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Effect of Different Sowing Dates and Establishment Methods on Growth, Yield and Economics of Mustard (*Brassica juncea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Adaption of Furrow Irrigated Raised Bed System (FIRBS) and date of seeding are one of the important input for crop production particularly for rabi crop. Early planting through raised bed of mustard can compensate the late planting at least 10-15 days. Under this circumstance the use of raised bed planter along with timely sowing of mustard can produce higher yield. An adaptive research trail was conducted during the rabi season of 2020-21 and 2021-22 at farmer's field in Jamui district to study the effect of different sowing dates and establishment methods of mustard crop. The trail was conducted in a factorial randomized block design with two method of sowing and three dates of sowing. The growth characters like plant height, leaf area index, no. of primary

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branches plant^{-1}, no. of secondary branch plant^{-1}, no. of silique plant^{-1}, no. of seeds silique^{-1} were recorded. Test weight, grain and straw yield was influenced significantly due to different sowing dates and sowing methods. Higher plant height at harvest stage (160 cm), leaf area index at 60 DAS (3.3), no. of primary branches plant^{-1} (4.0), no. of secondary branch plant^{-1} (7.8), no. of silique plant^{-1} (292.4), no. of seeds silique^{-1} (9.7), test weight (3.8), grain (10.1 q ha^{-1}) and straw yield (22.4 q ha^{-1}) were recorded when the crop was sown on 05th November during both years. Whereas the mustard crop sown on FIRBS recorded highest growth attributes, yield components and seed yield (12.5 q ha^{-1}) as compared to conventional method. Highest benefit cost ratio was calculated with (FIRBS) Furrow Irrigated Raised Bed system (2.0) as compared to all other treatments.

Keywords: Furrow irrigated raised bed system; conventional method; cost of cultivation; B:C ratio.

1. INTRODUCTION

"In terms of area and production, India has the second highest yield after Canada, 1.99 tha-1 in the world, Canada 2.28 tha-1, China 2.06 tha-1, while India's yield is only 1.04 thousand -1. -1" [1] (Anonymous, 2021). "Mustard (*Brassica juncea* L.) is the third most important edible oil crop in the world after soybean and palm oil. Although India is the world's leading oil producer, it is unable to meet the edible oil needs of its large growing population. Mustard (*Brassica juncea* L.) is commonly known as rye. Mustard seeds have a high energy content, 28-32% oil and a relatively high protein content (28-36%). Mustard oil has a special fatty acid composition, it contains about 20-28% oleic acid, 10-12% linoleic acid, 9.0-9.5% linolenic acid and 30-40% erucic acid, which is indigestible to animals, humans and organisms" (Al-Jasser and Al-Jasser, 2012). "Mustard oil is rich in tocopherols, which act as a preservative against rancidity due to their antioxidant properties" [2]. "In the last eight years, the productivity has increased significantly from 1840 kgha-1 in 2010-11 to 1980 kgha. in 2018-19 -1 and production increased from 61.64 million tonnes. in the 2010-11 season to 72.42 meters in the 2018-19 season. In India, rape-mustard crops are grown in a wide range of agro-climatic conditions, from hills in the northeast and northwest to irrigated/rainfed, early/late sowing, saline soils and mixed crops in the south. In 2018-2019, Indian mustard accounts for about 75-80% of the country's 6.23 million hectares during the 2018 crop season" (https://www.nfsm.gov.in 2018). "Mustard seeds are highly nutritious and contain 38-57% erucic acid, 5-13% linoleic acid and 27% oleic acid" [3]. India is the third largest country in edible oil economy after USA and China. Indian mustard is grown mainly in the states of Rajasthan, UP, Haryana, Madhya Pradesh, Gugrat, West Bengal, Assam, Bihar and Punjab (DES 2017 Indian mustard is very sensitive to climate change and soil fertility (Mandal and Sinha, 2004). Time sowing is very important in mustard production [4], the cultivated area of mustard is 89.34 mt and the productivity is 1187 kg ha-1. in rape-mustard production with a growth of 7.34% in the 1980s, while the state of Rajasthan topped the list. "It is the most important oilseed both in terms of area and production (DES, Government of Bihar 2019-2020). Mustard productivity in Bihar is lower than the national average. Among the several reasons for low productivity of mustard grown under residual moisture conditions, the main reasons are light sensitivity, lack of good agricultural practices such as optimal sowing and sowing/transplanting method. Canola mustard is highly sensitive to weather as shown by different responses to different sowing dates" (Kumar et al., 2010). "A one-month delay in sowing from mid-October resulted in 40% seed production" [5]. "The secret of increasing yield lies mainly in proper sowing" [6]. "Optimum sowing and sowing method significantly affected yield and production parameters. Therefore, optimal sowing and seeding method could be a better option to minimize the loss of mustard yield. So far, a seeding method like the furrow irrigation system (FIRBS) is a water-saving technology that saves 30-40% of water depending on the soil type. The method of planting raised beds can be a viable practice to reduce water loss and use the moisture retained in the soil" (Samar Pal Singh et al. 2019). "It is also suitable for seed production due to its bolder grain and easier threshing. In a situation where sowing can be delayed due to pre-sowing irrigation, dry sowing can be done with greater finesse and irrigated immediately after sowing" (Sharma et al. 2004). Therefore, this study investigated the effect of different seeding and planting. methods of mustard (*Brassica Juncea* L.) growth, yield and economy.

