Original Research Article

"AGRONOMIC EVALUATION OF MUSTARD (*Brassica juncea* L.) HYBRIDS UNDER AGRO-CLIMATIC CONDITIONS OF PRAYAGRAJ(U.P)"

Abstract

Field experimentation was conducted during Rabi 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The hybrids were sown. The research was laid out in Randomized Block Design with ten treatments each replicated three times. In that study the experiment recorded significant effect in M8 for Plant height (173.97), Plant dry weight (38.97), Number of secondary branches /plant (18.87), Number of siliqua/plant (475.27), Number of seeds/siliqua (13.64), Seed Yield (2507.54), Stover Yield (3686.24), Test weight (5.80), Seed size (2.75). However, Number of primary branches/plant (8.1) in M5, length of siliqua /plant (5.65 cm) in M6. Crop Growth Rate (22.08) in M7, Relative Growth Rate (0.17) in M-7, Days taken for 50% flowering in M2 (32.78) and Harvest Index (42.17) in M9 were observed.

At the same time higher gross returns (Rs162990.1/ha), net return (Rs113677.1/ha) and benefit cost ratio (2.305) was obtained in M8 hybrid.

Key Words:, *Agronomic evaluation, Economics, Growth, Yield, Mustard, Hybrids*

Comment [U1]: Keywords (bolden)

1. INTRODUCTION

Mustard (*Brassica spp.*) is the third important oilseed crop in the world after soybean and groundnut, respectively. In India, mustard is the second important edible oil seed after groundnut. Rapeseed and mustard are the major oilseed crops. It is traditionally grown everywhere in the country due to its high adaptability in

conventional farming systems. The oil obtained is the main cooking medium in northern India cannot be easily replaced by any other edible oil. The oilcake is mostly used as a cattle feed. The leaves of young plants are used as a green vegetable. The use of mustard oil for industrial purposes is rather limited on account of its high cost.

Mustard has primary center of its origin in central Asia with secondary centers in central and western China, Eastern India, Burma and through Iran to near East cultivated for centuries in many parts of Eurasia. However, the principle growing countries are Bangladesh, Central Africa, China, India, Japan, Nepal, and Pakistan as well as Southern Russia in north of the Caspian Sea (Kumar *et al*., 2016). Plant based edible oils are indispensable in the human diet and also an important ingredient of several industrial uses. Under the name's rapeseed and mustard, several oilseeds are belonging to the *cruciferae* are grown in India. They are generally divided into four groups: Brown mustard, Sarson, Toria and Taramira. In trade sarson, toria and taramira are known as rapeseed, and rai as mustard. India is among the largest vegetable oil economies in the world next only to USA, China and Brazil. *Brassica juncea* L. originally introduced from China into northeast India, from it has extended into Afghanistan via the Punjab. Eastern Afghanistan, together with the adjoining northwestern India, is one of the independent centers of origin of Brown sarson (*Brassica compestris* var. brown sarson). In India, the Brassica crops occupy the second largest position after groundnut, with 3.5 million hectares, production about 2 million tonnes of seed annually The oilseed sector constitutes an important determinant of agricultural economy in the country. The increasing population couples with rise in income led to higher demand of edible oils. Rapeseed-mustard after China and Canada, accounting for 16% of the global production. Quality breeding of rapeseed has been oriented largely by nutritional concerns of consumers and food industries.

Most mustard was prepared in the early days by pounding the seeds in a mortar and moistening them with vinegar. Today there are countless mustard varieties available throughout the world, each reflecting local, regional and national cuisine. Three types of mustard seeds are popularly used as condiments: pale yellow or white (*Brassica alba*), brown or oriental mustard (*Brassica junciea*) and black or dark brown mustard (*Brassica nigra*). A part from their use as spice mustards are widely used as green vegetables as a salad crop, as an important oil

seed crop (particularly in India where rape seed mustard is the largest vegetable oil next to groundnut), green manure or as fodder crop and for industrial oil purposes.

The production of rapeseed in India is around 16.2 million tones which accounts for about 18 per cent of the total oil seed production of the country. Indian mustard, brown and yellow Sarson, raya and toria crops are included in mustard rapeseed groups. These are grown mainly in Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana and Gujarat and in some areas of south like Andhra Pradesh, Karnataka and Tamil Nadu. Yellow Sarson is considered as *Rabi* crop in Assam, Bihar, Orissa and West Bengal whereas in Punjab, Haryana, Uttar Pradesh and Himachal Pradesh it is a catch crop. Earlier Brown Sarson was cultivated in most of the areas but now its area under cultivation is getting decreased and replaced by Indian Mustard. Brown Sarson has two ecotypes Lotni and Toria. Toria is short duration crop sown under irrigated condition.

