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Research Communication

Response of Indian mustard (*Brassica juncea*) to varying spacing and transplanting in north Gujarat region

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ABSTRACT

A field experiment was conducted at Castor Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat during the winter (*rabi*) season of 2020–21, to study the response of Indian mustard [*Brassica juncea* (L.) Czernj.] to different spacing and transplanting schedule in north Gujarat. The experiment was conducted in a split-plot design with 4 spacing in the main plots and 3 transplanting dates in the subplots, that were replicated 3 times. The maximum plant height at harvesting (189.18 cm) and crop-growth rate (11.69 g/plant/day) at 30–60 days after transplanting (DAT) were recorded with narrow spacing of 45 cm × 30 cm and higher dry-matter accumulation at 30 and 60 DAT (11.57 and 71.70 g/plant respectively) were recorded at 60 cm × 45 cm spacing. Indian mustard transplanted at 45 cm × 30 cm spacing recorded significantly higher seed yield (2,187.1 kg/ha), being statistically at par with spacing 45 cm × 45 cm spacing (2,070.4 kg/ha). In terms of seed yield, the crop transplanted on 10 November (2,142.7 kg/ha) outperformed the crop transplanted on 20 November (1,829.0 kg/ha), but it was statistically on a par with the crop transplanted on 31 October (1,996 kg/ha). The higher net returns (₹61,227/ha), production efficiency (19.59 kg/ha/day) and economic efficiency (₹548.5/ha/day) were registered at 45 cm × 30 cm spacing. Significantly higher net return realization (₹63,596/ha), production efficiency (19.13 kg/ha/day) and economic efficiency (₹567.8 /ha/day) were noted under 10 November transplanting.

Key words: Economic feasibility, Intensification, Indian mustard, Spacing, Transplanting

In the last 3 decades, the oilseeds sector has been one of the most active components of world agriculture, growing at a rate of 4.1%/year, outpacing the growth of agriculture and livestock products. The oilseeds account for 13% of the gross cropped area, 3% of the Gross National Product (GNP) and 10% value of all the agricultural commodities of the country (GoI, 2022). Productivity has improved significantly in India over the last ten years, from 1,185 kg/ha in 2008–09 to 1,511 kg/ha in 2018–19, and production has increased from 7.20 million tonnes in 2008–09 to 9.26 million tonnes in 2018–19 (GoI, 2019). After the United States, China, and Brazil, India became the world's fourth largest vegetable oil economy. Mustard (*Brassica* sp.) is one of the most widely grown oilseed crop and third most prominent source of vegetable oil in the world (Jat *et al*., 2018). Globally, vegetable oil has one of the highest shares (40%) of the production of all agricultural commodities. India is the largest importer of edible oils ($10.5 billion) in the world, followed by China and the USA. India's share of world edible vegetable oil imports is about 15% (FAO, 2019; Rathore *et al*., 2020). Thus, there is inevitable need to boost the oilseed production either through area expansion or productivity enhancement.

Indian mustard [*Brassica juncea* (L.) Czernj.] is a winter-season oilseed crop which thrives best in light to heavy loam soils in areas having 25 cm–40 cm rainfall. Among the several reasons responsible for low productivity of Indian mustard, non-adoption of good agronomic practices like optimum date of sowing and planting geometry are the most important. The plant population and date of sowing affect the yield to a greater extent. Due to the delayed cessation of the monsoon, farmers are forced to sow the crop late, resulting in low yields due to the negative influence of the monsoon on plant growth, flowering duration, seed production, and productivity (Bali *et al*., 2000). Transplanting the crop rather than normal drilling may be a costlier

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method of crop establishment; however, the labour requirement for sowing followed by thinning the crop, to remove extra plants, may be costlier. Hence, transplanted crop has the exact plant population with mathematical precision, and there is also some time benefit after harvest of the rainy (*kharif*) season crops. Through transplanting, the full potentiality of individual plants can be realized and yield more than drilling of seeds. The late sowing of Indian mustard cultivars results in yield losses and thus affects the supply-chain of the oil in the market. The forceful late-sowing conditions of the crop are mainly because of delayed harvesting of the *kharif* crops. In order to accommodate multiple cropping systems on scarcely available land, transplanting of seedlings rather than direct seeding of rapeseed-mustard shall be more advantageous.

