm^2 g^{-1}) followed by when sowing was done November 30 (S_3; 274.33 cm^2 g^{-1}). The SLA at 90 DAS decreased nearly 4-fold than 60 DAS. At 90 DAS the mean SLA values for crops sown under S_3 (64.37 cm^2 g^{-1}) was significantly higher than under S_1 (53.65 cm^2 g^{-1}) followed by S_2 (48.94 cm^2 g^{-1}) sowings. Nevertheless, the mean value for genotypes indicated the maximum for V_3 (65.60 cm^2 g^{-1}) and the minimum for V_4 (48.53 cm^2 g^{-1}). The difference between V_1, and V_4 was significant and as compared to other genotypes it was significantly higher for V_3 and followed a trend as: V_3>V_1>V_2 >V_5>V_4 (Table 4).

3.5 Specific leaf weight (mg cm^{-2})

Net assimilation rate (SLW) was determined at 30, 60 and 90 day after sowing (DAS). Values were calculated as mg dry matter production in cm^2 area.

During 2017-18 significant difference were observed with respect to sowing date (S), genotype (G) and S×G (Table 5). The mean SLW was minimum at 30 DAS and for genotypes it ranged from 1.78 mg cm^{-2} (V_5) to 2.90 mg cm^{-2} (V_3) and for sowing dates is ranged between 0.76 mg cm^{-2} (S_3) to 3.14 mg cm^{-2} (S_1). Differences between S_1, S_2 and S_3 sowing dates were significant and value under S_1 sowing was significantly higher than those for S_2, S_3 sowings. Mean values for sowing dates though about 1.5-fold increases at 60 DAS and the patterns for different genotypes and sowing dates were comparable. Mean values for different genotypes register the maximum for V_3 (5.85 mg cm^{-2}) and the minimum for V_1 (4.85 mg cm^{-2} 30 $days^{-1}$) and followed a pattern as: V_3>V_4>V_5>V_2>V_1. Differences between V_1 and V_4 were significant while in rest of the genotypes it was significantly higher for V_3. Values between S_1, S_2 and S_3 indicated significantly lower SLW when sowing was done on November 30 (S_3; 3.78 mg cm^{-2}) as compared to that when sowing was done on October 30 (S_1; 5.40 mg cm^{-2}) followed by when sowing was done November 15 (S_2; 6.83 mg cm^{-2}).

The mean SLW was at 90 DAS for genotypes ranged from 17.54 mg cm^{-2} (V_1) to 20.95 mg cm^{-2} (V_4) and for sowing dates is ranged between 17.35 mg cm^{-2} (S_3) to 20.98 mg cm^{-2} (S_2). Differences between S_1, and S_2 did not differ significantly and value under S_3 sowing was significantly lower than those for S_1, S_2 sowings.

3.6 Leaf area index

Leaf area index (LAI) was determined at 30, 60 and 90 day after sowing (DAS). During 2017-18 significant difference were observed with respect to sowing date (S), genotype (G) and S×G (Table 6).

The mean LAI values for genotypes at 30 DAS stage ranged between 0.55 (V_5) to 0.66 (V_3) and for sowing date is ranged between 0.51 (S_3) to 0.69 (S_2). Values for S_1, S_2 and S_3 sown condition differed significantly and higher for plant sown under late sown condition (S_2). As compared to 30 DAS the mean LAI at 60 DAS increased to a lesser extent. Mean value for different genotypes registered the maximum for V_3 (1.29) and the minimum for V_5 (0.91) and followed a pattern as: V_3>V_1=V_2>V_4 >V_5. Mean LAI between S_1 and S_2 (S_1; 1.20) (S_2; 1.16) did not differ significantly but significantly lower for (S_3; 1.04) when sowing was done on November 30 (Table 6). The mean LAI was at 90 DAS for genotypes ranged from 0.35 (V_5) to 0.52 (V_3) and for sowing dates is ranged between 0.42 (S_3) to 0.48 (S_1). Differences between S_1, and S_2 did not differ significantly and value under S_3 sowing was significantly lower than those for S_1, S_2 sowings.

