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Response of soybean (*Glycine max*) to phosphorus and sulphur in Acid alfisol of Meghalaya

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 1998 and 1999 on a phosphorus - and sulphur-deficient Hapludalf, to evaluate the influence of different levels of phosphorus and sulphur on yield, yield attributes, nutrient uptake and seed quality of soybean [*Glycine max* (L.) Merr.]. All the P and S levels significantly increased the grain and straw yields, pods/plant, 100-seed weight, oil and protein content and their yields and N P and S uptake by soybean. The N : S ratio in the seed reduced significantly by both P and S application. Interaction of P and S was also significant for all the parameters studied. Application of 60 kg P_2O_5 along with 40 kg S/ha was the optimum dose of P and S for getting the highest yield.

Key words : Acid soil, P and S interaction, Soybean, Nutrient uptake, Protein and oil content

Soybean is emerging as an important oilseed crop of Meghalaya. Soils of the state are acidic and deficient in available P and S. The P and S are known to be involved in major metabolic processes such as protein and oil synthesis in plants (Kumar and Singh, 1980). Soybean being a leguminous oilseed requires a higher and balanced dose of both P and S. The effect of applied P on crop growth depends on level of S in soil and vice versa as P and S both are absorbed by plants in anionic form from the soil. Both synergistic and antagonistic interactions have been reported between P and S (Ali, 1991). As very little information is available on P and S nutrition of soybean in acid soil of Meghalaya, the present experiment was conducted to study the individual and interaction effect of P and S application on yield, yield attributes, nutrient uptake and protein and oil content of soybean.

MATERIALS AND METHODS

The field experiment was conducted during the rainy (*kharif*) season of 1998 and 1999 at research farm of Soil Science Division, ICAR Research Complex for NEH Region, Umiam, Meghalaya, (25°41'N, 91°63'E). The mean annual rainfall of the area is 2,232 mm with more than 88% oc-

curring during May–October. The soil of experimental plot was Ultic Hapludalf with sandy loam texture having pH 4.26, organic carbon 1.62% and available N, P, K and S as 260, 13.4, 209 and 12.5 kg/ha respectively. Initial soil samples were analysed for different soil properties such as pH with a pH meter in a soil : water suspension of 1 : 2.5, organic carbon by Walkely and Black rapid titration method, available P (Bray P-2) by ascorbic acid method, available S by colorimetry after extracting with 0.15 m $CaCl_2$ and available N by alkaline $KMnO_4$ method (Tandon, 1993). Four levels of P (0,20, 40 and 60 kg P_2O_5/ha as diammonium phosphate) and 3 levels of S (0, 20 and 40 kg/ha as elemental sulphur) were applied in 12 treatment combinations, replicated thrice in factorial randomized block design. Elemental sulphur was applied 15 days before sowing to facilitate oxidation of S to sulphate form. A common basal dose of 25 kg N/ha as urea and 30 kg K_2O /ha as muriate of potash was also applied to all the plots. Soybean cv. 'Ankur' was grown as test crop. The grain and straw samples were collected at full maturity and analysed for P by vanado-molybdate yellow colour method, S by turbidimetry, N by micro-Kjeldahl method and oil by Soxhlet extraction (Tandon, 1993). Protein content was calculated by multiplying N content with the factor 6.25. Oil and protein yields were calculated as product of seed yield and their contents respectively.

RESULTS AND DISCUSSION

Grain and straw yield

The grain and straw yields of soybean increased significantly with increasing levels of both P and S (Table 1). The soil under study was deficient in both available P and S and therefore significant response of soybean to the applied nutrients is quite understandable. The interaction between P and S was significant for seed and straw yield of soybean. All the levels of S gave significantly higher yield at each P level and the highest seed yield (2.50 tonnes/ha) was recorded with a combination of 60 kg P_2O_5 and 40 kg S/ha. This positive significant interaction might be owing to increase in uptake of nutrients like N, P and S with the combined application of P and S, which helped in better nutrition of soybean for optimum growth and development.

