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Effects of date of sowing and panting geometry on yield attributes and yield of mustard crop

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Abstract
The present investigation entitled "Effects of date of sowing and panting geometry on yield attributes and yield of mustard crop" was conducted at Instructional Farm of Narendra Deva University of Agriculture and Technology Kumarganj, Ayodhya (U.P.) during rabi season of 2016-2017 and 2017-18. The experiment constituted of nine treatment combinations was laid out in Randomized Block Design (RBD). Narendra Rye-8501 variety was used. Yield atrributes namely Number of siliquae per plant, Length of siliqua (cm), Number of seeds per siliqua, Test weight (g), Seed yield (kg ha^{-1}), Straw yield (kg ha^{-1}), Biological yield (kg ha^{-1}) and Harvest index (%) were recorded or observed during the whole experiments. Yields and yield attributes was affected by planting geometry. Maximum number of siliquae $plant^{-1}$ (276.50 in 2016-17 and 282.13 in 2017-18), Maximum length of siliquae (7.83 cm. in 2016-17 and 8.10 cm. in 2017-18), Maximum number of number of seeds $siliquae^{-11}$ (14.33 in 2016-17 and 14.63 in 2017-18), Higher test weight (4.96 g. in 2016-17 and 4.99 g in 2017-18), Higher Seed yield (kg ha^{-1}) (20.85 in 2016-17 and 23.33 in 2017-18), Higher Straw yield (kg ha^{-1}) (72.92 in 2016-17 and 81.72 in 2017-18), Higher biological yield (93.77 during 2016-17 and 105.05 during 2017-18) and Maximum harvest index (%) (22.56 in 2016-17 and 22.55 in 2017-18) was obtained when crop was sown on 45×15cm planting geometry followed by45×20cm, 45×10cm and 45×25cm planting geometry during the both years. Yield and yields attributes was affected by Date of sowing. Maximum numbers of siliquae $Plant^{-1}$ (259.75 during 2016-17 and 265.00 during 2017-18), Maximum length of siliqua (7.70 cm.), Maximum numbers of seeds $siliqua^{-1}$ (14.23), Maximum test weight (4.93 g in 2016-17 and 4.96 g in 2017-18), Seed yield (kg ha^{-1}) was (21.33 in 2016-17 and 22.20 in 2017-18), Maximum Straw yield (kg ha^{-1}) (73.35 during 2016-17 and 76.36 during 2017-18), Maximum Biological yield (94.68 during 2016- 17 and 98.56 during 2017-18) and Maximum Harvest index(%) (22.54 in both years) was recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during both the years.

Keywords: Maximum, minimum, test weight, seed yield, straw yield, biological yield and harvest index

Introduction
India is one of the largest producers of rape seed and mustard in the world. India's contribution in the world's rape seed and mustard production is the highest of any country. The oil is utilized for human consumption throughout northern India in cooking and frying purpose. Rapeseed and mustard growing countries of the world are India, Canada, China, Pakistan, Poland, Bangladesh, and Sweden. India ranks first in the world in respect of acreage and second in production next to Canada. India produces 7.96 million tonnes from 9.89 million hectares with 11.88 qtl/ha productivity. In India its cultivation is mainly confined to Rajasthan, Madhya Pradesh, Haryana, Uttar Pradesh, West Bengal, Gujarat, Assam, Bihar, and Punjab.

In Uttar Pradesh, it is grown over an area of 1.67 million hectare with total production of about 0.77 million tonnes and productivity 11.62 qtl/ha. Rajasthan and Uttar Pradesh are the major mustard producing state in the country. Rajasthan is the largest mustard producer in the country with a contribution of (54%) to the country's total mustard production followed by Punjab and Haryana which simultaneously contributes (14%) in India, (D.E.S, New Delhi, 2014).

India is the third largest rapeseed-mustard producer in the world after China and Canada with 12 per cent of world's total production (2006-07). This crop accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop. Due to the gap between domestic availability and actual consumption of edible oils, Rapeseed-mustard is the major source of income especially even to the marginal and small farmers in rainfed areas since these

crops are cultivated mainly in the rain-fed and resource scarce regions of the country, their contribution to livelihood security of the small and marginal farmers in these regions is also very important. By increasing the domestic production substantial import substitution can be achieved. Due to its low water requirement (80-240 mm), rapeseed-mustard crops fit well in the rainfed cropping system. Cultivated in 26 states in the northern and eastern plains of the country, about 6.8 mha is occupied under these crops (2006-07). Nearly 30.7% area under rapeseed mustard is under rainfed farming.

