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RESPONSE OF DIFFERENT SOWING DATES ON MORPHO-PHYSIOLOGICAL PARAMETERS AND YIELD IN MUSTARD GENOTYPES

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ABSTRACT

The present investigation was undertaken to study the effect of sowing dates (30th October and 30th November) on ten genotypes (ACN-240, SKM-1626, ACN-226, ACN-244, ACN-250, ACN-255, T-9, ACN-237, PM-26 and TAM 108-1) of mustard. The experiment was undertaken during raby season 2020-21. Experimental design was FRBD replicated thrice. The observations on plant height, number of branches plant^{-1}, dry matter, leaf area, RGR, NAR, seed yield plot^{-1} and harvest index were recorded and calculated. Considering the all above parameters genotype ACN-250 followed by ACN-237 and ACN-226 were found to be promising genotypes when compared with two checks (PM-26 and TAM 108-1) and remaining genotypes when sown at 30th October. But 30th November sowing all these parameters were reduced, hence 30th October sowing can be considered as best sowing time for enhancing the morpho-physiological parameters, yield and harvest index. 30th October sowing with genotype ACN-250 proved to be best among the interactions for all morpho-physiological parameters (plant height, number of branches, dry matter, kafarea, RGR and NAR) yield and harvest index. Correlation was found highly significant and positive for all morphophysiological characters and harvest index with yield.

(Key words : Mustard genotypes, morpho-physiological parameters, yield, harvest index, correlation, interaction)

INTRODUCTION

Mustard (*Brassica juncea* L.) is the second important oil seed crop in India after groundnut in area and production. Indian mustard (*Brassica juncea)* is called as "Rai" or "Laha" is an important oil seed crop belonging to *Brassica* group. It belongs to family *Crucifereae* with Chromosome number 2n = 36. Important species of *Brassica* that are extensively cultivated are *Brassica juncea, Brassica campestris* and *Brassica napus.* Out of these, *Brassica juncea* and *Brassica campestris* are largely grown in India. Mustard is cultivated mostly under temperate climate. It is also cultivated in certain tropical and subtropical region as a cold weather crop.Major states producing mustard areUttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Haryana, Punjab, Assam, West Bengal and Bihar accounting for bulk of area under commercial cultivation. In Maharashtra the sole crop of mustard is seldom grown but with its low cost of production and high yielding potential it can be grown in Vidarbha.

Sowing date is one of the critical components affecting mustard crop productivity. It is one of the most important agronomic factors which have the way for better-use of time and play an important role to fully exploit the genetic potentiality of a variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall. Sowing period information is needed for various other purposes like adjusting crop rotations, cropping patterns, crop growth simulations and climate change impact studies (Singh *et al.,* 2018).

Sowing time influences phenological development of crop plants through temperature and heat unit. Sowing at optimum time gives higher yields due to suitable environment that prevails at all the growth stages (Singh *et al.,* 2017). Considering the above facts present investigation was carried out to study the effect of sowing dates on morpho-physiological characters and yield in mustard.

MATERIALAS AND METHODS

Present investigation was under taken during *rabi* 2020-21 on the farm of AICRP on linseed and mustard, College of Agriculture, Nagpur. Experiment was conducted in FRBD in three replications with two sowing dates i.e. 30th October and 30th November and ten genotypes including checks *viz.*, ACN-240, SKM-1626, ACN-226, ACN-244, ACN-250, ACN-255, T-9, ACN-237, PM-26 and TAM 108-1. Gross plot size was 3.15 m × 2.20 m and net plot size was 2.25 m × 2.00 m with spacing of 45 cm × 10 cm. Observations on plant height and number of branches plant^{-1} were recoded at maturity. Observations on total dry matter plant^{-1} and leaf area plant^{-1}were recorded at 25, 45, 65 and 85 DAS. RGR

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(Fischer, 1971) and NAR (Williams, 1946) were calculated at 25-45, 45-65 and 65-85 DAS. Harvest index was calculated by the procedure suggested by Donald and Hamblin, (1976). Yield plant^{-1}was also recorded. Simple correlation was computed by using the formula given by Singh and Chaudhary (1994).