Growing rapeseed-mustard as a second crop in rice-based system could bring an additional net income of Rs. 23,127/- per hectare per annum following standard package of practice (Singh *et al.,* 2010). Mustard is grown in sub-tropical climate it thrives well in dry n cool climate therefore mustard mostly grown as *rabi* season crop. It is grown in the areas receiving 625 – 1000mm yearly rainfall. This crop does not tolerate frost, so it requires clear sky with free frost conditions. It can be grown in wide varieties of soil that ranges from light to heavy loamy soils. Medium to deep soils with good drainage is best suitable for mustard cultivation. Soil ideal pH range for mustard is 6.0 to 7.5.

Despite the high quality of oil and meal and also its wide adaptability for varied agro- climatic conditions, the area, production and yield of rapeseed –mustard in India have been fluctuating due to various biotic and abiotic stresses coupled with India's domestic price support programme. Nevertheless, the crop has potential to ensure nutritional security and contribute to livelihood security. In Uttar Pradesh rapeseed and mustard is one of the major grown crop occupying 0.56 million ha of area with production and productivity of 0.699 million tonnes and 1,248 kg/ha, respectively. The seed and oil of mustard have a peculiar pungency due to presence of glucosinolate and its hydrolysis products such as Allyl Isothiocynate (0.30-0.35%). The productivity of the crop in the state (1,066 kg/ha) is quite

lower than developed countries mainly due to cultivation of age- old varieties having low yield potential (De *et al.*, 2014, Directorate of agriculture, 2014-15).

Keeping this points in view, the present investigation entitled **““Evaluation of mustard (*Brassica juncea* L.) Hybrids under climatic condition of Prayagraj’’** was conducted at Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during *rabi* season of 2020.

Comment [U2]: The objective of this study is.....

Objectives

1. To study the growth and yield of mustard varieties.
2. To evaluate the economics of different mustard varieties.

Comment [U3]:

2. MATERIALS AND METHODS

The experiment was carried out during rabi season of 2021 at he CRF (Crop Research farm), Department of Agronomy, Sam Higginbottom University of Agriculture Technology and Sciences Prayagraj (U.P.) . The Crop Research Farm is Situated at 25.75 0 N latitude, 87.19 E longitude at an altitude of 98 meter above mean sea level. This area is situated on the Right Side of the River Yamuna and by the Opposite side of Prayagraj City.

Comment [U4]: Recast the ordinates

All the facilities Required for crop cultivation were available. The experimental plot was Sandy loam in Texture, nearly Neutral in Soil reaction (pH) 7.1. low in organic carbon (0.112%), Available N –173.4 (kg/ha)available P 10.8 kg /ha and available K 206.4kg/Ha The Crop was sown on November 4th 2021using Hybrids .The experiment was laid out in Randomized Block Design comprised of 3 replications and total 10 treatments viz. T1 (M1), T2 (M2), T3 (M3),T4 (M4),T5(M5), T6 (M6), T7 (M7), T8 (M8) , T9 (M9) and T10 (M10)All nutrients were applied into the soil in the form of Urea, Single super phosphate (SSP) and Muriate of potash (MOP).The recommended Dose of Fertilizer is 80:40:40 Entire dose of P and K was applied basal for respective plots, half dose of N (as urea) was applied as basal, one-fourth at 30 days after sowing and remaining one-fourth at the time of flowering. The growth parameters were recorded at periodical intervals of 20,40,60,80,100 DAS and at harvest stagefrom the randomly selected five plants in each treatment. Statistically analysis was done using. (for example SPSS) for all the parameters in one-way Anova and means were compared at 5% probability level of significant results.

3.RESULTS AND DISCUSSION

The findings of the present experiment entitled, "Agronomic Evaluation of Mustard (*Brassica juncea* L.) Hybrids Under Agro-climatic Conditions of Prayagraj (U.P.)", are being presented and discussed in the following pages under appropriate headings. Data on pre-harvest and post-harvest observations were analyzed and discussion on experimental findings in the light of scientific reasoning has been stated.