Methods and Materials

The present investigation entitled **"**Effects of date of sowing and panting geometry on yield attributes and yield of mustard crop" was conducted at Instructional Farm of Narendra Deva University of Agriculture and Technology Kumarganj, Ayodhya (U.P.) during rabi season of 2016-2017 and 2017-18. The farm is located 42 Km away from Faizabad city on Faizabad-Raebareily road at 26˚47 N latitude and 82˚12 E longitude and about 113 meters above the mean sea level.

Detail of the experiment

The experiment constituted of nine treatment combinations was laid out in Randomized Block Design (RBD). The details of treatments are given below:

Date of sowing (Three)

D_1: 5 Oct.
D_2: 20 Oct.
D_3: 5 Nov.

Planting geometry (Four)

P_1: 45x10(cm.)
P_2: 45x15(cm.)
P_3: 45x20(cm.)
P_4: 45x25(cm.)

Treatment combination: 3 × 4 = 12

Table 1: Treatment combination

S. No.	Treatment	Symbols used
		Date of sowing
1.	5 Oct.	D_1
2.	20 Oct.	D_2
3.	5 Nov.	D_3
		Planting geometry (cm.)
1.	45 × 10	P_1
2.	45 × 15	P_2
3.	45 × 20	P_3
4.	45 × 25	P_4

Technical programme

1. Design: Randomized Block Design
2. Replication: 4
3. Number of treatment combinations: 12
4. Total number of plots: 48
5. Gross plot size: 5.0m × 4.0m = 20m^2
6. Net plot size: 4.0m × 3.0m = 12m^2
7. Variety: NDR-8501

Variety used

Narendra Rye-8501

This variety was identified in 1990 from ND university of Agriculture & technology, Kumarganj, Ayodhya, Uttar Pradesh. The material was obtained from Atwa, Uttar Pradesh. It is developed by the method of selection and suitable for cultivation in irrigated and salt- affected areas of Madhya Pradesh and Uttar Pradesh. It has plant hight-160-175 cm, maturity-125 days, oil content-39%, seed size- 4.9g, potential yield-2500 $kgha^{-1}$and average yield- 1100-1333 $kgha^{-1}$.

Observations recorded

Yield attributes

Number of siliquae per plant

The siliquae present on five randomly selected plants were separated and counted, average value was reported as number of siliquae $plant^{-1}$.

Length of siliqua (cm)

Length of five randomly selected siliquae from main shoot, primary and secondary branches were measured and averaged value were taken as length of siliqua in centimeter.

Number of seeds per siliqua

Twenty selected siliquae taken from respective plant were threshed, seeds were counted and average number of seed was reported as number of seed per siliqua.

Test weight (g)

Sample of seeds was drawn from the produce of each net plot and thousand seeds were counted from each treatment. The counted seed were weighed and recorded as test weight.

Seed yield (kg ha^{-1})

From the individual plot the crop of net plot area was harvested and dried. After air drying the produce was threshed and seeds were cleaned. The final seed weight was recorded in kg per plot and converted in to kg ha^{-1}.

Straw yield (kg ha^{-1})

Straw yield was computed by deducting the seed yield from the total biological yield recorded per plot and expressed in kg $hectare^{-1}$.

Biological yield (kg ha^{-1})

All above the ground plant parts of the net plot were dried and weighed in kg per plot to represent the biological yield and finally converted in to kg ha^{-1}.

Harvest index (%)

The ratio of economic yield to the biological yield was computed by using the following formula to calculate the harvest index:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

The significance of the overall differences among the treatments, by the 'F' test conclusion was drawn at 5 percent probability level. When 'F' value in the analysis of variance table was found to be significant, the critical difference (CD) was computed to test the significance of the difference between two treatments. In case of significant interaction, it has been explained by the corresponding two way table of means to locate the best treatment combination.

Table 2: Analysis of variance table

Source of variation	d.f.	S.S.	M.S.	F value	
				Cal.	Table
Replications	3				
Date of sowing	2				
Planting geometry	3				
(D x P)	6				
Error	33				
Total	47				

If the variance ratio was significant at 5 percent level of significance critical difference (C.D.) was calculated with the help of following formula:

$$SEm\pm = \sqrt{\frac{\text{Error variance}}{\text{Replication} \times \text{Date}}}$$

$$\textbf{SEm} \pm \textbf{ for variety } \sqrt{\frac{Ve}{r \times s}}$$

$$SEm \pm \text{ Planting geometry } \sqrt{\frac{\square\square\square}{\square \times \square}}$$

$$SEm \pm for\ interaction \sqrt{\frac{Ve}{r}}$$

CD at 5% for date of sowing = $\sqrt{2} \times$ SEm ± × t value at 5% for error df