RESULTS AND DISCUSSION

Plant height (cm) and number of branches plant^{-1}

The significantly higher plant height and number of branches plant^{-1} was recorded in 30thOctober sowing (183.03 cm and 4.34) when compared with 30thNovember sowing (163.58 cm and 3.63). This is due to reason that 30th October sown crop might have received optimum temperature and more sunshine hours as compared to 30thNovember sown crop and this might have accelerated the plant growth resulting into higher plant height and number of branches in 30thOctober sown crop.

Jiotode *et al.* (2017) conducted an experiment on *rabi* mustard consisting of five main treatments of sowing dates *viz.,* D_1 (42ndMW), D_2 (43rdMW), D_3 (44thMW), D_4 (45thMW) and D_5 (46thMW) and two sub treatments of varieties *viz*., V_1 (Pusa Bold) and V_2 (ACN-9) and reported that plant height and number of branches were more in V_1 (Pusa Bold) as compared to V_2 (ACN-9) when crop was sown in 43rdMW (22nd-28thOctober). They opined that thermal requirement and thermal use efficiency of mustard was also more when crop was sown on 43rdMW. This might be the reason for increase in plant height and number of branches when crop was sown on 30thOctober as compared to when crop was sown at 30thNovember.

The significantly higher plant height and number of branches plant^{-1} were observed in three genotypes ACN-250, ACN-237 and ACN-226 when compared with checks (PM-26 and TAM 108-1) and other genotypes (ACN-244, SKM-1626, ACN-255, T-9 and ACN-244). Results showed the highest plant height and number of branches plant^{-1}was observed in genotype ACN-250 (190.87 cm and 5.63) and lower in genotype ACN-240 (146.48 cm and 2.92). This might be due to their genetic constitution as compared to other genotypes.

Patel *et al.* (2017) assessed the effect of different sowing dates on growth of Indian mustard varieties. They found that at harvest the Varuna recorded significantly higher plant height and number of branches plant^{-1}as compared to Narendra Rai-1 and Kranti, this might be due to their own genetic characteristics.

Among the interactions the highest plant height and number of branches plant^{-1} was observed in genotype ACN-250 (G_5) with 30thOctober (D_1) sown condition, while lower in ACN-240 (G_1) with 30thNovember sowing condition (D_2).

Significant and highly positive association was found in plant height and number of branches plant^{-1} with seed yield (0.944** and 0.940**) at harvesting stage. Ilmulwar *et al.* (2003) and Dhongade *et al.*(2018) had also reported positive and significant association of plant height and number of branches plant^{-1}with seed yield in mustard.

Dry matter plant^{-1} (g)

At 25, 45, 65 and 85 DAS significantly higher dry matter production plant^{-1} was observed in 30th October sown crop plant^{-1} (5.83, 11.88, 45.76 and 58.45 g respectively) as compared to 30th November sown crop (4.10, 8.13, 33.88 and 44.16 g respectively). This might be due to the reason that 30th October sowing facilitates favourable environment for growth of the plant and higher PAR (photosynthetically active radiation) interception on leaf which maximize photosynthetic rate and ultimately dry matter accumulation.

Jain and Sandhu (2019) studied the radiation interception and growth dynamics in mustard under different dates of sowing. They found that the PAR interception was higher in 10th October sowing as compared to 5th November and 1st December sowing at the flowering and siliqua formation stage. This might have increased leaf area index under 10thOctober sowing. The PAR interception by the canopy influences the leaf photosynthesis efficiency, which turns in higher dry matter production.

At 25, 45, 65 and 85 DAS significantly highest total dry matter production was recorded in genotypes ACN-250, ACN-237 and ACN-226 which were superior over checks (PM-26 and TAM 108-1) and other genotypes(SKM-1626, ACN-244, T-9, ACN-255 and ACN-244). Data revealed that genotype ACN-250 performed best among all the genotypes for total dry matter production at all stages of observations (6.88, 12.04, 46.41 and 55.57 g at 25, 45, 65 and 85 DAS respectively). It might be due to their own genetic potential to produce higher translocate through better photosynthetic system. Whereas, genotype ACN-240 had lower dry matter accumulation at all stages of observations (2.96, 6.82, 35.95 and 45.92 g at 25, 45, 65 and 85 DAS).

