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EFFECT OF WEATHER PARAMETER ON RABI MUSTARD VARIETIES UNDER DIFFERENT SOWING DATES

Jiotode D.J., Parlawar N.D., Patil S.R., Kuchanwar O.D., Khawle V.S. and Dhanwate A.G.

College of Agriculture, Nagpur Dr. P.D.K.V. Akola (M.S) India
Email: *djiotode@rediffmail.com*

Abstract: The present investigation was carried out at Agronomy Farm, College of Agriculture, Nagpur during *rabi* season of 2015-16. The experiment was laid out in split plot design consisting five main treatments of sowing dates *viz.,* D_1 (42nd MW), D_2 (43rd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) and two sub-treatments of varieties *viz.,* V_1 (Pusa bold) and V_2(ACN-9) replicated thrice. The final plant population at harvest was not significantly influenced due to sowing dates. Plant height, number of branches plant^{-1}, dry matter accumulation plant^{-1}, total number of siliquae plant^{-1} and number of siliquae plant^{-1} was highest on D_2 (43rd MW). Highest seed yield ha^{-1} (820 kg) was recorded in the treatment D_2 (43rd MW). Gross monetary returns and net monetary returns and benefit cost ratio was highest in sowing on D_2 (43rd MW). Plant height, number of branches plant^{-1}, and dry matter accumulation plant^{-1} were significantly influenced on all growth stages. Variety V_1 (Pusa bold) found significantly superior over V_2 (ACN-9) for all the traits. The gross and net monetary returns and also benefit-cost ratio was more in V_1 (Pusa bold) variety which was superior with V_2 (ACN-9). Interaction effects of sowing dates and varieties were found to be non-significant in respect of growth, yield attributes, quality parameters and economics of mustard crop, except seed yield. Highest seed yield were recorded (853 kg ha^{-1}) between D_2 (43rd MW) and V_1 (Pusa bold) combination. It is inferred from this study that sowing of mustard during 43rd MW and the variety Pusa bold significantly improved all the growth, seed yield and yield components traits of mustard. Thermal requirement and thermal use efficiency of mustard was also more when crop was sown on 43rd MW (D_2).

Keywords: Mustard, Sowing, Varieties, Weather parameter

Introduction:

Mustard is important oilseeds crop. Seed contain 33 to 40 per cent oil and is mainly utilized for human consumption throughout northern India for cooking as well as frying purpose. In India, area under mustard cultivation is 71.30 lakh hectares producing about 73 lakh tones of seeds with average productivity of 1023 kg hectares (Anonymous, 2014a). Area was under mustard cultivation in Maharashtra was 12000 hectares with production of 4000 tones and average productivity of 308 kg ha^{-1} and 865 kg ha^{-1} area was under cultivation in Vidarbha region having production of 330 tones and productivity of 380 kg ha^{-1} (Anonymous, 2014b).

At present the yield of mustard is low, there are many reasons for low productivity of mustard, viz; cultivation under stored soil moisture or limited irrigation water etc. out of various package of practices primary factors like optimum sowing dates and suitable varieties for the region are the most important and hence these factors were considered on priority basis under the present study. Another reason of yield reduction is non-availability of suitable variety for a particular agro-climate.

Since the rate of development of crop & oil in seed is greatly influenced by the variation in temperature, humidity & other biotic factors. Sowing either too early or too late has been reported to be harmful. Not only dates of sowing but varieties or cultivar grown also have major contribution in increasing the yield potential in mustard. Adoption of improved variety and suitable crop management practices are important factor for improving crop productivity. Sowing time plays important role in crop husbandry and remains to be the prominent factors in deciding seed as well as oil yield. Optimum sowing time is an important non-monetary input and if managed properly, it helps to enhance seed yield. Sowing of mustard at inappropriate time reduce seed yield and yield attributes.

The study of efficient utilization of the weather parameters is necessary. With this contest the present study entitled "Effect of weather parameter on rabi mustard (*Brassica juncea*) varieties under different sowing dates" was carried out with the objectives (i) to find out the effect of weather parameter on growth & yield of mustard and (ii) to study the thermal requirement & thermal use efficiency of mustard variety.

