

Short Communication

Sulphur and Phosphorus Interaction in Nutrition of Indian Mustard (*Brassica juncea* L.) under Cold Arid Conditions of Ladakh

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Sulphur and phosphorus play an important role in improving both quality and quantity of oilseeds. Both the nutrients are taken up by the plants in anionic form. Sulphates tend to leach out more readily than phosphates due to very low adsorption on soil colloids. Hence, it is required to be applied in higher amounts, this indicates the need for proper balance of both the nutrients in the soil. Both synergistic and antagonistic interactions between S and P have been reported (Tandon, 1989). But, recent research has shown that the nature of S-P interaction depends on their rates of application and available P status in the soil. In general S-P interaction is synergistic at low to medium level of P and antagonistic only at higher levels usually at 60 kg or more P_2O_5 ha⁻¹ (Mandal *et al.*, 2002). Since, there is paucity of information on this aspect in cold arid region of Ladakh, therefore, the present investigation was conducted.

A field experiment was conducted for two consecutive years during summer season (kharif) of 2000 and 2001 at Thicksay Farm, RARS, SKUAST-K Leh (32.3°N, 77.3°E and 3400 m amsl) representing cold

arid region of J&K. The soil had sandy loam texture, pH 7.97, EC (1:2) 0.45 dS m⁻¹, oxidizable organic carbon 6.2 g kg⁻¹, alkaline KMnO₄ N 216 kg ha⁻¹, Olsen's P 9.4 kg ha⁻¹, IN NH₄OAc K 294 kg ha⁻¹ and 0.15% CaCl₂ S 11.5 kg ha⁻¹. The sixteen treatments, comprising 4 levels each of S (0, 25, 50, 75 kg ha⁻¹) applied through gypsum and P (0, 13.1, 26.2, 39.3 kg ha⁻¹) through DAP were replicated thrice in a randomized block design. Whole of S and P fertilizer was applied before sowing. Indian mustard (cv. RLM-514) was sown in last week of May and harvested in the second week of September. The crop was irrigated at weekly interval as there was negligible rainfall and the relative humidity remained between 34-42%. Seed and straw samples were collected at harvest and analyzed for S and P by digesting the material in MNO₃: HClO₄ (4:1) mixture. Total S was determined turbidimetrically and P by vanadomolybdo phosphoric yellow color method. The oil content of seed samples was estimated with petroleum ether using soxhlet extraction assembly.

The seed and straw yields of mustard increased significantly with the application of both S and P (Table 1). The response to added S was observed up to 50 kg ha⁻¹ in seed, however, straw yield increased

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Table 1. Effect of sulphur and phosphorus on seed, straw and oil yield and their uptake by mustard (pooled over 2 years)

Added P (kg ha ⁻¹)	Added S (kg ha ⁻¹)					Added S (kg ha ⁻¹)				
	0	25	50	75	Mean	0	25	50	75	Mean
	Seed yield (t ha ⁻¹)					Seed yield (t ha ⁻¹)				
0	1.22	1.72	2.03	2.18	1.79	4.14	5.64	6.58	7.15	5.88
13.1	1.61	2.07	2.22	2.31	2.05	5.15	6.72	7.20	7.65	6.68
26.2	1.92	2.20	2.38	2.47	2.24	5.95	7.17	7.74	8.20	7.27
39.3	2.07	2.28	2.42	2.44	2.30	6.17	7.60	8.08	8.29	7.60
Mean	1.71	2.07	2.26	2.35	—	5.35	6.78	7.40	7.88	—
CD (P=0.05)	P=0.14		S=0.14		PxS=0.27	P=0.33		S=0.33		PxS=0.67
	Oil content (%)					Oil yield (t ha ⁻¹)				
0	38.3	38.7	39.4	39.7	39.0	0.47	0.67	0.80	0.87	0.70
13.1	38.6	39.3	39.7	39.9	39.4	0.62	0.81	0.88	0.92	0.81
26.2	38.6	39.5	39.9	40.0	39.5	0.74	0.87	0.95	0.99	0.89
39.3	38.7	39.5	40.1	40.1	39.6	0.80	0.90	0.97	0.98	0.91
Mean	38.5	39.2	39.8	39.9	—	0.66	0.81	0.90	0.94	—
CD (P=0.05)	P=0.3		S=0.3		PxS=NS	P=0.03		S=0.03		PxS=0.06
	Sulphur uptake (kg ha ⁻¹)					Phosphorus uptake (kg ha ⁻¹)				
0	19.6	28.6	38.8	44.3	32.8	7.9	11.2	13.3	14.6	11.7
13.1	26.8	39.9	47.4	51.0	41.3	11.2	14.9	16.1	17.6	15.0
26.2	31.8	48.0	53.2	58.5	47.9	15.0	17.8	19.3	20.3	18.1
39.3	35.0	55.0	61.9	62.5	53.6	16.9	20.5	21.4	22.3	20.2
Mean	28.4	42.9	50.2	54.4	—	12.7	16.1	17.5	18.7	—
CD (P=0.05)	P=3.7		S=3.7		PxS = 7.4	P=1.7		S=1.7		PxS=3.4