Patel *et al.* (2017) found that variety Varuna recorded significantly higher dry matter accumulation at 60, 90, and at harvest as compared to varieties Narendra Rai-1 and Kranti respectively. It might be due to genetic characters of varietyVaruna.

Among the interactions 30thOctober sowing (D_1) with genotype ACN-250 (G_5) stood 1stin interaction for total dry matter production at all stages of observations (25, 45, 65 and 85 DAS). Whereas, 30thNovember sowing(D_2) with genotype ACN-240 (G_1) stood last in interaction for total dry matter production at all stages of observations.

At all stages of observations highly significant and positive correlation was noted between total dry matter production and seed yield (0.986**, 0.938**, 0.916**, and 0.843** at 25, 45, 65 and 85 DAS respectively). Ilmulwar*et al.* (2003) and Uke *et al.* (2011)had also noted significant and positive association of dry matter production with seed yield in mustard.

Leaf Area plant^{-1} (dm^{-2})

Leaf area plays an important determinant in dry matter production and photosynthesis and it is depending upon number and size of leaves. Correlation between leaf area and yield suggest importance in determining the plant yield.

Leaf area at 25, 45, 65 and 85 DAS was significantly higher in 1stdate of sowing D_1 (3.23, 9.87, 10.73 and 9.50 dm^2 respectively) when compared with 2nddate of sowing D_2 (1.64, 7.18, 8.51 and 7.83 dm^2 respectively). This might be due to reason that early sown crop maintained better plant-water relations like leaf water potential (LWP) and higher turgor potential which led to higher rate of photosynthesis due to more opening of stomata for longer period of time, faster cell division and enlargement leads to higher growth rate. Leaf area was increased from 25-65 DAS but later at 85 DAS it was decreased. It might be due to aging.

Patel *et al.* (2017) reported delayed, sowing by one month achieved lower leaf area at all the stages of mustard crop, which might be due to less vegetative growth because of less favourable environmental conditions when crop was sown too early and late sowing conditions.

At 25, 45, 65 and 85 DAS significantly higher leaf area was observed in genotypes ACN-250, ACN-237 and ACN-226 when compared with checks (PM-26 and TAM 108-1) and other genotypes (ACN-244, SKM-1626, T-9, ACN-255 and ACN-244). Data revealed the higher leaf area was found in genotype ACN-250 at all stages of observations (i.e. 3.22, 10.30, 11.85 and 11.03 dm^2 at 25,45,65 and 85 DAS respectively) and lower in ACN-240 at all the stages of observations (i.e. 1.70, 5.39, 6.62 and 5.86 dm^2 at 25,45,65 and 85 DAS respectively). This might be due to their genetic makeup as compared to other genotypes.

Mondal *et al.* (2018) investigated the morpho-physiological attributes in six *Brassica juncea* mutants *viz.,* MM01, MM02, MM04, MM08, MM09 and MM10. Results revealed that leaf area increased till 70 DAS and declined thereafter because of leaf shedding. At peak leaf area development stage (70 DAS) the mutant MM10 showed highest leaf area than other mutants and the lowest leaf area was recorded in mutant MM09 at most of the growth stages. The variation in the leaf area might be due to variation in number of leaves and the expansion of the leaf.

Among all the interactions 30thOctober sowing date (D_1) with genotype ACN-250 (G_5) was found to be best interaction for leaf area at each stage of observations (25, 45, 65, 85 DAS). While, 30thNovember sowing date (D_2) with genotype ACN-240 (G_1) was observed lower leaf area at all stages of observations.

Correlation studies revealed significant and positive association of leaf area with seed yield at all stages of observations (0.910**, 0.952**, 0.982** and 0.960** at 24, 45, 65 and 85 DAS respectively). Uke *et al.* (2011) and Raut *et al.* (2012) had also observed positive relationship between leaf area and seed yield of mustard.

