International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 787-791

Received: 15-11-2018
Accepted: 20-12-2018

Ashutosh Chaurasiya
Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

Sudhakar Singh
Department of Agronomy, Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh, India

Vipul Singh
Department of Agronomy, Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh, India

Nandan Singh
Department of Soil Science, Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh, India

Ankit Singh
Department of Agronomy, Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh, India

Correspondence
Vipul Singh
Department of Agronomy, Narendra Deva University of Agriculture and Technology, Ayodhya, Uttar Pradesh, India

Effect of nitrogen and sulphur nutrition on interaction effect, quality parameters, nutrient content or uptake & economics of Indian mustard (*Brassica juncea* L.) in western UP

Ashutosh Chaurasiya, Sudhakar Singh, Vipul Singh, Nandan Singh and Ankit Singh

Abstract
A field experiment was conducted to study the effect of nitrogen and sulphur nutrition on growth and yield of Indian mustard (*Brassica juncea* L.) in western UP during *Rabi* season of 2016 at Crop Research Centre (Chirori) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). The soil of the experimental field was well drained, sandy loam in texture and slightly alkaline in nature. It was low in organic carbon and nitrogen but medium in available phosphorus and potassium with an electrical conductivity (1:2, soil: water) of 1.65 dS/m. The experiment consisted of twelve treatment combinations with nitrogen and sulphur. The treatment consisted of four nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) and three sulphur levels (0, 20 and 40 kg ha^{-1}) were tested in Factorial Randomized Block Design (RBD) with three replications. The mustard variety Pusa Bold was grown and growth and yield, nutrient uptake, soil properties as influenced by different treatments were assessed.
Role of interaction effects enhances the growth & yield attributes, quality parameters, nutrient content & uptake and available nutrient balances in the soil with increasing trends of nitrogen from 0 to 120 kg N ha^{-1} and 0 to 40 kg S ha^{-1} caused significant results and found maximum at 120 kg N ha^{-1} and 40 kg S ha^{-1}. The nutrient content and uptake was also noticed higher with the application of 120 kg N ha^{-1}. Similarly, application of 40 kg S ha^{-1}gave protein content and nutrient (N, P, K and S) uptake by mustard crop. Available nutrients (N, P_2O_5, K_2O and S) status in soil after harvest of crop was increased with increase in the nitrogen levels upto 120 kg N ha^{-1} and sulphur levels upto 40 kg ha^{-1}. The highest net returns of 48,006 and B: C ratio of 2.25 was obtained with the application 120 kg N ha^{-1} than rest of nitrogen levels. With respect to sulphur levels, the highest net returns of 36,454 and B: C ratio of 1.65 was obtained with 40 kg S ha^{-1}. Thus it may be concluded that application of nitrogen at 120 kg N ha^{-1} and sulphur at 40 kg S ha^{-1} found economical in obtaining higher yields with higher net return and B: C ratio.

Keywords: nitrogen, sulphur nutrition, quality parameters, economics, uptake

Introduction
Oilseeds crops are the second most important determinant of agricultural economy, next only to cereals. India has the 5th largest vegetable oil economy in the world next to USA, China, Brazil and Argentina accounting for 7.4% world oilseed output; 6.1 % of oil meal production; 3.9% world oil meal export; 5.8% vegetable oil production; 11.2% of world oil import and 9.3% of the world edible oil consumption. In India, oilseeds contribute 3% and 10% to gross national products and value of all agricultural products, respectively, with 14 and 15 million people involved in oilseed cultivation and processing, respectively. India is one of the biggest importers of vegetable oils.
Indian mustard (*Brassica juncea* L.) belonging to the family cruciferae is one of the important oilseed crops and currently ranked as the world's third important oil seed crop in terms of production and area. Oil content in rapeseed & mustard varies from 33% to 46% and average oil recovery is around 32% to 38%. The global production of rapeseed-mustard was 71.09 mt from area of 36.15 m ha with productivity of 19.70 q ha^{-1}. In India, the annual production of rapeseed-mustard was about 58.03 lakh tonnes covering an area of about 61.90 lakh hectares with a total productivity of 0.94 tonnes ha^{-1}. Indian mustard (*Brassica juncea* L.) is predominantly cultivated in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat. During 2014-15 the area and production of mustard in

Uttar Pradesh was 8.00 lakh hectares and 6.40 lakh tones, respectively and average yield was 0.80 tones ha^{-1}. It is estimated that 58 mt of oilseeds will be required by the year 2020, wherein the share of mustard will be around 24.2 mt.