2. MATERIALS AND METHODS

During the 2020-21 and 2021-22 winter seasons, a Jmaui County farmer's field underwent an adaptive research trail as part of the Climate Resilient Agriculture Program. The climate of Jamui region is subtropical, semi-arid, with an annual rainfall of 1110 mm and the minimum temperature varied from 3.5 to 16.2 0 C and the highest temperature recorded between 23.0 and 34.2 0 C in the winter from 2020-2021 and 2021-22. The experiment was conducted in randomized blocks where the treatments included three sowing dates viz. 30 October, 15 November and 30 November and two different seeding methods viz. Furrow Irrigated Raised Bed System (FIRBS) and conventional cultivation were replicated five times each. The soil of the experimental field had a sandy composition, medium organic carbon (0.62%), nitrogen (220.2 kg ha-1), phosphorus (9.7 kg ha-1) and potassium K2O (72.2 kg ha -1) and pH 6.2. During the harvest season in 2020-21 and 2021-22, a total of 16.7 mm and 15.3 mm of rain fell. Each track covered one hectare of land with two cultivation methods (FIRBS) and conventional method (CT) and three sowing days. In FIRBS, one row was planted to the right of the pen at a distance of 60 x 60 cm (row to row) with a raised planter in powdery soil. In FP, the land was pre-treated with two plows and wooden planks, followed by pre-seed irrigation and the field was sown with a seed rate of 2.5 kg ha-1, while in FIRBS only two kg seed per hectare. The cultivar Pusa Sinappi -30 was sown in both years in all treatments. The crop is fertilized with the recommended dose of 80:60:40. As a basis, half of the amount of nitrogen and the total dose of phosphorus and potassium were applied, and the remaining half of nitrogen was treated on the surfaces after 30-35 DAS. The fertilizer source was DAP, urea and MOP for nitrogen, phosphorus and potassium. Irrigation was done twice, the first irrigation at 30-35 DAS and the second irrigation during the flowering of the crop season. Other management practices were applied according to the crop. Plant height (cm), leaf area index (LAI), number of primary branches and number of secondary branches were monitored at 30, 60 and 90 DAS.

2.1 Plant Height

Plant height was measured by selecting 5 random plants from each marked grid plot and plant height was measured on a metric scale from soil surface to plant tip at 30, 60, 90 DAS and harvest stage and averaged. value was calculated from all recorded data.

2.2 Leaf Area Index

Similarly, the leaf area of five plants was measured with an automatic leaf area meter at 30, 60 and 90 DAS from the harvest, and the leaf area was calculated using the following formula:

$$\text{Leaf Area Index} = \frac{\text{Leaf Area}}{\text{Ground Area}}$$

Leaf Area Index (LAI) = leaf area/ground area

2.3 No. of Primary and Secondary Branches

Five randomly selected plants marked with plant height were also used to count the number of primary and lateral branches according to plant height, and the average was calculated.

