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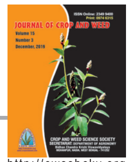

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Variation in yield and yield attributes of hybrid mustard (*Brassica juncea* M.) influenced by different spacing and fertilizer levels

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ABSTRACT

A field experiment was conducted in the new alluvial zone during rabi season of 2019-20 and 2020-21at District Seed Farm(22°93' N latitude, 88°53' E longitude and 9.75 m above mean sea level), Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal, India to study the effect of spacing and fertilizer levels on yield of hybrid mustard (Brassica juncea M.). Kesari gold variety was planted under split plot design at two different spacings (S_1: 30x10 cm; S_2: 45x10 cm) as main plot treatment and three fertilizer levels (F_1: NPK@80-50-50 kg ha^{-1}; F_2: NPK@100-60-60 kg ha^{-1}; F_3: NPK@120-70-70 kg ha^{-1}) as subplot treatment. Among the spacings, the highest seed yield (1948 kg ha^{-1} and 1887 kg ha^{-1}) was obtained with S_1. Highest seed yield (2018 kg ha^{-1} and 1937 kg ha^{-1}) was recorded in the plots fertilized with F_3 in both years of study. Interaction of spacing and fertilizer had a non-significant effect on seed yield. Increase in the number of branches per plant, number of siliqua per plant, number of seeds per siliqua and harvest index was recorded with S_2 and F_3. Highest oil content was found in wider spacing crops but less fertilised plots. Benefit cost ratio obtained under interaction of different spacing and fertilizer levels revealed that the highest profit was earned from the S_1F_2 plot.

Keywords: Fertilizer levels, hybrid mustard, oil content, seed yield, siliqua, spacing

Apart from cereals, oilseed crop is the second important foodgrains grown in India. Among the seven edible oilseed crops cultivated in India, rapeseed and mustard is a significant *rabi* oilseed crop. It belongs to genus *Brassica* of family *Cruciferae*. It is cultivated in diverse agro-climatic zones mostly in rainfed areas. Rapeseed and mustard occupy 6.4 million hectare of area in India resulted in 8.78 million tonnes of seed production. Rajasthan occupies first rank in production of rapeseed and mustard with 2.37 million hectare of area and 4.08 million tonnes of seed production followed by Haryana with 0.61million hectare of area and 1.25 million tonnes production and Uttar Pradesh with 0.75 million hectare of area and 1.12 million tonnes production (Anon., 2019).Indian mustard (*Brassica juncea* M.) is the main source of cooking oil in northern India among all other cultivated species and occupies about 80-85% of the total area under rapeseed and mustard cultivation.

Despite being one of the largest producers of oilseed at global level, India is heavily dependent on the import of edible oil to meet its requirement. This is mainly due to the demand-supply gap in edible oil. This gap needs to be bridged by increasing production and productivity of oilseed crops which can be done either through increasing the area under oilseed crop or through decreasing uncertainties in production. Uncertainties in production include erratic rainfall leading to moisture stress at different growth stages, higher temperature during crop establishment, cold spell, fog and intermittent rainfall during crop growth, farmers reluctance in using balanced fertilizer dose, adoption of proper plant protection measures to control insect pests, weeds and diseases which cause considerable loss in seed yield (Jha *et al*., 2012).

The best way to increase productivity is by improving fertilizer management, the right method and time of sowing, adoption of improved cultivars and proper disease management (Biswas *et al.*, 2016). Balanced application of fertilizer and optimum plant population are the key factors affecting seed yield. N, P, K and S are the key nutrients for growth and development of the mustard crop. Spacing in between plant rows regulates the uniform distribution of plants in the field. It has a direct impact on plant solar radiation absorption and has an indirect impact on water use efficiency and thus helps in proper utilization of natural resources (Lalitha and Chhabra, 2020). Higher plant population as a result of closer spacing helps in reduction of weed growth and lower plant population as a result

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of wider spacing makes higher availability of water and nutrients to individual plants that lead to higher production. Optimum doses of fertilizers should be applied at the right time with the proper method of application. Nitrogen is the most responsive nutrient to rapeseed-mustard. Now-a-days some improved varieties of mustard have been reported which respond up to 120 kg N ha^{-1} application (Kumar *et al.,* 2008). Split application of nitrogen with 50% as basal and 50% as top dressing after first irrigation gave better nitrogen use efficiency and higher seed yield (Gill *et al.,* 2018). Adequate phosphorus helps the mustard plant to partition of a major proportion of dry matter into seed.