RGR (Relative Growth Rate) (g g^{-1} day^{-1})

The relative growth rate during 25-45 DAS, 45-65 DAS and 65-85 DAS was found significant and the higher RGR was recorded in 1st date of sowing i.e. 30th October (0.0272, 0.1041 and 0.0754 g g^{-1} day^{-1} respectively) as compared to 2nd date of sowing i.e. 30th November (0.0231, 0.0933 and 0.0609 g g^{-1} day^{-1} respectively) at all stages of observations. This might be due to reason that the optimum sowing period during 30th October facilitates favourable climatic conditions in terms of temperature and photoperiod led to higher dry matter production and ultimately higher relative growth rate. Whereas, 30th October sown crop expose to low temperature during vegetative stage led to slow physiological processes and lower growth rate.

Kumar *et al.* (2018) studied the phenological and growth responses of Indian mustard (*Brassica juncea* L.) genotypes to different sowing dates. They reported that high temperature at 23rd September sown crop might have accelerated the plant growth which might have resulted into increased relative growth rate. Temperature gradient i.e. low temperature at vegetative phase and high temperature at reproductive phase during 21st November sown crop might have resulted into decreased relative growth rate.

At 25-45, 45-65 and 65-85 DAS significantly higher RGR was recorded in genotypes ACN-250, ACN-237 and ACN-226 which were superior over the checks (PM-26 and TAM 108-1) and other genotypes (SKM-1626, ACN-244, T-9, ACN-255 and ACN-244).Results showed that significantly highest RGR was found in genotype ACN-250 at all stages of observations (0.0348, 0.1225 and 0.0840 g g^{-1}day^{-1} at 25-45, 45-65 and 65-85 DAS respectively). This might be due to higher genetic potential for efficient utilization of photosynthates and produced higher dry matter. Whereas, significantly lower RGR was recorded in genotype ACN-240 at all stages of observations (0.0132, 0.0671 and 0.0458 g g^{-1}day^{-1} at 25-45, 45-65 and 65-85 DAS respectively). It might be due to lower genetic potential of the genotype as compared to other genotypes studied.

Dhongade *et al.* (2019) investigated M4 Indian mutants for morpho-physiological variability, they found significantly maximum RGR in mutants ACM_{18}, ACM_{12}, ACM_6, ACM_8, ACM_4 and ACM_7 when compared with check Bio-902 and Pusa bold. This might be due to their genetic makeup.

Among the interactions 30th October sowing (D_1) with genotype ACN-250 (G_5) was found the best interaction for relative growth rate at all stages of observations (25-45, 45-65 and 65-85 DAS). Whereas, 30th November sowing (D_2) with genotype ACN-240 (G_1) stood last in interaction for relative growth rate at all stages of observations.

Correlation studies revealed highly significant and positive association of RGR with seed yield (0.9.04**, 0.917** and 0.955** at 25-45, 45-65 and 65-85 DAS respectively) at all stages of observations. Ilmulwar *et al.* (2003), Uke *et al.* (2011) and Raut *et al.* (2012) had also found strong positive correlation of RGR with seed yield in mustard.

NAR (Net Assimilation Rate) (g d m^{-2} day^{-1})

The net assimilation rate during 25-45 DAS, 45-65 DAS and 65-85 DAS was found significant and the higher NAR was noted in 30th October sown crop (0.0432, 0.1651 and 0.0553 g dm^{-2} day^{-1} respectively) when compared with 30th November sown crop (0.0269, 0.1193 and 0.0394 g dm^{-2} day^{-1} respectively) at all stages of observations. This might be due to reason that the optimum sowing period during 30th October facilitates favourable temperature for higher assimilating surface which might have resulted into increased photosynthesis and assimilation rate. Whereas, during 30th November sowing expose to temperature gradient, means low temperature at vegetative phase and high temperature at reproductive phase resulted into lower leaf area production and ultimately decreased net assimilation rate.

Panda *et al.* (2004) investigated the influence of dates of sowing on crop physiology of Indian mustard. They reported that dates of sowing had significant effect on NAR values at all the crop growth stages. Delayed sowing after October 16th progressively and significantly decreased the NAR. It was due to decrease in mean temperature at later dates of sowing which reduced the leaf expansion and growth of the crop.

