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Impact of both organic and inorganic sources of nutrients on production and productivity of Indian mustard(*Brassica juncea* L.)

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Abstract

In the Agriculture Research Farm at Rama University, Mandhana, Kanpur, the current experiment, "Impact of both organic and inorganic sources of nutrients on production and productivity of Indian mustard (*Brassica juncea* L.)," was carried out from Rabi season 2022–23. Eight treatments and three replications were included in the Randomized Block Design (RBD) experiment, which was set up as follows: T1 = 100% RDF (80:60:40 NPK), T2 = 70% RDF (80:60:40 NPK), T3 = 100% RDF + FYM 10 t ha-1, T4 = 100% RDF + Azotobacter + PSB, T5 = 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB, T6 = 100% RDF + FYM 15 t ha1 + Azotobacter + PSB, T7 = 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB, T8 = 100% RDF + FYM 10 t ha-1 + Azotobacter + PSB, and T9 = NAA 125 ppm foliar spray at 30 and 45 DAT.As a consequence of the study, the maximum number of plants (9.56), plant height (128.96 cm), number of branches/plant (44.82), number of leaves/plant (19.50), number of siliqua/plant (121.67), length of siliqua (7.19 cm), number of seeds/siliqua (17.53), weight of siliqua (10.72 gm), and test weight (5.03g) were measured. Treatment T7 = 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB yielded the highest biological yield/ha (7784.70 kg), followed by treatment T5 = 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB, with a Harvest Index of 28.76. Based on these findings, local farmers in the Kanpur regions may consider treating their mustard fields with treatment T7 in order to increase output and improve quality.

Keywords: **RBD,** Azotobacter, PSB, FYM, RDF

Introduction

The key rabi oilseed crop mustard (*Brassica juncea* L.), which is a member of the "Cruciferae" family. Different regions in the country have different names for mustard seeds, such as Sarson, Rai or Raya, Toria or Lahi. Whereas laha, often known as mustard, and sarson and toria (Lahi) are more popularly recognised as rapeseed rai. A variety of factors contribute to the high nutritional value of mustard seeds, including their 37–49 percent oil content, 38–57% eruric acid, 27% oleic acid, 17–25% proteins, 8–10% fibres, 6–10% moisture, and 10-12% extractable compounds (Pandey et al., 2013). Because of its greater adaptability and capacity to take use of leftover moisture, this is a crop that might be grown in the winter (*Rabi*) season (Mukherjee, 2010).

Mustard is an important crop for the Indian economy, contributing 14% of the country's total cultivated land, 1.5% of its gross domestic product, and 80% of the value of all agricultural products. Merely 50% of the overall demand for edible oils is satisfied by domestic production; the remaining portion is imported. With a share of 27.8% in India's oilseed economy, it is the third most significant edible oilseed crop, behind soybean and peanuts. (Sahooet al., 2018). It is grown in the Indian states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat. This crop is India's principal edible oilseed crop, producing almost one-third of the nation's oil. Indian mustard is successfully grown as a rainfed crop on residual soil moisture in the state of Uttar Pradesh because of its deep root structure. It is grown on 0.70 Mha with a productivity of 1412 kg ha-^{1} and a yield of 0.99 Mt. (Anonymous, 2021)

Through nitrogen fixation, Azotobacter increases the amount of nitrogen available to plants, which in turn increases productivity. Likewise, Phosphate Solubilizing Bacteria (PSB) inoculation is essential for meeting the crop's need for more phosphate. PSB makes more native phosphorus that is fixed or inaccessible soluble and available to plants. In addition to improving soil fertility and organic matter content, regular application of organics in amounts sufficient to meet crop requirements increases crop output (Ramesh et al., 2008). By combining inorganic fertilizers with organic materials in different ratios of carbon to nitrogen prior to soil application, one can enhance the effectiveness of both inorganic fertilizers and organic manures. There is convincing proof that plants are fed more consistently and persistently when organic manures are present, and that chemical fertilizers are better utilized. When chemical fertilizers were combined with organic manures, their efficacy increased dramatically. Second, because of the enhanced physico-chemical qualities of the soil, the addition of organic manures in combination with inorganic fertilizers could also significantly reduce the nutrient losses from those sources. Overuse of chemical fertilizers depletes the biological capacity of soil and needs to be avoided since soil microflora handles all nutrient processing. The soil microflora derives its energy from organic matter, and the amount of organic carbon in the soil is thought to be a measure of its overall health. INM is a flexible method that maximizes farmers' profits and reduces their reliance on chemical sources of nutrients.

