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Effect of nitrogen and sulphur levels on yeild, nutrient content and uptake of mustard

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Abstract
A field trial was carried out during 2024-25 at the AICRP on Mustard, College of Agriculture, Nagpur, to evaluate the "Effect of nitrogen and sulphur levels on yield, nutrient content and uptake of mustard." The experiment tested three nitrogen levels (50, 65, and 80 kg ha^{-1}) and three sulphur levels (15, 30, and 45 kg ha^{-1}) on mustard grown in a medium black, clayey soil with moderately alkaline pH. The highest seed yield (18.25 q ha^{-1}) and stover yield (53.47 q ha^{-1}) were achieved with 80 kg ha^{-1} nitrogen, while 45 kg ha^{-1} sulphur produced significantly higher seed (18.02 q ha^{-1}) and stover yields (52.78 q ha^{-1}) compared to lower levels. Nutrient concentrations of N, P, K, and S improved in both seed (4.07, 0.67, 0.79, and 0.62%) and stover (0.75, 0.36, 0.60, and 0.26%). Similarly, nutrient uptake increased in seed (75.06, 12.48, 14.66, and 11.15 kg ha^{-1}) and stover (40.09, 19.54, 32.76, and 13.07 kg ha^{-1}). Overall, the study concluded that applying 80 kg ha^{-1} nitrogen along with 45 kg ha^{-1} sulphur significantly enhanced mustard yield, nutrient content, and nutrient uptake, indicating these levels as the most effective combination.

Keywords: Mustard, nitrogen, sulphur, yield, nutrient content and uptake

Introduction
Mustard (*Brassica juncea*), commonly known as *Sarson* or *Rai*, is an important rabi oilseed crop in India, cultivated on nearly 6.86 million hectares. It plays a vital role in diverse cropping systems, often grown after rice, maize, pearl millet, urad bean, groundnut, and sunflower in different states. Mustard seeds contain about 37-49% oil, and with low production costs and high yield potential, the crop holds considerable promise for large-scale cultivation in the country.

Nitrogen (N) is essential for rapid growth, higher productivity, and improved quality in mustard. It plays a critical role in the synthesis of plant proteins and chlorophyll and is required in greater amounts compared to other macronutrients. Being a mobile nutrient, nitrogen is transported from older to younger leaves, hence deficiency symptoms appear first on older foliage. Nitrogen deficiency results in thin, open canopies, shortened flowering duration, reduced pod set, and ultimately lower yield.

Sulphur (S) is recognized as the fourth major nutrient for oilseed crops due to its significance in growth, development, and oil synthesis (Patel *et al.*, 2024). It is involved in several physiological and metabolic functions, including enzyme activation, chlorophyll formation, and glucosinolate synthesis in mustard. Sulphur application also improves yield attributes, oil content, fatty acid composition, and glucosinolate levels. Ray and Sengupta (2012) reported that sulphur uptake was significantly higher (18.1 kg ha^{-1}) with 60 kg S ha^{-1} application, which was statistically comparable to 45 kg S ha^{-1} (17.47 kg ha^{-1}).

Materials and Methods
A field experiment was conducted during the rabi season of 2024-25 at the AICRP on Mustard research farm, College of Agriculture, Nagpur (Maharashtra). The site experiences a subtropical climate with dry conditions for most of the year and an average annual rainfall of 1064.1 mm. The mean annual temperature is 25.9°C, with seasonal variations: maximum temperature averages 33.7°C in *kharif* (June-Sept), 27.5°C in *rabi* (Oct-Jan), and 38.8°C in summer (Feb-May). May is typically the hottest month, with temperatures rising above 45°C

for 5-10 days. Minimum temperatures range from 8°C to 30.8°C, and relative humidity varies between 26.4% and 94.1%.

Before laying out the experiment, five soil samples were collected randomly from a 0-15 cm depth for chemical analysis. The soil at the site was clayey in texture, moderately alkaline (pH 7.93), and contained available nutrients: N (253.28 kg ha⁻¹), P (18.42 kg ha⁻¹), K (344.00 kg ha⁻¹), S (9.51 mg kg⁻¹), along with soil organic carbon (5.21 g kg⁻¹).

The experiment was laid out in a factorial randomized block design (FRBD) with three replications, comprising 9 treatment combinations of nitrogen (50, 65, and 80 kg N ha⁻¹) and sulphur (15, 30, and 45 kg S ha⁻¹). Each plot measured 18 m² (4.5 × 4.0 m), making a total of 27 plots. Data were analyzed statistically following the methods of Gomez and Gomez (1984), and treatment means were compared at a 5% level of significance using critical difference (C.D.). Relevant results were presented graphically.

Results and Discussion

Effect of nitrogen and sulphur on yield of mustard

An examination of data in Table 1. on seed yield, stover yield of mustard.

Seed yield (q ha^{-1})

The maximum seed yield of mustard (18.25 q ha⁻¹) was obtained with the application of 80 kg N ha⁻¹, which was statistically at par with 65 kg N ha⁻¹ (17.84 q ha⁻¹). A significant increase in seed yield was observed with increasing nitrogen levels, confirming that mustard responds positively to higher nitrogen supply. These findings are in line with the results of Neha *et al*. (2014) [15], who also reported enhanced seed and stover yield, growth attributes, and yield parameters with higher nitrogen application.