A field experiment was conducted during the winter (*rabi*) season of 2020–21 at Castor Mustard Research Station, Sardarkrushinagar Dantiwada Agricultural University, (24°19' N, 72°19' E, 154.52 m above mean sea-level), Gujarat, India. The soil was loamy sand, with *p*H 7.4, low in available nitrogen (134.7 kg/ha) and organic carbon (0.28%), medium in available phosphorus (54.3 kg/ha) and medium in available potassium (272.3 kg/ha). The mean maximum temperature ranged between 22.9 and 38.2°C, while mean minimum temperature ranged from 6.7 to 25.0°C during the period of experiment. The experiment consisted of 12 treatment combinations, comprising 4 spacing, viz. S_1, 45 cm × 30 cm; S_2, 45 cm × 45 cm; S_3, 60 cm × 30 cm; and S_4, 60 cm × 45 cm in main plots, and 3 date of transplanting, viz. D_1, 31 October; D_2, 10 November; D_3, 20 November in subplots, was undertaken in split-plot design (SPD) with 3 replications. The seedlings of Indian mustard variety 'GDM 4' recommended for this region (Prajapati *et al*., 2017) were raised in plastic plug trays with 72 cups. The soil mixed well with vermicompost and cocopit. Seeds were sown in the tray 14-days prior to scheduled date of transplanting. After application of fertilizer, 14-day old seedlings were transplanted manually in the moist main field as per treatments. The crop was raised with adopting standard package of practices. The recommended dose of fertilizer for Indian mustard crop, i.e., 50: 50: 0: 40 kg/ha N.P.K.S, was applied. Full dose of phosphorus, sulphur and half dose of nitrogen fertilizers were applied basal in main field just before the transplanting in the form of urea, diammonium phosphate and elemental sulphur and the remaining nitrogen was applied at 25–30 days after transplanting (DAT). First irrigation was given before transplanting of the crop. Remaining irrigations were given as per requirement. Total 6 irrigations were given during the crop period. Observations on chlorophyll content index and dry-matter accumulation were recorded at 30 and 60 DAT. Chlorophyll content index was measured by chlorophyll content meter (CCM-200). The crop-growth rate and relative growth rate were worked out as per Watson (1958) and Williams (1946), respectively at 30–60 DAT.

Production efficiency was calculated as:

$$\text{Production efficiency (kg/ha/day)} = \frac{\text{Seed yield (kg/ha)}}{\text{Crop duration (days)}}$$

Economics like cost of cultivation and net returns were worked out by considering prevailing local market prices of inputs during the period of investigation. Net return was estimated by subtracting total cost of cultivation from gross return. Benefit: cost ratio (BCR) was worked out through dividing gross return by total cost of cultivation. Economic efficiency of crop was calculated as:

$$\text{Economic efficiency (₹/ha/day)} = \frac{\text{Net return (₹/ha)}}{\text{Crop duration (days)}}$$

The data recorded for various parameters were statistically analysed by a procedure appropriate to the design of experiment as described by Gomez and Gomez (1984). The significance of difference was tested by "F" test at 5% level. The critical difference was calculated when the differences among treatments were found significant under "F" test. In remaining cases, only standard error of mean was worked out.

Different spacing significantly influenced the crop growth, viz. plant height, dry-matter accumulation, relative growth rate (RGR), crop-growth rate (CGR) and chlorophyll content index (Table 1). Significantly higher plant height at 90 DAT and at harvesting (187.33 and 189.18, respectively) and CGR at 30–60 DAT (11.69 g/plant/day) were recorded at 45 cm × 30 cm spacing. Dry-matter accumulation was significantly higher at 60 cm × 45 cm spacing at both the stages and it remained statistically at par with 60 cm × 30 cm and 45 cm × 45 cm spacings. The RGR and chlorophyll content index were unaffected by different spacing. In the increased population in narrow crop geometry, plants probably tended to be taller for getting light, which may result in increased plant height. Pandey *et al*. (2015) and Singh *et al.* (2019) also reported higher plant height with narrow spacing under transplanted Indian mustard. Among the different spacing, 60 cm × 45 cm accumulated significantly more dry-matter than rest of spacings owing to better growth and development of the individual plants. Singh and Dixit (1989) and Chaudhary *et al.* (2016) also reported similar results.

Plant height, dry-matter, chlorophyll content index, CGR and RGR were statistically equal under different dates of transplanting. However, numerically higher plant height was observed with 10 November at 90 DAT (176.66 cm) and at harvesting (177.78 cm).

