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Effects of different levels of Nitrogen and Sulphur on growth and yield attributes of Mustard (*Brassica juncea* L.)

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Abstract

The field experiment was carried out at Agriculture farm of Sri Durga Ji Post Graduate College Chandeshwar, Azamgarh during rabi *seasons of 2015-16 and 2016-17. The experiment was laid out in 4×4 factorial randomized block design with 16 treatments in three replications. The highest yield was obtained from 90 kg N ha^{-1} as compared to the control (N_1). Seed yield and seed oil content of the mustard significantly increased with the sulphur level. Application of 60 kg S ha^{-1} produced the highest yield. Similarly, 60 kg S ha^{-1} produced the highest oil content compared to the control (S_0). The interaction effect of nitrogen and sulphur at the rate of 90 kg N ha^{-1} and 60 kg S ha^{-1} produced significantly highest yield than control. The seed oil content of the mustard was also significantly influenced by the combined application of nitrogen and sulphur. The highest oil content was observed from the plot with 60 kg N ha^{-1} and 60 kg S ha^{-1} which was at par with 90 kg N ha^{-1} and 40 kg S ha^{-1} compared to the control plot which has the minimum oil content in the seed. There was increase in incremental yield and marginal profit with the increasing dose of N as the highest B:C ratio was obtained from 90 kg N ha^{-1} which was significantly greater than 60 kg N ha^{-1} and control.*

Key worlds: Mustard, oil content, sulphur, profit

Introduction

Indian mustard (*Brassica juncea* L.) commonly known as raya, rai or lahi is an important oilseed crop among the Brassica group of oilseed in India. It's the second most important edible oilseed crop in India after groundnut and accounts for nearly 30% of the total oilseeds produced in the country. Rapeseed-mustard is an important group of edible oil seed crops and contributes around 26.1% of the total oil seed production and contributes about 85% of the total rapeseed– mustard produced in India (Meena *et al.,* 2011). The first position in area and second position in Production after China (Anonymous, 2009). Nitrogen is the most important nutrient, which determines the growth of the mustard crop and increases the amount of protein and the yield. Phosphorus and potash are known to be efficiently utilized in the presence of nitrogen. It promotes flowering, setting of siliqua and in increase the size of siliqua and yield. Sulphur is also an important nutrient and plays an important role in physiological functions like synthesis of cystein, methionine, chlorophyll and oil content of oil seed crops. It is also responsible for synthesis of certain vitamins (B, biotin and thiamine), metabolism of carbohydrates, proteins and oil formation of flavored compounds in crucifers. *Brassica* has the highest sulphur requirement owing to the presence of sulphur rich glucosinolates (Bharose *et al.,* 2010). Sulphur deficiencies in India are widespread and scattered. Deficiency of sulphur in Indian soils is on increase due to intensification of agriculture with high yielding varieties and multiple cropping coupled with the use of high analysis sulphur free fertilizers along with the restricted or no use of organic manures have accrued in depletion of the soil sulphur reserve. Crops generally absorb sulphur and phosphorus in similar amounts. On average, the sulphur absorbed per tonne of grain production is 3-4 kilograms in cereals, 8 kilograms in pulses, and 12 kilograms in oilseeds. Soils, which are deficient in sulphur, cannot on their own provide adequate sulphur to meet crop demand resulting in sulphur deficient crops and sub-optimal yields (Chattopaddhyay *et al.,* 2012).

Materials and Methods

A field research was conducted at Crop Research Farm, Department of Agronomy, Shri Durga