Mustard crop responded favorably to nitrogen fertilization increases yield by influencing different growth parameters and by producing more vigorous growth and development as reflected via increasing plant height, number of flowering branches, total plant weight, leaf area index and number and weight of siliquae and seeds per plant.

Nitrogen is a major nutrient element that provides lush green color in crop (due to increase in chlorophyll) and its deficiency in arid and semi-arid regions is considerable because the amount of organic matters, which are the main nitrogen reserves, is very low in these regions and even if they were found, they would be quickly decomposed. Nitrogen increases the vegetative growth and delayed maturity of plants. Excessive use of this element may produce too much of vegetative growth, thus fruit production may be impaired. Moreover, nitrogen and sulphur are closely related with one another because both of these elements are required for protein synthesis and their amount in plant tissue always maintained at constant ratio.

Under present soil fertility status in India, sulphur is now recognized as the fourth nutrient element after nitrogen, phosphorus and potassium which are limiting the crop yield. Mustard a cruciferous crop, responds remarkably to sulphur application. Adequate supply of sulphur to rapeseed-mustard promotes the synthesis of sulphur containing essential amino acids, proteins and oil.

Application of fertilizers containing these two nutrient elements have been recognized to be the most important constraints and often inadequate application of nitrogen and sulphur at farmer's field reduce the yield levels of mustard. Under sulphur deficient soils, the full yield potential of mustard cannot be realized regardless of other nutrients applied or adoption of improved crop management practices. Thus, the application of nitrogen at 120 kg N ha^{-1} and sulphur at 40 kg S ha^{-1} found economical in obtaining higher yields with higher net return and B: C ratio.

Methodology

The experiment was conducted at the Crop Research Centre, Chirodi of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) which is located at latitude of 29^0 40′ N and longitude of 77^0 42′ E and at an altitude of 237 meter above mean sea level (MSL). Meerut lies in the heart of Western Uttar Pradesh and has semi-arid to sub-tropical climate. The treatments comprising of four graded levels of nitrogen and three graded levels of sulphur were laid out in factorial randomized block design with three replications. The treatment consisted of four nitrogen levels were 0, 40, 80 and 120 kg ha^{-1} and three sulphur levels 0, 20 and 40 kg ha^{-1} thus there were treatment combinations. The soil was sandy loam in texture low in organic carbon, available nitrogen and low in available potassium and medium in available phosphorus with an pH of 7.9 and electrical conductivity (1:2, soil: water) of 1.65 dS/m. The mustard variety Pusa Bold was grown and interaction effects, quality parameters, nutrient content & uptake, available nutrient balances in the soil and economics as influenced by different treatments were assessed.

Results and Discussion

Interaction effects

Nitrogen and sulphur levels did not show any significant interaction effect on plant height, leaf area index, and dry matter production $plant^{-1}$at all the crop growth stages while interaction effect between nitrogen and sulphur on number of primary and total branches $plant^{-1}$ at harvest was found significant. The treatment combination of 120 kg N ha^{-1} + 40 kg S ha^{-1} produced significantly higher branches than rest of the treatment combinations.

