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Effect of different seed rate and row spacing on growth, yield attributes and yield of Indian mustard under irrigated condition

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Abstract
A field experiment was carried out during *Rabi* season of 2024-25 at Research cum Instructional Farm, S.G.C.A.R.S, Jagdalpur, to find out the effect of different seed rate and row spacing on growth, yield attributes and yield of Indian mustard under irrigated condition. Experiment was laid out in factorial Randomized Complete Block Design involving four levels of seed rate *viz*., 3 kg ha^{-1}, 4 kg ha^{-1}, 5 kg ha^{-1} and 6 kg ha^{-1} and three different row spacings *i.e*. 25 cm, 35 cm and 45 cm replicated thrice. Lowest seed rate 3 kg ha^{-1} resulted significantly highest growth characteristics which was remain numerically at par with 4 kg seed rate ha^{-1} *viz.,* Number of primary branches (3.06 $plant^{-1}$) but highest and lowest plant population m^{-2} was recorded with 6 kg and 3 kg seed rate ha^{-1} respectively, yield attribute and yield included number of siliquas $palnt^{-1}$ (80.00), number of grains $siliqua^{-1}$ (12.28) was recorded highest with 3 kg seed rate per hectare, but grain yield (2151.11 kg ha^{-1}) and economics indicated the B: C ratio (2.48) was resulted highest with 4 kg seed rate ha^{-1}. Among various row spacing widest row spacing 45 cm resulted considerably the highest growth parameters *viz.*, number of primary branches $plant^{-1}$ (3.01 $Plant^{-1}$), but highest and lowest plant population m^{-2} was recorded with 25 cm and 45 cm row spacing respectively, yield attribute and yield included number of siliquas $plant^{-1}$(70.00), number of grains $siliqua^{-1}$ (11.85) was recorded highest with 45 cm row spacing, but grain yield (1967.50 kg ha^{-1}) and benefit cost ratio was (2.17) was recorded maximum with 35 cm row spacing.

Keywords: kg ha^{-1}, mustard, row spacing, seed rate, siliqua

Introduction
Mustard (*Brassica juncea* L.) is a C_3 dicotyledon plant that belongs to the Cruciferae family and the genus Brassica. Brassica consists of approximately 40 different species, specifically *Brassica juncea* L. cultivated widely in India also known as Indian mustard. Mustard is the most important oilseed crop and mustard oil is mostly liked and consumed in the north (61%) and east (35%) zones of India furthermore, about 25% of people in the west zone consumed and preferred mustard oil and total production of mustard during 2023-24 is approximately 13.16 million tonnes and approximately covers 8.85 million hectares of land area for cultivation with average productivity of 14.99 q ha^{-1}. Indian mustard (Brassica juncea L.) is mainly grown in the states of Rajasthan, Uttar Pradesh, Haryana, Gujarat, and Madhya Pradesh. It accounts for 32% of the overall oilseed production, establishing it as a crucial edible oilseed crop in the country. In Rajasthan, Indian mustard is one of the most significant oilseed crops, primarily cultivated for its oil. The state contributes 46.66% to the rapeseed-mustard production, with Madhya Pradesh at 14.36%, Haryana at 11.63%, and Uttar Pradesh at 8.81%. In Rajasthan, it is cultivated over an area of 3.37 million hectares, resulting in a production of 5.48 million tons and a productivity rate of 16.27 quintals per hectare (Anonymous, 2022) [1].

The state of Chhattisgarh is a major producer of rapeseed and mustard in India. During the Rabi season of 2020-21, mustard was grown on an area covering 36.22 thousand hectares, resulting in an annual production total of 18.73 thousand tonnes and a productivity rate of 517 kg per hectare

(Anonymous, 2021) [2].

Achieving the maximum yield of oilseed relies on various agronomic factors, with seed rate and spacing being the most critical. A significant element of crop ecology, production, and management that frequently hinders crop output is inadequate crop spacing in the field. The seed yield results from the interplay between genetic and environmental factors, such as soil type, sowing time and method, seed rate, fertilizers, and irrigation timing, where row spacing is crucial for attaining higher yields (Hussian *et al*. 2003) [11].

