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Effect of different levels of nitrogen and sulphur on Indian mustard (*Brassica juncea* L.)

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Abstract

Field experiment entitled “Effect of different levels of nitrogen and sulphur on growth and yield of Indian mustard *Brassica juncea* (L.)” was conducted at Agriculture Research Farm, Suresh Gyan Vihar University, Jaipur. The experiment comprised of four nitrogen levels (0, 40, 60 and 80 kg ha⁻¹) and four sulphur levels (0, 20, 40 and 60 kg ha⁻¹) tested in a Randomized Block Design and replicated three times. The growth characters such as plant height, number of primary and secondary branches plant⁻¹, number of leaves plant⁻¹ and dry matter accumulation plant⁻¹ were maximum at 80 kg N ha⁻¹ and 60 kg S ha⁻¹. The maximum seed yield was at 60 kg ha⁻¹ (1424 kg ha⁻¹), which was at par with 80 kg ha⁻¹. and stover yield (3920 kg/ha) was recorded at 80 kg N, which was at par with 60 kg N ha⁻¹. In case of sulphur application, the maximum seed yield was at 60 kg ha⁻¹ S (1372 kg ha⁻¹), which was at par with 40 kg ha⁻¹ S and stover yield (3652 kg ha⁻¹) was recorded at 60kg S ha⁻¹, which was at par with 40 kg S ha⁻¹.

Keywords: Different levels of nitrogen, sulphur, Indian mustard, *Brassica juncea* L.

Introduction

Indian Mustard [*Brassica juncea* L.] is commonly referred to as Indian mustard, brown mustard, or oriental mustard. In various regions of India, it is known by different names such as rai, raya, and laha in Hindi. It is thought that Indian mustard originated from *Brassica rapa* and *Brassica nigra* in the Middle East and Indian areas. Indian mustard can be distinguished from rapeseed by its taller height, a higher number of branches, tapering roots, and seeds that range in color from brown to dark brown. Both high and low temperature extremes during the vegetative and reproductive stages are believed to be beneficial for maximizing yield and improving the quantity and quality of oil. It is believed that Indian mustard evolved from *Brassica rapa* and *Brassica nigra* in the regions of the Middle East and India. Both extremes of high and low temperatures during the vegetative and reproductive phases are thought to enhance yield potential and improve both the quantity and quality of the oil. It has a considerable level of Erucic acid (40-50%) and glucosinolates (180-200 micromoles). The oil obtained from the seeds is commonly used for cooking in northern India. Furthermore, the leaves of young plants are utilized as a source of leafy greens, offering crucial sulfur and minerals in the diet. Nitrogen imparts dark green colour to plants simultaneously promotes vegetative growth and acts as a constituent of structural protein and protoplasm. Sulphur is required for biosynthesis of S containing essential amino acids and is also associated with N metabolism in the plant. Keeping the above in view, a study was undertaken to “Effect of different levels of nitrogen and sulphur on growth and of Indian mustard [*Brassica juncea* L.]”

Materials and Methods

A field experiment was conducted to assess the effects of different nitrogen and sulphur levels on the yield attributes, yield, and quality of Indian mustard [*Brassica juncea* L.] during the rabi season at the Agriculture Research Farm, Suresh Gyan Vihar University, Jaipur. The soil at the experimental site was classified as sandy loamy in texture, with a pH 8.25, electrical conductivity of (1:2 soil water suspension) at 250 °C is 1.42 dS/m, organic carbon content 0.23%, available nitrogen at 125.73 kg N/ha, available phosphorus at 17.92 kg P₂O₅/ha,

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available potassium at 151.76 kg K₂O/ha, and available sulphur at 8.10 kg/ha. The experimental design included four nitrogen levels (0, 40, 60, and 80 kg/ha) and four sulphur levels (0, 20, 40, and 60 kg/ha), arranged in a randomized block design with three replications. Nitrogen and sulphur were supplied using diammonium phosphate (DAP; 46% P₂O₅, 18% N) and urea (46% N), respectively. According to the treatment protocol, half of the nitrogen dose and the full sulphur dose were applied as a basal dressing, while the remaining nitrogen was applied after the first irrigation. Full doses of phosphorus and potassium were incorporated at sowing. The crop was sown at a spacing of 45 cm by 15 cm. Growth attributes and yield parameters were recorded at various crop growth stages and at maturity.

Result and Discussion

Nitrogen application

The plant height measured at 20 days after seeding (DAS) and at the time of harvest was not notably affected by different nitrogen levels; nevertheless, the application of 80 kg N ha⁻¹ led to a significant increase in plant height compared to the control and the 40 kg N ha⁻¹ treatment, while still being statistically similar to the 60 kg N ha⁻¹ treatment, supporting the results of Sukirtee *et al.* (2022) [20] and Singh and Kumar (2014) [16]. The increased availability of nitrogen promoted vegetative growth by enhancing cell size, the production of chlorophyll, and photosynthetic efficiency, which ultimately resulted in greater dry matter accumulation and improved plant structure (Sandhu, 2010; Singh and Kumar, 2014) [11, 16].