Pre-harvest observations

3.1 Plant height (cm) of different hybrids mustard

The plant height of mustard was recorded at 20, 40, 60 80 and 100 days after sowing (DAS).

At 20 DAS, significantly higher maximum plant height was recorded in hybrid M3 (22.23 cm).

At 40 DAS, significantly higher maximum plant height was recorded in hybrid M9 (54.12 cm) which was found to be statistically at par with hybrid M10 (51.77), M8 (51.77), M5 (51.37) and M6 (50.23 cm).

At 60 DAS, significantly taller plant height was recorded in hybrids M6 (119.53 cm), which was found to be statistically at par with hybrid M8(117.97 cm).

At 80 DAS, significantly maximum plant height was recorded in hybrid M8 (150.23 cm) which was found to be statistically at par with hybrid M6 (148.83 cm) and M10 (146.78 cm).

At 100 DAS, maximum plant height was recorded in hybrid M8 (173.97 cm) which was found to be statistically at par with hybrid M10 (170.97 cm).

Comment [U5]: This could be better presented in tabular form.

The hybrid M8 attained maximum plant height at all the stages of crop growth and tallest plant of hybrid M8 followed by M10 was mainly due to the varietal characteristics. The above findings are supported by **Kumari** *et al*., 2009.

3.2 Number of branches per plants

The number of branches/plants recorded at maturity. The data shows that there was a significant effect of different hybrids on the number of branches/plant.

Primary Branches

Among variety, M5 (8.10/plant) produced the significantly highest number of primary branches per plant.

Secondary Branches

Whereas the highest number of secondary branches (18.87/plant) in hybrid M8 which was found to be statistically at par with hybrid M3 (18.57/plant)

The higher number primary and secondary of branches during maturity was primarily because of higher LAI which increases the total energy available for formation of branches there by higher dry matter accumulation. These findings are supported by **Singh** 1989 and **Raquiballah** *et al*., 2006

Comment [U6]: Reorganize the paragraph

3.3 Days taken to 50% flowering

The significantly lower fifty percent of flowering was achieved (32.78 DAS) by the hybrid M-2 which was statistically at par with M4 (34.98 DAS), M3 (35.34 DAS) and M7 (35.54 DAS), M9 (35.58 DAS) and M1 (36.56 DAS).

Different varieties of mustard had significant influence on flowering characters at productive part flowering development stages which might be due to different crop growth maturity pattern in complete life cycle growth period. These findings are supported by **Kumar** *et al.*, 2017.

3.4 Dry weight of mustard hybrids

The dry weight of mustard was recorded at 20, 40, 60, 80 and 100 days after sowing (DAS).

At 20 DAS, maximum dry matter was recorded in hybrid M-6 (0.38 g/plant) and minimum was recorded in M3 (0.15 g/plant).

At 40 DAS, significantly maximum dry matter was recorded in M5 (8.93 g/plant) which was found to be statistically at par with hybrid M4 (8.04 g/plant) and M10 (7.87 g/plant).

At 60 DAS, significantly maximum dry matter was recorded in hybrid M-8 (29.57 g/plant) which was found to be statistically at par with hybrid M4 (28.33 g/plant).

At 80 DAS, significantly maximum dry matter was recorded in hybrid M-8 (35.67 g/plant) which was found to be statistically at par with hybrid M10 (35.33 g/plant).

At 100 DAS, significantly maximum dry matter was recorded in hybrid M-8 (38.97 g/plant) which was found to be statistically at par with hybrid M-4 (37.30 g/plant) and M2 (36.49 g/plant).

At maturity total dry matter per plant was significant which may be due to the longer duration of crop growth and higher LAI during later stages of its growth which was true indicative of photosynthates production

Comment [U7]: Reorganize the paragraph

3.5 Crop growth rate (g/m^2/day) of mustard hybrids

Crop growth rate (g/m^2/day) was recorded periodically recorded at 20-40, 40-60 60-80 and 80- 100 DAS. There was consistent increase crop growth rate up to maturity (Table 1).

At 0-20 DAS, higher crop growth rate was recorded in hybrid M-6 (0.87 g/m^2/day) and lower was recorded in hybrid M-4 (0.27

g/m^2/day).

At 20-40 DAS, higher crop growth rate was recorded in hybrid M-4 (8.84 g/m^2/day) and lower was recorded in hybrid M-2 (4.09 g/m^2/day).