Some researchers have determined that narrow row spacing yields better results and is more cost-effective compared to wider rows (Pereira *et al*. 1988) [18]. Plants that are cultivated in excessively wide rows may not make optimal use of natural resources like light, water, and nutrients, while those in excessively narrow rows could face significant competition for space both between and within rows (Ali *et al*. 1999) [3].

Consequently, it is of utmost importance to adjust the row spacing to enhance plant productivity. Christensen and Drabble (1984) [5] indicated that both B. napus and B. rapa exhibited greater grain yields at the narrower row spacing of 7.5 cm in comparison to the wider spacings of 15 and 23 cm. Furthermore, varying seed rates between 7 and 14 kg ha-1 did not significantly influence seed yield.

The seeding rate and row spacing are regarded as significant elements in optimizing plant population. Establishing a sufficient and uniform canola stand is essential for attaining high grain yield. The seed yield of canola depends on factors such as population density, the number of pods per plant, the number of seeds per pod, and seed weight. Nevertheless, the yield structure is highly adaptable and can be modified across a broad spectrum of populations (Diepenbrock, 2000) [9].

Materials and Methods

A study was carried out during the *Rabi* season of 2024-25 at the Research cum Instructional Farm, S.G. College of Agriculture and Research Station (IGKV), Jagdalpur, to investigate the impact of different seed rates and row spacings on the growth, yield attributes, and yield of Indian mustard under irrigated conditions. The experiment was designed using a Factorial Randomized Complete Block Design, which included four seed rate levels: 3 kg ha^{-1}, 4 kg ha^{-1}, 5 kg ha^{-1}, and 6 kg ha^{-1}, along with three distinct row spacings of 25 cm, 35 cm, and 45 cm, each replicated three times.

The recommended fertilizer dosage (RDF) utilized was N_2-P_2O_5-K_2O (100-60-40 kg ha^{-1}). Half of the suggested nitrogen dosage, along with the complete amounts of phosphorus and potassium, was applied as a basal application. The remaining half of the nitrogen was administered in two equal split doses: the first at 30 days post-sowing and the second at 61 days post-sowing of mustard.

The soil of the experimental field was classified as *Inceptisol*, characterized by low levels of available nitrogen. The availability of P_2O_5 and K_2O was moderate, while the organic carbon content was approximately neutral, with a pH that exhibited slightly acidic properties. Seeds of the DRMR 150-35 variety were sown in rows according to the designated layout, adhering to the specific row spacing requirements of the treatments. During the crop growth period, a total rainfall of 40.6 mm was recorded. The maximum and minimum temperatures, along with wind velocity, varied between 21.5 to 37.5 °C, 8.5 to 20 °C, and 1.5 to 2.6 km/h, respectively. The recommended agronomic practices were adhered to in order to cultivate the experimental crop. The recorded data were analyzed in accordance with the standard statistical analysis of variance procedure as proposed by Gomez and Gomez (1984) [10].

Outcome and Analysis

Growth characteristics

Plant population m^{-2}

Plant population data indicated that the initial plant population during At 25 DAS and final plant population during At 95 DAS. Different seed rates recorded major effect on initial and final plant population, from initial to final stage 3 kg ha^{-1} seed rate was recorded lowest (45.78, 43.78, respectively) plant population m^{-2} and 6 kg ha^{-1} seed rate was observed highest (76.67, 72, respectively) plant population m^{-2}, 6 kg ha^{-1} showed mathematically at par value to 5 kg ha^{-1} regarding final plant population.

Among different row spacing 25 cm row spacing had highest initial and final plant population (73.00, 71.25 respectively) and lowest initial and final plant population within one m^{-2} (53.92, 47.83) was observed with 45 cm row spacing. Similar finding also reported by De villiers & Agenbag (2007) [7].

No. of primary branches plant^{-1}

The No. of primary branches plant^{-1} that were counted on various observation days. The data indicated that the No. of primary branches plant^{-1} escalated swiftly from 60 to 90 days after sowing. Counted the No. of primary branches and found that it remained constant from At 90 DAS until harvest. The data clearly indicate that the production of main branches of plant^{-1} was considerably impacted by varying seed rates at all growth stages.

