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Effect of Chemical, Organic and Biofertilizer on Growth and Yield of Indian Mustard (*Brassica juncea* L.)

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Authors' contributions

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

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ABSTRACT

A field experiment was conducted at the Agriculture Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab during *rabi* season 2023-24. The experimental field was laid out in a randomized block design (RBD) with 8 treatments and replicated thrice. The treatment combinations are T_1- control, T_2- 100% Recommended Dose Nitrogen (RDN) and T_3- 75% RDN + 5t Farm Yard Manure (FYM) ha^{-1}, T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}, T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1}, T_6- 50% RDN + 10t FYM ha^{-1}, T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}, T_8- 50% RDN + *Azotobacter* 20 ml ha^{-1}. The result of present study revealed that the treatment T_4 (75% *RDN* + 5t FYM ha^{-1}+ *Azotobacter* 20 ml

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ha^{-1}) has shown significant result on plant population m^{-2}(at harvest) (14.5), plant height (153.2cm), number of branches plant^{-1} (20.5), chlorophyll content (µmol m^{-2}) (SPAD) (45.10), no. of siliqua plant^{-1}(300.10), no. of seeds siliqua^{-1} (18.0), siliqua length (cm) (5.90cm), test weight (g) (3.36g), seed yield q ha^{-1} (22.98 q ha^{-1}), straw yield q ha^{-1} (56.07 q ha^{-1}), biological yield q ha^{-1} (79.06 q ha^{-1}) and harvest index (%) (28.80%) were observed.

Keywords: Mustard; nitrogen; FYM; biofertilizer; growth; yield.

1. INTRODUCTION

"Indian mustard (*Brassica juncea* L.) is an important *rabi* season oilseed crop of the world which belongs to the family Brassicaceae. The ideal temperature for the growth of mustard is 15°C – 25°C and prefers a pH range of 6.0-7.5. The suitable soils are sandy loam to clay loam soil but thrive best on light loam soils and well drained soils. India is the third largest rapeseed-mustard producer country in the world after China and Canada. This crop accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop" [1]. "Mustard seed, in general, contains 30-33% oil, 17-25% proteins, 8-10% fibre, 6-10% moisture and 10-12% extractable substances" [2]. "Indian mustard is commonly known as "raya", and is considered a vital oil producing crop among Brassica in India" [3]. "Globally, the area and production of rapeseed and mustard during 2019-20 was 35.95 million hectares and 71.49 million tonnes, respectively [4]. In India, around 8.06 million hectare area is under rapeseed-mustard along with 11.75 million tonnes production and 1458 kg ha^{-1} productivity during 2021-2022" [5]. "It is mainly grown in northern part of India and Rajasthan is the largest producing state followed by Uttar Pradesh" [6]. "In Punjab state, it is grown on 43.9 thousand hectares with a production of 69.3 thousand tonnes with average yield of 15.79 quintals ha^{-1} (6.39 q acre^{-1}) during 2021-22" [7].

"Oilseeds are energy rich crops and obviously the requirement of major nutrient is very high. Chemical fertilizers played a major role in agricultural production and changed the country from a region of food scarcity to food sufficiency. But chemical fertilizers have also contributed significantly towards the pollution of water, air and soil and it alone cannot sustain the soil productivity. So the current trend is to explore the possibility of supplementing chemical fertilizers with organic ones which are eco-friendly and cost-effective" [8]. "The use of chemical fertilizers in combination with organic manure is essentially required to improve soil health" [9]. "Mustard (*Brassica juncea*) requires a relatively large amount of nutrients for realization of yield potential but inadequate supply often leads to low productivity" [10]. "The nutrient management is one of the most important agronomic factors that affect the Indian mustard" [11]. "Independent use of neither the chemical fertilizers nor the organic sources can sustain the fertility of soil and productivity of the crops in high input production system" [12]. "Under such situation, balance combinations of chemical fertilizers with organic resources such as farmyard manure (FYM) and biofertilizers like *Azospirillum* and Phosphate Solubilizing Bacteria (PSB) which are also eco-friendly and cost effective can be used to boost the production and also to improve fertilizer use efficiency" [13].