2.4 No. of Siliqua Plant^{-1}

Amount of siliqua calculated from five randomly selected plants in each grid. Si quantities of all five plants were calculated and the average recorded.

2.5 Number of Seeds Siliquae^{-1}

Five randomly selected siliquas were threshed and the seeds were obtained and counted and finally the average was recorded. of.

2.6 Grain Yield

Harvesting of individual plots was done during the physiological stage of maturity, when the pulp turned brown. Net was collected from a single valve and the produce was dried in the sun for a few days on a rake tray after proper marking. After drying, the crop was beaten with wooden sticks and cleaned separately. The final weight was recorded in kilograms by a net plot and finally converted to cents per hectare. of.

2.7 Stover Yield

The total biomass was weighed immediately before threshing. After removing the blade. The breaking yield was recorded by subtracting the seed weight from the total biomass. of.

2.8 Test Weight (g)

A representative sample of 1000 whole seeds was counted and weighed for each grid yield.

The weight of 1000 seeds was recorded in grams. of.

2.9 Harvest Index

The ratio of economic yield to biological yield was calculated using the following formula (Donald 1962).

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological yield}} \text{X100}$$

Data were recorded from an area enclosed in the quadrate of 0.5 m^2 randomly selected at three places in each treatment.

3. RESULTS AND DISCUSSION

Plant Height: Mustard seed height measured at different time intervals differed significantly between seeding methods and seeding days. Generally, plant height was highest in furrow irrigated raised bed system (FIRBS) than conventional method (CT) at all crop growth stages. Plant height was found to be higher in Furrow Irrigated Raised Bed System (FIRBS) where the crop was sown on 05 November which was same as 15 November and significantly higher than 25 November compared to conventional method. The estimate presented in Table 1 is clearly based on the fact that a significantly higher plant height was recorded in treatment T1 (FIRBS), i.e. 24.2 cm, 73.5 cm, 75.6 cm and 165.4 cm at 30 DAS, 60 DAS, 90 DAS and postharvest stages, which was higher than conventional method at all stages. Plant height at 30 DAS was not significantly affected by different sowing dates, which may be due to a similar growth pattern in the initial growing season, while plant height was significantly higher at 60 DAS, 90 DAS and harvest stage treatment S1 (sowing of November 05)).. compared to treatments S2 (15 November sowing) and S3 (25 November). date of sowing). The reason may be a longer harvest period. A similar observation was reported by Aziz et. et al. [7], Bazzaz et al. to [8] and Sand Cr. You don't do that. to (2021) as discussed above.

Leaf Area Index: Reading Table 1 clearly shows that the leaf area index (LAI) was significantly different in FIRBS at 60 DAS and 90 DAS compared to the conventional method. While at 30 DAS, LAI had no significant effect on leaf area index at 30 DAS, which may be due to slower growth rate at early stage of harvest. The data show that the leaf area index increased to 60 DAS and 90 DAS consecutively with different seeding methods. Treatment T1 (FIRBS) recorded the highest leaf area index, viz. 3.8 and 3.2 at 60 DAS and 90 DAS respectively compared to treatment T2 (conventional method), which may be due to higher photosynthesis and increased leaf formation (Samar Pal Singh et. until 2019). Among the different sowing dates, treatment S1 (sowing date 05 November) recorded 3.3 and 3.0 higher leaf area index at 60 and 90 DAS compared to treatments S2 (sowing date 15 November) and S3 (date of sowing November 25). In contrast, there are no significant differences at 30 DAS. Late sowing of about 20-25 days resulted in lower leaf area at all stages of mustard crop, which may be due to adverse environmental conditions that impair growth when the crop was sown under early and late sowing conditions. Similar findings were reported by Kumar et. al. (2015) and Avinash Patel et al. [3].