The accumulation of dry matter, the number of branches per plant, and the leaf area index all showed a gradual increase with higher nitrogen levels, with 80 kg N ha⁻¹ demonstrating significantly greater values than both the control and 40 kg N ha⁻¹, while being comparable to 60 kg N ha⁻¹. Compared to the control, dry matter accumulation rose by 30.29%, 28.76%, and 21.14% at 80, 60, and 40 kg N ha⁻¹, respectively. The rise in biomass production was attributed to improved nitrogen utilization and efficient allocation of assimilates into structural components (Bhattacharya, 2022) [1].

The yield characteristics, including the number of siliques per plant and seeds per silique, were notably affected by the application of nitrogen. The treatment with 60 kg N ha⁻¹ showed significantly greater results compared to the control and the 40 kg N ha⁻¹ treatment, while remaining statistically comparable to the 80 kg N ha⁻¹ treatment. The enhanced availability of nitrogen led to improved photosynthetic efficiency, better flower retention, increased pollen viability, and more effective translocation of assimilates, which contributed to greater pod development and seed set (Khare *et al.*, 2025; Sharma *et al.*, 2023) [5, 14].

The application of nitrogen led to a significant increase in seed yield, with the highest yield observed at 60 kg N ha⁻¹, which was comparable to that at 80 kg N ha⁻¹. Seed yield saw increases of 61.91%, 58.78%, and 40.23% with the application of 60, 80, and 40 kg N ha⁻¹, respectively, in comparison to the control. The highest biological yield recorded was 5317 kg ha⁻¹, achieved with 80 kg N ha⁻¹, which was due to enhanced source-sink dynamics and a greater availability of photo-assimilates (Sukirtee *et al.*, 2022; Sardana and Sheoran, 2011) [20, 12].

The nutrient levels and absorption (N, P, and K) in both seeds and stalks showed a notable increase with the application of nitrogen. The treatment of 80 kg N ha⁻¹ achieved the highest levels of nutrient uptake and protein concentration (25.10%), which was comparable to the results from the 60 kg N ha⁻¹ treatment, attributed to enhanced nitrogen uptake and improved

protein synthesis (Singh *et al.*, 2022; Singh, 2002) [18, 15]. Additionally, oil content benefited from higher nitrogen levels, with the 80 kg N ha⁻¹ treatment yielding the greatest oil content (39.61%), which was statistically similar to that of the 60 kg N ha⁻¹ treatment, consistent with previous research findings (Singh and Singh, 2005; Singh *et al.*, 2008) [19, 17].

Economic assessment indicated that an application of 60 kg N ha⁻¹ yielded the greatest net return (₹71,063 ha⁻¹) and a benefit-cost ratio of 2.66, surpassing both lower and higher levels of nitrogen. This enhanced profitability at this rate was linked to an optimal yield response concerning input expenses, aligning with findings from Rathore *et al.* (2014) [10] and Kumar *et al.* (2017) [6].

Sulphur application

The application of sulphur did not have a significant effect on plant height at 20 days after sowing (DAS); however, noticeable differences were seen at 30 DAS, 60 DAS, and at the time of harvest. The use of 60 kg S ha⁻¹ led to significantly greater plant height compared to both the control and the 20 kg S ha⁻¹ treatment, showing similar results to the 40 kg S ha⁻¹ application. At harvest, plant height was enhanced by 16.59%, 15.14%, and 7.78% for the 60, 40, and 20 kg S ha⁻¹ treatments, respectively, in comparison to the control. These results align closely with the findings of Kumar *et al.* (2017) [6].

The application of sulphur, especially at a rate of 60 kg S ha⁻¹, significantly increased dry matter accumulation, the number of branches per plant, and the leaf area index, with results similar to those observed at 40 kg S ha⁻¹. The leaf area index exhibited increases of 34.62%, 23.22%, and 26.21% with the application of 60, 40, and 20 kg S ha⁻¹, respectively, compared to the control. The enhancements in growth characteristics can be linked to improved root development, as well as better cell multiplication, elongation, and expansion due to enhanced sulphur nutrition during the key vegetative growth phase (Katiyar *et al.*, 2014; Naganjali *et al.*, 2023) [4, 7].

The application of 60 kg S ha⁻¹ notably enhanced the number of siliques per plant and seeds per silique when compared to the control and 20 kg S ha⁻¹, while showing similar results to 40 kg S ha⁻¹. The increase in siliques per plant was observed at 44.81%, 43.36%, and 34.85%, while seeds per silique saw an increase of 16.85%, 12.38%, and 8.27% with the use of 60, 40, and 20 kg S ha⁻¹, respectively, compared to the control.

The application of 60 kg S ha⁻¹ resulted in significantly greater seed, stalk, and biological yields. Compared to the control, seed yield showed increases of 36.45%, 32.70%, and 30.59% with the application of 60, 40, and 20 kg S ha⁻¹, respectively. The levels of sulphur did not significantly influence test weight. The highest harvest index of 27.08% was achieved with 60 kg S ha⁻¹ and was statistically comparable to that obtained with 40 kg S ha⁻¹. The observed increases in yields were primarily due to improved growth factors and enhanced movement of photosynthates to the reproductive structures (Rao *et al.*, 2013; Verma *et al.*, 2018; Rana *et al.*, 2020; Godara *et al.*, 2025) [19, 22, 8, 2].

