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Influence of sowing dates and cultivar selection on growth dynamics and yield performance of Indian mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted during the Rabi season of 2024-25 at the Organic Research Farm, Maharshi University of Information Technology, India, to evaluate the Influence of Sowing Dates and Cultivar Selection on Growth Dynamics and Yield Performance of Indian Mustard (*Brassica juncea* L.). The experimental soil was well-drained, sandy loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen, but medium in available phosphorus and potassium. The experiment was laid out in a factorial randomized block design (FRBD) with three replications, comprising four sowing dates-15th October (S1), 30th October (S2), 15th November (S3), and 30th November (S4)-and three varieties-Varuna (V1), Krishna (V2), and Laxmi (V3). The results revealed that the sowing date of 15th November (S3) significantly enhanced growth parameters such as plant height, shoot fresh and dry weight, and the number of primary and secondary branches. Yield attributes including silique length, number of siliquae per plant, seeds per silique, and 1000-grain weight were also highest under this treatment and were statistically at par with 30th November (S4). Similarly, grain, stover, and biological yield, along with harvest index and total uptake of nitrogen, phosphorus, and potassium, were maximized under the 15th November sowing. Among the varieties, Varuna (V1) recorded the best performance in terms of plant height, shoot biomass, number of branches, and all major yield attributes. It also showed the highest grain yield and nutrient uptake, followed closely by Laxmi (V3). Based on the findings, sowing on 15th November (S3) combined with the Varuna variety (V1) proved to be the most effective strategy for maximizing yield and economic returns under the given agro-climatic conditions.

Keywords: Indian Mustard, sowing dates, varieties, production potential, profitability

Introduction

Oilseeds, the raw material for vegetable oils, occupy a significant position in India's national economy, next to food grains, accounting for about 10% of the cultivated area and value of all agricultural produce. Globally, rapeseed-mustard ranks as the third most important oilseed crop after soybean and palm oil, accounting for roughly 28-30% of total oilseed production, with around 36-42 Mt of seed produced and 12-14 Mt of oil annually. India plays a significant role, contributing about 8-10% of world acreage and 15-20% of global production Rapeseed-Mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeis guineensis jacq*.) which contributes 28.6% in the production of oilseeds. The global production of rapeseed-mustard and its oil is around 38-42 and 12-14 mt respectively. India contributes 8.3% and 19.8% of world acreage and production respectively. Mustard plays an important role in the oil seed economy of the country. Rajasthan is the largest mustard-producing state in the country. In Uttar Pradesh, production is likely to increase from 613.5 lakh tonnes to 17 lakh tonnes. Mustard seed production in Madhya Pradesh is estimated to rise to 12.5 lakh tonnes from 8.5 lakh tonnes. In Punjab and Haryana, mustard seed production is expected 11.50 lakh tonnes, up from 9.5 lakh tonnes in the previous year. Indian mustard is an important *rabi* crop raised under rainfed areas of Haryana but also in adjoining Rajasthan. High probability of irregular monsoon not only jeopardizes the *kharif* production but *rabi* crops also due to inadequate moisture storage in the soil profile.

The seeds are highly nutritive containing 38- 57% erucic acid, 5-13% linoleic acid and 27% oleic acid. Mustard (*Brassica juncea* L.) also known by the name of Indian Mustard, belongs to the plant family Brassiceae (Cruciferae) or the Mustard family. In the trade, it is commonly referred to as Rapeseed-Mustard along with four others closely related cultivated oilseed species viz. *Brassica rapa*, *Brassica napus*, *Brassica carinata* and *Eruca sativa*. Over the past couple of decades, these crops have become one of the most important sources of vegetable oil in the world. Continuous improvement in Rapeseed-Mustard has resulted in nutritionally superior edible oil and meal as an important source of protein in Animal feed Mustard crops are commercially cultivated in more Than 60 countries and major producers include China, Canada, India, Australia and The Czech Republic.