The results revealed that, different spacing did not have

Table 1. Effect of spacing and date of transplanting on growth parameters of Indian mustard

Treatment	Plant height (cm)		Dry-matter accumulation (g)		Chlorophyll content index		CGR at 30–60 DAT	RGR at 30–60 DAT
	90 DAT	At harvesting	30 DAT	60 DAT	30 DAT	60 DAT	(g/plant/day)	(g/g/day)
Spacing								
S_1, 45 cm × 30 cm	187.33	189.18	9.19	56.55	25.67	29.64	11.69	0.0606
S_2, 45 cm × 45cm	175.79	176.97	10.53	64.12	24.81	27.68	8.82	0.0603
S_3, 60 cm × 30 cm	173.80	175.22	10.35	63.62	26.72	28.48	9.86	0.0603
S_4, 60 cm × 45 cm	161.61	163.52	11.57	71.70	25.68	27.94	7.42	0.0613
SEm±	4.75	3.79	0.43	2.78	0.65	0.87	0.50	0.0020
CD (P=0.05)	16.43	13.12	1.47	9.61	NS	NS	1.74	NS
Date of transplanting								
D_1, 31 October	173.02	175.11	10.44	64.48	25.56	28.74	9.51	0.0607
D_2, 10 November	176.66	177.78	10.56	66.07	25.05	28.92	9.81	0.0612
D_3, 20 November	174.23	175.78	10.23	61.45	26.56	27.66	9.04	0.0600
SEm±	3.51	2.63	0.37	2.04	0.43	0.67	0.36	0.0014
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

CGR, Crop-growth rate; RGR, relative growth rate; DAT, days after transplanting

any significant influence in number of seeds/siliqua, length of siliqua and 1,000-seed weight. Transplanting of seedlings at 45 cm × 30 cm spacing resulted in significantly higher seed yield (2187.1 kg/ha) and it remained statistically at par with spacing 45 cm × 45 cm and 60 cm × 30 cm spacings (Table 2). Crop growth rate was higher in wider spacing system owing to more availability and utilization of under-and above-ground resources. The growth characters and yield attributes, viz. branches and siliquae/plant, were higher under wider spacing than the narrow spacing. The decrease in seed yield with crop geometry of 60 cm × 45 cm was mainly due to less plant population/unit area. On the other hand, crop geometries of 45 cm × 30 cm and 45 cm × 45 cm having higher plant population/unit area resulted in higher seed yield. Our results confirm the findings of and Singh *et al*. (2006); Sahar *et al*. (2012) and Singh *et al*. (2019).

Seed yield was significantly higher (2,142.7 kg/ha) under 10 November and it was remained statistically at par with 31 October transplanting (Table 2). These results indicated that, initial growth and development of Indian mustard were adversely affected due to high temperature under earlier transplanting date, so in early transplanting plants got a transplanting shock and took some days to recover, which resulted reduced yield. Raised temperature during later crop stage in delayed transplanting, led higher aphid and powdery-mildew incidence. The late sowing/transplanting usually causes a decline in growth, leaf area

Table 2. Effect of spacing and date of transplanting on yield attributes, yield and economics of Indian mustard

Treatment	Length of siliqua (cm)	Seeds/ siliqua	1,000-seed weight (g)	Seed yield (kg/ha)	Net return (₹/ha)	Benefit: cost ratio	Production efficiency (kg/ha/day)	Economic efficiency (₹/ha/day)
Spacing								
S_1, 45 cm × 30 cm	5.41	14.24	5.04	2,187.1	61,227	2.51	19.59	548.5
S_2, 45 cm × 45 cm	5.33	14.47	5.21	2,070.4	60,596	2.70	18.52	541.6
S_3, 60 cm × 30 cm	5.19	14.01	5.15	1,954.1	54,311	2.49	17.49	486.0
S_4, 60 cm × 45 cm	5.32	14.60	5.42	1,745.9	48,547	2.49	15.63	434.3
SEm±	0.13	0.31		78.93	3,670.1	0.10	0.71	33.08
CD (P=0.05)	NS	NS	NS	273.12	NS	NS	2.46	NS
Date of transplanting								
D_1, 31 October	5.39	14.39	5.23	1,996.5	56,797	2.59	17.67	502.6
D_2, 10 November	5.25	14.56	5.30	2,142.7	63,596	2.76	19.13	567.8
D_3, 20 November	5.30	14.04	5.10	1,829.0	48,117	2.30	16.63	437.4
SEm±	0.09	0.21	0.13	59.21	2,753.2	0.07	0.53	24.75
CD (P=0.05)	NS	NS	NS	177.51	8,254.0	0.22	1.60	74.21

Economics is non-significant because according to different spacing cost is different. In lower spacing like 45 cm × 30 cm plant/ha was also maximum. For that nuresery plug tray, coco pit, compost and labour charge were higher. So yield and income were higher still net return was non-significant.

and shortening of reproductive phase due to faster maturation (forced maturity) thus, reduction in seed yield. High temperatures and long days accelerated rapid maturity and lower seed yield (Mondal *et al*., 2011).

In the different spacing, the maximum net returns (₹61,227/ha) were obtained from spacing 45 cm × 30 cm, followed by 45 cm × 45 cm, 60 cm × 30 cm and 60 cm × 45 cm spacing respectively. Maximum benefit: cost (B: C) ratio of 2.70 was recorded with 45 cm × 45 cm spacing, followed by 45 cm × 30 cm spacing. Among the various dates of transplanting, the maximum net returns of ₹63,596/ha and B : C ratio 2.76 were obtained under 10 November, followed by 31 October transplanting.

