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Effect of different sowing dates and crop geometry on productivity and profitability of Indian mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted during three consecutive rabi seasons of 2014-15 to 2016-17 to study the effect of different sowing dates and crop geometry on productivity and profitability of Indian mustard (*Brassica juncea* L.) at Rajamata Vijayaraj Scindia Krishi Visva Vidhyalay, Zonal Agricultural Research station Morena in Gird Agro-climatic zone. The experiment was laid out in split plot design with 3 sowing dates and 5 planting geometry replicated thrice. Results revealed that sowing of mustard crop in the 10thOctober during all three years produced significantly higher seed yield (2982 kg/ha). Among the planting geometry, significantly higher seed yield, was recorded with 30 cm× 10 cm followed by 45 cm × 15 cm as compared to rest of the spacing. Similar trend followed for net returns and B: C ratio.

Keywords: Sowing dates, planting geometry, seed and oil yield and economics

Introduction
Vegetable oil has one of the highest shares (40%) of the production of all agricultural commodities globally. India is the largest importer of edible oils ($10.5 billion) in the world followed by China & the USA. India's share of world edible vegetable oil imports is about 15% (FAO 2019). Indian vegetable oil economy is the world's fourth-largest after the USA, China, and Brazil with total oilseed production of 34.2 million tonnes (Mt) during 2019–20. Oilseed cultivation is under taken across India in an area of 26.0 Million hectares (Mha), mainly on marginal lands, dependent on monsoon rains (un-irrigated), and with low levels of input usage. Indian mustard (*Brassica juncea* L.) is an important winter (rabi) season oil seed crop. It is also known as Rai or Laha.

In India it is believed to be an introduction from China. It has been grown for oilseed, greens and as a spice. Oilseed crops occupy a significant place in the Indian economy, next to food grains. Rapeseed-mustard is the third important oilseed crop grown in the world after soybean (*Glycine max*) and palm (*Elaeisguneensis Jacq.*) oil. India is an important rapeseed mustard growing country in the world, occupying the third position in its production after Canada and China of the seven edible oilseeds cultivated in India, contribution of rapeseed-mustard (*Brassica spp.*) is 28.6% in the total production of oilseeds. In India, it is the second most important edible oilseed after soybean which shares 27.8% in the India's oilseed economy (Anonymous, 2020) [3] of the total cropped area in India, the share of oilseeds is 13.33% in which rapeseed-mustard accounts for more than 3% in India, rapeseed-mustard grown in 6.1Mha area with production of 8.3 Mt with average productivity of 1349 kg/ha (Anonymous 2020) [3]. In M.P., rapeseed-mustard grown in 691 thousand Hectare with production of 928.03 thousand tonnes with average productivity of 1343 kg/ha (Anonymous 2020) [3].

The sound management practices for rapeseed-mustard are needed for efficient use of limited moisture, available during the crop season especially at critical stages of crop growth, high evaporative demand (2-6mm day^{-1}), low (<0.25%) soil organic carbon, and poor crop management, which are restricting the national average productivity of oilseed Brassicas to 1.09 t ha^{-1}, as compared to the world's average of 1.83 t ha^{-1} (DRMR, 2013, Rathore *et al*., 2019) [10] in India. India occupies a prestigious position both in acreage and production of oilseed map of the world, but there is a huge gap between production potential and actual realization (Mukherjee, 2016; Chouksey *et al*., 2016) [9, 4]. Among the agronomic factors sowing time and spacing are well-known to play important roles in productivity (Kumar *et al*., 2017; Vaghasia *et al*., 2017) [7, 13]. Therefore, the present investigation was carried out to study the appropriate sowing time with optimum planting geometry for Indian mustard in Gird Agro-climatic zone.