In India, shrinking land resources coupled with an increased population exert huge pressure on the farmers, researchers, and agricultural policymakers to meet the food grain requirement of the nation. This enforces to search for newer vistas. With an optimum change in temperature and rainfall, the optimum time of sowing will also change, and ultimately the crop growth will also be affected. The weather parameters which determined the optimum date of sowing are supposed to be altered to some extent with climate change occurring in that region. In the last decade, against the normal precipitation of 54.9 mm rainfall during *rabi* season, the values differed every year due to change in climatic conditions. Indian mustard also suffers from frost at maturity phase and yields are drastically affected in winter season. Adoption of improved varieties and their timely sowing are important factors for improving their productivity

Rapeseed-mustard is commonly grown on marginal soils with low fertility, which predisposes the crop to nutrient stress. Among agronomic practices, sowing time is one of the most vital non-monetary inputs, significantly impacting both seed and oil yield potential. Recent studies have reaffirmed this critical role by highlighting how variations in sowing timing affect germination, growth dynamics, phenology, stress response, and yield outcomes (Frontiers 2022) In North India, mustard cultivation has traditionally been scheduled between early October and mid-November. However, evolving cropping systems and climatic fluctuations have shifted the practical sowing window toward late October, which often yields optimal productivity (Chaudhary et al., 2024; Fagodiya et al., 2024) [6, 9] For example, field trials in eastern Uttar Pradesh demonstrated that a sowing date of 26 October achieved 27-40% higher seed and stover yield compared to sowings on 5 and 15 November, along with superior oil, protein yield, and profitability. Similarly, research in Rajasthan under semi-rainfed conditions affirmed that sowing around 10 October enhanced branching, siliqua count, test weight, and overall yield and economic returns. Abiotic and biotic stressors significantly influence sowing date outcomes. Early sowing under high diurnal temperature regimes can impair germination and initial growth while promoting pests like pointed bug (*Bagrada hilaris*), cutworm (*Agrotis* spp.), and sow-fly larvae. Conversely, late sowing exposes crops to low-temperature stress during germination and early growth, as well as heightened aphid (Lipaphis spp.) infestation during flowering and pod development. Delayed sowing also leads to terminal heat stress, which can increase pollen sterility and reduce seed-set, thus diminishing yield and quality (Chauhan et al., 2020) [7] Thermal dynamics play a crucial role, too. Trials at Punjab Agricultural University (2020-22) revealed that early sowing (1 and 15 October) accelerated emergence, flowering, and lengthened seed-filling phases, resulting in increased plant height, dry matter accumulation, and branching. In contrast, 15 November sowing delayed development, reducing growth and yield due to suboptimal temperatures during early stages and excessive heat later.

The genotype × sowing date interaction is another critical factor. Genotypes respond variably to sowing timing, and yield attributes are significantly influenced by this interaction (Rajput et al., 1991; Pradhan et al., 2014) [23, 21]. Recent studies on 53 genotypes in Jharkhand demonstrated such interactions, identifying genotypes like Pusa Bold and BAUSM-92-1-1 with stable seed yield across varying sowing dates (21 October, 6 November, 21 November). Additionally, trials involving multiple genotypes found that a late sowing window combined with slightly increased seed rate maintained stable seed yield across diverse genotypes

