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Productivity and economics of Indian mustard (*Brassica juncea* L.) varieties as influenced by different date of sowing under semi-rainfed condition of Rajasthan

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Abstract
A field experiments was conducted during winter seasons of 2014 at Agronomy farm, SKN College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan. To study the yield attributes and yield and economics of Indian mustard (*Brassica juncea* L.) influenced by date of sowing and verities under rainfed condition of Rajasthan. Keeping in this view the experiment comprising of 3 dates of sowing ((D_1-30 September, D_2-10 October, D_3-20 October and D_4-30 October) and 4 varieties of Indian mustard (V_1– ranti, V_2–Pusa jai kisan, V_3–GM-3 and V_4– GDM-4) was laid out in split plot design. Results showed that both dates and varieties (10 Oct. and Pusa jai kisan) superior compare to rest of treatment. However, highest growth and yield attributes (plant height, primary and secondary branches, No. of siliqua (cm) per plant, seeds per siliqua, test weight, seed yield (q/ha) grain yield, gross return, net return and B:C ratio) was recorded under 10 Oct. and Pusa jai kisan variety.

Keywords: Date of sowing, varieties, yield parameters, economics, Indian mustard

Introduction
Indian mustard botanically known as *Brassica juncea* L. The family of mustard Brassicaceae (Crucifereae) has 36 chromosomes (2n). It is annual and one of the major rabi oilseed crop of India. It is commonly known as Rai Or Raya. Mustard is healthfully rich and its oil content ranges from 33 to 49 percent. Rapeseed mustard group of crops is the second most important oilseed crop after soybean in India. India is the second-largest grower (21.1 %) after Canada, and the third-largest producer (12.6 %) of rapeseed mustard after Canada and China in the world (Choudhary *et al*., 2023) [2]. Indian mustard is primarily cultivated in Rajasthan, Uttar Pradesh, Haryana, Gujarat and Madhya Pradesh. Indian mustard (*Brassica juncea*) is the second most important oilseed crop in India after groundnut sharing 27.8% in the India's oilseed production. The crop occupies an area of 8.74 m ha, with the production of 10.95 m tons and average productivity of 1270 kg/ha in the country (Anonymous, 2022) [1]. Indian mustard is an important *rabi* crop raised under rainfed areas of Rajasthan. 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. Different cultivars may respond differently to different sowing time (Rajput *et al.* 1991, Sharma and Kumar, 2023) [12, 16]. Mustard is the most responsive crop to weather and has different results at different sowing times. Sowing at times plays a prime role in providing growing conditions i.e. temperature, humidity, rain, and light intensity. The development period of mustard should synchronize with ideal conditions for better articulation of growth and yield. Rapeseed and mustard are usually sown by the end of September to the second fortnight of October in north India when grown as a sole crop or on dates of the main crop when sown as mixed or intercrop. But, with the development of new varieties of crops and the adoption of multiple cropping systems under irrigated conditions, it has become essential to extend their sowing from October to mid-

November or even later. Indian mustard is highly sensitive to climate change and soil fertility (Mandal and Sinha, 2004) [8]. Sowing time is a non-monetary input for optimizing the maximum dry matter accumulation and providing the most congenial conditions for maximum light interception and the best utilization of moisture and nutrients to better plant growth and seed yield (Pattam, 2017 and Singh *et al.*, 2011) [11, 19]. The present study was therefore, undertaken to determine the effects of sowing dates and varieties on growth, yield attributes and yield of Indian mustard.