At 40-60 DAS, significantly maximum crop growth rate was recorded in hybrid M-7 (22.08 g/m^2/day) which was found to be statistically at par with M-8 (21.84 g/m^2/day), M4 (21.34 g/m^2/day) and M-9 (21.25 g/m^2/day).

At 60-80 DAS, significantly maximum crop growth rate was recorded in hybrid M-8 (9.74 g/m^2/day) which was found to be statistically at par with M-1 (9.44 g/m^2/day), M-7 (9.15 g/m^2/day) and M-3 (8.93 g/m^2/day).

At 80-100 DAS, significantly maximum crop growth rate was recorded in hybrid M-8 (2.26 g/m^2/day) which was found to be statistically at par with M-5 (2.33 g/m^2/day), and M-1 (2.04 g/m^2/day).

At maturity the crop growth rate was higher in hybrid UMR-5 followed by hybrid UMR-4 which was due to higher dry matter production at respective stages of crop growth due to difference in dry matter accumulation. The physiological growth parameters like CGR and RGR differ significantly. These findings are supported by **Singh** 1989 and **Raquibullah** *et.al* 2006.

Comment [U8]: Tabulate your results

3.6 Relative growth rate (g/g/day) of mustard hybrids

Relative growth rate (g/g/day) was recorded periodically recorded at 20-40, 40-60, 60-80 DAS and 80-100 DAS. There was consistent decrease relative growth rate (g/g/day) up to maturity (Table. 2).

At 20-40 DAS, highest relative growth rate was recorded in variety M-7 (0.17 g/g/day) and lowest was recorded in variety M-5 (0.12 g/g/day)

At 40-60 DAS, highest relative growth rate was recorded in hybrid M-8 (0.16 g/g/day) and lowest with hybrid M-4, M-6 and M-10 (0.06 g/g/day).

At 60-80 DAS, highest relative growth rate was recorded in hybrid M-7 (0.012 g/g/day) and lowest with hybrid M-8 (0.009 g/g/day).

At 80-100 DAS, highest relative growth rate was recorded in hybrid M-1 (0.02 g/g/day)

Comment [U9]: ?

Post-harvest observations

3.7 Number of siliqua/plant

The number of siliqua/plant of mustard maximum number of siliqua/plant was recorded significantly higher in hybrid M-8 (475.27/plant). The number of siliqua/ plant were highest due to higher dry matter production.

3.8 Length of siliqua

The length of the siliqua of was recorded significantly higher in hybrid M-6 (5.65 cm).

3.9 Number of grains/siliqua

The number of seeds/siliqua of mustard was significantly maximum in hybrid M 8 (13.64) which was found to be statistically at par with hybrid M-10 (13.40), M 5 (13.23), M2 (12.93) and M-6 (12.87).

Larger the siliqua more the grains per siliqua and higher test weight were recorded in main shoot followed by primary and secondary branches.

3.10 Test weight

The maximum test weight of mustard was recorded in hybrid M-8 (5.80 g) which was found to be statistically at par with hybrid M-9 (5.67 g), M-2 (5.53), M3 (5.20 g) and M-5 (5.06 g).

The highest test weight was recorded in hybrid which was primarily due to higher number of branches and siliqua per plant.

3.11 Seed size

The hybrid M-8 recorded significantly higher seed size of mustard grain (2.75 mm) which was found to be statistically at par with hybrid M-4 (2.65 mm).

The varietal differences of yield attributes has also been reported by **Prakash** *et al*.,2000, **Roy** *et al*., 2005, **Singh** *et al*., 2006 and **Razzaque** *et al*., 2007.

3.12 Seed yield

The maximum seed yield of mustard was recorded in hybrid M-8 (2507.54 kg/ha) which was statistically at par with M9 (2480.67 kg/ha) and M 1 (2356.67 kg/ha).

The hybrid URM-1 recorded significantly highest seed yield this might be due to higher number of branches, siliqua, and highest seed weight per plant. The varietal differences in seed yield have also been reported by **Singh** *et al*., 2001, **Raquibullah** *et al*., 2006, **Razzaque** *et al*., 2007 and **Dehghani** *et al*., 2008.

3.13 Stover yield

The significantly maximum stover yield of mustard was recorded in hybrid M-8 (3687.24 kg/ha) which was statistically at par with M 4 (3516.20 kg/ha) and M 6 (3496.67 kg/ha).

The stover yield was highest due to higher dry matter accumulation in that hybrid.

