

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

ABSTRACT

The investigation was undertaken in view to assess the effect of interaction between nitrogen and sulphur on growth and yield of mustard (*Brassica juncea* L.) was carried out at the Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology Narendra Nagar, Kumarganj, Ayodhya (U.P.), India, during Rabi (winter) season of 2021-22. The experiments were conducted in Factorial randomized block design which comprised of 25 treatment combinations in which five levels of Nitrogen (0, 40, 80, 120, 160 kg N ha⁻¹ designated as N₀, N₁, N₂, N₃, N₄ respectively) and five levels of sulphur (0, 25, 35, 45, 55 kg S ha⁻¹ designated as S₀, S₁, S₂, S₃, S₄ respectively). The experiments were laid out in the two factors RCBD with three replications. The plant height, number of branches plant⁻¹, Dry matter accumulation, seed and stover yield increased with increasing N level of 160 kg N ha⁻¹ which was at par with 120 kg N ha⁻¹ and while significantly superior over rest of the levels of nitrogen. On the other hand, with increasing S levels, plant height increased significantly up to 55 kg S ha⁻¹. However, the number of branches plant⁻¹ and seed yield and shoot yield increased up to the highest dose of S (55 kg S ha⁻¹). Considering the combined effect of N and S, the treatment combination N₄S₄ produced the maximum seed yield (21.32 q ha⁻¹).

Keyword: Sulphur level, seed yield, Nitrogen level

INTRODUCTION

Indian mustard (*Brassica juncea* L.) belongs to family Cruciferae, is at most important winter (*rabi*) oil seed crop. India is one of the largest mustards growing country in the world, occupying the first position in area and third position in production after China and Canada. Rapeseed and mustard is the third important oilseed crop in the world after Soybean (*Glycine max*) and Palm (*Elaeis guineensis*). Among the seven edible oil seeds cultivated in India, rapeseed mustard (*Brassica spp.*) contributes 28.6 % in the total production of oil seed crops. Mustard is an important *rabi* crop of Rajasthan, Gujarat, M.P., Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Assam. In India, cultivation of mustard is done over an area of about 6.85 million hectares with production and productivity of 9.12 million tonnes and 1331 Kg ha⁻¹, respectively (Anonymus). In India, Rajasthan ranks first both in area and production and Gujarat state has the highest productivity of mustard. In U.P., Mustard is grown on 0.75 million hectares with production of 0.95 million tonnes and productivity of 1260 Kg ha⁻¹, (Ministry of Agriculture, 2019-20). The oil seed crops have a key role to human and animal nutrition for maintaining normal health. Indian mustard is a fairly high remunerative crop and a major source of high quality edible oil. The oil of rapeseed-mustard serves as a very good cooking medium and dietary fat

Comment [WU1]: The English is not right. There is punctuation problem throughout the manuscript.

Comment [WU2]: No need to state the designation in the abstract.

Comment [WU3]: Mention the values.

Comment [WU4]: More key words.

Comment [WU5]: The flow of the idea is not proper (from general to specific). The English should be improved. The introduction should be segmented into different paragraphs; it is a long, single paragraph in its current state.

of majority of population in Northern, North-Western, Central, Eastern and North-Eastern states. It's also most common medium of pickling and food preserving.

