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Effect of plant geometry on yield and economics of transplanted Indian mustard (*Brassica juncea* L.)

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Abstract
A field experimented was conducted at Research Farm, ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur during *rabi* season of 2016-17 to study the effect of plant geometry on yield and economics of transplanted Indian mustard. The results reveals that higher values of yield attributes and yield characters namely length of siliquae, number of seeds siliquae^{-1}, test weight, seed yield, stover yield, biological yield was exerted under row spacing of 60x30 cm of transplanted mustard. Economically, row spacing of 60x30 cm recorded higher gross returns, net returns and B: C ratio of transplanted mustard.

Keywords: Seed yield, siliquae, gross returns, mustard and economics

Introduction
India is one of the largest oilseeds producing country that covers one-fifth of the entire area under oilseed crops and also yields one-fifth of the total oilseed production in the world (Rajak *et al.*, 2011) [5]. Globally it is cultivated in estimated area, production and productivity of rapeseed-mustard is 36.52 m ha, 72.78 m t and 1,994 kg ha^{-1}, respectively (FAO, 2018). In India, among all the oilseed crops rapeseed-mustard occupying 7.20 million ha area and production of 8.0 million tonnes with average productivity of 11.13 q ha^{-1} (Ministry of Agriculture, 2017-18) [4]. The area, production and productivity of rapeseed-mustard in Rajasthan is 2183.04 thousand ha, 3401.12 thousand tonnes and 15.58 q ha^{-1}.

In order to increase the domestic production of oilseeds and make the country self-reliant in vegetable oils, the Government of India launched Technology Mission on Oilseeds (TMO) in May 1986 leading to the evolution of a Yellow Revolution, but after achieving this milestone in edible oil production, the momentum was lost after a few years owing to a number of reasons whatsoever and still, India shall need about 58 million tonnes of oilseed by the year 2020 for fulfilling their minimum nutritional requirement of 15.8 kg capita annum^{-1} from present level of 11.2 kg.

Rapeseed/mustard productivity is quite low in the country (1152 kg ha^{-1}) against the world average of 1400 kg ha^{-1} in world (Singh *et al.*, 2010) [8]. Of the several reasons, improper spacing is the most important one.

Establishment of optimum plant population by maintaining proper row spacing is one of the important factors to secure a better translocation of photosynthates, which render better yield of crop (Alam, 2004) [1]. Spacing is a non-monetary input, but it plays a vital role by changing the magnitude of competition. Among the agronomic factors known to augment the mustard production are spacing and plant geometry which plays a pivotal role in enhancing the production. Optimum row spacings are necessary for interception of sunlight to each strata of leaves. This will enhance the rate of photosynthesis and consequently, the dry matter production which can ultimately increase the crop yield. The plant density per unit area and the yield per plant are two most important and inter-dependent factors responsible for crop yield.

Transplanting of Indian mustard is gaining importance in present time due to higher yields and wider sowing window. Transplanting of Indian mustard rather than normal drilling perceived as costlier method of crop establishment, however, the labour requirement for sowing and then thinning the crop twice to remove extra plants in drilled crop may be more costlier. Transplanted crop have the exact plant population with mathematical precision, and there is also some time benefit after harvest of the *kharif* crops. Through transplanting, the full potentiality of individual plants can be realized and yield more than drilling of seeds.

However, information regarding plant geometry on yield and economics of transplanted Indian mustard in Rajasthan is lacking. Keeping in view the above discussed facts of sufficient information and sparce related research, the present investigation was undertaken to find out the effect of plant geometry on yield and economics of transplanted Indian mustard (*Brassica juncea* L.).

Materials and Methods

An experiment was conducted during *rabi* season of 2016-17 at Research Farm, ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur (situated at 27º15' N latitude and 77º03' E longitude with an altitude of 178.37 m above mean sea level). The soil was loamy sand in texture having a pH of 8.3 (Alkaline), EC 1.3 (dSm^{-1}), low in organic carbon (0.24%) and low available nitrogen (126.30 kg ha^{-1}), medium in available phosphorus (17.23 kg ha^{-1}) and low in available potassium (149.26 kg ha^{-1}). The experiment was conducted in randomized block design with replicate thrice consisted of four crop geometry treatments *viz.* 45x30 cm, 60x30 cm, 90x30 and 30x10 cm. The treatments were allocated randomly to each plot. Urea, di ammonium phosphate and murate of potash were used as a source of nitrogen, phosphorus and potassium. The crop was uniformly fertilized with 100 kg N, 60 kg P_2O_5 and 50 kg K_2O ha^{-1} giving a full dose of phosphorus and potassium as basal and nitrogen applied as basal as well as top dressing. The total rainfall experienced during the crop growth season was 55.8 mm in 2016-17. RH-406 variety of mustard was used as a test crop. Fifteen days old seedlings were transplanted on 13^{th} October and spacing maintained as per treatment. Other crop management methods were accompanied as per the recommendation of the area. The cost of different operations was calculated for different treatments on the basis of existing market prices of inputs and operations and the total cost was calculated by adding the expenditure involved in all kinds of operations as per treatment on per hectare basis in ₹ ha^{-1}. The gross returns were calculated by multiplying the total seed and stover yield with prevalent market prices of the items and then were presented on per hectare basis as per treatments. The net returns were computed by deducting the total cost of cultivation from the gross returns as per treatments. Benefit: Cost ratio was calculated by dividing net returns with the cost of cultivation for each treatment.