"Nitrogen is considered to be the most important nutrient, which determines the growth of the mustard crop and increases the amount of protein and yield. Nitrogen also affects the uptake of other essential nutrients and it helps in the better partitioning of photosynthates to reproductive parts which increase the seed: stover ratio" [14]. Farmyard manure supplies the essential plant nutrients N, P and K in available form to the plant through mineralization as it contains 0.5% N, 0.2% P and 0.5% K and it also improves the soil structure through aggregation [15], nutrient use efficiency, microbial action and ensures better availability of nutrients in soil. Bio fertilizers such as *Azotobacter* promotes seed germination and give initial vigor of plant by producing growth promoting substances [16]. "Integrated nutrient management is essential in sustaining high crop production over the years and also improves soil health by ensuring a safer environment" [17]. So the integrated nutrient supply system involving a combination of chemical fertilizers with organic sources and bio fertilizers has been quite promising in sustaining the soil health and productivity of Indian mustard.

2. MATERIALS AND METHODS

The present experiment entitled, "Influence of chemical, organic and bio-fertilizer on growth and yield of Indian mustard (*Brassica juncea* L.)" was conducted during rabi season 2023-24 at the Agriculture Research Farm, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab. The experimental site (Mandi Gobindgarh) is situated at 30.6642° N latitude and 76.2914° E longitude at an altitude of 268 meters above mean sea level.

The experiment comprised of 8 treatment combinations in randomized block design (RBD) with three replications. The treatment combinations are T_1- control, T_2- 100% Recommended Dose Nitrogen (RDN) and T_3- 75% RDN + 5t Farm Yard Manure (FYM) ha^{-1}, T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}, T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1}, T_6- 50% RDN + 10t FYM ha^{-1}, T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}, T_8- 50% RDN + *Azotobacter* 20 ml ha^{-1}. The soil pH is 8.4 which is slightly alkaline and electrical conductivity is within the normal range (0.13). From soil analysis that soil of the field was low in organic carbon (0.37%) and available nitrogen (155.6 kg N/ha). However, medium in soil available phosphorus (17.3 kg P_2O_5/ha) and high in soil available potassium (168 kg K2O/ha). Kesari 5111 variety of mustard with a seed rate of 3.75 kg ha^{-1} were used in the treatment. It was hand sown at a depth of 4-5 cm with row to row spacing of 45 cm and plant to plant spacing of 15 cm. Nitrogen was applied through urea in splits as chemical source of nutrient. Half dose of nitrogen was applied as basal dose at the time of sowing and remaining half dose of nitrogen was applied 30 days after sowing as per treatment. As per treatment, the seeds were inoculated with biofertilizer (*Azotobacter*) at the time of sowing and sown to the plots according to treatment wise. Farm yard manure from a dairy farm were also applied 15 days before sowing to the plots according to treatment wise. The data on growth parameters *viz*., plant population m^{-2} (at harvest), plant height (60, 90 days after sowing and at harvest), branches $plant^{-1}$ (60, 90 days after sowing and at harvest), chlorophyll content (60, 90 days after sowing) and yield attributes and yield *viz*., no. of siliqua $plant^{-1}$, no. of seeds $siliqua^{-1}$, siliqua length, test weight, grain yield, straw yield, biological yield and harvest index were observed at the time of harvest. Chlorophyll content was recorded using chlorophyll meter SPAD (Soil Plant Analysis Development). All data related to growth and yield was collected and the data analysis was done by using the statistical software OPSTAT,1998 [18]. One-way ANOVA was applied for data analysis from randomized block design according to the method given by Panse and Sukhatme [19].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Data regarding plant population m^{-2}, plant height, branches $plant^{-1}$ and chlorophyll content were shown in Table 1.