significantly and consistently with every successive increment of added S up to 75 kg ha⁻¹. The response to added P was restricted up to 26.2 kg ha⁻¹ in seed as well as straw yield. The increased yield due to S and P application is imminent as the soil of experimental field was deficient both in available (11.5 kg ha⁻¹) and P (9.4 kg ha⁻¹). Further, the fact assumes greater significance in Indian mustard, as it has higher S requirement (Patgiri and Baruah, 1993), particularly when the soil under study is deficient in available S. The cruciferous

group of oil seeds have relatively higher S requirement. Sulphur has been implicated in the formation of S containing amino acids and glucosinolates; the SH-sulphydryl groups attribute to the pungency in oils and thus improves the quality and quantity of oil seed. Significant interaction between S and P was observed in both seed and straw yield of mustard. The higher seed (2.47 t ha⁻¹) and straw (8.29 t ha⁻¹) yields were recorded with S₇₅P_{26.2} and S₇₈P_{39.3} treatments, respectively. Similar results were observed by Jaggi (1998).

The oil content and oil yield increased significantly with the application of both S and P. However, in case of oil content, the effect was significant up to 50 kg S ha⁻¹ and 13.1 kg P ha⁻¹ only. The oil yield increased significantly with every successive increment in S level up to 75 kg ha⁻¹. The effect of added P on oil yield was significant only up to 26.2 kg P ha⁻¹. Thereafter, it remained statistically at par with 39.3 kg ha⁻¹. The phosphorus is known to play an important role in carbohydrate metabolism and helps in conversion of carbohydrates into oil. The interaction effect of S and P on oil content was non-significant, however, significant interaction was observed on oil yield. As, oil yield is governed by seed yield rather than oil content, the highest oil yield (0.99 t ha⁻¹) was recorded with treatment combination of S₇₅P_{26.2} and it was statistically at par with S₇₅P_{39.3}, S₅₀P_{39.3} and S₅₀P_{26.2}.

Total S and P uptake increased significantly by the application of these nutrients. Total S uptake increased significantly with each increment of S and P up to 75 kg ha⁻¹ and 39.3 kg ha⁻¹, respectively. The increased uptake of S by mustard could be due to higher demand of crop for sulphur (Biswas *et al.*, 1995). Similarly, total P uptake also increased significantly up to its highest level applied. Although higher uptake of P was observed at 75 kg ha⁻¹ S level; yet it was not significantly higher than 50 kg ha⁻¹ S level. Increased S and P uptake with P application may be associated with higher biomass production and development of extensive and deep root system to trap more area for nutrient supply. The P uptake by Indian mustard is substantially less as compared with the S uptake. The interaction effect

of S and P on their uptake was significant. The highest total S and P uptake was recorded in plots where S and P were applied at their highest level i.e. 75 and 39.3 kg ha⁻¹, respectively. Synergistic interaction effect of S and P on their uptake by Indian mustard was also reported by Jaggi and Sharma (1977). They reported that in a soil deficient in both available S and P, their interaction of synergistic nature is possible even at their higher application rates.

A significant response of crop was observed up to 50 kg ha⁻¹ in seed and 75 kg ha⁻¹ in straw and oil yield. Synergistic interaction effect between S and P, was observed. The highest seed (2.47 t ha⁻¹) and oil yields (0.99 t ha⁻¹) were recorded at S₇₅P_{26.2}. However, the highest S and P uptake was recorded at S₇₅P_{39.3}.

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