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Effect of date and direction of sowing on growth performance and economic return of yellow mustard (*Sinapis alba*)

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Abstract
A field experiment was conducted during *Rabi* season of 2024 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences to determine **"**Effect of date and direction of sowing on growth and yield of Yellow Mustard". The treatments consisted of four dates of sowing (5th, 15th, 25th October and 4th November), along with direction of sowing (North-South and East-West). The experiment was laid out in a Randomized Block Design with 9 treatments and replicated thrice. The results revealed that the significantly higher plant height (103.61 cm), higher plant dry weight (27.10 g), maximum number of siliqua/plant (125.40), maximum number of seeds/siliqua (31.87), higher test weight (3.57 g), higher seed yield (2.05 t/ha) and higher stover yield (3.23 t/ha) were recorded with treatment 7 (25th October + East-West). The maximum gross return (INR 128435.00/ha), net return (INR 89078.99/ha) and B:C ratio (2.26) was significate as compared to all other treatments.

Keywords: Date of sowing, direction and yield, growth, yellow mustard

Introduction
Yellow mustard (*Sinapis alba* L.), a member of the *Brassicaceae* family, is a vital oilseed crop cultivated across various agro-climatic zones, particularly in semi-arid and temperate regions. It holds significant economic value due to its wide-ranging uses in the food industry, condiment manufacturing, and as a source of edible oil rich in unsaturated fatty acids. As global demand for oilseeds continues to rise, optimizing agronomic practices to enhance mustard productivity has become increasingly important.

Among various agronomic factors, sowing date and direction of sowing are critical in influencing crop growth, development and yield. Sowing date determines the crop's exposure to temperature, photoperiod and other climatic variables during key growth stages, while row direction can affect light interception, photosynthesis efficiency, and canopy microclimate. Improper timing or alignment may lead to suboptimal growth, reduced flowering, and poor seed set, ultimately affecting yield and quality.

Previous studies have shown that early or delayed sowing can significantly alter the phenological behavior of mustard and other oilseed crops, impacting plant height, branching, biomass accumulation and seed yield. Similarly, orientation of sowing rows—especially in relation to sun path—can influence light distribution within the canopy and soil temperature, thereby affecting physiological processes such as transpiration and nutrient uptake.

Mustard east-west sowing increased the seed and stick + straw yields by 8.3 and 5.1% respectively over the sowing in north-south direction. This could be attributed to better plant growth as measured in terms of yield attributes, viz. plant 'stand at maturity, plant height, siliquae/plant, seeds/silique and 1,000-seed weight, due to better light interception leading to prolonged photosynthetic activity in former as compared to earlier. (Bhan *et al.* 1995) [2]

The change in crop environmental conditions due to sowing dates is bound to affect the production potential of the crop. Different sowing dates provide variable environmental condition within the same location for growth and development of crop and its yield of Brassica species largely depends upon change in environment during crop growth (Panda *et al.* 2004; Prasad *et al.* 2018) [7, 8].

Looking to the above fact about importance of sowing time and sowing direction for optimizing yellow mustard growth and yield. Therefore, the present study aims to investigate the effect of date and direction of sowing on the growth, yield attributes and productivity of yellow mustard.

Materials and Methods

Experimental sites and soil

The experiment was conducted during the *Rabi* season of 2024 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The experimental site is geographically located at 25°24'42" N latitude, 81°50'56" E longitude and 98 m altitude from sea level. The site lies on the right side of the river Yamuna, opposite Prayagraj city and is approximately 5 km away from Prayagraj-Rewa Road.

Formulations Used for the Experiment

The experiment was conducted on yellow mustard crop, grown at a spacing of 40 cm × 15 cm. The experiment was laid out in a Randomized Block Design (RBD) with 9 treatments and 3 replications to evaluate the effect of Date and Direction of sowing on yellow mustard yield and growth.

The experiment consisted of two directions (North-South and East-West) and four date of sowing (5^{th}, 15^{th}, 25^{th} October and 4^{th} November) The Nine treatment combinations were:

T_1: North-South + 5^{th} October
T_2: North-South + 15^{th} October
T_3: North-South + 25^{th} October
T_4: North-South + 4^{th} November
T_5: East-West + 5^{th} October
T_6: East-West + 15^{th} October
T_7: East-West + 25^{th} October
T_8: East-West + 4^{th} November
T_9: Control (NW-ES) RDF = N-P-K 80-40-40 kg/ha