Plant population m^{-2} (at harvest): The results revealed that significantly higher plant population m^{-2} was observed at treatment T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (14.5) over T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (12.7), T_6- 50% RDN + 10t FYM ha^{-1} (12.4), T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1} (12.0), T_8- 50% RDN + *Azotobacter* 20 ml ha^{-1} (11.8) and T_1- control (11.0), but it was statistically at par with the treatments T_2- 100% RDN (13.3) and T_3- 75% RDN + 5t FYM ha^{-1} (13.0). The lower plant population per m^2 (11.0) was observed at treatment T_1- Control. With the judicious combined application of Nitrogen along with FYM and *Azotobacter* source of nutrient in T_4, which contributed favourable condition for plant growth by increasing the availability of nutrients to plant significantly enhanced the plant population m^{-2}. The results obtained from the present experiment are in near conformity with the findings of Gupta et al., [20].

Plant height (cm): According to research, a crucial rise in plant height peaked between 60 DAS and 90 DAS. Data regarding plant height is shown in Table 1. In 60 DAS, the highest plant height (73.10 cm) was observed with T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} which was statistically at par with the treatments T_2- 100% Recommended dose of Nitrogen (71.51 cm) and T_3- 75% RDN + 5t FYM (68.00 cm). In case of 90 DAS, there was significant increase in plant height. The tallest plant height (132.53 cm) was observed with T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} which was statistically at par with the treatments T_2- 100% Recommended dose of Nitrogen (127.50 cm). At harvest, the highest plant height (135.23 cm) was observed with T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} which was it was statistically at par with the treatments T_2- 100% Recommended dose of Nitrogen (130.90 cm). "The increase in plant height might be due to availability of nutrients throughout the crop growth by decomposition of FYM and supplying adequate amount of nitrogen and other nutrients, which encourage taller plant height. Integrated nutrient management increased the uptake of nutrients by crop contributed to higher vegetative growth. Nitrogen may influence the different physiological processes such as a cell elongation cell division, and chlorophyll production which resulted in better growth attributes. *Azotobacter* fixes atmospheric nitrogen in the soil and FYM improve the soil physio-chemical property. This results were almost similar with the findings" of Saha et al., [21] and Yadav et al., [22].

Number of branches plant^{-1}: The number of branches at 60 DAS and 90 DAS is significantly impacted by integrated nutrient management. In 60 DAS, the maximum number of branches plant^{-1} was observed with T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} (15.87) which was statistically at par with the treatments T_2- 100% Recommended dose of Nitrogen, T_3- 75% RDN + 5t FYM and T_7- 50% RDN + 10t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} (15.41, 15.00 and 14.52 respectively). In 90 DAS, the maximum number of branches plant^{-1} (19.56) was observed in T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} which was statistically at par with the treatments T_2- 100% Recommended dose of Nitrogen (19.15), T_3- 75% RDN + 5t FYM (19.00) and T_7- 50% RDN + 10t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} (18.76). At harvest, the maximum number of branches plant^{-1} (20.36) was observed with T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1} which was it was statistically at par with the treatments T_2- 100% Recommended dose of Nitrogen (20.00). The beneficial effects might have resulted due to combined application of inorganic fertilizer, organic manure and biofertilizer which satisfied the immediate nutrient requirements and also improved soil's environment for better plant growth. One of the normal effect of nitrogen on growth is to increase the branching of the inflorescence. The growth and yield characteristics were also enhanced by the additional *Azotobacter* application. The results were in accordance with the findings of Indira et al., [23] and Saha et al., [21].

Chlorophyll content (µmol m^{-2}) (SPAD): Significantly higher chlorophyll content in 60 DAS, was recorded in treatment T_4- 75% RDN + 5t FYM + *Azotobacter* recorded (39.11) which was statistically at par with the treatments T_2- 100% RDN (37.20). In case of 90 DAS, the highest chlorophyll content was recorded in treatment T_4- 75% RDN + 5t FYM + *Azotobacter* (45.10) which was statistically at par with the treatments T_2- 100% RDN (43.91) and T_3-75% RDN + 5t FYM (42.34). Nitrogen is an integral part of chlorophyll which is the primary absorber of light energy needed for photosynthesis in addition to its role in the formation of proteins. Chlorophyll content is maximum under integrated nutrient management treatments over control. "It is established fact that FYM improve physical, chemical and biological properties of soil and supplies essential plant nutrients for long term as entire crop period with slow pace while the inorganic fertilizer ensures readily available nutrients for a short period. The results were almost similar to the findings reported" by Bijarnia et al., [24].