Material and Method

The Rabi season of 2022–2023 saw the conclusion of the experiment named "Impact of both organic and inorganic sources of nutrients on production and productivity of Indian mustard (Brassica juncea L.)" at the Agriculture Research Farm, Rama University, Mandhana, Kanpur. Randomised Block Design (RBD) was used to set up the experiment, which included three replications and eight treatments: T1 = 100% RDF (80:60:40 NPK), T2 = 70% RDF (80:60:40 NPK), T3 = 100% RDF + FYM 10 t ha1, T4 = 100% RDF + Azotobacter + PSB, T5 = 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB, T6 = 100% RDF + FYM 15 t ha-1 + Azotobacter + PSB, T7 = 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB, and T8 = 100% RDF + FYM 10 t ha-1 + PSB. The crop was grown in 4 x 4 m plots spaced 45 X 10 cm apart. The statistical analysis of the experimental data was conducted using the standard statistical approach provided by Gomez and Gomez (1984).

Table 1: Impact of both organic and inorganic sources of nutrients on Initial plant population, Plant Height, Number of branches, Number of leaves/ plant, (at harvest stages), Dry matter Accumulation (gm/m^2) of Indian mustard (*Brassica juncea* L.)

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Treatments	Initial Plant population (15 DAS m^{-1})	Plant Height (cm at harvest stages)	Number of branches (at harvest stages)	Number of leaves/ plant (at harvest stages)	Dry matter Accumulation (gm/m^2)	Number of Siliqua (perplant)
T_1 =100% RDF (80:60:40 NPK)	9.32	116.02	33.32	14.17	493.487	110.51
T_2 = 70% RDF (80:60:40 NPK)	8.36	108.18	29.28	12.32	421.959	105.00
T_3 =100% RDF + FYM 10 t ha^{-1}	8.85	122.44	38.39	16.09	608.824	112.70
T_4 = 100% RDF + Azotobacter + PSB	8.65	113.75	35.89	15.40	505.144	115.09
T_5 =75% RDF + FYM 25 t ha^{-1} +Azotobacter + PSB	9.35	128.85	44.43	18.90	752.215	120.22
T_6 =100% RDF +FYM 15 t ha^{1}+Azotobacter + PSB	9.65	128.56	42.31	17.92	666.393	119.69
T_7 =100% RDF + FYM 20 t ha^{-1} + Azotobacter + PSB	9.82	131.96	46.82	19.50	748.47	123.67
T_8=100% RDF + FYM 10 t ha^{-1} + *Azotobacter*+ PSB	9.21	125.04	39.55	17.28	595.195	116.10
SEm$\pm$	0.24	1.44	1.18	0.55	9.36	1.28
CD=5%	NS	4.39	3.59	1.65	28.08	3.89

Table 2: Impact of both organic and inorganic sources of nutrients on Number of Siliqua (per plant), Length of Siliqua (cm), Number of seed (per plant), Test weight (gm), Biological Yield and Harvest Index of Indian mustard (*Brassica juncea* L.)

Treatments	**Length of Siliqua (cm)**	**Number of seed (per siliqua)**	**Test weight (gm)**	**Grain yield (kg/ha)**	**Straw Yield (kg/ha)**	**Biological Yield (kg/ha)**	**Harvest Index**
T_1 =100% RDF (80:60:40 NPK)	6.32	14.73	4.22	1520.91	3816.14	5337.06	28.50
T_2 = 70% RDF (80:60:40 NPK)	5.65	13.81	3.94	1262.52	3233.60	4496.12	28.08
T_3 =100% RDF + FYM 10 t ha^{-1}	6.48	15.69	4.50	1895.50	4541.77	6437.27	29.45
T_4 = 100% RDF + Azotobacter + PSB	6.15	15.01	4.30	1546.43	3839.63	5386.06	28.71
T_5 =75% RDF + FYM 25 t ha^{-1} +Azotobacter + PSB	6.97	16.98	4.87	2417.64	5464.62	7882.27	30.67