MATERIALS AND METHODS

The experiment was carried out at District Seed Farm(22°93' N latitude, 88°53' E longitude and 9.75 m above mean sea level), AB block of Bidhan Chandra KrishiViswavidyalaya, Kalyani, Nadia,West Bengal, India during *rabi* season (November – February) of 2019-20 and 2020-21. Temperature during different months of cropping period in the experimental plot ranged from 8.87 °C to 29.7°C (November, 2019 to February, 2020) and 9.2°C to 30.6°C (November, 2020 to February, 2021) in both years of the study. Rainfall was scarce during the cropping months in both the years. Maximum amount of rainfall obtained during these months was 2.79 mm and 0.8 mm in 2019-20 and 2020-21, respectively. During the experimentation period, the maximum relative humidity ranged between 95.24% to 98.06% and 89.7% to 93.5% while minimum relative humidity varied from 57.34% to 67.38% and 44.4% to 61.5% during the experimentation period of 2019-20 and 2020-21, respectively. The experiments were carried out on a medium land, well-drained Gangetic alluvial soil (order: Inceptisol), which belonged to the class of clayey loam having medium fertility (NPK @ 184.5-26.63-182.3 kg ha^{-1}) and almost neutral(PH-7.3) in reaction.

The experiment was performed under split plot design with 2 main plots, 3 subplots and 4 replications. Total 24 plots were taken, each with dimension of 3m×4m (12 m^2). Under main plot treatment two spacings were considered i.e., spacing 30×10 cm (S_1) and 45×10 cm(S_2) and under sub-plot treatment 3 different fertilizer doses were considered i.e. F_1=NPK @ 80-50-50 kg ha^{-1}, F_2=NPK @ 100-60-60 kg ha^{-1} and F_3=NPK @ 120-70-70 kg ha^{-1}. Fertilizers were applied in the field in 2 split doses, first as basal application of NPK @ F_1: 60-30-30 kg ha^{-1} , F_2: 80-40-40 kg ha^{-1} and F_3: 100-50-50 kg ha^{-1}and second as top dressing (21 DAS) with application of NPK @ 20-20-20 kg ha^{-1} to each of 24 plots. Kesari Gold was the hybrid mustard variety opted for the study. Kesari Gold is an early maturing variety (105-115 days) with 85% germination purity, 97% physical purity and 95% genetic purity.

The crop was sown in mid-November (15 November) with spacing S_1 and S_2 under main plot and fertilizer doses F_1, F_2 and F_3 under sub-plot treatment. The seed rate used was 2.5 kg ha^{-1}. The fertilizers were applied, firstly, as basal dose and then top dressing was done at 21 DAS. Before top dressing, thinning was done to remove extra mustard seedling and to maintain plant spacing of 10 cm in the plots. On the day of top dressing, first irrigation was given for proper availability of nutrients to the crop. One hand weeding is sufficient to control weeds in the plot which was done in 30 DAS. At 80% pod maturity stage, the crop was harvested by using sickle leaves 10-12 cm from the crop base and then it was dried under sun in the field for 2-3 days.