At 60 DAS to till at harvest, significantly greatest No. of primary branches plant^{-1} (2.60, 3.06, 3.06) was observed with 3 kg seed rate ha^{-1} and the minimum No. of primary branches plant^{-1} (1.70, 2.20, 2.20) had recorded with 6 kg seed rate ha^{-1}, At 90 DAS to At harvest, 3 kg ha^{-1} was observed statistically at par value with 4 kg seed rate ha^{-1}.

The data indicates that the row spacing positively influenced the number of primary branches plant^{-1}. At 60 DAS to at harvest, a row spacing of 45 cm resulted in more primary branches plant^{-1} (2.47, 3.01, 3.01) as compared to other treatments with varying row spacings, while, the lowest number of primary branches plant^{-1} (1.64, 2.23, 2.23) was recorded with 25 cm row spacing. At 60 DAS to at harvest, 45 cm row spacing was recorded statistically at par with 35 cm row spacing. The results are closely aligned with the findings of Mulvaney *et al.* (2019) [15], Sondhiya *et al.* (2019) [21] and Das *et al.* (2019) [6] who presented a similar perspective.

Yield attribute and yield

Number of siliquas plant^{-1}

The findings indicated that the utilization of different seed rates & row spacings significantly impacted number of siliqua plant^{-1}. No. of siliqua plant^{-1} increased significantly with decrease in the levels of seed rates up to a seed rate of 3 kg ha^{-1}. Highest number of siliqua plant^{-1} was recorded by the application of 3 kg seed rate ha^{-1} (80.00) which was at par with 4 kg ha^{-1} and least number of siliqua plant^{-1}(40.78) was observed with 6 kg seed rate ha^{-1}. Among the different row spacing, significantly maximum number of siliqua plant^{-1} (70.00) was observed with 45 cm row spacing and minimum siliqua plant^{-1} was observed with 25 cm row spacing. These results confirm close association with the earlier findings of Mulvaney *et al.* (2019) [15], Ray and Singh (2023) [19].

Number of grains siliqua^{-1}

The experimental data clearly indicates that different seeding rate and row spacing brought notable differences in the quantity of grains siliqua^{-1}. In case of various seed rates significantly highest grains siliqua^{-1} (12.28) was noted under application of 3 kg seed rate ha^{-1} which was statistically at par with 4 kg ha^{-1}. The lowest number of grains siliqua^{-1} (10.69) was recorded under 6 kg seed rate ha^{-1}. Different row spacings resulted significant impact on grains siliqua^{-1} of mustard. Maximum grains siliqua^{-1} (11.85) was observed with 45 cm row spacing which was recorded statistically at par with 35 cm row spacing (11.48) and lowest number of grains siliqua^{-1} (10.64) was observed with 25 cm row spacing. This outcome validates a strong connection with the previous results of Kwiatkowski (2012) [13] and Pandey *et al*. (2015) [17].

Grain yield (kg ha^{-1})

The grain yield of mustard is influenced by varying seed rates and row spacings. When examining different seed rates and row spacings, a significant impact on the grain yield of mustard was observed. The highest recorded grain yield was 2151.11 kg ha^{-1}, achieved with a seed rate of 4 kg ha^{-1}, while the lowest grain yield of 1391.11 kg ha^{-1} was noted with a seed rate of 6 kg ha^{-1}. Further data revealed that the application of 35 cm row spacing was recorded significantly maximum grain yield (1967.50 kg ha^{-1}) and the lowest grain yield (1689.17 kg ha^{-1}) was recorded with 45 cm row spacing. A lower seed rates (4 kg ha^{-1} followed by 3 kg ha^{-1}) and row spacing (35 cm followed by 25 cm) resulted in higher grain yield due to the higher plant population and optimal combination of row spacing and seed rate lead to more efficient resource utilization by allowing individual plants optimal space to develop. The results obtained were in strong alignment with the conclusions drawn by De Villiers and Agenbag (2007) [7], Morrison *et al*. (1981) [14], Kondra (1975) [12], Dekhane *et al*. (2024) [8], Beulah and Umesha (2022) [4].