Interaction effect between nitrogen and sulphur on siliqua $plant^{-1}$ and number of seeds $siliqua^{-1}$ was found significant the highest number of siliqua $plant^{-1}$ (285.90) was observed with the application of 120 kg N ha^{-1} + 40 kg S ha^{-1}. Increasing levels of nitrogen from 0 to 120 kg N ha^{-1} caused significant increase in yield and harvest index of crop. The significantly higher biological (6084 kg ha^{-1}), seed (1564 kg ha^{-1}), stover yield (4519 kg ha^{-1}) and harvest index (25.70) was registered with 120 kg N ha^{-1} compared to 80, 40kg N $ha^{-1}$and control. Sulphur application also increased the yield and harvest index of mustard crop. Application of 40 kg S ha^{-1} recorded significantly higher biological (5278 kg ha^{-1}), seed (1308 kg ha^{-1}), stover yield (3969 kg ha^{-1}) and harvest index (24.60) than rest of sulphur levels.

Interaction effect of nitrogen and sulphur levels on biological, seed and stover yield found significant the treatment combination 120 kg N ha^{-1} + 40 kg S ha^{-1} resulted in highest biological yield (6318 kg ha^{-1}), seed yield (1665 kg ha^{-1}) and stover yield (4652 kg ha^{-1}) than remaining treatment combinations.

Interaction effect between nitrogen and sulphur on oil and protein yield was found significant and highest oil yield (652.10 kg ha^{-1}) and protein yield (364.59 kg ha^{-1}) was obtained with combined application of 120 kg N ha^{-1} + 40 kg S ha^{-1}.

Interaction effect between nitrogen and sulphur application was found significant in respect of nitrogen content &uptake in seed and sulphur uptake by seed & total uptake. The highest nitrogen content (3.37) and uptake (52.82) in seed, sulphur uptake by seed (16.28 kg ha^{-1}) and total sulphur uptake (41.02 kg ha^{-1}) were noticed with combined application of 120 kg N ha^{-1} + 40 kg S ha^{-1} than rest of the treatment combinations.

The interaction effect in respect of primary branches, total branches, number siliquae $plant^{-1}$, length of siliquae, seed, stover and biological yields and harvest index were found significant. It therefore, appeared relevant to explain combined effects of nitrogen and sulphur fertilization of mustard.

The interaction between different levels of nitrogen and sulphur fertilization on seed yield of mustard was found significant and maximum yield was obtained with the combined application of nitrogen and sulphur at the rate of 120 kg N ha^{-1} and 40 kg S ha^{-1}. This indicates the synergistic effect of nitrogen and sulphur application in improving the productivity of mustard. Similarly, number of branches, number of siliquae, seeds $siliquae^{-1}$, stover, and biological yield was found significantly higher with the application of 120 kg N ha^{-1} and 40 Sha^{-1}. The application of nitrogen and sulphur improves the growth and development of crop resulted in higher values of yield attributes with the application of 120 kg N + 40 kg S ha^{-1} which provides higher yield of mustard crop. Similar findings were also reported by Dongarkar *et al*., (2005) [1] and Verma *et al*., (2012) [16].

Quality parameters

Application of nitrogen and sulphur caused significant increase in oil content and protein content in seeds. Increasing levels of nitrogen from 0 to 40 kg N ha^{-1} caused increase in oil content while further increase in nitrogen levels caused decrease in oil content. The protein content increased with increased in nitrogen levels up to 120 kg N ha^{-1}. Application of 120 kg N ha^{-1} gave significantly more oil and protein yield. Similarly, application of 40 kg S ha^{-1} gave significantly higher values of oil, protein content and oil & protein yield.

Oil content in seed increases significantly upto 40 kg N ha^{-1} and decreased thereafter at higher nitrogen rates however, the difference in oil content due to 40 kg N ha^{-1} and higher nitrogen levels was statistically non-significant (Table-4.8). As per pathway of degradation, carbohydrates are degraded to acetyl Co-A. In case of insufficient supply of nitrogen acetyl Co-A is used for the synthesis of fatty acids by using acetyl carrying proteins (ACP) resulting in higher oil content in seeds. Although nitrogen application resulted in reduce oil percent in seeds. These results confirm with findings of Singh and Meena (2003).

