Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region

By

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(J-19-M-608)

A Thesis submitted to Faculty of Agriculture

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AGRONOMY

DIVISION OF AGRONOMY

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Main Campus, Chatha, Jammu - 180009

2021

CERTIFICATE - I

This is to certify that the thesis entitled, **"Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region"** submitted in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture (Agronomy)** to the Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, is original work and has similarities with published work not more than minor similarities as per UGC norms of 2018 adopted by the University. Further, the level of minor similarities has been declared after checking the manuscript with **Urkund** software provided by the University.

The work has been carried out by **Mr. Vivek Sharma** under my supervision and guidance. No part of the thesis has been submitted for any other degree of diploma. It is further certified that help and assistance received during the course of thesis investigation have been duly acknowledged.

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CERTIFICATE- II

We, the members of the advisory Committee of **Mr. Vivek Sharma** Registration No. **J-19-M-608,** a candidate of the degree of **Master of Science in Agriculture (Agronomy),** have gone through the manuscript of the thesis entitled, **"Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the degree.

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ABSTRACT

Title of the Thesis	: **Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region.**
Name of the student	: **VIVEK SHARMA**
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ABSTRACT

The present investigation entitled "**Performance of Indian Mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region**" was conducted at the Research Farm, Division of Agronomy, Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu during the *Rabi*, 2020. The experiment was laid out in split-split plot design with three replications. The mainplot consisted of four varieties (RSPR 69, Pusa Mustard 26, RVM-2 and NRCHB 101), sub plot (Without FYM and FYM@ 5t ha^{-1}) and sub-sub plot consisted of three fertility levels ($N:P_2O_5:K_2O:S$)@ 60:30:15:20, ($N:P_2O_5:K_2O:S$)@ 80:40:20:25 and ($N:P_2O_5:K_2O:S$)@ 100:50:25:30 kg ha^{-1}. 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 (18.1 mg kg^{-1}).

Among the different Mustard varieties RVM-2 though at par with NRCHB 101 resulted in significant increase in growth, yield attributes, yield, nutrient uptake and quality attributes of Indian mustard than other varieties in comparison. FYM was applied two days before sowing. Addition of FYM@5 t ha^{-1} resulted in improved growth, yield attributes, yield, nutrient uptake and quality attributes of Indian mustard. Application of the nutrients was done as per treatment plan. The recommended dose of ($N:P_2O_5:K_2O:S$) as per the treatment plan was 60:30:15:20 kg ha^{-1}, 80:40:20:25 kg ha^{-1} and 100:50:25:30 kg ha^{-1}. Urea, diammonium phosphate, muriate of potash, and gypsum were used as nitrogen, phosphorus, potassium, and sulphur sources, respectively.As a basal dose, half of the nitrogen was applied along with the full doses of phosphorus, potassium, and sulphur at the time of sowing. The remaining nitrogen was used as a top dressing. Application of fertilizer dose ($N:P_2O_5:K_2O:S$)@100:50:25:30 kg ha^{-1} showed significantly higher growth, yield attributes, yield, nutrient uptake and quality attributes of Indian mustard which however was found to be at par with fertilizer dose of 80:40:20:25 kg ha^{-1} ($N:P_2O_5:K_2O:S$). Indian mustard variety RVM-2 in conjunction with application of FYM@ 5t ha^{-1} and fertility level of 80:40:20:25 kg ha^{-1} ($N:P_2O_5:K_2O:S$) fetched maximum B:C ratio.

On the basis of one year experiment, it may be concluded that 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 highergrowth, yield, nutrient uptake and quality of Indian Mustard under late sown conditions of Jammu region.

Key words: Indian mustard, Yield, Nutrient uptake, Varieties, FYM, fertility dose, Oil content

Signature of Major Advisor **Signature of Student**

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LIST OF ABBREVIATIONS

Abbreviation	Expansions
@	at the rate of
g	Gram
m^2	Square meter
ha	Hectare
kg	Kilogram
cm	Centimeter
DAS	Days after sowing
%	Per cent
viz.	Namely
B:C	Benefit cost ratio
₹	Rupees
DAP	Di-ammonium phosphate
MOP	Muriate of potash
KCl	Potassium chloride
mm	Millimeters
ºC	Degree Celsius
EC	Electrical conductivity
ppm	Parts per million
OC	Organic carbon
CD	Critical difference
SE (d)	Standard error of difference of means
NS	Non-significant
Fig.	Figure
i.e	That is
No.	Number
L	Litre

CHAPTER-1

INTRODUCTION

India is a major producer of oilseed crops all over the world. In India, there are nine oilseed crops out of which seven are edible oils i.e., soybean, groundnut, rapeseed mustard, sunflower, sesame, safflower, and Niger and two are non-edible oils namely castor and linseed. Mustard is one of the earliest recorded spices, dating back to around. Rapeseed-mustard is a collection of plants including toria, brown sarson, yellow sarson (*Brassica campestris*), Indian Mustard (*Brassica juncea*), black mustard (*Brassica nigra*) and taramira (*Brassica nigra*). Exotic Brassica species such as gobhi sarson (*Brassica napus*), Ethopian mustard (*Brassica carinata*), and white mustard (*Sinapis alba*) have been introduced in India.

According to the USDA, it was grown on 36.6 million hectares worldwide in 2018-2019, producing 72.4 MT with a productivity of 19.8 q ha^{-1} (Chand *et al.* 2021). During 2019-20, the world's total area, production, and yield of rapeseed-mustard were 35.95 million hectares (mha), 71.49 million tonnes (mt) and 1990 kg ha^{-1}, respectively. India is the world's third-largest rapeseed mustard producer (Rai *et al.* 2016) and 305.44 million tonnes of food seeds were produced in India in 2020-21, which is a new high. During the 2020-21 season, overall oilseed production is expected to reach 36.57 million tonnes. The acreage of rapeseed-mustard grew from 6.12 million ha^{-1} in 2018-19 to 6.86 million ha^{-1} in 2019-20 (Anonymous, 2021). India's current acreage and production contributions to the globe are 19.29 percent and 11.12 percent, respectively. In J&K, the productivity of rapeseed mustard is 6.98 q ha^{-1} which is 37.72 percent of world productivity and 67.85 percent of national productivity (Kumar *et al.* 2018). Low area under cultivation of rapeseed mustard and low production in non-traditional areas of the country, are two main factors for the oilseed shortfall in the country.

The poor average yield of mustard is related to the cultivation of conventional varieties and poor-quality seeds. With the right agronomic approaches and genotypes, mustard's production potential can be completely realized (Alam *et al.* 2014).

It is also true that genotypes don't always show the same phenotypic traits in different environments. As a result, better cultivar selection is a critical strategy for increasing output (Bal and Minhas. 2017). In Jammu region, Indian Mustard is grown in Maize-Mustard-Urdbean, Rice-Mustard-Mungbean, Sesame-Mustard, Basmati Rice-Mustard and Greengram- Mustard cropping system. Under the Basmati Rice–Mustard cropping system, the irrigated lands of the Jammu region have a lot of promise for higher productivity of Indian mustard crops. In Jammu region the basmati rice is sown in irrigated areas in June and harvested in mid-November. Due to late harvesting of basmati crop, the mustard crop can be sown as an alternative to wheat crop under late sown conditions due to higher profitability and favourable climatic conditions that favours the successful cultivation of Indian mustard crop. However, there is limited study on the suitability of several new high yielding cultivars and fertiliser recommendations for Indian mustard in the Jammu region under late sown conditions. The central variety release committee had released a few varieties of Indian mustard viz. RSPR 69, RH 749, RVM-2, Giriraj, NRCHB 101 etc which have showed a lot of promise in terms of higher productivity varying from 16-22 quintals per hectare under different agro ecosystems of Northern India, (Anonymous, 2019). These varieties, however needs to be evaluated in subtropical irrigated conditions of Jammu region under late sown conditions (second fortnight of November) for recommendation for general cultivation in the state.

Further fertilizers play a critical role in improving oil seed yields, nutrient efficiency, and balanced fertilisation and is key to achieve higher yields and nutrient use efficiency. Using the right fertiliser doses ensures a higher and longer-lasting production while fixing some nutritional deficits. Mustard productivity can be controlled by the selection of appropriate cultivars and fertility management (Bhat *et al.* 2006). Fertilizer application has been demonstrated to have a positive effect on mustard varieties. Among the macro nutrients, nitrogen and sulphur among the basic elements have significant effects, particularly on seed quality and quantity. Nitrogen is essential for strong growth, high yield and mustard quality. Nitrogen is essential for the production of plant proteins and chlorophyll, and is needed in a much larger quantity compared to other macronutrients. Sulphur is an important mineral for plants, and it has recently emerged as the third most important ingredient in oilseeds, as it plays a key role in nutrition.

Sulphur application increases the oil and protein content of seeds (Malhi *et al.* 2007). Phosphorus is one of the most important nutrients in crop nutrition, and it has been shown to have a vital role in the salinity-fertility interaction as well as increasing plant vigour and salt tolerance. Furthermore, potassium is recognised to have an important function in plant salt stress tolerance (Wang *et al.* 2013). The chlorophyll content (both a and b) in mustard leaf also increases with increasing levels of potassium application. Continuous nutrient extraction from soils, along with insufficient and unbalanced fertiliser application, has resulted in the formation of multinutrient deficits. One of the prerequisites for sustaining and boosting existing crop production levels is the preservation of native soil fertility in the country's extensively cultivated regions. Intensive cropping techniques extract significant amounts of plant nutrients from soil throughout the course of a year's worth of agricultural production (Sanyal *et al.* 2014).

One of the major impediments to better mustard yield, oil content, and other quality characteristics is unbalanced nutrition (Lal *et al.* 2016). Rapeseed - mustard is a high-energy crop with a high demand for major nutrients. In general, nutrient removal from Indian arable soil is projected to be as high as 34 metric tonnes per year, compared to estimated fertiliser usage of 27.7 metric tonnes, resulting in a 6.3 metric tonnes negative balance. The current fertiliser consumption ratio is 8.2:3.2:1, while 4:2:1 is the ideal. This shows sporadic and unbalanced fertiliser application (Chand *et al.* 2015). Nutrient imbalance is becoming more prevalent in the country's key mustard growing areas, posing a serious challenge to maintaining high mustard productivity. It signifies that nutrient loss exceeds nutrient supplies, resulting in poorer mustard productivity.

Application of a balanced fertiliser dosage, as well as organic manure, is required to maintain soil fertility. The integrated use of optimal dose of NPK and FYM promotes better and sustainable yields, while rectifying some of the micro and secondary nutrient deficiencies. Improving nutrient-use efficiency, lowering production costs, maintaining soil health and productivity, and increasing mustard productivity are all benefits of integrated nutrients management. Long term application of farmyard manure (FYM) has been found to gradually release macro and micro nutrients in accordance with plant demands in addition to having a chelating effect on fertiliser release. Farm Yard Manure aids in the growth of bacteria and their activities, which are critical for the easy availability of complex nutrients to plants.

Application of farm yard manure combined with sulphur has been shown to improve oil content and mustard productivity while also maintaining soil fertility and keeping soil in good condition (Kumar *et al.* 2019). Farm yard manure (FYM) in appropriate conjunction with fertilisers has been found to improve physical, chemical, and biological soil qualities, allowing for more economic and sustainable agriculture (Singh *et al.* 2020). Use of organic manures such as FYM increase soil quality and improves yield in mustard (Srikant *et al.* 2020). Thus, the application of organic manure (FYM) and mineral nutrient augment the soil fertility. It improves agricultural yields besides maintaining the physical, chemical, and biological characteristics of the soil. (Blanchet *et al.* 2016).

All these factors have necessitated research to determine the optimal fertiliser doses with or without farmyard manure application for the supply of vital micro and macro nutrients under late sown conditions in order to provide meaningful recommendations to farmers in the region. Since not much work has been done in Jammu region on the performance of different mustard varieties under late sown conditions to exploit its yield potential fully, it is important to identify suitable variety and optimum fertility schedules. Hence, keeping the above facts in the foremost place for developing the hypothesis of the problem at hand, a study entitled "**Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region**" was undertaken with the following objectives:

- To evaluate the growth and yield of Indian Mustard varieties at various fertility schedules under late sown conditions. of Jammu and
- to study the effect of varieties and fertility schedules on nutrient uptake and relative economics of Indian mustard.

CHAPTER-II

REVIEW OF LITERATURE

In this chapter efforts have been made to compile the relevant information on research work conducted in India and overseas on oilseed crops pertaining to the research entitled "**Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region**". The relevant literature has been scanned and reviewed under the following heads:

2.1 Effect of fertility schedule on growth and yield of mustard

Chand (2000) from Udaipur conducted an experiment to study the effect of FYM on yield of Indian mustard. The experiment consisted of two levels of FYM viz., (0 and 10 t ha^{-1}). The results revealed that application of FYM @ 10 t ha^{-1} resulted in maximum seed yield (1262 kg ha^{-1}) and stover yield (4000 kg ha^{-1}) than control.

Davaria, *et al*. (2001) from Junagadh carried out an experiment to study the effect of different phosphorus dosages i.e, 0, 25, and 50 kg ha^{-1} on the growth and yield of mustard. The results revealed that application of Phosphorus @ 50 kg ha^{-1} resulted in a significant increase in number of primary branches $plant^{-1}$ (6.9), secondary branches $plant^{-1}$ (12.6), siliquae $plant^{-1}$ (278), seeds $siliqua^{-1}$ (12.1), 1000-seed weight (3.54 g), seed yield (15.43 q ha^{-1}), and stover yield (39.44 q ha^{-1}) respectively than other treatments in comparison.

Misra (2003) from Kanpur conducted an experiment to study the effect of sulphur and potassium on the yield of mustard. Different fertility doses comprised of Sulphur @ 0, 20, 40 and 60 kg ha^{-1} and Potassium @ 0, 30, 60 and 90 kg ha^{-1} respectively. The results revealed that application of Sulphur @ 40 kg ha^{-1} resulted in significantly higher seed yield (2035 kg ha^{-1}) which was 27.59 per cent higher in comparison to the yield at control. Similarly, the application of Potassium @ 60 kg resulted in significantly higher seed yield (2085 kg ha^{-1}) which was 35.48% higher in comparison to the yield in control.

Singh *et al*. (2004) from Bharatpur studied the effect of different levels of Nitrogen @ (40,60 and 80 kg ha^{-1}) and Sulphur @ (20, 40 and 60 kg ha^{-1}) on seed yield of mustard. The results revealed that application of Nitrogen @ 80 kg ha^{-1} and Sulphur @ 60 kg ha^{-1} resulted in significantly higher seed yield (2,109 kg ha^{-1}) than other treatments in comparison.

Yogesh *et al*. (2009) from Allahabad conducted an experiment to study the effect of different fertility levels on the growth and yield of mustard. The treatments consisted of two levels of Nitrogen (80 and 100 kg ha^{-1}) and two levels of Phosphorus (40 and 60 kg ha^{-1}) respectively. The results revealed that Nitrogen @ 100 kg ha^{-1} and Phosphorus @ 60 kg ha^{-1} resulted in significantly higher seed yield (30.93 q ha^{-1}) and stover yield (59.44 q ha^{-1}) than other treatments in comparison.

Das *et al*. (2010) from Umiyam conducted an experiment to study the effect of organic and inorganic nutrient sources on yield of maize-mustard cropping system. Different treatments consisted of 100% NPK (50:60:30 kg ha^{-1}), 100% NPK in combination with FYM@ 2.5 t ha^{-1}, 50% NPK in combination with FYM@ 5 t ha^{-1}. The results revealed that application of 50 @ NPK and FYM @ 5 t ha^{-1} resulted in maximum siliquae $plant^{-1}$ (209), seeds per siliqua (10.75), test weight (4.73 g) and seed yield (1100 kg ha^{-1}) than other treatments in comparison.

Singh *et al.* (2010) from Varanasi carried out an experiment to study the effect of different fertility levels on productivity of mustard under late sown condition. The treatment consisted of different fertility levels i.e., 75% RDF, 100% RDF, 125% RDF and 150% RDF where RDF was 80, 40, 40, 30 kg nitrogen, phosphorus, potassium and sulphur ha^{-1} respectively. The results revealed that the application of 150% RDF resulted in significantly higher seed yield (230.2 kg ha^{-1}) than other treatment combinations in comparison.

Tripathi *et al*. (2010) from Pantnagar studied the effect of integrated nutrient management on Indian mustard (*Brassica juncea*) and reported that application of 2t FYM and 40 kg S combined with recommended or 75% RDF resulted in a significant increase in seed yield besides maximum net returns of Indian mustard than the application of RDF (1.69 t ha^{-1}) and 75% RDF (1.57 t ha^{-1}) alone.

Yadav *et al*. (2010) from Morena studied the effect of different fertility levels on Indian mustard and reported that use of 125% NPK fertilizer resulted in significantly higher growth, protein production and oil yield than other treatments which gave 29.03%, 19.59% and 8.30% more seed yield than 50, 75 and 100% recommended fertilizer dose, respectively.

Ghimire and Bana (2011) from Pantnagar conducted an experiment to study the effect of different doses of fertilizer on yield and quality of mustard. The results revealed that significantly higher seed yield (1.04 t ha^{-1}), stover yield (2.03 t ha^{-1}), oil yield (340 kg ha^{-1}) and protein content (23.7%) was recorded at 100% RDF (120 kg N, 17.4 kg P_2O_5 and 16.6 kg K_2O ha^{-1}) than other treatments in comparison.

Santosh *et al*. (2011) from Varanasi studied the effect of different levels of Nitrogen (0, 40, 60 and 80 kg ha^{-1}) and Sulphur (0, 15, 30 and 45 kg ha^{-1}) on the yield of Indian mustard under rainfed condition. The results revealed that the application of Nitrogen@ 80 kg ha^{-1} resulted in significantly higher seed yield (1.17 tonnes ha^{-1}) than other treatments in comparison. Similarly, the application of Sulphur @ 45 kg ha^{-1} resulted in significantly higher seed yield (1.18 tonnes ha^{-1}) being at par with Sulphur @ 30 kg ha^{-1}, respectively.

Cheema *et al*. (2012) from Faisalabad carried out a field experiment to study the effect of different levels of K (0, 30, 60, 90,120 kg ha^{-l}) on two canola cultivars viz. Bulbul-98 and Zafar-2000. The results revealed that highest seed yield (3067.24 kg ha^{-l}) was obtained when K was applied at 120 kg ha^{-1} than other treatments in comparison.

Jat *et al.* (2013) from Jaipur conducted an experiment to study the effect of FYM on yield of mustard. The experiment consisted of three levels of FYM viz., control, 5 t ha^{-1} & 10 t ha^{-1} respectively. The results revealed that application of FYM @ 10 t ha^{-1} resulted in maximum seed yield (16.9 q ha^{-1}) and stover yield (40.6 q ha^{-1}).

Kumawat *et al.* (2014) from Bikaner conducted an experiment to study the effect of integrated nutrient management on growth and yield of Indian mustard. Treatment consisted of three levels of FYM viz., control, 10 t ha^{-1} & 20 t ha^{-1}. The results revealed that application of FYM @ 20 t ha^{-1} resulted in significantly higher plant height, dry matter accumulation, seeds siliqua^{-1} and test weight than other treatments in comparison

Kumar (2014) from Pantnagar carried out a field trial to study the effect of different fertility levelson growth characteristics, yield attributes, and yield of Indian mustard (*Brassica juncea L.*)cultivar RGN-73. Different fertility levels comprised of Nitrogen @ 60, 80 and 100 kg ha^{-1}, Phosphorus @ 20 and 40 kg ha^{-1} and Potassium @ 0 and 30 kg ha^{-1} respectively. The results revealed that significantly higher growth characteristics such as plant height (200.3 cm), leaf area index (0.7), crop growth rate (0.046 g m^{-2} day^{-1}), yield attributes such as siliquae plant^{-1} (256.6), seeds siliqua^{-1} (13.8), test weight (3.9 g) and seed yield (1925 kg ha^{-1}) was recorded with the application of Nitrogen @ 100 kg ha^{-1}, Phosphorus @ 40 kg ha^{-1} and Potassium @ 30 kg ha^{-1}, respectively.

Meena (2016) from Kota conducted an experiment to study the effect of different fertility levels on the growth and productivity of hybrid Indian mustard and reported that 100 % RDF application (80 kg N + 40 kg P_2O_5) resulted in significantly higher seed yield (2372 kg ha^{-1}) and other yield characteristics viz. number of primary branches plant^{-1} (4.55), number of secondary branches plant (9.40), number of siliquae plant^{-1} (195.35), test weight (4.63), stover yield (4771 kg ha^{-1}), oil content (41.30%) and oil yield (933 kg ha^{-1}) respectively than other treatments in comparison.

Jat *et al*. (2017) from Sardarkrushinagar studied the effect of different NPK levels on the performance of Indian mustard and observed that application of Nitrogen @80 kg ha^{-1} resulted in a significant increase in seed yield besides maximum net returns of Indian Mustard than theapplication of 60 and 100 kg N ha^{-1} (4.40 and 11.54% respectively).

Kumar *et al*. (2017) from Faizabad studied the effect of different fertility levels on the growth andyield of Indian mustard. The results revealed that significantly higher growth characteristics, yield attributes, and seed yield (22.75 q ha^{-1}) were obtained using the combined application of RDF ($N:P_2O_5:K_20:S$ @ 120:60:40:30 Kg ha^{-1}) and vermicompost @ 5.0 t ha^{-1} respectively.

Kumar *et al*. (2017) from Moradabad conducted an experiment to study the effect of macro nutrients and FYM on productivity of mustard. The results revealed that the application of 75% NPK in combination with Sulphur @ 40 kg ha^{-1} and FYM@ 10 mt ha^{-1} resulted in maximum growth and yield attributing characters viz plant height (174.63 cm), number of branches plant^{-1} (24.47), test weight (5.52 g), seed yield (1541.5 kg ha^{-1}) and stover yield (5161.0 kg ha^{-1}) respectively.

Jat *et al*. (2018) from Sardarkrushinagar studied the effect of different fertility levels on the growth and yield of Indian mustard. Different fertility levels comprised of Nitrogen @80, 100 and 120 kg ha^{-1} and Phosphorus @ 20 and 40 kg ha^{-1}. The results revealed that application of Nitrogen @ 120 kg ha^{-1} along with 20 kg P_20_5 resulted in significantly higher seed yield (2595 kg ha^{-1}) than other treatments in comparison.

Panotra *et al.* (2018) from Jammu conducted an experiment at Baghpat to study the effect of different fertility levels on growth and yield of Indian mustard under irrigated conditions. Different fertility levels comprised of Nitrogen @ 0, 50 and 100 kg ha^{-1} and Phosphorus @ 0, 40 and 80 kg ha^{-1} respectively. The results revealed that the application of Nitrogen @ 100 kg ha^{-1} and Phosphorus @ 80 kg ha^{-1} resulted in maximum seed yield (15.94 q ha^{-1}) and stover yield (16.58 q ha^{-1}) than other treatments in comparison.

Raghuvanshi *et al.* (2018) from Faizabad conducted an experiment to study the performance of mustard (*B. juncea*) at different N levels (0, 40, 80 and 120 and 160 kg ha^{-1}) and reported that application of N @ 120 kg ha^{-1} resulted in significantly higher seed yield (16.44 q ha^{-1}) than other treatments in comparison.

Tomar (2018) from Pantnagar conducted an experiment to study the effect of different Nitrogen levels on mustard cultivar. Different nitrogen levels comprised of Nitrogen @ 80, 100 and 120 Kg ha^{-1}, respectively. The results revealed that significantly higher yield attributes such as seeds $siliquae^{-1}$ (15.4),length of siliqua (4.3 cm), 1000-seed weight (4.3 g) and seed yield (2135 kg ha^{-1}) was obtained with the application of Nitrogen @ 120 kg ha^{-1} which was 29.2% and 17.5% higher over-application of Nitrogen @ 80 kg and 100 kg ha^{-1}.

Yadav and Dhanai (2018) from Jhansi studied the effect of different doses of nitrogen and sulphur on seed yield and other characters on 'Varuna' variety of Indian mustard. Different fertility doses comprised of Nitrogen @ 40, 80 and 120 kg ha^{-1} and Sulphur @15, 30 and 45 kg ha^{-1} respectively. The results revealed that application of Nitrogen @ 120 kg ha^{-1} and Sulphur @ 45 kg ha^{-1} resulted in significantly higher seed yield (1869 kg ha^{-1}) than other treatment combinations in comparison.

Kumar *et al*. (2019) from Agra conducted an experiment to study the effect of biofertilizers and farmyard manure on sustainable production of Indian mustard (*Brassica juncea*). Treatments consisted of two levels of FYM (control and 5 t ha^{-1}) and NPK @ (50:30:20, 75:45:30, 100:60:40 kg ha^{-1}) respectively. The results reveal that among different fertility levels maximum seed yield (19.74 q ha^{-1}), stover yield (65.16 kg ha^{-1}), oil content (39.4 %) and oil yield (777.7 kg ha^{-1}) was obtained with the application of NPK @ 100:60:40 kg ha^{-1} than other treatment combinations in comparison. Similarly, application of FYM @ 5 t ha^{-1} resulted in maximum seed yield (17.32 q ha^{-1}), stover yield (57.30 q ha^{-1}), oil content (38.9 %) and oil yield (673 kg ha^{-1}) than control respectively.

Kumar *et al*. (2019) from Varanasi conducted an experiment to study the effect of FYM on the production of mustard. Treatments comprised of four levels of FYM (control, 6 t ha^{-1}, 10 t ha^{-1}, 20 t ha^{-1}). The results revealed that the application of FYM @ 10 t ha^{-1} resulted in maximum number of siliquae $plant^{-1}$(381.40), test weight (5.52 g), seed yield (1541.5 kg ha^{-1}) and stover yield (5161.0 kg ha^{-1}) than other FYM levels in comparison.