3.14 Harvest index

The maximum harvest index of mustard was recorded in hybrid M-9 (42.17 %) which was statistically at par with M 8 (40.48 %), M1 (40.10 %), M3 (39.46 %) and M2 (39.24 %).

C. Economics of mustard hybrids

3.15 Cost of cultivation (INR/ha)

The cost of cultivation of hybrid rice is presented in the table 3 Cost of cultivation (Rs 49313.00/ha) was calculated taking into consideration all the cost incurred during cultivation.

3.16 Gross Returns (INR /ha)

The gross return of hybrid rice has been presented in table 3. Maximum gross return (Rs 162990.00/ha) was obtained from treatment M 8. Lowest was recorded in M 7 (Rs 122893.6 /ha).

3.17 Net Returns (INR /ha)

The net return of hybrid rice has been presented in table 3 The treatment M-8 recorded the highest net return (Rs 113677.10 /ha) lowest in M7 (Rs 73580.55)

3.18 Benefit Cost Ratio

Maximum benefit cost ratio of 2.30 was recorded in the treatment M-8 because of higher net return and lowest in M6 (Rs 1.51). This result

is supported by **Fayez *et al*. (2015).**

S.No.	ybrids	Plant Height (cm)	Number of primary branches/plant	Number of secondary branches/plant	CGR (g/m^2 /day)	RGR (g/g /day)	Days taken to 50% flowering	Dry Weight (g/Plant)
1	-1	130.37	5.0	14.17	17.22	0.07	36.56	35.27
2	-2	145.97	5.4	15.23	19.26	0.09	32.78	36.49
3	-3	142.73	4.9	18.57	20.74	0.08	35.34	35.33
4	-4	128.23	5.0	13.33	21.34	0.06	34.98	37.30
5	-5	135.33	8.1	13.33	20.75	0.09	39.64	34.33
6	-6	157.23	4.9	14.77	16.81	0.06	42.72	33.83
7	-7	149.29	5.4	16.77	22.08	0.07	35.54	32.37
8	-8	173.97	5.3	18.87	21.84	0.16	47.01	38.97
9		154	6.87	14.17	21.25	0.08	35.	33.

		-9	.37					58	97	
				170	5.4	15.23	18.26	0.06	41.	35.
	10	-10	.97					37	77	
	F test			S	S	S	S	NS	S	S
				2.	0.4	0.69	0.36	0.01	1.9	1.1
	Sem(±)		57				3	9	8	
	CD			7.	1.23	2.11	1.20	-	4.5	2.5
	(0.05)		79					6	3	

Table:1. Performance of mustard hybrids on growth attributes at harvest

Comment [U10]: Table heading should be at the top.

Table:2. Performance of mustard hybrids on yield attributes

S.No.	Hybrids	Number of Siliqua/ Plant	Length of Siliqua/ Plant (cm)	Number of seeds/Siliqua	Seed Yield (kg/ha)	Stover Yield (kg/ha)	Seed Size(mm)	Test Weight(g)	Harvest Index (%)
1	M-1	**458.80**	**5.21**	11.60	**2356.67**	**3523.33**	2.20	5.03	**40.10**
2	M-2	369.53	4.45	**12.93**	2250.00	3483.33	2.21	**5.53**	39.24
3	M-3	302.47	4.77	11.53	2123.67	3433.33	2.03	**5.20**	39.46
4	M-4	**441.17**	4.23	10.00	2113.33	3516.20	**2.65**	4.93	38.23

5	M-5	364.13	4.67	**13.23**	2080.67	3400.00	1.93	5.06	37.41
6	M-6	314.00	**5.65**	**12.87**	1910.00	3496.67	1.93	4.63	35.32
7	M-7	223.00	4.15	11.80	1890.67	3300.00	2.03	4.33	36.39
8	M-8	**475.27**	4.65	**13.64**	**2507.54**	**3686.24**	**2.75**	**5.80**	**40.48**
9	M-9	364.13	4.67	11.23	**2480.67**	3400.54	1.95	5.67	**42.17**
10	M10	370.27	5.17	**13.40**	1953.33	3450.00	2.03	4.63	36.13
F test		S	S	S	S	S	S	S	S
Sem(±)		29.69	0.10	0.27	62.87	45.95	0.16	0.28	1.085
CD (0.05)		90.07	0.31	0.82	190.69	139.38	0.50	0.75	3.29

Table 3. Performance of Mustard hybrids on economics.