Increasing levels of nitrogen from 0 to 120 kg N ha^{-1} caused significant increase in oil yield of mustard. The oil yield is the function of oil content in seed and seed yield. The oil content in seeds increased with the application of nitrogen up to 40 kg N ha^{-1} and decreased thereafter while seed yield was found maximum at 120 kg N ha^{-1}, the decrease in oil content at higher nitrogen rates was compensated by seed yield and resulted in more oil yield at 120 kg ha^{-1}. Similar findings were also reported by Patil and Bhargav (1987) [8] and Singh *et al.*, (1992) [13]

The protein content was increased significantly with increasing levels of nitrogen and found maximum at 120 kg ha^{-1} (Table-4.9). This may be due the fact that more availability of nitrogen at 120 kg ha^{-1} increased the nitrogen content in seeds with the application of higher levels of nitrogen. Nitrogen is a basic constituent of protein and with the increase in the rates of nitrogen application; the availability increased which resulted in increased protein content in seeds. These findings are conformed with findings of Trivedi (1997) [15] and Kumar *et al*., (2011) [4, 5].

Protein yield was found maximum at 120 kg N ha^{-1} (Table-4.9). The protein yield is the function of protein content in seeds and seed yield which also observed significantly higher with the application of 120 kg N ha^{-1} and thus resulted more protein yield. Similar result findings were also reported by Singh and Meena (2003).

Oil content of mustard seed and oil yield increased significantly due to sulphur application and found maximum at 40 kg S ha^{-1} (Table-4.8). Sulphur plays an important role in the formation of more glycosides and glucocinolate and activation of enzymes, which as in biochemical reaction with the plant and on hydrolysis produce higher amount of oil as well as alkyl isothiocyanate, which is responsible for pungency.Oil yield is additive effect of oil content and seed yield which was noticed maximum at 40 kg S ha^{-1} resulted in higher oil yield. The results are in close conformity with the findings of Giri *et al*., (2003) [2] and Sah *et al*., (2013) [11].

The protein content and protein yield in seed was found maximum at 40 kg S ha^{-1} (Table-4.9). The protein content was depend on nitrogen content in seed which was noticed higher at 40 kg S ha^{-1} and resulted in more protein content in seeds. The protein yield is the additive effect of protein content and seed yield which noted higher at 40 kg S ha^{-1} and inturn resulted in more protein yield. Similar findings were also reported by Mehdi *et al*., (2006) [6] and Kumar *et al*., (2011) [4, 5].

Nutrient content and uptake

Application of nitrogen and sulphur caused significant increase in nutrient content and uptake by mustard crop. Significantly higher nitrogen, phosphorus, potassium and sulphur content and uptake was observed with 120 kg N ha^{-1}compared to 80, 40and 0 kg N ha^{-1}. Application of 40 kg S ha^{-1} significantly higher nitrogen, phosphorus, potassium and sulphur content and uptake at harvest were recorded with over other sulphur levels.

Application of sulphur from 0 to 40 kg S ha^{-1} caused increase in nutrient content (N, P, K and S) and uptake by seed and stover and higher values noticed at 40 kg S ha^{-1}. This might be due to the application of sulphur improve the root development. Which absorb more nutrients from the soil and resulted in higher nutrient content. The nutrient uptake is the additive effect of nutrient content and yield which was higher at 40 kg S ha^{-1}resulted in more nutrient uptake. These results are confirmed with the findings of Kumar and Trivedi (2012) and Singh *et al*., (2015) [4].

Nutrient balance in soil

The soil available nutrients *viz*., nitrogen and sulphur increased significantly with application of 120kg N ha^{-1}compared to80, 40 and 0 kg N ha^{-1}. Soil available P2O5 andK2O did not show significant effect with application of nitrogen and sulphur levels. After harvest of crop, available nitrogen & sulphur in soil increased with increase in the sulphur levels from 0 to 40 kg S ha^{-1} and found highest with 40 kg S ha^{-1} over 20 kg Sha^{-1} and control. The soil availability of P2O5 and K2O was found non-significant with the application of nitrogen and sulphur levels.