Mukherjee (2020) from Kalyani conducted an experiment to study the influence of different fertilizer doses on the yield of Indian mustard. Different fertility doses comprised of Nitrogen @ 30 45, 60, 75 and 90 kg ha^{-1}, Phosphorus @ 20, 30, 40, 50 and 60 kg ha^{-1} and Potassium@ 20, 30, 40, 50 and 60 kg ha^{-1} respectively. The results revealed that application of NPK @ 75:50:50 kg ha^{-1} resulted in significantly higher seed yield (1751 kg ha^{-1}) than other treatments in comparison.

2.2 Effect of different mustard varieties on growth, yield, quality, nutrient uptake and economics of mustard

Sharma (2013) from Morena conducted an experiment to study the performance of different mustard varieties (Varuna, Kranti, Rohini, JM–1 and JM–2) and reported that Rohini resulted in significantly higher seed and stover yield (2465 and 5350 kg ha^{-1}) than other varieties in comparison.

Haldar *et al*. (2014) from Mohanpur conducted an experiment to study the performance of different mustard varieties (NRCHB 101, SEJ-2, Ashirwad, $NPJ^{-}112$, JD-6, K-6 and B-9 as a control). The results revealed that significantly higher seed yield was observed in K-6 (1566 and 1633 kg ha^{-1}) in first and second year, respectively than other varieties in comparison.

Dinda *et al*. (2015) from Mohanpur conducted a study on the performance of different mustard varieties (NRCHB 101, NPJ-112, JD-6 and SEJ-2) under late sown conditions and reported that NRCHB 101 achieved significantly higher seed yield (1.54 t ha^{-1}) than other mustard varieties viz. NPJ-112, JD-6 and SEJ-2 in comparison.

Biswas *et al*. (2019) from Mohanpur conducted a field experiment on the performance of different hybrid mustard varieties (Kesari Gold, JD 6, B 85, RW 351, RW 8559 and B9) under late sown conditions. The results revealed that maximum seed yield was achieved by Kesari Gold than other varieties in comparison.

Lal *et al*. (2020) from Bikaner conducted an experiment with four mustard varieties (RGN-73, RGN-229, RH-30 and Pusa bold) under late sown conditions and reported that variety Pusa bold gave significantly higher plant height and test weight than other varieties in comparison whereas, RGN-73 gave significantly higher siliquae per plant (170.1) seed yield (1231 kg ha^{-1}), stover yield (4597 kg ha^{-1}) and biological yield (5828 kg ha^{-1}) than other varieties in comparison.

Priyanka *et al*. (2020) from Hisar conducted an experiment to study the performance of different mustard varieties (Kranti, Giriraj, CS-54 and CS-58). The results revealed that maximum seed and stover yield were observed in variety CS-58 (21.84 and 78.41 q ha^{-1}) than other varieties in comparison.

2.3 Effect of fertility schedules on nutrient uptake and economics of mustard

Singh *et al*. (2004) from Kota conducted an experiment to study the effect of Nitrogen @ (40, 60 and 80 kg N ha^{-1}) and Sulphur @ (20, 40 and 60 kg S ha^{-1}) on the economics of mustard. The results revealed that application of N @ 80 kg ha^{-1} resulted in maximum net return and benefit: cost ratio of ₹ 15,799 ha^{-1} and 2.69, during the first year and ₹ 18,193 ha^{-1} and 2.87 during the second year, respectively. Application of Sulphur @ 60 kg ha^{-1} gave maximum net return and benefit: cost ratio of ₹ 14,774 ha^{-1} and 2.95 during the first year and ₹ 17,058 ha^{-1} and 2.76 during the second year, respectively than other treatment combinations in comparison.

Nayak *et al.* (2006) from Varanasi conducted an experiment to study the growth and nutrient uptake patterns of Indian mustard (*Brassica juncea*) at various levels of N and S. Three nitrogen levels (90, 120, and 150 kg N ha^{-1}) and three sulphur levels were used in the treatments (0, 25 and 50 kg S ha^{-1}). The results revealed that application of Nitrogen @ 150 kg ha^{-1} and Sulphur @ 50 kg ha^{-1} resulted in maximum nutrient uptake than other treatment combinations in comparison.

Singh *et al*. (2010) from Varanasi carried out a field trial to study the effect of different fertility levels on the economics of Indian mustard (*Brassica juncea L.*) under late sown conditions. Different fertility levels comprised of four fertility levels i.e. 75% RDF, 100% RDF, 125% RDF and 150% RDF where RDF was N:P_2O_5:K_20:S @ 80, 40, 40, 30 kg ha^{-1}, respectively. The results revealed that application of 100% RDF produced highest net return (₹ 21,281 ha^{-1}) and B:C ratio (2.29) than other treatments in comparison.

Kumar *et al*. (2017) from Pantnagar conducted an experiment to study the effect of nutrient levels on yield, nutrient uptake, and economics of Indian mustard (*Brassica juncea L.*). Treatment consisted of 3 levels of Nitrogen (60, 80, and 100 kg ha^{-1}), 2 levels of phosphorus (20 and40 kg ha^{-1}) and 2 levels of potassium (0 and 30 kg ha^{-1}) respectively. The results revealed that the highest seed yield (1.93 t ha^{-1}), nutrient uptake (99 kg N, 42 kg P_2O_5, and 172 kg K_2O ha^{-1}), and benefit: cost ratio (1.54) were recorded with the application of N:P_20_5:K_20 @ 100:40:30 kg ha^{-1} than other fertility levels in comparison.

Jat *et al*. (2018) from Sardarkrushinagar studied the effect of different fertility levels on the economics of Indian mustard. Different fertility levels comprised of Nitrogen @80, 100 and 120 kg ha^{-1}, Phosphorus @ 20 and 40 kg ha^{-1} and Potassium @ 0 and 30 kg ha^{-1} respectively. The results revealed that the application of Nitrogen @ 120 kg ha^{-1}, Phosphorus @ 40 kg ha^{-1} and Potassium @ 30 kg ha^{-1} resulted in significantly higher net returns (₹ 67180 ha^{-1}) and B: C ratio (3.62) than other treatments in comparison.

Panotra *et al*. (2018) from Jammu conducted an experiment to study the economics and influence of different fertility levels on growth and yield of Indian mustard under irrigated condition. Different fertility levels comprised of Nitrogen @ 0, 50 and 100 kg ha^{-1} and Phosphorus @ 0, 40 and 80 kg ha^{-1} respectively. The results revealed that application of Nitrogen @ 100 kg ha^{-1} and Phosphorus @ 80 kg ha^{-1} resulted in maximum B:C ratio (2.34), highest gross return (₹ 25450) and highest net return (₹ 14551) respectively than other treatments in comparison.

Mohapatra *et al*. (2020) from Bhubaneswar studied the effect of three nitrogen levels (80, 100, 120 kg ha^{-1}), two Phosphorus levels (20, 40 kg P_20_5 ha^{-1}) and two potassium levels (0, 30 kg K_2O ha^{-1}) on economics of the Indian mustard variety. The results revealed that application of N:P_2O_5:K_20 @ (100:40:30) resulted in maximum net return (₹ 21112 ha^{-1}) and B:C ratio (1.80) respectively.

Mukherjee *et al*. (2020) from Kalyani conducted an experiment to study the effect of different fertilizer doses on nutrient uptake and economics of Indian mustard. Treatment consisted of 5 doses of nutrients N:P_20_5:K_20 @ (30:20:20, 45:30:30, 60:40:40, 75:50:50 and 90:60:60 kg ha^{-1}). The Results revealed that application of $NP_2O_5K_20$ @75:50:50 gave maximum net return (₹ 43,250 ha^{-1}) and B:C ratio of 3:01 than other treatments in comparison.

CHAPTER-III

MATERIALS AND METHODS

The current study, titled "Performance of Indian Mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region," was conducted during *Rabi* 2020-21 at the Research Farm, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu. This chapter contains a precise description of materials used and methodology adopted either in the field or in the laboratory during the course of investigation.

3.1 Experimental Site

3.1.1 Location

The field experiment was conducted during the *Rabi* season, 2020-21 at the Research Farm of the Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology, Main campus Chatha, Jammu. Geographically, the experimental site was located at $32^0$39′33′′ North latitude and $74^0$48′45′′ East longitude with an altitude of 293 meters above mean sea level in the Shiwalik foothills of North- Western Himalayas.

3.1.2 Climate and weather

The experimental site was sub-tropical in character with hot and dry early summers followed by hot and humid monsoons and cold winters. The mean annual rainfall varies from 1050 - 1115 mm out of which about 75 per cent is received from June to September. However, the total rainfall and its distribution are subject to large variations. During the summer and winter, the mean maximum and minimum temperatures fluctuate significantly. In the months of May and June, the temperature can reach 45°C, while in thewinter, especially in December and January, the temperature can drop to 2°C.The weather data for a crop season was recorded at the meteorological observatory of our university campus and has been presented graphically in Fig. (3.1) and tabulated in Appendix I. During the crop growth period from 47^{th} Meteorological week to 14^{th} Meteorological week, the mean maximum and minimum temperature varied from 14.9 to 31^0C and 2.9 to 13.7 ^{0}C, respectively. Both maximum and minimum temperature showed a fluctuation throughout the crop growth period. The total rainfall received during the crop season was 157.6 mm

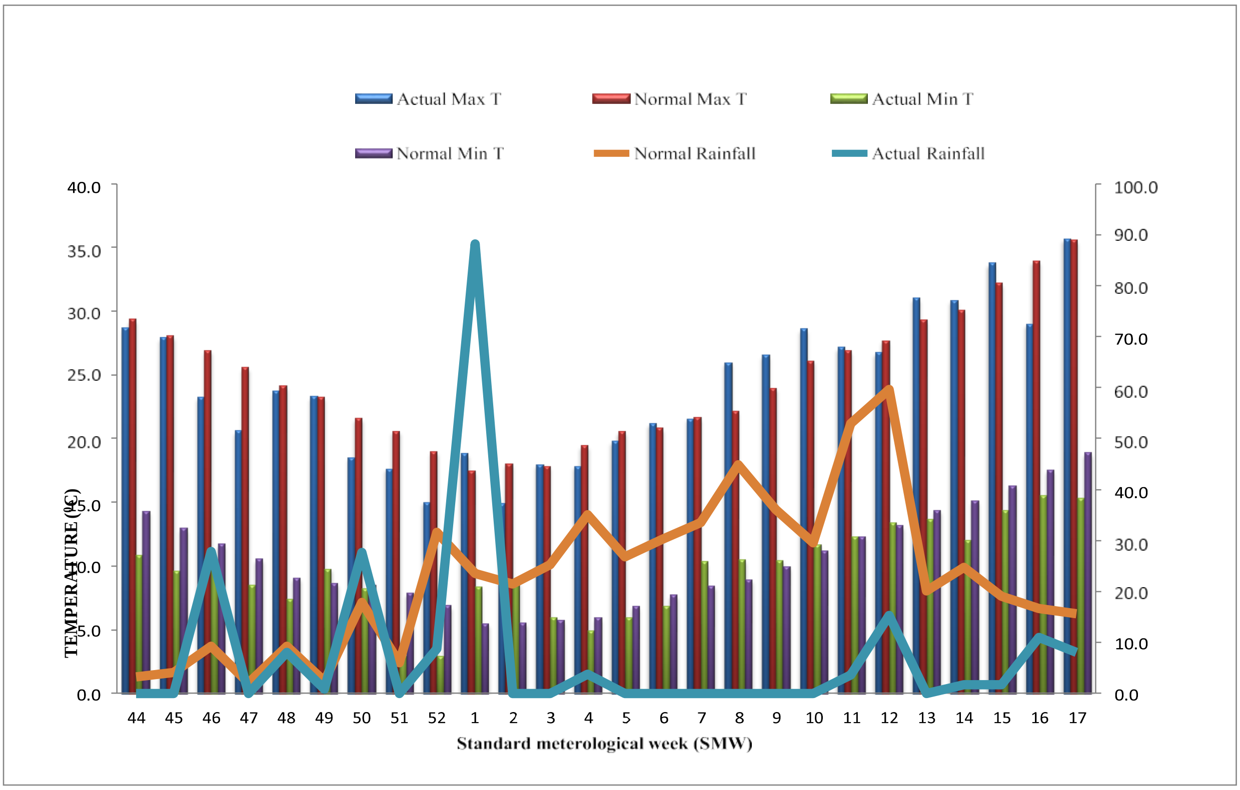


Fig: 3.1 Weekly observed and normal values of different weather parameters during crop growing period (*Rabi* 2020-21)

3.2 SOIL CHARACTERISTICS

3.2.1 Physico-chemical properties

In order to find out mechanical composition and fertility status of the soil of experimental site, samples were collected randomly from 0-15 cm soil layer. A composite soil sample was prepared and analysed separately for different physio-chemical characteristics of the soil. (Table 3.1)

Table 3.1: Initial Physico-chemical properties of experimental site (0-15 cm depth)

S. No.	Parameters	Value	Methods Employed
A	Mechanical properties		
i)	Sand (%)	63.51	Bouyoucous Hydrometer method (Piper,1966)
ii)	Silt (%)	13.32	
iii)	Clay (%)	23.17	
	Textural Class	Sandy clay loam	Textural Diagram (Black,1965)
B	Chemical properties		
i)	pH	7.45	1:2.5 Soil water suspension measured with glass electrode pH(Jackson,1973)
ii)	EC (dS m^{-1})	0.21	1:2.5 Soil water suspension used for pH determination (Jackson,1973)
iii)	Organic carbon (%)	61	Walkley and Black method (Jackson, 1973)
iv)	Available N (kg ha^{-1})	230	Alkaline potassium permangnate method (Subbiah and Asija,1956)
v)	Available P(kg ha^{-1})	14.31	Sodium bicarbonate extractable p method (Olsen *et al*. 1954)
vi)	Available K (kg ha^{-1})	150	Ammonium acetate extractable kmethod (Jackson,1973)
vii)	Available S (kg ha^{-1})	19.1	Turbidmetric method (Chesnin and Yien, 1950)

The analysis revealed that the soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction, medium in organic carbon, available phosphorus, available potassium and available sulphur and low in available nitrogen.

3.3 CROPPING HISTORY

The details of the crops and cropping systems used on the experimental field for the previous few years prior to the start of the experiment is as under.

Table 3.2: Cropping history of the experimental field

Year	**Season**	
	Kharif	***Rabi***
2018-19	Rice	Wheat
2019-20	Rice	Wheat
2020-21	Rice	Mustard

3.4 EXPERIMENTAL DETAILS

3.4.1 Treatment details

The experiment was laid out in spilt-split plot design, comprised of four varieties in main plot, without farmyard manure and with farmyard manure in sub plot and three fertility levels in sub-sub plot with three replications. The details of treatment wise layout plan of the presented study are depicted in Figure 3.2

Main plots (Varieties) = 4

V1- RSPR 69

V2- Pusa Mustard 26

V3- RVM 2

V4- NRCHB 101

Sub Plot (FYM) = 2

M1- Without FYM

M2- FYM @5 t ha^{-1}

Sub-sub plot (Fertility levels of N:P: K and Sulphur (kg ha^{-1}) = 3

F1- 60:30:15:20 kg ha^{-1}

F2- 80:40:20:25 kg ha^{-1}

F3- 100:50:25:30 kg ha^{-1}

3.4.2 Experimental details

- Design : Split-split plot design
- Test crop : Mustard
- Season : *Rabi*, 2020
- Sowing date : 24th, November, 2020
- Number of treatments : 24
- Number of replications : 03
- Total plots : 72
- Location : Research farm, Division of Agronomy, SKUAST Jammu, Chatha

3.5 Details of cultural operations

The details of various cultural operations carried out during the course of field experimentation are given in Table 3.3

Table 3.3 Calander of different cultural operations carried out during experimentation

S. No	Nature of operation	Date of operation	Details of cultural operation
1	Preparation of field	20 Nov, 2020	Tractor-drawn implements were used to prepare the experimental field.
2.	FYM application@ 5t ha^{-1}	21 Nov, 2020	FYM was used in accordance with the treatment plan.
3.	Lay out of experiment	24 Nov, 2020	Field layout was done manually with the help of rope and liner.
4.	Fertilizer application	24 Nov, 2020	Full dose of P, K, S along with half dose of N was applied manually.
5.	Sowing of mustard	24 Nov, 2020	According to the treatments, line sowing wasdone manually at 30 cm x 10 cm spacing.
6.	Herbicide application	24 Nov, 2020	Application of pre-emergence herbicide (Pendimethalin 30% EC @ 1 kg a i. ha^{-1}).
7.	Thinning	30 Dec, 2020	Thinning was done to keep the plant population at an optimal level.
8.	Top dressing	3 Jan, 2021	Urea was top dressed manually as per the treatment plan.
9.	Plant protection measures	17 Feb, 2021	Imidacloprid @ 30g ha^{-1} was used against aphid attack and Metalaxyl 8% + Mancozeb 64% WP @ 2000 g ha^{-1} was used against Alternaria blight.
10.	Harvesting	5 April, 2021	Crop was harvested manually.
11.	Threshing	9 April, 2021	Manual threshing was done.

3.5.1 Field preparation

After harvest of the previous crop, the experimental field was tilled with tractor drawn cultivator, followed by two harrowing with disc harrow to break the clods for making pulverized seed bed. The trial field was then laid out in accordance with the layout plan with irrigation routes and channels. The entire experimental area was divided into 72 plots, each measuring 20.4 m^2. In the field, plot routes, replication borders, and drainage ditches were all manually created.

3.5.2 Fertilizer application

The application of the nutrients was done as per treatment plan. The recommended dose of $N:P_20_5:K_2O:S$ as per the treatment plan was 60:30:15:20 kg ha^{-1}, 80:40:20:25 kg ha^{-1}, 100:50:25:30 kg ha^{-1} respectively. Urea, diammonium phosphate, muriate of potash, and gypsum were used as nitrogen, phosphorus, potassium, and sulphur sources, respectively.As a basal dose, half of the nitrogen was applied along with the full doses of phosphorus, potassium, and sulphur at the time of sowing. The remaining nitrogen was used as a top dressing. With each increase in fertility doses, Nitrogen was increased at the rate of 20 kg ha^{-1}, Phosphorus at the rate of 10 kg ha^{-1}, Potassium at the rate of 5 kg ha^{-1} and Sulphur at the rate of 5 kg ha^{-1} respectively.

Table 3.4: Details of applied nutrient doses as per treatment plan in mustard crop

Doses of Nitrogen	**Nitrogen (Kg ha^{-1})**		**Phosphorus**	**Potash**	**Gypsum**
	Basal	**Top dressing**			
60 kg N ha^{-1}	**30**	**30**	**30**	**15**	**20**
80 Kg N ha^{-1}	**40**	**40**	**40**	**20**	**25**
100 kg N ha^{-1}	**50**	**50**	**50**	**25**	**30**

3.5.3 Sowing

Mustard seeds were sown on 24th Nov, 2020. Seed rate used was 6 kg ha^{-1}. Line sowing was done manually,keeping row to row distance of 30 cm. The total number of rows in each plot were 17.

3.5.4 Thinning

The desired plant population was maintained uniformly either by gap filling or thinning within 8-12 days of seeding. The final thinning was done at 30 DAS to maintain uniform intra row plant spacing in each plot.

3.5.5 Weed control

Pendimethalin 30% EC was applied as a pre-emergence herbicide on the day of sowing@ 1 kg a.i. ha^{-1} in 500-600 litres water for successful weed control. Hand weeding was also done from time to time to keep weeds under control.

3.5.6 Plant protection measures

Imidacloprid @ 30g ha^{-1} was used against aphid attack and Metalaxyl 8% + Mancozeb 64% WP @ 2000 g ha^{-1} was used against Alternaria blight.

3.5.7 Harvesting of crop

The crop was harvested when it reached full maturity, as determined by visual inspection. The mustard crop was harvested on April 5, 2021. Sickles were used to harvest the crop. The seed moisture level was at 12-14 percent at harvest, and the straw colour had transformed from green to golden yellow. The crop plants were allowed to sun dry for 2-3 days after being cut from the ground level. After drying, the harvested product from the net plot size was tied into bundles, labelled, and the weight of the bundles was recorded using a spring balance.

3.5.8 Threshing of crop

Before threshing, the net plot's produce was weighed and recorded individually. The seed weight from the net plot was recorded after threshing with a wooden stick. To calculate stover yield, the entire produce of each plot was subtracted from the seed weight.

3.6 Observations recorded

3.6.1 Soil Analysis

Before sowing the crop, soil samples were taken from the experimental field up to a depthof 15 cm. Standard methods were used to calculate the initial parameters of the soil, such as pH, EC, Organic Carbon, available Nitrogen, Phosphorus, Potassium, and Sulphur. The samples were dried in the shade and then filtered through a 2 m sieve before being analysed.

3.6.1.2 pH

pH was determined by suspension of soil and water (1:2.5) using glass-calomel electrode (Jackson, 1973).

3.6.1.3 Electrical Conductivity (dS m^{-1})

Electrical Conductivity was determined by salt bridge measurement from the suspension used for pH determination (Jackson, 1973).

3.6.1.4 Organic carbon (%)

Organic carbon was determined by dichromate oxidation of organic matter (Jackson, 1973).

3.6.1.5 Available nitrogen (kg ha^{-1})

Available nitrogen was determined by modified alkaline permanganate method as described by Subbiah and Asija (1956) and was expressed in (kg ha^{-1}).

3.6.1.6 Available phosphorus (kg ha^{-1})

Available phosphorus was determined using 0.5 M sodium bicarbonate (pH = 8.5) extractable P method described by Olsen *et al.* (1954). The intensity of colour developedby stannous chloride was measured at 660 nm on spectrophotometer and was expressed asP kg ha^{-1}.

3.6.1.7 Available potassium (kg ha^{-1})

Available K was extracted with neutral normal ammonium acetate solution as described by Jackson (1973) and potassium was determined by flame photometer and expressed as K kg ha^{-1}.

3.6.1.8 Available sulphur (kg ha^{-1})

The available sulphur content of soil was extracted by calcium chloride (0.15 per cent $CaCl_2.2H_2O$). 5 g of air-dried soil was taken and 25 ml Calcium chloride solution (0.15%) was added to it and was shaken for 30 minutes. The suspension was filtered through Whatman No. 42. 10 ml of the filtrate was pipette out readings were taken using spectrophotometer at wavelength of 420 nanometer.

3.6.2 Growth parameters

For all the growth and development studies during the crop growth period, five plants were selected randomly and tagged in each plot except for that of leaf area index and dry matter accumulation where plants were selected from border rows for recording observations. Initially the growth parameters were recorded at 30, 60, 90 and 120 days after sowing till harvesting.

3.6.2.1 Plant height (cm)

The height of all five tagged plants was measured in centimetre from the ground level to the tip of the Plant at 30, 60, 90 and 120 DAS and average of all the five plants was taken for statistical analysis.

3.6.2.2 Dry matter accumulation (g m^{-2})

Plant samples for dry matter accumulation were taken from the second row of each side at different stages by clipping the plants close to the soil surface from each plot. They were sundried and thereafter shifted in the oven to dry at a temperature of 65±5°C till a constant weight was achieved and dry matter accumulation was recorded which was expressed as dry weight in g m^{-2}.

.3.6.2.3 Leaf area index

Leaf area index was recorded at 30, 60 and 90 days after sowing using the given formula

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area per plant (cm}^2\text{)}} \times \text{correction factor}$$

3.6.2.4 Crop growth rate (g m^{-2} day^{-1})

The increase in plant material per unit time or cumulative crop growth rate (CGR)was calculated as per the formula given by Radford (1967) and was expressed as g m^{-2} day^{-}

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

W_1 = Weight at T_1 of the period

W_2 = Weight at T_2 of the Period

T_1 = Time in date at the start of the period

T_2 = Time in the date at the end of the period

3.6.3 Yield attributes

3.6.3.1 Number of primary branches $plant^{-1}$

The total number of primary branches produced $plant^{-1}$ counted at maturity of five randomly tagged plants in all the treatments. The mean of five plants were recorded as the number of primary branches plant$^{-1.}$

3.6.3.2 Number of secondary branches plant^{-1}

The total number of secondary branches plant^{-1} was counted at maturity of five randomly tagged plants in all the treatments. The mean of five plants was recorded as the number of secondary branches plant^{-1}.

3.6.3.3 Number of siliquae plant^{-1}

Total number of siliquae plant^{-1} was recorded from five tagged plants at harvest. Mean of five plants was recorded as the number of siliquae produced plant^{-1}.

3.6.3.4 Number of seeds siliqua^{-1}

Seeds of five siliquae per plant from randomly five tagged plants were recorded at harvest. Mean number of seeds of five siliquae per plant of five tagged plants was recorded as number of seeds siliquae-1

3.6.3.5 1000-seed weight (g)

One thousand seeds were randomly selected from each net plot's bulk produce and counted, weighed, and expressed as 1000-seed weight in grams.

3.6.3.6 Biological yield (kg ha^{-1})

Biological yield was calculated by adding the respective yields of seed and stover in kg ha^{-}

3.6.3.7 Seed yield (kg ha^{-1})

The threshed seed of mustard crop obtained from each net plot were weighed separately and finally converted into (kg ha^{-1}) by multiplying with conversion factor given below.

$$\text{Seed yield (kg ha}^{-1}\text{)} = \frac{\text{Yield obtained from net plot (kg)}}{\text{Area of net plot} \times 100} \times 10{,}000$$

3.6.3.8 Stover yield (kg ha^{-1})

The total biological yield (seed + straw) from the net plot was recorded and stover yield was worked out by subtracting the seed yield from the biological yield and expressed in (kg ha^{-1}) by multiplying with the same conversion factor employed for seed yield of mustard.