Yield attributes

The pods/plant and 100-seed weight of soybean increased significantly with increasing doses of P and S over the control. The pods/plant and 100-seed weight increased by 37 and 8.4% respectively with 60 kg P_2O_5/ha and the same were increased by 7.6 and 2.6% respectively with 40 kg S/ha over the control. The relative contribution of P was more than S in this regard. The interaction effect of P and S was significant, thereby indicating a more beneficial effect of the 2 in combination. All the levels of S increased the 100-seed weight as well as pods/plant significantly at each level of P. The results indicated that the utilization of S for plant growth was associated with a concomitant supply of phosphorus. The pods/plant and 100-seed weight were maximum under treatment combination of 60 kg P_2O_5/ha and 40 kg S/ha.

Nutrient uptake

The P and S uptake by soybean seed and straw increased significantly with their respective increase in doses (Table 2). The P and S uptake was higher in seed than straw, which might be due to the fact that absorbed P and S were partitioned more in the seed which led to their apparent depletion in straw. The P × S interaction was significant for P and S uptake and followed the pattern of seed yield. The highest P and S uptake by seed was recorded with the combination of 60 kg P_2O_5 and 40 kg S/ha. This increase in P uptake by S application might be due to increase in soil-available P, as both of these nutrients are absorbed by plants as anions, and if one is available in higher amount, the available pool for other will also increase. Application of P significantly increased S uptake of soybean, which could be due to greater root proliferation and increased activity of S-solubilizing bacteria, resulting in a beneficial effect on S absorption (Singh *et al.* 1986).

Table 1. Effect of P and S levels on yield and yield attributes of soybean (pooled mean of 2 years)

P_2O_5	Sulphur (kg/ha)			
(kg/ha)	0	20	40	Mean
		Grain yield (tonnes/ha)		
0	1.13	1.25	1.52	1.30
20	1.61	1.72	1.85	1.72
40	2.00	2.12	2.20	2.10
60	2.30	2.38	2.50	2.39
Mean	1.76	1.86	2.01	
CD (P=0.05)	P= 0.02	S = 0.02	P × S= 0.04	
		Straw yield (tonnes/ha)		
0	1.87	2.21	2.70	2.26
20	2.83	2.94	3.06	2.94
40	3.22	3.37	3.45	3.34
60	3.55	3.74	3.89	3.72
Mean	2.86	3.06	3.27	
CD (P=0.05)	P = 0.05	S = 0.04	P × S = 0.08	
		Pods/plant		
0	55.20	56.50	58.95	56.88
20	60.90	63.40	66.20	63.50
40	68.60	70.80	73.80	71.06
60	75.50	77.30	81.00	77.93
Mean	65.05	67.00	69.98	
CD (P=0.05)	P = 0.17	S = 0.15	P × S = 0.30	
		100-grain weight (g)		
0	11.57	11.71	11.97	11.75
20	12.08	12.15	12.26	12.16
40	12.34	12.42	12.48	12.41
60	12.55	12.56	13.12	12.74
Mean	12.13	12.21	12.45	
CD (P=0.05)	P = 0.04	S = 0.03	P × S = 0.07	

Table 2. Effect of P and S application on nutrient uptake and quality of soybean (pooled mean of 2 years)