Materials and Methods

The field experiments were conducted during three consecutive rabi seasons of 2014-15, 2015-16 and 2016-17 at Rajamata Vijayaraj Scindia Krishi Visva Vidhyalay, Zonal Agricultural Research station Morena (MP) in Gird Agro-climatic zone. The weather conditions during the growing season of the crop have been described in Table 1. The maximum temperature ranged between 26.0–37.5 ^{0}C, 25.6-37 ^{o}C and 23.9-40.0^0 during 2014–15, 2015-16 and 2016-17 respectively. Rainfall data were recorded using a rain gauge installed at the experimental site (monthly rainfall data has been provided in Table 1). During 2014-15, 2015-16 and 2016-17, 25.7, 14.7 and 23 mm respectively rainfall were received in during crop season. The experiment was conducted at the RVSKVV –ZARS Morena, India (25^0 15 to 26^0 45 N latitude and 70^{0}30E longitude, 174.31 m above mean sea level). The study area is categorized under Gird Agro-climatic zone. The climate of this zone is characterized as semi-arid and extremely hot during May-June and cold during December-January. Experiment conduct during the winter seasons of 2014–15, 2015-16 and 2016-17. The soil of the experimental field was sandy loam in texture of old alluvial plain and having electrical conductivity (EC) 0.33 dS m^{-1}, pH 7.80 of 1:2 soil water ratio, soil organic carbon stock (SOC) 6.45 Mg ha^{-1}, low in organic carbon (OC) content (0.30%), available N (185 kg ha^{-1}), P (9.1 kg ha^{-1}), S (9.5 kg ha^{-1}), and Zn (0.50 mg kg^{-1}), whereas medium in available K (191 kg ha^{-1}), and Cu (0.33 mg kg^{-1}), Fe (6.6 mg kg^{-1}) and Mn (4.2 mg kg^{-1}) above their critical limits for deficiency. The bulk density of the soil was 1.52 Mg m^{-3} and the infiltration rate 4.7 mm h^{-1}. The experiments were laid out in split plot design with three dates of sowing (Table - 2) in main plots *viz*., D_1:10th October, D_2:20th October and D_3:30th October date of sowing and each main plot were further divided in five sub plots to accommodate planting geometry *viz*., S_1: 30 × 10 cm, S_2: 30 × 20 cm, S_3: 30× 30 cm, S_4: 45 × 15 cm and S_5: 45 × 30 cm with three replications. Mustard variety RH-749 was grown as per scheduled date and respective spacing of the treatments. The recommended dose of fertilizer of N 80, P40, k 20 and S 25 kg/ha for mustard crop was applied. Full dose of P, K and S with half dose of nitrogen fertilizers were drilled just before the sowing as a basal application through urea, DAP, MOP and elemental sulphur and remaining half dose of nitrogen were applied at 25-30 DAS after thinning operation. Need based irrigation was given. The observations pertaining to various growth parameters, yield attributes and yield were recorded at harvest on the basis of 5 randomly selected plants from every plot. Economics was computed using the prices of inputs as per prevailing local market rates and minimum support price of mustard seed. The benefit: cost ratio was calculated by using net return divided by total cost of cultivation involved. The standard analysis of variance (ANOVA) technique prescribed for the split plot design was performed to compare the treatment means for each year separately and was pooled. Treatment means were compared at the 5% level of significance (P=0.05) using least significant difference (LSD) and hence results based on pooled analysis are presented here to draw logical inferences.

Results and Discussion

Crop growth and yield attributes: The pooled analysis of the growth and yield attributes of Indian mustard was not influenced significantly due to different sowing dates (Table 2). Only insignificant improvement was associated with First date of sowing in respect to plant height, number of primary branches/plants, number of siliquae/plant, No. of seeds siliquae, Length of siliquae and test weight over remaining sowing dates. However, planting geometry significantly influenced the number of primary branches/plant and number of siliquae/plant. Wider spacing of 45 × 30 cm produced 6.62 and 301.23 higher number of primary branches/plant and number of siliquae/plant over the recommended spacing of 30 cm × 10 cm. Concomitant increase in yield attributes with widening of row spacing from 30 cm to 45 cm may be due to lesser competition for resources exploitation among plants (Shivani and Kumar, 2002) [17] which led to increased branches and siliquae/plant. These results are in accordance with the findings of Lakra *et al*. (2018) [8] and Jat *et al*. (2019) [5]. However, plant height, number of seeds/siliquae, length of siliqua and test weights remained unaffected due to planting geometry