S.No.	Hybrids	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1	M-1	49313.00	153183.60	103870.60	2.106
2	M-2	49313.00	146250.00	96937.00	1.965
3	M-3	49313.00	138038.60	88725.55	1.799
4	M-4	49313.00	137366.50	88053.45	1.785
5	M-5	49313.00	135243.60	85930.55	1.742
6	M-6	49313.00	124150.00	74837.00	1.517
7	M-7	49313.00	122893.60	73580.55	1.492
8	M-8	49313.00	**162990.10**	**113677.10**	**2.305**
9	M-9	49313.00	161243.60	111930.60	2.269
10	M-10	49313.00	126966.50	77653.45	1.574

CONCLUSION

Comment [U11]: Conclusion and Recommendations

The results were concluded that based on experimentation the hybrid M-8 performs positively and has higher growth and yield parameters in mustard.

The conclusion drawn are based on one season data only which requires further confirmation for recommendation.

References

Amit, K., Mahapatra, B.S., Singh, V.P., Anil, S., Negi, M.S. and Mohan, S. 2017. Effect of nutrient levels on yield, nutrient uptake and economics of Indian mustard (*Brassica juncea*) in tarai region of Uttarakhand. *Indian Journal of Agronomy* **62**(3): 378-381.

Arthamwar, D.N., Shelke and Ekshinge. 1996. Effect of nitrogen and phosphorus on yield of Indian mustard (*Brassica juncea*). *Indian Journal of Agronomy* **41**(2): 282-285.

Banik, P., Adhikary, S. and Begehi, D.K. 1992. Varietal option for rapeseed and mustard in Bihar plateau.

Indian Agriculturist **36**(2): 95-99.

Chaubey, M.K., Singh, P.C. and Kumar, R. (2008. Effect of integrated nutrient management on yield of mustard and soil fertility. *Annual Plant and Soil Research* **10**(2): 143- 145.

Chaudhary, A.K., Dorsal, S.L. and Oberia, D.S. 1985. Production of mustard in Rajasthan.Indian *Farming* **25**(4): 19-21.

Dashora, L. N. 2013. Effect of sulphur on productivity of Indian mustard [(*Brassica juncea* (L.)Czern and Coss.)] Genotypes (Doctoral dissertation, MPUAT, Udaipur).

Dhobale, M.V., Mulgir, K.S. and Bhale, V.M. 1997. Effect of sowing dates on growth and yield of different varieties of mustard. *Journal of Maharashtra Agriculture Universities* **22**(2): 190-192.

Duan, Y.H., Zhang, Y.L., Ye, T., Fan, X.R., Xu, G.H. and Shen, Q.R. 2007. Responses of ricecultivars with different nitrogen use efficiency to partial nitrate nutrition. *Annal Bot* **99**: 1153-60.

Ghanbahadur, M.R. and Lanjewar, B.K. 2002. Influence of sowing dates, irrigation levels andmulching on nutrient uptake and yield of mustard cv. ACN-9. *Journal of Soils and Crops* **16**(1): 158-164.

Goyal, K.S., Das, B., Singh, R. and Mohanty, A.K. 2006. Influence of the thermal environment

phenology, growth and development of mustard varieties. *Journal of Oils and Crops* **16**(2): 283-290.

Haridarshan, C., Virender, S. and Pushpa, S. 2017. Variability in Indian mustard (*Brassica juncea*) genotypes in response to applied phosphorus. *Indian Journal of Agronomy* **62**(3):374-377.

Harpreet, S. and Singh, R.P. 2015. Effect of nutrient management practices on yield and quality of Indian mustard (*Brassica juncea*) under late sown condition. *Ann. Agric. Res. New Series* **36**(1): 65-7.

Jaiswal, A.D., Singh, S.K., Singh, Y.K., Surendra Singh and Yadav, S.N. 2015. Effect of sulphur and boron on yield and quality of mustard (*Brassica juncea* L.) grown on vindhyan red soil. *Journal of the Indian Society of Soil Science* **63**(3): 362-364.

Jat, G., Sharma, K.K., Kumawat, B.L. and Bairwa, F.C. 2008. Effect of FYM and mineral nutrients on yield attributes yields and net return of mustard. *Annual Plant Soil Research* **10**(1): 92-95.