At 25-45, 45-65 and 65-85 DAS significantly higher NAR was observed in genotypes ACN-250, ACN-237 and ACN-226 when compared with the checks (PM-26 and TAM 108-1) and other genotypes (ACN-244, SKM-1626, ACN-255, T-9 and ACN-244).Results showed that significantly highest NAR was recorded in genotype ACN-250 at all stages of observations (0.0493, 0.1782 and 0.0624 g dm^{-2} day^{-1} at 25-45, 45-65 and 65-85 DAS respectively). This might be due to higher genetic potential to produce higher leaf expansion which led to enhanced photosynthesis and ultimately net assimilation rate. Whereas, significantly lower NAR was found in genotype ACN-240 at all stages of observations (0.0126, 0.0870 and 0.0297 at 25-45, 45-65 and 65-85 DAS respectively). It might be due to their lower genetic potential when compared to other genotypes studied.

Increase in NAR during reproductive phase might be due to increased efficiency of leaves for photosynthesis as a response of photosynthetic apparatus to increase demand for assimilates by growing seed fraction (Dhongade *et al.,* 2019) in Indian mustard.

Among the interactions 30th October sown crop (D_1) with genotype ACN-250 (G_5) was found to be the best interaction for net assimilation rate (NAR) at all stages of observations (25-45, 45-65 and 65-85 DAS). Whereas, 30th November sown crop (D_2) with genotype ACN-240 (G_1) was observed the lower interaction for net assimilation rate (NAR) at all stages of observations.

Correlation data showed significant and highly positive association of NAR with seed yield (0.987**, 0.957** and 0.967** at 25-45, 45-65 and 65-85 DAS respectively). Ilmulwar *et al.* (2003) and Uke *et al.* (2011) had also reported positive correlation of NAR with seed yield in mustard.

Harvest Index (%)

Significantly higher harvest index was recorded in 30th October sown crop (24.76 %) as compared to 30th November sown crop (19.52 %). This might be due to reason that early sown crop (30th October) crop received optimum temperature at the time of harvesting which led to higher plant height, leaf area, dry matter production and number of branches. While, late sown (30th November) crop expose to higher temperature at the time of harvesting might have resulted into lower plant height, number of branches, leaf area and dry matter accumulation.

Kumar *et al.* (2018) observed that among the sowing dates the harvest index was highest in crop sown October 16th and lowest was found in crop sown on November 21st. This might be due to reason that on 16th October sowing the prevailing temperature at the time of harvesting was optimum for mustard crop. Hence, 16th October sown crop had normal sowing condition for mustard that might have resulted into higher dry matter accumulation, maximum number of primary and secondary branches and siliqua plant^{-1} which led to increase harvest index, while, on 21st November sowing the high temperature was prevailing at the time of harvesting might have resulted into lower dry matter accumulation, less number of primary and secondary branches which led to decrease harvest index in Indian Mustard.

Significantly higher harvest index was observed in genotypes ACN-250, ACN-237 and ACN-226 which were superior over the checks (PM-26 and TAM 108-1) and other genotypes (ACN-244, SKM-1626, ACN-255, T-9 and ACN-244). Similarly higher harvest index was found in genotypes PM-26 and TAM 108-1 when compared with remaining genotypes. Significantly moderate to lower harvest index was calculated in genotypes ACN-244, SKM-1626, ACN-255, T-9 and ACN-240 in a descending manner. Data showed that significantly highest harvest index was recorded in genotype ACN-250 (27.90 %) and lower in ACN-240 (15.78 %). This might be due to genotype-to-genotype variation between their genetic potential.

Kumar *et al.* (2018) conducted field experiment to study the effect of different sowing dates on yield and yield attributes of Indian mustard. The highest harvest index was recorded in genotype RH-0116 and lowest harvest index was recorded in genotype RH-1019. This is because of variation in different genotypes in their genetic makeup.

Results showed that significantly highest harvest index was observed at 30th October sown crop (D_1) with genotype ACN-250 (G_5) and lower was recorded at 30th November sown crop (D_2) with genotype ACN-240 (G_2).

