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Performance Evaluation of Different Indian Mustard (*Brassica juncea*) Varieties to Various Fertilizer Rates under Late Sowing Irrigated Conditions in the Jammu Region

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during the *rabi* season of 2020 at the Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, to evaluate the effect of Indian mustard (*Brassica juncea* L.) varieties, farmyard manure (FYM) application and different fertilizer levels on productivity and profitability under late sown irrigated conditions. The treatment consisted of four varieties *viz.,* V_1-RSPR 69, V_2-Pusa Mustard 26, V_3-RVM 2 and V_4-NRCHB 101 in main plot; FYM @5 t ha^{-1} and no FYM in sub plot and three fertilizer levels in sub-sub plots *i.e.,* F_1-NPKS (60:30:15:20 kg ha^{-1}), F_2-NPKS (80:40:20:25 kg ha^{-1}) and F_3-NPKS (100:50:25:30), which were laid out in split-split plot design with three replications. Results indicated that variety RVM-2 recorded significantly higher growth, yield attributes and seed yield which were statistically at par with NRCHB 101. Application of FYM @ 5 t ha^{-1} significantly improved growth and yield of mustard compared to no FYM. Similarly, fertilizer aapplication at 100:50:25:30 kg ha^{-1} ($N:P_2O_5:K_2O:S$) resulted in significantly higher growth, yield attributes and seed yield and was statistically comparable with 80:40:20:25 kg ha^{-1}. The combination of variety RVM-2, FYM@ 5t ha^{-1} and fertilizer dose of 80:40:20:25 kg ha^{-1} recorded the highest B: C, indicating its suitability for maximizing productivity and profitability of Indian mustard.

Keywords: Indian mustard; growth; yield; varieties; FYM; fertility does; oil content.

1. INTRODUCTION

"India is a major producer of oilseed crops worldwide. Of the nine oilseed crops cultivated in the country, seven are used for edible oils, soybean, groundnut, rapeseed-mustard, sunflower, sesame, safflower, and niger, while two are used for non-edible oils, namely castor and linseed. Mustard is one of the earliest recorded spices, dating back to approximately 3000 BC" (Mehra, 1968). In 2019–2020, the global area, production, and yield of rapeseed-mustard were 35.95 million hectares, 71.49 million tonnes, and 1,990 kg per hectare, respectively. India is the third-largest producer of rapeseed-mustard in the world (Rai *et al*., 2016). The area under rapeseed-mustard cultivation in India increased from 6.12 million hectares in 2018–19 to 6.86 million hectares in 2019–20 (Anonymous, 2021; Srikant *et al.,* 2020). India currently contributes 19.29 percent of the global acreage and 11.12 percent of global production of rapeseed-mustard. In Jammu & Kashmir, the productivity of rapeseed-mustard is 6.98 quintals per hectare, accounting for 37.72 percent of the global average productivity and 67.85 percent of the national average (Kumar *et al*., 2018).

The Central Variety Release Committee has released several promising Indian mustard varieties namely RSPR 69, RH 749, RVM-2, Giriraj, and NRCHB 101—which have demonstrated high productivity ranging from 16 to 22 quintals per hectare across different agro-ecosystems in Northern India (Anonymous, 2019). Nonetheless, these varieties need to be evaluated under subtropical, irrigated conditions of the Jammu region, particularly under late-sown conditions (i.e., the second fortnight of November), to assess their suitability for general cultivation in the Union Territory of Jammu and Kashmir (Chand *et al.,* 2021). Furthermore, fertilizers play a critical role in improving oilseed yields, enhancing nutrient efficiency, and promoting balanced fertilization. They are essential for achieving higher productivity and better nutrient use efficiency (Chand & Pavithra, 2015). Applying the correct dose of fertilizers not only ensures sustained and increased production but also helps to correct specific nutrient deficiencies.

Mustard productivity can be influenced significantly by the selection of appropriate cultivars and effective fertility management (Kaur *et al*., 2017) and (Bhat *et al*., 2006). Fertilizer application has been shown to positively impact the growth and yield of mustard varieties. Among the macronutrients, nitrogen and sulphur are particularly important, especially in terms of seed quality and quantity (Kour *et al.,* 2017). Nitrogen is vital for vigorous plant growth, high yields, and overall crop quality. It is a key component in the synthesis of plant proteins and chlorophyll and is required in larger quantities than most other macronutrients. Sulphur, on the other hand, is an essential plant nutrient that has recently gained prominence as the third most important element in oilseed nutrition. It plays a crucial role in plant metabolism and productivity. Sulphur application has been shown to increase the oil and protein content of seeds (Bharat *et al*., 2022) and (Malhi *et al*., 2007). Phosphorus is one of the most important nutrients in crop nutrition and plays a vital role in salinity-fertility interactions, as well as in enhancing plant vigour and salt tolerance. Additionally, potassium is known to play a significant role in plant salt stress tolerance (Wang *et al*., 2013). The chlorophyll content (both a and b) in mustard leaves also increases with higher levels of potassium application.