Kamol, K.B., Sakil, M., Muhammad, S. and Bishan, L.D.C. 2016. Yield attributes and oil content of different mustard (*Brassica campestris* L.) varieties effected by different levels of fertilizers. *Asian J. Med. Biol. Res*. **2**(1): 143-147.

Karoria, B.S. 2008. Effect of varieties and irrigation schedules on yield of mustard (*Brassica juncea* L.) (Doctoral dissertation, JNKVV, Jabalpur).

Karthikeyan, K.and Shukla, L.M. 2008. Effect of boron and sulphur interaction on uptake and quality parameters of mustard (*Brassica juncea* L.) and sunflower (*Helianthus annus* L.) *Journal of Indian Society of Soilscience*. **56**(2):225-230.

Kumar, A. and Singh, R.P. 1989. Agronomic investigations on rapeseed and mustard at Parntnagar Paper presented at *Barassica* sub network meeting held at G.B. Pant Univ.of AgriC. and Tech., Pantnagar, Jan. 4-6.

Kumar, A., Mahapatra, B.S., Singh, V.P., Shukla, A., Negi, M.S., Yadav, A.S., Singh, P., Gaurendra, G. and Singh, M. 2017. Effect of nutrient levels on yield, nutrient uptakeand economics of Indian mustard (*Brassica juncea*) in tarai region of Uttarakhand. *Indian Journal of Agronomy* **62**(3): 378-381.

Kumar, A., Yadava, D.K. and Rana, D.S. 2012. Rapeseed-mustard in India: Present scenario, future projections and R & D issues. *Indian Farm* **62**(8): 14-21.

Kumar, D. and Malik, R.S. 1983. Salt tolerance of six Indian mustard cultivars. *Indian Journal of Agronomy* **28**(4): 225-231.

Kumar, H. and Yadav, D.S. 2007. Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars. *Indian Journal of Agronomy* **52**(2): 154-157.

Kumar., Arvind and Singh, R.P. 1985. Oilseeds research at Pantnagar, Expt Tech. Bull. III. GB. Pant Univ of Agric. and Tech., Pantnagar.

Kumar ,S,; tirupathi,P.M. and singh ,R.(2001).response of indian mustard to sources and levels and sulphur in partially reclaimed salt affected soils.Indian journal of agriculture science., 72(1);21-2.

Kumari, A. 2009. Evaluation of hybrid varieties of mustard (*Brassica juncea* L.) under different sowing time and spacing (Doctoral dissertation, GB Pant University of Agriculture and Technology, Pantnagar-263 145 (Uttarakhand).

Madhavilatha, A., Satyanarayan, V., Kumar, B.V. and Rao, P.C. 1997. Integrated weed management in mustard. *J. Oilseeds Res*. **14**(1): 100-101.

Mahendra, K. T., Alice, B., Dahryn, T., Sambhu, C.M. and Snehasis, J. 2015. Evaluation of plant growth, yield and yield attributes of bio-field energy treated mustard (*Brassica juncea*) and chick pea (*Cicer arietinum*) seeds. *Agriculture, Forestry and Fisheries* **4**(6): 291-295.

Meena, D.R., Chauhan, J.S., Singh, M., Singh, K.H. and Meena, M.L. 2013. Genetic variation and correlations among physiological characters in Indian mustard (*Brassica juncea* L.) under high temperature stress. *Indian Journal of Genetics* **73**(1): 101-104.

Meena, D.S., Meena, V.R. and Meena, A.K. 2013. Fertilizer management studies on growth and productivity of hybrid Indian mustard [*Brassica juncea* (L.)]. *Journal of OilseedBrassica* **4**(1): 39-42.

Meena, M.C., Patel, K.P. and Ramani, V.P. 2013. Effect of FYM and sewage sludge application on yield and quality of pearl millet-mustard cropping system and soil fertility in a Typic Haplustept. *Journal of the Indian Society of Soil Science* **61**(1): 55-58.

Nayak, R.L., Mandal, D.M. and Zaman, A. 1984. Mustard under irrigated and rainfedconditions in WB. *Indian Farming* **24**(5): 18-19.

Pandey, S., Manoj, K.M. and Tripath, M.K. 2013. Study of inheritance of erucic acid in Indian mustard (*Brassica juncea* L.). *Octa Journal of Biosciences* **1**: 77-84.

Pachauri, R. K., Trivedi, S. K. and Kumar, Y. 2012. "Effect of sulphur levels on growth, yield and quality of Indian mustard genotypes and their economics". *Journal of Soils and Crops*. **22**(2): 258-263.

