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Shubhankar Baliyan
Ph.D Scholar, Department of
Agronomy, GBPUA&T,
Pantnagar, Uttarakhand, India

Radha Upadhyay
Ph.D Scholar, Department of
Agronomy, GBPUA&T,
Pantnagar, Uttarakhand, India

Siddhant Gupta
Ph.D Scholar, Department of
Agronomy, GBPUA&T,
Pantnagar, Uttarakhand, India

Shilpa saini
Ph.D Scholar, Department of
Agronomy, GBPUA&T,
Pantnagar, Uttarakhand, India

Omvati Verma
²Professor, Department of
Agronomy, GBPUA&T,
Pantnagar, Uttarakhand, India

Mukesh Kumar
Assistant Professor, Department of
Agronomy, RMP (P.G.) College,
Gurukul, Haridwar, Uttarakhand,
India

Corresponding Author:
Shubhankar Baliyan
Ph.D Scholar, Department of
Agronomy, GBPUA&T,
Pantnagar, Uttarakhand, India

Effect of nitrogen and sulphur on growth and yield of Indian mustard (*Brassica juncea* L.)

Shubhankar Baliyan, Radha Upadhyay, Siddhant Gupta, Shilpa saini, Omvati Verma and Mukesh Kumar

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Abstract

Indian mustard (*Brassica juncea* L.) is an oilseed crop whose productivity is influenced by balanced nutrient management. Nitrogen promotes vegetative growth, leaf area, chlorophyll formation, and photosynthetic activity, whereas sulphur supports protein synthesis, enzyme activity, oil formation, and nitrogen utilization. The present study evaluated the combined influence of nitrogen and sulphur on the growth and yield performance of Indian mustard. Application of these nutrients improved plant height, number of branches, dry matter accumulation, siliquae per plant, seeds per silique, test weight, seed yield, and stover yield compared with inadequate nutrient supply. Balanced application produced better crop establishment and reproductive development than the individual or imbalanced use of either nutrient. The interaction between nitrogen and sulphur enhanced nutrient uptake and yield attributes, resulting in improved productivity. Therefore, an optimum combination of nitrogen and sulphur is essential for achieving higher mustard yield, better nutrient-use efficiency, and sustainable soil fertility under field conditions.

Keywords: Indian mustard, *Brassica juncea*, nitrogen, sulphur, growth attributes, seed yield

Introduction

Mustard (*Brassica juncea* L.) is very adaptive oilseed crop valued globally for its oil, medicinal, agricultural and economically importance. Mustard belongs to family Brassicaceae and requires a decent amount of soil moisture during the growth season, a dry time during harvest, and somewhat cool temperatures are all necessary for mustard. It is an important source of proteinrich feed for cattle and makes a substantial contribution to the production of edible oil. Mustard seeds contain about 40–42% oil and 30–45% protein, making them highly nutritious and economically valuable. Besides edible oil, mustard is used in the manufacture of medicines, soaps, hair oils, lubricants, and as a condiment in culinary preparations (Pandey *et al.*, 2020) ^[1].

After soybeans, rapeseed-mustard is the second most significant oilseed crop in the world and makes a significant contribution to the production of edible oil. After China and Canada, India is the world's third-largest producer of rapeseed-mustard. Over 7.99 million hectares of rapeseedmustard were planted in 2021–2022, yielding 11.96 million tonnes with an average productivity of 1,497 kg/ha (Directorate of Economics and Statistics. 2023) ^[2]. The crop contributed significantly to the nation's total oilseed production and area, and it was essential in supplying the growing demand for edible oils.

Although there are significant improvements in mustard production, but the average productivity in India are still remains below its attainable potential yield due to imbalanced nutrient management. This suggests that there is plenty of room to increase productivity through improved balanced nutrient management. Nitrogen (N) is the most important nutrient, and being a constituent of protoplasm and protein, it is involved in several metabolic processes that strongly influence growth, productivity and quality of crops (Reddy and Reddy 1998) ^[3, 4]. Sulphur plays a significant role in the biosynthesis of proteins and it is essential to numerous enzyme reactions in every living cell. Sulphur is the key building block in growth and regulation of metabolism as part of amino acids methionine, cysteine, and cystine (Sahu *et al.*, 2025) ^[5].