Yield Attributes and Yield: Data regarding number of silique plant^{-1}, number of seeds silique^{-1}, siliqua length and were shown in Table 2.

Number of silique plant^{-1}: Maximum number of silique plant^{-1} (300.10) was recorded in treatment T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} but was statistically at par with the following treatments T_2- 100% RDN (289.30), T_3- 75% RDN + 5t FYM ha^{-1} (280.50) and T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacte*r 20 ml ha^{-1} (278.90). The increase in nitrogen supply results in greater cell size and more cell division, which in turn produces more number of branches and eventually more silique can develop. Application of *Azotobacter* and FYM in addition to inorganic fertilizer promoted the growth and yield attributes and controls the availability of nutrients to the crop. As a result, it promotes flowering and produces more silique per branches. Significant enhancement in overall growth of the plant as a result of increased photosynthetic efficiency. Thus, increased availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased no. of siliquae per plant. The results were in accordance with the results of Saha et al., [21], Yadav et al., [22].

Number of seeds siliqua^{-1}: revealed that significantly maximum number of seeds silique^{-1} (18.00) was recorded in treatment T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} over T_6- 50% RDN + 10t FYM ha^{-1}, T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1} and T_8- 50% RDN + *Azotobacter* 20 ml ha^{-1} (16.1, 15.7 and 15.00) respectively, but it was statistically par with the remaining treatments T_2-100% RDN, T_3- 75%

RDN + 5t FYM ha^{-1} and T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (17.3, 17.00 and 16.8) respectively. In contrast, the treatment T_1-Control (13.6) exhibit the minimum number of seeds siliqua^{-1} among all the treatments. The number of seeds siliqua^{-1} in mustard was significantly influenced by the balanced nutrient management techniques. The higher numbers of seeds per silique appear to be the result of increased availability of photosynthates, metabolites, and nutrients to establish reproductive structures. The results were almost similar to the findings of Indira et al., [25], Saha et al., [21], Yadav et al., [22].

Siliqua length (cm): indicated that significantly higher siliqua length (5.90) was recorded in treatment T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} over T_7-50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (5.00 cm), T_6-50% RDN + 10t FYM ha^{-1} (4.60 cm), T_5-75% RDN+ *Azotobacter* 20 ml ha^{-1} (4.30 cm), T_8-50% RDN + *Azotobacter* 20 ml ha^{-1} (4.00 cm) and T_1-Control (3.50 cm) but was at par with treatments T_2-100% RDN (5.60 cm) and T_3-75% RDN + 5t FYM ha^{-1} (5.40 cm). The lowest siliqua length (3.50 cm) was observed in T_1- control among all the treatments. The combined application of FYM, nitrogen and *Azotobacter* might increase plant nutrient availability, which result into better nourishment of plants and thus, results in the increase in length of siliquae in mustard. The results were in accordance with those reported by Indira et al., [23] Yadav et al., [22], Singh et al., [26].

Table 1. Effect of chemical, organic and biofertilizer on growth parameters of Indian mustard (*Brassica juncea* L.)

