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Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars

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ABSTRACT

A field experiment was conducted during the two consecutive winter (*rabi*) seasons of 2000-01 and 2001-02 at Agronomy Research Farm of NDUAT, Faizabad to find out the optimum dose of phosphorus and sulphur for Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] cultivars. The treatment consisted of four levels of P (0, 13.1, 26.1 and 39.3 kg/ha) and four levels of sulphur (0, 15, 30 and 45 kg/ha) applied though diammonium phosphate and elemental sulphur in split-plot design replicated thrice. A significant response of crop was observed up to 26.2 kg P and 30 kg S/ha in seed and stover yields. Nutrient uptake was also highest under these treatments. The optimum dose of S and P was computed as 47.5 and 40.2 kg, and 44.0 and 40.2 kg for the first and second years respectively. Highest net returns of Rs 12.729 and 13,734/ha were recorded with the application of 39.3 and 45 kg/ha P and S respectively. However, net returns of Rs 1.10 and 1.18/ha/Re invested were highest at 26.2 and 30 kg P and S respectively. 'NDR 8501' recorded the highest seed yield of 2.01 and 2.00 t/ha, and stover yield of 6.03 and 5.90 t/ha during 2000-01 and 2001-02 respectively, followed by 'Varuna'.

Key words: Cultivars, Growth, Phosphorus, Sulphur, Yield

Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] is the most important oilseed crop. It is responsive to chemical fertilisers, especially sulphur and phosphorus. Sulphur application is expressed on yield and oil content of the produce. It is involved in the synthesis of essential amino acids like cysteine, cystine and methionine; the SH sulphyldryl linkages provide the source of pungency in the oil (Pradhan and Sarkar, 1998). Phosphorus stimulates pod setting, helps in improving the seed weight and peroxides and an extensive and vigorous root system. It also helps in better partitioning of photosynthates to reproductive parts which increase the seed: stover ratio (Prasad *et al.*, 1991). The present investigation was therefore carried out to study the effect of phosphorus and sulphur levels on the performance of Indian mustard.

MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) season of 2000-01 and 2001-02 at Agronomy Research Farm of NDUAT, Faizabad. There were 32 treatment combinations comprising two cultivars ('NDR 8501' and 'Varuna') in main plot; and four levels of phosphorus (0, 13.1, 26.2 and 39.3 kg P/ha) and four levels of sulphur (0, 15, 30 and 45 kg S/ha) in subplot treatment, replicated thrice in split-plot design. Net plot size was 4 m × 3 m with 40 cm row spacing and 10 cm plant-to-plant spacing respectively. The soil was silty loam with pH 8.2 and 7.9, containing organic carbon 0.43% and 45%, available N 179.8 and 181.8 kg/ha, P 6.9 and 6.8 kg/ha, K 215.4 and 216.7 kg/ha and sulphur 8.1 and 8.35 kg/ha during the first and second years, respectively. The crop was sown on 4 November 2000 and 9 November 2001 and harvested on 20 March 2001 and 4 April 2002. Data on growth, yield and oil content etc. were recorded as per standard procedures. Economics of the different treatments was also computed as per standard procedures.

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RESULTS AND DISCUSSION

Growth and yield

Various levels of phosphorus and sulphur significantly influenced the growth and yield attributes, viz. platn height, number of branches, leaf-area index, dry-matter accumulation, siliquae/plant, seeds/siliqua and test weight in both the years. The plant height increased significantly with each increment in the dose of phosphorus and sulphur up to 13.1 kg P and 15 kg S/ha. However, the differences in plant height due to further increase in the dose of P and S were not significant. The rate of increase in plant height was more at lower doses (13.1 kg P and 15 kg S/ha), beyond which it declined, perhaps due to better nutritional environment for plant growth at active vegetative

Table 1. Effect of phosphorus and sulphur levels on growth, yield components, yield and oil content of Indian mustard