3.7 Leaf area ration ($cm^2\ g^{-1}$)
Leaf area ration (LAR) was determined at 30, 60 and 90 day after sowing (DAS). During 2017-18 significant difference were observed with respect to sowing date (S), genotype (G) and S×G (Table 7). The mean LAR ($cm^2\ g^{-1}$) values for genotypes at 30 DAS stage ranged between 206 $cm^2\ g^{-1}$ (V_3) to 457.37 $cm^2\ g^{-1}$ (V_5) and for sowing date is ranged between 144.87 $cm^2\ g^{-1}$ (S_3) to 636 $cm^2\ g^{-1}$ (S_2). Values for S_1 and S_2 sown condition did not differed significantly and but significantly higher for plant sown under very late sown condition (S_3). As compared to 30 DAS the mean LAI at 60 DAS decreased to a lesser extent. Mean value for different genotypes registered the maximum for V_1 (116.17 $cm^2\ g^{-1}$) and the minimum for V_5 (0.91) and followed a pattern as: V_1>V_2>V_3>V_5 >V_4. Mean LAI between S_1 and S_2 (S_1; 1.20 $cm^2\ g^{-1}$) (S_2;1.16 $cm^2\ g^{-1}$) did not differ significantly but significantly higher for (S_3;148.61 $cm^2\ g^{-1}$) when sowing was done on November 30. The mean LAI was at 90 DAS for genotypes ranged from 12.28 $cm^2\ g^{-1}$ (V_5) to 17.88 $cm^2\ g^{-1}$ (V_3) and for sowing dates is ranged between 10.07 $cm^2\ g^{-1}$ (S_2) to 22.99 $cm^2\ g^{-1}$ (S_3). Differences between S_1, and S_2 did not differ significantly and value under S_3 sowing was significantly higher than those for S_1, S_2 sowings.

4. Discussion
In mustard higher leaf area development during vegetative phase is desirable as it supports production of more and deeper root system enabling plants to extract moisture from deeper soil layers and enhancing their tolerance under moisture deficit condition at latter phases of growth. It is also desirable that during flower and siliqua development phase's leaf area should decrease to reduced transpirational losses. As siliqua and stem of mustard are green, therefore, they are self-sufficient to supply photoassimilates to developing siliqua and seeds. Between 60-90 DAS leaf area decrease significantly in all the genotype (Table 2). Increased CGR, in spite of decreased leaf area $plant^{-1}$ after 60 day after sowing, further confirmed that major role for siliqua and contained seed development is been played by green walls of siliqua and stem, leaves has no major contribution in plant growth once reproductive phase has started.

Specific leaf area (SLA), specific leaf weight (SLW) leaf area index (LAI) and leaf area ratio (LAR) indicated that specific leaf area (SLA) and leaf area ration (LAR) at 30 DAS was the maximum and gradually declined till maturity, specific leaf weight (SLW) was the maximum at 90 DAS while leaf area index (LAI) was the maximum in at 60 DAS. The increment in SLW after 30 DAS has been observed to be due to significant reduction in leaf area. This also supported that in mustard though after 60 DAS leaf area declined but crop maintain higher dry matter accumulation on an account of photosynthetic apparatus other than leaves, i.e., green siliqua and stem. Same result also observed by Singh *et al.* 2004 [12], Kumari *et al*. 2012 [9], Akhter *et al.* 2014 [1], Singh *et al.* 2014 a, b [13, 14].

Table 1: Leaf number ($plant^{-1}$) in five genotypes of mustard at 30, 60 and 90 day after sowing (DAS) sown at three different dates during *rabi* 2017-18.

S. No.	Genotype*	Year 2017-18											
		30 DAS			Mean	60 DAS			Mean	90 DAS			Mean
		Sowing date#				Sowing date#				Sowing date#			
		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
1.	V_1	5.12	4.45	3.12	4.23	28.33	28.83	18.55	25.24	48.00	48.90	29.79	42.23
2.	V_2	5.30	4.58	2.89	4.26	30.11	35.81	19.50	28.47	51.20	53.66	32.10	45.65
3.	V_3	5.17	5.34	3.45	4.65	25.44	39.82	21.91	29.06	51.93	62.48	37.10	50.51
4.	V_4	5.19	4.35	2.89	4.14	21.89	27.21	16.35	21.82	42.80	45.98	20.43	36.40
5.	V_5	4.67	4.89	1.77	3.78	21.89	24.92	15.85	20.89	38.53	39.99	29.79	36.11
	Mean	5.09	4.72	2.82		25.53	31.32	18.43		46.49	50.20	29.84	
		S.Em±		CD (5%)		S.Em±		CD (5%)		S.Em±		CD (5%)	
Sowing date (S)		0.11		0.31		0.61		1.77		1.48		4.28	
Genotype (G)		0.14		0.40		0.79		2.29		1.91		5.53	
S×G		0.24		0.69		1.37		3.96		3.31		9.58	