Five plants were randomly selected from each plot and tagged. Different yield parameters like number of branches per plant, number of siliqua per plant were recorded at harvest. The mean of the five plants were represented as number of branches per plant and number of siliquas per plant. Siliqua length and number of seeds per siliqua is obtained by means of randomly five selected siliqua from tagged plants. Seed yield and stover yield were recorded from each plot (4m× 3m) and then converted into kg ha^{-1}. Test weight was obtained by weighing 1000 seeds from seed yield of each plot by using weighing balance. Harvest Index is the success in partitioning assimilated photosynthates (Asefa, 2019). Harvest index was calculated by using the following formula:

Harvest index = (Economic yield/Biological yield) × 100

The oil content (%) in seed was determined by using Soxhlet apparatus with hexane as an organic solvent according to A.O.A.C. (1995), and then oil yield was calculated.

Oil (%) = [weight of oil (g)/weight of samples (g)] × 100

RESULTS AND DISCUSSION

Number of branches per plant

Significantly higher number of branches per plant (5.6 and 5.5) were observed at wider plant spacing under S_2treatment in two subsequent years which was at par with the number of branches at closer spacing under treatment S_1 in 2019-20 but in 2020-21, it was followed by S_1. Pooled results also showed a higher number of branches per plant (5.5) at wider spacing which was statistically at par with S_1(Table 1). Highest number of branches (5.7 and 5.5) were observed with treatment F_3 which were statistically at par with treatment F_2 followed by treatment F_1 in the years 2019- 20 and 2020-21, respectively. Pooled data showed that the highest number of branches per plant (5.6) were recorded with treatment F_3 (NPK@120-70-70 kg ha^{-1}) which was statistically at par with treatment F_2but significantly higher over treatment F_1. Similar findings were also reported by Sondhiya *et al.* (2019) and Nautiyal *et al.* (2020).

Number of siliqua per plant

Number of siliqua per plant is an important attribute which governs the seed yield in mustard plants. From

Table 1: Effect of different spacing and fertilizer levels on number of branches per plant, number of siliqua per plant and number of seeds per siliqua in hybrid mustard during 2019-20 and 2020-21.

Treatment	Yield attributes of hybrid mustard								
	No. of branches per plant			No. of siliqua per plant			No. of seed per siliqua		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Spacing									
S_1	5.5	5.3	5.4	260	225.2	243	13.1	11.1	12.1
S_2	5.6	5.5	5.5	296	242.7	269	14.2	12.0	13.1
SEm(±)	0.05	0.04	0.04	3.35	4.90	2.41	0.19	0.28	0.16
CD(0.05)	**0.25**	**0.19**	**0.17**	**15.08**	**22.07**	**10.82**	**0.86**	**1.30**	**0.74**
Fertilizer									
F_1	5.4	5.2	5.3	258	212.5	235	11.9	10.7	11.3
F_2	5.6	5.5	5.5	281	238.7	259	14.1	11.8	12.9
F_3	5.7	5.5	5.6	296	250.6	273	14.9	12.1	13.5
SEm(±)	0.06	0.05	0.05	4.10	6.00	2.95	0.23	0.35	0.20
CD(0.05)	**0.21**	**0.16**	**0.15**	**12.65**	**18.51**	**9.08**	**0.72**	**1.09**	**0.62**
Spacing × Fertilizer									
S_1F_1	5.3	5.0	5.2	242	203	222	11.6	10.3	10.9
S_1F_2	5.5	5.3	5.4	265	228	247	13.4	11.3	12.4
S_1F_3	5.6	5.4	5.5	276	244.5	260	14.3	11.6	13.0
S_2F_1	5.5	5.3	5.4	276	222	249	12.2	11.2	11.7
S_2F_2	5.7	5.6	5.6	296	249.5	272	14.8	12.2	13.5
S_2F_3	5.8	5.6	5.6	316	256.7	286	15.5	12.5	14.0
SEm(±)	0.09	0.07	0.07	5.80	8.49	4.16	0.33	0.50	0.28
CD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

(S_1: 30×10 cm; S_2: 45×10 cm; F_1: NPK@80-50-50 kg ha^{-1}; F_2: NPK@100-60-60 kg ha^{-1}; F_3: NPK@120-70-70 kg ha^{-1})