Materials and methods:

The experiment was laid out in "split plot design" with five treatments of dates of sowing (D_1 – 42nd MW, D_2 – 43rd MW, D_3 – 44th MW. D_4 – 45th MW D_5 – 46th MW) under main plot treatments and two varieties (V_1 - Pusa bold, V_2 - ACN-9) as sub plot treatment forming 10 treatment combination and replicated three times during *rabi* 2015 at Agronomy farm, College of Agriculture, Nagpur. The gross and net plot size were 3.6 m x 4.8 m and 2.7 m x 4.2 m, respectively. A spacing of 45 x 15cm was adopted by using 5 kg seed ha^{-1}. The pre harvest biometric observations on plant stand, were recorded at the time of harvest and plant height (cm), number of branches $plant^{-1}$, dry matter accumulation $plant^{-1}$ were recorded periodically at 30 days interval after sowing and at harvest from five representative plants. The post harvest biometric observations were recorded on total number of siliquae $plant^{-1}$, seed yield $plant^{-1}$ (g), seed yield (kg ha^{-1}), biomass yield (kg ha^{-1}), straw yield $plant^{-1}$ (g) and straw yield (kg ha^{-1}) after harvest from five representative plants. The benefit : cost ratio was worked out by the dividing the gross monetary returns (Rs.ha^{-1}) with total cost of cultivation (Rs.ha^{-1}). Temperature (Thermal) requirement, also referred as thermal unit, for each calendar day during crop period, for all the treatment were calculated from daily weather data on maximum and minimum temperature as under

$$\text{Thermal requirement} = \frac{T_{Max} + T_{Min}}{2} - T_{Base}$$

Where, T_{Max} – Maximum temperature ,
T_{Min} – Minimum temperature
T_{Base} – Base temperature (5 ^{0}C)

Base temperature is the temperature below which the physiological activities in plant practically cease and as a result plant does not show any growth. It is considered as 5 ^{0}C for mustard crop. Further total thermal unit requirement over crop period under each treatment was calculated by summation. In present study base temperature for mustard was taken as 5 ^{0}C. Thermal use efficiency (kg/ha/D ^{0}C) on the basis of grain yield, straw yield, and biomass yield of mustard varieties.

The data collected during the course of investigation was statistically analyzed by adopting standard method known as "Analysis of variance" (Panse and Sukhatme, 1971). Wherever the results were found significant, critical difference (C.D.) were worked out at 5 per cent level of probability of comparison of treatment means. The treatment effects were presented by making table of means with appropriate standard error (S.E.) and C.D. value.

Results and Discussion:

Pre-harvest studies

Data regarding pre-harvest traits as influenced by various treatments are presented in Table-1.

Table 1. Influence of various treatments on different pre-harvest traits of mustard at different growth stages

Treatments	Final plant stand $plot^{-1}$	Plant height (cm)				Number of branches $plant^{-1}$				Dry matter accumulation $plant^{-1}$			
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Sowing Dates													
D_1 – 42nd MW	156	10.23	136.30	148.17	158.88	2.73	5.89	8.74	9.82	6.85	15.78	23.77	32.39
D_2 – 43rd MW	159	10.50	141.93	154.48	163.51	2.99	6.02	9.79	10.16	7.53	16.33	24.43	33.48
D_3 – 44th MW	157	9.35	133.08	142.12	156.51	2.53	5.78	8.44	9.56	6.55	15.50	22.76	32.13
D_4 – 45th MW	155	9.08	131.98	140.93	151.87	2.32	5.61	8.08	9.46	6.22	14.41	19.68	30.32
D_5 – 46th MW	154	8.75	129.40	138.30	148.08	2.12	5.45	7.73	9.0	5.83	13.77	18.42	28.38
SE (m)±	1.07	0.38	0.63	0.92	1.20	0.02	0.03	0.09	0.11	0.09	0.16	0.23	0.33
CD at 5%	N.S.	N.S.	2.05	3.01	3.76	N.S.	0.12	0.30	0.33	N.S.	0.54	0.76	1.06
Varieties													
V_1 – Pusa bold	157	9.93	135.75	146.53	159.14	2.64	5.79	8.92	10.03	7.07	16.07	22.45	32.43
V_2 – ACN-9	156	9.24	133.33	143.07	152.40	2.44	5.70	8.19	9.17	6.12	14.24	21.37	30.25
SE (m)±	0.74	0.24	0.39	0.44	0.91	0.02	0.02	0.08	0.10	0.06	0.12	0.16	0.18
CD at 5%	N.S.	N.S.	1.22	1.38	2.84	N.S.	0.08	0.28	0.31	N.S	0.39	0.51	0.57

Interaction													
SE (m)±	1.66	0.54	0.86	0.98	2.17	0.02	0.03	0.14	0.18	0.13	0.27	0.30	0.41
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
G.M.	156	9.58	134.54	144.8	155.77	2.54	5.75	8.56	9.6	6.59	15.16	21.81	31.34

The data presented in table-1 revealed that final plant stand at harvest of mustard as influenced by different sowing dates was statistically non-significant during the investigation. The data revealed that interaction effect due to sowing dates and varieties on emergence count at 15 DAS and final plant stand at harvest was found to be non-significant during the study.