Ji Post Graduate College, Chandesar, Azamgarh with two factors, Nitrogen with four levels (0, 30, 60 & 90 kg N ha-1) and Sulphur with four levels (0, 20, 40 & 60 kg S ha-1) were arranged in factorial randomized complete block design. Sixteen treatments combination (N_1S_0, N_1S_1, N_1S_2, N_1S_3, N_2S_0, N_2S_1, N_2S_2, N_2S_3, N_3S_0, N_3S_1, N_3S_2, N_3S_3, N_4S_0, N_4S_1, N_4S_2 and N_4S_3) were replicated thrice. Observations were recorded on plant height (cm), number of branches, leaf area index (LAI), dry matter accumulation per plant, number of siliquae per plant, length of siliquae, number of seeds per siliquae, seed yield per plant (g), 1000-seed weight (g), grain yield (q/ha), stover yield (q/ha) and harvest index (%) along with quality traits such as protein content (%), oil content (%), nitrogen uptake by crop and Sulphur uptake by crop as well as soil properties such as soil pH, nitrogen (%), available phosphorus (ppm), available potassium (meq/100 g soil) and available sulphur (ppm). The data were subjected to statistical analysis to obtain information on the mean performance and to assess the association between yield and its components. Benefit-Cost ratio was calculated on the basis of standard procedure and all the cost related with labor, inputs, and farm cost are included. Total benefit was calculated on the basis of grain yield value.

Results and Discussion

Plant height

In general, different levels of nitrogen and sulphur significantly increased plant height at harvest stage during both the years (Table 1).

Plant height is useful index of the development phases of the plant to give an idea about dry matter production leading to ultimate yield. On an average, plant height remained higher during second year in comparison to first year and highest at harvest stage. The maximum plant height was recorded at the maximum dose of nitrogen i.e. 90 kg N/ha (N_4) during all the stages of the observation in both the years of experimentation. The minimum plant height was observed in control, where 0 kg N/ha (N_1) was fertilized. These results are in conformity with the findings of Gawai *et al.* (1994). Similarly, Sinha (1979) also reported an increase in plant height with the increase in nitrogen rates up to 120 Kg/ha and explained it due to increase in nitrogen uptake.

The plant height was increased significantly with increasing level of sulphur at each growth stages and at harvest. The significantly highest plant height was recorded at 60 kg S/ha (S_3) which followed by 40 kg S/ha (S_2) and 20 kg S/ha (S_1). The minimum plant height was recorded with S0 (0 kg S/ha)

The effect of interaction of different levels of nitrogen with sulphur levels on plant height has significantly influenced the performance. The data (Table 1) indicates that increase of nitrogen levels has increased the plant height at all the level of sulphur application in both the years. The maximum plant height

Table 1: Effect of different levels of nitrogen and sulphur on plant height, leaf area index, no. of primary branches, no. of secondary branches and no. of siliquae per plant during 2015-16 and 2016-17

Treatment	Plant height (cm) at harvest		Leaf Area Index (LAI) at 90 DAS		No. of primary branches at 90 DAS		No. of secondary branches at 90 DAS		No. of siliquae/ plant	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Nitrogen level										
N_1	127.03	128.37	3.25	3.28	5.73	5.79	14.93	15.09	217.80	220.08
N_2	137.02	139.63	3.50	3.57	6.18	6.30	16.11	16.41	234.92	239.40
N_3	141.15	143.10	3.61	3.66	6.37	6.46	16.59	16.82	242.00	245.34
N_4	145.27	147.60	3.71	3.77	6.56	6.66	17.08	17.35	249.07	253.06
S.Em (±)	2.51	2.13	0.09	0.05	0.16	0.09	0.41	0.25	5.98	3.65
C.D. at 5%	7.24	6.15	0.25	0.16	0.45	0.27	1.18	0.72	17.27	10.55
Sulphur level										
S_0	127.68	129.19	3.26	3.30	5.76	5.83	15.01	15.19	218.91	221.49
S_1	136.15	138.59	3.48	3.54	6.14	6.25	16.00	16.29	233.43	237.62
S_2	141.36	143.50	3.61	3.67	6.38	6.48	16.62	16.87	242.37	246.02
S_3	145.27	147.42	3.71	3.77	6.56	6.65	17.08	17.33	249.07	252.76
S.Em (±)	2.51	2.13	0.09	0.05	0.16	0.09	0.41	0.25	5.98	3.65
C.D. at 5%	7.24	6.15	0.25	0.16	0.45	0.27	1.18	0.72	17.27	10.55

was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), respectively.

Leaf area index (LAI)

Leaf area index (LAI) is an important plant index, determining the capacity of plants in trapping solar energy for photosynthesis. The maximum LAI were recorded at 90 kg N/ha (N_4) closely followed by 60 kg N/ha (N_3) and 30 kg N/ha (N_2). The minimum LAI was observed in control, where no nitrogen was applying.

