Effect of Biofertilizers and Nutrients on Mustard (*Brassica juncea*): A Review

Abstract

This review explores the impact of biofertilizers and nutrients on mustard (*Brassica juncea*) cultivation. Mustard, a vital oilseed crop in India, faces challenges such as low productivity and environmental concerns due to excessive chemical fertilizer usage. The paper emphasizes the significance of integrated nutrient management, combining chemical and organic sources, including biofertilizers. The study evaluates the effects on various growth parameters, yield attributes, economic aspects, soil nutrients, and microbial properties. Biofertilizers applications, particularly *Azotobacter*, PSB and SSB, show promising results in enhancing growth metrics, yield, and nutrient uptake. The judicious combination of chemical fertilizers and biofertilizers demonstrates the potential for improving mustard crop productivity while maintaining environmental sustainability.

Keywords: *Biofertilizers, economic aspects, growth parameters, microbial properties, mustard, nutrients, yield attributes*.

1. INTRODUCTION

Oilseeds stand out as one of India's most significant crops due to their greater tolerance to a variety of agroclimatic conditions. Mustard, a substantial oilseed crop, is extensively cultivated on most continents. Canada leads in land area, covering 8 million ha, followed by China (7 million ha) and India (6 million ha). India secures the third position in rapeseed and mustard production after Canada and China. Rapeseed-mustard ranks second in overall oil production in India after peanuts (Shekhawat *et al.*, 2012). Crucial for edible oils in the northern and eastern parts of India, rapeseed and mustard dominate over 80 percent of the area under oilseeds crop during the *rabi* season. In India around 6.69 million hectare area is under Rapeseed and mustard along with 10.11 million tonnes production and 1511 kg/ha productivity (source Anonymous 2021). Mustard seeds, excellent sources of protein and oil, contain modest levels of glucosinolates, with 46–48% oil and 43–46% protein (Hagos*et al.*, 2020).

The foliage type mustard green is believed to have originated in the Himalayan region of India and has been consumed for more than 5,000 years. Recently, fully expanded tender leaves are eaten as vegetables in Africa and many parts of Asia, often shredded, cooked, and served as a side dish with staple food. The seed leftovers also contribute to Indian livestock and poultry feed (Manohar *et al.*, 2009). This energy-rich crop plays a vital role in human nutrition and animal feed, holding a significant position in the diet of the Indian population. Rapeseed and mustard have numerous industrial uses, and their oilcake can also serve as manure.

Despite its significance, India grapples with lower productivity compared to major rapeseed-mustard growing countries. In 2013-16, the average yield in India was a mere 1161 kg/ha, whereas the global average stood significantly higher at 2144 kg/ha. Remarkably, the European Union showcased the highest productivity at 3640 kg/ha. To address long-term soil fertility and production challenges while mitigating pollution, a combination of plant nutrients from organic and inorganic sources, along with bio-fertilizers, is employed (Antil and Narwal, 2007). A consensus exists that nitrogen fertilizer yields the most significant benefits in enhancing crop yields among all nutrient supplements applied to soil.

The increased focus on environmental concerns due to the continued use of chemical fertilizers prompts a shift in agricultural practices. Integrated nutrient management, characterized by reduced chemical fertilizer input, involves combining chemical fertilizers with organic products such as animal manure, crop wastes, green manure, and composts. Organic manures are recognized for their positive impact on the physical, chemical, and biological aspects of the soil, influencing growth and enhancing plant production (Molla *et al.*, 2005; Meunchang*et al.*, 2006).

In light of the need for more knowledge-intensive agriculture to keep pace with population growth and resource constraints, a major hurdle is the predominant cultivation of oilseeds under energy-starved conditions. The growth and productivity of crops are significantly influenced by the type and concentration of fertilizers in the growth media (Kirkby and Mengel, 1967). Fertilizers are essential for achieving commercial vegetable production and are common cultural practices globally. Commercial and subsistence farming, as reported by Masarirambi*et al.* (2010), relies on the use of inorganic fertilizers due to their ease of application, prompt absorption, and utilization by crops.