Harvest index was found significantly and positively associated with seed yield (0.960**). Dhongade

Table 1. Response of different sowing dates on plant height, number of branches plant^{-1} and dry matter in mustard genotypes

Sowing Date / Genotypes	Plant height (cm)			No. of branches plant^{-1}			Dry matter (g) at 25 DAS			Dry matter (g) at 45 DAS			Dry matter (g) at 65 DAS			Dry matter (g) at 85 DAS		
	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)
ACN-240 (G_1)	160.7	132.6	146.68	3.40	2.43	2.92	3.92	1.99	2.96	8.74	4.90	6.82	41.66	30.22	35.95	53.23	38.61	45.92
SKM-1626 (G_2)	184.2	160.7	172.45	3.79	3.17	3.48	5.48	3.69	4.59	11.73	7.84	9.79	45.03	34.17	39.60	58.73	43.17	50.56
ACN-226 (G_3)	190.8	178.4	184.67	5.10	4.24	4.68	6.67	4.94	5.81	13.20	9.28	11.24	47.02	38.94	42.99	61.64	46.19	53.92
ACN-244 (G_4)	176.0	163.5	169.78	3.59	3.50	3.55	5.04	4.24	4.64	11.12	8.13	9.63	44.34	34.56	39.46	56.04	44.00	50.02
ACN-250 (G_5)	196.8	183.7	190.27	6.41	4.84	5.63	7.96	5.79	6.88	14.05	10.02	12.04	50.38	42.43	46.41	62.55	48.59	55.57
ACN-255(G_6)	171.8	143.5	157.65	3.49	3.00	3.25	4.61	3.27	3.94	9.78	6.97	8.38	43.68	33.54	38.62	54.35	42.17	48.27
T-9(G_7)	180.4	148.8	164.67	3.74	2.67	3.21	5.21	2.92	4.07	11.46	7.15	9.31	44.66	32.93	38.80	56.56	41.04	48.80
ACN-237 (G_8)	192.7	180.6	186.70	5.34	4.54	4.94	7.49	5.41	6.46	13.78	9.75	11.77	49.70	41.97	45.84	62.03	47.76	54.90
PM-26 (G_9)	188.6	173.2	180.92	4.42	4.13	4.28	6.17	4.51	5.35	12.79	8.76	10.78	45.71	35.17	40.45	60.03	45.31	52.67
TAM 108-1 (G_{10})	188.0	170.6	179.30	4.13	3.79	3.96	5.79	4.27	5.04	12.21	8.48	10.35	45.42	34.90	40.17	59.40	44.75	50.08
Mean (D)	183.03	163.58		4.34	3.63		5.83	4.10		11.88	8.13		45.76	35.88		58.45	44.16	
	D	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**
SEm ±	**1.171**	**2.618**	**4.535**	**0.064**	**0.143**	**0.248**	**0.07**	**0.15**	**0.26**	**0.07**	**0.15**	**0.25**	**0.22**	**0.50**	**0.86**	**0.19**	**0.42**	**0.73**
CD at 5%	**3.352**	**7.497**	**12.98**	**0.183**	**0.411**	**0.712**	**0.19**	**0.42**	**0.73**	**0.18**	**0.42**	**0.73**	**0.63**	**1.42**	**2.47**	**0.54**	**1.21**	**2.10**

D_1 = 1stDate of sowing (30thOctober), D_2 = 2nd Date of sowing (30th November), G = Genotype, D = Date of sowing

Table 2. Response of different sowing dates on leaf area and RGR in mustard genotypes

