Influence of chemical, organic and biofertilizers on growth, yield attributes and yield of Indian mustard (*Brassica juncea* L.)

Abstract

A field experiment was conducted at the Agriculture Research Farm, School of Agricultural Sciences and Technology, RIMT University, MandiGobindgarh, Punjab during *rabi*season 2023-24 to study the "Influence of chemical, organic and biofertilizer on growth, yield attributes and yield of Indian mustard (*Brassicajuncea* L.)". 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% RDN and T_3- 75% RDN + 5t FYMha^{-1}, T_4- 75% RDN + 5t FYMha^{-1} + *Azotobacter* 20 ml ha^{-1}, T_5- 75% RDN+ *Azotobacter*20 ml ha^{-1}, T_6- 50% RDN + 10t FYMha^{-1}, T_7- 50% RDN + 10t FYMha^{-1} + *Azotobacter*20 ml ha^{-1}, T_8- 50% RDN + *Azotobacter*20 ml ha^{-1}.The result of present study revealed that the treat3ment T_4 (75% *RDN*+ 5t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}) has shown significant result on plant population m^{-2}(at harvest) (14.5), plant height (cm) (153.2cm), number of branches plant^{-1} (20.5), chlorophyll content (µmole 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}), stoveryieldq ha^{-1}(56.07 q ha^{-1}), biological yieldq ha^{-1} (79.06 q ha^{-1}) and harvest index (%) (28.80%).

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Comment [A2]: Mention the abbreviation in detail(RDN,FYM)

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Key words: Mustard, nitrogen, FYM, Bio-fertilizer, growth, yield.

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 (Kumar *et al.*, 2013).Mustard seed, in general, contains 30-33% oil, 17-25% proteins, 8-10% fibre, 6-10% moisture and 10-12% extractable substances (Pandey *et al.*, 2013). Indian mustard is commonly known as "raya", and is considered a vital oil producing

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Comment [A9]: According to the journals instructions crop among Brassica in India (Meena *et al.*, 2018). Globally, the estimated area, production and yield of mustard during 2018-19 was 36.59 million hectares (mha), 72.37 million tonnes (mt) and 1980 kg ha^{-1}, respectively (Anonymous, 2020). In India, it is grown in an area of 6.1 mha with a production of 8.3 mt and 1349 kg ha^{-1} productivity during 2018-19 (Anonymous, 2021). It is mainly grown in northern part of India and Rajasthan is the largest producing state followed by Uttar Pradesh (Sodani*et al.*, 2017). In Punjab state, it is grown on 43.9 thousand hectares with a production of 69.3 thousand tonnes during 2021-22 (Anonymous 2023-24). The average yield was 15.79 quintals ha^{-1} (6.39 q $acre^{-1}$).

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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 (Datta *et al*. 2009). The use of chemical fertilizers in combination with organic manure is essentially required to improve soil health (Prasad *et al*., 2017). *Brassica juncea* requires a relatively large amount of nutrients for realization of yield potential but inadequate supply often leads to low productivity (Tripathi *et al*., 2010). The nutrient management is one of the most important agronomic factors that affect the Indian mustard (Hadiyal*et al*., 2017). 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 (Thaneshwar*et al*., 2017). Under such situation, balance combinations of chemical fertilizers with organic resources such as farmyard manure (FYM) and bio-fertilizers 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 (Singh and Sinsinwar, 2006).

Comment [A13]: Mustard(*Brassica juncea*)

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 (Singh and Meena, 2004). 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 (Kumawat *et al*., 2018), 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 (Yadav *et al*., 2010). Integrated nutrient management is essential in sustaining high crop production over the years and also improves soil health by ensuring a safer environment (Pal and Pathak, 2016). 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.

Materials and methods

The present experiment entitled, "Influence of chemical, organic and bio-fertilizer on growth, yield attributes and yield of Indian mustard (*Brassica juncea* L.)" was conducted during rabiseason 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% RDN and T_3- 75% RDN + 5t 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}. 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 bio fertilizer (*Azotobacter*) at the time of sowing and sown to the plots according to treatment wise. The data on growth parameters (plant population m^{-2}, plant height (cm), branches plant^{-1} and chlorophyll content), yield attributes (no. of siliqua plant^{-1}, no. of seeds siliqua^{-1}, siliqua length and test weight) and yield (grain yield, stover yield, biological yield and harvest index) were observed.