Physiological Parameters determination

The experiment was conducted to study the physiological growth parameters of the crop during its growth stages. At 15 DAS (Days After Sowing), 5 plants were randomly tagged from each plot to observe the growth pattern. The plant height was measured using a scale at 20 DAS and continued at 20-day intervals throughout the crop growth period. To record the dry weight, 5 plants, excluding the tagged ones, were collected from each plot at 20-day intervals. These plants were first dried in open air and then placed in a hot air oven for 24 hours to ensure complete drying. After drying, the dry weight of the samples was measured using a weighing balance. The collected dry weight data were then utilized to calculate the Crop Growth Rate (CGR) and Relative Growth Rate (RGR) using a standard formula. This process helped in understanding the growth performance and biomass accumulation of the crop under the given experimental conditions.

$$CGR = (W2-W1)/ \{S(T_2-T_1)\}$$

Where:
W1 = Dry weight per unit area at time T_1 (initial time)
W2 = Dry weight per unit area at time T_2 (final time)
S = Ground area (m^2)
T_2-T_1 = Time interval between two successive samplings (days)

Same way the Relative Growth Rate (RGR) also been calculated by using the formula-

$$RGR\ (g/g/day) = \log_e W_2 - \log_e W_1 / (T_2-T_1)$$

Where,

Loge W1 = Natural log of the initial dry weight (g) of the plants at time T_1
Loge W2 = Natural log of the dry weight (g) of the plants after a certain time interval T_2
T_1 = Initial time of data collection (days)
T_2 = Time after a certain interval (days)

Statistical Analysis

The collected data were analyzed using MS Excel software and the results were expressed as arithmetic mean values with standard deviation (±SD). The Analysis of Variance (ANOVA) method of Gomez and Gomez (1984) was used to determine the significant differences between treatments. The significance level was set at $p<0.05$, meaning the differences among treatments were considered statistically significant if the P-value was less than 0.05.

Economic Analysis

The economic analysis was conducted to evaluate the cost-effectiveness of different treatments in yellow mustard cultivation. The following economic parameters were considered:

- **Cost of Cultivation (INR):** It refers to the total expenditure incurred during the cultivation process, including the cost of seeds, fertilizers, pesticides, labor, irrigation, machinery and land rent. This helps in understanding the total investment required for crop production.
- **Gross Return (INR):** It represents the total income generated from the sale of yellow mustard seeds without deducting any production costs.
- **Net Return (INR):** The profit earned after deducting the total cost of cultivation from the gross return, indicating the actual income from yellow mustard production.
- **Benefit-Cost (B:C) Ratio:** It is calculated by dividing the gross return by the total cost of cultivation. B:C ratio greater than 1 indicates a profitable investment, whereas a ratio less than 1 suggests a loss.

This analysis provided a clear understanding of the profitability and economic feasibility of different treatments in yellow mustard cultivation.

Results and Discussion

Plant height (cm)

The plant height of yellow mustard was recorded at different intervals i.e., 20, 40, 60, 80 DAS and At harvest differed significantly influenced by date and direction of sowing.

At harvest, the highest plant height was observed in the treatment seven with October 25^{th} sowing date + East-West direction (103.61 cm) which was significantly higher over rest of the treatments.

Significant and higher plant height was observed East-West with 25^{th} October sown yellow mustard might be due to

favorable temperature, improved nutritional conditions for plant growth during active vegetative stages, leading to an increase in cell multiplications, elongation and expression in the plant body, all of which contributed to the increase in plant height. Plant height is an important index for studying the growth and development of the crop plant. Due to the indeterminate growth habit shown by the Brassica sp. leads to the continuous increase in the plant height with the advancement in age of crop. Sharma and Thakur (1993) [10] conducted a field experiment to evaluate the performance of Gobhi Sarson (*B. napus*) under different dates of sowing viz., October 15th, October 30th, November 15th and November 30th and found that the plant height reduced significantly under late sown crop as compared to early sown crop.

Plant dry weight (g/plant)

At harvest, the highest plant dry weight was observed in the treatment 7 with October 25th sowing date + East-West sowing direction (27.10 g) which was significantly higher over rest of the treatments.

Dry matter accumulation is also an important growth parameter affecting the photosynthetic efficiency (sink) of the crop which ultimately influences the crop yield. Dudhade *et al.* (1996) [3] stated that delay in sowing of Indian mustard from October 15th adversely affected the dry matter accumulation/plant. Singh *et al.* (2002) reported that the dry matter accumulation of Brassica was significantly reduced with delay in sowing due to the increased temperatures during latter reproductive phase (36.0 to 41.5 °C). Kaur *et al.* (2018) [4] reported that oilseed rape (*B. napus*) sown on 15th October (15835 kg/ha) recorded significantly higher dry matter accumulation over crop sown on 30th October and 15th November on 120 DAS.