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Beside oil, the leaves of young plants are used as green fodder. These seeds are highly nutritive value containing 38-57 % erucic acid, 5-13 % linoleic acid and 27 % oleic acid. The per capita per day oil availability is 19 g as against recommended oil 33 g per day per capita by medical scientists. The fertilizers have played a prominent role in increasing the oil seed production. The oil content in mustard seeds varies from 37-39% (Bhowmik *et al.*, 2014), balanced fertilization is the key to achieve higher production and increasing nutrient use efficiency. In our country, oil seed crops are predominantly grown under rainfed condition in less fertile marginal lands with low input supply. The importance of nitrogen to achieve the higher production potential in mustard is well recognized. Nitrogen is an important metabolic element for growth and development of plant. It is considered essential for metabolic activities and transformation of energy and essential for metabolism of protein and other biochemical product such as nucleic acid, chlorophyll and protoplasm. Nitrogen provides deep green colour to leaves due to better chlorophyll synthesis which increases the effective area of photosynthesis and resulting in higher dry matter, (Singh and Kumar 2014). It is thus, the basic constituent of plant life. It tends to encourage vegetative growth and governs a considerable degree to the utilization of other nutrients. Significant response of seed crop to the tune of 30-40% was recorded due to the use of secondary and micronutrients and with significant residual effect in cropping system. Sulphur has been recognized as an essential element for plant and animal growth. Sulphur plays a vital role in the increasing yield and quality of Indian mustard. Application of Sulphur in combination with balanced amount of other nutrients on soil properties and is used as soil amendment to improve availability of other nutrient in soil (Verma *et al.*, 2018). It also plays an important role in protein synthesis. It is known to be indispensable for many reactions in all living cells. It is the constituent of the amino acids like methionine, cysteine and cystine. Sulphur level significantly influenced the seed and stover yield of mustard (Sharma *et al.* 2008). Deficiencies of any one or all of these essential amino acids cause serious human malnutrition. There is widespread deficiency of sulphur in the country (Hegde and Babu, 2009). The present production is not adequate to meet the edible oil requirement of our fast growing population. A wide gap exists between the demand and supply resulting into a large scale import of fat and oils at the expense of valuable foreign exchange. Rapeseed – mustard is one of the most important Rabi oil seed crops of Northern India grown mainly for edible oil and cakes for animals. In order to meet the edible oil requirement of our fast growing

Comment [WU7]: English?

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population the efforts are to be made to increase the production and productivity of oil seed crops.

Aim of the research

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Material and Methods

The experiment ~~was~~ ~~were~~ conducted at the research farm ~~was~~ ~~conducted~~ at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), India, during the Rabi season of 2021-22. The farm is located at 42 km away from Ayodhya city road at 26.47° N latitude, 82.12° E longitude and an altitude of about 113 metres above the mean sea level. Narendra-8501 (*Brassica juncea* L.) was used as a test crop which is a high yielding and short duration mustard variety. The experiment ~~was~~ ~~were~~ laid out in a Factorial Randomized Block design (FRBD) with three replications of each fertilizer treatments consisted of 5 levels of N (0, 40, 80, 120, 160 kg N ha⁻¹ designated as N₀, N₁, N₂, N₃, N₄ respectively); five levels of sulphur (0, 25, 35, 45, 55 kg S ha⁻¹ designated as S₀, S₁, S₂, S₃, S₄ respectively). There were 25 treatment combinations. Each block consisted of 25 plots and individual plot was 5m × 4m = 20m² in size. The row-to-row and seed to seed distance were 45cm and 15cm, respectively. Land preparation was started after harvesting of *kharif* crop. One ploughing was done by disc plough followed by two ploughing by tractor drawn cultivator and planking was done invariably after each ploughing to get the fine seed bed. Layout was carefully done as per technical programme of the experiments.

Comment [WU11]: The English in the materials and methods section is very poor. It is also written as a single paragraph similar to the introduction; it should be segmented into different paragraphs. The experimental design (the factors, N & S, and the responses) should be clearly presented (in tabular form).

Comment [WU12]: Repetition - copied from the abstract. The English is also poor.

The crop was fertilized with a uniform dose of phosphorus and potassium at the rate of 60 kg and 40 kg ha⁻¹, respectively. However, nitrogen was applied as per treatments. Urea, DAP and Muriate of potash were used as the source of nitrogen, phosphorus and potassium. The full dose of phosphorus and potassium and half dose of nitrogen ~~was~~ ~~were~~ applied as basal dose and remaining half dose of nitrogen was given in two equal splits as top dressing each after first and second irrigations. Full dose of sulphur through elemental sulphur as per the treatments (0, 25, 35, 45 and 55 kg/ha) was given at seven days before sowing of sowing. Mustard seeds were sown in lines at the distance of 45 cm with the help of seed drill. The seed rate was used 5 kg ha⁻¹. Mustard tagging can be done with the help of tags. Thinning was done in two phases.

Comment [WU13]: Why these values?