Yield

Seed yield of Indian mustard was significantly influenced by various sowing schedule and planting geometry (Table 2). Sowing (D_1) 10thOctober first sowing significantly out yielded (2982 kg/ha) other dates of sowing (D_2). The higher seed yield with early sowing could be attributed to its beneficial influence on yield attributes because the crop has longer growth period and favourable soil moisture and temperature during crop growth period. The results of present study were also supported by the earlier findings of Alam *et al*. (2015) [1] in mustard. However, mustard grown at 30 × 10 cm and 45 × 15 cm remained statistically at par with each other but maintained their significant superiority over the rest of the wider spacing treatments in respect of seed yield. These findings were in conformity with those of Khajuria *et al*. (2017) [6], Lakra *et al*. (2018) [8] and Jat *et al*. (2019) [5].

Oil content and oil yield

Although the oil content remained the same over sowing schedules (Table 3) significantly higher oil yield was recorded in First date of sowing due to higher seed yield. However, different planting geometry showed significant influence on oil content and oil yield. Significantly higher oil content and its yield was observed under narrow spacing 30 × 10 cm over rest of the spacings but it remained statistically on par with 45 × 15 cm spacing with regard to oil content only. These results are in accordance with the findings of Singh *et al*. (2018) [12].

Economics

Higher gross returns, net returns and benefit: cost ratio was recorded with 10thOctober date of sowing (D_1). Mustard sown during 10thOctober (D_1) earned maximum net profit of Rs. 88990/ha, which was higher over the net returns values of later sown (D_2) and (D_3) crop (Table 3). Mustard sown at 30 × 10 cm obtained higher gross returns, net returns and B:C ratio and it remained statistically on par with 45 × 10 cm. Similar results have also been earlier reported by Lakra *et al*. (2018) [8], Singh *et al*. (2018) [12] and Jat *et al*. (2019) [5] It could be concluded that mustard crop should be sown during 10th of October at a spacing 30 cm × 10 cm for achieving higher yield and monetary returns under Gird Agro-climatic zone.

Table 1: Weather conditions during crop period in 2014-15, 2015-16and 2016-17

Month	Temp(ºC)						Mean RH (%)						Rainfall (mm)			Pan Evaporation (mm day^{-1})		
	Max			Min			07.20 h			14.20 h								
	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17	2014-15	2015-16	2016-17
October	36.2	37.0	34.1	18.6	20.4	20.9	67.2	61.2	75.1	42.3	42.3	49.3	-	-	-	5.8	3.7	6.9
November	34.9	30.5	32.0	13.4	14.4	13.3	68.1	64.4	67.4	40.1	38.1	35.3	-	7	-	3.0	6.7	4.2
December	28.5	28.7	29.6	8.4	6.1	9.5	76.1	76.1	76.6	43.7	56.7	34.3	8.5	5	-	2.2	4.1	2.4
January	26.0	25.6	23.9	6.2	7.4	6.5	85.1	88.3	79.6	46.4	69.3	42.0	1	-	22.0	2.4	1.2	1.2
February	29.4	29.9	29.6	9.4	8.7	9.5	67.1	83.7	84.9	31.4	67.6	33.4	16.2	-	-	4.1	4.8	2.5
March	37.5	36.4	40.0	14.7	14.3	11.2	59.4	82.2	66.1	30.5	71.2	27.9	-	2.7	1.0	8.0	9.4	7.6

Table 2: Effect of sowing date and planting geometry on growth, yield attributes and yield of Indian mustard (Pooled data of 3 years)

Treatments	Plant height (cm)	No. Of primary branches plant^{-1}	No. Of siliquae plant^{-1}	No. Of seeds siliqua^{-1}	Length of siliquae (cm)	1000 seed weight(g)	Seed yield (kg^{-1})
Date of Sowing							
D_1- 10Octo.	234.85	6.99	299.33	16.08	5.01	6.59	2982
D_2-20Octo.	231.93	6.35	284.04	15.72	4.64	5.92	2841
D_3-30Octo.	217.82	5.96	268.55	14.6.5	4.60	5.82	2508
S.Em	3.80	0.05	5.03	0.47	0.15	0.12	30
CD at 5%	NS	0.21	20.12	NS	NS	NS	119
Spacing(cm)							
S_1-30X10	226.35	6.13	238.67	15.27	4.69	6.64	2931
S_2-30X20	224.18	6.18	276.22	15.46	4.67	7.05	2732
S_3-30X30	232.69	6.27	282.60	15.29	4.69	6.74	2795
S_4-45X15	229.47	6.62	282.94	15.51	4.94	6.66	2841
S_5-45X30	228.13	6.96	301.23	15.89	4.77	6.48	2785
S.Em	3.27	0.06	13.95	0.31	0.14	0.17	69
CD at 5%	NS	0.17	40.73	NS	NS	NS	202