*Genotype: V_1; Pusa mustard 25, V_2; Pusa mustard 26, V_3; BPR-541-4, V_4; RH-406 and V_5; Urvashi

#S_1, S_2 and S_3 represent sowing dates, i.e., timely sown (October 30), late sown (November 15) and very late sown (November 30) respectively.

Table 2: Leaf area ($cm^2\ plant^{-1}$) in five genotypes of mustard at 30, 60 and 90 day after sowing (DAS) sown at three different dates during *rabi* 2017-18.

S. No.	Genotype*	Year 2017-18											
		30 DAS			Mean	60 DAS			Mean	90 DAS			Mean
		Sowing date#				Sowing date#				Sowing date#			
		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
1.	V_1	504.37	561.24	389.50	485.03	1093.50	950.71	934.94	993.05	437.40	380.29	373.97	397.22
2.	V_2	522.98	575.57	395.23	497.93	937.25	1123.00	922.03	994.10	374.90	449.20	368.81	397.64
3.	V_3	506.89	584.27	458.71	516.62	1222.48	798.87	1083.30	1034.88	488.99	319.55	433.32	413.95
4.	V_4	494.70	559.31	384.86	479.62	795.20	963.55	609.88	789.54	318.08	385.42	243.95	315.82
5.	V_5	436.02	479.22	411.69	442.31	753.64	802.93	620.37	725.65	298.12	304.50	248.15	283.59
	Mean	492.99	551.92	408.00		960.42	927.81	834.10		383.50	367.79	333.64	
		S.Em±		CD (5%)		S.Em±		CD (5%)		S.Em±		CD (5%)	
Sowing date (S)		8.08		23.40		28.01		81.17		11.03		31.94	
Genotype (G)		10.43		30.20		36.17		104.78		14.24		41.24	
S×G		18.06		52.31		62.65		181.49		24.66		71.43	

*Genotype: V_1; Pusa mustard 25, V_2; Pusa mustard 26, V_3; BPR-541-4, V_4; RH-406 and V_5; Urvashi.

#S_1, S_2 and S_3 represent sowing dates, i.e., timely sown (October 30), late sown (November 15) and very late sown (November 30) respectively.

Table 3: Leaf dry weight (g $plant^{-1}$) in five genotypes of mustard at 30, 60 and 90 day after sowing (DAS) sown at three different dates during *rabi* 2017-18.

S. No.	Genotype*	Year 2017-18											
		30 DAS			Mean	60 DAS			Mean	90 DAS			Mean
		Sowing date#				Sowing date#				Sowing date#			
		S_1	S_2	S_3		S_1	S_2	S_3		S1	S2	S3	
1.	V_1	1.62	1.37	0.27	1.09	5.43	6.08	2.88	4.80	7.45	7.46	5.59	6.84
2.	V_2	1.74	2.01	0.42	1.39	5.60	6.65	3.09	5.11	7.65	8.35	6.05	7.35
3.	V_3	1.89	2.22	0.53	1.55	5.15	7.71	3.65	5.50	8.25	8.47	5.11	7.28
4.	V_4	1.39	1.29	0.19	0.95	5.11	5.30	2.77	4.39	7.06	6.88	5.49	6.48
5.	V_5	1.15	1.12	0.15	0.81	4.11	5.06	2.71	3.96	5.33	6.60	5.01	5.65
	Mean	1.56	1.60	0.31		5.08	6.16	3.02		7.15	7.55	5.45	
		S.Em±		CD (5%)		S.Em±		CD (5%)		S.Em±		CD (5%)	
Sowing date (S)		0.03		0.10		0.15		0.45		0.15		0.45	
Genotype(G)		0.05		0.13		0.19		0.56		0.20		0.58	
S×G		0.08		0.23		0.34		0.98		0.34		1.00	

*Genotype: V_1; Pusa mustard 25, V_2; Pusa mustard 26, V_3; BPR-541-4, V_4; RH-406 and V_5; Urvashi.
#S_1, S_2 and S_3 represent sowing dates, i.e., timely sown (October 30), late sown (November 15) and very late sown (November 30) respectively.