Materials and Methods

The experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture Unioversity, Jobner, Jaipur (Rajasthan) in the Field No. 10B during Rabi, 2014. Geographically, Jobner is situated 45 km west of Jaipur at 26006′ North latitude and 75028′ East longitude at an altitude of 427 meter above mean sea level (MSL). This region falls under agro-climatic zone III A (Semi-Arid Eastern Plain). The sandy loam soil of the experimental field was low in organic carbon (0.21 %), available nitrogen (136 kg N ha^{-1}), medium in available phosphorus (21.35 kg P_2O_5 ha^{-1}) and available potash (219 kg K_2O ha^{-1}) with 8.15 pH. The experiment comprising of 3 dates of sowing ((D_1- 30 September, D_2- 10 October, D_3- 20 October and D_4– 30 October) and 4 varieties of Indian mustard (V_1– Kranti, V_2– Pusa jai kisan, V_3– GM-3 and V_4– GDM-4) was laid out in split plot design. The sowing dates were allocated in the main plots and varieties in the sub-plots and were replicated thrice. The uniform basal application of recommended dose of fertilizer (RDF) of 60 kg N + 40 P_2O_5 kg ha^{-1} was applied through urea and diammonium phosphate, respectively. Half of the entire quantity of nitrogen and full quantity of phosphorus were applied as basal at the time of sowing. The remaining dose of nitrogen was top dressed at flowering stage of crop. The size of each experimental plot was 4 m x 3 m and plant population was maintained manually by thinning after 10 days of germination. Seeds were sown at the rate of 5 kg seed ha^{-1} in rows spaced 40 cm apart and 3-4 cm deep by a hand drawn drill. Meteorological observations were recorded during the experimentation. The observations on plant height and number of branches per plant were recorded manually on five randomly selected representative plants from each plot of each replication separately as well as yield and yield attributing characters were recorded as per the standard method. Yield attributes were also recorded at physiological maturity stage (Patel and Mehta 1987) [10]. The economics of the treatments was worked out considering the prevailing cost of inputs and outputs. All the results were then analyzed statistically for drawing conclusion using Analysis of variance (ANOVA) technique for SPD as prescribed by (Gomez and Gomez, 1984) [4]. Standard error of mean in each case was calculated at 5% levels of probability.

Results and Discussion

Growth attributes

The data revealed that date of sowing significant variations showed in plant height, number of primary branches and number of secondary branches under varying date of sowing. Mustard crop under date of sowing highest number of plant height (182.2 cm), primary branches (7.29) and number of secondary branches (13.36) recorded on 10 October (D_2), respectively. Above mentioned all growth parameters (plant height, primary and secondary branches) decreased with progressive delay in sowing from 10 October. This decreased growth parameters with delayed sowing might be due to the fact that prevailing weather conditions during different phenological development stages of the crop might have adversely affected the crop growth, which ultimately resulted into shortened maturity period compared to early sown crop. These findings are confirmatory with those of Singh *et al*. (2002) [18, 21], Tripathi *et al*. (2021) [23], Samota *et al.* (2022) [15], Sharma and Kumar (2023) [16] and Kumar *et al.* (2024) [7] who have reported progressively decrease in plant height, number of branches and with delay in sowing time. Mustard varieties showed statistically significant variation in plant height, number of primary and secondary branches under varying date of sowing at various crop varieties. Mustard crop Verities found significantly highest number of plant height (175.7 cm), primary (6.87) and secondary (12.82) branches recorded in pusa jai kisan, respectively which was statistically at par with Kranti variety. Pusa jai kisan and Kranti varieties were significantly superior over the GM-3 and GMD 4 varieties. The differences in varieties of Indian mustard with respect to plant height, primary branches and secondary branches might be due to the difference in their genetic constitution. Corroborative findings indicating variability and genotypic variations amongst Indian mustard variety have also been reported by Panwar *et al.* (2000) [9], Singh and Singh, (2002) [18, 21], Singh *et al*. (2010) [20], Ranabhat *et al.* (2021) [14], Samota *et al.* (2022) [15] Sharma and Kumar (2023) [16] and Kumar *et al.* (2024) [7] in respect of plant height, number of primary and secondary branches.

Yield attributes and yield

Yield attributes and yield of crop plants depends upon source-sink relationship and also on the different components of source (leaves, number of branches, and finally, dry matter accumulation before anthesis) and sink (number of siliquae per plant, number of seeds per siliqua, siliqua length at harvest, test weight and seed yield per plant (Singh *et al*., 2017) [17]. Mustard crop sown on 10 October produced significantly higher siliquae per plant (242.8), seeds per siliquae (14.54) test weight (4.45 g) and seed yield (15.59 $qha.^{-1}$), respectively over sowing on 30 September and statically at par on 20 October. Delayed sowing from 10 October to 30 October caused progressively reduction in all the yield attributes *viz*., siliquae per plant, seeds per siliqua and test weight which ultimately resulted in reduction in seed yield per hectare higher seed yield with early sowing could be attributed to its beneficial influence on yield attributes because the crop had longer growth period and favorable temperature during crop growth period. The decline in yield in later sown crops might be due to shorter duration of vegetative and reproductive phase, which allowed less time for siliquae formation and development of seeds. These findings are in line with the results of Jadhav and Singh (1992) [5], Gare *et al*. (1996) [3], Surekha and Reddy (1996) [22], Singh and Singh, (2002) [18, 21], Samota *et al*., 2022 [15], Tripathi *et al*. (2021) [23], Sharma and Kumar (2023) [16] and Kumar *et al*., 2024 [7]. Mustard variety pusa jai kisan gave significantly highest seed yield 15.65 per hectare over all the varieties under study, followed by karanti, GDM-4 and GM-3. Highest seed yield per hectare of variety pusa jai kisan might be attributed to better yield attributing character *viz*., highest number of siliquae per plant (231.4) and number of seeds per siliqua (14.33). The test weight was non-significantly influenced under the varietals variations. The variety Pusa jai kisan had higher number of siliquae per plant. This might be due to maximum number of primary and secondary branches per plant which ultimately resulted in to