CD at 5% for planting geometry = $\sqrt{2} \times$ SEm ± × t value at 5% for error df

CD at 5% for Interaction = $\sqrt{2} \times$ SEm ± for interaction effect × t value at 5% for error df

Result and Discussion

Table 3 revealed that Number of siliquae Plant^{-1} was significantly affected by different date of sowing. Maximum numbers of siliquae Plant^{-1} (259.75 during 2016-17 and 265.00 during 2017-18) were recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during the both years. Data pertaining to number of siliquae plant^{-1} as affected by date of sowing and planting geometry have been presented in Table 3. A perusal of data showed that different planting geometry influenced significantly to the number of siliquae Plant^{-1}. Higher number of siliquae Plant^{-1} (276.50 in 2016-17 and 282.13 in 2017-18) was recorded when crop was sown on 45×15 cm which was significantly superior over 45×20, 45×10 cm and 45×25 cm planting geometry. The lowest number of siliquae Plant^{-1} was recorded when sowing was done at 45×25 cm planting geometry during the both years. Table 3 revealed that Length of siliqua was significantly affected by different date of sowing. Maximum length of siliqua (7.70 cm.) was recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during the both years.

Data pertaining to length of siliqua (cm.) as affected by date of sowing and planting geometry have been presented in Table 3. A perusal of data showed that different planting geometry influenced significantly to the number of siliquae Plant^{-1}. Maximum length of siliqua (7.83 cm. in 2016-17 and 8.10 cm. in 2017-18) was recorded when crop was sown on 45×15 cm which was significantly superior over 45×20 cm and 45×10 and 45×25 cm planting geometry. The minimum length of siliqua was recorded when sowing was done at 40×15 cm planting geometry during the both years.

Table 3 revealed that Number of seeds siliqua^{-1} was significantly affected by different date of sowing. Maximum numbers of seeds siliqua^{-1} (14.23) were recorded with 20 Oct followed by 5 Nov and then 5 Oct sowing during the both years. Data pertaining to number of seeds siliqua^{-1} as affected by date of sowing and planting geometry have been presented in Table 3. A perusal of data showed that different planting geometry influenced significantly to the number of seeds siliqua^{-1}. Maximum number of seeds siliqua^{-1} (14.33 in 2016-17 and 14.63 in 2017-18) was recorded when crop was sown on 45×15 cm which was significantly superior over 45×20 cm and 45×10 cm and 45×25 cm planting geometry. The minimum number of seeds siliqua^{-1} (12.40 in 2016-17 and 12.63 in 2017-18) was recorded when sowing was done at 45×25 cm planting geometry during the both years.

Table 3 revealed that Test weight was significantly affected by different date of sowing. Maximum test weight (4.93 g in 2016-17 and 4.96 g in 2017-18) was recorded with 20 Oct followed by 5 Nov (4.88 g in 2016-17 and 4.91 g in 2017-18) and then 5 Oct date of sowing during the both years. Data pertaining to test weight (g.) as affected by date of sowing and planting geometry have been presented in Table 3. A perusal of data showed that different planting geometry influenced significantly to the test weight. Maximum test weight (4.96 g. in 2016-17 and 4.99 g in 2017-18) was recorded when crop was sown on 45×15 cm which was significantly superior over 45×20 cm, 45×10 and 45×25 cm planting geometry. The minimum test weight (4.80 g. in 2016-17 and 4.84 g in 2017-18) was recorded when sowing was done at 40×15 cm planting geometry during the both years.

Table 4 revealed that The Seed yield (kg ha^{-1}) was significantly affected by different date of sowing. Maximum Seed yield (21.33 in 2016-17 and 22.20 in 2017-18) was recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during the both years. Data pertaining to Seed yield (kg ha^{-1}) as affected by date of sowing and planting geometry have been presented in Table 4. A perusal of data showed that different planting geometry influenced significantly to the Seed yield. Maximum Seed yield (20.85 in 2016-17 and 23.33 in 2017-18) was recorded when crop was sown on 45×15 cm which was significantly superior over 45×20 cm, 45 ×10 and 45×25 cm planting geometry. The minimum Seed yield was recorded when sowing was done at 45×25 cm planting geometry during the both years.