Table 1. Plant height and leaf area index as influenced by different sowing methods and dates

Treatments	Plant Height (cm)				Leaf Area Index		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS
T_1 - FIRBS	24.2	73.5	75.6	165.4	1.6	3.8	3.2
T_2 - CT	19.5	62.3	60.8	150.2	1	2.7	2.2
F- test	S	S	S	S	S	S	S
Sed+	0.16	0.39	0.54	0.43	0.077	0.16	0.11
CD (P=0.5)	0.47	1.15	1.60	1.28	0.22	0.47	0.32
S_1 - 05^{th} Nov	23.4	69.7	68.7	160	1.4	3.3	3
S_2 - 15^{th} Nov	23	68.5	64.2	158.2	1.3	3.2	2.9
S_3 - 25^{th} Nov	21.4	65.2	61.5	155.4	1.2	3	2.7
F- test	S	S	S	S	S	S	S
Sed+	0.13	0.31	0.14	0.36	0.77	0.13	0.089
CD (P=0.5)	0.37	0.91	0.41	1.06	2.29	0.37	0.26

Abbreviations used: CT – Conventional Tillage, DAS – Days After Sowing

No. of Primary & Secondary branches plant^{-1}: Information about No. plant-1 of primary and secondary branches of mustard according to sowing methods and date of sowing.Treatment T1 (FIRBS) primary and secondary branches 4.2 and 10.5 significantly higher than treatment T2 (CT) 3.4 and 7. Seed culture 05.11. recorded a significantly higher no. 4 and 8.5 of the main and side branches compared to other seeding days. Late sowing on November 25 recorded a smaller no. plant-1 of primary and secondary branches may be due to the stress caused by high temperatures in late-sown crops, which ultimately reduced forest formation and plant growth then branches. By planting date, mustards planted on November 3 had the highest number of siliquae plant-1 (689.9) compared to other planting dates. The higher value may be due to early establishment of crops, better biomass production and longer crop duration. Mondal et al. [4], Aziz et al. [7] and Gawariya et al. [9] supported the results.

No. of Siliqua plant^{-1}: Treatment T1 (Furrow Irrigated Raised Bed System) recorded significantly highest silk content in Plant-1 (308) compared to conventional method (272.4). On the date of sowing Treatment S1 (05.11.) greater no. Siliqua Plant-1 (302.1) compared to all other seed date treatments. The higher value may be due to early establishment of crops, better biomass production and longer crop duration. Bhuiyan et al. at [10], Alam et al. at [11], Sandeep De. you turn [1] also reported a similar finding.

No. of Seeds Siliqua^{-1}: Data on No. effects of seed silique-1 on sowing method and sowing date recorded. The significantly highest No. seed silique-1 (12.5) was recorded in treatment T1 (FIRBS) compared to treatment T2 (8.6). The higher the no. Silique-1 FIRBS seeds can be attributed to proper aeration of the soil solution and maintenance of nutrition. The mustard crop sown with treatment V1 (November 05) was significantly higher. seed silique-1 (10.4) in treatment V2 (November 15) and treatment V3 (November 25). Higher value due to strong crop growth and more photosynthetic substances from a large no. in favorable agricultural weather conditions. Similar findings were reported by Bhuiyan et. to [10], Alam et al. to [11], Sandeep De. et al. [1].

Test weight: A significantly higher test weight (4.2) was recorded for treatment T1 (FIRBS) compared to treatment T2 (CT). If there were no significant differences between different sowing days.

Grain and Straw yield: Comparing different seeding methods, the method of planting on a raised bed was found to be better for increasing the mustard production. Treatment T1 (FIRBS) produced significantly the highest grain and blade yields of 12.5 and 26.8 q. ha-1. The higher value of FIRBS showed excellent performance, which is 47% better than the traditional method. Which may be due to better seed germination and root proliferation, reduces the mechanical strength of plant roots, increases soil porosity, and promotes crop growth and root penetration of water stagnation after watering, improving crop water use efficiency. Raised bed planting