Table 2: Effect of different spacing and fertilizer levels on seed yield, stover yield and harvest Index of hybrid mustard during 2019-20 & 2020-21

Treatment	Yield attributes of hybrid mustard								
	Seed yield(kg ha^{-1})			Stover yield(kg ha^{-1})			Harvest Index		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Spacing									
S1	1948	1887	1917	4134	3886	4010	32	32.6	32.3
S2	1781	1740	1761	3938	3709	3824	31	31.9	31.5
SEm(±)	36.50	24.92	26.52	57.40	48.09	35.33	0.42	0.23	0.29
CD(0.05)	**164.29**	**112.19**	**119.35**	**258.35**	**216.4**	**158.96**	**NS**	**NS**	**1.33**
Fertilizers									
F1	1650	1617	1634	3691	3564	3630	31	31.1	31.0
F2	1924	1886	1905	4207	3852	4029	31	32.8	32.1
F3	2018	1937	1978	4209	3973	4091	33	32.7	32.4
SEm(±)	44.7	30.53	32.4	70.30	58.89	43.26	0.51	0.29	0.36
CD(0.05)	**137.75**	**94.07**	**100.08**	**216.63**	**181.48**	**133.29**	**1.58**	**0.90**	**1.12**
Spacing × Fertilizers									
S1F1	1718	1656	1687	3650	3631	3640	32	31.3	31.6
S1F2	2001	1967	1984	4325	3929	4127	31	33.4	32.5
S1F3	2125	2038	2082	4427	4099	4263	33	33.2	32.8
S2F1	1583	1578	1580	3734	3507	3620	30	31.0	30.4
S2F2	1848	1805	1826	4088	3774	3931	31	32.4	31.1
S2F3	1911	1837	1874	3992	3847	3919	30	32.3	32.3
SEm(±)	63.23	43.17	45.93	99.42	83.29	61.17	0.72	0.41	0.51
CD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

(S_1: 30×10 cm; S_2: 45×10 cm; F_1: NPK@80-50-50 kg ha^{-1}; F_2: NPK@100-60-60 kg ha^{-1}; F_3: NPK@120-70-70 kg ha^{-1})

Economics of hybrid mustard production :

Treatment	Cost of cultivation (₹)		Grain yield (₹)		Stover yield (₹)		Gross return (₹)		Net return (₹)		B-C ratio	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
S_1F_1	45589	45589	72156	73278	7300	7262	79456	80540	33867	34951	**1.7**	**1.8**
S_1F_2	46392	46392	89250	90182	8650	7858	97900	98040	51508	51648	**2.1**	**2.1**
S_1F_3	47198	47198	84042	87040	8854	8198	92896	95238	45698	48040	**2.0**	**2.0**
S_2F_1	45333	45333	66486	69827	7468	7014	73954	76841	28621	31508	**1.6**	**1.7**
S_2F_2	46136	46136	77616	79871	8176	7548	85792	87419	39656	41283	**1.9**	**1.9**
S_2F_3	46942	46942	80262	81287	7984	7694	88246	88981	41304	42039	**1.9**	**1.9**

(S_1: 30×10 cm; S_2: 45×10 cm; F_1: NPK@80-50-50 kg ha^{-1}; F_2: NPK@100-60-60 kg ha^{-1}; F_3: NPK@120-70-70 kg ha^{-1})