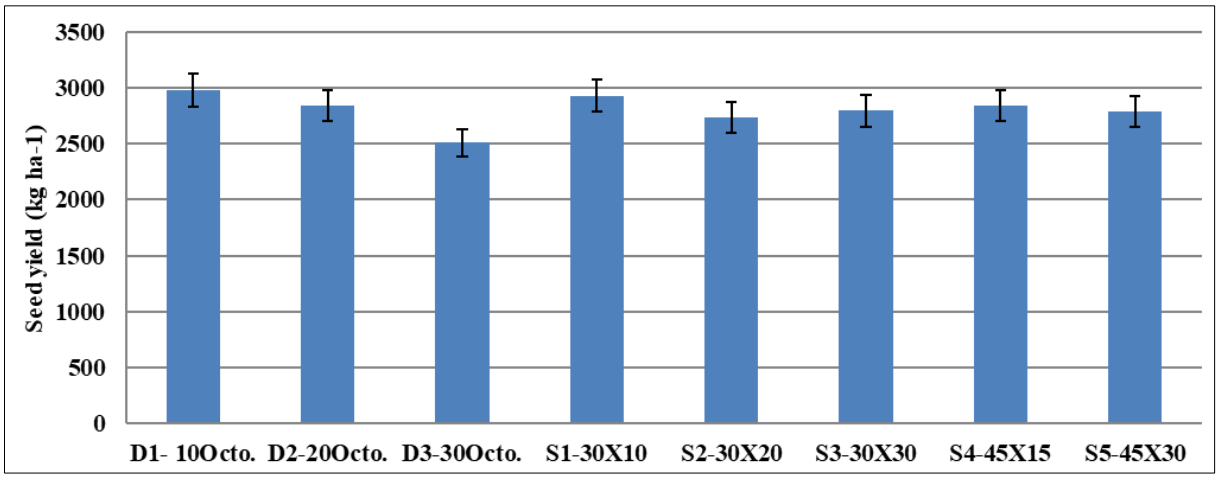

Fig 1: Seed yield (kg ha-1)

Table 3: Effect of sowing date and planting geometry on oil yield and economics and production efficiency of Indian mustard (Pooled data of 3 years)

Treatments	Oil content (%)	Oil yield (kg ha^{-1})	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio	Production efficiency (kg/ha/day)
Date of Sowing						
D_1- 10Octo.	39.97	1191	117490	88990	3.12	19.36
D_2-20Octo.	39.38	1127	112607	84107	2.95	18.94
D_3-30Octo.	39.25	984	98796	70296	2.46	17.17
Spacing(cm)						
S_1-30X10	39.42	1155	115447	86167	2.94	19.54
S_2-30X20	39.57	1081	107640	78360	2.67	18.21
S_3-30X30	39.19	1095	110081	80801	2.75	18.63
S_4-45X15	39.87	1132	111935	83905	2.99	18.94
S_5-45X30	39.60	1103	109729	81699	2.91	18.56