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T_6 =100% RDF +FYM 15 t ha^{1}+Azotobacter + PSB	6.83	16.64	4.77	2128.36	4927.31	7055.67	30.17
T_7 =100% RDF + FYM 20 t ha^{-1} + Azotobacter + PSB	7.21	17.53	5.03	2467.25	5562.46	8029.70	30.73
T_8=100% RDF + FYM 10 t ha^{-1} + *Azotobacter*+ PSB	6.87	15.96	4.58	1930.56	4613.88	6544.44	29.50
SEm±	0.31	0.28	0.09	105.23	126.83	142.24	0.35
CD=5%	0.39	0.84	0.27	315.69	384.68	426.72	1.05

Plant Population

The information demonstrated that throughout the year, there was no discernible variation in the plant population running meter-1 among all treatments. In comparison to other treatments during the research years, the maximum plant population was observed under (9.82 m^{-1}) T7: 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB. This was followed by the application of T5: 75% of RDF + FYM 25 t ha-1 + Azotobacter + PSB. During the course of the experiment, the treatment with 70% RDF (T2) (9.82 m^{-1}) yielded the lowest plant population.

Plant height (cm at harvest stages)

Plant height arose in all treatments exceeding 70% RDF, according to the data. Throughout the year, it was discovered that all of the treatments had significantly increased plant height. The application of 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB (T7) was the treatment that produced the highest plant height among the treatments at different stages of observation. This treatment was statistically comparable to the applications of 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB (T5) and 100% RDF + FYM 15 t ha-1 + Azotobacter + PSB (T6), but it was significantly better than all other treatments at every stage of growth throughout the crop period. The availability of nutrients during the crop growth phase as a result of FYM breakdown may be the cause of the rise in plant height. Higher vegetative growth was a result of enhanced nitrogen uptake by the crop through integrated nutrient management. Nitrogen has the potential to impact various physiological processes, including cell division, elongation, and chlorophyll production, ultimately leading to improved growth characteristics. Similar findings were in agreement with those reported by Hadiyal*et al*.(2017), Khambalkar*et al*.(2017), Kumar *et al*.(2018) and Devkota*et al*.(2020).

Plant height (cm at harvest stages)

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Number of branches plant^{-1}(at harvest stages)

During the research year, the application of 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB (T7) resulted in the highest number of branches per plant at all stages, followed by 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB (T5), and the lowest at 70% RDF (T2). Plant-1's increased branch count may be the result of enhanced nutrient availability from the combined application of biofertilizer and 100% RDF with FYM. A bigger number of branches was the outcome of the plant system's favorable synthesis of growth-promoting components due to a superior supply of nutrients. These outcomes closely correspond with those of Tripathi*et al*.(2013), Saha*et al*.(2015), Hadiyal*et al*.(2017).

Dry matterAccumulation (gm/m^2)

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The Dry Matter Accumulation (gm/m^2)progressively increased as crop age increased, reaching a maximum at 90 days into the year, after which it gradually decreased. During the experimentation year, the application of 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB (T7) resulted in a significantly greater number of functional leaves plant-1. All growth stages throughout the year showed statistically equal variations in the Dry Matter Accumulation (gm/m^2) amongst 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB (T7), 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB (T5), and 100% RDF + FYM 15 t ha-1 + Azotobacter + PSB (T6). In contrast, plant-1 of Indian mustard had the fewest functioning leaves (plant-1), with 70% RDF (T2) over the entire research year. The increase in the Dry Matter Accumulation (gm/m^2) may be the result of taller plants and optimal nutrient availability from the combined application of biofertilizer and 100% RDF with FYM. More leaves were produced by the plant system's beneficial synthesis of growth-promoting components as a result of a greater nutritional supply. These outcomes closely correspond with those of Tripathi*et al*.(2013), Saha*et al*.(2015), Hadiyal*et al*.(2017).

Yield attributes

Any crop's yield is primarily determined by two factors: the number of plants per unit area and yield plant-1. Data related to yield attributes, specifically the number of siliqua plants-1, siliqua length, number of siliqua seeds-1, weight of siliqua plants-1, weight of seeds plant-1, and 1000-grain weight of Indian mustard recorded at physiological maturity, are shown in Table 2. It is evident from Table 2 that, when compared to 70% RDF alone during the experimentation year, these attributes were significantly influenced by different combinations of organic and inorganic sources of nutrients. The combination of 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB (T7) produced the highest yield attributing characters among the various organic and inorganic sources of nutrients. This combination was statistically comparable to that of 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB (T5) and significantly better than the other combined application of organic and inorganic sources of nutrients. Nonetheless, the application of 70% RDF (T2) throughout the year resulted in noticeably decreased yield assigning characteristics. improved yield characteristics by applying both organic and inorganic sources of nutrients simultaneously. This created a favourable environment for plant growth by making more nutrients available to the plant and boosting branching and leaf area for photosynthesis.