Sowing Date /	Leaf area (dm^2) at 25 DAS			Leaf area (dm^2) at 45 DAS			Leaf area (dm^2) at 65 DAS			Leaf area (dm^2) at 85 DAS			RGR ($g\ g^{-1}\ day^{-1}$) at 25-45 DAS			RGR ($g\ g^{-1}\ day^{-1}$) at 45-65 DAS		
Genotypes	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)
CN-240 (G_1)	2.54	0.84	1.70	6.92	3.86	5.39	8.00	5.24	6.62	7.24	4.47	5.86	0.015	0.011	0.013	0.075	0.058	0.067
SKM-1626 (G_2)	3.20	1.30	2.25	10.03	6.49	8.26	10.46	7.66	9.06	9.22	7.80	8.51	0.025	0.020	0.023	0.101	0.088	0.095
ACN-226 (G_3)	3.43	2.13	2.78	10.92	8.82	9.88	11.29	10.30	10.80	10.81	9.21	10.01	0.033	0.028	0.031	0.118	0.109	0.113
ACN-244 (G_4)	3.11	1.50	2.31	9.63	7.03	8.34	10.37	7.78	9.08	8.45	7.10	7.78	0.023	0.022	0.022	0.098	0.091	0.095
ACN-250 (G_5)	3.82	2.61	3.22	11.36	9.23	10.30	13.07	10.62	11.85	12.21	9.83	11.03	0.038	0.031	0.034	0.127	0.117	0.122
ACN-255(G_6)	2.89	1.10	2.00	8.27	5.64	6.96	9.42	7.14	8.28	7.93	6.95	7.29	0.019	0.018	0.019	0.086	0.078	0.082
T-9(G_7)3.14	0.96	2.05	9.87	4.75	7.32	10.17	6.63	8.41	8.84	5.91	7.38	0.020	0.015	0.018	0.091	0.073	0.082	
ACN-237 (G_8)	3.64	2.32	2.98	11.19	9.05	10.13	12.63	10.13	11.39	10.95	9.81	10.38	0.036	0.030	0.033	0.120	0.112	0.116
PM-26 (G_9)	3.35	1.91	2.63	10.36	8.72	9.54	11.05	9.46	10.50	9.88	8.95	9.42	0.031	0.026	0.028	0.111	0.103	0.107
TAM 108-1 (G_{10})	3.24	1.72	2.48	10.17	8.26	9.22	10.82	9.67	10.25	9.53	8.55	9.04	0.029	0.024	0.026	0.109	0.099	0.104
Mean (D)	3.23	1.64		9.87	7.18		10.73	8.51		9.507	7.832		0.027	0.023		0.104	0.093	
	D	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**
SEm ±	**0.039**	**0.088**	**0.153**	**0.130**	**0.291**	**0.504**	**0.125**	**0.280**	**0.485**	**0.113**	**0.253**	**0.439**	**0.0003**	**0.0007**	**0.0011**	**0.0006**	**0.0012**	**0.0021**
CD at 5%	**0.113**	**0.254**	**0.440**	**0.372**	**0.833**	**1.444**	**0.359**	**0.802**	**1.390**	**0.324**	**0.726**	**1.258**	**0.0008**	**0.0018**	**0.0032**	**0.0015**	**0.0035**	**0.0061**

D_1 = 1st Date of sowing (30th October), D_2 = 2nd Date of sowing (30th November), G = Genotype,

Table 3. Response of different sowing dates on leaf area and RGR in mustard genotypes