Treatment	Growth characters at 90 DAS				Siliquae/ plant (mean)	Seeds/ siliqua (mean)	Test weight (g) (mean)	Seed yield (t/ha)		Stover yield (t/ha)		Oil content (%)	
	Plant height (cm)	Primary branches/ plant	Leaf-area index	Dry-matter accumulation (g/plant)				2000-01	2001-02	2000-01	2001-02	2000-01	2001-02
Cultivar													
'NDR 8501'	161.1	6.8	4.9	53.6	354	13.3	4.49	2.11	2.01	5.49	5.39	38.13	36.63
'Varuna'	172.9	5.5	4.7	49.7	323	12.5	4.08	1.90	1.81	6.06	4.91	40.98	38.44
CD (P=0.05)	5.6	1.1	0.7	3.9	23	0.7	0.28	0.20	0.14	0.33	0.30	2.26	1.21
P level (kg P/ha)													
0	154.0	5.3	4.7	41.2	280	11.5	3.89	1.34	1.29	5.12	5.00	35.87	35.54
13.1	165.7	6.2	4.8	48.1	311	12.3	4.14	1.54	1.51	5.29	5.15	36.76	36.00
26.2	169.2	6.3	4.9	54.9	338	13.1	4.41	1.96	1.87	5.42	5.29	37.11	36.98
39.3	172.1	6.5	5.0	61.7	348	13.9	4.70	2.00	1.90	5.52	5.32	39.00	38.18
CD (P=0.05)	5.5	0.4	0.7	1.9	18	1.0	0.26	0.39	0.37	0.21	0.21	0.14	0.09
S level (kg/ha)													
0	148.5	4.8	4.2	48.8	239	11.0	3.92	1.41	1.36	5.29	5.16	36.15	35.94
15	165.5	5.7	4.5	50.5	286	11.8	4.16	1.71	1.66	5.34	5.19	38.29	38.33
30	169.8	6.4	5.0	52.4	319	12.6	4.40	2.01	1.96	5.38	5.24	39.76	38.71
45	173.9	7.4	5.5	54.1	353	13.7	4.65	2.11	2.00	5.43	5.34	40.32	39.18
CD (P=0.05)	5.2	1.2	0.5	1.1	19	1.1	0.26	0.29	0.28	0.15	0.12	0.07	0.07

stages as a result of improvement in root growth, cell multiplication, elongation and cell expression in the plant body (Steffenson, 1954), which ultimately increased the plant height. Application of 13.1 kg P/ha and 30 kg S/ha produced more number of primary branches at 90 days after sowing (DAS) compared with the control. This was probably due to adequate application of phosphorus and sulphur, which were directly involved in better absorption of applied nutrients and cell multiplication as well as expansion of deep green colour of leaves due to better chlorophyll synthesis in comparison with plants deficient in phosphorus and sulphur.

Values of leaf-area index were not influenced by variety and dose of phosphorus. However, application of 30 and 45 kg S/ha significantly increased the value of leaf-area index. An increase in the level of P and S significantly improved the dry-matter accumulation. Variety 'NDR 8501' produced higher dry matter than 'Varuna'. Better nutrition to plants resulted in more height and number of branches and other growth parameters, which resulted in higher dry-matter production. These results are in conformity with those reported by Prasad *et al.* (1991) and Pradhan and Sarkar (1998).

The number of siliquae/plant significantly increased up to 26.2 kg P/ha and 30 kg S/ha during both the seasons. The highest number of siliquae of 242.75 and 334.24/plant were recorded with 39.3 kg P and 45 kg S/ha during 2000-01 and 2001-02 respectively. The highest number of seeds/siliqua was recorded at 39.3 kg P and 45 kg S/ha, which was on a par with that of 26.2 kg P and 30 kg S ha, and was significantly superior to the control and 13.1 kg P and 15 kg S/ha during 2000-01 and 2001-02. The maximum test weight of 4.69 and 4.63 g/1,000 seeds was recorded with 90 kg P_2O_5 and 45 kg S/ha, and minimum in the control (3.89 and 3.84 g/1,000 seeds) during the first and second years respectively). This may be due to large amount of phosphorus found in the seed and siliqua, which is considered essential for seed formation and boldness of seeds. Prasad *et al.* (1991) reported that sulphur in the presence of phosphorus stimulates flowering and seed formation in siliqua. These results are also in accordance with those of Singh and Kumar (1996).

Among the cultivars, 'NDR 8501' recorded significantly higher values of growth and yield attributes over 'Varuna' in both the years. This was because phosphorus promotes extensive and vigorous root system for effective absorption of applied nutrients, whereas sulphur resembles nitrogen in being able to

Table 2. Effect of different levels of phosphorus and sulphur on uptake of P and S by Indian mustard and economics of different treatments

Treatment	Uptake (kg/ha)		Economics (Rs/ha)		
	Phosphorus	Sulphur	Cost of cultivation	Net returns	Net returns/Re invested
Variety					
'NDR 8501'	11.50	23.96	10,882	12,180	1.12
'Varuna'	11.70	21.85	10,882	10,994	1.01
CD (P=0.05)	1.60	2.98			
P level (kg P/ha)					
0	8.80	20.67	9,949	9,769	0.98
13.1	10.40	21.46	10,572	10,841	1.02
26.2	12.32	23.16	11,193	12,331	1.10
39.3	12.90	25.96	11,815	12,729	1.08
CD (P=0.05)	1.90	3.08			
S level (kg/ha)					
0	8.60	20.78	9,451	7,776	0.82
15	10.22	23.08	10,405	10,843	1.04
30	12.40	23.71	11,359	13,398	1.18
45	13.20	25.50	12,313	13,734	1.11
CD (P=0.05)	1.88	2.08			

improve cell division, cell elongation as well as having a favourable effect in chlorophyll synthesis (Steffenson, 1954). These results are in close conformity with the findings of Singh and Kumar (1996).