The application of a balanced fertilizer dosage, along with organic manure, is essential for maintaining soil fertility (Lal *et al.,* 2016). The integrated use of optimal doses of NPK and farmyard manure (FYM) promotes better and more sustainable yields while also correcting deficiencies in micro- and secondary nutrients. (Kaur *et al*., 2017) and (Kumar *et al*., 2019; Sanyal et al., 2014). The combined use of FYM and chemical fertilizers enhances soil health and nutrient availability, leading to improved mustard yield, oil content, and sustainable soil fertility. (Singh *et al*., 2020) and (Blanchet *et al*., 2016). The study aims to evaluate the performance of Indian mustard varieties under different fertility schedules to optimize yield in late-sown irrigated conditions of the Jammu region.

2. MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 2020-21 at Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, located at 32^0 39´ 33´´ N latitude and 74^0 48´ 45´´ E longitude and 293 meters above mean sea level, in the subtropical foothills of the Shivalik Himalayas. The climate of experimental site is subtropical with hot and dry early summers followed by hot and humid monsoon season and cold winters. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in nature having pH of 7.45, EC (0.21 dS m^{-1}), organic carbon (0.61%), low in available nitrogen (230 kg ha^{-1}), medium in phosphorus (14.31 kg ha^{-1}), potassium (150 kg ha^{-1}) and sulphur (19.1 mg kg^{-1}). The experiment consisted of four Varieties *i.e.,* V_1-RSPR 69, V_2-Pusa Mustard 26, V_3-RVM 2 and V_4-NRCHB 101 in main plot and two with or without FYM in sub plot and three fertilizer levels *i.e.,* F_1 NPKS (60:30:15:20 kg ha^{-1}), F_2 NPKS (80:40:20:25 kg ha^{-1}) and F_3 NPKS (100:50:25:30) in sub-sub plot. The treatments were evaluated in split-split plot design with 3 replications. The enrichment of nutrients with FYM @ 5t ha^{-1} was done fifteen days prior to sowing. The recommended dose of N: P_2O_5: K_2O was 60:30:15 kg ha^{-1}. Half of the nitrogen was applied as basal dose along with the full doses of phosphorus, potassium and sulphur either alone or in enriched form at the time of sowing as per the treatment plan. The remaining half dose nitrogen was used as a top dressing. The nutrients sources applied in the experiment for supply of nitrogen, phosphorus, potassium and sulphur were urea, diammonium phosphate, muriate of potash and sulphur bentonite, respectively. The Indian mustard was sown @ of 5 kg ha^{-1}. The crop was sown in tractor lines 30 cm apart. The thinning was carried out 25-30 DAS to maintain a planting 30±10 cm plant to plant distance. The final thinning was done at 30 DAS to maintain uniform intra row plant spacing in each plot. Agronomic parameters were recorded when the crop attained fully ripening. The agronomic parameters included were number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$, 1000-seed weight, stover yield and seed yield. All the collected data was subjected to statistical analysis by analysis of variance method (Gomez and Gomez, 1984). Economic data analysis was carried by mathematical method.

3. RESULTS AND DISCUSSION

3.1 Yield, Yield Attributes and Quality Parameters

Data pertaining to yield, yield attributes and quality parameters such as number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$, test weight (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), oil yield and protein content, were influenced by varieties, application of FYM and different fertility levels (Table 1).