Data collected in respect of mean periodical plant height of mustard as influenced by different treatments indicated that mean height of plant increases with successive stages of crop growth from 9.58 cm at 30 DAS to 155.77 cm at harvest stages. Mean height was increase in between 30 to 60 DAS. Thereafter it slowed down towards maturity. The data indicated that sowing dates showed at 30 DAS non significant variation on plant height while statistically significant at 60, 90 DAS and at harvest. From all observations D_2 (43rd MW) recorded significantly more plant height at 60 and 90 DAS and at harvest than rest of sowing dates. At 60 and 90 DAS treatment D_3 (44th MW) at par with D_4 (45th MW), at harvest D_1 (42nd MW) at par with D_3 (44th MW) while lowest plant height at D_5 (46th MW). The accumulated heat units and the number of days of maximum plant height decreased due to successive delay in sowing. Similarly results were reported by Singh *et. al.* (1993), Shivani and Sanjiv Kumar (2002) and Ghanbahadur and Lanjewar (2004). The data also revealed that plant height was non significant at 30 DAS while significant at 60, 90 DAS and at harvest. The plant height was significantly maximum in V_1 (Pusa bold) over V_2 (ACN-9). Reduction in plant height may be due to shorter life span of variety resulted forced maturity. Similar, results were reported by Sharma (2006) and Awasthi *et. al.,* (2007). Interaction due to sowing dates with varieties was found to be non-significant at all the stage of crop growth.

The data revealed that, the number branches plant^{-1} were increased progressively with enhancement in crop duration. The number of branches plant^{-1} at 30 DAS was 2.54 and 9.6 at harvest. Effect of sowing dates does not show significance influence on number of branches plant^{-1} at 30 DAS while significant at 60, 90 DAS and at harvest. Sowing date D_2 (43rd MW) recorded significantly higher number of branches plant^{-1} over D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW). Treatment D_1 (42nd MW) at par with D_3 (44th MW) at 60, 90 DAS and treatment D_1 (42nd MW) at par with D_3 (44th MW) and D_3 (44th MW) at par with D_4 (45th MW) at harvest, lowest number of branches recorded at treatment D_5 (46th MW). However, it was observed that significant reduction in number of branches per plant with delay in sowing by each successive meteorological week due to high temperature. These findings are close accordance with Belgammwar (1998), Ghanbahadur and Lanjewar (2004). Varieties showed significant influence on number of branches plant^{-1} at all growth stages but non significant at 30 DAS. V_1 (Pusa bold) found significantly superior over V_2 (ACN-9) at all periodic interval. Reduction in number of branches plant^{-1} due to genetic variation in variety. These results were in conformity with the finding of Ghanbahadur and Lanjewar (2004). Interaction effect between sowing dates with varieties was found to be non-significant at all stage of crop growth during the experimentation.

Accumulation dry matter plant^{-1} (g) is considered as the best index of crop growth put forth by crop. It would be observed that the rate of dry matter accumulation plant^{-1} was found progressively increased with physiological maturity of crop. The crop was slow in dry matter accumulation up to 30 DAS and produced only 6.59 g mean dry matter accumulation plant^{-1} (g). The mean maximum accumulation of dry matter plant^{-1} (g) was 31.34 g at harvest. Effect of sowing dates on dry matter accumulation plant^{-1} was non significant at 30 DAS while significant at 60, 90 DAS and at harvest, dry matter accumulation plant^{-1} was significantly maximum in D_2 (43rd MW) over the D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) while at par with D_1 (42nd MW) at 90 DAS, D_1 (42nd MW) at par with D_3 (44th MW) at 60 DAS and at harvest while significantly lowest among treatments D_5 (46th MW).Dry matter accumulation plant^{-1} (g) was decreased due to late sowing. Optimum sowing period facilitates luxurious crop growth resulting in maximum dry matter accumulation. These results are conformation with the finding reported by Rajendra Kumar *et. al.,* (2002), Ghanbahadur and Lanjewar (2004) and Sharma (2006). Dry matter accumulation plant^{-1} (g) due to influence of varieties was found non significant at 30 DAS while significant at 60, 90 DAS and at harvest. However, with passage of time dry matter accumulation plant^{-1} found to be significantly increased. It was recorded 32.43 g significantly maximum at harvest in V_1 (Pusa bold). V_1 (Pusa bold) found to be superior over V_2 (ACN-9) over all treatments. Dry matter net assimilation rate was higher in V_1 (Pusa bold) due to more number of days were required for 50 per cent flowering. These are in accordance with the findings reported by the Bhalerao (1997). Interaction effect between sowing dates with varieties was found to be non-significant at all stage of crop growth during the experimentation.