Sulphur application also showed a significant effect on seed yield. The highest yield (18.02 q ha⁻¹) was recorded with 45 kg S ha⁻¹, which was significantly superior to 15 kg S ha⁻¹ (17.06 q ha⁻¹) and statistically comparable with 30 kg S ha⁻¹ (17.67 q ha⁻¹). The interaction between nitrogen and sulphur levels was significant, and the combined application of 80 kg N ha⁻¹ and 45 kg S ha⁻¹ produced the highest seed yield. Similar results were reported by Tetarwal *et al*. (2013) [12], who found that seed and stover yields increased significantly up to 30 kg S ha⁻¹, and Solanki *et al*. (2015), who observed substantial improvement in seed yield with sulphur application, with maximum yields achieved at 50 kg S ha⁻¹.

Stover Yield (q ha^{-1})

Stover yield was significantly influenced by nitrogen levels. The highest stover yield (53.47 q ha⁻¹) was obtained with 80 kg N ha⁻¹, which was significantly superior to 50 kg N ha⁻¹ (48.78 q ha⁻¹) and statistically at par with 65 kg N ha⁻¹ (52.28 q ha⁻¹). This indicates that higher nitrogen application significantly increases straw yield over lower levels. Similar observations were reported by Kapur *et al.* (2010) [3], who noted significantly higher yields with 60 kg S ha⁻¹, though these were at par with 45 and 30 kg S ha⁻¹ in terms of the number of primary and secondary branches per plant.

Sulphur fertilization also contributed significantly to stover yield. The highest stover yield was obtained with 45 kg S ha⁻¹, which was statistically comparable with 30 and 60 kg S ha⁻¹. The interaction between nitrogen and sulphur was found to be significant. Raman and Trivedi (2012) [8] similarly reported that seed and stover yields of mustard increased significantly with each successive increment in sulphur application. They observed that sulphur application at 20, 40, and 60 kg ha⁻¹ increased seed yield by 13.9%, 28.1%, and 28.6%, respectively, over the control, averaged over two years.

Table 1: Effects of nitrogen and sulphur levels on yield attributes of mustard.

Treatments	Seed yield	Stover yield
Levels of nitrogen		
N_1 (50 kg Nitrogen ha^{-1})	16.65	48.78
N_2 (65 kg Nitrogen ha^{-1})	17.84	52.28
N_3 (80 kg Nitrogen ha^{-1})	18.25	53.47
SE (m) ±	0.2	0.5
CD at 5%	0.5	1.4
Levels of Sulphur		
S_1 (15 kg Sulphur ha^{-1})	17.06	49.99
S_2 (30 kg Sulphur ha^{-1})	17.67	51.76
S_3 (45 kg Sulphur ha^{-1})	18.02	52.78
SE (m) ±	0.2	0.5
CD at 5%	0.5	1.4
Interaction (Nitrogen X Sulphur)		
SE (m) ±	0.3	0.8
CD at 5%	0.8	2.4

Effect of nitrogen and sulphur on content of mustard

Data presented in Table 2 revealed that the highest concentrations of N (4.07% in seed and 0.75% in stover), P (0.67% and 0.36%), K (0.79% and 0.60%), and S (0.62% and 0.26%) were recorded under the N_3 treatment (80 kg N ha⁻¹), followed closely by 65 kg N ha⁻¹. The improvement in nutrient content with higher nitrogen application may be attributed to its vital role in rapid growth, higher productivity, and quality enhancement in mustard. Nitrogen is fundamental for protein and chlorophyll synthesis and is required in greater quantities than other macronutrients. Being mobile within the plant, nitrogen is translocated from older to younger leaves, hence deficiency symptoms first appear in older foliage. Similar findings were reported by Hossain *et al*. (2012) [2], who observed that N, P, K, and S concentrations in seeds increased with higher nitrogen levels, with maximum N content (3.6%) recorded at 150 kg N ha⁻¹.

Sulphur application also had a significant impact on nutrient content. The highest values of N (4.06% in seed and 0.73% in stover), P (0.66% and 0.35%), K (0.76% and 0.59%), and S (0.60% and 0.26%) were observed in the S_3 treatment (45 kg S ha⁻¹), followed by 30 kg S ha⁻¹. The growing importance of sulphur fertilization in improving yield and quality of Indian mustard is now well recognized. Mustard has a comparatively higher sulphur requirement for optimum growth, development, and oil synthesis. Neha *et al*. (2014) [5] also reported that application of 60 kg S ha⁻¹ significantly increased sulphur concentration in both seed and stover, while 40 kg S ha⁻¹ improved sulphur content by 13.6% and 38.2% over 20 kg S ha⁻¹ and control, respectively. However, further increase in sulphur beyond this level was found to be statistically at par.

Table 2: Effects of nitrogen and sulphur levels on content (%) of mustard.