Crop growth rate (g/m^2/day)

The growth rate of yellow mustard crop, measured in grams per square meter per day (g/m^2/day), exhibited significant variations across different stages of development (0-20, 20-40, 40-60, 60-80 and 80 DAS-At harvest) At 60-80 DAS interval, non-significant difference was recorded among all the treatments. Statistically highest crop growth rate was recorded (7.99 g/m^2/day) with treatment 7 [East-West + 25th October].

CGR and RGR are the growth indices which are calculated from the change in dry matter accumulation to study the growth of the plant within a particular time interval. Panda *et al.* (2004) [7] evaluated the growth and development of Indian mustard under different dates of sowing and stated that CGR decreased significantly with delay in sowing and the highest values of CGR were calculated in crop sown on 16th October whereas the least values were calculated on 15th November sowing at all the growth stages. Kumari and Rao (2005) [6] emphasized that CGR in *B. juncea* was lowest in crops sown earlier than 1st October whereas it increased under 15th and 30th October sown crop due to higher temperature prevailed during initial stages of the crop growth. Kumar *et al.* (2018) [5] found the minimum crop growth rate (2.57 g/m2/day) in crop sown on 21st November whereas maximum crop growth rate (3.59 g/m2/day) under 23rd September sown crop at Hisar.

Relative growth rate (g/g/day)

The Relative growth rate (g/g/day) of yellow mustard was recorded at 20-40, 40-60, 60-80 and 80-At harvest, Relative growth rate typically measured in units of mass per mass per time. The highest RGR data was recorded in between 20-40 DAS.

During 20-40 DAS, treatment 8 (East-West + 4th November) was recorded with significant difference highest Relative growth rate (0.152 g/g/day) over all the treatment. Rameshwar *et al.* (2000) [9] found that RGR increased with delay in sowing of *B. napus*. Kumari and Rao (2005) **[6]** reported that RGR was lowest in crop sown earlier than 1st October in *B. juncea* due to higher temperature prevailed during initial stages of the crop growth.

Table 1: Effect of date and direction of sowing on Plant height (cm), Dry Weight/plant (g) and Yield of Yellow mustard.

Treatments	Plant height (cm) (At Harvest)	Dry Weight/plant (g) (At Harvest)	CGR (g/m^2/day) 60-80 DAS	RGR (g/g/day) 20-40 DAS
T_1	99.35	24.55	7.81	0.151
T_2	98.72	24.09	7.66	0.151
T_3	101.71	26.29	8.40	0.150
T_4	100.76	25.35	7.69	0.150
T_5	100.11	24.91	7.78	0.148
T_6	101.27	25.72	7.96	0.150
T_7	103.61	27.10	7.99	0.148
T_8	102.41	26.47	7.92	0.152
T_9	97.97	24.04	7.89	0.148
F-Test	S	S	NS	NS
SEm (±)	0.34	0.24	0.22	0.002
CD(p=0.05)	1.02	0.73	-	-

Economics

The economic analysis showed significant differences among treatments in terms of cost of cultivation, gross returns, net returns and B:C ratio. The maximum gross return (1,28,435.00 INR/ha) and net return (89,078.99 INR/ha) were achieved in Treatment 7 (East-West + 25th October).

Highest benefit cost ratio (2.26) was recorded in treatment 7 [East-West + 25th October] as compared to other treatments. Higher B:C ratio was observed with East-West direction along with 25th October sown yellow mustard might be due to increased economic performance of crop such as yield of seed and stover which in turn led to higher gross returns and net returns.

Table 3: Economics of different treatments in yellow mustard.

Treatments	Cost of Cultivation (INR/ha)	Gross Return (INR/ha)	Net return (INR/ha)	B:C Ratio
T_1	39356.01	90480.00	51123.99	1.29
T_2	39356.01	84430.00	45073.99	1.14
T_3	39356.01	112940.00	73583.99	1.87
T_4	39356.01	107485.00	68128.99	1.73
T_5	39356.01	97365.00	58008.99	1.47
T_6	39356.01	108040.00	68683.99	1.74
T_7	39356.01	128435.00	89078.99	2.26
T_8	39356.01	116475.00	77118.99	1.96
T_9	39356.01	82565.00	43208.99	1.10

Conclusion

It is concluded that Yellow Mustard sown on 25th October in East-West direction of sowing recorded highest benefit cost ratio.

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