Post –harvest studies

Data regarding post harvest traits as influenced by various treatments are presented in Table-2.

Table 2. Influence of various treatments on different post-harvest traits, Thermal requirement and thermal use efficiency of mustard at different growth stages

Treatments	Final plant stand plot^{-1}	No. of siliquae plant^{-1}	Seed yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biomass (kg ha^{-1})	Thermal requirement (°C days)	Thermal use efficiency (kg/ha/D °C)			Total cost of cultivation (Rs ha^{-1})	Gross monetary return (Rs ha^{-1})	Net monetary return (Rs ha^{-1})	B:C ratio
									Grain yield (kg/ha /D °C)	Straw yield (kg/ha /D °C)	Biomass yield (kg/ha /D °C)				
Sowing Dates															
D_1 – 42nd MW	156	134.87	6.33	19.43	771	1949.8	2720.8	1763.19	0.44	1.11	1.54	15625	28275	12650	1.81
D_2 – 43rd MW	159	141.98	7.27	21.05	820	2126.6	2946.6	1818.88	0.45	1.17	1.62	15625	30083	14458	1.93
D_3 – 44th MW	157	125.83	6.12	16.58	727	1729.9	2456.9	1672.22	0.43	1.03	1.47	15625	26669	11044	1.71
D_4 – 45th MW	155	116.17	5.57	14.49	648	1488.7	2136.7	1602.39	0.40	0.93	1.33	15625	23755	8130	1.52
D_5 – 46th MW	154	109.56	5.08	12.59	579	1255.3	1834.3	1553.37	0.37	0.81	1.18	15625	21239	5614	1.36
SE (m)±	1.07	2.28	0.14	0.32	14.21	50.63	109.8					-	879	879	-
CD at 5%	N.S.	7.10	0.46	1.03	46.33	165.08	334.4					-	2865	2865	-
Varieties															
V_1 – Pusa bold	157	129.92	6.69	17.54	733	1827.6	2560.6	1632.0	0.45	1.12	1.56	15625	26864	11239	1.72
V_2 – ACN-9	156	121.44	5.46	16.12	686	1645.7	2331.7	1535.51	0.44	1.07	1.51	15625	25144	9519	1.61
SE (m)±	0.74	1.11	0.32	0.44	14.89	52.06	113.05					-	945	945	-
CD at 5%	N.S.	3.50	1.02	1.39	46.91	164.02	339.15					-	2980	2980	-
Interaction															
D1V1					789										
D1V2					753										
D2V1					853										
D2V2					788										
D3V1					750										
D3V2					705										
D4V1					671										
D4V2					624										
D5V1					600										
D5V2					558										
SE (m)±	1.66	2.49	0.73	0.98	33.30	116.41	145.3					-			-
CD at 5%	N.S.	N.S.	N.S.	N.S.	104.90	336.77	460.7					-	N.S.	N.S.	-
G.M.	156	125.68	6.07	16.83	709	1717.66	2426.78	1653.94	0.42	1.03	1.46	15625	26004	10379	1.66

From the data it would be noticed that various treatments showed significant influence on the number of siliquae plant^{-1}. Mean number of siliquae plant^{-1} was 125.68. Data indicated that, sowing time showed significance influence on number of siliquae plant^{-1}. D_2 (43rd MW) produce more number of siliquae plant^{-1} over D_1 (42nd

MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) while treatment D_4 (45th MW) found to be at par with D_5 (46th MW). Siliquae initiation was progressively delayed due to late sowing as the crop took more days to flower initiation in late or advanced sowing after branching. These findings were close accordance with the Balgamwar (1998), Shashtry and Arvind kumar (1981). Among the two varieties V_1 (Pusa bold) found to be significantly superior over V_2 (ACN-9). It seems due to variation in respect of number of siliquae plant^{-1} among different mustard varieties. Interaction effect between sowing dates with varieties was found to be non-significant at all stage of crop growth during the experimentation.