Material and Methods

The experiment was carried out at Crop Research Farm, Department of Agronomy Maharishi University of Information Technology Lucknow (U.P.) India to study the influence of different sowing dates and different varieties in Split Plot Design (Table 1), replicated three times. The maximum and minimum temperatures recorded were 30.2 ºC and 4.3 ºC during the crop growth period. Relative humidity ranges between 41.9-97.5% during crop growth period. The area receives mean annual rainfall between 587.6-369.8 mm. The soil of the experimental field was sandy loam in texture, low in available nitrogen (230.0 kg ha^{-1}) and organic carbon (0.45%), medium in available phosphorous (14.5 kg ha^{-1}) and potassium (210.0 kg ha^{-1}) and slightly alkaline (pH 7.8) in reaction with electrical conductivity of 0.25 dS m^{-1}. The crop variety Varuna, Krishna, Laxmi was sown on 15 October 2024 and harvested on 08 March 2025. The seed rate was 5 kg ha^{-1}. The recommended dose of nitrogen (60 kg ha^{-1}) was applied in two equal split, the half as basal and the remaining half was top dressed 2 times at the time of first and second irrigation. The whole quantity of potassium (40 kg ha^{-1}) was applied as basal dose through Murate of Potash at 8-10 cm depth along with half dose of nitrogen prior to sowing. Phosphorous was applied as basal dose (40 kg ha^{-1}) through DAP. One thinning was done after 30 days of sowing to maintain a plant to plant distance of about 20 cm. Weeding and hoeing operation were performed manually after first and second irrigation at proper soil moisture condition of the soil. At the harvest, number of seed $siliquae^{-1}$, 1000 grains weight, seed yield and stover yield were calculated. The cost of labour incurred in performing different operation was also included. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software based programme, and the treatment means were compared at $P<0.05$ level of probability using t-test and calculating CD values.

Result and Discussion

Effect of different sowing dates and varieties on growth of mustard

Effect of different sowing dates, the treatment, S3 (15th November 2024) recorded significantly highest plant height (175.24 cm) followed by S_4 (30th November 2024). The lowest plant height (147.85 cm) was observed in S_1 (15th October 2024) treatment. Among the different varieties, the highest plant height recorded with V_1 (Varuna) followed by V_3 (Laxmi). The lowest plant height (153.09 cm) recorded in V_2 (Krishna) treatment.

Table 1: Effect of sowing dates and varieties on plant height, fresh and dry weight of shoot and primary and secondary branches at harvest stages of mustard crop

Treatments		Plant height (cm)	Fresh weight of shoot (g plant^{-1})	Dry weight of shoot (g plant^{-1})	Primary branches Plant^{-1}	Secondary branches Plant^{-1}
Sowing Dates						
15th October 2024	S_1	147.85	191.23	34.83	5.43	10.83
30th October 2024	S_2	154.18	322.66	42.03	5.78	11.50
15th November 2024	S_3	175.24	351.73	52.32	6.60	12.32
30th November 2024	S_4	161.14	343.01	49.50	6.42	12.05
SEm±		3.31	6.82	0.81	0.15	0.27
C D (P=0.05)		9.71	27.09	2.85	0.42	0.78
Varieties						
Varuna	V_1	164.41	323.95	47.40	6.52	12.22
Krishna	V_2	153.09	285.27	37.77	6.00	11.25
Laxmi	V_3	161.30	307.75	44.95	6.36	11.76
SEm±		2.86	5.79	0.82	0.08	0.24
C D (P=0.05)		8.41	17.52	2.47	0.24	0.74

Effect of different sowing dates, the treatment, S3 (15th November 2024) recorded significantly highest fresh weight of shoot (351.73 g plant^{-1}), which was at par with S_4 (30th November 2024). The lowest fresh weight of shoot (191.23 g plant^{-1}) was observed in S_1 (15th October 2024) treatment. Among the different varieties, the highest fresh weight of shoot recorded with V_1 (Varuna), which was at par with V_3 (Laxmi). The lowest fresh weight of shoot (285.27 g plant^{-1}) recorded in V_2 (Krishna) treatment. The results were in accordance with those reported by Devi *et al.* (2017) [28] and Uikey *et al.* (2017) [29].

Effect of different sowing dates, the treatment, S3 (15th November 2024) recorded significantly highest dry weight of shoot (52.32 g plant^{-1}), which was at par with S_4 (30th November 2024). The lowest fresh weight of shoot (34.83 g plant^{-1}) was observed in S_1 (15th October 2024) treatment. Among the different varieties, the highest dry weight of shoot recorded with V_1 (Varuna), which was at par with V_3 (Laxmi). The lowest dry weight of shoot (37.77 g plant^{-1}) recorded in V_2 (Krishna) treatment. The results were in accordance with those reported by Hossain *et al.* (2015) [13], Akhter *et al.* (2015) [1] and Habibi and Fazily (2020) [12].

