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EFFECT OF SULPHUR, PHOSPHORUS AND MOLYBDENUM ON YIELD AND NUTRIENT UPTAKE BY BLACKGRAM (*Phaseolus mungo*) IN ACIDIC ALFISOL OF MEGHALAYA

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ABSTRACT

A field experiment was conducted on an acidic Alfisol of Meghalaya to study the effect of sulphur, phosphorus and molybdenum on yield and nutrient uptake by black gram (*Phaseolus mungo* L). Application of S, P and Mo resulted in significant increase of grain yield and total nutrient uptake by grain. Highest grain yield, N, P and Mo uptake by grain and available S, P and Mo content in soil were recorded with the application of 30, 26 and 1 kg sulphur, phosphorus and molybdenum/ha ($S_{30}P_{26}Mo_1$), respectively, whereas S uptake and protein content were maximum in $S_{60}P_{26}Mo_1$ treatment. SxPxMo interaction was significant for grain yield, protein content, nutrient uptake and soil available nutrients.

INTRODUCTION

Meghalaya has a very little share of 0.01% area and 0.06% of total pulses production in India (Anonymous, 2000). Blackgram (*Phaseolus mungo* L.) is emerging as an important pulse crop as it can be grown successfully in maize-blackgram cropping sytem under rainfed conditions. The yield of this crop is low due to inadequate supply of plant nutrients in the acidic soils of this region (Singha and Sarma, 2001). Soils of Meghalaya are deficient in phosphorus, sulphur and molybdenum (Patiram et al. 2001). Response of soybean to P and S application in acid soil of Meghalaya (Majumdar et al. 2001) and that of cowpea to Mo in soils of Tripura (Laskar et al. 1983) has been reported. However, the information on individual and interactive effect of these nutrients on blackgram in acid soils of North Eastern Hills Region is very meagre. The present investigation was therefore conducted to study the effect of S, P and Mo on yield, quality and nutrient uptake by blackgram and post harvest soil available nutrient status in acid soil of Meghalaya.

MATERIALS AND METHODS

A field experiment was conducted during the kharif seasons of 1999 and 2000 at the research farm of ICAR Research Complex for North Eastern Hills Region, Umiam, Meghalaya (980m above m.s.l.) on a sandy loam Typic Hapludalf with pH 4.83, organic carbon 1.4% available P, S and Mo 7.5, 12.5 and 0.04 kg/ha, respectively. There were 18 treatment combinations consisting of 3 levels of S (0 30 and 60 kg S/ha as gypsum), 3 levels of P (0, 13 and 26 kg P/ha as DAP) and 2 levels of Mo (0 and 1 kg Mo/ha as sodium molybdate) in factorial RBD with 3 replications. Blackgram (cv. DPU-88-1) was sown as test crop during the 2nd week of August with spacing of 30×10 cm. A basal dose of N and K @ 30 and 40 kg/ha was applied at the time of sowing. Grain samplex collected after harvesting the crop were dried at 60°C, ground and digested in diacid in diacid mixture (HNO3 : HClO4 :: 10:4 by volume). In the digested extracts, P and Mo were analysed colorimetrically by vanado-molybdate (Tandon 1993) and thiocyanate (Purvis and Peterson 1956) methods, respectively and sulphur was analysed turbidimetrically (Chesnin and Yien 1950). Nitrogen content in grain was analysed by micro-Kjeldahl method and protein content was calculated by multiplying the nitrogen content of grain with 6.25. Soil samples were collected after the harvest of 2nd crop and available

P, S and Mo were extracted by Bray P_2, 0.15% $CaCl_2$ and ammonium oxalate (pH 3.3), respectively and analysed by standard methods (Page et al. 1982).

RESULTS AND DISCUSSION

Yield and protein content

Application of S and P significantly influenced the grain yield and protein content of blackgram (Table 1). There was an increase of 39.5 and 61.5% in grain yield over control due to application of S and P @ 30 and 26 kg/ha, respectively. Response of blackgram to applied S and P may be due to low availability of these nutrients in soil. Interaction of P with both S and Mo was significant. Application of S @ 30 kg/ ha increased the grain yield significantly at all the levels of P, however relative yield response due to S application decreased at increasing P levels. Similar results were observed by Kumar and Singh (1980). The highest significant grain yield (12.64 q/ha) was recorded at $S_{30}P_{26}$ combination. Application of Mo also increased the grain yield at all the P levels. P levels upto 26 kg P/ha increased the grain yield significantly over control at both Mo levels. The interactions of S, P and Mo were also significant and highest grain yield (13.91 q/ha) was recorded in $S_{30}P_{26}Mo_1$ treatment, which was at par with $S_{60}P_{26}Mo_0$ (13.17 q/ha). Straw yield also behaved almost similar like grain yield.