The data in respect of seed yield plant^{-1} as influenced by different treatments revealed that seed yield plant^{-1} (g) was influenced significantly due to various treatments. On an average, the mean seed yield plant^{-1} (g) of 6.07 g was recorded. Among sowing dates, sowing on D_2 (43rd MW) recorded significantly higher seed yield plant^{-1} (7.27 g) than D_1 (42nd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) while treatment D_1 (42nd MW) found to be at par with D_3 (44th MW). Delay in sowing might be reducing the seed yield plant^{-1} (g) due to environmental conditions. The results are in close accordance with the findings of Ghanbahadur and Lanjewar (2004). Different varieties had significant influence on the seed yield plant^{-1}. The variety V_1 (Pusa bold) recorded higher seed yield plant^{-1} (6.69 g) than V_2 (ACN-9). This result is due to the variety to variety variation between their potential to produce seed yield plant^{-1} (g). The results are in conformation with the findings reported by Bhalerao (1997). Interaction effect between sowing dates and varieties found to be non-significant.

The data in respect of straw yield plant^{-1} as influenced by different treatments revealed that straw yield plant^{-1} (g) was influenced significantly due to vary treatments. On an average, the mean straw yield plant^{-1} (g) found 16.83 g was recorded. Among the sowing dates, on D_2 (43rd MW) recorded significantly higher straw yield plant^{-1} (21.05) than D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) but found to be at par with D_1 (42nd MW). Delay in sowing was significantly reduced the straw yield plant^{-1} (g) due to environmental conditions. Difference in varieties significantly influence over straw yield plant^{-1}. The variety V_1 (Pusa bold) found to be at par with V_2 (ACN-9) producing straw yield plant^{-1} (g) which was (17.54 g) as compared with V_2 (ACN-9). The interaction effect between sowing dates and varieties were found to be non-significant.

The mean seed yield was observed to be 709 (kg ha^{-1}). Seed yield showed significant influence on date of sowing. Sowing date D_2 (43rd MW) recorded highest value of seed yield (820 kg ha^{-1}) over D_1 (42nd MW), D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW). D_1 (41st MW) found to be at par with D_3 (44th MW). Sowing in 42nd MW resulted in early flowering, longer seed filling period, a longer reproductive phase and ultimately a higher seed yield per unit area. Increased yield contributing characters reflected in higher seed yield. These results are in conformation with the findings of Shashtry and Arvind Kumar (1981), Tyagi *et.al,* (1996), Zora Singh *et.al,* (1998) and Ghanbahadur and Lanjewar (2004) who also reported significant influence of sowing date on seed yield in mustard. Seed yield showed significant influence on variety. Variety V_1 (Pusa bold) recorded highest value of seed yield (733 kg ha^{-1}) than V_2 (ACN-9). Higher seed yield from V_1 (Pusa bold) due to longer seed filling period and longer reproductive phase resulted in higher yield. These findings are closed accordance with Shashtry and Arvind Kumar (1981) and Gupta and Saini (2004). Significant influence on sowing dates and varieties observed on seed yield (kg ha^{-1}). D_2 (43rd MW) sowing with combination with V_1 (Pusa bold) in every row proved significantly superior over rest of the treatment combination.

The data regarding mean straw yield kg ha^{-1} exhibited that various treatments showed significant influence over straw yield kg ha^{-1}. The mean straw yield was 1717.66 kg ha^{-1}. Among the five dates of sowing, the mean straw yield kg ha^{-1} was observed to be highest while mustard sown on D_2 (43rd MW) recorded significantly higher straw yield ha^{-1} (2126.6 kg) as compared with the mustard sown on D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) while found to be at par with D_1 (42nd MW). Among two different varieties *i.e.* V_1 (Pusa bold) and V_2 (ACN-9), variety V_1 (Pusa bold) found to be significantly superior over V_2 (ACN-9), with straw yield 1827.6 kg ha^{-1}.The interaction effect of sowing dates and varieties on mean straw yield ha^{-1} were found to be significant. The straw yield ha^{-1} for mustard sown on D_2 (43rd MW) recorded higher straw yield ha^{-1} (2126.6 kg) over rest of the treatment combinations. This might be due to the cumulative effect of all the growth characters which was higher in this interaction.