3.6.3.9 Harvest index (%)

The ratio of economic yield to the biological yield (harvest index) was computed using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (seeds)}}{\text{Biological yield (seed + stover)}} \times 100$$

3.7 Nutrient uptake studies

3.7.1 Nutrient Content in plant

Plant samples were taken during harvesting to determine N, P, K, and S concentrations. From each plot mustard seeds were taken for uptake studies. The samples were oven dried before being finely crushed with an electric grinder and tested for nitrogen, phosphorus, potassium, and sulphur levels. The uptake of N, P, K, and S in seed and stover samples was estimated by multiplying the percent nutrient content by the dry matter accumulation, as shown in the formula below:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient Content (\%) x dry matter accumulation (kg ha}^{-1}\text{)}}{100}$$

The details of various methods which were followed to determine the N, P, K and S uptake of mustard seed and stover have been given in Table 3.5.

Table 3.5: Details of method employed for chemical analysis of seed and stover and samples of mustard

S. No.	Nutrient assessed	Method employed
1	Nitrogen	Modified microkjeldhal method (Piper, 1966)
2	Phosphorus	Vanadomolybdo phosphoric acid method (Jackson,1973)
3	Potassium	Flame photo meter method (Jackson, 1973)
4	Sulphur	Turbidmetric method, (Chesnin and Yien, 1950)

3.8 Quality Attributes

3.8.1 Protein content in seed (%)

Protein content was calculated by using following formula Protein content (%) = Nitrogen content (%) x 6.25.

3.8.2 Oil content in seed (%)

Oil content of oven dried seeds was estimated by extracting oil using petroleum ether (60 – 80º C) as solvent and Soxhlet Apparatus (Sadasivam and Manickam, 1992).

3.8.3 Oil yield (kg ha^{-1})

Oil yield kg ha $^{-1}$ was calculated by using following formula Oil yield (kg ha^{-1}) = Seed oil content (%) x Seed yield (kg ha $^{-1}$).

3.8 Relative economics

3.8.1 Cost of cultivation (₹ha^{-1})

The overall cost was estimated by aggregating the expenditure involved in all types of operations as per treatment on per hectare basis in ha^{-1}, and the cost of different operations was calculated for different treatments on the basis of existing market values of inputs and operations.

3.8.2 Gross returns (₹ha^{-1})

Gross returns were computed by multiplying total seed and stover yields by current market prices, and then presented on a per hectare basis for each treatment.

3.8.3 Net returns (₹ha^{-1})

The total cost of cultivation was subtracted from the gross returns for each treatment to calculate net returns.

3.8.4 Benefit: Cost Ratio (₹ha^{-1})

For each treatment, the benefit: cost ratio was computed by dividing net returns by the cost of cultivation.

$$\text{Benefit: Cost Ratio} = \frac{\text{Net Returns (₹ ha}^{-1})}{\text{Cost of Cultivation (₹ ha}^{-1})}$$

3.9 Statistical Analysis

The data in the thesis is presented as mean values. The analysis of variance is used to statistically analyse all of the observations. On the basis of the null hypothesis, the results were tested for the treatments mean using the F-test of significance (Cochran and Cox, 1957). Standard errors with a threshold difference of 5% of significance were computed where necessary to distinguish treatment effects from chance effects (Panse and Sukhamate, 1967). Below is a key for degrees of freedom used in analysis of variance (ANOVA).

Table 3.6. Analysis of variance (ANOVA)

Sources of variation	**Degree of freedom**
Replication (r-1)	3-1 = 2
Main Plot (V) (v-1)	4-1 = 3
Error (a) (r-1) (v-1)	(3-1) (4-1) = 6
Sub Plot (M) (m-1)	2-1 = 1
V×M (V-1) (M-1)	(4-1) (2-1) = 3
Error (b) (r-1) (m-1)	4 (3-1) (2-1) = 8
Sub-Sub Plot (F) (f-1)	(3-1) = 2
V×F (v-1) (f-1)	(4-1) (3-1) =6
M×F (m-1) (f-1)	(2-1) (3-1) = 2
V×M×F (v-1) (m-1) (f-1)	(4-1) (2-1) (3-1) = 6
Error (c) V×M (r-1) (f-1)	4×2 (3-1) (3-1) = 32
Total (rvmf-1)	**72-1=71**

CHAPTER-IV

EXPERIMENTAL RESULTS

The results obtained during the course of investigation entitled "Performance of Indian Mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region" during *Rabi* 2020-2021 have been described in this chapter under following heads. The data recorded was analyzed and presented through tables and graphs.

4.1 Growth Parameters

The growth of mustard crop was measured in terms of plant height (cm), leaf area index, drymatter accumulation (m^2) and crop growth rate (g m^{-2} day^{-1}).

4.1.1 Plant height (cm)

Plant height is an important parameter reflecting the growth of the crop plant. In general, plant height increased with the advancement of the crop age till harvest, and a conspicuous increase was observed between 60 and 90 DAS. The data presented in Table 4.1 revealed that varieties (V) differed significantly in plant height with varying level of FYM (M) and fertility level (F). Among the different varieties at 30 DAS and subsequent growth stages of Indian mustard variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a significant taller plant (9.0, 61.2, 180.1, 181.2 cm) than V1 (RSPR-69) and V2 (Pusa mustard 26) at all stages of observation.

A significant increase in plant height was recorded with the application of M2 (FYM @ 5t) ha^{-1} (8.1, 56.3, 173.8, 174.4 cm) at 30, 60, 90, and 120 DAS respectively compared to M1 (no FYM application).

Among the different fertility levels (F1, F2 and F3), significantly higher plant height at 30, 60, 90, and 120 DAS respectively was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied (7.99, 56.32, 173.60, 174.18 cm) in comparison to the fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) application and fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) application. Whereas, lowest plant height was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) (7.4, 55.4, 172.5 and 173.1cm).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table. 4.1.1).

Interaction effect of varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V) significantly higher plant height was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) in comparison to the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F_1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) at 30 DAS. The lowest plant height was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}). However, at other growth stages i.e., 60 DAS, 90 DAS, and 120 DAS respectively significantly higher plant height was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest plant height was observed with application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of FYM (M) x fertility levels (F) application was also found to be significant. At same level of FYM (M), a significantly higher plant height was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) in comparison to fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:15 kg ha^{-1}) and fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) at 30 DAS. However, lowest plant height was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

At 60 DAS significantly higher plant height was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}). However, at other growth stages i.e., 90 DAS and 120 DAS respectively, significantly higher plant height was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest plant height was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) was also found to be significant. At same level of varieties (V) and FYM (M) significantly higher plant height was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at 30 60, 90, and 120 DAS respectively. However, lowest plant height was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}). However interaction effect of application of fertility F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) was found to be at par with fertility level F2 and F3 at 60, 90 and 120 DAS respectively at same level of Varieties (V) and FYM (M).

However, interaction effect of varieties FYM (V×M) was found to be non-significant.

Table 4.1. Effect of different varieties, farmyard manure and various fertilizer doses on plant height (cm) of Indian mustard at various growth stages.

Treatments	30 DAS	60 DAS	90 DAS	120 DAS
(V) Varieties				
(V1) RSPR 69	6.84	51.47	167.25	167.71
(V2) Pusa mustard 26	6.32	50.63	165.33	165.76
(V3) RVM 2	9.04	61.22	180.18	181.22
(V4) NRCHB 101	8.65	60.04	179.75	180.21
SEm±	0.60	2.45	2.80	2.80
CD (5%)	2.09	8.47	9.68	9.67
(M) Farmyard manure application				
(M1) Without FYM	7.28	55.34	172.45	173.04
(M2) FYM @ 5 t ha^{-1}	8.15	56.34	173.80	174.40
SEm±	0.04	0.13	0.20	0.20
CD (5%)	0.15	0.42	0.67	0.65
(F) Fertility levels (N:P_20_5:K_20:S kg ha^{-1})				
(F1) 60:30:15:20 kg ha^{-1}	7.45	55.48	172.56	173.16
(F2) 80:40:20:25 kg ha^{-1}	7.70	55.72	173.22	173.83
(F3) 100:50:25:30 kg ha^{-1}	7.99	56.32	173.60	174.18
SEm±	0.02	0.10	0.10	0.11
CD (5%)	0.08	0.29	0.30	0.31
Interactions				
(V×M) Variety × FYM	NS	NS	NS	NS
(V×F) Variety × Fertility levels	0.16	0.58	0.61	0.63
(M×F) FYM × Fertility level	0.11	0.41	0.43	0.44
(V×M×F) Variety × FYM× Fertility level	0.22	0.83	0.87	0.89

Table 4.1.1 Interaction effect of different varieties, farmyard manure and various fertilizer doses on plant height (cm) of Indian Mustard at 30 DAS

(VxMxF)	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	6.34	7.11	5.62	6.56	8.42	8.87	8.05	8.66
F2	6.39	7.27	5.78	6.80	8.62	9.42	8.22	9.09
F3	6.57	7.38	6.18	7.02	8.76	10.17	8.44	9.45

VxM	M1	M2	Mean V
V1	6.43	7.25	6.84
V2	5.86	6.79	6.32
V3	8.60	9.48	9.04
V4	8.24	9.06	8.65
Mean M	7.28	8.15	

VxF	F1	F2	F3	MeanV
V1	6.72	6.83	6.97	6.84
V2	6.09	6.29	6.6	6.32
V3	8.64	9.02	9.46	9.04
V4	8.35	8.66	8.95	8.65

MxF	F1	F2	F3
M1	7.10	7.25	7.49
M2	7.80	8.14	8.50
Mean F	7.45	7.70	7.99

	C.D.	SE(d)	SEm±
Factor (V)	2.09	0.85	0.60
Factor (M)	0.15	0.06	0.04
(VxM)	NS	0.13	0.09
Factor (F)	0.08	0.04	0.02
VxF	0.16	0.07	0.05
MXF	0.11	0.05	0.04
VXMXF	0.22	0.11	0.07

V1- RSPR 69 **V2-** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.1.2 Interaction effect of different varieties, farmyard manure and various fertilizer doses on plant height (cm) of Indian mustard at 60 DAS

(VxMxF)								
	V1		V2		V3		V4	
	M1	M2	M1	M2	M1	M2	M1	M2
F1	51.04	51.71	49.71	50.30	60.57	61.06	59.44	60.04
F2	51.16	51.80	49.77	50.54	60.81	61.60	59.61	60.48
F3	51.22	51.88	50.02	53.47	60.95	62.35	59.83	60.84
VxM				VxF				
	M1	M2	Mean V		F1	F2	F3	Mean V
V1	51.14	51.80	51.47	V1	51.37	51.48	51.55	51.47
V2	49.83	51.44	50.63	V2	50.00	50.16	51.75	50.63
V3	60.78	61.67	61.22	V3	60.81	61.21	61.65	61.22
V4	59.62	60.45	60.04	V4	59.74	60.04	60.33	60.04
Mean M	55.34	56.34			C.D.	SE(d)	SEm±	
MxF				Factor (V)	8.47	3.47	2.45	
				Factor (M)	0.42	0.18	0.13	
	F1	F2	F3	(VxM)	NS	0.37	0.26	
				Factor (F)	0.29	0.14	0.10	
M1	55.19	55.34	55.50	VxF	0.58	0.28	0.20	
M2	55.78	56.10	57.13	MXF	0.41	0.20	0.14	
Mean F	55.48	55.72	56.32	VXMXF	0.83	0.40	0.28	

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.1.3 Interaction effect of different varieties, farmyard manure and various fertilizer doses on plant height (cm) of Indian mustard at 90 DAS

VxMxF

	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	166.20	167.54	163.91	164.50	179.47	179.96	179.14	179.74
F2	167.04	167.63	163.97	167.41	179.71	180.50	179.31	180.18
F3	167.05	168.02	164.22	167.98	179.85	181.59	179.53	180.60

VxM

	M1	M2	Mean V
V1	166.77	167.73	167.25
V2	164.03	166.63	165.33
V3	179.68	180.68	180.18
V4	179.32	180.17	179.75
Mean M	172.45	173.80	

VxF

	F1	F2	F3	Mean V
V1	166.87	167.34	167.53	167.25
V2	164.20	165.69	166.10	165.33
V3	179.71	180.11	180.72	180.18
V4	179.44	179.74	180.07	179.75

MxF

	F1	F2	F3
M1	172.18	172.51	172.66
M2	172.93	173.93	174.54
Mean F	172.56	173.22	173.60

	C.D.	SE(d)	SEm±
Factor (V)	9.68	3.96	2.80
Factor (M)	0.67	0.29	0.20
(VxM)	NS	0.58	0.41
Factor (F)	0.30	0.15	0.10
VxF	0.61	0.30	0.21
MXF	0.43	0.21	0.15
VXMXF	0.87	0.42	0.30

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_{2}0_{5}:K_{2}O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_{2}O_{5}:K_{2}O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_{2}O_{5}:K_{2}O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.1.4 Interaction effect of different varieties, farmyard manure and various fertilizer doses on plant height (cm) of Indian mustard at 120 DAS respectively

VxMxF								
	V1		V2		V3		V4	
	M1	M2	M1	M2	M1	M2	M1	M2
F1	166.86	168.00	164.19	164.96	180.43	181.02	179.6	180.20
F2	167.40	168.09	164.43	167.87	180.77	181.56	179.77	180.77
F3	167.51	168.37	164.68	168.44	180.91	182.61	179.99	180.94
VxM				VxF				
	M1	M2	MeanV		F1	F2	F3	Mean V
V1	167.26	168.15	167.71	V1	167.43	167.75	167.94	167.71
V2	164.43	167.09	165.76	V2	164.57	166.15	166.56	165.76
V3	180.70	181.73	181.22	V3	180.72	181.17	181.76	181.22
V4	179.78	180.64	180.21	V4	179.90	180.27	180.46	180.21
Mean M	173.04	174.40			C.D.	SE(d)	SEm±	
MxF				Factor (V)	9.67	3.96	2.80	
				Factor (M)	0.65	0.28	0.20	
	F1	F2	F3	(VxM)	N/A	0.57	0.40	
				Factor (F)	0.31	0.15	0.11	
M1	172.77	173.09	173.27	VxF	0.63	0.31	0.21	
M2	173.54	174.57	175.09	MXF	0.44	0.21	0.15	
Mean F	173.16	173.83	174.18	VXMXF	0.89	0.43	0.31	

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

4.1.2 Leaf Area Index

Varieties (V) differed significantly in leaf area index with varying level of FYM (M) and fertility (F) from 30 DAS onwards up to 90 DAS. However, no leaves were present at 120 DAS respectively. The data presented in Table 4.2 revealed that varieties (V) at varying FYM (M) and fertility levels (F) differed significantly in leaf area index of Indian mustard up to 90 DAS. At 30 DAS and subsequent growth stages of Indian mustard variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a significantly higher leaf area index (1.58, 3.60, and 4.92) at 30, 60, and 90 DAS than V1 (RSPR-69) and V2 Pusa Mustard 26 in comparison under late sown conditions of Jammu region. However, a lowest leaf area index was recorded in V2 (Pusa mustard 26) variety (1.12, 3.10, and 4.07) at 30, 60, 90, and 120 DAS respectively.

Similarly, a significant increase in leaf area index was recorded with the application of M2 (FYM @ 5t) ha^{-1} (1.54, 3.51, and 4.84) than M1 (no FYM application) in comparison (1.12, 3.16, and 4.17) at 30, 60 and 90 DAS respectively.

Among the different fertility levels (F1, F2 and F3), a significantly higher leaf area index was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied (1.45, 3.40 and 4.63) at 30, 60 and 90 DAS respectively than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) application (1.13, 3.22 and 4.27).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table. 4.2.1)

Interaction effect of varieties (V) × fertility level (F) was found to be significant. At same level of varieties significantly higher leaf area index was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest leaf area index was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of FYM (M) x fertility levels (F) application was also found to be significant. At same level of FYM (M), a significantly higher leaf area index was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at 30, 60, and 90 DAS respectively. However, lowest leaf area index was obtained with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At same level of varieties (V) and FYM (M), significantly higher leaf area index was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) . The, lowest leaf area index was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) .

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

Table 4.2: Effect of different varieties, farmyard manure and various fertilizer doses on leaf area index of Indian mustard at various crop growth stages

Treatments	**30 DAS**	**60 DAS**	**90 DAS**
(V) Varieties			
(V1) RSPR 69	1.19	3.14	4.12
(V2) Pusa mustard 26	1.12	3.10	4.07
(V3) RVM 2	1.58	3.60	4.92
(V4) NRCHB 101	1.44	3.47	4.89
SEm±	0.07	0.10	0.21
CD (5%)	0.26	0.37	0.74
(M) (Farmyard manure application			
(M1) Without FYM	1.12	3.16	4.17
(M2) FYM @ 5 t ha^{-1}	1.54	3.51	4.84
SEm±	0.02	0.02	0.03
CD (5%)	0.07	0.07	0.11
(F) Fertility levels ($N:P_20_5:K_20:S$ kg ha^{-1})			
(F1) 60:30:15:20 kg ha^{-1}	1.13	3.22	4.27
(F2) 80:40:20:25 kg ha^{-1}	1.42	3.38	4.60
(F3) 100:50:25:30 kg ha^{-1}	1.45	3.40	4.63
SEm±	0.01	0.009	0.01
CD (5%)	0.03	0.02	0.03
Interactions			
(V×M) Variety × FYM	NS	NS	NS
(V×F) Variety × Fertility levels	0.07	0.05	0.05
(M×F) FYM × Fertility level	0.05	0.03	0.03
(V×M×F) Variety × FYM× Fertility level	0.10	0.07	0.07

Table 4.2.1 Interaction effect of different varieties, farmyard manure and various fertilizer doses on leaf area index of Indian mustard at 30 DAS

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	0.60	1.29	0.51	1.27	1.29	1.59	1.01	1.49
F2	1.10	1.53	1.07	1.38	1.45	1.78	1.41	1.66
F3	1.11	1.54	1.08	1.42	1.45	1.9	1.41	1.68

VxM			
	M1	**M2**	**Mean V**
V1	0.94	1.45	1.19
V2	0.89	1.36	1.12
V3	1.40	1.76	1.58
V4	1.28	1.61	1.44
Mean M	1.12	1.54	

VxF				
	F1	**F2**	**F3**	**Mean V**
V1	0.94	1.31	1.32	1.19
V2	0.89	1.23	1.25	1.12
V3	1.44	1.61	1.67	1.58
V4	1.25	1.54	1.54	1.44

MxF			
	F1	**F2**	**F3**
M1	0.85	1.26	1.26
M2	1.41	1.59	1.63
Mean F	1.13	1.42	1.45

	C.D.	**SE(d)**	**SEm±**
Factor (V)	0.26	0.10	0.07
Factor (M)	0.07	0.03	0.02
(VxM)	NS	0.06	0.04
Factor (F)	0.03	0.01	0.01
VxF	0.07	0.03	0.02
MXF	0.05	0.02	0.01
VXMXF	0.10	0.05	0.03

V1- RSPR 69 **V2** (Pusa mustard 26) **V3**- RVM 2 **V4**- (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.2.2 Interaction effect of different varieties, farmyard manure and various fertilizer doses on leaf area index of Indian mustard at 60 DAS

VxMxF

	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	2.96	3.19	2.78	3.17	3.38	3.59	3.13	3.52
F2	2.99	3.35	2.98	3.34	3.46	3.83	3.35	3.72
F3	3.02	3.36	3.00	3.35	3.47	3.91	3.36	3.75

VxM

	M1	M2	Mean V
V1	2.99	3.30	3.14
V2	2.92	3.29	3.10
V3	3.43	3.77	3.60
V4	3.28	3.67	3.47
Mean M	3.16	3.51	

VxF

	F1	F2	F3	Mean V
V1	3.08	3.17	3.19	3.14
V2	2.98	3.16	3.17	3.10
V3	3.48	3.64	3.69	3.60
V4	3.33	3.54	3.56	3.47

MxF

	F1	F2	F3
M1	3.06	3.19	3.21
M2	3.37	3.56	3.59
Mean F	3.22	3.38	3.40

	C.D.	SE(d)	SEm±
Factor (V)	0.37	0.15	0.10
Factor (M)	0.07	0.03	0.02
(VxM)	NS	0.06	0.04
Factor (F)	0.02	0.01	0.009
VxF	0.05	0.02	0.01
MXF	0.03	0.01	0.01
VXMXF	0.07	0.03	0.02

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.2.3 Interaction effect of different varieties, farmyard manure and various fertilizer doses on leaf area index of Indian mustard at 90 DAS

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	3.78	4.24	3.42	4.20	4.51	4.84	4.20	4.99
F2	3.89	4.45	3.82	4.55	4.67	5.41	4.65	5.39
F3	3.9	4.47	3.85	4.58	4.69	5.44	4.67	5.47
VxM				**VxF**				
	M1	**M2**	**Mean V**		**F1**	**F2**	**F3**	**Mean V**
V1	3.85	4.39	4.12	**V1**	4.01	4.17	4.18	4.12
V2	3.7	4.44	4.07	**V2**	3.81	4.18	4.21	4.07
V3	4.62	5.23	4.92	**V3**	4.68	5.04	5.06	4.92
V4	4.50	5.29	4.89	**V4**	4.6	5.02	5.07	4.89
Mean M	4.17	4.84			**C.D.**	**SE(d)**	**SEm±**	
MXF				**Factor (V)**	0.74	0.30	0.21	
				Factor (M)	0.11	0.04	0.03	
	F1	**F2**	**F3**	**(VxM)**	NS	0.09	0.06	
				Factor (F)	0.03	0.01	0.01	
M1	3.98	4.25	4.27	**VxF**	0.07	0.03	0.02	
M2	4.57	4.95	4.99	**MXF**	0.05	0.02	0.01	
Mean F	4.27	4.60	4.63	**VXMXF**	0.11	0.05	0.03	

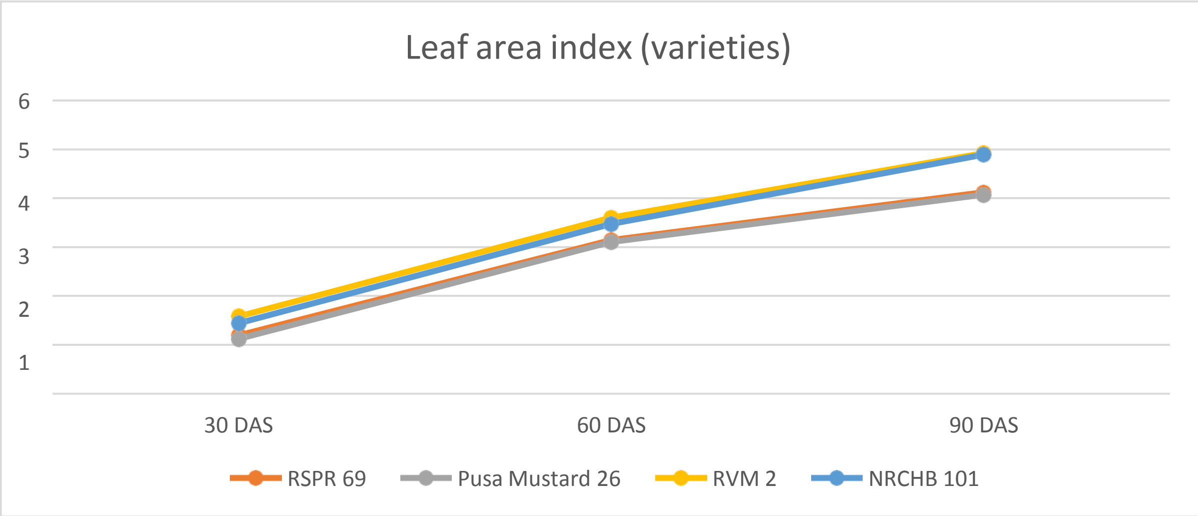
V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

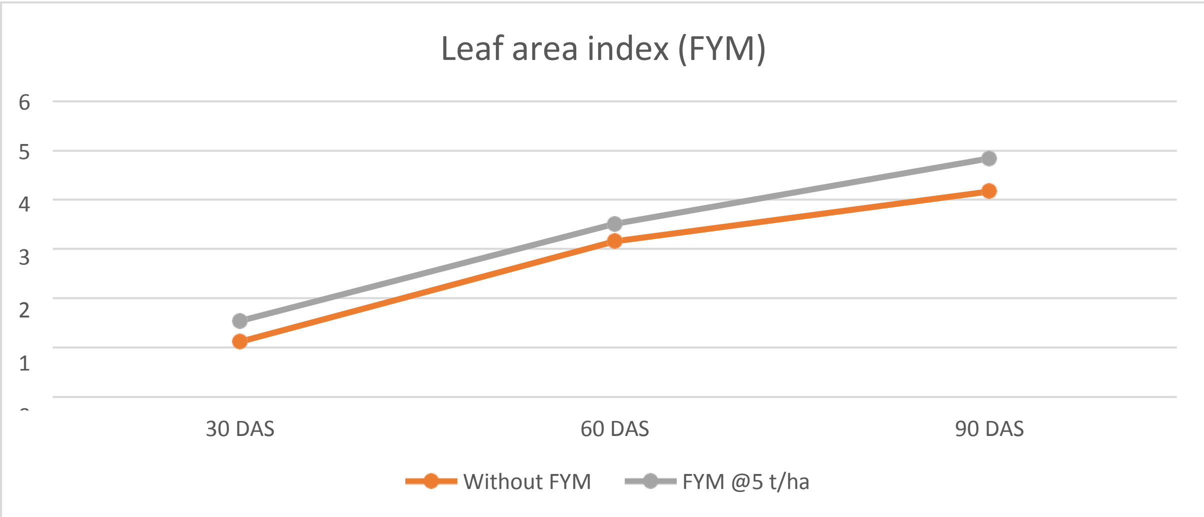
M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}





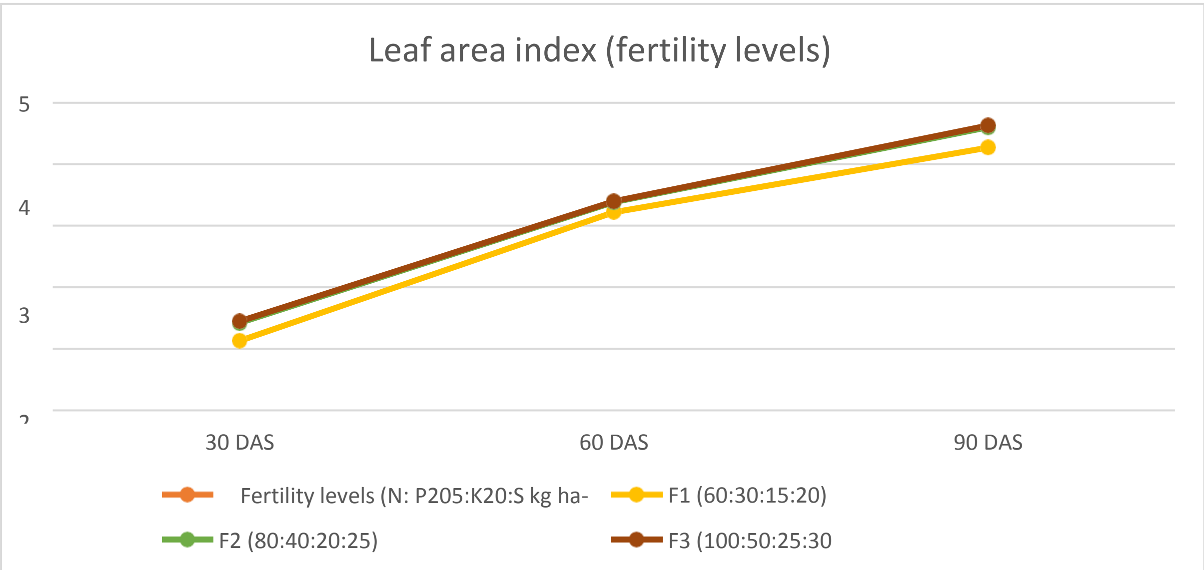


Fig. 4.2 Effect of different varieties, farmyard manure and various fertilizer doses on leaf area index of Indian mustard at various crop growth stages

4.1.3 Dry matter accumulation (g m^{-2})

The dry matter accumulation increased significantly from 30 DAS till harvest in all varieties at all events of FYM (M) and fertility levels (F) (Table 4.3). The rate of accumulation was faster till 90 DAS and declined at later stage. At 30 DAS and subsequent growth stages of Indian mustard, V3 (RVM-2) showed significantly higher values of dry matter accumulation than other varieties in comparison (66.62, 200.58, 561.11 and 743.36) under late sown conditions of Jammu region. The lowest dry matter accumulation was recorded in V2 (Pusa mustard 26) variety (54.78, 176.12, 440.62, and 589.87) as observed at 30, 60, 90, and 120 DAS respectively.