The sulphur nutrition also produced significant variation on LAI at various stages. The significantly highest LAI was recorded with application of 60 kg S/ha (S_3) as compared to rest of the sulphur treatments.

The interaction effect between different levels of nitrogen and sulphur fertilization on leaf area index was found to be significant during both the years at 90 days stage. The data indicates that increase of nitrogen levels has increased the LAI at all the level of sulphur application in both the years. The maximum LAI was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), respectively during 2015-16 and 2016-17.

Number of branches per plant

Number of primary and secondary branches showed a significant increase at harvest with each incremental dose of nitrogen fertilization up to 90 kg N/ha during both the years.

With each incremental dose of sulphur fertilization the number of primary and secondary branches increased significantly at harvest during both the years. Application of 40 and 60 Kg S/ha, though being at par, produced significantly more number of primary and secondary branches in comparison to lower sulphur levels during the years 2015-16 and 2016-17.

The interaction effect between different levels of nitrogen and sulphur fertilization on number of branches per plant was found to be significant during both the years at 90 DAS. The data (Table 1) indicates that increase of nitrogen levels has increased the number of branches per plant at all the level of sulphur application in both the years. The maximum number of branches per plant was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), respectively during 2015-16 and 2016-17.

Number of siliquae per plant

The primary branches had more number of siliquae per plant followed by secondary branches during both the years. (Table 1). Different levels of nitrogen and sulphur fertilization significantly increased number of siliquae per plant during both the years 2015-16 and 2016-17.

With the increase in rates of nitrogen fertilization up to 90 kg N/ha, the number of siliquae per plant increase significantly in comparison with lower levels during both the years. However, number of siliquae per plant during both the years increase significantly up to 90 kg N/ha.

Sulphur levels significantly increased the number of siliquae per plant up to 60 kg S/ha during both the years. The interaction effect between different levels of nitrogen and sulphur fertilization on number of siliquae per plant at harvest was found to be significant during both the years. The data (Table 1) indicates that increase of nitrogen levels has increased the number of siliquae per plant at all the level of sulphur application in both the years. The maximum number of siliquae per plant was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), respectively.

Number of seeds per siliquae

Data on number of seeds per siliquae are presented in Table 2. The data revealed significant variation due to different nitrogen and sulphur fertilizer during both the years of study. Number of seeds per siliquae was significantly increased at all nitrogen levels over control. The significantly highest number of seeds per siliquae was recorded at 90 kg N/ha (N_4) followed by 60 kg N/ha (N_3) and 30 kg N/ha (N_2). The lowest number of seeds per siliquae was recorded in control (N_0).

Similarly, sulphur application also produced significant variation on number of seeds per siliquae. Increasing sulphur levels progressively increased the number of seeds per siliquae during both the years. The significantly highest number of seeds per siliquae was recorded with to application of 60 kg S/ha (S_3) which remained at par with application 40 kg S/ha (S_2).

The interaction effect between different levels of nitrogen and sulphur fertilization on number of seeds per siliquae at harvest was found to be significant during both the years. The maximum number of seeds per siliquae was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), during both the years 2015-16 and 2016-17.

Seed weight per plant (g)

The primary branches have maximum seed weight per plant during both the years (Table 2).

Table 2: Effect of different levels of nitrogen and sulphur on total nitrogen uptake & total sulphur uptake by crop and BCR during 2015-16 and 2016-17.

Treatment	Total nitrogen uptake by crop (kg/ha)		Total sulphur uptake by crop (kg/ha)		BCR	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Nitrogen level						
N_1	34.81	35.18	34.81	35.18	1.23	1.22
N_2	41.34	42.12	41.34	42.12	1.23	1.23
N_3	48.13	48.80	48.13	48.80	1.23	1.23
N_4	51.97	52.81	51.97	52.81	1.27	1.27
S.Em (±)	1.14	0.70	1.14	0.70		
C.D. at 5%	3.30	2.03	3.30	2.03		
Sulphur level						
S_0	38.63	39.09	38.63	39.09	1.24	1.23
S_1	40.74	41.48	40.74	41.48	1.25	1.24
S_2	47.12	47.83	47.12	47.83	1.25	1.24
S_3	49.76	50.51	49.76	50.51	1.26	1.25
S.Em (±)	1.14	0.70	1.14	0.70		
C.D. at 5%	3.30	2.03	3.30	2.03		

Different levels of nitrogen and sulphur fertilization significantly influenced the seed weight per plant during both the year 2015-16 and 2016-17.