Recent years have seen the inclusion of biofertilizers, containing living cells of various microorganisms, in the integrated nutrient supply system. Biofertilizers, through biological processes, can convert nutritionally essential components from an unavailable to an available form, thereby increasing crop yields (Hegde *et al.*, 1999). While playing vital roles in soil fertility, crop productivity, and agriculture production, biofertilizers cannot replace chemical fertilizers, which remain indispensable for achieving maximum crop yields. Instead, they serve to supplement chemical fertilizers to meet the integrated nutrient demands of crops.

2. EFFECT OF BIOFERTILIZER AND NUTRIENTS ON THE GROWTH OF MUSTARD

The impact of biofertilizers and nutrients on crop growth parameters has been a subject of considerable research, shedding light on key findings. According to Hadiyal*et al.* (2017), the levels of bio-fertilizers significantly influenced the number of primary and secondary branches per plant. Notably, treatments involving *Azotobacter* inoculums exhibited the highest values for these growth metrics. Furthermore, the treatments with PSB and *Azotobacter*, each at 10 ml/kg seed inoculation, demonstrated comparable statistics to *Azotobacter* spp. @ 10 ml/kg seed inoculation (B1) and PSB spp. @ 10 ml/kg seed inoculation (B2). This could be attributed to the application of bio-fertilizers, contributing to the secretion of growth-promoting substances that enhance root development, water transportation, and the uptake and decomposition of nutrients.

Meena *et al.* (2013) conducted a field experiment in Kota, Rajasthan, during the rabi seasons of 2009-10 and 2010-11, focusing on clay soils to determine the optimal dose of chemical fertilizers and biofertilizers for enhancing productivity, profitability, and the quality of Indian mustard. Their findings revealed that the application of 100% RDF (N80P17.5S60) seed inoculation with *Azotobacter*& PSB together expanded the number of essential and auxiliary branches/plant. Moreover, the plant height, primary, and secondary branches significantly increased with the application of 60 kg S/ha, while remaining statistically comparable with 45 kg S/ha and 30 kg S/ha (Kapur *et al.*, 2010).

An experiment conducted at BHU, Varanasi, highlighted that the application of sulfur @ 45 kg/ha resulted in the maximum plant height and branches/plant. This was statistically comparable to 30 kg S/ha, but both were significantly higher than other treatments, i.e., 0 and 15 kg S/ha (Kumar *et al.*, 2011). The increasing sulfur levels were also found to significantly enhance the chlorophyll content (a, b, and total) of mustard leaves. The highest chlorophyll content (a - 0.8%, b – 1.13%, and total – 1.94%) was recorded with 45 kg S/ha (Parmar and Parmar, 2012).On loamy sand soil in Dhani (Hisar), Kumar (1994) conducted an experiment testing the effects of *Azotobacter*chrococcum isolate 103 and its mutants Mac 27 and Mal 27 on mustard cv. RH-30. The results demonstrated that, compared to controls, the soil isolate 103 and the mutants Mac 27 and Mal 27 significantly enhanced plant height and the number of primary and secondary branches per plant.

Chauhan *et al.* (1996) reported a notable increase in the number of branches per plant in the mustard crop due to seed inoculation either by *Azotobacter* or Azospirillum compared to the control. In 1990, Kharodia and Patel claimed that as nitrogen levels increased from 25 to 100 kg/ha, the height of plants and the number of primary and secondary branches per plant both witnessed dramatic increases. A field experiment conducted by Rana and Rana in 2003 aimed to determine how Indian mustard responded to nitrogen and sulfur levels over the rabi seasons. The results indicated considerable increases in plant height, branch count, and dry matter accumulation with the application of nitrogen up to 60 kg N/ha. Raghuvanshi *et al.* (2018) found that nitrogen application up to 160 kg N ha-1 recorded a significant increase in plant height, the number of branches, and dry matter accumulation per plant.