Statistical analysis and interpretation of data

Data recorded on relative composition of weeds in the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984) [3].

The levels of significance used in 'F' and 't' test was p= 0.05. Critical difference values were calculated where F test was found significant.

Results and Discussions

Crop geometry exerted significant effect on yield attributes, yield and economics of transplanted mustard. Significantly higher siliquae length (5.79 cm), number of seeds $siliquae^{-1}$ (18.98) and test weight (6.06 g) were recorded under spacing of 60x30 cm which was statistically at par with 45x30 and 90x30 cm spacing, respectively (Table 1). However least values of above characters was noted under spacing of 30x10 cm. This might be due to optimum plants population per unit area, the plant received better nutrients, moisture and space to produce more number of branches and number of siliquae with highest dry biomass production. Similar results were also reported by Singh and Verma (1993) [11]; Sahoo *et al*. (2000) [7].

Among the crop geometry/spacing, 60x30 cm recorded significantly higher seed yield (3574 kg ha^{-1}), stover yield (10210 kg ha^{-1}) and biological yield (13784 kg ha^{-1}) during experimentation. However, 60x30 cm was statistically at par rest of the treatments except for 30x10 cm spacing (Table 2). In case of harvest index, significantly higher value was noted under spacing of 90x30 cm which was statistically at par with 60x30 cm and 45x30 cm, respectively.

Increase in yield may be due to optimum plants population per unit area, plant received better nutrition and optimum space to produce more growth and yield contributing attributes like more number of branches and number of siliquae thereby produced higher yields. Similar results were also reported by Sahar *et al.* (2012) [6]; Singh *et al*. (2015) [9].

A perusal of data (Table 3) indicated that the higher gross returns (₹ 117949 ha^{-1}), net returns (₹ 91974 ha^{-1}) as well as B:C ratio of the magnitude 3.54 were recorded under spacing of 60x30 cm which was statistically at par with spacing of 90x30 cm over rest of the treatments during experimentation. However, least cost of cultivation was also observed under spacing of 90x30 cm. This might be because of higher seed and stover yields with less cost of cultivation as compared to other treatments which led to higher net returns. The above result is in agreement with the findings of Singh and Prasad (2003) [10].

Table 1: Siliquae length (cm), seeds $siliquae^{-1}$ and test weight (g) of transplanted mustard as influenced with crop geometry

Treatment	Siliquae length (cm)	Seeds $siliquae^{-1}$	Test weight (g)
45x30 cm	5.73	18.54	5.94
60x30 cm	5.79	18.98	6.06
90x30 cm	5.66	18.34	5.99
30x10 cm	3.55	11.49	3.75
S.Em±	0.10	0.28	0.14
C.D. at 5%	0.32	0.90	0.45
CV (%)	3.79	3.29	5.23

Table 2: Seed yield, stover yield, biological yield (kg ha^{-1}) and harvest index (%) of transplanted mustard as influenced with crop geometry

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
45x30 cm	3298	9464	12762	26.01
60x30 cm	3574	10210	13784	26.06
90x30 cm	3418	9400	12818	26.54
30x10 cm	2007	7641	9649	20.92
S.Em±	156	1660	490	1.35
CD at 5%	499	519	1568	1.35
CV (%)	10.16	11.31	8.00	4.31

Table 3: Relative economics (₹ ha^{-1}) of transplanted mustard as influenced with crop geometry

Treatment	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
45x30 cm	26175	108827	82652	3.16
60x30 cm	25975	117949	91974	3.54
90x30 cm	25775	112782	87007	3.38
30x10 cm	26375	66241	39866	1.51
S.Em±	-	16491	16491	0.64
C.D.at 5%	-	5155	5155	0.20
CV(%)	-	10.16	13.68	13.90

Conclusion

On the basis of one year experiment it may be concluded that row spacing of 60 x 30 cm spacing registered significantly higher values of yield attributes and yield along with higher gross returns, net returns and B:C ratio of transplanted mustard under the agro-climatic condition of Bharatpur (Raj.).

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