Production (19.59 kg/ha/day) and economic (548.5/ha/day) efficiency were significantly higher at 45 cm × 30 cm spacing; however, production efficiency was on par with 45 cm × 45 cm and 60 cm × 30 cm spacings (Table 2). Indian mustard transplanted on 10 November registered significantly higher production (₹19.13 kg/ha/day) and economic (567.8/ha/day) efficiency.

Based on 1 year findings, it is concluded that 14 days old seedling of Indian mustard transplanted at spacing of 45 cm × 30 cm on 10 November gave higher seed yield and higher net returns under loamy sand soil of North Gujarat.

REFERENCES

Bali, A.S., Shah, M.H., and Hasan, B. 2000. Effect of plant density on brown sarson under different levels of nitrogen and phosphorus. *Indian Journal of Agronomy* **45**: 174–178.

Chaudhary, S., Shukla A., Bhushan, C. and Negi, M.S. 2016. Assessment of the system of root intensification in rapeseed–mustard (*Brassica* spp*). Indian Journal of Agronomy* **61**(1): 119–122.

FAO, 2019. Oilseeds and oilseed products. (In) *OECD-FAO Agricultural Outlook 2019–2028/FAO 2019,* Food and Agriculture Organization of the United Nation, Rome, Italy p. 47.

GoI, 2018–19. *Directorate of Economics and Statistics*, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi.

GoI, 2022. *Directorate of Oilseeds Development*, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi. Available at http://oilseeds.dac.gov.in/Introduction.aspx. > accessed on 8th February 2022.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research,* edn 2. John Wiley & Sons, Interscience Publication, New York, USA.

Jat, A.L., Rathore, B.S., Desai, A.G. and Shah, S.K. 2018. Production potential, water productivity and economic feasibility of Indian mustard (*Brassica juncea* L.) under deficit and adequate irrigation scheduling with hydrogel. *Indian Journal of Agricultural Sciences* **88**(2): 212–215.

Mondal M.R.I., Begum, F. and Saiyed, I.M. 2011. Effect of planting dates on seed and oil yield of rapeseed (*Brassica campestries* L.) genotype BCYS-03. SAARC *Journal of Agriculture* **9**(1): 85–93.

Pandey, N.M., Dubey, S.K. and Singh, G. 2015. Response of Indian mustard (*Brassica juncea*) genotypes under different planting geometry. *Current Advances in Agricultural Sciences* **7**(1): 79–81.

Prajapati, K.P., Patel, P.J., Patel J.R., Jat, A.L., Gangwar, G.P., Patel, B.K. and Desai, A.G. 2017. GDM 4: High yielding, high oil content and bold seeded variety of Indian mustard [*Brassica juncea* (L). Czern & Coss]. *Journal of Oilseeds Research* **34**(4): 191–194.

Rathore, S.S., Shekhawat, K., Babu, S. and Singh, V.K. 2020. Mitigating moisture stress in *Brassica juncea* through deficit irrigation scheduling and hydrogel in Ustocherpts soils of semi-arid India. *Heliyon 6* doi.org/10.1016/j.heliyon.2020.e05786.

Sahar, K., Delkhosh, B., Hossein, A., Rad, S. and Zandi, P. 2012. The effect of different rates of nitrogen and plant density on qualitative and quantitative traits of Indian mustard. *Advances in Environmental Biology* **6**(1): 145–152.

Singh, H.V., Choudhary, R.L., Meena, M.D., Dotaniya, M.L., Meena, M.K., Jat, R.S., Premi, O.P. and Rai, P.K. 2019. Productivity enhancement of Indian mustard (*Brassica juncea*) through innovative crop establishment technique. *Indian Journal of Agricultural Sciences* **89**(10): 1,669–1,673.

Singh, S.S. and Dixit, R.S. 1989. Response of mustard to various levels of irrigation and nitrogen. *Indian Journal of Agronomy* **34**(3): 307–311.

Singh, T., Dahiya, K.S. and Sindhu, M.S. 2006. Effects of genotype, seedling age and row spacing on performance of transplanted African mustard (*Brassica carinata*) under late-sown conditions. *Indian Journal of Agronomy* **51**(3): 221–224.

Watson, D.J. 1958. *Leaf Growth in Relation to Crop yield-the growth of leaves*. Milthorp, F.L. (ed.). Butterworths, London.

Williams, R.F. 1946. The physiology of plant growth with special relation reference to the concept of net assimilation rate. *Annals of Botany* **10**: 41–72.