Effect of different sowing dates, the treatment, S3 (15th November 2024) recorded significantly primary branches (6.60 plant^{-1}), which was at par with S_4 (30th November 2024). The lowest primary branches (5.43 plant^{-1}) was observed in S_1 (15th October 2024) treatment. Among the different varieties, the highest primary branches recorded with V_1 (Varuna), which was at par with V_3 (Laxmi). The lowest primary branches (6.00 plant^{-1}) recorded in V_2 (Krishna) treatment.

Effect of different sowing dates, the treatment, S3 (15th November 2024) recorded significantly secondary branches (12.32 plant^{-1}), which was at par with S_4 (30th November 2024). The lowest secondary branches (10.83 plant^{-1}) was observed in S_1 (15th October 2024) treatment. Among the different varieties, the highest secondary branches recorded with V_1 (Varuna), which was at par with V_3 (Laxmi). The lowest secondary branches (11.25 plant^{-1}) recorded in V_2 (Krishna) treatment. The results were in accordance with those reported by Alam *et al.* (2014) [2].

Effect of different sowing dates and varieties on yield attributes of mustard crop

Yield attributes *viz.*, silique length (cm), Number of silique plant^{-1}, Number of seed silique^{-1} and test grains of mustard were affected significantly by various treatments involving different sowing dates and varieties (Table 2 and Fig 2).

Table 2: Effect of sowing dates and varieties on yield attributes of mustard crop

Treatments		Yield attributes			
		Silique length (cm)	Number of siliqua plant^{-1}	Number of seed siliqua^{-1}	Test weight (g)
Sowing Dates					
15th October 2024	S_1	3.31	211.66	11.72	4.96
30th October 2024	S_2	3.79	216.24	12.20	4.97
15th November 2024	S_3	4.58	233.12	13.69	4.99
30th November 2024	S_4	4.40	228.00	13.40	4.98
SEm±		0.06	4.98	0.18	0.10
C D (P=0.05)		0.20	14.27	0.51	NS
Varieties					
Varuna	V_1	4.13	225.80	13.40	4.49
Krishna	V_2	3.78	217.07	12.13	4.32
Laxmi	V_3	3.98	224.30	13.08	4.38
SEm±		0.06	2.26	0.20	0.12
C D (P=0.05)		0.17	6.98	0.57	NS

It is observed from the data in the table that sowing dates significantly influenced the silique length. Amongst the treatments, the treatment S_3 (15th November 2024) recorded maximum silique length (5.58 cm), which was at par with S_4 (30th November 2024) as compared to the remaining treatments. The treatment S_1 (15th October 2024) recorded significantly lowest silique length (22.3 cm). Among the different varieties, the highest silique length (4.13 cm) recorded with the application of V_1 (Varuna), which was at par with V_3 (Laxmi). Significantly lowest silique length

(3.78 cm) was found under the treatment V_2 (Krishna). Silique length was not significantly influenced by the interaction effect between different sowing dates and varieties of mustard. The results were in accordance with those reported by Kumar *et al.* (2008) [17], Banik *et al.* (2009) [4] and Kumari *et al.* (2012) [18].

It is obvious from the data in the table that sowing dates significantly influenced the number of siliqua plant^{-1} production. Amongst the treatments, S_3 (15th November 2024) recorded higher number of siliqua plant^{-1} (233.12), which was at par with S_4 (30th November 2024) as compared to the remaining treatments. The treatment S_1 (15th October 2024) recorded lowest (211.66) number of siliqua plant^{-1}. Variation in number of siliqua plant^{-1} due to varieties treatments was also observed. The treatment V_1 (Varuna) recorded significantly higher number of siliqua plant^{-1} (225.80), which was at par with V_3 (Laxmi). The significantly lowest number of siliqua plant^{-1} was found under the treatment V_2 (Krishna). The results were in accordance with those reported by Jat *et al.* (2013) [14] and Patel *et al.* (2017) [20].