Table 3: Yield attributes of Indian mustard as affected by date of sowing and planting geometry

Treatments	No. of silique plant^{-1}		Length of siliqua (cm.)		No. of seeds siliqua^{-1}		Test weight (g)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Date of sowing								
5 Oct.	239.15	243.95	7.20	7.45	13.23	13.50	4.83	4.86
20 Oct.	259.75	265.00	7.78	8.05	14.08	14.35	4.93	4.96
5Nov.	254.60	259.75	7.58	7.78	13.75	14.05	4.88	4.91
SEm±	5.02	4.29	0.13	0.14	0.25	0.24	0.09	0.09
CD at 5%	14.44	12.36	0.38	0.41	0.73	0.70	0.27	0.26

Planting geometry								
45X10 cm	237.87	242.67	7.53	7.70	13.83	14.13	4.85	4.88
45X15 cm	276.50	282.13	7.83	8.10	14.33	14.63	4.96	4.99
45X20 cm	267.83	273.27	7.73	7.97	14.17	14.47	4.90	4.94
45X25 cm	222.47	226.87	6.97	7.20	12.40	12.63	4.80	4.84
SEm±	6.48	5.54	0.17	0.18	0.33	0.31	0.12	0.12
CD at 5%	18.64	15.96	0.49	0.53	0.94	0.91	NS	NS

Table 4: Yield of mustard as affected by date of sowing and planting geometry

Treatments	Seed yield (qtl ha$^{-1)}$		Straw yield (qtl ha$^{-1)}$		Biological yield (qtl ha$^{-1)}$		Harvest index (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Date of sowing								
5 Oct.	17.26	18.00	59.80	62.36	77.06	80.36	22.39	22.38
20 Oct.	21.33	22.20	73.35	76.36	94.68	98.56	22.54	22.54
5Nov.	17.50s	21.61	61.23	75.65	78.73	97.26	22.24	22.24
SEm±	0.34	0.36	1.24	1.27	1.52	1.765	0.40	0.44
CD at 5%	1.00	1.05	3.59	3.66	4.37	5.07	NS	NS
Planting geometry								
45X10 cm	17.87	19.47	61.77	67.18	79.53	86.65	22.29	22.30
45X15cm	20.85	23.33	72.92	81.72	93.77	105.05	22.56	22.55
45X20 cm	19.47	21.52	66.77	73.90	86.23	95.42	22.45	22.46
45X25 cm	16.60	18.10	57.82	63.03	74.42	81.13	22.24	22.24
SEm±	0.45	0.47	1.61	1.64	1.96	2.27	0.52	0.56
CD at 5%	1.29	1.35	4.63	4.72	5.64	6.56	NS	NS

Table 4 revealed that The Straw yield (kg ha^{-1}) was significantly affected by different date of sowing. Maximum Straw yield (73.35 during 2016-17 and 76.36 during 2017-18) was recorded with 20 Oct variety followed by 5 Nov Oct and then 5 Oct date of sowing during the both years.

Data pertaining to Straw yield (kg ha^{-1}) as affected by date of sowing and planting geometry have been presented in Table 4. A perusal of data showed that different planting geometry influenced significantly to the Straw yield. Maximum Straw yield(72.92 in 2016-17 and 81.72 in 2017-18) were recorded when crop was sown on 45×15 cm which was significantly superior over 45×20 cm, 45×10 cm and 45×25 cm planting geometry. The minimum Straw yield was recorded when sowing was done at 45×25 cm planting geometry during the both years.

Table 4 revealed that The Biological yield (kg ha^{-1}) was significantly affected by different date of sowing. Maximum Biological yield (94.68 during 2016-17 and 98.56 during 2017-18) was recorded with 20 Oct variety followed by 5 Nov and then 5 Oct date of sowing during the both years. Data pertaining to Biological yield (kg ha^{-1}) as affected by date of sowing and planting geometry have been presented in Table 4. A perusal of data showed that different planting geometry influenced significantly to the Biological yield. Maximum Biological yield(93.77 during 2016-17 and 105.05 during 2017-18) were recorded when crop was sown on 45×15 cm which was significantly superior over 45×20 cm, 45×10 cm and 40×25 cm planting geometry. The minimum Biological yield (74.42 during 2016-17 and 81.13 during 2017-18) was recorded when sowing was done at 40×25 cm planting geometry during both the years.

Table 4 revealed that The Harvest index (%) was affected by different date of sowing. Maximum Harvest index (22.54 in both years) was recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during both the years. Data pertaining to Harvest index (%) as affected by date of sowing and planting geometry have been presented in Table 4. A perusal of data showed that different planting geometry influenced none significantly to the Harvest index. Maximum Harvest index (22.56 in 2016-17 and 22.55 in 2017-18) was recorded when crop was sown on 45×15 cm which was superior to 45×20, 45×10 cm planting geometry. The minimum Harvest index (22.24) was recorded when sowing was done at 45×25 cm planting geometry during the both years.