Treatments		Plant Population m^{-2}	Plant Height (cm)			Number of Branches Plant^{-1}			Chlorophyll Content (μmol m^{-2})	
			60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS
T_1	Control	11.0	54.21	109.00	111.12	12.00	16.00	16.10	30.01	35.29
T_2	100% Recommended dose of Nitrogen (RDN)	13.3	71.51	127.50	130.90	15.41	19.15	20.00	37.20	43.91
T_3	75% RDN + 5t FYM ha^{-1}	13.0	68.00	123.15	127.00	15.00	19.00	19.60	36.15	42.34
T_4	75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1}	14.5	73.10	132.53	135.23	15.87	19.56	20.36	39.11	45.10
T_5	75% RDN + *Azotobacter* 20ml ha^{-1}	12.0	59.02	115.50	120.10	13.15	17.54	18.00	33.52	40.10
T_6	50% RDN + 10t FYM ha^{-1}	12.4	62.36	117.33	122.52	13.96	18.00	18.71	34.00	41.00
T_7	50% RDN + 10t FYM ha^{-1}+ *Azotobacter* 20ml ha^{-1}	12.7	66.14	122.24	125.11	14.52	18.76	19.32	35.70	41.93
T_8	50% RDN + *Azotobacter* 20ml ha^{-1}	11.8	57.02	112.30	116.40	12.56	16.02	17.26	32.61	38.85
C.V.		**7.6**	**9.23**	**6.00**	**6.06**	**9.44**	**7.93**	**7.58**	**8.43**	**8.11**
SE(d)		**0.7**	**3.25**	**3.64**	**3.70**	**0.721**	**0.714**	**0.719**	**1.073**	**1.219**
C.D. (p=0.05)		**1.7**	**5.33**	**6.09**	**6.24**	**1.53**	**0.96**	**0.97**	**2.53**	**2.78**

Table 2. Effect of chemical, organic and biofertilizer on yield attributes of Indian mustard (*Brassica juncea* L.)

Treatment		No. of silique plant^{-1}	No. of seeds silique^{-1}	Silique length (cm)	Test weight 1000 seed weight (g)
T_1	Control	239.50	13.6	3.50	2.56
T_2	100% RDN	289.30	17.3	5.60	3.25
T_3	75% RDN + 5t FYM ha^{-1}	280.50	17.0	5.40	3.16
T_4	75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20 ml ha^{-1}	300.10	18.0	5.90	3.36
T_5	75% RDN + *Azotobacter* 20 ml ha^{-1}	255.30	15.7	4.30	2.87
T_6	50% RDN + 10t FYM ha^{-1}	260.50	16.1	4.60	2.95
T_7	50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}	278.90	16.8	5.00	3.00
T_8	50% RDN + *Azotobacter* 20 ml ha^{-1}	245.60	15.0	4.00	2.72
C.D. (p=0.05)		**38.21**	**1.7**	**0.97**	**0.23**
SE(d)		**17.64**	**0.8**	**0.44**	**0.13**
C.V.		**8.04**	**6.0**	**11.4**	**8.67**

Table 3. Effect of chemical, organic and biofertilizer on yield of Indian mustard (*Brassica juncea* L.)

Treatment		Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1	Control	13.52	41.21	54.74	24.69
T_2	100% RDN	21.48	54.94	76.42	28.10
T_3	75% RDN + 5t FYM ha^{-1}	20.24	54.82	75.07	26.96
T_4	75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}	22.98	56.07	79.06	29.06
T_5	75% RDN + *Azotobacter* 20 ml ha^{-1}	16.48	46.48	62.95	26.17
T_6	50% RDN + 10t FYM ha^{-1}	17.57	49.20	66.78	26.31
T_7	50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}	19.24	52.77	72.02	26.71
T_8	50% RDN + *Azotobacter* 20 ml ha^{-1}	15.29	44.92	60.22	25.39
C.D. (p=0.05)		2.97	2.83	5.51	0.98
SE(d)		1.37	2.46	3.36	0.71
C.V.		9.17	9.87	10.60	5.33

Test weight (g): Maximum test weight was recorded in treatment T_4 - 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (3.36 g) over treatment T_6 - 50% RDN + 10t FYM ha^{-1} (2.95 g), T_5 - 75% RDN + *Azotobacter* 20 ml ha^{-1} (2.87 g), T_8 - 50% RDN + *Azotobacter* 20 ml ha^{-1} (2.72 g) and T_1 - Control (2.56 g) but was at par with treatments T_2- 100% Recommended dose of Nitrogen (RDN) (3.25 g), T_3 - 75% RDN + 5t FYM ha^{-1} (3.16 g) and T_7 - 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (3.00 g). From the different treatments the least test weight is observed in treatment T_1 – Control (2.56 g). Judicious combination of FYM, biofertilizers and chemical, fertilizers promotes profitable and sustainable production. The biofertilizers plays a significant role in improving the nutrient's supplies by way of nitrogen fixation and their availability in crop production have a positive impact on crop growth. It improves flowering thus, results in more silique per branches and raised the weight of 1000 seeds. The results obtained from the present experiment are in near conformity with the findings of Saha et al., [21] and Indira et al., [23].