Nitrogen (N) and sulfur (S) are both necessary for improving mustard growth, yield, and quality.

Nitrogen gives plants a dark green hue while also encouraging vegetative development and serving as a component of protoplasm and structural proteins (Sukirtee *et al.*, 2022) ^[6]. Sulfur is linked to N metabolism in plants and is necessary for the manufacture of S-containing essential amino acids (Kacjan Marsic *et al.*, 2021) ^[7]. It significantly affects the amount of seed oil in oilseed crops. Nitrogen (N) and sulfur (S) assimilation processes are thought to be functionally linked and well-coordinated with one another (Kabdal *et al.*, 2018) ^[8]. Research has shown that N and S can have both antagonistic and synergistic effects on plants, depending on the ratio and rate of application (Mansoori, 2012) ^[9]. There is less study on how applying N and S together affect mustard yield and quality. Thus, the current study was conducted to examine how the applications of N and S effects on mustard yield and growth.

Material and Methods

A field experiment was carried out at the research farm of Raja Mahendra Partap (Post Graduate) college, Gurukul Narsan, Haridwar (Uttarakhand) during the rabi season (2021-2022). The farm is situated in alluvial belt of Ganga in Uttarakhand. Geographically, Gurukul Narsan fall in the subtropical, semi-arid climate and is situated between 29.7024 °N latitude and 77.8496 ° S longitude. The elevation of Gurukul Narsan from sea level is 261 meters. The average annual temperature in Gurukul Narsan is 23.7 °C in a year and the average rainfall is 1170 mm. The soil of experimental site was sandy loam in texture, low in organic carbon 0.34 %, low in available nitrogen 174.4 kg/ha, medium in available phosphorus 25.8 kg/ha and medium in available potassium 220.7 kg/ha also pH and Electrical conductivity was neutral and normal.

The experiment was laid out in randomized block design with twelve treatments that replicated thrice. The twelve treatments comprised three nitrogen and four sulphur levels viz., Sulphur

levels 0, 20, 40, 60 kg/ha and Nitrogen 0, 60, 90 kg/ha. Crop was sown on 2 November 2021. The recommended dose of other fertilizer (RDF) for phosphorous and potassium in Indian mustard were 40 and 20 kg/ha respectively. Observations for Measurements of yield and yield contributing characters were taken after 30, 60 and 90 days after sowing. At harvest, seed and stover yields were recorded. The harvested plant samples at maturity were washed well with distilled water, dried in the air and then in an oven at 65 °C to a constant weight.

Results and Discussion

Growth attributes

Results showed that plant height at harvesting was significant effected with different levels of nitrogen and sulphur. The treatment (60 kg S/ha + 90 kg N/ha) achieved the significantly highest plant height (167.3 cm) significantly better than all other treatments. This was followed by treatment S₂N₂ (40 kg S/ha + 90 kg N/ha) (160.7 cm) and S₁N₂ (20 kg S/ha + 90 kg S/ha) (156.3 cm), whereas the minimum plant height (100.4 cm) was observed under the control treatment. These results clearly shows that higher dose of applied nitrogen being a structural constituent of amino acids, proteins, nucleic acids and chlorophyll stimulates cell division, cell elongation and photosynthetic activity leading to increased plant stature (Ladha *et al.*, 2005; Singh *et al.*, 2013) ^[10]. ^[11] Sulphur works in conjunction with nitrogen by involving in the synthesis of sulphur amino acids (cysteine and methionine), proteins, enzymes, which contributes to the improvement of Nitrogen use efficiency and biomass synthesis Sukirtee *et al.*, (2022) ^[6]. This improves the performance of treatment S₃N₂ (60 kg S/ha + 90 kg N/ha) which shows the synergistic effect of nitrogen and sulphur and helps in nutrient assimilation and photosynthetic efficiency (Singh *et al.*, (2023) ^[12], Chauhan *et al.*, (2021) ^[13] and Kumar *et al.*, (2022) ^[14].