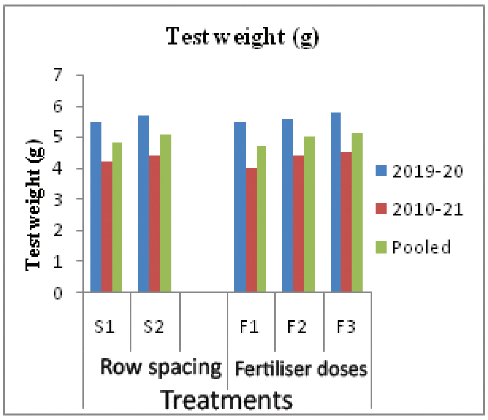
Table 1 we found that S_2 treatment resulted in a significantly higher number of siliqua per plant (296 and 242) in 2019-20 and 2020-21, respectively as compared to closer spacing (30×10 cm). Pooled results also showed a similar trend. Number of siliqua per plant was significantly affected by the amount of fertilizer applied. Highest number of siliqua per plant (296 and 250) was obtained with the application of NPK@120-70-70 kg ha^{-1} under F_3 treatment followed by treatment $F_2$and F_1in respective years. Pooled data also showed a similar result and the highest number of siliqua per plant were obtained under treatment F_3(NPK@120-70-70 kg ha^{-1}) followed by treatment F_2 and F_1. The above findings were also confirmed by Sondhiya *et al*. (2019) and Yadav and Dhanai (2020).

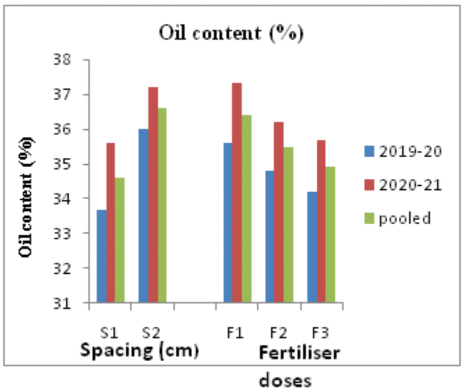
Number of seeds per siliqua

Seeds are principal attributes governing the economic yield of the mustard crop. In case of oilseed, the oil content is a quality parameter which is dependent on seed quality and seed yield. Number of seeds per siliqua significantly varies with different crop geometry. Highest number of seeds per siliqua (14.2 and 12) were obtained when mustard was sown at wider spacing (treatment S_2) during *rabi* season of 2019-20 and 2020-21, respectively. Pooled results also showed the same trend of response. Nutrients applied to the crop and numbers of seeds per siliqua were directly related. The range of number of seeds per siliqua at harvest under different subplot treatments varied between 11.9-14.9 and 10.7-12.1 in 2019-20 and 2020-21, respectively (Table 1). The highest number of seeds per siliqua (14.9 and 12.1) were obtained with F_3 followed by F_2 and F_1 treatment in the respective years. In the case of pooled data, the highest number of seeds per siliqua was obtained with F_3 followed by F_2 and F_1. Arif *et al.* (2012) and Saini *et al.* (2020) had also reported similar results.

Seed yield

Seed yield is the most important parameter which governs the selection and adoption of new agro-techniques of crop production. Seed yield is significantly affected by the crop geometry and responsiveness to different levels of fertilizer application. Lesser row spacing resulted in a higher number of plants per plot than in wider row spacing thus resulting in the higher seed yield. Seed yield obtained varies between 1781 kg ha^{-1}to 1948 kg ha^{-1} and 1740 kg ha^{-1}to 1887 kg ha^{-1}(Table 2) in both the years of experimentation. In case of pooled data, the highest seed yield was obtained under S_1 treatment and lowest yield was obtained with S_2 treatment. Higher seed yield was obtained during the first year of experimentation than in the second year. During the first year (2019-20), seed yield varied to the tune of 2018 kg ha^{-1}, 1924 kg ha^{-1} and 1650 kg ha^{-1} being highest with F_3 which was at par with F_2 treatment and followed by F_1 treatment. When pooled data was





analysed, it was observed that application of higher amount of fertilizers increased the growth as well as yield of the crop. These findings are in conformity with Sandhu *et al*. (2015) and Premi *et al.* (2013).

Stover yield

Highest stover yield (4134 kg ha^{-1}, 3886 kg ha^{-1} and 4010 kg ha^{-1}) was obtained with treatment S_1 followed by treatment S_2 in both the respective seasons and pooled value under consideration. Stover yield varied with the amount of nutrient applied to the crop. Nitrogen is the chief nutrient which contributes to the growth and development of the mustard plant. Highest stover yield was obtained with the application of the highest amount of fertilizer under F_3 which was at par with F_2 and followed by treatment F_1. Pooled analysed data of the respective years of experiment followed the same trend (Table 2). Similar findings were conformated by Sandhu *et al.* (2015).