Table 2. Growth parameters as influenced by different sowing methods and dates

Treatments	No. of primary branches plant^{-1}	No. of secondary branches plant^{-1}	No. of Siliqua plant^{-1}	No. of seeds Solique^{-1}	Test wt. (g)
T_1 - FIRBS	4.2	10.5	308.4	12.5	4.2
T_2 - CT	3.4	7	272.4	8.6	3.4
F- test	S	S	S	S	S
Sed+	0.26	0.15	0.28	0.17	0.09
CD (P=0.5)	0.77	0.44	0.83	0.50	0.27
S_1 - 05th Nov	4	8.5	302.1	10.4	3.9
S_2 - 15th Nov	3.8	7.8	292.4	9.7	3.8
S_3 - 25th Nov	3.6	7.5	280	9	3.7
F- test	S	S	S	S	NS
Sed+	0.066	0.12	0.23	0.14	0.08
CD (P=0.5)	0.18	0.35	0.68	0.41	0.23

Abbreviations used: FIRBS- Furrow Irrigated Raised Bed System CT – Conventional Tillage CD – Critical Difference

Table 3. Grain yield, Straw yield and Harvest index influenced by different sowing methods and dates

Treatments	Grain Yield q ha^{-1}	Straw yield q ha^{-1}	Harvest Index
T_1 - FIRBS	12.5	26.8	31.8
T_2 - CT	8.5	19.9	29.9
F- test	S	S	S
Sed+	0.11	0.15	0.15
CD (P=0.5)	0.32	0.44	0.44
S_1 - 05th Nov	10.1	22.4	31
S_2 - 15th Nov	9.6	21.8	30.5
S_3 - 25th Nov	8.8	20.3	30.2
F- test	S	S	NS
Sed+	0.09	0.12	0.12
ssCD (P=0.5)	0.26	0.35	0.35

Abbreviations used: CT – Conventional Method

Table 4. Economics influenced by different sowing methods and dates

Treatments	Cost of cultivation Rs. ha^{-1}	Gross return Rs. ha^{-1}	Net Returns ha^{-1}	B:C ratio
T_1 - FIRBS	21,250	63,150	41,900	2.0
T_2 - CT	18,500	42,925	24,425	1.3
S_1 - 05th Nov	20,500	51,005	30,505	1.5
S_2 - 15th Nov	20,500	48,480	27980	1.3
S_3 - 25th Nov	20,500	44,176	23,676	1.1

Abbreviations used: CT – Conventional Method

method on sandy loam soil is useful and effective for economic yield advantage over other irrigation levels because it improved crop characteristics and yellow sarson yield. A similar observation was found by Singh Samar Pal et al. [12], Kapila Shekhwat et. al. (2016). Larger planting saved 35% of water and resulted in 32% better water use efficiency (Buttler et. to 2006). The crop sown on November 5 gave a significantly higher grain and abata yield of 10.1 and 22.4 q ha-1 compared to that sown on November 15 and 25, which was due to a higher plant height, no. primary and lateral branches plant-1 no. silicon plant-1, no. seed silique-1 and other growth parameters. A similar result, such as higher seed yield, was observed by Mondal et. et al. [4], Awasthi U.D. you don't do that ai. [13], Aziz et. ai., [7] Kaj Gawariya et. al. [9].

Harvest Index: Treatment T1 (Furrow Irrigated Raised Bed System) found significantly highest yield index (31.8) compared to conventional method (29.9). On the other hand, no significant differences were observed in different sowing days [14-17].

Economics: Maximum gross return (Rs. 63,150 ha^{-1}), net return (Rs. 41,900 ha^{-1}) and B:C ratio (2.0) were recorded by Furrow Irrigated Raised Bed System as compared to Conventional Method of sowing. Where as in different sowing methods on 05th Nov. date of sowing calculated higher Maximum gross return (Rs. 48,480 ha^{-1}), net return (Rs. 27,980 ha^{-1}) and B:C ratio (1.3) as compared to other sowing dates [18-21].

4. CONCLUSION

From the above experiment, it can be concluded that the different sowing methods and date of sowing significantly influenced the growth, yield and economic parameters as well as the productivity. Comparing various sowing methods, raised bed planting method found to be superior for raising the mustard crop as it maintains the proper aeration and nutrient in soil solution. Raised bed planting increases soil porosity, improves seed germination and root proliferation, decreases mechanical resistance to plant roots, promotes crop growth, and prevents water stagnation after irrigation, all of which contribute to an increase in the crop's water use efficiency.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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