Data regarding seed yield, straw yield, biological yield and harvest index is shown in Table 3.

Seed yield (q ha^{-1}): results revealed that the treatment T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} recorded significantly higher seed yield (22.98 q ha^{-1}) of *Brassica juncea* over T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (19.24q ha^{-1}), T_6- 50% RDN + 10t FYM ha^{-1} (17.57q ha^{-1}), T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1} (16.48q ha^{-1}), and T_8- 50% RDN + *Azotobacter* 20 ml ha^{-1} (15.29q ha^{-1}) but was statistically par with T_2-100% RDN (21.48q ha^{-1}) and T_3- 75% RDN + 5t FYM ha^{-1} (20.24q ha^{-1}). "In contrast, the lowest seed yield (13.52q ha^{-1}) was observed in T_1- control among all the treatments. This might be due to delayed release of nutrient from FYM, which reduces nitrogen loss and efficient use of macro and micronutrients. The production of growth promoting and antifungal substances by *Azotobacter* and nitrogen fixation was perhaps the cause for maximum yields. Organic fertilizer, releasing their own nutrients might have increase the nutrient use efficiency of applied inorganic fertilizer in Indian mustard. Adequate supply of available nutrients to crop resulting in better growth and development ultimately reflected into better grain yields. These findings were almost similar to the results reported" by Indira et al., [23], Singh V [27], Nagdive et al., [28].

Straw yield (q ha^{-1}): Results shows that the treatment T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} recorded significantly higher grain yield (56.07 q ha^{-1}) of *Brassica juncea* over T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1} (46.48q ha^{-1}) and T_8- 50% RDN + *Azotobacter* 20 ml ha^{-1} (44.92q ha^{-1}) but it was statistically par with 100% RDN (54.94q ha^{-1}), T_3- 75% RDN + 5t FYM ha^{-1} (54.82q ha^{-1}) and T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (52.77q ha^{-1}) and T_6- 50% RDN + 10t FYM ha^{-1} (49.20q ha^{-1}). In comparison with all the other treatments, T_1- control (41.21 q ha^{-1}) exhibits the lowest straw yield. Significant increase in straw yield is due to the beneficial effects of inorganic N, FYM and *Azotobacter* on the growth and yield attributes in plant. Higher yield attributes may be due to the more nutrient contribution by its incorporation towards the nutrition, since FYM is a source of various primary, secondary and micronutrients and when applied with inorganic fertilizer N, it acts as a slow releasing source of N, which could reduce the Nitrogen losses. The increase in straw yield with biofertilizer was mainly due to the increase in almost all growth and yield contributing characters, which eventually lead to a significant increase in straw yields. The results were in accordance with those reported by Singh V [27] and Nagdive et al., [28].

Biological yield (q ha^{-1}): The treatment with application of T_4- 75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} recorded significantly higher biological yield (79.06q ha^{-1}) over T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1} (62.95q ha^{-1}), T_6- 50% RDN + 10t FYM ha^{-1} (66.78q ha^{-1}), T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (72.02q ha^{-1}) and T_8- 50% RDN + *Azotobacter* 20 ml ha^{-1} (60.22q ha^{-1}) and T_1 -Control (54.74) but was statistically par with T_2-100% RDN (76.42q ha^{-1}), T_3- 75% RDN + 5t FYM ha^{-1} (75.07q ha^{-1}) and T_7- 50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1} (72.02q ha^{-1}). This might be mainly due to increase in dry matter and number of branches and leaves, which was the result of increase in yield. In addition, N is an essential nutrient which promotes the cell development, cell division and photosynthesis activity and thus, it increases the yield as well as quality of the crop. The results obtained in present experiment are in close conformity with the findings of Saha et al., [27], Singh et al., [28].