The data revealed that the biomass ha^{-1} was significantly influenced due to variation among the sowing dates of mustard varieties. On an average, the mean biomass of 2426.78 kg ha^{-1} was recorded. Among the five dates of sowing, the mean biomass kg ha^{-1} was observed to be highest while mustard sown on D_2 (43rd MW) recorded significantly higher biomass (2946.6 kg ha^{-1}) as compared with the mustard sown on D_3 (44th MW), D_4 (45th MW) and D_5 (46th MW) found to be at par with D_1 (42nd MW) while D_1 (42nd MW) found to be at par with D_3 (44th MW). Among two different varieties V_1 (Pusa bold) and V_2 (ACN-9), variety V_1 (Pusa bold) found to be significantly superior over V_2 (ACN-9), with 2560.6 kg ha^{-1} biomass. The interaction effect of sowing dates and varieties on mean biomass kg ha^{-1} were found to be significant. The biomass ha^{-1} for mustard sown on D_2 (43rd MW) recorded higher biomass (2946.6 kg ha^{-1}) over rest of the treatment combinations. This might be due to the cumulative effect of all the growth characters which was higher in this interaction.

Weather parameter

Data collected on thermal requirement for the mustard are presented in Table-2 The thermal requirement is reduced as the sowing is delayed. Sowing in 43rd MW recorded highest thermal requirement and sowing in 46th MW recorded the lowest thermal requirement. Similar results are reported by Singh *et al.* (2014). The different varieties recorded different thermal requirement variety Pusa bold recorded highest thermal requirement followed by variety ACN-9 Similar result are reported by Singh *et al.* (2014).

Data collected on thermal use efficiency on the basis of grain yield, straw yield and biomass yield for various varieties of mustard are presented in Table-2. Data revealed that different sowing dates showing thermal use efficiency in case of grain yield in mustard crop. Sowing on 43rd MW recorded higher thermal use efficiency (0.45kg/ha/D^{0}C) and it was significantly superior over other sowing. The lowest thermal use efficiency was recorded with sowing in 46th MW. Same trend were observed in straw yield and in biomass yield where plant with sowing taken on 43rd MW shown significantly higher thermal use efficiency i.e. (1.17 and 1.62 kg/ha/D^0 C), respectively. Thermal use efficiency reduced with late sowing date on 46th MW for both straw yield and biomass yield. Similar results reported Akhter *et. al.,* (2016). Data also revealed that variation among different varieties in respect of grain yield, straw yield and biomass yield. In grain yield, variety Pusa bold has shown significant highest thermal use efficiency (0.45 kg/ha/D ^{0}C) which is followed by variety ACN-9, in straw yield variety Pusa bold has significant highest thermal use efficiency (1.12 kg/ha/D ^{0}C) followed by variety ACN-9. The highest thermal use efficiency is shown by variety Pusa bold with biomass yield (1.56 kg/ha/D ^{0}C) which is followed by variety ACN-9. Similar result reported by Akhter *et. al.,* (2016).

Economic study

Data regarding gross monetary returns, net monetary returns and B: C ratio is presented in Table-2. The mean gross and net monetary returns were Rs. 26004 ha^{-1} and Rs. 10379, respectively. Highest gross and net monetary returns of Rs. 30083 and Rs. 14458 ha^{-1} respectively, were recorded when crop sown on 43rd MW which was significantly superior over other sowing dates. Increase in net and gross monetary return is due to significant increase in the economic yield of mustard. Highest gross monetary returns of Rs. 26864 ha^{-1} and net monetary returns of Rs. 11239 ha^{-1} were recorded with variety Pusa bold which was significantly superior over variety ACN-9. Interaction of sowing dates and varieties was found to be non-significant. Mean B: C ratio of mustard crop obtained was 1.66. Highest B: C ratio of 1.93 was recorded with sowing on 43rd MW as compared to other sowing dates. Increase in B: C ratio is due to significant increase in gross monetary return. Comparatively higher B: C ratio 1.72 is recorded with variety Pusa bold over ACN-9.

On the basis of result obtained during the course of present experimentation, it is concluded .that Sowing of mustard during 43rd MW significantly improved all the growth and yield components as compared to sowing of mustard during 42nd, 44th, 45th and 46th MW resulting in significant increase in seed yield of mustard. Among the two different cultivars of mustard, Pusa bold recorded significantly higher growth rate, seed yield and yield components, resulting as compare to ACN-9. Thermal requirement and thermal use efficiency of mustard was more when crop sown on 43rd MW (D_2).

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