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In the first phase dense emerging seedlings were uprooted after 10 days of sowing. Second phase of thinning was completed 25 DAS by maintaining plant to plant and row to row distance as 45 cm and 15 cm,

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respectively. One hand weeding was done by khurpi at 45 days after sowing to keep the field weed free. Two irrigations were given to the mustard crop. First irrigation was done at rosette stage (25 DAS) and second irrigation was done at siliqua formation stage (55 DAS) of the crop. Tube well was the source of irrigation. The crop was infested with aphids (*Lipaphis ysimi*) at the time of siliqua filling. The insects were controlled successfully by spraying rogar at the rate of 250 ml per hectare was sprayed at pod formation stage. The crop was kept under constant observations from sowing to harvesting. Five plants (5) from each plot were selected at random and were tagged for data collection. Some data were collected from sowing to harvesting with 30 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The crop was harvested plot wise 90% siliqua were matured, was done on 20 February 2022. These seed yield and stover yield plot^{-1} were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters: 1) Plant height (cm), 2) Number of branches plant^{-1} , 3) Dry matter accumulation (g ha^{-1}), 4) Leaf area index, 5) biological yield, seed yield (q ha^{-1}), 6) Stover yield (q ha^{-1}), and 7) harvest index (%). The textural class was determined by Triangular method (Bouyoucos, 1936). Soil pH (1:1.25 soil:water) was estimated by (Glass electrode pH meter Jackson, 1973). Soil organic carbon was calculated (Walkley & black's rapid titration method 1934). EC dSm^{-1} at 25 °C (Conductivity Bridge Jackson, 1973). Available N (kg ha^{-1}) was estimated by Alkaline potassium permanganate method (Subbiah and Asija, 1956). Available P_2O_5 (kg ha^{-1}) was calculated by Olsen's method (Olsen's *et al.* 1954) Available K_2O (Kg ha^{-1}) was recorded by Flame photometer (Jackson, 1973). The collected data are statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Duncan's Multiple Range Test (DMRT) with Least significant difference value was determined with appropriate level of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

Results and Discussion

The data pertaining to plant height recorded at different growth stages had non-significant effect on plant height at 30 (DAS) of crop growth. Maximum plant height was recorded at higher 160 kg N ha^{-1} , which was *at par* with 120 kg N ha^{-1} , 80 kg N ha^{-1} , while significantly superior over rest of the N levels. The plant height increased significantly with levels of nitrogen. The results are in close conformity with those of Chandra and Damor (1982), Singh (1984), Ali

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and Rahman (1986), Khan *et al.* (1993). Different Sulphur levels had significant effects on plant height at all stages except, 30 DAS. Plant height increases significantly with increases in sulphur doses up to 55 kg S ha⁻¹. Higher plant height was recorded under 55 kg S ha⁻¹, which was at par with 45 kg S ha⁻¹ and 35 kg S ha⁻¹, while significantly superior over rest of the treatments at all stages of crop growth. The results of present investigation are also in agreement with the finding of Khan *et al.* (1993) and Singh and Saran (1993). Number of branches plant⁻¹ of mustard is significantly affected by nitrogen and sulphur levels. Number of branches plant⁻¹ increased with increasing level of nitrogen, recorded the higher number of branches plant⁻¹ was recorded with 160 kg N ha⁻¹ which was at par with 120 kg N ha⁻¹ and 80 kg N ha⁻¹ while significantly superior over rest of the N levels. The progressive increase in growth of plants with successive increments in the levels of nitrogen are in agreement with Kachroo and Kumar (1999) and Chubey *et al.* (2001). Higher number of branches plant⁻¹ was recorded with 55 kg S ha⁻¹, which was at par with 45 kg S ha⁻¹ and 35 kg S ha⁻¹ while significantly superior over rest of the treatments. Higher number of branches plant⁻¹ was recorded with 55 kg S ha⁻¹, which was at par with 45 kg S ha⁻¹ and 35 kg S ha⁻¹ while significantly superior over rest of the treatments.

Table-1
Effect of different nitrogen and sulphur levels on growth parameters of mustard at harvest stage.