Patel,G.M., Patel,B.T., Dodia, I.N., Bhatt, V.K.and Bhatt, R.K. 2009. Effect of sources and level of sulphur on yield, quality and nutrient uptake of mustard (*Brassica juncea* L.) varieties in sandy loamy soil. *Journal of Soil and Crops*. **19**(1):30-35.

Patidar,M; singh,M.P;Singh ,B. and raj singh (2000).varietal performances of india mustard under different fertility levels in arid zone .Central Arid Zone research institute ,jodhpur. *current agriculture*., vol.24 No.1-2:89-91.

Rajpar, I., Bhatti, M. B., Zia-ul-hassan, Shah, A. N. and Tunio, S. D. 2011. Humic acid improves growth, yield and oil content of brassica compestris l. *Pak. J. Agri., Agril. Engg., Vet. Sci*. **27** (2): 125-133.

Ramanmurthy, M. (1984). Ed. Advances in oilseeds production technology. Indian Council of Agricultural Research, New Delhi, Pp 23.

Rathore, S.S., Shekhawat, K., Dass A., Premi, O.P., Rathore, B.S., Singh V.K. 2019. Deficit Irrigation Scheduling and Superabsorbent Polymer-Hydrogel Enhance Seed Yield, Water Productivity and Economics of Indian Mustard Under Semi-Arid Ecologies. Irrigation and Drainage.

Saran., Ganga and Giri, G. 1984. Studies on comparative performance of mustard varieties under dryland condition. *Indian Journal of Agronomy* **29**(1): 398-401.

Sharma, D.K. 1986. Soil moisture and nitrogen studies in mustard (*Brassica juncea* L.). Ph.D, Thesis submitted to G.B. Pant Univ. of Agric. & Tech., Pantnagar.

Sharma, D.K. and Kumar, A. 1989. Effect of water stress on plant water relations and yield of varieties Indian mustard (*Brassica juncea* sub sp. Juncea). *Indian Journal of Agricultural Science* **59**(5): 281-285.

Shekhawat, K., Rathore, S.S., Premi, O.P., Kandpal and Chauhan, J.S. 2012. Advances in agronomic management of Indian mustard (*Brassica juncea* (L.) Czernj.Cosson): Anoverview. *International Journal of Agriculture* 1-14.

Shyamraj. 1986. Evaluation of mustard (*Brassica juncea* L.) cultivars under late planted conditions. M. Sc. (Ag.) Thesis, G.B. Pant Univ. of Agric. and Tech., Pantnagar.

Singh, C., Singh, P. and Rajbir, S. 2012. Oil crops of mustard (*Brassica juncea* L.) general introduction. Modern techniques of raising field crops. *Oxford & IBH publishing Company Pvt. Ltd. New Delhi. p.* 337-354.

Singh, R.K. 1989. Effect of different levels of nitrogen on promising varieties of mustard (*Brassica juncea*
L.) M. Sc. Ag., Thesis G.B. Pant Univ. of Agric. & Tech.,Pantnagar.

Singh, R.K., Singh, Y., Singh, A.K., Kumar, R. and Rakesh, V.K. 2010. Productivity and economics of mustard (*Brassica juncea*) varieties as influenced by different fertility levels under late sown condition. *Indian Journal of Soil Conservation* **38**(2): 121- 124.

Singh, R.P. and Kumar, A. 1990. Effect of varieties and planting geometry levels on late-sown lndian mustard (*Brassica juncea*). *Indian Journal of Agriculture Science* **60**(6): 392-395.

Singh, S.M., Dahiya, D.R. and Singh, R.P. 1985. Effect of varying rectangularities nitrogen and varieties on yield and yield attributes of mustard. *Indian attributes Journal of Agronomy* **30**(1): 79-83.

Singh, S.P. and Pal, M.S. 2011. Effect of integrated nutrient management on productivity, quality, nutrient uptake and economics of mustard (*Brassica juncea*). *Indian Journalof Agronomy* **56**: 381-387.

Yadav, S.N., Singh, S.K. and Omkar Kumar. 2016. Effect of boron on yield attributes, seed yield and oil content of mustard (*Brassica juncea* L.) on an inceptisol. *Journal of the Indian Society of Soil Science* **64**(3):291-29

Comment [U12]: Use journal format to list references.