Yield Biological Yield

Table 2 shows the impact of both organic and inorganic nutrition sources on the biological yield of Indian mustard. revealed a noteworthy rise in all treatments exceeding 70% RDF on its own (T2) during the course of the trial year.

Throughout the year, the highest reported biological output of 8029.7 kg ha-1 was produced with T7 (100% RDF + FYM 20 t ha-1 + Azotobacter + PSB), followed by T5 (75% RDF + FYM 25 t ha-1 + Azotobacter + PSB) at 7642.15 kg ha-1 and, at the lowest, 4369.59 kg ha-1 at 70% RDF (T2). Additionally, during the research year, it was noted that the integration of 100% RDF + FYM 10 t ha-1 (T3) demonstrated a significant improvement in biological yield over 100% RDF + Azotobacter + PSB (T4), 100% RDF (T1), and 70% RDF (T2) alone. The application of T7 (100% RDF + FYM 20 t ha-1 + Azotobacter + PSB) resulted in an increase in biological yield mostly because of an increase in dry matter and the number of branches and leaves. These factors were caused by an increase in plant height, total nutrient uptake, water holding capacity, and soil fertility.

Seed and stover Yield

Table 2's data unambiguously demonstrated that, throughout the study year, all treatments exhibited a considerable variation in grain and stover yield as a result of varying combinations of organic and inorganic nutrition sources exceeding 70% RDF alone. When it came to different combinations of organic and inorganic sources of nutrients, the application of 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB (T7) was comparable to the application of 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB (T5). It also produced a significantly higher grain and stover yield than the application of 70% RDF (T2) alone, and it recorded the maximum seed and stover yield as compared to the other treatment combinations. Additionally, it was found that applying 100% RDF (T1) alone resulted in 46.77% lower stover yield and 63.52% greater grain yield when combined with FYM @ 20 t ha-1 and Azotobacter + PSB. During the experimental year, the combination of 75% RDF with FYM@ 25t ha-1 and Azotobacter + PSB (T5) resulted in a 92.49% increase in grain yield and a 72.00% increase in stover yield compared to the application of 70% RDF (T2) alone. The growth and yield characteristics of Indian mustard may have increased as a result of the integration of inorganic and organic nutrition sources, leading to an increase in grain and stover production. In addition to releasing their own nutrients, organics may have improved Indian mustard's ability to utilise the nutrients from applied inorganic fertiliser. Sufficient availability of nutrients for crop growth and development, which in turn leads to improved grain and stover yields. The rise in nearly all growth and yield-contributing traits, which ultimately resulted in a notable increase in grain and stover yields, was the primary cause of the yield increases using biofertilizers.

Harvest index

The grain yield to biological yield ratio is called the harvest index. Upon reviewing the data in Table 2, it became evident that different combinations of inorganic and organic sources of nutrients had a substantial impact on the harvest index throughout the year. When it came to different combinations of organic and inorganic sources of nutrients, the application of 100% RDF + FYM 20 t ha-1 + Azotobacter + PSB (T7) recorded the highest harvest index compared to the other combinations. It was also statistically comparable to the applications of 75% RDF + FYM 25 t ha-1 + Azotobacter + PSB (T5) and 100% RDF + FYM 15 t ha-1 + Zamotobacter + PSB (T6).Additionally, throughout the study year, it was noted that the harvest index significantly increased with the integration of 100% RDF + FYM 10 t ha-1 (T3) compared to 100% RDF + Azotobacter + PSB (T4), 100% RDF (T1), and 70% RDF alone. During the test year, the harvest index was significantly lower when 70% RDF (T2) was applied alone as opposed to various combinations of organic and inorganic sources of nutrients. With 100% RDF + FYM @ 20 t ha-1 + Azotobacter + PSB (T7) applied, the harvest index increased. This was primarily because of the higher grain yield in comparison to biological yield, which was ultimately the outcome of the maximum number of siliqua plant-1 and the number of siliqua seeds that were obtained from an adequate supply of nutrients during crop growth. It has been demonstrated that combining inorganic fertiliser with organic manures significantly boosts its effectiveness.

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