Harvest index (%): Treatment T_4- 75% RDN + 5t FYM + *Azotobacter* recorded significantly higher harvest index (29.06%) of *Brassica juncea* over T_3- 75% RDN + 5t FYM (26.96%), T_7- 50% RDN + 10t FYM + *Azotobacter* (26.71%) T_6- 50% RDN + 10t FYM (26.31%), T_5- 75% RDN+ *Azotobacter* (26.17%), T_8- 50% RDN + *Azotobacter* (25.39%) and T_1- control (24.69%) but it was statistically par with treatment T_2- 100% RDN (28.10%). T_1- control (24.69%) exhibits the lowest harvest index among all the treatments which is followed by T_8- 50% RDN + *Azotobacter* (25.39%). The integration of FYM along with nitrogen and *Azotobacter* might increase plant nutrient availability, which results into better nourishment of plants. And the slow released of nutrient from FYM, reducing nitrogen loss and maximizing the usage of macro and micronutrients also resulted in higher harvest index. These findings were almost similar to the results reported by Indira et al., [23], Singh et al., [26].

4. CONCLUSION

This study has explored a case study by employing different INM treatments while mustard crop productivity and economic efficiency were the study parameters. The study showed the application of organic inputs in combination with inorganics could substantially impact the growth and productivity of mustard. The use of 5t FYM ha^{-1}, including *Azotobacter* (20 ml ha^{-1}) coupled with 75% RDN of chemical fertilizers, impacts the increasing response of mustard yield parameters compared to other treatment combinations and this can be adopted for farmers' practice in mustard agriculture in the aspects of agronomic benefits. Finally, the INM practice is absolutely indispensable not only to sustain the growth of mustard; however, also to maintain responsible alternatives to increase production as well as economic benefits, which could satisfy the trueness of the hypothesis.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kumar A, Premi OP, Thomas L. Rapeseed-mustard cultivation in India- an overview. National Research Centre on Rapeseed-Mustard, Bharatpur (Rajasthan). 2013; 303321.
2. Pandey S, Manoj KM, Tripath MK. Study of inheritance of erucic acid in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. Octa J Biosci. 2013;1:77-84.
3. Meena M, David AA, Kumar S. Effect of different levels of NPK and zinc sulphate on yield and oil content in mustard (*Brassica juncea* L.) Var. Jai Kisan. Int J Pure Appl Biosci. 2018;6:722-727.
4. ICAR- Directorate of Rapeseed-Mustard Research. (Indian Council of Agricultural Research) Sewars, Bharatpur 321303 (Rajasthan), India; 2021.
5. Agricultural Statistics at a Glance. Area, production and yield of rapeseed-mustard along with coverage under irrigation during 2020-21 and 2021-22. Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers, Government of India. 2021;53.
6. Sodani R, Singhal R K, Gupta S, Gupta N, Chauhan KS, Chauhan J. Performance of yield and yield attributes of ten Indian Mustard (*Brassica juncea* L.) Genotypes under Drought Stress. Int J Pure Appl Biosci. 2017;5(3):467-476.
7. Anonymous (2023-24) Package of Practices for Crops of Punjab Rabi. Punjab Agricultural University, Ludhiana, India. 2022-23;22-32.
8. Datta JK, Banerjee A, Sikdar MS, Gupta S, Mondal NK. Impact pf combined exposure of chemical fertilizer, bio-fertilizer and compost on growth, physiology and productivity of *Brassica campestris* in old alluvial soil. J Env Biol. 2009;30(5):797-800.
9. Prasad J, Karmakar S, Kumar R, Mishra B. Influence of integrated nutrient on yield and soil properties in maize in an Alfisol of Jharkhand. J Ind Soc Soil Sci. 2017;58(2): 200-204.
10. Tripathi MK, Chaturvedi S, Shukla DK, Mahapatra BS. Yield performance and quality in Indian mustard (*Brassica juncea*) as affected by integrated nutrient management. Ind J Agron. 2010;55(22): 138-42.
11. Hadiyal JG, Kachhadiya SP, Ichchhuda PK, Kalsaria RN. Response of Indian mustard (*Brassica juncea* L.) to different levels of organic manures and bio-fertilizers. J Pharmacogn Phytochem. 2017;6(4):873-875.
12. Thaneshwar, Singh V, Prakash J, Kumar M, Kumar S, Singh RK. 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 Condition of Upper Gangetic Plain Zone of India. Int J Curr Microbiol Appl Sci. 2017;6(1):922-932.
13. Singh R, Sinsinwar BS. Effect of integrated of nutrient management and growth, yield, oil content and nutrient uptake of Indian mustard (*Brassica juncea*) in eastern part of Rajasthan. Ind J Agric Sci. 2006;76(5): 78-96.
14. Singh A, Meena NL. Effect of nitrogen and sulphur on growth, yield attributes and seed yield of mustard (*Brassica juncea* L.) in eastern plains of Rajasthan. Ind J Agron. 2004;49(3):186-8.
15. Kumawat A, Yadav RS, Pareek NK. Residual effect of FYM and fertilizers on soil fertility, productivity and economics of