Treatments		Plant height (cm)	Number of branches plant ⁻¹	Dry matter accumulation (g plant ⁻¹)	Leaf area index
A. Nitrogen levels					
N	0 kg N ha ⁻¹	145.73	18.15	30.97	1.64
N1	40 kg N ha ⁻¹	152.00	19.15	37.16	1.66
N2	80 kg N ha ⁻¹	158.27	20.34	40.26	1.68
N3	120 kg N ha ⁻¹	162.97	20.94	42.19	1.69
N4	160 kg N ha ⁻¹	164.54	21.14	42.97	???
<i>SEm</i> ±		2.62	0.355	0.621	0.034
<i>CD (P= 0.05)</i>		7.46	1.011	1.763	0.097
B. Sulphur levels					
S0	0 kg S ha ⁻¹	140.81	18.78	34.76	1.65
S1	25 kg S ha ⁻¹	148.55	19.59	38.32	1.66
S2	35 kg S ha ⁻¹	157.84	20.40	39.90	1.67
S3	45 kg S ha ⁻¹	162.48	21.00	41.87	1.70
S4	55 kg S ha ⁻¹	164.03	21.21	42.66	1.71
<i>SEm</i> ±		2.62	0.355	0.621	0.028
<i>CD (P= 0.05)</i>		7.46	1.011	1.763	0.08

Comment [WU19]: The same way discussing results creates redundancy in the statements and does not create appetite for readers. What are the scientific reasons for the increments in plant heights and branches/plant?

Comment [WU20]: What does an increase in dry matter accumulation imply in terms of improvement the productivity?

Comment [WU21]: How does this parameter related with the productivity of the plant?

Comment [WU22]: Why there is no data?

Comment [WU23]: What is meant by this?

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Table 2. Effect of different nitrogen and sulphur levels on yield of mustard crop.

Symbol	Treatments	Yield			
		Biological yield (qha ⁻¹)	Seedy yield (qha ⁻¹)	Stover yield (qha ⁻¹)	Harvest index (%)
A. Nitrogen level					
N0	0 kg N ha ⁻¹	69.61	15.37	54.24	22.07
N1	40 kg N ha ⁻¹	82.34	18.44	63.90	22.39
N2	80 kg N ha ⁻¹	88.28	19.98	68.31	22.62
N3	120 kg N ha ⁻¹	91.68	20.94	70.74	22.83
N4	160 kg N ha ⁻¹	92.53	21.32	71.21	23.04
SEm±		1.593	0.326	1.219	0.412
CDat5%		4.530	0.927	3.466	1.173
B. Sulphur level					
S0	0 kg S ha ⁻¹	76.90	17.25	59.65	22.40
S1	25 kg S ha ⁻¹	83.81	19.01	64.80	22.65
S2	35 kg S ha ⁻¹	87.26	19.80	67.47	22.65
S3	45 kg S ha ⁻¹	91.58	20.78	70.81	22.65
S4	55 kg S ha ⁻¹	92.45	21.17	71.28	22.86
SEm±		1.593	0.326	1.219	0.412
CDat5%		4.530	0.927	3.466	1.173

Data pertaining to dry matter accumulation as influenced by different levels of nitrogen and sulphur. Dry matter accumulation increased with increase in nitrogen levels up to 160 kg N ha⁻¹, which was *at par* with 120 kg N ha⁻¹ and 80 kg N ha⁻¹, while it is significant over rest of the treatments. Similar results have also been reported by Patel and Shelke (1998), Bhari *et al.* (2000). Higher dry matter accumulation recorded under 55 kg S ha⁻¹ which was *at par* with 45 kg S ha⁻¹ and 35 kg S ha⁻¹, while significantly superior over rest of the treatments. Increasing the dry matter accumulation in plants with increasing the level of sulphur. Singh and Dhiman (2005) also reported similar results. Leaf area index of mustard is significantly influenced by the nitrogen and sulphur levels. The data pertaining to leaf area index recorded at different crop growth stages as influenced by treatment. Higher leaf area index was recorded with 160 kg N ha⁻¹, which was *at par* with 120 kg N ha⁻¹ and 80 kg N ha⁻¹ while significantly superior over rest of the nitrogen levels. This significant increase in growth characters with nitrogen fertilization has also been reported by Kumar and Gangwar (1985), Singh *et al.* (1998) and Bhari *et al.* (2000). Different sulphur level brought significant influence on LAI at all the stages, higher leaf area index (LAI) was recorded at 55 kg S ha⁻¹.