Treatment	Nutrient uptake (kg/ha)					Oil content (%)	Protien content (%)	Oil yield (kg/ha)	Protien yield (kg/ha)	N : S ratio
	P		S		N					
	Grain	Straw	Grain	Straw	Grain					
P_2O_5 (kg/ha)										
0	5.95	1.04	3.63	2.60	82.4	17.58	39.26	230.1	515.4	22.78
20	8.52	1.52	5.38	4.14	112.6	19.36	40.45	336.2	700.2	20.68
40	11.47	1.92	7.18	5.22	141.3	20.00	41.51	422.9	874.3	19.52
60	13.93	2.40	8.76	6.83	162.7	20.26	42.02	486.5	1,007.0	18.48
CD (P=0.05)	0.23	0.14	0.07	0.09	0.50	0.12	0.08	2.8	8.8	0.11
S (kg/ha)										
0	8.69	1.27	5.34	3.40	109.0	17.33	38.54	307.5	681.6	20.8
20	9.82	1.67	6.09	4.68	125.7	19.04	41.01	359.7	770.6	20.72
40	11.38	2.20	7.28	6.01	139.5	21.52	42.88	439.6	870.5	19.57
CD (P=0.05)	0.19	0.12	0.06	0.08	0.40	0.10	0.07	2.4	7.6	0.11
CD (P=0.05)*	0.39	0.25	0.12	0.17	0.90	0.20	0.14	4.9	15.2	0.20

*CD (P=0.05) for P × S

The N uptake of soybean seed increased significantly by all the levels of P and S (Table 2). This increase in N uptake of soybean by P and S application might be due to increased nodulation as well as N fixation by nodules (Agarwal and Mishra, 1994). A combination of P and S significantly increased the N uptake, showing a synergistic effect and the maximum value of N uptake recorded in the treatment combination of 60 kg P_2O_5 + 40 kg S/ha.

Protein and oil content

Protein and oil contents of the soybean seed increased significantly with increasing dose of P or S (Table 2). On an average, 60 kg P_2O_5 /ha increased protein and oil content by 7.03 and 15.24% respectively over the control. The increase in oil content with P application could be due to the fact that P helped in synthesis of fatty acids and their esterification by accelerating biochemical reactions in glyoxalate cycle (Dwivedi and Bapat, 1998). The increase in protein and oil content due to 40 kg S/ha was 11.26 and 24.17% respectively. The increase in oil content with S application might be due to the fact that S helped in oil synthesis by enhancing the level of thioglucosides (Dwivedi and Bapat, 1998). Soybean responded more to S in increasing oil and protein content of seed, as also reported by Kumar and Singh (1981). The interaction between P and S was significant. All the S levels increased both oil and protein contents significantly at every level of P. The maximum protein and oil content were recorded with a treatment combination of 60 kg P_2O_5 and 40 kg S/ha.

Protein and oil yield

The protein and oil yields increased significantly with increasing levels of P and S (Table 2). The protein and oil yields were influenced more by phosphorus than by sulphur. The oil and protein yields were increased by 111.4 and 95.4% with 60 kg P_2O_5 /ha, while the same were increased by 42.9 and 27.2%, respectively, by 40 g S/ha over the control. The interaction between P and S was significant indicating that the combined application of P and S would be more useful for the improvement of seed quality of soybean when both of these nutrients were deficient in the soil. All the levels of S increased the protein as well as oil yield significantly at each level of P_2O_5. Maximum yield of oil and protein (571.2 and 1,108.7 kg/ha respectively) was obtained by combined application of 60 kg P_2O_5 and 40 kg S/ha.

Nitrogen : Sulphur ratio

The application of P and S significantly reduced N : S ratio (Table 2). The wide N : S ratio at lower doses of P and S application indicated a deficiency of S, while a narrow ratio indicated sufficiency of S or possibly a deficiency of N (Dwivedi and Bapat, 1998), as increasing levels of N to meet the S levels were not applied (Agarwal and Mishra, 1994). Lowering of N : S ratio proved beneficial in increasing the yield and quality of soybean seeds. The N : S ratio of 17.7 at 60 kg P_2O_5 + 40 kg S/ha was the most optimum for soybean under such soil.

Thus, it can be inferred from the study that application of 60 kg P_2O_5 and 40 kg S/

ha may be an optimum dose of these nutrients to get higher yield with better-quality soybean in acidic soils of Meghalaya.

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