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Results and discussion

Growth parameters

Data regarding Growth parameters viz., plant population m^{-2}, plant height (cm), no. of branches plant-1 and chlorophyll content(µmole m^{-2}) (SPAD) are mentioned in Table 1.

Plant population m^{-2} (at harvest)- The results revealed that significantly higher plant population per 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 organic and inorganic source of nutrient, 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.*,(2023).

Comment [A21]: There is no need to mention the details of the transaction because they are shown in the tables. It is sufficient to mention T4, and this note applies to it wherever it is found in the results chapter.

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Plant height (cm)- Results revealed that significantly higher plant height (153.2 cm) was recorded in treatment T_4-75% RDN + 5t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}but was statistically at par with the treatments T_2 -100% (RDN) (148.0 cm), T_3-75% RDN + 5t FYM ha^{-1}(145.0 cm) and T_7- 50% RDN + 10t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}(141.1 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 also recorded bySaha *et al.*, (2015), Yadav *et al.*,(2023).

Number of branches $plant^{-1}$- Results has shown that significantly higher number of branches $plant^{-1}$ (20.5) was recorded in treatment T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter*20 ml $ha^{-1}$and it was statistically at par with the treatments T_2 -100% RDN (20.0), T_3- 75% RDN + 5t FYM ha^{-1}(19.6) and T_7- 50% RDN + 10t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}(19.1). The beneficial effects might have resulted due to combined application of inorganic fertilizer, organic manure and biofertilizers 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. This results were also recorded by Indira *et al.*, (2021 a),Saha *et al*., (2015).

Chlorophyll content (µmole m^{-2}) (SPAD)- Treatment T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}recorded significantly higher chlorophyll content (45.10) and it was statistically at par with rest of the treatments T_2- 100% RDN (43.91), T_3-75% RDN + 5t FYM ha^{-1}(42.34), T_7- 50% RDN + 10t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}(41.93) and T_6- 50% RDN + 10t FYM ha^{-1}(41.00). 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 present findings have been supported by Bijarnia*et al.*, (2017).

Table 1: Effect of chemical, organic and bio-fertilizer on plant population m-2, plant height (cm), no. of branches plant-1 and chlorophyll content (µmole m^{-2}) (SPAD)

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Treatment		Plant population m^{-2}	Plant height (cm)	No. of branches $plant^{-1}$	Chlorophyll content (µmole m^{-2}) (SPAD)
T_1	Control	11.0	116.2	15.4	35.29
T_2	100% RDN	13.3	148.0	20.0	43.91
T_3	75% RDN + 5tFYM ha^{-1}	13.0	145.0	19.6	42.34
T_4	75% RDN + 5t FYM ha^{-1}+ *Azotobacter* 20 ml ha^{-1}	14.5	153.2	20.5	45.10
T_5	75% RDN + *Azotobacter* 20 ml ha^{-1}	12.0	130.5	18.0	40.10
T_6	50% RDN + 10t FYM ha^{-1}	12.4	135.0	18.7	41.00
T_7	50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}	12.7	141.1	19.1	41.93
T_8	50% RDN + *Azotobacter* 20 ml ha^{-1}	11.8	125.4	17.0	38.85
C.D.(p=0.05)		1.7	17.0	2.3	4.66
SE(m)		0.5	5.55	0.77	1.52
SE(d)		0.7	7.86	1.09	2.15
C.V.		7.6	7.03	7.2	6.42

Yield Attributes

Data regarding yield attributes viz., number of silique plant^{-1},number of seeds siliqua^{-1},Siliqua length (cm) and Test weight (g)are mentioned 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 present findings are confirmed with the findings of Saha *et al*., (2015), Yadav *et al*., (2023).

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 present findingswere supported with the findings of Indira et al., (2021 b), Saha *et al*., (2015), Yadav *et al.*, (2023).

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. Similar results were recorded by Indira et al., (2021 b), Yadav *et al*., (2023), Singh *et al*., (2022).