Similarly, a significant increase in dry matter accumulation was recorded with the application of M2 (FYM @ 5t) ha^{-1} (61.72, 195.45, 516.97 and 689.63) at 30, 60, 90, and 120 DAS respectively than M1 (no FYM application) in comparison (60.45, 181.50, 588.50, and 647.32).

Among the different fertility levels (F1, F2 and F3), significantly higher dry matter accumulation (61.48, 192.35, 511.77 and 681.28) was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied at 30, 60, 90 and 120 DAS respectively than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) (60.56, 181.84, 586.52 and 645.69) respectively.

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages. (Table 4.3.1).

Interaction effect of Varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V), significantly higher dry matter accumulation was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at 30, 60, and 120 DAS respectively. However, lowest dry matter accumulation was observed with the application of fertility level F1 $N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}. At 90 DAS, significantly higher dry matter accumulation was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of FYM (M) x fertility levels (F) application was also found to be significant. At same level of FYM (M), a significantly higher dry matter accumulation was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at 30, 60, 90, and 120 DAS respectively. However, lowest dry matter accumulation was obtained with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At same levels of varieties (V) and FYM (M), significantly higher dry matter accumulation was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) at 30, 90, and 120 DAS respectively. At 60 DAS significantly higher dry matter accumulation was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest dry matter accumulation was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) at 60 DAS.

However, interaction effect of varieties (V) × FYM (M) was found to be non-significant.

Table 4.3 Effect of different varieties, farmyard manure and various fertilizer doses on dry matter accumulation (g m^{-2}) of Indian mustard at various crop growth stages

Treatments	30 DAS	60 DAS	90 DAS	120 DAS respectively
(V) Varieties				
(V1) RSPR 69	56.70	181.00	463.35	616.82
(V2) Pusa mustard 26	54.78	176.12	440.62	589.87
(V3) RVM 2	66.62	200.58	561.11	743.36
(V4) NRCHB 101	66.24	196.20	545.88	723.86
SEm±	2.82	4.3	20.860	25.37
CD (5%)	9.74	15.17	71.99	87.56
(M) Farmyard manure application				
(M1) Without FYM	60.45	181.50	488.50	647.32
(M2) FYM @ 5 t ha^{-1}	61.72	195.45	516.97	689.63
SEm±	0.20	0.7	2.439	2.61
CD (5%)	0.68	2.34	7.94	8.50
(F) Fertility levels (N:P_20_5:K_20:S kg ha^{-1})				
(F1) 60:30:15:20 kg ha^{-1}	60.56	181.84	486.52	645.69
(F2) 80:40:20:25 kg ha^{-1}	61.22	191.23	509.91	678.47
(F3) 100:50:25:30 kg ha^{-1}	61.48	192.35	511.77	681.28
SEm±	0.10	0.3	2.79	2.93
CD (5%)	0.29	1.10	8.05	8.45
Interactions				
(V×M) Variety × FYM	NS	NS	NS	NS
(V×F) Variety × Fertility levels	0.59	2.21	16.11	16.91
(M×F) FYM × Fertility level	0.41	1.56	11.39	11.96
(V×M×F) Variety × FYM× Fertility level	0.83	3.13	22.78	23.92

Table 4.3.1 Interaction effect of different varieties, farmyard manure and various fertilizer doses on dry matter accumulation (g m^{-2}) of Indian mustard at 30 DAS

VxMxF

	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	55.70	57.04	53.41	54.00	65.97	66.46	65.64	66.24
F2	56.54	57.13	53.47	56.91	66.21	67.00	65.81	66.68
F3	56.55	57.22	53.72	57.17	66.35	67.75	66.03	67.04

VxM

	M1	M2	Mean V
V1	56.27	57.13	56.70
V2	53.53	56.02	54.78
V3	66.18	67.07	66.62
V4	65.82	66.65	66.24
Mean M	60.45	61.72	

VxF

	F1	F2	F3	Mean V
V1	56.37	56.84	56.88	56.70
V2	53.70	55.19	55.45	54.78
V3	66.21	66.61	67.05	66.62
V4	65.94	66.24	66.53	66.24

MxF

	F1	F2	F3
M1	60.18	60.51	60.66
M2	60.93	61.93	62.29
Mean F	60.56	61.22	61.48

	C.D.	SE(d)	SEm±
Factor (V)	9.74	3.99	2.82
Factor (M)	0.68	0.29	0.20
(VxM)	NS	0.59	0.41
Factor (F)	0.29	0.14	0.10
VxF	0.59	0.29	0.20
MXF	0.41	0.20	0.14
VXMXF	0.83	0.41	0.29

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.3.2 Interaction effect of different varieties, farmyard manure and various fertilizer doses on dry matter accumulation (g m^{-2}) of Indian mustard at 60 DAS

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	162.16	184.16	156.36	179.76	191.4	200.96	182.5	197.43
F2	177.86	191.5	173.36	186.13	196.36	207.16	194.46	203.03
F3	178.5	191.83	173.7	187.4	196.63	210.96	194.7	205.1

VxM	**M1**	**M2**	**Mean V**
V1	172.84	189.16	181.00
V2	167.81	184.43	176.12
V3	194.8	206.36	200.58
V4	190.55	201.85	196.20
Mean M	181.50	195.45	

VxF	**F1**	**F2**	**F3**	**Mean V**
V1	173.16	184.68	185.16	181.00
V2	168.06	179.75	180.55	176.12
V3	196.18	201.76	203.8	200.58
V4	189.96	198.75	199.9	196.20

MxF	**F1**	**F2**	**F3**
M1	173.10	185.51	185.88
M2	190.58	196.95	198.82
Mean F	181.84	191.23	192.35

	C.D.	**SE(d)**	**SEm±**
Factor (V)	15.17	6.21	4.39
Factor (M)	2.34	1.01	0.71
(VxM)	NS	2.03	1.43
Factor (F)	1.10	0.54	0.38
VxF	2.21	1.08	0.76
MXF	1.56	0.76	0.54
VXMXF	3.13	1.53	1.08

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.3.3 Interaction effect of different varieties, farmyard manure and various fertilizer doses on dry matter accumulation (g m^{-2}) of Indian mustard at 90 DAS

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	437.96	469.10	360.50	456.36	546.73	561.30	506.16	554.10
F2	458.40	476.76	445.83	466.06	554.20	572.83	544.86	560.36
F3	460.10	477.76	447.30	467.66	554.63	576.96	545.36	564.43
VxM				**VxF**				
	M1	**M2**	**Mean V**		**F1**	**F2**	**F3**	**MeanV**
V1	452.15	474.54	463.35	**V1**	453.53	467.58	468.93	463.35
V2	417.87	463.36	440.62	**V2**	408.43	455.95	457.48	440.62
V3	551.85	570.36	561.11	**V3**	554.01	563.51	565.8	561.11
V4	532.13	559.63	545.88	**V4**	530.13	552.61	554.9	545.88
Mean M	488.50	516.97			**C.D.**	**SE(d)**	**SEm±**	
MXF				**Factor (V)**	71.99	29.50	20.86	
				Factor (M)	7.94	3.45	2.43	
	F1	**F2**	**F3**	**(VxM)**	NS	6.89	4.87	
				Factor (F)	8.05	3.95	2.79	
M1	462.84	500.82	501.85	**VxF**	16.11	7.90	5.59	
M2	510.21	519.00	521.70	**MXF**	11.39	5.59	3.95	
Mean F	486.52	509.91	511.77	**VXMXF**	22.78	11.18	7.90	

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.3.4 Interaction effect of different varieties, farmyard manure and various fertilizer doses on dry matter accumulation (g m^{-2}) of Indian mustard at 120 DAS respectively

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	572.6	625.73	490.00	609.26	719.80	743.93	670.66	733.53
F2	608.73	640.73	592.33	625.33	732.23	761.66	721.33	745.40
F3	611.06	642.06	594.13	628.20	732.93	769.60	722.06	750.20
VxM				**VxF**				
	M1	**M2**	**Mean V**		**F1**	**F2**	**F3**	**Mean V**
V1	597.46	636.17	616.82	**V1**	599.16	624.73	626.56	616.82
V2	558.82	620.93	589.87	**V2**	549.63	608.83	611.16	589.87
V3	728.32	758.40	743.36	**V3**	731.86	746.95	751.26	743.36
V4	704.68	743.04	723.86	**V4**	702.1	733.36	736.13	723.86
Mean M	647.32	689.63			**C.D.**	**SE(d)**	**SEm±**	
MxF				**Factor (V)**	87.56	35.87	25.37	
				Factor (M)	8.50	3.69	2.61	
				(VxM)	NS	7.38	5.22	
	F1	**F2**	**F3**	**Factor (F)**	8.45	4.15	2.93	
M1	613.26	663.65	665.05	**VxF**	16.91	8.30	5.87	
M2	678.11	693.28	697.51	**MXF**	11.96	5.87	4.15	
Mean F	645.69	678.47	681.28	**VXMXF**	23.92	11.74	8.30	

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

4.1.4 Crop growth rate (g m^{-2} day^{-1})

Data pertaining to crop growth rate revealed that among the different varieties (V) of Indian mustard, variety (V3) RVM 2 though at par with V4 (NRCHB 101) obtained statistically superior values of CGR (2.22, 4.46, 12.01, and 6.07) at 0-30, 30-60, 60- 90 DAS and 90-120 DAS respectively than V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of Jammu region (Table 4.4). However, lowest CGR was observed in V2 (Pusa mustard 26) (1.82, 4.04, 8.81 and 4.97) at all growth stages.

FYM (M) had a significant influence on crop growth rate at all periodic intervals. Crop growth rate increased up to 90 DAS thereafter a decline in crop growth rate was observed. A significant increase in crop growth rate was recorded with the application of M2 (FYM @ 5t) ha^{-1} (2.05, 4.45, 10.71, 5.75) at 0-30, 30-60, 60- 90 DAS, and 90-120 DAS respectively than M1 (no FYM application) (2.01, 4.03, 10.23 and 5.29).

Among the different fertility levels (F), a significantly higher crop growth rate was recorded in plots where fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) was applied (2.04, 4.36, 10.64 and 5.65) than fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}) application (2.01, 4.04, 10.15 and 5.30) at all growth stages.

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.4.1).

Interaction effect of varieties × fertility level (V×F) was found to be significant. At same level of varieties (V), significantly higher crop growth rate was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}) at 0-30 DAS, 30-60 DAS, and 90-120 DAS respectively and the lowest crop growth rate was observed with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}). However, at 60-90 days interval significantly higher crop growth rate was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}) and fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

Interaction effect of FYM x fertility levels (M×F) application was also found to be significant. At same level of FYM (M), significantly higher crop growth rate was with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at 0-30 DAS, 30-60 DAS, and 90-120 DAS respectively. However, lowest crop growth rate was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

At 60-90 days intervals higher crop growth rate was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At same level of varieties (V) and FYM (M) significantly higher crop growth rate was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at 0-30 DAS, 30-60, and 90-120 DAS respectively. However, lowest CGR was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) . At 60-90 days intervals significantly higher crop growth rate was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

Table 4.4 Effect of different varieties, farmyard manure and various fertilizer doses on crop growth rate (g m^{-2} day^{-1}) of Indian mustard at various crop growth stages

Treatments	**0-30 DAS**	**30-60 DAS**	**60-90 DAS**	**90-120 DAS respectively**
(V) Varieties				
(V1) RSPR 69	1.89	4.14	9.41	5.11
(V2) Pusa mustard 26	1.82	4.04	8.81	4.97
(V3) RVM 2	2.22	4.46	12.01	6.07
(V4) NRCHB 101	2.20	4.33	11.65	5.93
SEm±	0.09	0.06	0.56	0.15
CD (5%)	0.32	0.23	1.93	0.53
(M) Farmyard manure application				
(M1) Without FYM	2.01	4.03	10.23	5.29
(M2) FYM @ 5 t ha^{-1}	2.05	4.45	10.71	5.75
SEm±	0.007	0.02	0.08	0.02
CD (5%)	0.02	0.07	0.27	0.07
(F) Fertility levels (N:P_20_5:K_20:S kg ha^{-1})				
(F1) -60:30:15:20 kg ha^{-1}	2.01	4.04	10.15	5.30
(F2) -80:40:20:25 kg ha^{-1}	2.04	4.33	10.62	5.61
(F3) -100:50:25:30 kg ha^{-1}	2.04	4.36	10.64	5.65
SEm±	0.003	0.01	0.09	0.01
CD (5%)	0.01	0.03	0.25	0.03
Interactions				
(V×M) Variety × FYM	NS	NS	NS	NS
(V×F) Variety × Fertility levels	0.02	0.07	0.51	0.07
(M×F) FYM × Fertility level	0.01	0.05	0.36	0.05
(V×M×F) Variety × FYM× Fertility level	0.02	0.10	0.73	0.10

Table 4.4.1 Interaction effect of different varieties, farmyard manure and various fertilizer doses on crop growth rate (g m^{-2} day^{-1}) of Indian mustard at 0-30 DAS

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	1.85	1.90	1.78	1.8	2.19	2.21	2.18	2.20
F2	1.88	1.90	1.78	1.89	2.20	2.23	2.19	2.22
F3	1.88	1.90	1.79	1.90	2.21	2.25	2.20	2.23
VxM				**VxF**				
	M1	**M2**	**Mean V**		**F1**	**F2**	**F3**	**Mean V**
V1	1.87	1.90	1.89	**V1**	1.87	1.89	1.89	1.89
V2	1.78	1.86	1.82	**V2**	1.79	1.84	1.84	1.82
V3	2.20	2.23	2.22	**V3**	2.20	2.22	2.23	2.22
V4	2.19	2.22	2.20	**V4**	2.19	2.20	2.21	2.20
Mean M	2.01	2.05			**C.D.**	**SE(d)**	**SEm±**	
MxF				**Factor (V)**	0.325	0.13	0.09	
				Factor (M)	0.023	0.01	0.007	
	F1	**F2**	**F3**	**(VxM)**	NS	0.02	0.01	
				Factor (F)	0.01	0.005	0.003	
M1	2.00	2.01	2.02	**VxF**	0.02	0.01	0.007	
M2	2.03	2.06	2.07	**MXF**	0.01	0.007	0.005	
Mean F	2.01	2.04	2.04	**VXMXF**	0.02	0.01	0.01	

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:$P_2 0_5$:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.4.2 Interaction effect of different varieties, farmyard manure and various fertilizer doses on crop growth rate (g m^{-2} day^{-1}) of Indian mustard at 30-60 DAS

VxMxF	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	3.54	4.23	3.43	4.19	4.18	4.48	3.89	4.37
F2	4.04	4.47	3.99	4.30	4.33	4.67	4.28	4.54
F3	4.06	4.48	3.99	4.34	4.34	4.77	4.28	4.60

VxM	M1	M2	Mean V
V1	3.88	4.40	4.14
V2	3.80	4.28	4.04
V3	4.28	4.64	4.46
V4	4.15	4.50	4.33
Mean M	4.03	4.45	

VxF	F1	F2	F3	Mean V
V1	3.89	4.26	4.27	4.14
V2	3.81	4.15	4.17	4.04
V3	4.33	4.50	4.55	4.46
V4	4.13	4.41	4.44	4.33

MxF	F1	F2	F3
M1	3.76	4.16	4.17
M2	4.32	4.50	4.55
Mean F	4.04	4.33	4.36

	C.D.	SE(d)	SEm±
Factor (V)	0.23	0.09	0.06
Factor (M)	0.07	0.03	0.02
(VxM)	NS	0.06	0.04
Factor (F)	0.03	0.01	0.01
VxF	0.07	0.03	0.02
MXF	0.05	0.02	0.01
VXMXF	0.10	0.05	0.03

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.4.3 Interaction effect of different varieties, farmyard manure and various fertilizer doses on crop growth rate (g m^{-2} day^{-1}) of Indian mustard at 60-90 DAS

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	9.19	9.49	6.80	9.22	11.84	12.01	10.78	11.88
F2	9.35	9.50	9.08	9.33	11.92	12.18	11.68	11.91
F3	9.38	9.53	9.12	9.34	11.93	12.2	11.68	11.97

VxM			
	M1	**M2**	**Mean V**
V1	9.31	9.51	9.41
V2	8.33	9.29	8.81
V3	11.90	12.13	12.01
V4	11.38	11.92	11.65
Mean M	10.23	10.71	

VxF				
	F1	**F2**	**F3**	**Mean V**
V1	9.34	9.43	9.45	9.41
V2	8.01	9.20	9.23	8.81
V3	11.92	12.05	12.06	12.01
V4	11.33	11.79	11.83	11.65

MxF			
	F1	**F2**	**F3**
M1	9.65	10.51	10.53
M2	10.65	10.73	10.76
Mean F	10.15	10.62	10.64

	C.D.	**SE(d)**	**SEm±**
Factor (V)	1.93	0.79	0.56
Factor (M)	0.27	0.11	0.08
(VxM)	NS	0.23	0.16
Factor (F)	0.25	0.12	0.09
VxF	0.51	0.25	0.18
MXF	0.36	0.18	0.12
VXMXF	0.73	0.35	0.25

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_{2}0_{5}:K_{2}O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_{2}O_{5}:K_{2}O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_{2}O_{5}:K_{2}O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.4.4 Interaction effect of different varieties, farmyard manure and various fertilizer doses on crop growth rate (g m^{-2} day^{-1}) of Indian mustard at 90-120 DAS respectively

VxMxF

	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	4.48	5.22	4.31	5.09	5.76	6.08	5.48	5.98
F2	5.01	5.46	4.88	5.30	5.93	6.29	5.88	6.16
F3	5.03	5.47	4.89	5.35	5.94	6.42	5.89	6.19

VxM

	M1	M2	Mean V
V1	4.84	5.38	5.11
V2	4.69	5.25	4.97
V3	5.88	6.26	6.07
V4	5.75	6.11	5.93
Mean M	5.29	5.75	

VxF

	F1	F2	F3	Mean V
V1	4.85	5.23	5.25	5.11
V2	4.70	5.09	5.12	4.97
V3	5.92	6.11	6.18	6.07
V4	5.73	6.02	6.04	5.93

MXF

	F1	F2	F3
M1	5.01	5.42	5.44
M2	5.597	5.80	5.86
Mean F	5.305	5.618	5.65

	C.D.	SE(d)	SEm±
Factor (V)	0.53	0.21	0.15
Factor (M)	0.07	0.03	0.02
(VxM)	NS	0.06	0.04
Factor (F)	0.03	0.01	0.01
VxF	0.07	0.03	0.02
MXF	0.05	0.02	0.01
VXMXF	0.10	0.05	0.03

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

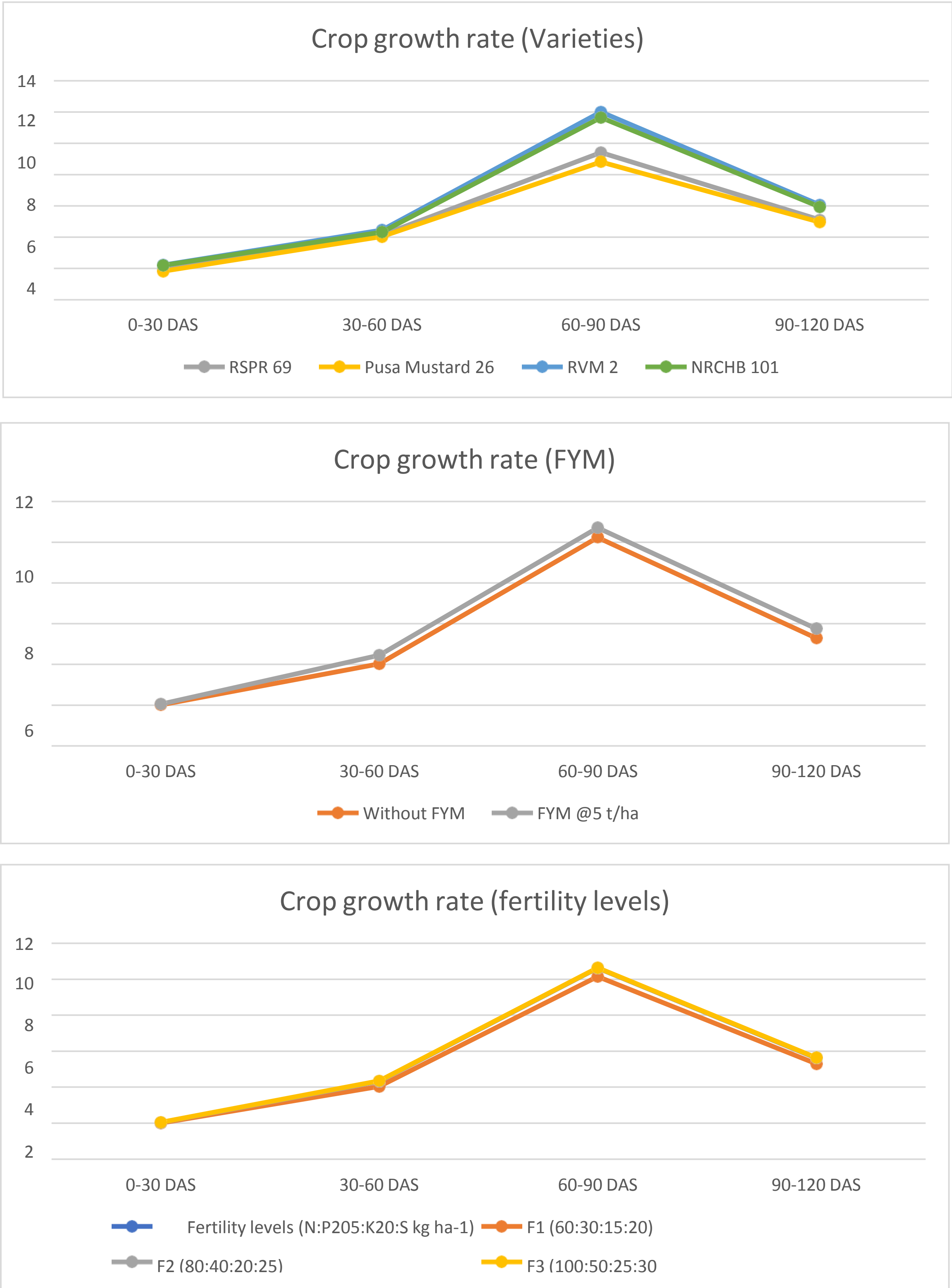


Fig 4.4 Effect of different varieties, farmyard manure and various fertilizer doses on crop growth rate (g m^{-2} day^{-1}) of Indian mustard at various crop growth stages

4.2 Yield attributes

4.2.1 Number of branches plants^{-1}

The data presented in Table 4.5 revealed that different varieties (V), FYM (M), and fertility levels (F) significantly influenced the number of branches plant^{-1} of Indian mustard. Among the different varieties (V) of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a higher number of branches per plant (14.15) as compared to V1 (RSPR-69) and V2 (Pusa mustard 26). The lowest number of branches per plant was recorded in V2 (Pusa mustard 26) variety (11.93).