Comment [WU27]: Incomplete statement.

Comment [WU28]: This style of interpreting the results has been repeated many times and it is boring to do so!

¹which was significantly superior over 25 kg S ha⁻¹ and 0 kg S ha⁻¹ while at par with 45 kg S ha⁻¹ and 35 kg S ha⁻¹.

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Application of nitrogen at different level showed the significant variation for seed yield per hectare under the present trial. With increasing nitrogen levels, Significantly higher seed yield was obtained with 160 kg N ha⁻¹ (N₄) which is 21.32 q ha⁻¹ at par with 120 kg N ha⁻¹ (N₃), which is 20.94 q ha⁻¹, while significantly superior over rest of the levels of nitrogen, and the lowest was recorded at (N₀) which is control. These results are in conformity with that of Tomar et al. (1997), Bhari et al. (2000), Bhlaerao et al. (2002). Statistically, yield of mustard The data pertaining to stover yield presented in Table 1 and indicated that the different dose of nitrogen and sulphur levels influenced the stover yield (q ha⁻¹).

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¹). The highest stover yield was obtained with the application of 160 kg N ha⁻¹, and which was at par with the application of 120 kg N ha⁻¹ while significantly superior over the rest level of nitrogen. The data pertaining to biological yield in Table 2 indicated that the different dose of nitrogen and sulphur levels influenced the biological yield (kg ha⁻¹). Significantly higher biological yield was obtained with the application of 160 kg N ha⁻¹, and which was at par with the application of 120 kg N ha⁻¹ while significantly superior over the rest level of nitrogen. Harvest index of crop did not vary significantly level by different levels of nitrogen doses and sulphur levels. This might be due to the fact that nitrogen application increased all the growth contributing characters viz. plant height, branches plant⁻¹, leaf area and dry matter accumulation which enhanced the stover production. The beneficial effect of nitrogen fertilization on stover yield of mustard has also been reported by Tomer et al. (1997), Singh and Singh (1998), Singh et al. (1998) Bhari et al. (2000) and Bhalerao (2001). The higher seed yield was obtained with higher dose of sulphur by 55 kg S ha⁻¹, which was at par with 45 kg S ha⁻¹ and while significantly superior over rest doses of sulphur. The higher stover yield was obtained with the application of 55 kg S ha⁻¹ which was at par with 45 kg S ha⁻¹ while significantly superior over rest of the S levels. The higher biological yield was obtained with the application of 55 kg S ha⁻¹ which was at par with the application of 45 kg S ha⁻¹ while significantly superior over rest of the treatments. Harvest index of crop did not vary at significant level at a different level of sulphur doses. The increase in seed yield under adequate sulphur supply might be ascribed mainly due to the combined effect of higher number of siliqua plant⁻¹, more number of seed siliqua⁻¹ and higher 1000-seed weight, which was the result of better translocation of photosynthates from source to sink. Sulphur also stimulates the pod setting, seed formation and oilsynthesis.

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¹while significantly superior over rest of the treatments. Harvest index of crop did not vary at significant level at a different level of sulphur doses. The increase in seed yield under adequate sulphur supply might be ascribed mainly due to the combined effect of higher number of siliqua plant⁻¹, more number of seed siliqua⁻¹ and higher 1000-seed weight, which was the result of better translocation of photosynthates from source to sink. Sulphur also stimulates the pod setting, seed formation and oilsynthesis.

thesis in these seeds of mustard and it increases the biological, seed and stover yields of mustard.

Rana et al. (2005) and Dongarkar et al. (2005) also reported the similar results.

Conclusion

Thus, the application of 160 kg N ha⁻¹ and 55 kg S ha⁻¹ seems to be the best option for maximum plant

growth and high yield under eastern UP. The study is to be continued for a few more years to draw a definite conclusion for application of liquid biofertilizers and variable source of nutrients in mustard.

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Comment [WU38]: Very shallow and not a conclusion in fact!

Comment [WU39]: Very limited number of references have been used.

ongrowth,yield,nutrienuptakeandconomicsofIndianmustard(*B.juncea*)underrainfed condition. *Indian J. Agron.***50** (4): 314-316.

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