Harvest Index

The proportion between grain yield and biological yield is noted as the harvest index. Harvest index indicates the partitioning of photosynthates from source (green vegetative parts) to sink (grain). Importance of row spacing on the harvest index was non-significant in the first year as well as in the 2nd year of the experiment but pooled analysed data of the harvest index significantly varied with the row spacing of mustard. Maximum harvest index (32.3) was obtained at closer row spacing than wider row spacing (Table 2). Harvest index significantly varied with the fertilizer doses. Harvest index was directly related with the seed yield and biological yield as like seed yield and stover yield increases with the increase in fertilizer doses, similar pattern of variation was found in case of harvest index. Maximum harvest index (33 and 32.7) was observed with the application of highest doses of fertilizer (F_3: NPK@120-70-70 kg ha^{-1}) in both years which was at par with F_2 in 2019-20 but significantly varied in 2020-21(Table 2). In case of pooled analysis, maximum harvest index (32.4) was obtained under treatment F_3 which was at par with F_2 followed by F_1. Richa *et al.*, (2019) and Yadav and Dhanai (2018) also reported similar results.

Test weight

The seed weight expresses the magnitude of seed development, which is a key yield determinant factor. Test weight comprises weight of 1000 seed in case of mustard. Crop sown either at wider spacing or closer spacing had non-significant effect on test weight. Application of NPK significantly increased the test weight of the mustard. Highest test weight (5.8 and 4.5) was observed under F_3 treatment (NPK@120-70-70 kg ha^{-1}) which was at par with F_2 treatment (NPK@100-60-60 kg ha^{-1}) followed by F_1 treatment (NPK@80-50-50 kg ha^{-1}). Test weight plays an important role for exhibiting the yield potential of the crop. Pooled analysis revealed the similar result and maximum test weight (5.1) was found under F_3 treatment which was at par with F_2 treatment followed by F_1(Fig 1.a). Similar findings were also reported earlier by Rathi *et al*. (2019) and Saini *et al*. (2020).

Oil content

Oil content is an important parameter governing the quality of the yield. Significant variation was observed in the oil content of mustard seed under different spacings between the rows. Higher oil content was recorded from the crops planted in the second year than in the first year. Maximum oil content (36% and 37.2%) was observed in seeds obtained under treatment S_2 followed by treatment S_1 with oil content 33.7% and 35.6% in both years. Amount of fertilizer applied to the crop and oil content was inversely related. As we increase the amount of nitrogen fertilizer, oil content decreases. Maximum oil content (35.6% and 37.3%) was observed with the application of lowest amount of fertilizer (NPK@80-50-50 kg ha^{-1}) which was at par with the oil content (34.8% and 36.2%) obtained with F_2 followed by F_3 (NPK@120- 70-70 kg ha^{-1}) at which lowest oil content was observed (Fig. 1b). Pooled data also showed similar results. Oil content varied to the tune of 36.4%, 35.5% and 34.9% at different treatments F_1, F_2 and F_3 respectively. Oil content may go up to 41% in Southern Bengal condition (Das *et al.,* 2019). Similar results were also reported in the findings of Sondhiya *et al*. (2019) and Sandhu *et al*. (2015).

CONCLUSION

From the findings of two-year study it can be concluded that better performance in yield (1917 kg ha^{-1} and 1905 kg ha^{-1}) was seen in crops sown at closer spacing (S_1= 30 cm×10 cm) and plot treated with maximum fertiliser dose (F_3: NPK@120-70-70 kg ha^{-1}). Although from an economic point of view, we can say that the highest benefit-cost ratio (2.1) was obtained under treatment S_1F_2[mustard planted at closer spacing (30×10 cm) in medium fertilised plots (NPK@100-60-60 kg ha^{-1})].