Table 4: Specific leaf area (cm^2 g^{-1}) in five genotypes of mustard at 30, 60 and 90 days after sowing (DAS) sown at three different dates during *rabi* 2017-18.

S. No.	Genotype*	Year 2017-18											
		30 DAS			Mean	60 DAS			Mean	90 DAS			Mean
		Sowing date#				Sowing date#				Sowing date#			
		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
1.	V_1	312.63	418.65	1693.71	808.33	200.55	156.22	326.23	227.67	58.37	51.02	66.83	58.74
2.	V_2	302.16	286.40	947.60	512.05	171.69	169.55	298.67	213.30	49.00	53.84	61.13	54.66
3.	V_3	268.64	264.98	868.21	467.28	237.75	105.81	296.89	213.48	59.33	37.63	99.83	65.60
4.	V_4	356.22	437.03	2091.73	961.66	158.79	181.82	220.44	187.01	45.05	55.98	44.56	48.53
5.	V_5	396.43	438.47	2863.99	1232.96	183.88	158.84	229.42	190.71	56.51	46.26	49.52	50.76
	Mean	327.21	369.10	1693.05		190.53	154.45	274.33		53.65	48.94	64.37	
		S.Em±		CD (5%)		S.Em±		CD (5%)		S.Em±		CD (5%)	
Sowing date (S)		31.66		91.73		6.78		19.65		1.20		3.47	
Genotype (G)		40.88		118.42		8.76		25.37		1.55		4.48	
S×G		70.80		205.11		15.17		43.95		2.68		7.76	

*Genotype: V_1; Pusa mustard 25, V_2; Pusa mustard 26, V_3; BPR-541-4, V_4; RH-406 and V_5; Urvashi.
#S_1, S_2 and S_3 represent sowing dates, i.e., timely sown (October 30), late sown (November 15) and very late sown (November 30) respectively.

Table 5: Specific leaf weight (mg cm^{-2}) in five genotypes of mustard at 30, 60 and 90 days after sowing (DAS) sown at three different dates during *rabi* 2017-18.

S. No.	Genotype*	Year 2017-18											
		30 DAS			Mean	60 DAS			Mean	90 DAS			Mean
		Sowing date#				Sowing date#				Sowing date#			
		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
1.	V_1	3.21	2.45	0.70	2.12	4.99	6.41	3.16	4.85	17.63	19.73	15.25	17.54
2.	V_2	3.32	3.50	1.07	2.63	5.95	5.92	3.37	5.08	20.41	18.64	16.49	18.51
3.	V_3	3.73	3.80	1.16	2.90	4.22	9.95	3.39	5.85	16.87	26.94	12.00	18.60
4.	V_4	2.82	2.30	0.52	1.88	6.39	5.50	4.57	5.49	22.37	17.86	22.61	20.95
5.	V_5	2.64	2.33	0.36	1.78	5.46	6.36	4.39	5.41	17.94	21.71	20.38	20.01
	Mean	3.14	2.88	0.76		5.40	6.83	3.78		19.04	20.98	17.35	
		S.Em±		CD (5%)		S.Em±		CD (5%)		S.Em±		CD (5%)	
Sowing date (S)		0.07		0.20		0.147		0.426		0.61		1.77	
Genotype (G)		0.09		0.26		0.190		0.550		0.79		2.28	
S×G		0.15		0.44		0.329		0.953		1.36		3.95	

*Genotype: V_1; Pusa mustard 25, V_2; Pusa mustard 26, V_3; BPR-541-4, V_4; RH-406 and V_5; Urvashi.
#S_1, S_2 and S_3 represent sowing dates, i.e., timely sown (October 30), late sown (November 15) and very late sown (November 30), respectively.

Table 6: Leaf area index (LAI) in five genotypes of mustard at 30, 60 and 90 days after sowing (DAS) sown at three different dates during *rabi* 2017-18.