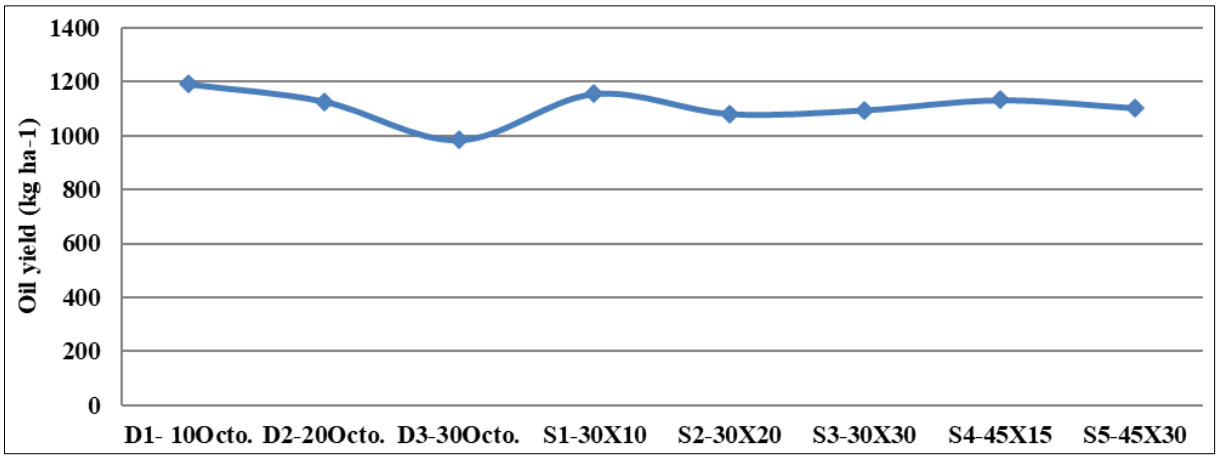

Fig 2: Oil yield (kg ha-1)

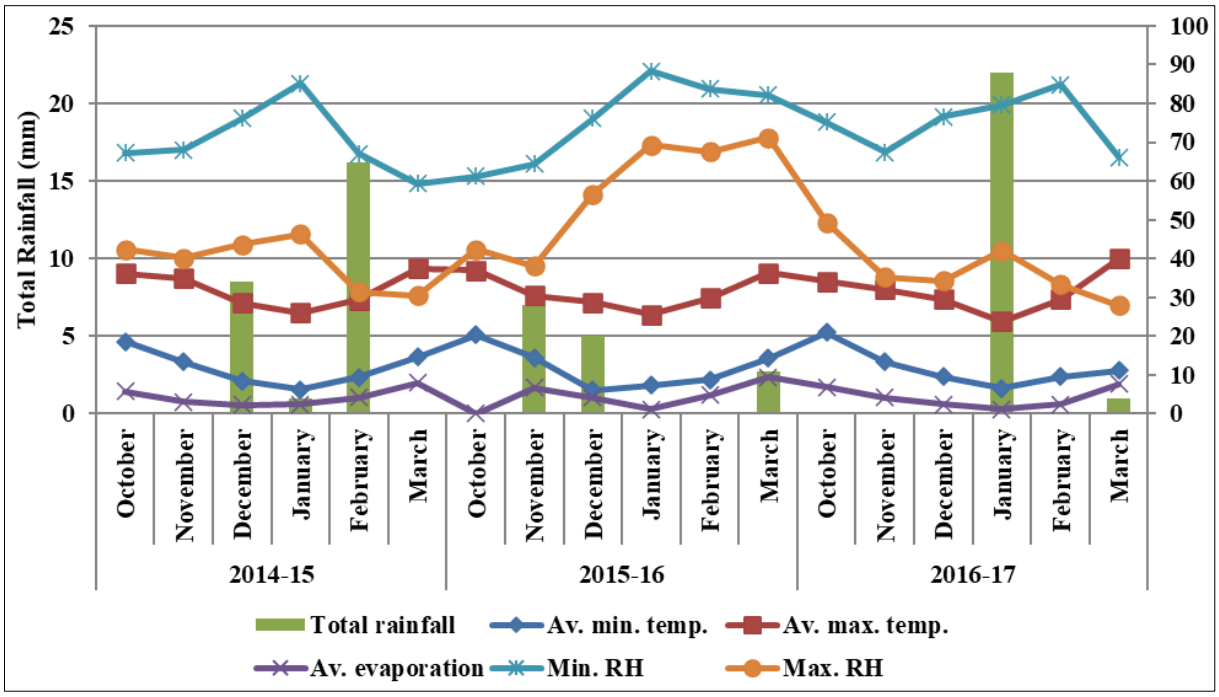

Fig 3: Av. Evaporation (mm)/ Av. Temperature (oC)/ Relative Humadity (%)

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