Similarly, a significant increase in number of branches per plant was recorded with the application of M2 (FYM @ 5t) ha^{-1} (13.39) than M1 (no FYM application) in comparison (12.72).

Among the different fertility levels (F), a significantly higher number of branches was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied (13.18) than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) (12.82). However, it was at par with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) in comparison (13.15).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (V×F), and Varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.5.1).

Interaction effect of varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V), significantly higher number of branches per plant was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). The lowest number of branches per plant was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) .

Interaction effect of FYM x fertility levels (MxF) application was also found to be significant. At same level of FYM (M), significantly higher number of branches per plant was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at harvest. The lowest number of branches per plant was obtained with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) .

Interaction of varieties x FYM x fertility levels (V×M×F) was also found to be significant. At same level of varieties (V) and FYM (M), significantly higher number of branches per plant was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, a lowest number of branches per plant was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) at harvest.

However, Interaction effect of varieties × FYM (V× M) was found to be non-significant.

4.2.2 Number of siliquae plant^{-1}

The number of siliquae plant^{-1} was significantly influenced in respect of different varieties (V), FYM (M), and fertility levels (F). The data presented in Table 4.5 revealed that different varieties (V), FYM (M), and fertility levels (F) significantly influenced siliquae plant^{-1} of Indian mustard. Among the different varieties of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a higher number of siliquae plant^{-1} (129.25) than (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However lowest siliquae plant^{-1} was recorded in V2 (Pusa mustard 26) variety (103.57).

Similarly, a significant increase in siliquae plant^{-1} was recorded with the application of M2 (FYM @ 5t) ha^{-1} (124.96) than M1 (no FYM application) in comparison (110.98).

Among the different fertility levels (F), significantly higher siliquae plant^{-1} was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) of fertilizer was applied (121.80) than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) (111.25). However, it was at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) in comparison (120.85).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.5.2). Interaction effect of varieties × fertility level (V×F) was found to be significant. At same level of varieties (V), significantly higher number of siliquae plant^{-1} was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) . However, lowest number of siliquae plant^{-1} was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) .

Interaction effect of FYM x fertility levels (M×F) application was also found to be significant. At same level of FYM (M), higher number of siliquae $plant^{-1}$ was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at harvest. However, lowest number of siliquae $plant^{-1}$ was obtained with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) .

Interaction of varieties x FYM x fertility levels (V×M×F) were also found to be significant. At same level of varieties (V) and FYM (M), significantly higher number of siliquae $plant^{-1}$ was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) . However, a lowest number of siliquae $plant^{-1}$ was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

4.2.3 Number of seeds $siliqua^{-1}$

The data presented in (Table 4.5) revealed that different varieties (V), FYM (M), and Fertility levels (F) significantly influenced seeds $siliqua^{-1}$ of Indian mustard. Among the different varieties of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a significantly higher values of seeds $siliqua^{-1}$ (13.67) than V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, the lowest seeds $siliqua^{-1}$ was recorded in V2 (Pusa mustard 26) variety (11.63).

Similarly, a significant increase in seeds $siliqua^{-1}$ was recorded with the application of M2 (FYM @ 5t) ha^{-1} (13.07) than M1 (no FYM application) in comparison (12.40).

Among the different fertility levels (F), significantly higher seeds $siliqua^{-1}$ was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) of fertilizer was applied (12.87) than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) (12.51). However, it was at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) in comparison (12.84).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.5.3).

Interaction effect of varieties × fertility level (V×F) was found to be significant. At same level of varieties significantly higher number of seeds siliqua^{-1} was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}). However, a lowest number of seeds siliqua^{-1} was observed with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}) .

Interaction of FYM x fertility levels (M×F) application was also found to be significant. At same level of FYM (M), a significantly higher number of seeds siliqua^{-1} was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}) at harvest. However, a lowest number of seeds siliqua^{-1} was obtained with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}) .

Interaction of varieties x FYM x fertility levels (V×M×F) were also found to be significant. At same level of varieties (V) and FYM (M), significantly higher number of seeds siliqua^{-1} was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}). However, a lowest number of seeds siliqua^{-1} was observed with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of Varieties × FYM (V×M) was found to be non-significant.

4.2.4 1000 -seed weight (g)

Different varieties, FYM, and fertility levels significantly influenced the test weight. The data presented in (Table 4.5) revealed that different varieties (V), FYM (M), and fertility levels (F) significantly influenced the test weight of Indian mustard. Among the different varieties of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a higher test weight (3.99) than V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, the lowest test weight was recorded in V2 (Pusa mustard 26) variety (3.07).

Similarly, a significant increase in test weight was recorded with the application of M2 (FYM @ 5t) ha^{-1} (3.88) than M1 (no FYM application) in comparison (3.19).

Among the different fertility levels (F), significantly higher test weight was recorded in plots where fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) was applied (3.66) than fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}) (3.11). However, it was at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) in comparison (3.63).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and Varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.5.4).

Interaction effect of varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V) significantly higher test weight was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest test weight was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of FYM x fertility levels (M×F) application was also found to be significant. At same level of FYM (M), significantly higher test weight was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at harvest. However, lowest test weight was obtained with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At same level of varieties and FYM, significantly higher test weight was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest test weight was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

Table: 4.5 Effect of different varieties, farmyard manure and various fertilizer doses on yield attributes of Indian mustard at harvest

Treatments	Number of Branches per plant	Number of Silique per plant	Number ofseeds per siliquae	Test weight (g)
(V) Varieties				
(V1) RSPR 69	12.46	115.07	12.16	3.16
(V2) Pusa mustard 26	11.93	103.57	11.63	3.07
(V3) RVM 2	14.15	129.25	13.67	3.99
(V4) NRCHB 101	13.66	123.98	13.48	3.91
SEm±	0.21	4.69	0.21	0,21
CD (5%)	0.74	16.20	0.74	0.75
(M) Farmyard manure application				
(M1) Without FYM	12.72	110.98	12.40	3.19
(M2) FYM @ 5 t ha^{-1}	13.39	124.96	13.07	3.88
SEm±	0.03	0.67	0.03	0.04
CD (5%)	0.11	2.21	0.11	0.13
(F) Fertility levels ($N:P_20_5:K_20:S$ kg ha^{-1})				
(F1) 60:30:15:20 kg ha^{-1}	12.82	111.25	12.51	3.31
(F2) 80:40:20:25 kg ha^{-1}	13.15	120.85	12.84	3.63
(F3) 100:50:25:30 kg ha^{-1}	13.18	121.80	12.87	3.66
SEm±	0.01	0.36	0.01	0.01
CD (5%)	0.03	1.06	0.03	0.04
Interactions				
(V×M) Variety × FYM	NS	NS	NS	NS
(V×F) Variety × Fertility levels	0.07	2.12	0.07	0.09
(M×F) FYM × Fertility level	0.05	1.50	0.05	0.06
(V×M×F) Variety × FYM× Fertility level	0.11	3.00	0.11	0.13

Table 4.5.1 Interaction effect of different varieties, farmyard manure and various fertilizer doses on number of branches per plant of Indian mustard at harvest

VxMxF

	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	12.12	12.58	11.28	12.06	13.74	14.07	12.97	13.76
F2	12.23	12.79	11.68	12.41	13.9	14.64	13.42	14.16
F3	12.24	12.81	11.71	12.44	13.92	14.67	13.44	14.24

VxM

	M1	M2	Mean V
V1	12.19	12.73	12.46
V2	11.56	12.30	11.93
V3	13.85	14.46	14.15
V4	13.27	14.06	13.66
Mean M	12.72	13.39	

VxF

	F1	F2	F3	Mean V
V1	12.35	12.51	12.52	12.46
V2	11.677	12.04	12.07	11.93
V3	13.91	14.27	14.29	14.15
V4	13.37	13.79	13.84	13.66

MXF

	F1	F2	F3
M1	12.53	12.80	12.82
M2	13.12	13.50	13.54
Mean F	12.82	13.15	13.18

	C.D.	SE(d)	SEm±
Factor (V)	0.74	0.30	0.21
Factor (M)	0.11	0.04	0.03
(VxM)	NS	0.09	0.06
Factor (F)	0.03	0.01	0.01
VxF	0.07	0.03	0.02
MXF	0.05	0.02	0.01
VXMXF	0.11	0.05	0.03

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.5.2 Interaction effect of different varieties, farmyard manure and various fertilizer doses on siliquae per plant of Indian mustard at harvest

VxMxF	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	96.233	118.23	82.43	107.50	120.06	129.63	110.5	125.43
F2	111.93	125.56	101.10	113.86	125.03	135.83	122.46	131.03
F3	112.56	125.9	101.43	115.13	125.30	139.63	122.7	131.76

VxM	M1	M2	Mean V
V1	106.91	123.23	115.07
V2	94.98	112.16	103.57
V3	123.46	135.03	129.25
V4	118.55	129.41	123.98
Mean M	110.98	124.96	

VxF	F1	F2	F3	Mean V
V1	107.23	118.70	119.23	115.07
V2	94.96	107.48	108.28	103.57
V3	124.85	130.43	132.46	129.25
V4	117.96	126.75	127.23	123.98

MxF	F1	F2	F3
M1	102.30	115.13	115.5
M2	120.20	126.57	128.10
Mean F	111.25	120.85	121.80

	C.D.	SE(d)	SEm±
Factor (V)	16.20	6.64	4.69
Factor (M)	2.21	0.96	0.67
(VxM)	NS	1.92	1.35
Factor (F)	1.06	0.52	0.36
VxF	2.21	1.04	0.73
MXF	1.50	0.73	0.52
VXMXF	3.00	1.47	1.04

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.5.3 Interaction effect of different varieties, farmyard manure and various fertilizer doses on seeds per siliqua of Indian mustard at harvest

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	11.82	12.28	10.98	11.76	13.26	13.59	12.79	13.58
F2	11.93	12.49	11.38	12.11	13.42	14.16	13.24	13.98
F3	11.94	12.51	11.41	12.14	13.44	14.19	13.26	14.06

VxM			
	M1	**M2**	**Mean V**
V1	11.89	12.43	12.16
V2	11.26	12.00	11.63
V3	13.37	13.98	13.67
V4	13.09	13.88	13.48
Mean M	12.40	13.075	

VxF				
	F1	**F2**	**F3**	**Mean V**
V1	12.05	12.21	12.22	12.16
V2	11.37	11.74	11.77	11.63
V3	13.43	13.79	13.81	13.67
V4	13.19	13.61	13.66	13.48

MXF			
	F1	**F2**	**F3**
M1	12.21	12.49	12.51
M2	12.80	13.19	13.22
Mean F	12.51	12.84	12.87

	C.D.	**SE(d)**	**SEm±**
Factor (V)	0.742	0.30	0.21
Factor (M)	0.113	0.04	0.03
(VxM)	NS	0.09	0.06
Factor (F)	0.039	0.01	0.01
VxF	0.079	0.03	0.02
MXF	0.056	0.02	0.01
VXMXF	0.111	0.05	0.03

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.5.4 Interaction effect of different varieties, farmyard manure and various fertilizer doses on test weight (g) of Indian mustard at harvest

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	2.79	3.25	2.43	3.21	3.56	3.98	3.22	4.01
F2	2.90	3.56	2.83	3.54	3.72	4.46	3.67	4.41
F3	2.91	3.58	2.86	3.57	3.74	4.49	3.69	4.49

VxM			
	M1	**M2**	**Mean V**
V1	2.86	3.46	3.16
V2	2.71	3.44	3.07
V3	3.67	4.31	3.99
V4	3.52	4.31	3.91
Mean M	3.19	3.88	

VxF				
	F1	**F2**	**F3**	**Mean V**
V1	3.02	3.23	3.24	3.16
V2	2.82	3.18	3.21	3.07
V3	3.77	4.09	4.11	3.99
V4	3.62	4.04	4.09	3.91

MXF			
	F1	**F2**	**F3**
M1	3.00	3.28	3.30
M2	3.61	3.99	4.03
Mean F	3.31	3.63	3.66

	C.D.	**SE(d)**	**SEm±**
Factor (V)	0.75	0.31	0.21
Factor (M)	0.13	0.06	0.04
(VxM)	NS	0.12	0.08
Factor (F)	0.04	0.02	0.01
VxF	0.09	0.04	0.03
MXF	0.06	0.03	0.02
VXMXF	0.13	0.06	0.04

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

Yield and Harvest index

4.3.1 Seed yield (kg ha^{-1})

The perusal of the data presented in (Table 4.6) indicated that different treatments i.e., varieties (V), FYM (M) and fertility levels (F) significantly influenced the seed yield of Indian mustard during the crop season. Indian mustard variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in significantly higher seed yield (1,516.66 kg ha^{-1}) than V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of Jammu region. However, lowest seed yield was recorded in V2 (Pusa mustard 26) variety (1130.56 kg ha^{-1})

Similarly, significant increase in seed yield was recorded with application of M2 (FYM @ 5t) ha^{-1} (1414.44 kg ha^{-1}) than M1 (no FYM application) in comparison (1252.17 kg ha^{-1}).

Among the different fertility levels (F), significantly higher seed yield was recorded in plots where fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) was applied (1379.08 kg ha^{-1}) than fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}) (1255.83 kg ha^{-1}). However, it was at par with application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}) in comparison (1365.00 kg ha^{-1}).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F) and varieties × FYM × fertility levels (V×M×F) application was observed (Table 4.6.1). Interaction effect of varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V), significantly higher seed yield was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F1 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}). However, lowest seed yield was observed with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

Interaction effect of FYM (M) x fertility levels (F) application was also found to be significant. At same level of FYM (M), significantly higher seed yield was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}) at harvest. However, lowest seed yield was obtained with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At same level of varieties (V) and FYM (M), significantly higher seed yield was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest seed yield was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

4.3.2 Stover yield (kg ha^{-1})

The data presented in (Table 4.6) revealed that varieties (V) differed significantly in stover yield with varying level of FYM (M) and fertility level (F). Among the different varieties of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in significantly higher stover yield (6,263.33 kg ha^{-1}) than V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, the lowest stover yield was recorded in V2 (Pusa mustard 26) variety (5,128.88 kg ha^{-1}).

Similarly, significant increase in stover yield $plant^{-1}$ was recorded with application of M2 (FYM @ 5t) ha^{-1} (5,791.94 kg ha^{-1}) than M1 (no FYM application) in comparison (5,560.27 kg ha^{-1}).

Among the different fertility levels (F), significantly higher stover yield was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied (5,761.66 kg ha^{-1}) than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) application (5,587.08 kg ha^{-1}). However, it was at par with application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) in comparison (5,679.58 kg ha^{-1}).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F) and Varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.6.2).

Interaction effect of varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V) significantly higher stover yield $plant^{-1}$ was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}). However, lowest stover yield $plant^{-1}$ was observed with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of (M) x fertility levels (F) application was also found to be significant. At same level of FYM (M), significantly higher stover yield $plant^{-1}$ was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha-

^{1}) at harvest. However, lowest stover yield plant^{-1} was obtained with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At same level of varieties (V) and FYM (M), significantly higher stover yield plant^{-1} was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}). However, lowest stover yield plant^{-1} was observed with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

4.3.2 Biological yield (kg ha^{-1})

The data presented in (Table 4.6) revealed that varieties (V) differed significantly in biological yield with varying level of FYM (M) and fertility level (F). Among the different varieties of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in significantly higher biological yield (7,780.8 kg ha^{-1}) than V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, the lowest biological yield was recorded in V2 (Pusa mustard 26) variety (6,259.4 kg ha^{-1}).

Similarly, significant increase in biological yield plant^{-1} was recorded with application of M2 (FYM @ 5t) ha^{-1} (7,206.8 kg ha^{-1}) than M1 (no FYM application) in comparison (6,812.4 kg ha^{-1}).

Among the different fertility levels (F), significantly higher biological yield was recorded in plots where fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) was applied (7,145.9 kg ha^{-1}) than fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}) application (6,842.9 kg ha^{-1}). However, it was at par with application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}) in comparison (7,040.0 kg ha^{-1}).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F) and Varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.6.3).

Interaction effect of varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V) significantly higher biological yield plant^{-1} was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}). However, lowest biological yield plant^{-1} was observed with the application of fertility level F1 (N:P_20_5:K_20:S @

60:30:15:20 kg ha^{-1}).

Interaction effect of (M) FYM x fertility levels (F) application was also found to be significant. At same level of FYM (M), significantly higher biological yield $plant^{-1}$ was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) at harvest. However, lowest biological yield $plant^{-1}$ was obtained with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At same level of varieties (V) and FYM (M), significantly higher biological yield $plant^{-1}$ was observed with the application of fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}). However, lowest biological yield $plant^{-1}$ was observed with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

4.3.3 Harvest index (%)

The data presented in (Table 4.6) revealed that different varieties (V), FYM (M) and Fertility levels (F) significantly influenced the harvest index of Indian mustard. Among the different varieties (V) of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a higher harv est index (19.39) than V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, the lowest harvest index was recorded in V2 (Pusa mustard 26) variety (18.03).

Similarly, significant increase in harvest index per plant was recorded with application of M2 (FYM @ 5t) ha^{-1} (19.56) than M1 (no FYM application) in comparison (18.32).

Among the different fertility levels (F), significantly higher harvest index was recorded in plots where fertility level F3 (N:P_20_5:K_20:S @ 100:50:25:30 kg ha^{-1}) was applied (19.29) than fertility level F1 application (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}) (18.31) However, it was at par with application of fertility level F2 (N:P_20_5:K_20:S @ 80:40:20:25 kg ha^{-1}) in comparison (19.23).

A non-significant interaction effect between Varieties × FYM application (V×M), Varieties ×Fertilizer dose (V×F), FYM application × Fertilizer doses (M×F) and Varieties × FYM × Fertility doses (V×M×F) was observed.

Table 4.6 Effect of different varieties, farmyard manure and various fertilizer doses on yield and harvest index of Indian mustard at harvest

Treatments	Seed yield (Kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
(V) Varieties				
(V1) RSPR 69	1,247.7	5,275.5	6,523.3	19.1
(V2) Pusa mustard 26	1,130.5	5,128.8	6,259.4	18.0
(V3) RVM 2	1,516.6	6,263.3	7,780.8	19.3
(V4) NRCHB 101	1,438.2	6,036.6	7,474.8	19.2
SEm±	58.2	185.5	240.4	0.2
CD (5%)	200.9	640.3	829.7	0.8
(M) Farmyard manure application (M)				
(M1) Without FYM	1,252.1	5,560.2	6,812.4	18.3
(M2) FYM @ 5 t ha^{-1}	1,414.4	5,791.9	7,206.8	19.5
SEm±	8.8	13.7	18.7	0.09
CD (5%)	28.9	44.8	60.9	0.3
(F) Fertility levels (N:P_20_5:K_20:S kg ha^{-1})				
(F1) 60:30:15:20 kg ha^{-1}	1,255.8	5,587.0	6,842.9	18.3
(F2) 80:40:20:25 kg ha^{-1}	1,365.0	5,679.5	7,040.0	19.2
(F3) 100:50:25:30 kg ha^{-1}	1,379.0	5,761.6	7,145.9	19.2
SEm±	7.9	12.4	16.2	0.09
CD (5%)	22.9	35.9	46.9	0.2
Interactions				
(V×M) Variety × FYM	NS	NS	NS	NS
(V×F) Variety × Fertility levels	45.8	71.8	93.8	NS
(M×F) FYM × Fertility level	32.4	50.8	66.3	NS
(V×M×F) Variety × FYM× Fertility level	64.8	101.6	132.6	NS

Table 4.6.1 Interaction effect of different varieties, farmyard manure and various fertilizer doses on seed yield (kg ha^{-1}) of Indian mustard at harvest

VxMxF

	V1		V2		V3		V4	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	1,136.6	1,253.3	1,030.0	1,140.0	1,343.3	1,443.3	1,263.3	1,436.6
F2	1,196.6	1,330.0	1,080.0	1,223.3	1,433.3	1,696.0	1,400.0	1,560.0
F3	1,203.3	1,366.6	1,083.3	1,226.6	1,446.6	1,736.3	1,409.3	1,563.6

VxM

	M1	M2	Mean V
V1	1,178.8	1,316.6	1,247.7
V2	1,064.4	1,196.6	1,130.5
V3	1,407.7	1,625.5	1,516.6
V4	1,357.5	1,518.8	1,438.5
Mean M	1,252.1	1,414.4	

VxF

	F1	F2	F3	Mean V
V1	1,195.0	1,263.3	1,285.0	1,247.7
V2	1,085.0	1,151.6	1,155.0	1,130.5
V3	1,393.3	1,565.0	1,591.6	1,516.6
V4	1,350.0	1,480.0	1,485.5	1,438.5

MXF

	F1	F2	F3
M1	1,193.3	1,277.5	1,285.6
M2	1,318.3	1,452.5	1,472.5
MeanF	1,255.8	1,365.0	1,379.0

	C.D.	SE(d)	SEm±
Factor (V)	200.9	82.3	58.2
Factor (M)	28.9	12.5	8.89
(VxM)	NS	25.1	17.7
Factor (F)	22.9	11.2	7.9
VxF	45.8	22.5	15.9
MXF	32.4	15.9	11.2
VXMXF	64.8	31.8	22.5

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

Table 4.6.2 Interaction effect of different varieties, farmyard manure and various fertilizer doses on stover yield (kg ha^{-1}) of Indian mustard at harvest

VxMxF								
	V1		V2		V3		V4	
	M1	M2	M1	M2	M1	M2	M1	M2
F1	5,063.3	5,320.0	4,943.3	5,180.0	6,040.0	6,240.0	5,843.3	6,066.6
F2	5,156.6	5,360.0	5,073.3	5,226.6	6,126.6	6,353.3	5,990.0	6,150.0
F3	5,206.6	5,546.6	5,120.0	5,230.0	6,156.6	6,663.3	6,003.3	6,166.6
VxM				VxF				
	M1	M2	Mean V		F1	F2	F3	Mean V
V1	5,142.2	5,408.8	5,275.5	V1	5,191.6	5,258.3	5,376.6	5,275.5
V2	5,045.5	5,212.2	5,128.8	V2	5,061.6	5,150.0	5,175.0	5,128.8
V3	6,107.7	6,418.8	6,263.3	V3	6,140.0	6,240.0	6,410.0	6,263.3
V4	5,945.5	6,127.7	6,036.6	V4	5,955.0	6,070.0	6,085.0	6,036.6
Mean M	5,560.2	5,791.94			C.D.	SE(d)	SEm±	
MXF				Factor (V)	640.3	262.3	185.5	
				Factor (M)	44.8	19.4	13.7	
	F1	F2	F3	(VxM)	NS	38.9	25.5	
				Factor (F)	35.9	17.6	12.4	
M1	5,472.5	5,586.6	5,621.6	VxF	71.8	35.2	24.9	
M2	5,701.6	5,772.5	5,901.6	MXF	50.8	24.9	17.6	
Mean F	5,587.0	5,679.5	5,761.6	VXMXF	101.6	49.8	35.2	

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

Table 4.6.3 Interaction effect of different varieties, farmyard manure and various fertilizer doses on biological yield (kg ha^{-1}) of Indian mustard at harvest

VxMxF								
	V1		V2		V3		V4	
	M1	M2	M1	M2	M1	M2	M1	M2
F1	6,200.0	6,573.3	5,973.3	6,320.0	7,383.3	7,683.3	7,106.6	7,503.3
F2	6,353.3	6,690.0	6,153.3	6,450.0	7,560.0	8,013.3	7,390.0	7,710.0
F3	6,410.0	6,913.3	6,203.3	6,456.6	7,603.3	8,441.6	7,412.6	7,726.6
VxM				VxF				
	M1	M2	Mean V		F1	F2	F3	Mean V
V1	6,321.1	6,725.5	6,523.3	V1	6,386.6	6,521.6	6,661.6	6,523.3
V2	6,110.0	6,408.8	6,259.4	V2	6,146.6	6,301.6	6,330.0	6,259.4
V3	7,515.5	8,046.1	7,780.8	V3	7,533.3	7,786.6	8,022.5	7,780.8
V4	7,303.1	7,646.6	7,474.8	V4	7,305.0	7,550.0	7,569.6	7,474.8
Mean M	6,812.4	7,206.8			C.D.	SE(d)	SEm±	
MXF				Factor (V)	829.7	339.9	240.4	
				Factor (M)	60.9	26.4	18.7	
	F1	F2	F3	(VxM)	NS	52.9	37.4	
				Factor (F)	46.9	23.0	16.2	
M1	6,665.8	6,864.1	6,907.3	VxF	93.8	46.0	32.5	
M2	7,020.0	7,215.8	7,384.5	MXF	66.3	32.5	23.0	
MeanF	6,842.9	7,040.0	7,145.9	VXMXF	132.6	65.1	46.0	