highest seed yield per plant per and per hectare over other varieties under investigation. The variety GM-3 gave significantly lowest seed yield than other varieties under investigation due to its other poorest yield contributing characters, which ultimately resulted in lowest number of siliquae per plant as well as siliqua length. The variety karanti ranked second which significantly with GDM-4, in respect of number of siliquae per plant 231.4, number of seeds per siliqua, 14.33 and seed yield 14.88 q/ha per hectare. Further the variability in seed yield (q/ha) of different Indian mustard varieties might be attributed to their genetic constitution. These findings are in line with the results of Rana and Pachauri (2001) [13], Singh and Singh, (2002) [18, 21], Singh *et al.* (2010) [20], Singh *et al.* (2017) [17], Ranabhat *et al.* (2021) [14] and Panwar *et al.* (2000) [9], Samota *et al.* (2022) [15] Sharma and Kumar (2023) [16] and Kumar *et al.* (2024) [7].

Economics

Further examination of the data also showed that different date of sowing and varieties varied significantly. Among sowing dates, sowing 10 October recorded significantly higher gross returns (Rs. 46763/ha), net returns (Rs. 39663/ha) and B: C ratio (5.59) over sowing on 30 October and 30 September. But the sowing on 10 October and 20 October was found statistically at par each another. Variety pusa jai kisan recorded significantly higher gross returns (Rs. 46948/ha), net returns (Rs. 39848/ha) and B: C ratio (5.61) over GM-3 and GDM-4. But kranti variety and pusa jai kisan variety as found statistically at par with each another. The economics of mustard was calculated on the basis of input and output of yield so that higher yield basis the results are in conformity with those reported by Singh and Singh, (2002) [18, 21], Singh *et al.* (2010) [20], Kamaliya *et al.* (2022) [6] and Samota *et al.* (2022) [15].

Table 1: Effect of date of sowing and different varieties on growth, yield attributes, yield and economics of Indian mustard.

Treatments	Plant height (cm)	Branches / plant		Siliqua/plant	Seeds/siliqua	Test weight (g)	Seed yield (q/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Primary	Secondary							
A. Date of sowing										
D_1- 30 September	166.0	6.05	11.82	209.5	13.24	4.14	13.64	40915	33815	4.76
D_2- 10 October	182.2	7.29	13.36	242.8	14.54	4.45	15.59	46763	39663	5.59
D_3- 20 October	177.4	6.84	12.47	227.0	14.29	4.33	14.83	44495	37395	5.27
D_4 – 30 October	147.3	5.35	10.27	182.7	11.95	3.91	12.15	36438	29338	4.13
$SEm_{\pm}$	5.23	0.20	0.43	5.84	0.38	0.12	0.48	1452	1452	0.20
CD at 5%	15.70	0.59	1.28	17.52	1.13	0.37	1.45	4356	4356	0.61
B. Mustard varieties										
V_1 – Kranti	175.0	6.47	12.19	223.6	13.70	4.27	14.88	44648	37548	5.29
V_2- Pusa jai kisan	175.7	6.87	12.82	231.4	14.33	4.32	15.65	46948	39848	5.61
V_3- GM-3	160.5	6.19	11.28	200.3	13.32	4.11	12.34	37013	29913	4.21
V_4- GDM-4	161.7	6.01	11.64	206.8	12.67	4.12	13.33	40003	32903	4.63
$SEm_{\pm}$	3.99	0.15	0.33	5.30	0.33	0.11	0.36	1089	1089	0.15
CD at 5%	11.96	0.44	0.98	15.90	1.00	NS	1.09	3266	3266	0.46

Conclusion

On the basis of findings present research work it can be concluded that Indian mustard can be sown by October 10 for higher grow, yield attributes and yield and pusa jai kisan variety proved to be highest yielder under rainfed conditions of sandy loam soils in arid/semi arid regions of Rajasthan.

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