Economics

Gross returns, net return and benefit cost (B: C) ratio were increased with various nitrogen and sulphur levels. Among nitrogen levels, the highest net returns of 48,006and B: C ratio of 2.25 was obtained with 120 kg N ha^{-1}and was significantly superior to80, 40 and 0 kg N ha^{-1}.With respect to sulphur levels, the highest net returns of 36,454 and B: C ratio of1.67 was obtained with 40 kg S ha^{-1}and significantly superior to 20 and 0 kg S ha^{-1}.

The total variable cost of cultivation increased slightly with difference sources of fertilizer. The highest cost of cultivation (Rs.21333 Rs.ha^{-1}), gross returns (Rs.69339 ha^{-1}), net returns (Rs.48006 ha^{-1}) and B: C ratio (3.25) was recorded with the application of 120 kg N ha^{-1}. Each increasing level of nitrogen increased the economic yield significantly which ultimately resulted in increased gross and net returns ha^{-1}. Reager *et al*., (2006) and Rathore *et al*. (2014).

The highest cost of cultivation (Rs.21820 Rs.ha^{-1}), highest gross returns (Rs.58274 ha^{-1}) and net returns (Rs.36454 ha^{-1}) were recorded with the application of 40 kg S ha^{-1}. Each increasing level of sulphur increased the economic yield significantly which ultimately resulted in increased gross and net returns ha^{-1}. The highest B: C ratio (2.67) was observed with the application of 40 kg S ha^{-1}. Similar trends were also observed by Kumar and Trivedi and (2012) [3] Pachauri *et al*., (2012) [7].

Table 1: Interaction effect of varying levels of nitrogen & sulphur nutrition on growth & yield attributes at harvest.

Treatments	Sulphur levels (kg ha^{-1})					
	At harvest stage					
Nitrogen levels (kg ha^{-1})	Total branches	Siliqua plant^{-1}	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
0	11.60	222.09	3947	910	3037	23.04
40	16.24	245.35	5135	1243	3892	24.20
80	19.02	281.03	5712	1417	4295	24.80
120	25.10	285.90	6318	1665	4653	26.35
SEm±	0.52	4.06	25	10	20	0.15
CD at 5%	1.53	11.92	73	29	58	0.44

Table 2: Interaction effect of varying levels of nitrogen & sulphur nutrition on protein yield, nutreint content & uptake at harvest

Treatments	Sulphur levels (kg ha^{-1})				
	At harvest stage				
Nitrogen levels (kg ha^{-1})	Protein yield	Nitrogen content in seed	Nitrogen uptake by seed	Sulphur uptake by seed	Total sulphur uptake
0	114.02	2.00	18.24	4.83	13.35
40	213.87	2.75	34.22	9.21	22.45
80	261.44	2.94	41.83	11.50	30.40
120	364.59	3.50	58.33	16.28	41.02
SEm±	5.07	0.04	0.81	0.27	0.73
CD at 5%	14.87	0.11	2.37	1.06	2.14

Table 3: Effect of nutrient management available nutrient in soil and stover in mustard

Treatments	Available nutrient			
	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Sulphur (kg ha^{-1})
Nitrogen level (kg ha^{-1})				
0	165.19	16.98	212.325	7.95
40	183.68	17.42	218.54	8.40
80	196.73	18.52	223.33	8.66
120	217.27	19.36	230.04	9.12
SEm±	4.00	0.37	2.23	0.17
CD at 5%	11.75	1.10	6.54	0.51
Sulphur levels (kg ha^{-1})				
0	181.47	17.70	218.74	7.82
20	190.35	17.98	220.73	8.78
40	200.33	18.53	223.97	8.99
SEm±	3.47	0.32	1.93	0.15
CD at 5%	10.18	0.90	5.66	0.44
Initial value	163.42	14.80	168.20	7.40