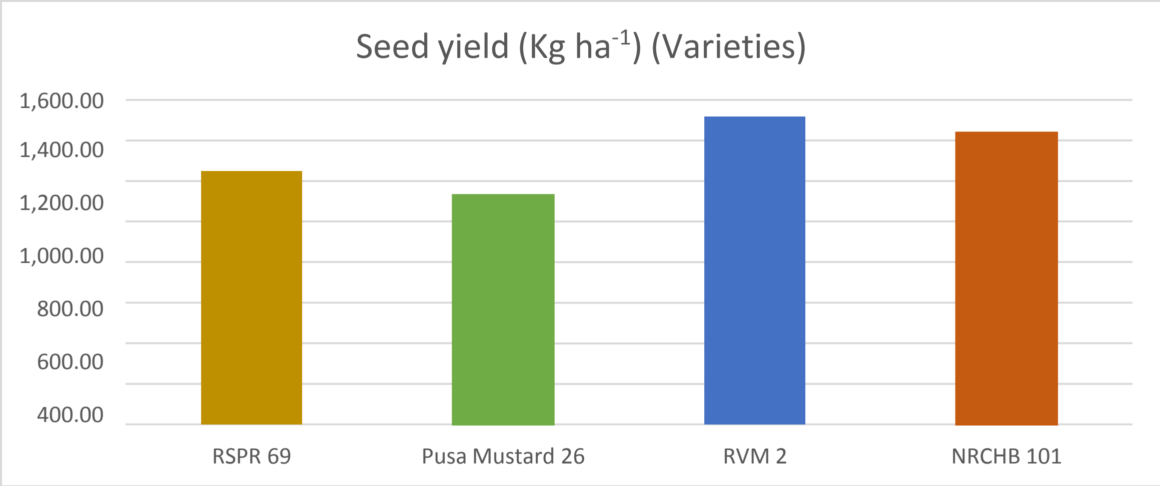
V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

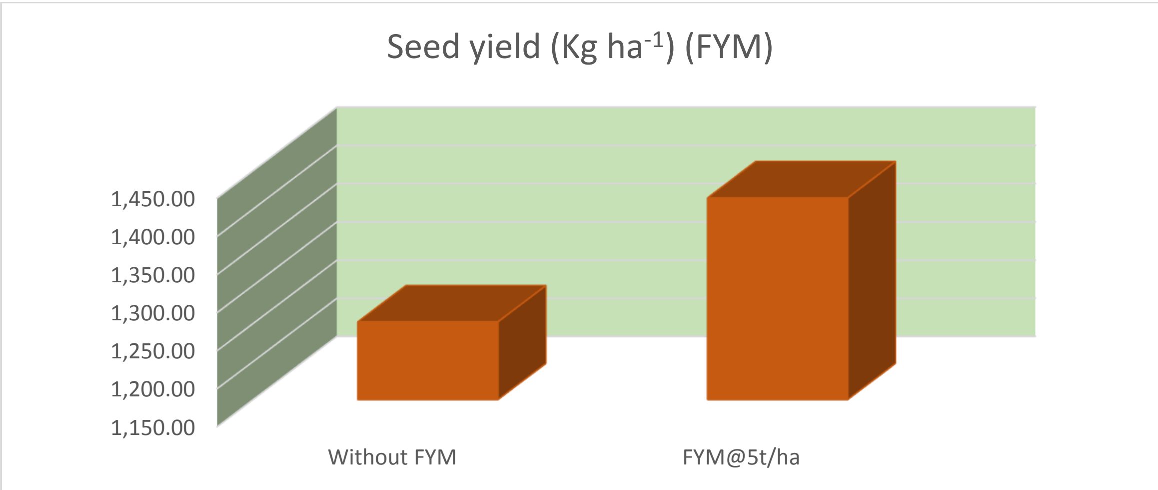
M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}





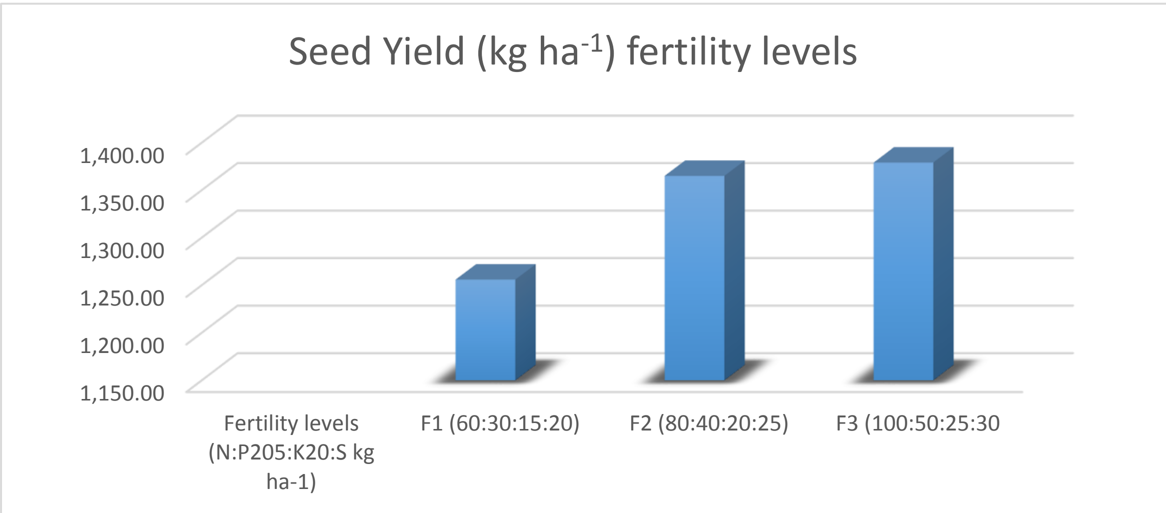
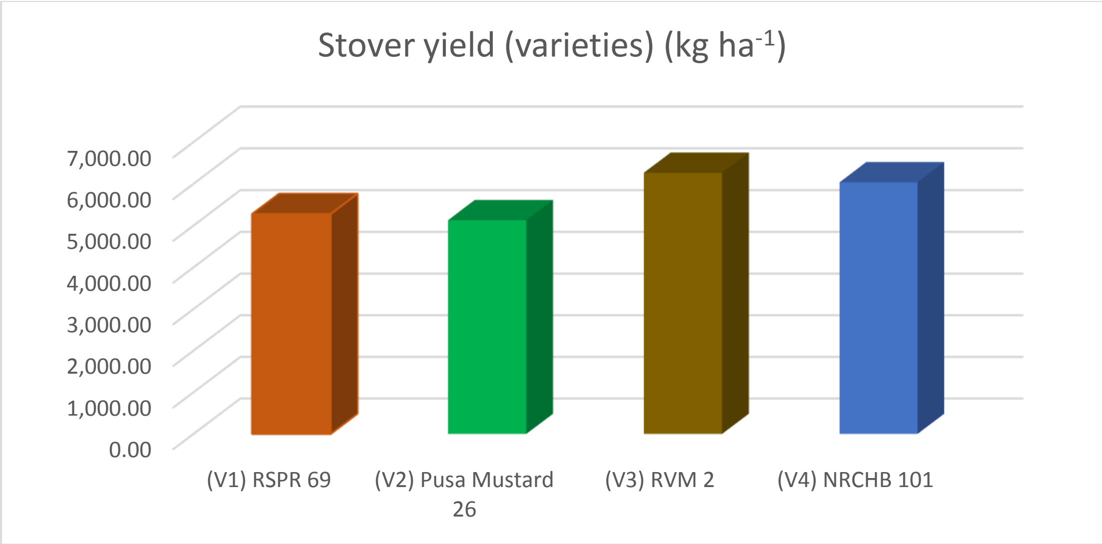
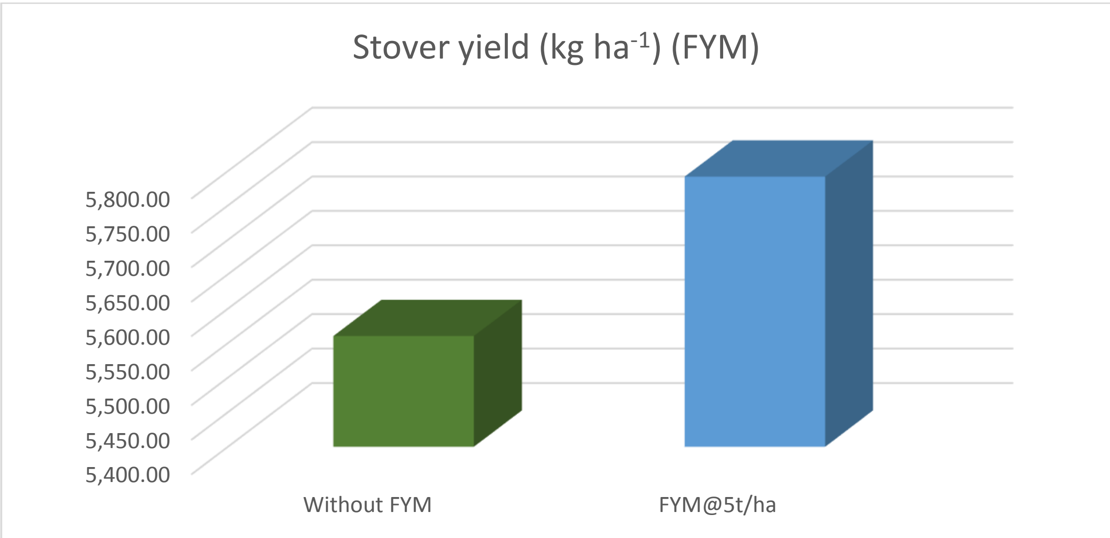


Fig 4.6 Effect of different varieties, farmyard manure and various fertilizer doses on seed yield (kg ha^{-1}) of Indian mustard at harvest





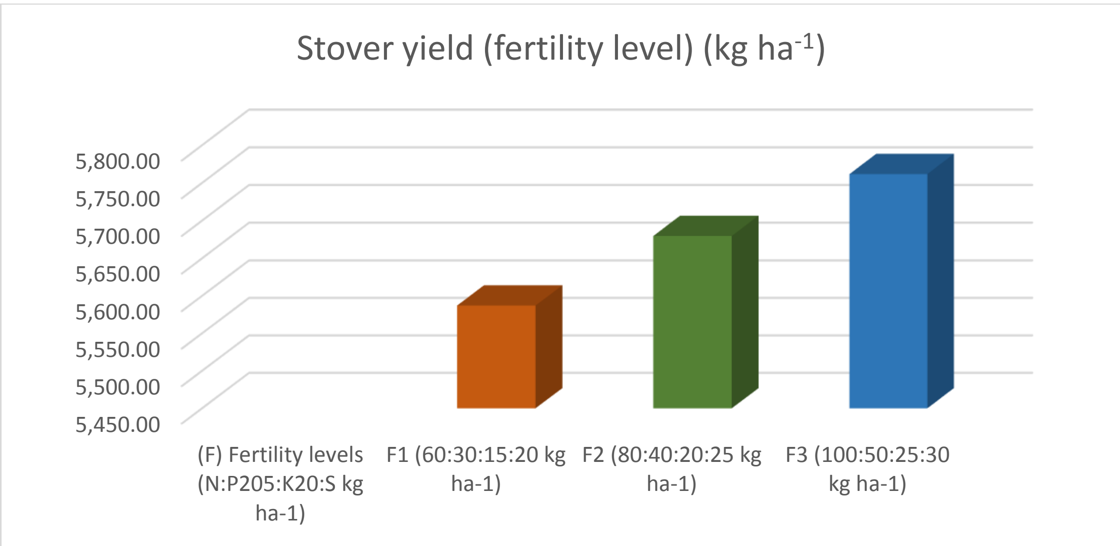


Fig. 4.6 Effect of different varieties, farmyard manure and various fertilizer doses on stover yield (kg ha^{-1}) of Indian mustard at harvest

4.4 Nutrient uptake studies

The perusal of the data presented in (Table 4.7) indicated that different treatments i.e., varieties (V), FYM (M), and fertility levels (F) significantly influenced the nutrient uptake of Indian mustard during the crop season. Among the different varieties (V), the Indian mustard variety V3 (RVM-2) resulted in significantly higher nutrient uptake than (V4) NRCHB – 101, V1 (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, the lowest nutrient uptake was recorded in V2 (Pusa mustard 26) variety.

Similarly, significant increase in nutrient uptake was recorded with application ofM2 (FYM @ 5t) ha^{-1} than M1 (no FYM application) in comparison.

Among the different fertility levels (F), significantly higher nutrient uptake was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied than fertility level ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) application.

A non-significant interaction effect between varieties × FYM application (V×M), varieties × Fertilizer dose (V×F), FYM application × Fertilizer doses (M×V), and varieties × FYM ×Fertility doses (V×M×F) was observed.

Table 4.7 Effect of different varieties, farmyard manure and various fertilizer doses on nutrient uptake (kg ha^{-1}) of Indian mustard at harvest

Treatments	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})		Sulphur (kg ha^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
(V) Varieties								
(V1) RSPR 69	34.99	21.63	5.88	8.55	14.06	58.00	5.74	15.38
(V2) Pusa mustard 26	31.15	20.40	5.23	8.04	12.49	55.55	5.11	14.47
(V3) RVM 2	43.99	26.40	7.40	10.47	17.71	70.52	7.23	18.85
(V4) NRCHB 101	41.75	25.18	7.03	9.96	16.80	67.43	6.86	17.94
Sem±	0.457	0.312	0.076	0.129	0.182	0.935	0.074	0.231
CD (5%)	1.57	1.07	0.26	0.44	0.63	3.22	0.25	0.79
(M) Farmyard manure application								
(M) Without FYM	34.37	22.01	5.78	8.65	13.78	59.75	5.64	15.57
(M2) FYM @ 5 t ha^{-1}	41.57	24.80	6.99	9.86	16.75	66.00	6.84	17.75
SEm±	0.37	0.14	0.06	0.06	0.14	0.49	0.06	0.11
CD (5%)	1.21	0.47	0.20	0.21	0.48	1.59	0.19	0.37
(F) Fertility levels (N:P$_2$0$_5$:K$_2$0:S kg ha^{-1})								
(F1) 60:30:15:20 kg ha^{-1}	35.72	22.68	6.01	8.94	14.35	61.00	5.87	16.10
(F2) 80:40:20:25 kg ha^{-1}	38.49	23.51	6.48	9.29	15.48	62.99	6.32	16.73
(F3) 100:50:25:30 kg ha^{-1}	39.70	24.03	6.67	9.53	15.96	64.64	6.52	17.15
SEm±	0.33	0.13	0.05	0.06	0.13	0.35	0.05	0.11
CD (5%)	0.96	0.39	0.16	0.18	0.38	1.02	0.15	0.32
Interactions								
(V×M) Variety × FYM	NS	NS	NS	NS	NS	NS	NS	NS
(V×F) Variety × Fertility levels	NS	NS	NS	NS	NS	NS	NS	NS
(M×F) FYM × Fertility level	NS	NS	NS	NS	NS	NS	NS	NS
(V×M×F) Variety× FYM× Fertility level	NS	NS	NS	NS	NS	NS	NS	NS

4.5 Quality parameters

4.4.1 Protein content (%)

The data regarding protein is given in (Table 4.8) which indicates that different treatments i.e., FYM (M) and fertility levels (F) significantly influenced the Protein content of Indian mustard during the crop season. However, treatment consisting of varieties (V) was found to be non-significant. Results revealed that FYM (M) and Fertility levels (F) significantly influenced the Protein content of Indian mustard.

A significant increase in protein content was recorded with application of M2 (FYM @ 5t) ha^{-1} (17.87 %) than M1 (no FYM application) in comparison (16.83).

Among the different fertility levels (F), significantly higher protein content was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied (17.64 %) than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) application (17.07 %).

A non-significant interaction effect between varieties × FYM application (V×M), varieties × Fertilizer dose (V×F), FYM application × Fertilizer doses (M×F), and varieties × FYM × fertility doses (V×M×F) was observed.

4.4.2 Oil content (%)

The data regarding oil content is given in (Table 4.8) which indicates that different treatments i.e., varieties (V), FYM (M), and fertility levels (F) significantly influenced the oil content of Indian mustard during the crop season. Results revealed that among the different varieties (V) Indian mustard variety V3 (RVM-2) resulted in a significantly higher oil content (38.45 %) than NRCHB – 101, V1 (RSPR-69), and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, the lowest oil content was recorded in V2 (Pusa mustard 26) variety (37.18 %).

Similarly, significant increase in oil content was recorded with application of M2 (FYM @ 5t) ha^{-1} (37.81 %) than M1 (no FYM application) in comparison (37.77 %).

Among the different fertility levels (F), the significantly higher oil content was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied (37.80) than fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) application (37.77 %).

A non-significant interaction effect between varieties × FYM application (V×M), varieties × Fertilizer dose (V×F), FYM application × Fertilizer doses (M×F), and varieties × FYM × Fertility doses (V×M×F) was observed.

4.4.3 Oil Yield (kg ha^{-1})

The data presented in Table 4.8 revealed that different varieties (V), FYM (M) and Fertility levels (F) significantly influenced the oil yield of Indian mustard. Among the different varieties (V) of Indian mustard, variety V3 (RVM-2) though at par with V4 (NRCHB 101) resulted in a significantly higher oil yield (587.03 kg ha^{-1}) than (RSPR-69) and V2 (Pusa mustard 26) in comparison under late sown conditions of the Jammu region. However, lowest oil yield was recorded in V2 (Pusa mustard 26) variety (413.38 kg ha^{-1}).

Similarly, significant increase in oil yield $plant^{-1}$ was recorded with application of M2 (FYM @ 5t) ha^{-1} (533.56 kg ha^{-1}) than M1 (no FYM application) in comparison (471.32 kg ha^{-1}).

Among the different fertility levels (F), significantly higher oil yield was recorded in plots where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied (520.16 kg ha^{-1}). However, the lowest oil yield was recorded in plots where fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) was applied (472.70 kg ha^{-1}).

A significant interaction effect of Varieties × fertility levels (V×F), FYM × fertility levels (M×F), and varieties × FYM × fertility levels (V×M×F) application was observed at all the growth stages (Table 4.8.1). Interaction effect of Varieties (V) × fertility level (F) was found to be significant. At same level of varieties (V) significantly higher oil yield was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}). However, lowest oil yield was observed with the application of fertility level F1 ($P_2O_5:K_2O$:S @ 60:30:15:20 kg ha^{-1}).

Interaction effect of FYM (M) x fertility levels (F) application was also found to be significant. At same level of FYM (M), a siginificantly higher oil yield was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) at harvest. However, lowest oil yield was obtained with the application of fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}).

Interaction effect of varieties (V) x FYM (M) x fertility levels (F) were also found to be significant. At the same level of varieties (V) and FYM (M), a significantly higher oil yield $plant^{-1}$ was observed with the application of fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_20_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest oil yield $plant^{-1}$ was observed with the application of fertility level F1 (N:P_20_5:K_20:S @ 60:30:15:20 kg ha^{-1}).

However, interaction effect of varieties × FYM (V×M) was found to be non-significant.

Table 4.8: Effect of different varieties, farmyard manure and various fertilizer doses on quality attributes of Indian mustard at harvest

Treatments	Protein content (%)	Oil content (%)	Oil yield (kg ha^{-1})
(V) Varieties			
(V1) RSPR 69	17.31	37.39	460.50
(V2) Pusa mustard 26	17.07	37.18	413.38
(V3) RVM 2	17.60	38.45	587.36
(V4) NRCHB 101	17.43	38.13	548.85
SEm±	0.12	0.02	21.70
CD (5%)	NS	0.08	74.89
(M) Farmyard manure application			
(M1) Without FYM	16.83	37.77	471.32
(M2) FYM @ 5 t ha^{-1}	17.87	37.81	533.73
SEm±	0.06	0.001	3.35
CD (5%)	0.22	0.004	10.92
(F) Fertility levels (N:P_20_5:K_20:S kg ha^{-1})			
(F1) 60:30:15:20 kg ha^{-1}	17.07	37.77	472.70
(F2) 80:40:20:25 kg ha^{-1}	17.35	37.79	512.68
(F3) 100:50:25:30 kg ha^{-1}	17.64	37.80	522.19
SEm±	0.07	0.001	3.0
CD (5%)	0.21	0.002	8.65
Interactions			
(V×M) Variety × FYM	NS	NS	NS
(V×F) Variety × Fertility levels	NS	NS	17.31
(M×F) FYM × Fertility level	NS	NS	12.24
(V×M×F) Variety × FYM× Fertility level	NS	NS	24.48

Table 4.8.1 Interaction effect of different varieties, farmyard manure and various fertilizer doses on oil yield (kg ha^{-1}) of Indian mustard at harvest

VxMxF								
	V1		**V2**		**V3**		**V4**	
	M1	**M2**	**M1**	**M2**	**M1**	**M2**	**M1**	**M2**
F1	418.57	462.70	375.95	416.95	519.05	558.70	481.27	548.40
F2	441.20	491.36	394.50	447.66	554.33	657.13	533.69	595.81
F3	443.97	505.23	395.93	449.28	559.75	673.24	537.63	596.28
VxM				**VxF**				
	M1	**M2**	**Mean V**		**F1**	**F2**	**F3**	**Mean V**
V1	434.58	486.43	460.50	**V1**	440.63	466.28	474.60	460.50
V2	388.79	437.96	413.38	**V2**	396.45	421.08	422.60	413.38
V3	544.37	629.69	587.03	**V3**	538.87	605.73	616.49	587.03
V4	517.53	580.16	548.85	**V4**	514.83	564.75	566.95	548.85

Mean M	471.32	533.56			**C.D.**	**SE(d)**	**SEm±**
MXF				**Factor (V)**	70.89	30.68	21.70
				Factor (M)	10.92	4.74	3.35
	F1	**F2**	**F3**	**(VxM)**	NS	9.48	6.70
				Factor (F)	8.65	4.24	3.00
M1	448.71	480.93	484.32	**VxF**	17.31	8.49	6.01
M2	496.69	547.99	556.01	**MXF**	12.24	6.01	4.24
Mean F	472.70	514.46	520.16	**VXMXF**	24.48	12.01	8.49

V1- RSPR 69 **V2** (Pusa mustard 26) **V3-** RVM 2 **V4-** (NRCHB 101)

M1- Without FYM and **M2-** FYM @ 5 t ha^{-1}

F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}

F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}

F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

4.4 Relative economics

4.4.1 Cost of cultivation (₹ ha^{-1})

Data on the cost of cultivation (Table 4.9) revealed that all the varieties (V) had similar cost of cultivation (₹ 20,846 ha^{-1}).

Similarly, application of (M2) FYM @ 5t ha^{-1} resulted in higher cost of cultivation (₹ 21596 ha^{-1}) whereas lowest Cost of cultivation (₹ 20,096 ha^{-1}) was recorded in the treatment in which (M1) no FYM was used.

Among the different fertility levels (F1, F2 and F3), higher cost of cultivation (₹21801 ha^{-1}) was recorded where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied whereas lowest cost of cultivation (₹19,892 ha^{-1}) was observed in treatments where fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) was used.

4.4.2 Gross return (₹ ha^{-1})

Data on the Gross return (Table 4.9) revealed that among different varieties (V) higher gross return was obtained in RVM 2 (₹ 70,525 ha^{-1}) whereas lowest gross return was obtained in V2 (Pusa mustard 26) (₹ 52,570 ha^{-1}).

Similarly, application of (M2) FYM @ 5t ha^{-1} resulted in higher gross return (₹ 65,771 ha^{-1}) whereas lowest gross return (₹ 58,225 ha^{-1}) was recorded in the treatment in which (M2) no FYM was used.

Among the different fertility levels (F1, F2 and F3), higher gross return (₹64,127 kg ha^{-1}) was recorded where fertility level F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied whereas lowest gross return (₹58396 kg ha^{-1}) was observed in treatments where fertility level F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) was used.

4.4.3 Net return (₹ ha^{-1})

Data on the Net return (Table 4.9) revealed that among different varieties (V) higher net return (₹ 49,678 ha^{-1}) was obtained in (V3) RVM 2 whereas lowest net return (31,724 ha^{-1}) was obtained in V2 (Pusa mustard 26).

Similarly, application of (M2) FYM @ 5t ha^{-1} resulted in higher net return (₹ 44,175 ha^{-1}) whereas lowest net return (₹ 38,129 ha^{-1}) was recorded in the treatment in which (M1) no FYM was used

Among the different fertility levels (F1, F2 and F3), higher net return (₹ 42,326 ha^{-1})

was recorded where F3 ($N:P_20_5:K_20:S$ @ 100:50:25:30 kg ha^{-1}) was applied whereas lowest net return (₹38,504 ha^{-1}) was observed in treatments where F1 ($N:P_20_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) was used.

4.4.4 Benefit: cost ratio

Data on the B:C ratio revealed that (V3) RVM 2 in combination with FYM (M2) and fertility level F3 ($N:P_2O_5:K_20:S$ @ 80:40:20:25 kg ha^{-1}) fetched maximum B:C ratio (2.65) whereas (V2) Pusa mustard in combination with treatment no FYM (M1) and fertility level F1 ($N:P_2O_5:K_20:S$ @ 60:30:15:20 kg ha^{-1}) had minimum B:C ratio (1.50).