Table 1: Effects of nitrogen and sulphur on plant height, number of primary and secondary branches of Indian mustard

Treatment	Dose of nutrients (kg/ha)	Plant Height at Harvest in cm	Primary Branches per plant	Secondary Branches per plant
S ₀ N ₀	S ₀ N ₀	100.4	3.3	5.2
S ₀ N ₁	S ₀ N ₆₀	138.4	5.0	11.1
S ₀ N ₂	S ₀ N ₉₀	150.6	5.6	13.0
S ₁ N ₀	S ₂₀ N ₀	104.2	3.6	5.8
S ₁ N ₁	S ₂₀ N ₆₀	141.9	5.6	12.6
S ₁ N ₂	S ₂₀ N ₉₀	156.3	6.2	14.4
S ₂ N ₀	S ₄₀ N ₀	105.4	3.8	5.9
S ₂ N ₁	S ₄₀ N ₆₀	149.5	5.8	14.2
S ₂ N ₂	S ₄₀ N ₉₀	160.7	6.8	15.6
S ₃ N ₀	S ₆₀ N ₀	107.3	4.2	6.3
S ₃ N ₁	S ₆₀ N ₆₀	155.4	6.4	15.2
S ₃ N ₂	S ₆₀ N ₉₀	167.3	7.1	16.6
SEm ±		1.3	0.2	0.2
CD (p=0.05)		2.6	0.4	0.4

Different combinations of Nitrogen and Sulphur significantly affected the number of primary and secondary branches per plant (Table 1). The results shows that treatment S₃N₂ (60 kg S/ha + 90 kg N/ha) produce significantly higher number of primary (7.1) branches per plant, which was also at par with treatment S₂N₂ (40 kg S/ha + 90 kg N/ha) 6.8 primary branches per plant. The lowest primary branches per plant recorded with control treatment (S₀N₀) . The significantly highest number of secondary branches (16.6) per plant was recorded with treatment S₃N₂ , followed by treatment S₂N₂ (40 kg S/ha + 90 kg N/ha), S₃N₁ (60 kg S/ha + 60 kg N/ha) and S₁N₂ with (15.6), (15.2) and (14.4) branches per plant respectively. The untreated control had the lowest

vegetative development with only 5.2 secondary branches per plant. The higher number of primary and secondary branch production with higher Nitrogen and Sulphur rates due to increased in photosynthetic efficiency, greater dry matter production and greater translocation of assimilates to actively growing tissues Singh *et al.*, (2023) ^[12], Rathore *et al.*, (2020),. Nitrogen encourages vegetative growth with the increase of chlorophyll content, robust vegetative growth and the production of better amounts of carbohydrates, which then lead to the initiation and development of axillary buds while sulphur encourages enzyme activity, synthesis of amino acids and formation of protein, causing vigorous branching Fazili *et al.*,

(2008) ^[15], Jamal *et al.*, (2010) ^[16]. Nitrogen and sulphur were synergistic and increased nutrient-use efficiency and partitioning of assimilates which in turn led to increased primary and secondary branch formation supported research by Chauhan *et al.*, (2021) ^[13], Sukirtee *et al.*, (2022) ^[6] and Meena *et al.*, (2022) ^[14].

Economic and Biological Yield

Table 1: Effects of nitrogen and sulphur on economic and biological yield of Indian mustard

Treatment	Dose of nutrients (kg/ha)	Economic yield (kg/ha)	Biological Yield (kg/ha)
S ₀ N ₀	S ₀ N ₀	720.3	1274.0
S ₀ N ₁	S ₀ N ₆₀	1108.5	3185.5
S ₀ N ₂	S ₀ N ₉₀	1300.9	3683.8
S ₁ N ₀	S ₂₀ N ₀	860.4	1488.1
S ₁ N ₁	S ₂₀ N ₆₀	1280.5	3538.4
S ₁ N ₂	S ₂₀ N ₉₀	1491.0	4075.4
S ₂ N ₀	S ₄₀ N ₀	948.4	1610.1
S ₂ N ₁	S ₄₀ N ₆₀	1508.0	3971.3
S ₂ N ₂	S ₄₀ N ₉₀	1667.7	4320.2
S ₃ N ₀	S ₆₀ N ₀	1028.0	1704.9
S ₃ N ₁	S ₆₀ N ₆₀	1548.0	4202.1
S ₃ N ₂	S ₆₀ N ₉₀	1882.3	4573.6
SEm +		16.08	26.49
CD (p=0.05)		47.34	81.21