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REFERENCES

Anonymous, 2019. Agricultural Statistics at a Glance. Agricultural Statistics Division, Department of Agriculture and Cooperation and Farmers Welfare, Ministry of Agriculture, GOI, New Delhi.

AOAC, 1995 Official Methods of Analysis. 16th Edition, Association of Official Analytical Chemists, Washington DC.

Arif, M., Shehzad, M. A. and Mushtaq, S. 2012. Inter and intra row spacing effects on growth, seed yield and oil contents of white mustard (*Sinapis alba* L.) under rainfed conditions. *Pakistan J. Agri. Sci.,* **49**: 21-25.

Asefa, G. 2019. The role of Harvest Index in improving crop productivity. *J. Nat. Sci. Res.*, **9**:24-28.

Das, A., Ray, M., Murmu, K. and Dey, S. 2019. Growth, yield and quality of hybrid mustard as affected by crop geometry and varieties. *J. Pharm. Phyto.*, **8**: 2388-2393.

Gill, S. C., Sharma, R. K, Tripathi, S. C., Chhokar, R. S., Meena, R.P. and Jha, A. 2018.Nitrogen top dressing just before irrigation improves wheat productivity and nitrogen use efficiency and profitability. *J. Cer. Res.,* **11**:17-22.

Jha, G. K., Pal, S., Mathur, V. C., Bisaria, G., Anbukkani, P., Burman, R.R., and Dubey, S.K. 2012. *Edible oilseeds supply and demand scenario in India: Implications for policy*. Division of Agricultural Economics, Indian Agricultural Research Institute.

Kumar, A., Premi, O.P. and Thomas, L. 2008. Rapeseed-Mustard cultivation in India-An Overview. *National Research Centre on Rapeseed-Mustard*.

Lalitha, M. and Chhabra, V. 2020. Response of oilseed crops to planting methods and spacing. *J. Agri. Res. Life Sci.*, **1**: 172-175.

Nautiyal, A.,Barthwal, A. and Saxena, A.K. 2020.Growth and yield attributes of mustard (*Brassica juncea* L.), var. Pant Brassica-21 scheduled on irrigation level and row spacing. *J. Phar. Phytochem.*, **9**:300-303.

Premi, O. P., Kandpal, B. K., Rathore, S. S., Shekhawat, K. and Chauhan, J. S. 2013. Green manuring residue recycling and fertilizer application affects productivity and sustainability of Indian mustard (*Brassica juncea* L.) in Indian semi-arid tropics. *Industrial Crops Prod.,* **41**:423-429.

Rathi, N., Singh, B., Hooda V.S., Harender and Mohsin M. 2019. Impact of different doses of fertilizer and crop geometry on growth, seed and oil quality, consumptive water use, water use efficiency and soil moisture extraction in late sown Indian mustard (*Brassica juncea*L.) crop. *Int. J. Plant Soil Sci.*, **27**:1-7.

Saini, L. B., Kakraliya, M. and Kumar, P. 2020. Effect of different levels of NPK and sulphur on growth and yield attributes of rapeseed (*Brassica campestris* var. Toria). *Int. J. Curr. Micro. App. Sci.*, **9**:1805-1811.

Sandhu, P.S., Mahal, S.S. and Sardana, V. 2015. Performance of promising hybrids of Indian mustard (*Brassica juncea* L. Czern&Coss) under varying levels of nitrogen and row spacing. *J. Crop and Weed*, **11**:204-207.

Sondhiya, R., Pandey, R. and Namdeo, K.N. 2019. Effect of plant spacings on growth, yield and quality of mustard (*Brassica juncea* L.) genotypes. *Ann. Plant and Soil Res.,* **22**:172-176.

Yadav, M.S. and Dhanai, C.S. 2018. Effects of fertilizers on yield and yield attributing characters of mustard *(Brassica juncea* L. Czern&Coss). *J. Pharma. Phytochem.,***7**:2300-2303.