S. No.	Genotype*	Year 2017-18											
		30 DAS			Mean	60 DAS			Mean	90 DAS			Mean
		Sowing date#				Sowing date#				Sowing date#			
		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
1.	V_1	0.63	0.70	0.49	0.61	1.37	1.19	1.17	1.24	0.55	0.48	0.47	0.50
2.	V_2	0.65	0.72	0.49	0.62	1.17	1.40	1.15	1.24	0.47	0.56	0.46	0.50
3.	V_3	0.63	0.73	0.57	0.65	1.53	1.00	1.35	1.29	0.61	0.40	0.54	0.52
4.	V_4	0.62	0.70	0.48	0.60	0.99	1.20	0.76	0.99	0.40	0.48	0.30	0.39

5.	V_5	0.55	0.60	0.51	0.55	0.94	1.00	0.78	0.91	0.37	0.38	0.31	0.35
	Mean	0.62	0.69	0.51		1.20	1.16	1.04		0.48	0.46	0.42	
		S.Em±		CD (5%)		S.Em±		CD (5%)		S.Em±		CD (5%)	
Sowing date (S)		0.01		0.03		0.04		0.10		0.01		0.04	
Genotype (V)		0.01		0.04		0.05		0.13		0.02		0.05	
S×G		0.02		0.07		0.08		0.23		0.03		0.09	

*Genotype: V_1; Pusa mustard 25, V_2; Pusa mustard 26, V_3; BPR-541-4, V_4; RH-406 and V_5; Urvashi.

#S_1, S_2 and S_3 represent sowing dates, i.e., timely sown (October 30), late sown (November 15) and very late sown (November 30), respectively.

Table 7: Leaf area ratio (cm^{-2} g^{-1}) in five genotypes of mustard at 30, 60 and 90 days after sowing (DAS) sown at three different dates during *rabi* 2017-18.

S. No.	Genotype*	Year 2017-18											
		30 DAS			Mean	60 DAS			Mean	90 DAS			Mean
		Sowing date#				Sowing date#				Sowing date#			
		S_1	S_2	S_3		S_1	S_2	S_3		S_1	S_2	S_3	
1.	V_1	138.99	183.65	523.69	282.11	91.94	71.64	184.93	116.17	12.64	10.88	30.13	17.88
2.	V_2	135.61	128.90	387.95	217.49	75.14	77.27	161.17	104.52	12.52	10.74	24.45	15.90
3.	V_3	122.00	119.77	376.23	206.00	101.65	49.54	161.09	104.09	12.57	8.44	26.11	15.70
4.	V_4	156.81	191.22	826.86	391.63	71.78	79.59	115.56	88.98	10.63	11.38	14.84	12.28
5.	V_5	170.94	189.08	1066.09	475.37	81.36	85.13	120.31	95.60	10.35	8.89	19.44	12.89
	Mean	144.87	162.52	636.16		84.37	72.63	148.61		11.74	10.07	22.99	
		S.Em±		CD (5%)		S.Em±		CD (5%)		S.Em±		CD (5%)	
Sowing date (S)		20.19		58.49		3.82		11.08		0.94		2.72	
Genotype (G)		26.06		75.51		4.94		14.30		1.21		3.51	
S×G		45.15		130.78		8.55		24.76		2.10		6.08	

*Genotype: V_1; Pusa mustard 25, V_2; Pusa mustard 26, V_3; BPR-541-4, V_4; RH-406 and V_5; Urvashi.

#S_1, S_2 and S_3 represent sowing date, s i.e., timely sown (October 30), late sown (November 15) and very late sown (November 30) respectively.

5. Conclusions

Leaf number $plant^{-1}$, shoot dry weight $plant^{-1}$, leaf area $plant^{-1}$ and leaf dry weight $plant^{-1}$ of mustard genotypes was the maximum when sown on November 15(S_2). These parameters decreased significantly when sowing was done on November 30 (S_3). These parameters, though as compared to S_2were lower in S_1, but differences in normal (S_1) and late (S_2) sowings were marginal.

Specific leaf area (SLA) and leaf area ration (LAR) at 30 DAS was the maximum and gradually declined till maturity, specific leaf area (SLA) and leaf area ration (LAR) was the maximum crop sown on November 30 (S_3) registered higher SLA than when shown on November 15 (S_2) or October 30 (S_1). As compared to other sowing dates, crop under November 30 sowing always registered significantly lower SLW. Leaf area index (LAI) was the maximum at 30 DAS and then declined progressively, Genotype BPR-541-4 (V_3) registered maximum LAI while minimum for Urvashi (V_5).

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