Table 4: Economics of various treatment combinations

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit :cost ratio
Nitrogen levels (kg ha^{-1})				
0	19506	38344	18838	1.97
40	20115	51634	31519	2.57
80	207424	59446	38722	2.87
120	21333	69339	48006	3.25
Sulphur levels (kg ha^{-1})				
0	19506	51602	32096	2.65
20	20663	54176	33513	2.62
40	21820	58274	36454	2.67

References

1. Dongarkar KP, Pawar WS, Khawale VS, Khutate N G, Gudadhe NN. Effect of nitrogen and sulphur on growth and yield of mustard (*Brassica juncea* L.). Journal of Soils and Crops. 2005; 15(1):163-167.
2. Giri MD, Abdul Hamid Giri DG, Kumar RP. Effect of irrigation and source of sulphur on quality and uptake of nutrients of mustard. Journal of Soils Crops. 2003; 13(1):131-134
3. Kumar R, Trivedi SK. Effect of levels and sources of sulphur on yield, quality and nutrient uptake by mustard (*Brassica juncea* L.). Progressive Agriculture. 2012; 12(1):69-73.
4. Kumar, Santosh, Verma SK, Singh TK, Singh, Shyambeer. Effect of nitrogen and sulphur on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea* L.) under rained condition. Indian Journal of Agricultural Sciences. 2011; 81(2):45-90.
5. Kumar S, Tiwari SK, Singh SS. Effect of sources and levels of sulphur on growth yield and quality of sunflower. Indian Journal of Agronomy. 2011; 56(3): 242-246.
6. Mehdi SS, Singh OP, Singh P. Influence of sulphur fertilization on various quality characters on Indian mustard (*Brassica juncea* L.) in the north western tract of Uttar Pradesh. Environment and Ecology. 2006; 24(2): 338-340.
7. Pachauri RK, Trivedi SK, Kumar Y. Effect of sulphur levels on growth, yield and quality of Indian mustard

genotypes and their economics. Journal of Soils and Crops. 2012; 22(2):258-263.
8. Patil BN, Bhargava SC. Seed quality studies in rapeseed mustard in relation to nitrogen nutrition. Annals of plant Physiology. 1987; 35(1):81-87
9. Rathore SS, Kapila S, Premi OP, Kandpal BK, Chauhan JS. Comparative effect of irrigation systems and nitrogen fertigation on growth, productivity and water-use efficiency of Indian mustard (*Brassica Juncea* L.) under semi-arid conditions of Rajasthan. Indian Journal of Agronomy. 2014; 59(1):112-118.
10. Reager ML, Sharma SK, Yadav RS. Yield attributes, yield and nutrient uptake of Indian mustard (*Brassica juncea* L.) as influenced by nitrogen levels and its split application in arid western Rajasthan. Indian Journal of Agronomy. 2006; 51(3):213-216.
11. Sah D, Sewak R, Singh AK, Swami S. Growth, yield and profitability of Indian mustard (*Brassica juncea* (L.) Czern &Coss) with different weed control measures and sulphur levels. Agricultural Science Digest. 2013; 33(1):15-20.
12. Singh, Amar, meena NL. Effect of nitrogen and sulphur on growth, yield attributes and seed yield of mustard (*Brassica juncea* L.) in eastern plain zone of Rajasthan. Indian Journal of Agronomy. 2004; 49(3):186-189.
13. Singh, Bikram, Singh BP, Faroda AS. Effect of irrigation and nitrogen levels on yield and its characteristics of *Brassica* species. Indian Journal of Agronomy. 1992; 39(2):266-269.
14. Singh U, Tomar SS, Rameshwar, Choudhary S. Yield, nutrient uptake and economics of Indian mustard as influenced by varieties, sources and levels of sulphur. Annals of Plant and Soil Research. 2015; 17(3):266-268.
15. Trivedi SK, Sharma UK. Response of mustard to nitrogen and sulphur fertilization. Crop Research. 1997; 13(1):87-89.
16. Verma CK, Prasad K, Yadav DD. Studies on response of sulphur, zinc and boron levels on yield, economics and nutrients uptake of mustard (*Brassica juncea* L.). Crop Research. 2012; 44(1, 2):75-78.