Table 4.9 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 return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
(V) Varieties				
(V1) RSPR 69	20846	58,021	37,175	1.78
(V2) Pusa mustard 26	20846	52,570	31,724	1.52
(V3) RVM 2	20846	70,525	49,678	2.37
(V4) NRCHB 101	20846	66,877	46,031	2.20
(M) Farmyard manure application (M)				
(M) Without FYM	20096	58,225	38,129	1.89
(M2) FYM @ 5 t ha^{-1}	21596	65,771	44,175	2.04
(F) Fertility levels ($N:P_20_5:K_20:S$ kg ha^{-1})				
(F1) 60:30:15:20 kg ha^{-1}	19892	58,396	38,504	1.93
(F2) 80:40:20:25 kg ha^{-1}	20846	63,472	42,626	2.04
(F3) 100:50:25:30 kg ha^{-1}	21801	64,127	42,326	1.93

DISCUSSION

The experimental results presented in the previous chapter gave a detailed account of the "**Performance of Indian Mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region**" during *Rabi* 2020-2021. The most important experimental findings are discussed below, along with possible explanations and evidences where ever necessary, in order to determine the cause-and-effect relationship between different treatments with respect to the various attributes studied and sort out information of practical value. A crop's growth and yield performance are determined by the number of metabolic processes occurring in the plant body, which are influenced by the type of variety used and the optimum fertility levels used in conjunction with FYM.

The yield potential is no doubt dependent on the variety hence it becomes necessary to evaluate proper studies to find out the variety that will show better result. Various growth parameters and yield attributes can also be improved by providing the crop with appropriate fertility dosesin combination with FYM. Under this situation, it becomes imperative to evaluate the variety, FYM and appropriate fertility levels to become sustainable in oil seed production besides saving foreign exchequer.

5.1 Growth characteristics

Indian mustard varieties (V) differed significantly for various growth characteristics. Among the different varieties at 30 DAS and subsequent growth stages of Indian mustard variety (V3) RVM-2 though at par with (V4) NRCHB 101 resulted in significantly higher plant height, leaf area index, dry matter accumulation and crop growth rate than (V1) RSPR-69 and (V2) Pusa Mustard 26 in comparison at various growth stages under late sown conditions of Jammu region. However lowest plant height, leaf area index, dry matter accumulation and crop growth rate was recorded in (V2) Pusa Mustard 26 variety. The explanation for this could be due to stronger genetic traits of (V3) RVM 2, which allow it to use photosynthates more efficiently, thereby resulting in higher plant height, leaf area index, dry matter accumulation and crop growth rate. These results are in agreement with Singh *et al*. (2010) who conducted an experiment.to study the growth of Indian mustard varieties at increasing fertility schedules under late sown conditions and found that varieties differed significantly for various growth characteristics.

Similarly, significant increase in plant height was recorded with application of (M2) FYM @ 5tha^{-1} at 30, 60, 90 and 120 DAS than (M1) no FYM application in comparison. Treatments in which (M2) FYM @ 5t ha^{-1} was used resulted in significantly higher plant height, leaf area index, dry matter accumulation and crop growth rate than (M1) no FYM application in comparison at various growth intervals. The significant improvement in various growth characteristics due to application of (M2) FYM over (M1) no FYM may be due to more nutrient availability in soil than (M1) no FYM. On average, well decomposed FYM contains essential macronutrients like nitrogen, phosphorus and potassium, and a variety of other micronutrients. FYM not only provides macro and micronutrients, but it also boosts the availability of inorganic nutrients, resulting in a positive effect on the plant's overall growth characteristics. Because of the balanced nutritional environment in both the soil rhizosphere and the plant system, it also plays a significant role in better root development and increased microbial activity. These results are in line with the findings of Kumar *et al* (2019) who also performed an experiment to study the effect of FYM on sustainable production of Indian mustard and found that application of FYM resulted in an increasing in growth characteristics.

Fertility levels too differed significantly for various growth characteristics. Application of fertility level F3 (N:P_2O_5:K_2O:S @ 100:50:25:30 kg ha^{-1}) though at par with the application of fertility level F2 (N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}) resulted in significant increase in plant height, leaf area index, dry matter accumulation and crop growth rate at various growth stages of Indian mustard. However, lowest plant height, leaf area index, dry matter accumulation and crop growth rate was observed with the application of fertility level F1 (N:P_2O_5:K_2O:S @ 60:30:15:20 kg ha^{-1}). Improved nutrient availability in the soil may have higher meristematic activity (cell multiplication and elongation), resulting in increased plant height, LAI, dry matter accumulation, and crop growth rate as a result of increased fertility doses. High fertility levels during the early stages of crop growth may have also resulted in a stronger start and early seedling vigour, resulting in higher nutrient uptake during the early stages of crop growth. These results are in agreement with the findings of Kumar *et al* (2017) who studied the effect of different fertility levels on growth of Indian mustard and observed that with increasing fertility levels, an increasing trend was shown in growth characteristics.

5.2 Yield attributes

Indian mustard varieties (V) differed significantly for various yield attributes. Among different varieties of Indian mustard variety (V3) RVM 2 though at par with (V4) NRCHB 101 resulted in significantly higher yield attributes viz. branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1} and test weight than (V1) RSPR-69 and (V2) Pusa Mustard 26 in comparison under late sown conditions of Jammu region. However lowest yield attributes viz. branch plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1} and test weight were recorded in (V2) Pusa Mustard 26 variety. This might be due to better genetic makeup of (V3) RVM 2. These results are in agreement with Dinda *et al* (2015) who carried out an experiment to study the effect of varieties of mustard on yield of mustard and observed that there was a significant difference among all the varieties with respect to their performance in the field.

Similarly, significant increase in yield attributes viz. branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1} and test weight were recorded with application of (M2) FYM @ 5t ha^{-1} at harvest than (M1) no FYM application in comparison. This could be attributed to increased photosynthesis and assimilation rates, which would result in a large improvement in yield attributes. These results are in agreement with Kumar *et al*. (2017) who carried an experiment to study the effect of integrated nutrient management on growth and yield of mustard and found that application of FYM in combination with inorganic fertilisers increased yield attributes.

Fertility levels too differed significantly for various growth characteristics. Application of fertility level F3 (N:P_2O_5:K_2O:S @ 100:50:25:30 kg ha^{-1}) though at par with the application of fertility level F2 (N:P_2O_5:K_2O:S @ N:P:K:S @ 80:40:20:25 kg ha^{-1}) resulted in an increase in yield attributes viz. branches plant^{-1}, siliquae plant^{-1}, seeds siliqua^{-1} and test weight. However, lowest yield attributes viz. branches plant^{-1}, siliquae plant^{-1},seeds siliqua^{-1} and test weight was observed with the application of fertility level F1 (N:P_2O_5:K_2O:S @ 60:30:15:20 kg ha^{-1}). This could be due to an increase in general vitality and crop growth. All needed 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 in greater growth and more photosynthate translocation from source to sink, resulting in higher yield attributes. These results are in line with the findings of Kumar *et al* (2017) who studied the effect of different fertility levels on growth of Indian mustard and observed that with increasing fertility levels yield attributes also increased.

5.3 Seed yield, Stover yield, biological yield and Harvest index

Indian mustard varieties (V) differed significantly for seed yield, stover yield and harvest index. Among different varieties of Indian mustard variety (V3) RVM-2 though at par with (V4) NRCHB 101 resulted in significantly higher seed yield, stover yield, biological yield and harvest index than (V1) RSPR-69 and (V2) Pusa Mustard 26 in comparison at harvest stage under late sown conditions of Jammu region. However lowest seed yield, stover yield, biological yield and harvest index was recorded in (V2) Pusa Mustard 26 variety. More yield of (V3) RVM 2 might be due to the sum total effect of enhanced growth and increase in yield contributing characters. Higher seed, stover yields and biological yield in (V3) RVM 2 could be attributed to improved expression of growth and yield traits, leading in increased yield. These results are in agreement with Patidar *et al*. (2000) who carried an experiment on varietal performance of Indian mustard under different fertility level and observed that superior genotype resulted in higher yield characteristics in mustard.

Similarly, significant increase in seed yield, stover yield, biological yield and harvest index was recorded with application of (M2) FYM @ 5t ha^{-1} at harvest than(M1) no FYM application in comparison. This might be due to gradual mineralization and availability of nutrients resulting in increased moisture holding capacity of soil due to FYM application. These results are in agreement with Sukmal *et al.*, (2004) who also observed similar trend with application of FYM.

Fertility levels too differed significantly for various yield parameters. Higher seed yield was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest seed yield was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}). Significantly higher stover yield was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) than the application of fertility level (F2) $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1} and fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) in comparison. However, lowest stover yield was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}). Similarly, significantly higher biological yield was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) than the application of fertility level (F2) $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1} and fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) in comparison. However, lowest biological yield was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}).Significantly higher harvest index was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}. However, lowest harvest index was obtained with the application of fertility level F1

(N:P_2O_5:K_2O:S @ 60:30:15:20 kg ha^{-1}. This could be due to larger nutrient dosages resulting in improved growth and, as a result, a rise in various yield components due to adequate supply of major plant nutrients, which eventually boosts seed yield, stover output, and subsequently the harvest index. These results are in agreement with Ghimire *et al*. (2011) who carried an experiment on the effect of fertility level on growth and yield of mustard and observed that increasing fertility levels resulted in an increase in yield.

5.4 Nutrient uptake studies

Uptake of nutrients (N:P_2O_5:K_2O:S) by crop is a function of the nutrient content in plant and dry matter accumulation per unit area. N:P_2O_5:K_2O:S uptake in seed and stover was significantly influenced by different varieties. Significantly higher N:P_2O_5:K_2O:S uptake by seed and stover was obtained by variety (V3) RVM-2 of Indian mustard than (V4) NRCHB 101, (V1) RSPR 69 and (V2) Pusa mustard 26 in comparison. However, lowest nutrient uptake by seed and stover was obtained by (V2) Pusa mustard 26. Mukherjee (2020) also reported that nutrient uptake of Indian mustard was significantly affected by varieties.

Similarly, significant increase in nutrient uptake by seed and stover was recorded with application of (M2) FYM @ 5t ha^{-1} at harvest than (M1) no FYM application in comparison. This may be due to the fact that FYM application in conjunction with mineral nutrients enhances the nutrientuptake mainly due to better growth and dry matter accumulation. The balanced nutrition also enhances the synergistic effect on uptake of other plant nutrients. Greater nutrient uptake couldalso be the result of increased nutrient availability to plants and improved soil physical conditions. These results are in agreement with Jat *et al*. (2013) who carried an experiment to study the effect of FYM and mineral nutrients on yield, content and uptake of nutrients in mustard and observed that each successive increasing levels of FYM and mineral nutrients individually and in combination significantly increased the nutrient uptake as well.

An increasing trend of nutrient uptake was recorded with increasing fertility levels. Significantly higher nutrient uptake was observed with the application of fertility level (F3) N:P_2O_5:K_2O:S 100:50:25:30 kg ha^{-1} than the application of fertility level F2 (N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}) and fertility level F1 (N:P_2O_5:K_2O:S @ 60:30:15:20 kg ha^{-1}) in comparison. However, lowest nutrient uptake was obtained with the application of N:P_2O_5:K_2O:S @ 60:30:15:20 kg ha^{-1}. The higher uptake at increased fertility doses might be due to increased growth, vigour and more cell division, photosynthesis rate and root activities of plants. These results are in agreement with Chauhan *et al*. (2020) who carried an experiment on the effect of fertility levels on nutrient uptake in mustard and resulted in an increase in nutrient uptake with increasing fertility level.

5.5 Quality attributes

Quality parameters viz. oil content and oil yield were interrelated. Oil yield is the result of seed yield and oil content and both of these components were influenced by plant growth and yield contributing attributes. Protein content is also the result of nitrogen content in seed. Varieties showed a non-significant on protein content of Indian mustard. Among different varieties significantly higher oil content and oil yield was recorded in (V3) RVM 2 in comparison to (V4) NRCHB 101, (V1) RSPR 69 and (V2) Pusa mustard 26. However, lowest oil content and oil yield wasobserved in (V2) Pusa mustard 26. This might be due to superior genetic ability of (V3) RVM 2. Varietal difference in oil content and oil yield was also reported by Kashyap *et al*. (2017).

Similarly, significant increase in quality attributes viz. protein content, oil content and oil yield were recorded with application of (M2) FYM @ 5t ha^{-1} at harvest than no FYM (M1) application in comparison. This might be due to increased availability of nutrients in the soil. Higher availability of nitrogen results in more nitrogen content hence more protein content. FYM in combination with Sulphur also increases oil content and oil yield. These results are inagreement with Singh *et al*. (2006) who studied evaluation of yield and quality aspects of indian mustard under integrated nutrient management and observed that quality attributes increased significantly with application of FYM.

Protein content, oil content and oil yield increased significantly with increasing fertility levels. Significantly higher yield attributes viz. protein content, oil content and oil yield were observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) than the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) in comparison. However, lowest quality attributes were obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}). Increase in oil content and oil yield 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 innitrogen 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) who carried an experiment on the effect of different fertility levels on growth, yield attributes, yield and quality of Indian mustard and observed that increasing fertility increased quality attributes as well.

5.4 Relative economics

The practicability and usefulness of treatments are judged ultimately in terms of net returns and B: C ratio. The results of present study showed that gross returns, net returns and B: C ratio were markedly influenced by different varieties (V), FYM application (M) and fertility levels (F). Among different varieties (V3) RVM 2 fetched maximum gross return, net return and B:C ratio at same cost of cultivation. This was due to higher biological yield obtained with (V3) RVM 2 because of its inherent character. These results are in agreement with Kumari *et al*. (2012) who carried a study on the productivity, nutrient uptake and economics of mustard hybrid and observed that varieties with better yield gave maximum B:C ratio.

Similarly, treatments in which (M2) FYM @ 5t ha^{-1} was applied fetched maximum gross return,net return and B:C ratio than (M1) no FYM application in comparison. This might be due to higher production i.e, more biological yield in the treatments in which (M2) FYM @ 5t ha^{-1} was employed so gross return and net return also increased leading to more B:C ratio. These results are in agreement with Mukherjee (2016) who carried studies on the effect of integrated nutrient management on growth and productivity of Indian mustard and observed that application of FYM resulted in an increase in yield attributes and yield which ultimately resulted in a higher B:C ratio.

Application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) fetched maximum gross return and net return than the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15: kg ha^{-1}) in comparison. However, application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) fetched maximum B:C ratio. This might be due to lower cost of cultivation with the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) than the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}). These results are in agreement with Singh *et al*. (2010) who studied the response of fertility levels on economics of Indian mustard and observed an increase in B:C ratio with increasing fertility levels.

CHAPTER –VI

SUMMARY AND CONCLUSION

An experiment entitled, "**Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region**" was carried out during the year Rabi 2020-21. The data recorded in respect of physico-chemical properties of the experimental site revealed that the soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction, low in available nitrogen, but medium in organic carbon, available phosphorus, available potassium and available sulphur. The experiment was laid out in split – split plot design with 24 treatments and three replications. The main plot consisted of four varieties (RSPR 69, Pusa Mustard 26, RVM 2 and NRCHB 101), sub plot (Without FYM and FYM @5 t ha^{-1}) and sub-sub plot consisted of three fertility levels ($N:P_2O_5:K_2O:S$) @ 60:30:15:20, ($N:P_2O_5:K_2O:S$) @ 80:40:20:25 and ($N:P_2O_5:K_2O:S$) @ 100:50:25:30. The salient findings of the present investigation have been summarized in thischapter.

6.1 Effect of Varieties

Indian mustard varieties (V) differed significantly for various growth characteristics. Among the different varieties at 30 DAS and subsequent growth stages of Indian mustard (V3) RVM-2 variety though at par with (V4) NRCHB 101 resulted in a higher plant height, leaf area index, dry matter accumulation and CGR than RSPR-69 and Pusa Mustard 26 in comparison under late sown conditions of Jammu region. However lowest growth characteristics were recorded in (V2) Pusa Mustard 26 variety.

Varieties (V) differed significantly for various yield attributes. Among different varieties of Indian mustard (V3) RVM-2 variety though at par with (V4) NRCHB 101 recorded higher yield attributes viz. branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and test weight than RSPR-69 and Pusa Mustard 26 in comparison at harvest under late sown conditions of Jammu region. However lowest yield attributes viz. branch $plant^{-1}$, siliqua $plant^{-1}$, seeds $siliqua^{-1}$ and test weight were recorded in (V2) Pusa Mustard 26 variety.

Varieties (V) differed significantly for seed yield, stover yield, biological yield and harvest index. Among different varieties of Indian mustard (V3) RVM-2 variety though at par with (V4) NRCHB 101 resulted in a higher seed yield, stover yield, biological yield and harvest index than (V1) RSPR-69 and (V2) Pusa Mustard 26 in comparison at harvest stage under late sown conditions of Jammu region. However lowest seed yield, stover yield, biological yield and harvest index was recorded in (V2) Pusa Mustard 26 variety.

Uptake of nutrients (N, P, K and S) by crop is a function of the nutrient content in plantand dry matter accumulation per unit area. N, P, K and S uptake in seed and stover was significantly influenced by different varieties (V). Significantly higher N, P, K and S uptake by seed and stover was obtained by (V3) RVM 2 variety of Indian mustard than (V4) NRCHB 101, (V1) RSPR69 and (V2) Pusa mustard 26 in comparison. However, lowest nutrient uptake by seed and stover was obtained by Pusa mustard 26.

Varieties (V) did not differ significantly for protein content of Indian mustard. Among different varieties significantly higher oil content and oil yield was recorded in (V3) RVM 2 in comparison to (V4) NRCHB 101, (V1) RSPR 69 and (V2) Pusa mustard 26. However, lowest oil content and oil yield was observed in Pusa mustard 26.

The results of present study showed that gross returns, net returns and B: C ratio weremarkedly influenced by different varieties, FYM application and fertility levels. Among different varieties (V3) RVM 2 fetched maximum gross return, net return and B:C ratio at same cost of cultivation.

6.2 Effect of farmyard manure

Significantly higher Plant height was recorded with application of (M2) FYM@ 5t ha^{-1} at all stages than (M1) no FYM application in comparison. Treatments in which (M2) FYM@ 5t ha^{-1} was used resulted in significantly higher leaf area index, dry matter accumulation and CGR than (M1) without FYM in comparison at various growth intervals.

Similarly, significant increase in yield attributes viz. branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and test weight were recorded with application of (M2) FYM@ 5t ha^{-1} at harvest than no FYM application in comparison.

Significant increase in seed yield, stover yield, biological yield and harvest index was recorded with application of (M2) FYM@ 5t ha^{-1} at harvest than (M1) no FYM application in comparison.

Significant increase in nutrient uptake by seed and stover was recorded with application of (M2) FYM@ 5t ha^{-1} at harvest than (M1) no FYM application in comparison.

Significant increase in quality attributes viz. protein content, oil content and oil yield were recorded with application of (M2) FYM@ 5t ha^{-1} at harvest than (M1) no FYM application in comparison.

Similarly, treatments in which (M2) FYM@ 5t ha^{-1} was applied fetched maximum gross return, net return and B:C ratio than (M1) no FYM application in comparison.

6.3 Effect of different fertility levels

Fertility levels too differed significantly for various growth characteristics. Application of fertility level F3 ($N:P_2O_5:K_2O:S$ @100:50:25:30 kg ha^{-1}) though at par with the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @80:40:20:25 kg ha^{-1}) resulted in significant increase in plant height. However, lowest plant height was observed with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}).

Application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) resulted in significantly higher leaf area index, dry matter accumulation and crop growth rate than the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) in comparison at various crop growth intervals. However, lowest leaf area index, dry matter accumulation and crop growth rate was observed with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}).

Fertility levels also differed significantly for various yield attributes. Application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) though at par with the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) resulted in significant increase in yield attributes viz. branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and test weight. However, lowest yield attributes viz. branches $plant^{-1}$, siliqua $plant^{-1}$, seeds $siliqua^{-1}$ and test weight was observed with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}).

Fertility levels (F) too differed significantly for various yield parameters. Significantly higher seed yield was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest seed yield was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}). Significantly higher stover yield was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) than the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) and application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) in comparison. However, lower stover yield was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}). Significantly higher biological yield was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest biological yield was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}). Significantly, higher harvest index was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) that was statistically at par with with the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}). However, lowest harvest index was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}).

An increasing trend of N, P, K, S uptake was recorded with increasing fertility levels.

Significantly higher nutrient uptake was observed with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) than application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) and with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) in comparison. However, lowest nutrient uptake was obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}).

Protein content, oil content and oil yield increased significantly with increasing fertility levels (F). Significantly higher yield attributes viz. protein content, oil content and oil yield wereobserved with the application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) than the application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) in comparison. However, lowest quality attributes were obtained with the application of fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}).

Application of fertility level F3 ($N:P_2O_5:K_2O:S$ @ 100:50:25:30 kg ha^{-1}) fetched maximum gross return and net return than fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) and fertility level F1 ($N:P_2O_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}) incomparison. However, application of fertility level F2 ($N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}) fetched maximum B:C ratio.

CONCLUSION

On the basis of one year study, it may be concluded that

- Among the different Mustard varieties RVM 2 though at par with NRCHB 101 resulted in significant increase in growth, yield attributes, yield, nutrient uptake and quality attributes of Indian mustard than other varieties in comparison. Addition of FYM@5 t ha^{-1} resulted in improved growth, yield attributes, yield, nutrient uptake and quality attributes of Indian mustard. Application of fertilizer dose @80:40:20:25 kg ha^{-1} ($N:P_2O_5:K_2O:S$) fetched 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, nutrient uptake and quality of Indian Mustard under late sown conditions of Jammu region.

REFERENCES

Alam, M.M., Begum, F. and Roy, P., 2014. Yield and yield attributes of rapeseed mustard (Brassica) genotypes grown under late sown condition. *Bangladesh Journal of Agricultural Research*. **39**(2): 311-336.

Anonymous. 2019. Annual report. Directorate of Rapeseed-mustard research.

Anonymous. 2021. Annual report. Directorate of Rapeseed-mustard research.

Bal, S.K. and Minhas, P.S., 2017. Atmospheric stressors: challenges and coping strategies. In *Abiotic stress management for resilient agriculture* Springer, Singapore. Pp 9-50

Bhat, S.A., Khan, F.A. and Khan, M.I., 2006. Effect of nitrogen and phosphorus on growth, nutrient content, seed yield and quality of mustard. *Indian Journal of Plant Physiology*, **11**(3): 281-286.

Biswas, P.K., Ferdous, L.J., Roy, T.S. and Masum, S.M., 2019. Performance of rapeseed and mustard with different planting techniques. *Bangladesh Agronomy Journal*, **22**(1): 79-88.

Biswas, S., Mukherjee, B., Munshi, A., Chongre, S. and Ray, M., 2019. Evaluation of Mustard Hybrid varieties in Gangetic Plains of West Bengal, India. *International Journal of Current Microbiology and Applied Sciences*, **8**(10): 585-590.

Blanchet, G., Gavazov, K., Bragazza, L. and Sinaj, S., 2016. Responses of soil properties and crop yields to different inorganic and organic amendments in a Swiss conventional farming system. *Agriculture, Ecosystems & Environment*, **2**(3): 116-126.

Chand, R. and Pavithra, S., 2015. Fertilizer use and imbalance in India: analysis of states. *Economic and Political Weekly*. Pp 98-104.

Chand, S., 2007. Effect of integrated nutrient management on yield and nutrient use efficiency in mustard (*Brassica juncea* L.). *SAARC Journal of Agriculture*, **5**(2): 93-100.

Chand, S., Anwar, M., Patra, D.D. and Khanuja, S.P.S., 2004. Effect of mint distillation waste on soil microbial biomass in a mint-mustard cropping sequence. *Communications in Soil Science and Plant Analysis*, **35**(1-2): 243-254.

Chand, S., Patidar, O.P., Chaudhary, R., Saroj, R., Chandra, K., Meena, V.K., Limbalkar, O.M., Patel, M.K., Pardeshi, P.P. and Vasisth, P., 2021. Rapeseed-Mustard Breeding in India: Scenario, Achievements and Research Needs. *Brassica Breeding and*

Biotechnology. Pp 110-116

Chauhan Z. Patel, D.K and Bhabhor, K. 2020. Effect of Nitrogen, Phosphorus and Sulphur on Yield, Nutrient Uptake and Soil Fertility after Harvest of Mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied Sciences*, **9**(6): 3506-3512.

Cheema, M.A., Sattar, A., Wahid, M.A., Saleem, M.F. and Sadiq, S., 2012. Growth, yield and quality response of various canola cultivars under agro-ecological condition of Faisalabad. *Pakistan Journal of Agricultural Sciences*, **49**(1): 35-39.

Chesnin, L. and Yien, C.H., 1950. Turbid metric method for determination of sulphur. *Soil Science Society of America* **4**(1): 149-151.

Cochran, W. G. and G. M. Cox 1957. Experimental Desighn.2nd Edn. *Asia publishing House, Bombay, London, New York*. Pp.148-181.

Das, A., Patel, D.P., Munda, G.C. and Ghosh, P.K., 2010. Effect of organic and inorganic sources of nutrients on yield, nutrient uptake and soil fertility of maize (*Zea mays*)-mustard (*Brassica campestris*) cropping system. *Indian Journal of Agricultural Sciences*, **80**(1): 85-88.

Davaria, R.L., Khanpara, V.D., Kaneria, B.B., Mathukia, R.K. and Asodaria, K.B. 2001. Effect of phosphorus and sulphur on growth, yield, quality and nutrient content of mustard (*Brassica juncea*). *Gujarat Agricultural University Research Journal*, **26**(2): 77-79.

Dinda, N.K., Ray, M and Sarkar, P. 2015. Effect of sowing date vis-a-vis variety of rapeseed and Mustard on growth, yield and aphid infestation in Gangetic plains of West Bengal. *The Ecoscan*, **9**(1&2): 21-24.