It is obvious from the data in the table that number of seed silique^{-1} significantly varied due to different sowing dates. Amongst all the sowing dates treatments, the significantly higher number of seed silique^{-1} (13.69 siliqua^{-1}) was recorded under S_3 (15th November 2024), which was at par with S_4 (30th November 2024). The significantly lowest number of seed silique^{-1} (11.72) was recorded under the treatment S_1 (15th October 2024). Variations number of seed silique^{-1} due to different varieties treatments was significant. Amongst the different varieties treatments, the treatment V_1 (Varuna) recorded superior number of seed silique^{-1} (13.40), which was at par with V_3 (Laxmi) as compared to the remaining treatments. However, the significantly lowest number of seed silique^{-1} (12.13) was found under the treatment V_2 (Krishna).

It is clear from the data in the table that test weight of mustard varied non-significant due to different sowing dates. Amongst all the treatments, the highest test weight (4.99 g) was recorded under S_3 (15th November 2024). The lowest test weight recorded in S_1 (15th October 2024) treatment. The variations in test weight due to different varieties treatment were also observed. The higher test weight (4.49 g) was observed in treatment V_1 (Varuna). The lowest test weight (4.32 g) was recorded under the treatment V_2 (Krishna). The results were in accordance with those reported by Singh *et al.* (2017) [20] and Kumar *et al*. (2018) [16].

Effect of different sowing dates and varieties on Productivity

Data with regard to the effect of sowing dates and varieties on grain yield, stover yield, biological yield and harvest index of mustard crop are mentioned in Table 3 and depicted in Fig 3.

Table 3: Effect of sowing dates and varieties on yield (q ha^{-1}) of mustard crop

Treatments		Yield (q ha^{-1})			Harvest index (%)
		Grain	Stover	Biological	
Sowing Dates					
15th October 2024	S_1	7.40	24.28	31.68	23.36
30th October 2024	S_2	7.99	25.34	33.33	23.97
15th November 2024	S_3	10.20	29.39	39.59	25.76
30th November 2024	S_4	9.85	28.31	38.04	25.58
SEm±		0.13	0.43	0.58	0.09
C D (P=0.05)		0.38	1.22	1.76	0.29
Varieties					
Varuna	V_1	9.70	27.92	37.62	25.78
Krishna	V_2	7.95	26.54	34.49	23.05
Laxmi	V_3	8.92	27.32	36.24	24.61
SEm±		0.15	0.48	0.52	0.08
C D (P=0.05)		0.42	1.36	1.54	0.23

It is evident from the data given in Table 3 and Fig 3 that the grain yield significantly varied with different sowing dates treatments. The maximum grain yield (10.20 q ha^{-1}) was recorded under the treatment S_3 (15th November 2024), which was at par with S_4 (30th November 2024), respectively. The significantly lowest grain yield (7.40 q ha^{-1}) was observed under the treatment S_1 (15th October 2024). Among the different varieties treatments, the treatment V_1 (Varuna) obtained significantly higher grain yield followed by V_3 (Laxmi). The significantly lowest grain yield (7.95 q ha^{-1}) was recorded under the treatment V_2 (Krishna). The results were in accordance with those reported by Jat *et al.* (2013) [14] and Patel *et al.* (2017) [20].

It is evident from the Table (3) that the stover yield significantly differed with different sowing dates treatments. The maximum stover yield (29.39 q ha^{-1}) was recorded in treatment S_3 (15th November 2024), which was at par with S_4 (30th November 2024), respectively. The significantly lowest stover yield (24.28 q ha^{-1}) was observed under treatment S_1 (15th October 2024). Among the different varieties was recorded under the treatment V_1 (Varuna) (27.92 q ha^{-1}), which was statistically at par with the treatments V_3 (Laxmi). The significantly lowest straw yield (26.54 q ha^{-1}) was found under the treatment V_2 (Krishna).