Sowing Date /	RGR ($g\ g^{-1}\ day^{-1}$) at 65-85 DAS			NAR ($g\ dm^{-2}\ day^{-1}$) at 25-45 DAS			NAR ($g\ dm^{-2}\ day^{-1}$) (45-65) DAS			NAR ($g\ dm^{-2}\ day^{-1}$) (65-25) DAS			Harvest Index (%)			Seed yield $plot^{-1}$ (kg)		
Genotypes	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)	D_1	D_2	Mean(G)
ACN-240 (G_1)	0.051	0.040	0.045	0.031	0.012	0.021	0.099	0.074	0.087	0.037	0.021	0.029	19.47	12.09	15.78	0.73	0.42	0.58
SKM-1626 (G_2)	0.075	0.055	0.065	0.041	0.022	0.032	0.164	0.110	0.137	0.053	0.034	0.044	24.15	16.35	20.25	0.95	0.60	0.78
ACN-226 (G_3)	0.085	0.070	0.077	0.048	0.033	0.041	0.193	0.136	0.165	0.063	0.049	0.056	28.57	24.07	26.33	1.01	0.87	0.95
ACN-244 (G_4)	0.072	0.056	0.064	0.040	0.025	0.032	0.158	0.117	0.137	0.051	0.038	0.044	21.29	20.16	20.96	0.90	0.69	0.80
ACN-250 (G_5)	0.091	0.076	0.084	0.057	0.041	0.049	0.201	0.155	0.178	0.069	0.055	0.062	30.27	25.53	27.90	1.29	1.00	1.15
ACN-255(G_6)	0.062	0.051	0.056	0.035	0.020	0.027	0.139	0.100	0.119	0.043	0.027	0.035	19.82	16.19	18.01	0.86	0.64	0.75
T-9(G_7)	0.064	0.050	0.057	0.037	0.016	0.027	0.147	0.090	0.119	0.048	0.030	0.039	22.73	12.09	17.41	0.90	0.52	0.72
ACN-237 (G_8)	0.089	0.072	0.080	0.050	0.035	0.042	0.194	0.153	0.173	0.066	0.052	0.059	28.72	24.58	26.65	1.22	0.92	1.07
PM-26 (G_9)	0.082	0.068	0.075	0.045	0.031	0.038	0.178	0.129	0.153	0.060	0.042	0.051	26.45	22.48	24.47	1.00	0.84	0.93
TAM 108-1 (G_{10})	0.080	0.065	0.073	0.044	0.029	0.036	0.178	0.125	0.149	0.058	0.041	0.050	26.14	21.20	23.67	0.97	0.78	0.88
Mean (D)	0.075	0.060		0.043	0.026		0.165	0.119		0.055	0.039		24.76	19.52		0.98	0.73	
	D	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**	**D**	**G**	**D×G**
SEm ±	**0.0004**	**0.0009**	**0.0015**	**0.0004**	**0.0008**	**0.0014**	**0.0014**	**0.0032**	**0.0056**	**0.0003**	**0.0007**	**0.0012**	**0.35**	**0.79**	**1.37**	**0.012**	**0.028**	**0.049**
CD at 5%	**0.0011**	**0.0025**	**0.0044**	**0.0010**	**0.0023**	**0.0040**	**0.0041**	**0.0092**	**0.0160**	**0.0008**	**0.0020**	**0.0035**	**1.02**	**2.27**	**3.94**	**0.035**	**0.081**	**0.141**

D_1 = 1st Date of sowing (30th October), D_2 = 2nd Date of sowing (30th November), G = Genotype, *et al.* (2019) had also observed significantly positive relation of harvest index with seed yield.

Yield plot^{-1} (kg)

Seed yield plot^{-1} was significantly highest in 1st date of sowing i.e. 30thOctober (0.98 kg) when compared with 2nddate of sowing i.e. 30thNovember (0.73 kg). This might be due to reason that early sowing facilitates optimum environmental conditions for better crop growth in terms of maximum assimilating surface (leaf area) that enhances the rate of photosynthesis which led to higher dry matter accumulation, higher plant height, more number of branches plant^{-1} and ultimately resulted into higher seed yield.

Keerthi *et al.* (2017) tested the Indian mustard (*Brassica juncea* L.) genotype RH-749 having four different dates of sowing *viz.,* 15th October, 25thOctober, 5thNovember and 15th November for yield attributes, yield and quality. They reported that early (October 15th and 25th) sown crop received the optimum environmental conditions required for better crop growth in terms of higher dry matter accumulation and maximum number of seeds siliqua^{-1} led to higher seed yield. Whereas, late (November 5th and 15th) sown crop expose to higher temperature at the time of harvesting resulted into less number of primary and secondary branches and siliquae plant^{-1} led to lower seed yield.

Significantly higher seed yield plot^{-1} was reported in genotypes ACN-205, ACN-237 and ACN-226 as compared to checks(PM-26 and TAM 108-1) and other genotypes (ACN-244, SKM-1626, ACN-255, T-9 and ACN-244).Data revealed that significantly highest seed yield plot^{-1} was found in genotype ACN-250 (1.15 kg) than other genotypes, while significantly lower in genotype ACN-240 (0.58 kg). This might be due to genetic potential of genotype ACN-250 to produce higher leaf area which enhances the photosynthetic rate, dry matter accumulation and ultimately yield of the crop.

Jiotode *et al.* (2017) reported that different varieties had significant influenced on the seed yield. The variety V1 (Pusa Bold) recorded higher seed yield than V2 (ACN-9). This might be due to variety-to-variety variation between their genetic potential to produce more seed yield.

Among the interactions significantly highest seed yield plot^{-1} was recorded at 30th October sowing (D_1) with genotype ACN-250 (G_5), while lower in 30th November sowing (D_2) with genotype ACN-240 (G_1).

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