Economics

B:C ratio

The values presented explain the impact of various seed rates and row spacings on the benefit cost ratio. In case of seed rates, it is apparent from the data that the notably high benefit-cost ratio of 2.48 was recorded with a seed rate of 4 kg per hectare. Conversely, the lowest benefit-cost ratio of 1.24 was noted with a seed rate of 6 kg per hectare. Among various row spacings, the highest benefit-cost ratio of 2.17 was observed at a row spacing of 35 cm, while the lowest ratio of 1.76 was found at a row spacing of 45 cm. These results align closely with the findings of Sawle *et al*. (2022) [20].

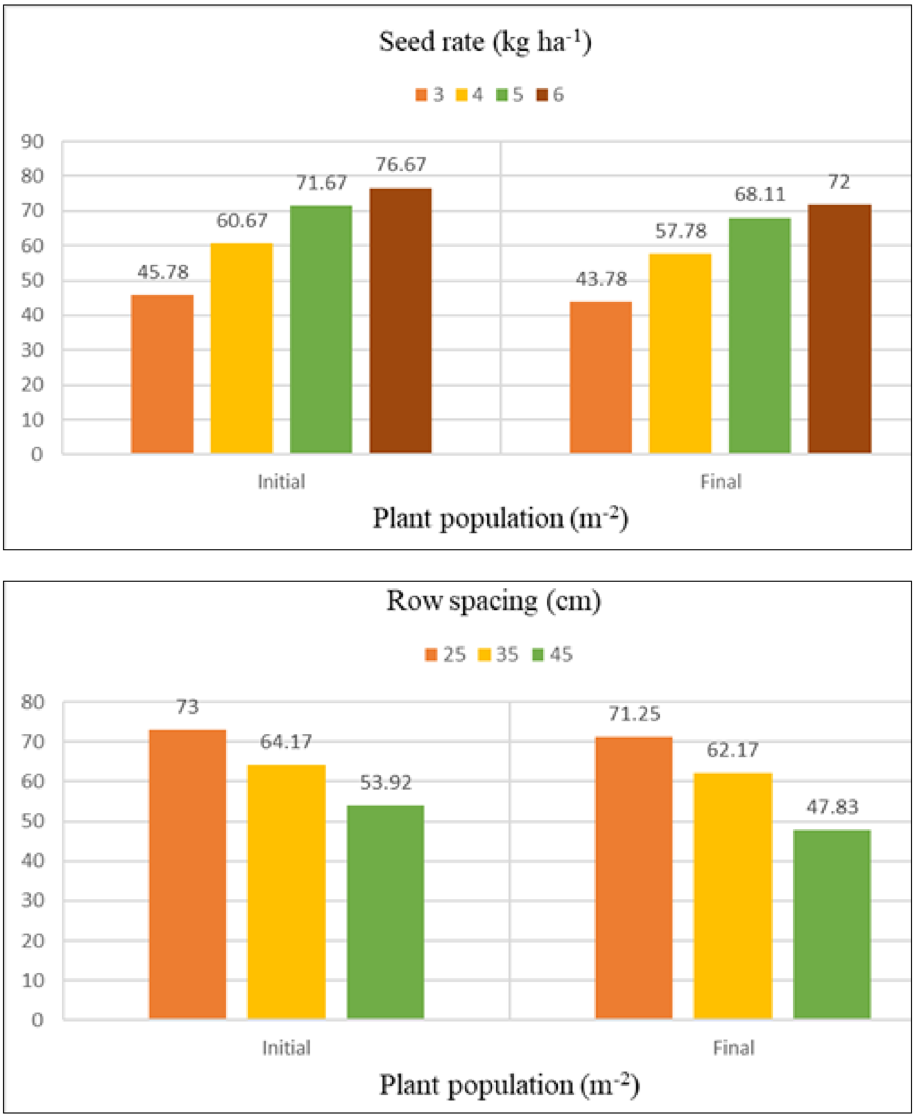
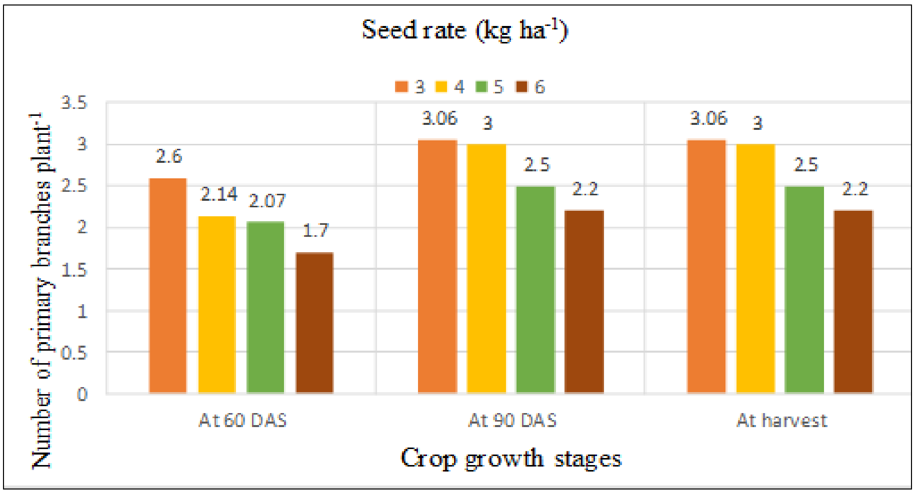