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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, bio-fertilizers and chemical, fertilizers promotes profitable and sustainable production. The bio-fertilizers 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 ofSaha *et al*., (2015) and Indira *et al*., (2021 b).

Table 2: Effect of chemical, organic and bio-fertilizer on number of silique plant^{-1},number of seeds siliqua^{-1},Siliqua length (cm) and Test weight (g)

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	Treatment	No. of silique plant^{-1}	No. of seeds silique^{-1}	Silique length (cm)	Test 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} +	278.90	16.8	5.00	3.00

	***Azotobacter* 20 ml ha^{-1}**				
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**	**0.42**
SE(m)		**12.47**	**0.5**	**0.31**	**0.13**
SE(d)		**17.64**	**0.8**	**0.44**	**0.19**
C.V.		**8.04**	**6.0**	**11.4**	**8.02**

Yield

Data regarding yield viz., Seed yield (q ha^{-1}), Straw yield (q ha^{-1}), Biological yield (q ha^{-1}) and Harvest index (%)-are mentioned 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 FYMha^{-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. Similar reports have also been reported by Indira *et al*., (2021 b), Singh V (2020), Nagdive e*t al*., (2007).

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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 FYMha^{-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 yields with biofertilizers was mainly due to the increase in almost all growth and yield contributing characters, which eventually lead to a significant increase in stover yields. These results were supported with the findings of Singh V (2020),Nagdive*et al*., (2007).

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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 FYMha^{-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*., (2015), Singh *et al*., (2022).

Harvest index (%)-Results shows that the treatment T_4- 75% RDN + 5t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}recorded significantly higher harvest index (28.80%) of *Brassica juncea* over T_6- 50% RDN + 10t FYM ha^{-1}(26.45%),T_5- 75% RDN+ *Azotobacter* 20 ml ha^{-1}(26%), T_8- 50% RDN + *Azotobacter*20 ml ha^{-1}(25.19%) and T_1- control (24.51%) but it was statistically par with T_2- 100% RDN (27.87), T_3- 75% RDN + 5t FYMha^{-1}(27.32%) and T_7- 50% RDN + 10t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}(26.81%). This might be due to the slow released of nutrient from FYM, reducing nitrogen loss and maximizing the usage of macro- and micronutrients. The production of growth promoting and antifungal substances by *Azotobacter* and nitrogen fixation was perhaps the reason for higher yields. Similar results were also reported by Indira *et al*., (2021 b), Singh *et al*., (2022).

Comment [A29]: Explanations are repeated. Please give better explanations

Table 3: Effect of chemical, organic and bio-fertilizer on Seed yield (q ha^{-1}), Straw yield (q ha^{-1}), Biological yield (q ha^{-1}) and Harvest index (%)

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Treatment		Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1	**Control**	**13.52**	**41.21**	**54.74**	**24.51**
T_2	**100% RDN**	**21.48**	**54.94**	**76.42**	**27.80**
T_3	**75% RDN + 5t FYM ha^{-1}**	**20.24**	**54.82**	**75.07**	**27.32**
T_4	**75% RDN + 5t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}**	**22.98**	**56.07**	**79.06**	**28.80**
T_5	**75% RDN + *Azotobacter*20 ml ha^{-1}**	**16.48**	**46.48**	**62.95**	**26.00**
T_6	**50% RDN + 10t FYM ha^{-1}**	**17.57**	**49.20**	**66.78**	**26.45**
T_7	**50% RDN + 10t FYM ha^{-1} + *Azotobacter* 20 ml ha^{-1}**	**19.24**	**52.77**	**72.02**	**26.81**
T_8	**50% RDN + *Azotobacter* 20 ml ha^{-1}**	**15.29**	**44.92**	**60.22**	**25.19**
C.D.(p=0.05)		**2.97**	**7.66**	**9.70**	**2.56**
SE(m)		**0.97**	**2.50**	**3.16**	**0.83**
SE(d)		**1.37**	**3.54**	**4.48**	**1.18**
C.V.		**9.17**	**8.66**	**8.02**	**5.45**

Conclusion

On the basis of the present experiment, it was concluded that among the various treatment, the application of75% RDN + 5t FYM ha^{-1}+ *Azotobacter*20 ml ha^{-1}was found to be beneficial for growth and yield of mustard.

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