The significantly highest seed weight per plant was recorded at 90 kg N/ha (N_4) followed by 60 kg N/ha (N_3) and 30 kg N/ha (N_2). The lowest seed weight per plant was recorded in control (N_0).

Sulphur application also produced significant variation on seed weight per plant. Increasing sulphur levels progressively increased the seed weight per plant during both the years. The significantly highest seed weight per plant was recorded with to application of 60 kg S/ha (S_3) which remained at par with application 40 kg S/ha (S_2).

The interaction effect between different levels of nitrogen and sulphur fertilization on seed weight per plant at harvest was found to be significant during both the years. The maximum seed weight per plant was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), during both the years 2015-16 and 2016-17.

1000-seed weight (g)

Data on test weight (1000-seed weight) pertaining to different nitrogen, and sulphur are presented in Table 4.2 during both the years of study. Higher test weight was recorded during second year as compared to first year. There was significant improvement in test weight with increase in nitrogen level. The significantly highest test weight was recorded under plot fertilized with 90 kg N/ha (N_4) followed by 60 kg N/ha (N_3) and 30 kg N/ha (N_2). The lowest test weight was recorded in control (N_0).

Levels of sulphur fertilization on test weight proved significant result during both the years. The test weight was increased significantly with increasing level of sulphur. The significantly highest test weight recorded with application of 60 kg S/ha (S_3) followed by 40 kg S/ha (S_2) and 20 kg S/ha (S_1).

The interaction effect between different levels of nitrogen and sulphur fertilization on test weight at harvest was found to be significant during both the years. The maximum test weight was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), during both the years 2015-16 and 2016-17.

Yield

Grain and Stover yield (q/ha)

Data pertaining to grain and stover yield by different level of nitrogen and sulphur levels presented in Table 4.2. There was significant variation due to all experimental variables on grain and stover yield during both the years of experimentation. Grain and stover yield significantly increased with progressive increase in nitrogen levels. The significantly highest grain and stover yield was recorded under plot fertilized with 90 kg N/ha (N_4) followed by 60 kg N/ha (N_3) and 30 kg N/ha (N_2). The lowest grain and stover yield was recorded in control (N_0).

Sulphur application brought about significant effect on grain and stover yield production during both years. Increasing level of sulphur significant increase in grain and stover yield. Accordingly, application of

60 kg S/ha (S_3) produced maximum grain and stover yield and showed its significant superiority over 40 kg S/ha (S_2) and 20 kg S/ha (S_0).

The effect of interaction of different levels of nitrogen with sulphur levels on grain and stover yield has significantly influenced the performance. Overall interaction of these four nitrogen levels under four sulphur levels indicated superiority in yield and stover. The data (Table 2) indicates that increase of nitrogen levels has increased the grain and stover yield at all the level of S application during both the years. The maximum grain and stover yield was observed at 90 kg N/ha (N_4) in combination with 60 kg S/ha (S_3), during both the years 2015-16 and 2016-17.

Economics

Different levels of nitrogen and sulphur fertilization influenced the cost of cultivation, additional benefit over control, net return and benefit cost ratio during both the years are presented in Table 2.

Maximum cost of cultivation was recorded at 90 kg N/ha (N_4) followed by 60, 30 and 0 kg N/ha (N_0), respectively in both the years.

However, higher net returns were obtained at 90 kg N/ha (N_4) during 2015-16 and 2016-17 resulting in higher returns during both the years. The BCR at 90 kg N/ha (N_4) over control was 1.27 and 1.27, respectively during 2015-16 and 2016-17.

With successive increase in sulphur application the cost of cultivation and gross returns increased and the maximum increase was up to 60 kg S/ha (S_3) during both the years. However, higher net returns was obtained when sulphur was applied @ 60 kg/ha during both the years. The BCR at 60 kg S/ha (S_3) over control was 1.26 and 1.25, respectively during 2015-16 and 2016-17.

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