Fig 1: Impact of varying seed rates and row spacing on plant population.



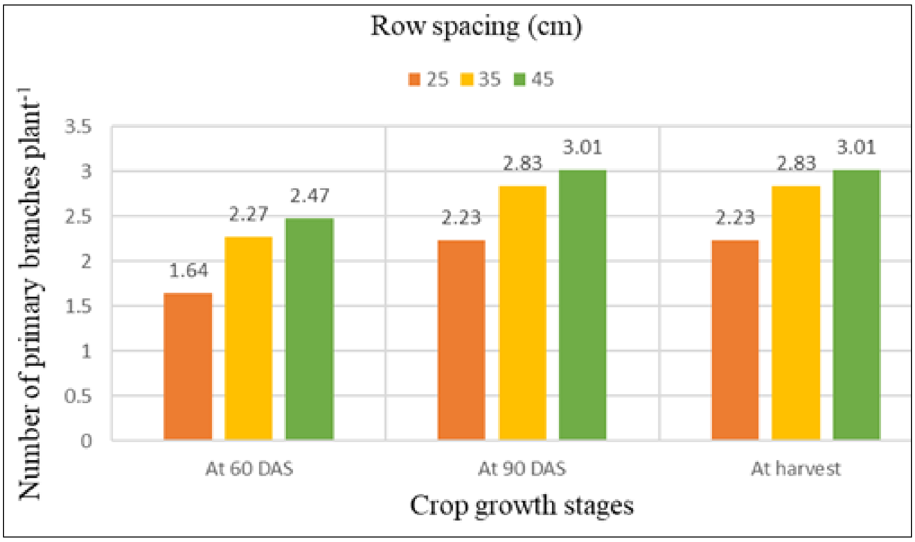


Fig 2: Impact of varying seed rates and row spacing on the number of primary branches per plant of mustard at different growth stages.

Table 1: Effect of different seed rate and row spacing on number of siliqua plant^{-1}, number of grains siliqua^{-1}, grain yield, and B:C ratio of mustard

Treatment	Number of siliquas plant^{-1}	Number of grains siliqua^{-1}	Grain yield (kg ha^{-1})	B:C ratio
Seed rate				
3 kg ha^{-1}	80.00	12.28	1923.33	2.12
4 kg ha^{-1}	75.26	11.50	2151.11	2.48
5 kg ha^{-1}	58.67	10.83	1787.78	1.88
6 kg ha^{-1}	40.78	10.69	1391.11	1.24
S.Em±	1.63	1.09	38.35	0.06
CD (P=0.05)	4.74	10.05	111.09	0.18
Row spacing				
25 cm	56.25	10.64	1783.33	1.86
35 cm	64.58	11.48	1967.50	2.17
45 cm	70.00	11.85	1689.17	1.76
S.Em±	1.41	0.32	33.21	0.05
CD (P=0.05)	4.10	0.95	96.21	0.15
Interaction (Seed rate x Row spacing)				
S.Em±	2.83	0.65	66.43	0.10
CD (P=0.05)	NS	NS	192.42	NS
CV (%)	7.72	10.05	6.34	9.72

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