Summary and Conclusion

Number of siliquae plant^{-1} showed that different planting geometry significantly to the number of siliquae plant^{-1}. Maximum number of siliquae plant^{-1}(276.50 in 2016-17 and 282.13 in 2017-18) were recorded when crop was sown on 45×15cm planting geometry which was significantly superior over rest of all three planting geometry i.e. 45×10cm, 45×20 and 45×25 cm planting geometry during the both years. The minimum number of siliquae plant^{-1}was recorded when sowing was 45×25cm planting geometry.Length of siliquae (cm) showed that different planting geometry significantly to the length of siliquae (cm). Maximum length of siliquae (7.83 cm. in 2016-17 and 8.10 cm. in 2017-18) were recorded when crop was sown on 45×15cm planting geometry which was significantly superior over rest of all three planting geometry i.e. 45×10cm, 45×20 and 45×25 cm planting geometry during the both years. The minimum length of siliquae was recorded when sowing was 45×25cm planting geometry. Number of seeds siliquae^{-1}showed that different planting geometry significantly to the number of seeds siliquae$^{-1.}$ Maximum number of number of seeds siliquae^{-11} (14.33 in 2016-17 and 14.63 in 2017-18) were recorded when crop was sown on 45×15cm planting geometry which was significantly superior over rest of all three planting geometry i.e. 45×10cm, 45×20 and 45×25 cm planting geometry during the both years. The lowest number of seeds siliquae^{-1}was recorded when sowing was 45×25cm planting geometry during the both years. Test weight was affected significantly due to planting geometry. Higher test weight (4.96 g. in 2016-17 and 4.99 g in 2017-18) were observed when it was sown on 45×15cm planting geometry during the both years. Seed yield (kg ha^{-1}) was significantly affected by planting geometry. Significantly higher seed yield (20.85 in 2016-17 and 23.33 in 2017-18) were obtained when crop was sown on 45×15cm which have significant superior over crop sown on 45×20, 45×10 and 45×25cm planting geometry during both the years. Straw

yield (kg ha^{-1}) was significantly affected by planting geometry. Significantly higher straw yield (72.92 in 2016-17 and 81.72 in 2017-18) were obtained when crop was sown on 45×15cm which has significant superior over crop sown on 45×20, 45×10 and 45×25cm planting geometry during the both years. Biological yield (kg ha^{-1}) was significantly affected by planting geometry. Significantly higher biological yield (93.77 during 2016-17 and 105.05 during 2017-18) were obtained when crop was sown on 45×15cm which has significant superior over crop sown on 45×20, 45×10 and 45×25cm planting geometry during the both years. Harvest index (%) was affected by planting geometry. Significantly maximum harvest index (22.56 in 2016-17 and 22.55 in 2017-18) was obtained when crop was sown on 45×15cm which has significant superior over crop sown on 45×20, 45×10 and 45×25cm planting geometry during the both years.

Maximum numbers of siliquae$Plant^{-1}$ (259.75 during 2016-17 and 265.00 during 2017-18) were recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during the both years. Maximum length of siliqua (7.70 cm.) was recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during the both years. Maximum numbers of seeds $siliqua^{-1}$ (14.23) were recorded with 20 Oct followed by 5 Nov and then 5 Oct sowing during the both years. Maximum test weight (4.93 g in 2016-17 and 4.96 g in 2017-18) was recorded with 20 Oct followed by 5 Nov (4.88 g in 2016-17 and 4.91 g in 2017-18) and then 5 Oct date of sowing during bothS years. Seed yield (kg ha^{-1}) was significantly affected by different date of sowing. Maximum Seed yield (21.33 in 2016-17 and 22.20 in 2017-18) was recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during the both years. Straw yield (kg ha^{-1}) was significantly affected by different date of sowing. Maximum Straw yield (73.35 during 2016-17 and 76.36 during 2017-18) was recorded with 20 Oct variety followed by 5 Nov Oct and then 5 Oct date of sowing during the both years. Biological yield (kg h^{a-1}) was significantly affected by different date of sowing. Maximum Biological yield (94.68 during 2016-17 and 98.56 during 2017-18) was recorded with 20 Oct variety followed by 5 Nov and then 5 Oct date of sowing during the both years. Harvest index (%) was affected by different date of sowing. Maximum Harvest index (22.54 in both years) was recorded with 20 Oct followed by 5 Nov and then 5 Oct date of sowing during both the years.

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