Among the different varieties of Indian mustard, RVM 2, although at par with NRCHB 101, resulted in significantly higher yield, yield attributes and quality parameters namely, siliquae $plant^{-1}$(129.25), seeds $siliqua^{-1}$ (13.67), test weight (3.99 g), seed yield (1516.6 kg ha^{-1}), stover yield (6263.2 kg ha^{-1}), oil yield (587.36 kg ha^{-1}) and protein content (17.60 %) than RSPR-69 and Pusa Mustard 26 under late-sown conditions in the Jammu region. However, the lowest yield attributes, namely, siliquae $plant^{-1}$ (115.07), seeds $siliqua^{-1}$(11.63), test weight (3.07 g), seed yield (1247.7 kg ha^{-1}) and stover yield (5128.8 kg ha^{-1}), oil yield (460.50 kg ha^{-1}) and protein content (17.31%) were recorded in the Pusa Mustard 26 variety. This might be due to the better genetic makeup of RVM 2. These results are consistent with those of Dinda *et al.,* (2015). Similarly, a significant increase in yield attributes and quality parameters, such as siliquae plant^{-1}(124.96), seeds siliqua^{-1} (13.07), test weight (3.88 g), seed yield (1414.4 kg ha^{-1}), stover yield (5791.9 kg ha^{-1}), oil yield (533.75 kg ha^{-1}) and protein content (17.87 %) were recorded with the application of FYM@ 5t ha^{-1} at harvest than no FYM application in comparison. This could be attributed to increased photosynthesis and assimilation rates, which would result in a large improvement in the yield attributes. These results are consistent with those of Kumar *et al*., (2017). Fertility levels too differed significantly for various growth characteristics. Application of $N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha$^{-1,}$ though at par with the application of $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha$^{-1,}$ resulted in an increase in yield attributes and quality parameters *viz.,* siliquae plant^{-1}(121.80), seeds siliqua^{-1}(12.87), test weight (3.66 g), seed yield (1379 kg ha^{-1}), stover yield (5761.6 kg ha^{-1}), oil yield (522.19 kg ha^{-1}) and protein content (17.64 %). However, the lowest yield attributes, namely, siliquae plant^{-1}(111.25), seeds siliqua^{-1}(12.51), test weight (3.31), seed yield (1225.8 kg ha^{-1}), stover yield (5587.0 kg ha^{-1}), oil yield (472.70 kg ha^{-1}) and protein content (17.07 %) were observed with the application of $N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}. This could be due to an increase in the general vitality and crop growth. All the required nutrients are incorporated into the soil, which stimulates rapid vegetative growth and branching, thereby increasing the sink size and improving yield attributes. Improved nutrient availability may also contribute to greater growth and increased photosynthate translocation from source to sink, resulting in higher yield attributes. These results are in line with the findings of Kumar *et al*., (2017). This could be due to larger nutrient dosages resulting in improved growth and, as a result, a rise in various yield components due to an adequate supply of major plant nutrients, which eventually boosts seed yield, stover output, and subsequently the harvest index. These results are consistent with those of Ghimire *et al*., (2011). This might be due to increased sulphur levels in the soil resulting in more oil synthesis and increase in glucosides. Increase in protein content was mainly due to increase in nitrogen content in plants. Availability of more Sulphur also increases the conversion of fatty acid metabolites to the end product of fatty acids. These results are in agreement with Kumar *et al*., (2017). The interaction effect between the fertility schedules and varieties (V×F), manure application and varieties (M×V) and Varieties, manure application and fertility schedules (V×M×F) was found to be significant.

Table 1. Effect of different varieties, farmyard manure and various fertilizer doses on yield attributes, yield and quality attributes of Indian mustard

Treatments	Number of Silique per plant	Number of seeds per siliquae	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Protein content (%)	Oil yield (kg ha^{-1})
(V) Varieties							
V_1-RSPR 69	115.07	12.16	3.16	1247.7	5275.5	17.31	460.50
(V_2) Pusa mustard 26	103.57	11.63	3.07	1130.5	5128.8	17.07	413.38
(V_3) RVM 2	129.25	13.67	3.99	1516.6	6263.3	17.60	587.36
(V_4) NRCHB 101	123.98	13.48	3.91	1438.2	6036.6	17.43	548.85
SEm±	4.69	0.21	0.21	58.2	185.5	0.12	21.70
CD (5%)	16.20	0.74	0.75	200.9	640.3	0.22	74.89
(M) Farmyard manure application							
(M_1) Without FYM	110.98	12.40	3.19	1252.1	5560.2	16.83	471.32
(M_2) FYM @ 5 t ha^{-1}	124.96	13.07	3.88	1414.4	5791.9	17.87	533.73
SEm±	0.67	0.03	0.04	8.8	13.7	0.06	3.35
CD (5%)	2.21	0.11	0.13	28.9	44.8	0.22	10.92
(F) Fertility levels ($N:P_2O_5:K_2O:S$ kg ha^{-1})							
(F_1) 60:30:15:20 kg ha^{-1}	111.25	12.51	3.31	1255.8	5587.0	17.07	472.70
(F_2) 80:40:20:25 kg ha^{-1}	120.85	12.84	3.63	1365.0	5679.5	17.35	512.68
(F_3) 100:50:25:30 kg ha^{-1}	121.80	12.87	3.66	1379.0	5761.6	17.64	522.19
SEm±	0.36	0.01	0.01	7.9	12.4	0.07	3.0
CD (5%)	1.06	0.03	0.04	22.9	35.9	0.21	8.65
Interactions							
(VxM) Variety x FYM	NS	NS	NS	NS	NS	NS	NS