The highest levels of nitrogen and sulfur content in both seed and stalk (4.19% N and 0.55% S) were observed with an application rate of 60 kg S ha⁻¹, which was statistically comparable to the 40 kg S ha⁻¹ treatment. The uptake of nitrogen by seed and stalk was greatest with 60 kg S ha⁻¹, measuring 61.14 and 20.05 kg ha⁻¹, respectively. In comparison to the control, nitrogen uptake in the seed increased by 67.49%, 61.61%, and 47.37% with the application of 60, 40, and 20 kg S ha⁻¹, respectively, while in the stalk it increased by 44.48%,

38.97%, and 28.61% under the same treatments.

The uptake of sulphur showed a notable increase with elevated sulphur levels, which can be linked to enhanced nutrient availability, improved crop growth, and a rise in sulphur concentration in the soil solution due to competitive adsorption effects (Zizala *et al.*, 2008; Shaoo *et al.*, 2018) [24, 13]. The protein content reached its peak at 24.71% with the application of 60 kg S ha⁻¹ and was comparable to that achieved with 40 kg S ha⁻¹. The rise in protein content was associated with heightened synthesis of sulphur-containing amino acids and their subsequent transformation into proteins (Hossain *et al.*, 2012;

Upadhyay, 2012) [3, 21].

The maximum net returns of ₹64,191 ha⁻¹ were achieved with an application of 60 kg S ha⁻¹. Compared to the control, net returns rose by 39.92%, 38.32%, and 39.05% with the use of 60, 40, and 20 kg S ha⁻¹, respectively. Nevertheless, the highest benefit-cost ratio was observed at 20 kg S ha⁻¹, attributed to reduced input costs and significant improvements in yield. These outcomes are consistent with the research conducted by Yadav and Debbarma (2012) [23].

Table 1: Growth and yield attributes of mustard as influenced by varying levels of nitrogen and sulphur nutrition

Treatments	Plant height (cm)	Leaf area index	Branches per plant	Dry matter accumulation (g/plant)	Siliqua plant ⁻¹	Seed siliqua ⁻¹	1000 seed weight (g)
Nitrogen level (kg ha⁻¹)							
0	99.50	2.93	6.72	43.75	102.3	8.00	4.10
40	136.00	3.55	7.47	53.00	146.5	9.33	4.18
60	148.75	3.80	7.75	56.33	155.8	10.33	4.22
80	147.92	3.92	8.16	57.00	150.3	10.61	4.17
SEm ±	2.84	0.07	0.15	0.96	2.8	0.26	0.08
CD at 5%	8.20	0.19	0.44	2.78	8.2	0.74	NS
Sulphur levels (kg ha⁻¹)							
0	121.08	2.93	6.80	40.17	133.5	8.75	4.06
20	130.50	3.70	7.44	54.17	135.7	9.47	4.15
40	139.42	3.61	7.86	57.58	141.8	9.83	4.21
60	141.17	3.95	8.00	58.17	143.8	10.22	4.24
SEm ±	2.84	0.07	0.15	0.96	2.8	0.26	0.08
CD at 5%	8.20	0.19	0.44	2.78	8.2	0.74	NS

Table 2: Biological, seed, stover and oil yield, harvest index and oil content as influenced by varying levels of nitrogen and sulphur nutrition

Treatments	Biological yield (kg ha ⁻¹)	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)	Protein content	Oil content (%)
Nitrogen level (kg ha⁻¹)						
0	3179	879	2300	27.50	22.29	35.52
40	4931	1333	3598	27.00	24.57	36.20
60	5204	1424	3781	27.29	25.76	37.35
80	5317	1396	3920	26.26	26.20	37.50
SEm ±	72	22	54	0.25	0.29	0.59
CD at 5%	209	65	157	0.73	0.85	1.71
Sulphur levels (kg ha⁻¹)						
0	3882	1012	2870	26.01	20.13	35.51
20	4825	1314	3511	27.27	23.74	36.32
40	4900	1335	3565	27.35	26.85	37.14
60	5024	1372	3652	27.43	28.09	37.60
SEm ±	72	22	54	0.25	0.29	0.59
CD at 5%	209	65	157	0.73	0.85	1.71

Table 3: Economics of mustard crop as influenced by various nutrient management treatments

Treatments	Gross return (₹ha ⁻¹)	Net return (₹ha ⁻¹)	B:C ratio
Nitrogen level (kg ha⁻¹)			
0	60192	36952	1.58
40	91701	66204	2.59
60	97688	71063	2.66
80	96650	68896	2.48
Sulphur levels (kg ha⁻¹)			
0	70166	47327	2.04
20	90241	65242	2.59
40	91666	64907	2.40
60	94160	65641	2.28

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