It is evident from the table (3) that the biological yield significantly differed with different sowing dates treatments. The biological yield increased with increase in level of sowing dates. The significantly higher biological yield (39.59 q ha^{-1}) was recorded in treatment S_3 (15th November 2024), which was at par with S_4 (30th November 2024), respectively. The significantly lowest biological yield (31.68 q ha^{-1}) was observed under treatment S_1 (15th October 2024). The biological yield significantly varied with the different variety's treatments. The treatment V_1 (Varuna) obtained significantly higher biological yield (37.62 q ha^{-1}) which was statistically at par with the

treatments V_3 (Laxmi). The significantly lowest biological yield (34.49 q ha^{-1}) was found under the treatment V_2 (Krishna). These findings are in conformity with the results of Jat *et al.* (2013) [14] and Habibi and Fazily (2020) [12].
Harvest index was affected significantly by various treatment including different sowing dates and different varieties treatments. Among the harvest index the highest harvest index was recorded in S_3 (15th November 2024), which was significantly higher than the all other treatments. The lowest harvest index was recorded in S_1 (15th October 2024). Among the different varieties treatments highest harvest index was recorded in V_1 (Varuna). The lowest harvest index recorded in V_2 (Krishna) treatment.

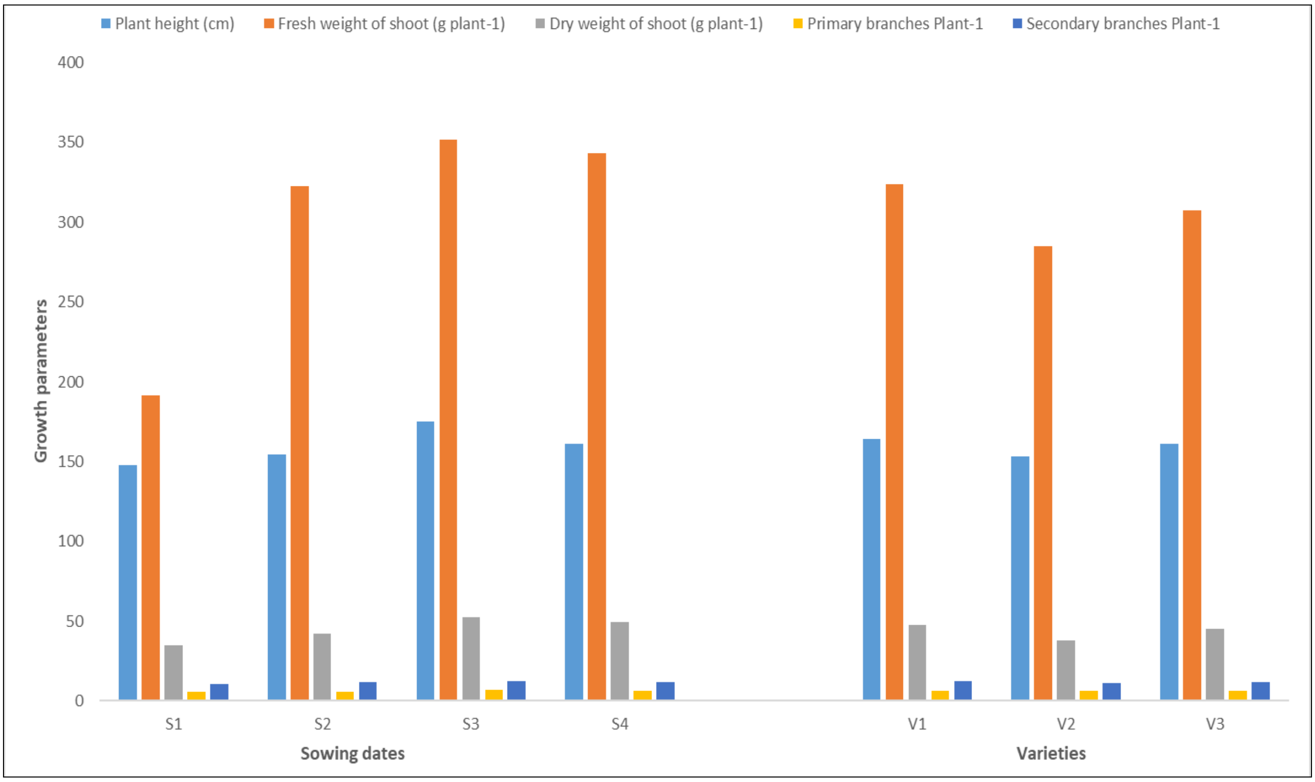

Fig 1: Effect of sowing dates and varieties on plant height, fresh and dry weight of shoot and primary and secondary branches at harvest stages of mustard crop