Treatments	Seed Content (%)				Stover content (%)			
	N	P	K	S	N	P	K	S
Levels of Nitrogen								
N_1 (50 kg Nitrogen ha^{-1})	4.00	0.62	0.72	0.54	0.66	0.33	0.55	0.21
N_2 (65 kg Nitrogen ha^{-1})	4.06	0.66	0.73	0.58	0.72	0.34	0.58	0.22
N_3 (80 kg Nitrogen ha^{-1})	4.07	0.67	0.79	0.62	0.75	0.36	0.60	0.26
SE (m) ±	0.02	0.007	0.01	0.01	0.01	0.01	0.01	0.006
CD at 5%	0.05	0.01	0.03	0.02	0.02	0.02	0.03	0.01
Levels of Sulphur								
S_1 (15 kg Sulphur ha^{-1})	4.01	0.64	0.73	0.57	0.68	0.33	0.55	0.22
S_2 (30 kg Sulphur ha^{-1})	4.05	0.65	0.75	0.58	0.72	0.34	0.58	0.23
S_3 (45 kg Sulphur ha^{-1})	4.06	0.66	0.76	0.60	0.73	0.35	0.59	0.26
SE (m) ±	0.02	0.007	0.1	0.01	0.01	0.01	0.01	0.006
CD at 5%	0.05	0.01	--	0.02	0.02	0.02	--	0.01
Interaction (Nitrogen X Sulphur)								
SE (m) ±	0.03	0.01	0.02	0.011	0.01	0.01	0.02	0.01
CD at 5%	0.08	0.02	--	0.033	0.04	0.04	--	0.02

Effect of nitrogen and sulphur on uptake of mustard

Data presented in Table 3 indicated that the maximum uptake of N (75.06 kg ha^{-1} in seed and 40.09 kg ha^{-1} in stover), P (12.48 and 19.54 kg ha^{-1}), K (14.66 and 32.76 kg ha^{-1}), and S (11.15 and 13.07 kg ha^{-1}) was recorded under the N_3 treatment (80 kg N ha^{-1}), followed closely by 65 kg N ha^{-1}. These results emphasize the positive effect of nitrogen fertilization on nutrient uptake in mustard. Keerthi *et al*. (2017) [4] also reported that nitrogen application significantly enhanced seed and biological yields up to 100 kg N ha^{-1}, with the highest total N uptake (82.4 and 79.3 kg ha^{-1}) recorded at 100 kg N ha^{-1}, while uptake declined with reduced N levels.

Sulphur fertilization also had a significant influence on nutrient uptake. The highest values of N (73.61 and 37.66 kg ha^{-1}), P (12.09 and 18.44 kg ha^{-1}), K (14.05 and 30.58 kg ha^{-1}), and S (10.74 and 12.22 kg ha^{-1}) were observed in the S_3 treatment (45 kg S ha^{-1}), followed by 30 kg S ha^{-1}. These findings are in agreement with Panchal *et al.* (2011) [6], who demonstrated that seed, protein, and oil yields of mustard increased significantly with nitrogen and sulphur application, both individually and in combination, across two years of experimentation. They further noted that nutrient uptake, particularly N and S, showed significant improvement up to 100 kg N and 40 kg S ha^{-1} compared to the control.

Table 3: Effects of nitrogen and sulphur levels on uptake (kg ha^{-1}) of mustard.

Treatments	Seed uptake (kg ha^{-1})				Stover uptake (kg ha^{-1})			
	N	P	K	S	N	P	K	S
Levels of Nitrogen								
N_1 (50 kg Nitrogen ha^{-1})	65.99	10.98	12.22	9.07	32.02	15.61	26.34	10.12
N_2 (65 kg Nitrogen ha^{-1})	74.82	11.59	13.38	10.64	36.84	17.29	30.07	11.84
N_3 (80 kg Nitrogen ha^{-1})	75.06	12.48	14.66	11.15	40.09	19.54	32.76	13.07
SE (m) ±	0.72	0.18	0.18	0.13	0.48	0.36	0.55	0.16
CD at 5%	2.15	0.55	0.53	0.38	1.43	1.09	1.66	0.48
Levels of Sulphur								
S_1 (15 kg Sulphur ha^{-1})	69.30	11.28	12.85	9.83	35.14	16.56	28.08	10.93
S_2 (30 kg Sulphur ha^{-1})	72.97	11.68	13.36	10.29	36.15	17.44	30.51	11.87
S_3 (45 kg Sulphur ha^{-1})	73.61	12.09	14.05	10.74	37.66	18.44	30.58	12.22
SE (m) ±	0.72	0.18	0.18	0.13	0.48	0.36	0.55	0.16
CD at 5%	2.15	0.55	--	0.38	1.43	1.09	--	0.48
Interaction (Nitrogen X Sulphur)								
SE (m) ±	1.24	0.32	0.31	0.22	0.83	0.63	0.96	0.28
CD at 5%	3.72	0.95	--	0.65	2.48	1.88	--	0.83

Conclusion

It is concluded that application of 80 kg ha^{-1} N and 45 kg ha^{-1} S is best treatment followed by 65 kg ha^{-1} N and 30 kg ha^{-1} S treatment combination for getting sustainable yield, content and uptake of mustard.

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