Yield and quality

The seed and stover yields and oil content were significantly influencd by different phosphorus and sulphur levels. The highest seed yield, stover yield and oil content were recorded at 39.3 kg P/ha and 45 kg S/ha, which were on a par with those at 26.2 kg P/ha and 30 kg S/ha, and these were significantly superior to the control during both the years. The increase in the seed yield and oil content due to application of 13.1, 26.2 and 39.3 P/ha over the control was 13.38, 40.52 and 42.25% during 2000-01, and 13.96, 41.32 and 43.98% during 2001-02. The increae in oil content due to application of 39.3 kg P/ha over control was 7.6 and 6.92% during the first and second years respectively. Ghosh *et al.* (2000) reported similar results. The increase in the seed yield and oil content due to application of 15, 30 and 45 kg S/ha over the control was 20.58, 42.3 and 48.0% during the first year and 22.0, 43.5 and 46.9% during the second year, whereas the increase in oil content due to 45 kg S/ha over the control was 11.53 and 9.02% during 2000-01 and 2001-02 respectively.

'NDR 8501' produced significantly higher seed and stover yields over 'Varuna'. 'NDR 8501' recorded seed yield of 2.11 and 2.01 t/ha, which in turn recorded 10.8 and 11.0% higher seed yield than 'Varuna'. 'Varuna' showed 7.4 and 4.94% higher oil content than 'NDR 8501' during the first and second years, respectively. This might be due to the positive effect of sulphur along with phosphorus and other nutrients on yield, which is mostly caused by changes in the phytochrome balance and expression of sink-source relationship. The increase in oil content with increase in S level might be due to the involvement of sulphur in electron-transport chain. According to Singh and Singh (1977), the increase in oil content was mainly due to increase in glucoside formation (allyisothiocynate) and also sulphur as a constituent of multi-enzyme complex. The oil content increased successively with increase in P level, probably because it is a constituent of phospholipid and is essential for its synthesis. Maraghatham and Chellambudu (2000) also reported similar results.

Response curve

The seed yield of Indian mustard showed second polynomial increase ($y = a+bx+cx^2$) with successive increase in sulphur doses. The optimum dose of sulphur was computed to be 47.5 and 40.2 kg/ha and the maximum 58.9 and 49.5 kg/ha during the first and second years respectively. The seed yield of Indian mustard also showed second polynomial increase with successive increase in phosphorus level. The optimum dose of phosphorus computed was 44.0 and 40.2 kg P/ha and the maximum 55.0 and 50.9 kg P/ha during the first and second years respectively.

Nutrient uptake

The increase in the levels of P and S increased the uptake of P. However, the differences were statistically significant only up to 26.2 kg P and 30 kg S/ha. Further increase in the dose of Pand S did not result in significant increase in P uptake by the crop. Uptake of S also increased with increase in the levels of P and S. Application

of 26.2 kg P/ha significantly increased the S uptake over the control. Application of S also resulted in significant increase in the S uptake over the control only. Its application at 45 kg S/ha also showed significant S uptake over that of 15 kg S/ha. The increase in nutrient uptake was mainly due to better nutrition, which resulted in better growth and yield and ultimately in higher uptake of nutrients.

Economics

The increase in the levels of P and S increased the cost of cultivation. Net returns were also higher with increasing P and S levels. The highest net return of Rs 12,729 and Rs 13,734 /ha was recroded at 39.3 kg P/ha and 45 kg S/ha respectively. 'NDR 8501' was more remunerative than 'Varuna'. Net return/Re invested was the highest, being Rs 1.10 and Rs 1.18/ha at 26.2 kg and 13.1 kg P and S respectively.

It was concluded that Indian mustard variety 'NDR 8501' fertilized with 26.2 kg P and 30 kg S/ha is beneficial and effective doses for growth, yield attributes and yield. For oil content, 'Varuna' proved superior to 'NDR 8501'.

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