3. EFFECT OF BIOFERTILIZER AND NUTRIENTS ON YIELD AND YIELD ATTRIBUTES

Optimal nutrient management plays a crucial role in determining the yield and quality of mustard crops, as evidenced by various studies. In the research conducted by Dutta *et al.* (2009), it was found that the yellow sarson crop achieved maximum seeds per siliqua, test weight, and seed yield under the treatment receiving 60% N fertilizer, 75% P fertilizer, and 12 kg/ha biofertilizer. Similarly, Solanki *et al.* (2015) reported that the maximum yield was obtained when P and S were applied at 50 kg/ha, along with seed inoculation with PSB biofertilizer.Yadav *et al.* (2010) observed a considerable enhancement in the grain yield of the mustard crop with the application of various doses of sulfur and biofertilizer. Singh *et al.* (2014) noted that higher doses of nitrogenous fertilizer (80 kg/ha) resulted in the maximum seed yield of mustard, showcasing the importance of nitrogen management.

Piri and Sharma (2007) demonstrated that mustard seed yield increased significantly with the application of sulfur, with increments of 9%, 16%, and 23% over the control observed with the application of 15, 30, and 45 kg sulfur/ha, respectively.Kapur *et al.* (2010) conducted an experiment highlighting that the seed yield of the mustard crop reached its maximum (1.81 t/ha) with the application of 60 kg S/ha, showing a 45% increase over the control. Yadav *et al.* (2010) further supported these findings, reporting varying seed yields corresponding to different sulfur application rates.Kharodia and Patel (1990) emphasized the positive impact of nitrogen application at 100 kg/ha on the number of pods per plant, 1000-seed weight, seed and stalk yield in mustard. Kumar (1994) concluded that specific microbial isolates significantly increased various growth parameters and seed yield compared to the control.

Chauhan *et al.* (1996) revealed the positive influence of *Azotobacter* inoculation on pods per plant, seeds per pod, test weight, seed, and stover yields in mustard. Patidar *et al.* (2000) conducted a field experiment, indicating that 60 kg N/ha significantly increased seed yield in mustard.Ram *et al.* (2013) reported a considerable increase in various parameters, including the total number of siliquae, seeds, and 1000-seed weight, with increasing nitrogen levels. Verma and Dawson (2018) highlighted the significance of sulfur levels, showing that higher levels led to increased siliquae/plant, seeds/siliqua, test weight, seed yield, and harvest index.Neha *et al.* (2014) observed that treatment with 40 kg S/ha considerably increased seed output and stover yield in mustard. Kumar *et al.* (2001) conducted a field experiment, noting that test weight and seed yield were maximum at specific nitrogen and phosphorus levels.Potdar *et al.* (2019) concluded that the application of 60 kg P2O5/ha + FYM @ 5 t/ha resulted in a significantly maximum seed yield over the control. These studies collectively underscore the significance of precise nutrient management for optimizing mustard crop yields and quality.

4. EFFECT OF BIOFERTILIZER AND NUTRIENTS ON ECONOMICS AND SOIL NUTRIENTS

Several studies have investigated the economic aspects of mustard cultivation, shedding light on the impact of various factors on net returns and benefit-cost ratios. Hadiyal*et al.* (2017) highlighted that seed inoculation with *Azotobacter* spp. + PSB spp. (each @ 10 ml/kg seed) (B3) resulted in the highest net returns of ₹ 86,629 per hectare and a B:C ratio of 3.40. The application of 80 kg N/ha yielded the highest net returns, followed by 40 kg N/ha and the control, emphasizing the positive correlation between nitrogen doses and mustard yield (Kumar *et al.*, 2013).

Vijayeswarudu *et al.* (2021) emphasized the significance of nutrient management, reporting that the application of PSB + Sulphur at 45 kg/ha recorded higher gross returns (₹ 117,000.00), net returns (₹ 79,573.58), and benefit-cost ratio (2.12). In contrast, the minimum gross returns were ₹ 75,400.00. Sharma *et al.* (1995) supported the importance of microbial inoculation, revealing that the highest net return was obtained with *Azotobacter* inoculation compared to the control.Kharodia and Patel (1990) delved into the impact of nitrogen levels, reporting that the highest net income was secured under 100 kg N/ha compared to other nitrogen levels. Pachauri *et al.* (2012) conducted a field experiment focusing on sulfur levels, indicating that the maximum net return of ₹ 42,018 was obtained with the application of 90 kg S/ha.