Economic yield of Indian mustard was significantly influenced by the combined application of nitrogen and sulphur levels (Table 2). Results showed that significantly higher economic yield (1882.3 kg/ha) was recorded with the treatment S₃N₂ (60 kg S/ha + 90 kg N/ha), followed by the treatments S₂N₂ (40 kg S/ha + 90 kg N/ha) (1667.7 kg/ha) and S₃N₁ (60 kg S/ha + 60 kg N/ha) (1548.0 kg/ha), whereas the lowest economic yield (720.3 kg/ha) was observed under the control treatment S₀N₀. At every sulphur level, increasing nitrogen levels from 0 to 60 and subsequently to 90 kg/ha resulted in a marked improvement in economic yield. Similarly, increasing sulphur levels application from 0 to 60 kg/ha at each nitrogen level also produced higher seed yield, indicating the complementary role of these nutrients in mustard production. The significant increase in economic yield under higher levels of nitrogen and sulphur application attributed to improved vegetative growth, enhanced photosynthetic efficiency, greater nutrient uptake and efficient translocation of assimilates towards developing siliquae and seeds (Singh and Singh 2018). Both nitrogen and sulphur are important elements produces better growth, yield and quality of mustard. Nitrogen imparts green colour to plants which promote vegetative growth and act as a constituent of structural protein, protoplasm, nucleic acids and chlorophyll, thereby stimulating vegetative growth and dry matter production (Bhardwaj *et al.*, 2025) ^[17]. Sulphur is required for biosynthesis of Sulphur containing essential amino acids and is also associated with N metabolism in plant (Kacjan Marsic *et al.*, 2021) ^[7]. Sulphur has significant influence on seed oil content in oilseed crops. Assimilatory pathways of nitrogen and sulphur believed to be functionally integrated and well-coordinated with each other (Kabdal *et al.*, 2018; Fazili *et al.*, 2008) ^[8, 15] these similar study also supported by (Sukirtee *et al.*, 2022) ^[6].

Biological yield of Indian mustard was significantly influenced by the increased levels of nitrogen and sulphur (Table 2). Results showed that treatment S₃N₂ (60 kg S/ha + 90 kg N/ha) produced significantly higher biological yield (4573.6 kg/ha) among all other treatments, followed by treatment S₂N₂ (40 kg S/ha + 90 kg N/ha) (4320.2 kg/ha) and S₃N₁ (60 kg S/ha + 60 kg N/ha) (4202.1 kg/ha) respectively. The control treatment produced lowest grain yield (1274.0 kg/ha). The progressive increase in biological yield from the control treatment with increasing levels of sulphur and nitrogen indicated that the application of these fertilizers

promoted the overall growth and dry matter production of mustard crop (Qidwai *et al.*, 2024) ^[18]. This is because nitrogen is a key component of amino acids, proteins and chlorophyll, and increases leaf area, photosynthesis and dry matter productivity. Besides the benefits of nitrogen fertilizer to crop growth, sulphur enhances the nitrogen utilization capacity of plants and facilitates efficient nitrogen metabolism *et al.*, 2008; Sukirtee *et al.*, 2022) ^[6].

Conclusion

The study revealed that the balanced application of nitrogen and sulphur produced in higher number of Growth and yield attributes of Indian mustard. The treatment with (60 kg S/ha + 90 kg N/ha) (S₃N₂) resulted higher economic and biological yield as compared to all other treatments. The findings revealed that balanced use of nitrogen and sulphur nutrition are critical factors in obtaining growth and yield potential of Indian mustard and could be valuable in improving crop productivity in the field.

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