pearl millet (*Pennisetum glaucum* L.). J Soil Water Cons. 2018;17(11):102-106.
16. Yadav HK, Thomas T, Sharma V. Effect of different levels of Sulphur and bio-fertilizers on the yield on mustard (*Brassica juncea* L.) and soil properties. J Agric Phys. 2010;10:61-65.
17. Pal RL, Pathak J. Effect of integrated nutrient management on yield and economics of mustard. Int J Sci Nature. 2016;2:255-261.
18. Sheoran OP, Tonk DS, Kaushik LS, Hasija RC, Pannu RS. Statistical software package for agricultural research workers. Department of Mathmetics Statistics, CCS HAU, Hisar. 1998;139-143.
19. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian Council of Agricultural Research Publication. 1985;87-89.
20. Gupta S, Maurya NK, Pal RK, Yadav R, Singh D. Effect of organic and inorganic sources of nutrient on production and productivity of Indian mustard (*Brassica juncea L*.). The Pharm Innov J. 2023;12(6): 3788-3792.
21. Saha PK, Malik GC, Bhattacharyya P, Banerjee M. Integrated nutrient management on growth and productivity of rapeseed- mustard cultivars. Int J Bio- res and Stress Manag. 2015;6(2):192-197.
22. Yadav R, Maurya NK, Pal RK, Gupta S, Singh G. Effect of organic and inorganic source of nutrition on growth and yield of Indian Mustard (*Brassica juncea* L.). The Pharm J. 2023;12(6):4074-4078.
23. Indira G, Yadav RB, Vivek, Naresh RK, Chandra MS, Shivangi, Nath A, Pachauri RK. Effect of different nutrients and its integration on growth, yield and quality of double zero Indian mustard (*Brassica juncea* L.). Int J Plant Soil Sci. 2021a;33 (22):1-11.
24. Bijarnia AL, Yadav RS, Rathore PS, Singh SP, Saharan B, Choudhary R. Effect of integrated nutrient management and weed control measures on growth and yield attributes of mustard (*Brassica juncea L.*). J Pharmacogn Phytochem. 2017;6(4):483-488.
25. Indira G, Yadav RB, Vivek, Naresh RK, Chandra MS, Chandrakanth A, Shivangi, Nath A. Effect of different nutrient management practices on productivity and profitability of double zero Indian mustard (*Brassica juncea* L.). Int J Env Climate Change. 2021 b;11(12):10-17.
26. Singh M, Goyal G, Tripathi A, Kishore N. Effect of Integrated nutrient management on growth and yield of mustard (*Brassica juncea* L.). Curr J App Sci Tech. 2022;41 (19):32-38.
27. Singh V. Effect of integrated nutrient management in pearl millet (*Pennisetum glaucum L.)*- Indian mustard (*Brassica juncea L*) crop sequence. Ann Plant Soil Res. 2020;22(4):349-353.
28. Nagdive SJ, Bhalerao PD, Dongarwar UR, Goud VV. Effect of irrigation and nutrient management on yield, quality and uptake of nutrients by mustard (*Brasiica juncea L.).* J Soils Crops. 2007;17(1):128-132.

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