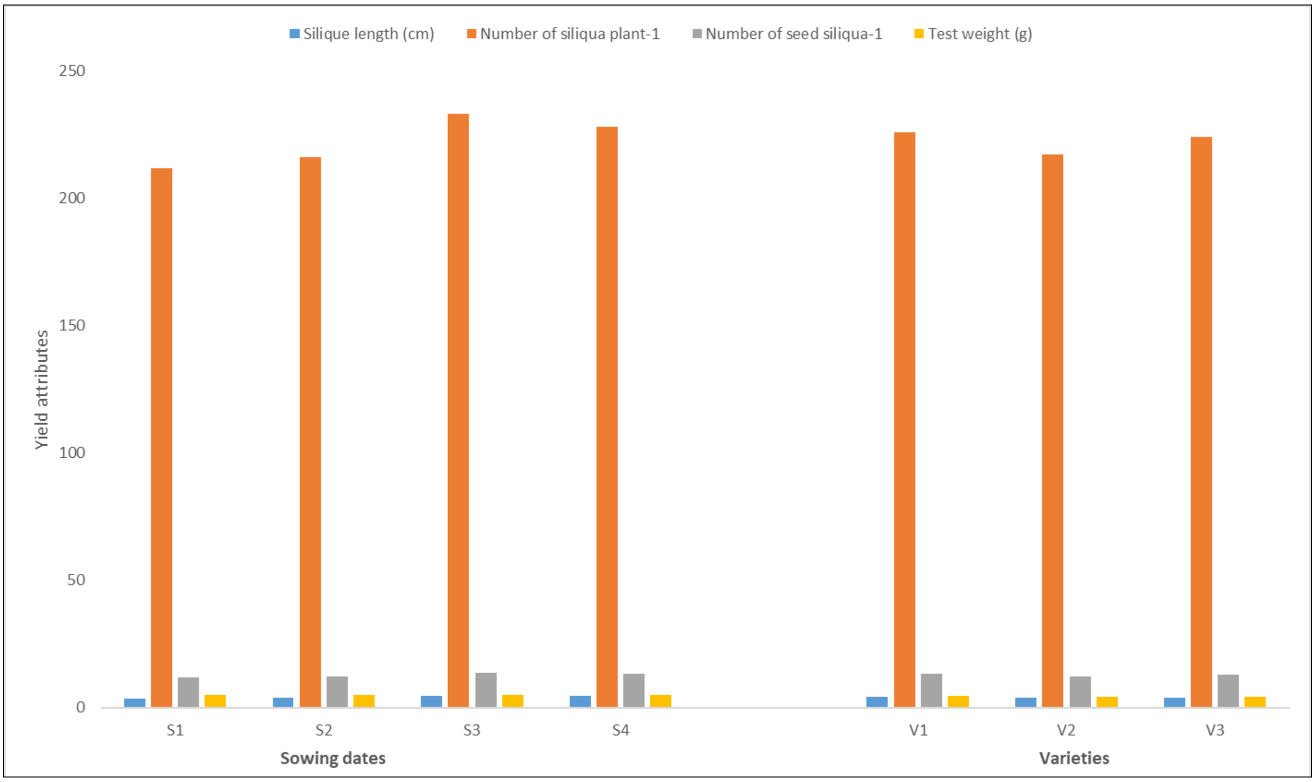

Fig 2: Effect of sowing dates and varieties on yield attributes of mustard crop

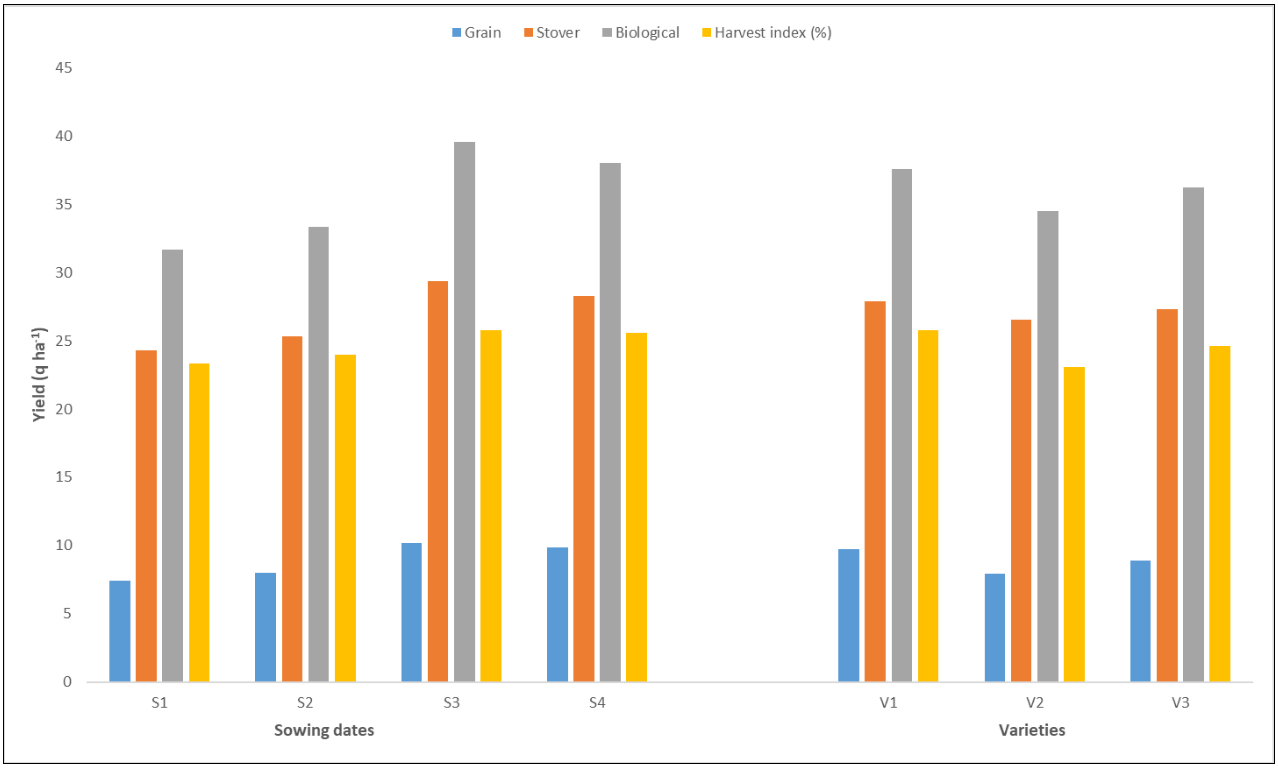

Fig 3: Effect of sowing dates and varieties on yield (q ha^{-1}) of mustard crop

Conclusion

It is clear that maximum crop yield was achieved with 15th November 2024. Among the different variety's treatments, the highest crop yield was recorded with the application of Varuna. Thus, it may be concluded that application of 15th November 2024 and Varuna seems to best option for achieving higher yield of mustard crop.

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