Sharma *et al.* (2018) provided insights into the combination of nutrient application, concluding that the application of NPK-80:40:40 with 20 kg sulfur/ha, followed by RDF (80:40:40) + 10 kg sulfur/ha, yielded the maximum net return and benefit-cost ratio (3.17). These studies collectively underscore the economic implications of various agronomic practices, providing valuable insights for mustard cultivation management.

5. EFFECT OF BIOFERTILIZER AND NUTRIENTS ON SOIL NUTRIENTS

Various studies have delved into the impact of nitrogen and sulfur levels on the nutrient content and uptake in mustard crops. Rana *et al.* (1991) conducted a field experiment on nitrogen-deficient sandy loam soil in Baraut (M.P.), exploring four nitrogen levels (0, 50, 100, and 150 kg/ha). They reported a significant increase in nitrogen content and uptake by mustard seed and stover with nitrogen application ranging from 0 to 150 kg/ha. Similarly, on loamy sand soil in Jobner (Rajasthan), Rathore and Manohar (1992) observed a significant rise in mustard nitrogen content with increasing nitrogen levels from 0 to 180 kg/ha.In another context, Sharma *et al.* (1995) found that *Azotobacter* inoculation significantly increased nitrogen uptake compared to the control. Verma *et al.* (2012) contributed to this field with a winter season experiment in Kanpur, focusing on sulfur levels (0, 20, 40, and 60 kg S/ha). Their results highlighted that the application of 60 kg S/ha led to significantly higher nutrient uptake (N, P, K, and S) compared to the control, 20 kg S/ha, and 40 kg S/ha.

Furthermore, Parmar & Parmar (2012) noted that nitrogen application up to 100 kg N/ha significantly increased nitrogen and phosphorus content in seed and stover, potassium content in seed, and sulfur content in stover. The uptake of nitrogen, phosphorus, potassium, and sulfur by seed and stover also increased significantly with nitrogen application levels up to 75 kg/ha. These studies collectively provide valuable insights into the influence of nitrogen and sulfur levels on nutrient content and uptake in mustard crops.

6. EFFECT OF BIOFERTILIZER AND NUTRIENTS ON SOIL MICROBIAL PROPERTIES

In the study conducted by Kumar *et al.* (2011), it was observed that the application of 75% RDF + 25% N through PM + *Azotobacter* + PSB resulted in the highest bacterial population (30.29 at 45 DAS, 51.22 at 90 DAS, and 50.10× 107 CFU/g soil at the harvest stage), fungal population (25.94 at 45 DAS, 45.52 at 90 DAS, and 39.80× 107 CFU/g soil at the harvest stage), and actinomycetes population (33.15 at 45 DAS, 48.74 at 90 DAS, and 41.36× 106 CFU/g soil at the harvest stage) in Indian mustard. This was notably higher compared to other nutrient sources, as indicated by the pooled analysis. The lower microbial population observed at harvest compared to the 90 DAS stage was attributed to the rapid decomposition of organic matter at peak growth stages and reduced nutrient availability during the flowering stage (Babu *et al.*, 2017).

Alami *et al.* (2018) focused on total soil microbial analysis and found that the highest increase in total microbial population occurred in biofertilizer with molasses carrier media. During harvesting, a lower bacterial population was noted in the last sowing due to initially low decomposition of organic matter in the soil, resulting in a reduced microbial population in later stages. This decrease was further linked to a decline in carbon availability for the microbes (Yuste *et al.*, 2007). Additionally, the microbial breakdown of easily available organic carbon from mustard crops was highlighted as a process that could release crucial nutrients for plant absorption.

7. CONCLUSION

In conclusion, a balanced approach to nutrient management withto integrating biofertilizers, other organic sources and chemical fertilizers is significantly important. This approach not only addresses the challenges associated withmustard cultivation but also promotes sustainable and environmentally friendly agricultural practices. The findings suggest that a careful and informed combination of biofertilizers and nutrients can contribute to increased productivity, profitability, and soil health in mustard cultivation.

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