Ghimire, T.B. and Bana, O.P.S.2011. Effect of fertility levels on mustard (*Brassica juncea*) seed yield, quality and economics under varying poplar (Populus deltoides) tree densities. *Indian Journal of Agronomy*, **56**(4): 346-350.

Jackson, M. L.1973. Soil chemical analysis. *Asia publication house, Bombay*. pp. 165-167

Jat, A. L. Desai, A. G. Prajapati, K. P. Patel, P. J. & Patel, J. R. 2018. Effect of fertility levels on growth, yield and economics of Indian mustard (*Brassica juncea* L.) under north Gujarat region. *Journal of Pharmacognosy and Phytochemistry*, **7**(3): 1649-1652.

Jat, A.L., Patel, B.K. and Prajapati, K.P.2017. Influence of NPK levels on performance of

Indian mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied Sciences*, **6**(8): 1986-90.

Jat, G., Sharma, K.K. and Choudhary, R., 2013. Effect of FYM and mineral nutrients on yield, content and uptake of nutrients in mustard. *Annual Agricultural Research New Series*, **34**(3): 236-240.

Kashyap, S.K., Singh, R.K. and Dahiphale, A.V., 2017. Compitative behavior of mustard (*Brassica juncea* (L.) czernj. and cosson) varieties against weeds. *Journal of Pharmacognosy and Phytochemistry*, **6**(6): 1466-1469.

Kumar, A., Mahapatra, B.S., Yadav, A., Kumari, U., Singh, S.P. and Verma, G. 2017 b. Effect of different fertility levels on growth, yield attributes, yield and quality of Indian mustard (*Brassica juncea* L.). *Annuals of Agricultural Research.*, **38**(1): 98-103.

Kumar, R, Slathia, P.S., Peshin, Rajinder., Gupta, S.K. and Nain, M.S., 2018. Performance analysis of rapeseed-mustard crop under different agro-climatic conditions of Jammu Division of J & K state. *Indian Journal of Agricultural Sciences*, **88**(3): 463-468.

Kumar, S. and Singh, R.K. 2017. Effect of integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.) in irrigated condition of upper gangetic plain zone of India. *International Journal of Current Microbiology and Applied Sciences*, **6**(1): 922-932.

Kumar, V. and SINGH, S., 2019. Effect of fertilizers, biofertilizers and farmyard manure on sustainable production of Indian mustard (*Brassica juncea*). *Annals of Plant and Soil Research*, **21**(1): 25-29.

Kumar, V., Singh, R.K. and Kumar, D.M., 2019. Effect of farm yard manure and Sulphur on production of Indian mustard: A review. *Journal of Pharmacognosy and Phytochemistry*, **8**(3): 2290-2294.

Kumar, V., Singh, V., Singh, S. and Tiwari, N.K., 2017. Effect of macro-nutrients and farm yard manure on productivity and profitability of mustard (*Brassica juncea* L.) in Western Uttar Pradesh, India. *Asian Journal of Soil Science and Plant Nutrition* **1**(3): 1-6

Kumari, A. and Singh, R.P., 2012. Productivity, nutrient uptake and economics of mustard hybrid (*Brassica juncea*) under different planting time and row spacing. *Indian*

Journal of Agronomy, **57**(1): 61-67.

Kumawat, A., Pareek, B.L., Yadav, R.S. and Rathore, P.S., 2014. Effect of integrated nutrient management on growth, yield, quality and nutrient uptake of Indian mustard (*Brassica juncea*) in arid zone of Rajasthan. *Indian Journal of Agronomy*, **59**(1): 119-123.

Lal, B., Rana, K.S., Gautam, P., Rana, D.S., Meena, B.P. and Meena, R.K., 2016. Productivity of Ethiopian Mustard+ Chickpea Intercropping System Influenced by Moisture Conservation Practices and P and S Fertilization. *National Academy Science Letters*, **39**(4): 251-254.

Lal, M., Kumar, S., Kumawat, S.M., Yadav, R.S. and Kharia, S.K., 2020. Performance of mustard (*Brassica juncea* L.) varieties under Azadirachta indica L. shade and open condition in hot-arid region of Rajasthan. *Journal of Agrometeorology*, **22**(2): 132-139.

Malhi, S.S., Gan, Y. and Raney, J.P., 2007. Yield, seed quality, and sulfur uptake of Brassica oilseed crops in response to sulfur fertilization. *Agronomy Journal*, **99**(2): 570-577.

Meena, D.S., Meena, V.R. and Meena, A.K., 2016. Fertilizer management studies on growth and productivity of hybrid Indian mustard *Brassica juncea* (L.). *Journal of Oilseed Brassica*, **1**(1): 39-42.

Mehra, K. L. 1968 History and ethnobotany of mustard in India. *Advancing Frontiers of Plant Sciences*. 19:51-59.

Misra, S.K., 2003. Effect of sulphur and potassium on yield, nutrient uptake and quality characteristics of mustard (*Brassica juncea* L.) in Udic Haplustepts of Kanpur. *Journal of the Indian Society of Soil Science*, **51**(4): 544-548.

Mohapatra, S., Satapathy, M.R., Sahoo, T.R. and Nanda, S.P., 2020. Effect of different levels of Fertilisers on yield, nutrient uptake and economics of Indian Mustard (*Brassica juncea* L.). **9**(6): 483-486

Mukherjee, D., 2016. Studies on integrated nutrient management on growth and productivity of Indian mustard (*Brassica juncea*) in high altitude range of Himalaya. *Journal of Oilseeds Research*, **33**(1): 33-37.

Mukherjee, D., 2020. Yield, nutrient uptake and economics of Indian mustard (*Brassica juncea*) influenced by nutrient doses and planting geometry under new alluvial zone of West

Bengal. *The Indian Society of Oil Seeds Research*, **37**(3): 225-229

Mukherjee, D.,2020 Effect of cultivars and fertility levels on growth, nutrient uptake and quality of mustard (*Brassica juncea* (L.) Czem and Coss.) grown in rice fallow in gangetic plains. *Annual Agriculture Research New Series.* **41** (4): 382-390

Nayak, H., Bohra, J.S. and Yadav, S.P., 2006. Growth and nutrient uptake of indian mustard [*Brassica juncea* (L.) Czern and Coss.] genotypes as influenced by nitrogen and sulphur fertilization under irrigated condition. *Ecology, Environment and Conservation*, **26**(12): 79-83.

Olsen, S.R., 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate, *US Department of Agriculture.* Pp 939

Panotra, N. and Kumar, A., 2018. Economics and influence of fertility levels on growth and yield of Indian mustard (*Brassica juncea* Coss) under irrigated condition. *International Journal of Communication Systems*, **6**(2): 2324-2326.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for agricultural workers. *3rd ICAR publications*: 1-359.

Patidar, M., Singh, M.P., Singh, B. and Raj, S., 2000. Varietal performance of Indian mustard under different fertility levels in arid zone. *Current Agriculture*, **24**(1/2): 89-91.

Piper, C. S. 1966. Soil and Plant Analysis. *Inter Science Publisher Inc. New York.*

Priyanka, R.P., Yadav, R., Kumar, N. and Dhillon, A., 2020. Performance of different Indian mustard (*Brassica juncea*) varieties with saline water and graded fertilizer doses under semi-arid conditions of Haryana. *Journal of Environmental Biology*. **12**(3): 332-47.

Radford, P.J., 1967. Growth analysis formulae-their use and abuse. *Crop science,* **7**(3): 171-175.

Raghuvanshi, N., Kumar, V. and Dev, J., 2018. Effect of nitrogen levels on mustard (*Brassica juncea* (L.) Cuzern and Coss.) varieties under late sown condition. *Current Journal of Applied Science and Technology*, **30**(2): 1-8.

Rai, S.K., Charak, D. and Bharat, R., 2016. Scenario of oilseed crops across the globe. *Plant Archives*, **16**(1): 125-132.

Sadasivam, S. and Manickam, A. 1992. Biochemical methods for agricultural sciences. *Wiley*

Eastern Limited, *New Delhi*. Pp 11-12

Santosh, K., Verma, S.K., Singh, T.K. and Shyambeer, S., 2011. Effect of nitrogen and sulphur on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea*) under rainfed condition. *Indian Journal of Agricultural Sciences*, **81**(2): 145-149.

Sanyal, S.K., Majumdar, K. and Singh, V.K., 2014. Nutrient management in Indian agriculture with special reference to nutrient mining relooks. *Journal of the Indian Society of Soil Science*, **62**(4): 307-325.

Sharma, P., 2013. Effect of varieties and fertility levels on yield and nutrient uptake of mustard in western region of Madhya Pradesh. *Technofame-A Journal of Multidisciplinary Advance Research*, **2**(2): 67-69.

Singh, A. and Meena, N.L., 2004. Effect of nitrogen and sulphur on growth, yield attributes and seed yield of mustard (*Brassica juncea*) in eastern plains of Rajasthan. *Indian journal of Agronomy*, **49**(3): 186-188.

Singh, N., Pandey, S. B., Ranjan, R., Verma, A.K., Pathak, R. K., Dubey, S., Rajput,N. and Singh, R., 2020. Integrated use of organic (FYM), inorganic and biofertilizer (PSB) on productivity, nutrient uptake of wheat and soil properties. *The Pharma Innovation Journal*, **9**(3): 345-347.

Singh, R. and Singh, S.K., 2006. Evaluation of yield and quality aspects of Indian mustard (*Brassica juncea* L. Czernj & Cosson) under integrated nutrient management. *Annals of Agricultural Research*, **27**(3): 148-153

Singh, R.K., Singh, A.K. and Kumar, R., 2010. Effect of Fertility Level on Nutrient Uptake, Yield and Quality of Indian Mustard *Brassica juncea* (L.) Czern and Coss. Varieties under Late Sown Condition. *Environment & Ecology*, **28**(3a): 1764-1767.

Singh, R.K., Singh, Y., Singh, A.K., Kumar, R. and Singh, 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.

Somondal, P., Haldar, P. and Ray, M., 2014. Performance of different rapeseed-mustard varieties in gangetic plains of West Bengal, India. *Plant Archives*, **14**(1): 479-481.

Srikant, K. Yashwant, S. & Menon, S. 2020. Effect of organic manures in cultivation of mustard. *International Journal of All Research Education and Scientific Methods*,

8(3): 2455-6211.

Subbaiah, B.V., 1956. A rapid procedure for estimation of available nitrogen in soil. *Current Science*, 25: 259-260.

Tomar, A., 2018. Response of Indian mustard cultivar RH 749 to different fertility levels under tarai conditions of Uttarakhand. *Journal of Pharmacognosy and Phytochemistry*, **7**(4): 2111-2113.

Tripathi M.K. Chaturvedi S. Shukla D.K. and Mahapata B.S. 2010. Yield performance and quality in Indian mustard (*Brassica juncea*) as affected by integrated nutrient management. *Indian Journal of Agronomy*, **55**(2): 138-42.

Walkley, A. and Black, I.A., 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, **37**(1): 29-38.

Wang, M., Zheng, Q., Shen, Q. and Guo, S., 2013. The critical role of potassium in plant stress response. *International journal of molecular sciences*, **14**(4): 7370-7390.

Yadav, K.G., Kushwaha, C., Singh, P.K., Kumar, M. and Yadav Nishant, S.K., 2017. Effect of nutrient management on yield and nutrient uptake by Indian mustard (*Brassica juncea* L). *Journal of Pharmacognosy and Phytochemistry*, **1**(4): 556-559.

Yadav, M.S. and Dhanai, C.S., 2018. Effect of fertilizers on yield and yield attributing characters of mustard (*Brassica juncea* L. Czern & Coss). *Journal of Pharmacognosy and Phytochemistry*, **7**(2): 2300-03.

Yadav, R.P., Tripathi, M.L. and Trivedi, S.K., 2010. Yield and quality of Indian mustard (*Brassica juncea*) as influenced by irrigation and nutrient levels. *Indian Journal of Agronomy*, **55**(1): 56-59.

Yogesh, K., Dawson, J., Kishanrao, Z.K., Dixit, P.M. and Rahul, K., 2009. Effect of nitrogen, phosphorus and sulphur fertilization on growth and yield of mustard (*Brassica juncea Coss*). *International Journal of Agricultural Sciences*, **5**(2): 396-398.

APPENDIX I

Mean weekly meteorological data during crop growing season (*Rabi*, 2020-21)

SMW*	Date & Month	Actual Max. Temp (˚C)	Actual Min. Temp (˚C)	Normal Max.Temp (˚C)	Normal Min. Temp (˚C)	Actual Rainfall (mm)	Normal Rainfall (mm)
47	19 Nov to 25 Nov	20.6	8.5	25.6	10.6	0.0	0.8
48	26 Nov to 02 Dec	23.7	7.4	24.1	9.1	8.0	3.7
49	3 Dec to 9 Dec	23.3	9.8	23.2	8.7	0.8	0.9
50	10 Dec to 16 Dec	18.5	8.3	21.6	8.5	27.6	7.1
51	17 Dec to 23 Dec	17.6	3.0	20.6	7.9	0.0	2.4
52	24 Dec to 31 Dec	15.0	2.9	19.0	6.9	8.8	12.6
1	1 Jan to 7 Jan	18.8	8.4	17.4	5.5	88.2	9.4
2	8 Jan to 14 Jan	14.9	8.7	18.0	5.6	0.0	8.6
3	15 Jan to 21 Jan	17.9	6.0	17.8	5.8	0.0	10.1
4	21 Jan to 28 Jan	17.8	5.0	19.4	5.9	3.8	14.0
5	29 Jan to 04 Feb	19.8	6.0	20.5	6.9	0.0	10.7
6	05 Feb to 11 Feb	21.1	6.9	20.8	7.7	0.0	12.1
7	12 Feb to 18 Feb	21.5	10.4	21.6	8.5	0.0	13.4
8	19 Feb to 25 Feb	25.9	10.5	22.1	9.0	0.0	17.9
9	26 Feb to 4 Mar	26.5	10.4	23.9	10.0	0.0	14.4
10	05 Mar to 11 Mar	28.6	11.7	26.1	11.2	0.0	11.8
11	12 Mar to 18 Mar	27.1	12.3	26.9	12.3	3.6	21.2
12	19 Mar to 25 Mar	26.7	13.4	27.6	13.2	15.2	23.8
13	26 Mar to 1 April	31.0	13.7	29.3	14.4	0.0	8.1
14	2 April to 8 April	30.8	12.0	30.0	15.1	1.6	9.9

SMW* Standard Meteorological Week

APPENDIX II

Cost of cultivation of mustard under different treatment combinations

Input	Quantity (ha^{-1})	Unit	Rate (₹$unit^{-1}$)	Total cost (₹ ha^{-1})
Land preparation	6	Man days	315	1890
Seed rate				
RSPR-69/Pusa mustard 2 /RVM 2/NRCHB 101	6	kg	90	540
Sowing	8	Man days	315	2520
Fertilizer application (N:P_20_5:K_20:S kg ha^{-1})				
Urea (60 kg ha^{-1} N) (80 kg ha^{-1} N) (100 kg ha^{-1} N)	105 140 175	kg	5.64	592 789 986
DAP (30 kg ha^{-1} P_2O_5) (40 kg ha^{-1} P_2O_5) (50 kg ha^{-1} P_2O_5)	65 87 109	kg	22.65	1476 1969 2462
MOP (15 kg ha^{-1} K_2O) (20 kg ha^{-1} K_2O) (25 kg ha^{-1} K_2O)	25 33 42	kg	19.00	475 633 792
Gypsum (20 kg ha^{-1} S) (25 kg ha^{-1} S) (30 kg ha^{-1} S)	85 106 128	kg	5.0	425 532 638
Herbicides				
Pendimethalin	3.7	litre	440	1,628
Herbicide Application	2	Man days	315	630
Insecticide				
Cohigan	30	gram	150	150
Insecticide Application	2	Man days	315	630
Fungicide				
Syscon	2000	gram	1100	2200
Fungicide Application	2	Man days	315	630
Thinning	6	Man days	315	1890
Harvesting (M)	6	Man days	315	1890
Threshing and winnowing	5	Man days	315	1575
Total (With application of N:P_20_5:K_20:S kg ha^{-1} **@ 60:30:15:20 kg ha^{-1}** **Total (With application of** N:P_20_5:K_20:S kg ha^{-1} **@ 80:40:20:25 kg ha^{-1}** **Total (With application of** N:P_20_5:K_20:S kg ha^{-1} **@ 100:50:25:30 kg ha^{-1}**				19,142 20,096 21,051

Cost of cultivation of mustard under different treatment combinations

Input	Quantity (ha^{-1})	Unit	Rate (₹unit^{-1})	Total cost (₹ ha^{-1})
Land preparation	6	Man days	315	1890
Seed rate				
RSPR-69/Pusa mustard 2 /RVM 2/NRCHB 101	6	kg	90	540
Sowing	8	Man days	315	2520
Fertilizer application ($N:P_2O_5:K_2O:S$ kg ha^{-1})				
Urea (60 kg ha^{-1} N) (80 kg ha^{-1} N) (100 kg ha^{-1} N)	105 140 175	kg	5.64	592 789 986
DAP (30 kg ha^{-1} P_2O_5) (40 kg ha^{-1} P_2O_5) (50 kg ha^{-1} P_2O_5)	65 87 109	kg	22.65	1476 1969 2462
MOP (15 kg ha^{-1} K_2O) (20 kg ha^{-1} K_2O) (25 kg ha^{-1} K_2O)	25 33 42	kg	19.00	475 633 792
Gypsum (20 kg ha^{-1} S) (25 kg ha^{-1} S) (30 kg ha^{-1} S)	85 106 128	kg	5.0	425 532 638
FYM	5	Tonnes	300	1500
Herbicides				
Pendimethalin	3.7	litre	440	1,628
Herbicide Application	2	Man days	315	630
Insecticide				
Cohigan	30	gram	150	150
Insecticide Application	2	Man days	315	630
Fungicide				
Syscon	2000	gram	1100	2200
Fungicide Application	2	Man days	315	630
Thinning	6	Man days	315	1890
Harvesting (M)	6	Man days	315	1890
Threshing and winnowing	5	Man days	315	1575
Total (With application of $N:P_2O_5:K_2O:S$ kg ha^{-1} **@ 60:30:15:20 kg ha^{-1} +FYM** **Total (With application of** $N:P_2O_5:K_2O:S$ kg ha^{-1} **@ 80:40:20:25 kg ha^{-1} +FYM** **Total (With application of** $N:P_2O_5:K_2O:S$ kg ha^{-1} **@ 100:50:25:30 kg ha^{-1} + FYM**				20,642 21,596 22,551

APPENDIX III

Effect of different treatment combinations on Relative economics (₹ ha^{-1}) of Indian mustard

Relative economics (₹ ha^{-1})				
Treatments	**Cost of cultivation (₹ ha^{-1})**	**Gross return (₹ ha^{-1})**	**Net return (₹ ha^{-1})**	**B:C ratio**
V1F1M1	19142	52855	33713	1.76
V1F2M1	20096	55645	35549	1.77
V1F3M1	21051	55955	34904	1.66
V1F1M2	20642	58280	37638	1.82
V1F2M2	21596	61845	40249	1.86
V1F3M2	22551	63550	40999	1.82
V2F1M1	19142	47895	28753	1.50
V2F2M1	20096	50220	30124	1.50
V2F3M1	21051	50375	29324.	1.39
V2F1M2	20642	53010	32368.	1.57
V2F2M2	21596	56885	35289	1.63
V2F3M2	22551	57040	34489.	1.53
V3F1M1	19142	62465	43323.	2.26
V3F2M1	20096	66650	46554	2.32
V3F3M1	21051	67270	46219	2.20
V3F1M2	20642	67115	46473	2.25
V3F2M2	21596	78895	57299	2.65
V3F3M2	22551	80755	58204	2.58
V4F1M1	19142	58745	39603	2.07
V4F2M1	20096	65100	45004	2.24
V4F3M1	21051	65534	44484	2.11
V4F1M2	20642	66805	46164	2.24
V4F2M2	21596	72540	50944	2.36
V4F3M2	22551	72540	49988	2.22

V1- RSPR 69 **V2-** Pusa Mustard 26 **V3-** RVM 2 **V4-** NRCHB 101

M1- Without FYM and **M2-** FYM @5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

APPENDIX IV

Effect of different treatment combinations on Nutrient content (%) of Indian mustard

Treatment	Nitrogen			Phosphorus			Potassium			Sulphur		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
V1F1M1	2.65	0.39	3.04	0.44	0.15	0.60	1.06	1.06	2.12	0.43	0.27	0.70
V1F2M1	2.69	0.39	3.09	0.45	0.15	0.61	1.08	1.07	2.15	0.44	0.28	0.72
VIF3M1	2.73	0.40	3.13	0.45	0.15	0.61	1.08	1.08	2.17	0.44	0.28	0.72
V1F1M2	2.82	0.42	3.24	0.47	0.16	0.64	1.13	1.12	2.26	0.46	0.30	0.76
V1F2M2	2.84	0.42	3.26	0.47	0.16	0.64	1.14	1.13	2.27	0.46	0.30	0.77
V1F3M2	2.88	0.43	3.32	0.48	0.17	0.65	1.16	1.154	2.31	0.47	0.31	0.78
V2F1M1	2.50	0.36	2.86	0.42	0.140	0.56	0.99	1.000	1.99	0.41	0.25	0.66
V2F2M1	2.66	0.39	3.05	0.44	0.15	0.60	1.06	1.06	2.13	0.43	0.27	0.71
V2F3M1	2.72	0.39	3.11	0.45	0.15	0.60	1.08	1.162	2.24	0.44	0.28	0.72
V2F1M2	2.81	0.42	3.23	0.47	0.16	0.63	1.13	1.124	2.25	0.46	0.29	0.76
V2F2M2	2.82	0.42	3.24	0.47	0.16	0.64	1.13	1.128	2.26	0.46	0.30	0.76
V2F3M2	2.87	0.43	3.30	0.48	0.17	0.65	1.15	1.149	2.30	0.47	0.30	0.78
V3F1M1	2.71	0.40	3.11	0.45	0.15	0.61	1.09	1.08	2.17	0.44	0.28	0.73
V3F2M1	2.75	0.40	3.15	0.46	0.16	0.62	1.10	1.1	2.20	0.45	0.29	0.74
V3F3M1	2.77	0.41	3.18	0.46	0.16	0.63	1.11	1.10	2.22	0.45	0.29	0.75
V3F1M2	2.85	0.42	3.27	0.47	0.16	0.64	1.14	1.14	2.28	0.46	0.30	0.77
V3F2M2	2.88	0.43	3.32	0.48	0.17	0.65	1.16	1.15	2.31	0.47	0.31	0.78
V3F3M2	2.92	0.44	3.36	0.49	0.17	0.66	1.18	1.17	2.35	0.48	0.31	0.79
V4F1M1	2.67	0.39	3.07	0.45	0.15	0.60	1.07	1.07	2.14	0.43	0.28	0.71
V4F2M1	2.69	0.39	3.09	0.45	0.15	0.61	1.08	1.07	2.16	0.44	0.29	0.72
V4F3M1	2.75	0.40	3.15	0.46	0.16	0.62	1.10	1.1	2.20	0.45	0.27	0.74
V4F1M2	2.83	0.42	3.25	0.47	0.16	0.64	1.13	1.132	2.27	0.46	0.30	0.76
V4F2M2	2.86	0.43	3.29	0.48	0.17	0.65	1.15	1.145	2.29	0.47	0.30	0.77
V4F3M2	2.92	0.44	3.36	0.49	0.17	0.66	1.17	1.168	2.34	0.48	0.31	0.79

V1- RSPR 69 **V2-** Pusa Mustard 26 **V3-** RVM 2 **V4-** NRCHB 101
M1- Without FYM and **M2-** FYM @5 t ha^{-1}
F1- $N:P_20_5:K_2O:S$ @ 60:30:15:20 kg ha^{-1}
F2- $N:P_2O_5:K_2O:S$ @ 80:40:20:25 kg ha^{-1}
F3- $P_2O_5:K_2O$:S @ 100:50:25:30 kg ha^{-1}

APPENDIX V

Effect of different treatment combinations on oil content (%)

Oil content (%)	
Treatments	**Oil content (%)**
V1F1M1	36.82
V1F2M1	36.86
V1F3M1	36.89
V1F1M2	36.91
V1F2M2	36.94
V1F3M2	36.96
V2F1M1	36.49
V2F2M1	36.51
V2F3M1	36.54
V2F1M2	36.56
V2F2M2	36.59
V2F3M2	36.62
V3F1M1	38.64
V3F2M1	38.67
V3F3M1	38.69
V3F1M2	38.71
V3F2M2	38.74
V3F3M2	38.77
V4F1M1	38.09
V4F2M1	38.12
V4F3M1	38.15
V4F1M2	38.17
V4F2M2	38.19
V4F3M2	38.22

V1- RSPR 69 **V2-** Pusa Mustard 26 **V3-** RVM 2 **V4-** NRCHB 101

M1- Without FYM and **M2-** FYM @5 t ha^{-1}

F1- N:P_20_5:K_2O:S @ 60:30:15:20 kg ha^{-1}

F2- N:P_2O_5:K_2O:S @ 80:40:20:25 kg ha^{-1}

F3- P_2O_5:K_2O :S @ 100:50:25:30 kg ha^{-1}

CERTIFICATE- IV

Certified that all necessary corrections as suggested by the External examiner and advisory committee have been duly incorporated in the thesis entitled **"Performance of Indian mustard (*Brassica juncea*) varieties at varying fertility schedules under late sown irrigated conditions of Jammu region"**, submitted by **Mr.Vivek Sharma,** Registration No. **J-19-M-608**.

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