Treatments	Number of Silique per plant	Number of seeds per siliquae	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Protein content (%)	Oil yield (kg ha^{-1})
(VxF) Variety x Fertility level	2.12	0.07	0.09	45.8	71.8	NS	17.31
(MxF) FYM x Fertility level	1.50	0.05	0.06	32.4	50.8	NS	12.24
(VxMxF) Variety x FYM x Fertility level	3.00	0.11	0.13	64.8	101.6	NS	24.48

Table 2. Effect of different varieties, farmyard manure and various fertilizer doses on relative economics of Indian mustard at harvest

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C
(V) Varieties				
(V_1) RSPR 69	20846	58021	37175	1.78
(V_2) Pusa mustard 26	20846	52570	31724	1.52
(V_3) RVM 2	20846	70525	49678	2.37
(V_4) NRCHB 101	20846	66877	46031	2.20
(M) Farmyard manure application				
(M_1) Without FYM	20096	58225	38129	1.89
(M_2) FYM @ 5 t ha^{-1}	21596	65771	44175	2.04
(F) Fertility levels ($N:P_2O_5:K_2O:S$ kg ha^{-1})				
(F_1) 60:30:15:20 kg ha^{-1}	19892	58396	38504	1.93
(F_2) 80:40:20:25 kg ha^{-1}	20846	63472	42626	2.04
(F_3) 100:50:25:30 kg ha^{-1}	21801	64127	42326	1.93

3.2 Economics

The practicability and usefulness of treatments are judged ultimately in terms of net returns and the B: C ratio. The results of the present study showed that gross returns, net returns, and B: C ratio were markedly influenced by different varieties, FYM application, and fertility levels. Among the different varieties, RVM 2 fetched the maximum gross returns (70,525 ₹ ha^{-1}), net returns (49678 ₹ ha^{-1}), and B:C (2.37) ratio at the same cost of cultivation. This was due to the higher biological yield obtained with RVM 2 because of its inherent characteristics. These results are consistent with those of Kumari *et al.*, (2012). Similarly, treatments in which FYM@ 5t ha^{-1} was applied fetched maximum gross return (65771 ₹ ha^{-1}), net return (44175 ₹ ha^{-1}), and B:C (2.04) ratio than no FYM application in comparison. This might be due to higher production, that is, more biological yield in the treatments in which FYM@ 5t ha^{-1} was employed, so gross returns and net returns also increased, leading to a higher B:C ratio. These results are consistent with those of Mukherjee *et al.,* (2016). Application of $N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1} fetched maximum gross returns (64127 ₹ ha^{-1}) and net returns (42626 ₹ ha^{-1}) than the application of $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1} and $N:P_2O_5:K_2O:S$ @ 60:30:15: kg ha^{-1} However, application of $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1} fetched maximum B:C ratio (2.04). This might be due to lower cost of cultivation with the application of $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1} than the application of $N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}. These results are in agreement with Singh *et al*., (2010).

4. CONCLUSION

Among different Mustard varieties, RVM 2 though at par with NRCHB 101 resulted in significant increase in growth, yield attributes, yield and quality attributes of Indian mustard than other varieties in comparison. Addition of FYM@5 t ha^{-1} resulted in improved growth, yield attributes and yield of Indian mustard. Application of fertilizer dose @80:40:20:25 kg ha^{-1} ($N:P_2O_5:K_2O:S$) raised maximum B:C ratio. However, RVM 2 variety in conjunction with application of FYM@ 5t ha^{-1} and fertilizer dose of 80:40:20:25 kg ha^{-1} ($N:P_2O_5:K_2O:S$) gave maximum B:C ratio (2.65) and hence can be recommended for higher growth, yield and quality of Indian Mustard under late sown conditions of Jammu region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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