The protein content of grains significantly increased by the application of P, S and Mo as well (Table 1). As P and S are the constituents of protein molecules, their application might have enhanced the synthesis of P and S containing amino acids in the grain. Application of Mo would have helped in biological N_2 fixation and N-assimilation (Dwevedi et al. 1990). Interaction of PxS,PxMo, SxMo and PxSxMo were all significant for protein content. S levels upto 30 kg/ha increased the protein content significantly at all P levels. Mo did not increase the protein content significantly at any level of P but the P levels increased the protein content significantly when applied along with Mo. Similar was the case for SxMo interaction. Maximum protein content (27.87%) was recorded in $S_{60}P_{26}Mo_1$ treatment combination followed by $S_{30}P_{26}Mo_1/S_{60}P_{13}Mo_1$ (26.25%) and $S_{30}P_{13}Mo_1$ (26.12 %).

Nutrient uptake

Nitrogen uptake by grain was significantly increased with application of 30 kg S, 1 kg Mo/ha and at all levels of P (Table 2) which was apparently due to favourable effect of S, P and Mo on N absorption and higher dry matter production. The increase in N uptake was not significant beyond 30 kg S/ha which may be attributed to inhibition effect of higher doses of S on N uptake (Dwivedi and Bapat 1998). Combination of S and P application also significantly increased the N uptake showing the synergistic effect up to 30 kg S/Ha. Mo application significantly increased the N uptake by 13.6%, which may be due to the fact that molybdenum is essential for nitrate reductase enzyme for the assimilation of N. Interaction of SxPxMo was significant for N uptake by grain. Maximum N uptake was observed at $S_{30}P_{26}Mo_1$ (58.42 kg/ha).

Application of S resulted in significant increase in P uptake by grain upto 30 kg/ha beyond which it showed a decreasing trend Table 2). This was probably due to competition between these two anions for adsorption sites on soil colloids at higher levels of S application (Bapat et al. 1986). It was further confirmed by the content of available S in the soil which also significantly increased only upto 30 kg S/ha (Table 3). Phosphorus application upto 26 kg/ha increased the P uptake significantly. Application of Mo also significant which might be due to increased efficiency of blackgram to utilize applied P when S was applied along with it (Khandkar and Shinde 1991). SxPxMo interaction was also significant for P upake suggesting the interdependence of all these nutrients. Maximum P uptake (3.77 kg/ha) was recorded in $S_{30}P_{26}Mo_1$.

Sulphur uptake by grain increased up to 50 kg S/ha which is quite expected in low S soil and may be attributed to release of more SO_4^{2-} ions through added gypsum. Increase in S uptake by blackgram due to S application was earlier reported by Singh et al. (1998). P application, which seemed to have induced

better root development as well as increased activity of S-oxidising bacteria also had beneficial effect on S uptake and consequently, application of 26 kg P/ha increased the S uptake significantly over control. A significant interaction was found between P and S levels for S uptake. Maximum S uptake (5.98 kg/ha) has found when 60 kg P/ha increased the S uptake significantly over control. A significant interaction was found between P and S levels for S uptake. Maximum S uptake (5.98 kg/ha) was found when 60 kg P/ha increased the S uptake. Maximum S uptake (5.98 kg/ha) was found when 60 kg S was applied with 26 kg P/ha. These results indicated that application of S and P was found to be complementary to each other and their effect was synergistic on S uptake by blackgram. PxMo interaction was significant and application of P @ 26 kg/ha increased the S uptake significantly when applied with 1 kg Mo/ha. Combined effect of S, P and Mo on S uptake was also significant. Maximum S uptake (6.23 kg/ha) was recorded in $S_{60}P_{26}Mo_0$.

The uptake of Mo increased significantly upto 30 kg S, 13 kg P and 1 kg Mo/ha. At higher levels of S (60 kg/ha), there was a decrease in Mo uptake. A possible reason for this might be the similar size and shape of MoO_4^{2-} and SO_4^{2-} ions, which compete with each other for abosrption sites on root surface (Singh and Kumar 1979). Available Mo in the soil was also significantly decreased at higher level of S application (Table 3). Application of Mo increased the Mo uptake uniformly at all the P levels. This stimulating effect of P might be attributed to the formation of phospho-molybdate complex anions, which are more readily absorbed by plants (Barshad, 1951). The interaction of S, P and Mo was also significant on Mo uptake and maximum Mo uptake (24.59 g/ha) was observed in $S_{30}P_{26}Mo_1$.

Nutrient uptake data on N, P and Mo thus revealed that $S_{30}P_{26}Mo_1$ treatment recorded maximum absorption of these nutrients resulting in highest grain yield (Table 1). However, S uptake did not commensurate well with grain yield. Maximum grain yield was recorded at 30 kg S/ha suggesting that this level fulfilled the plants S requirement.

Soil properties

S application upto 30 kg/ha resulted in significant residual buildup of available S, P and Mo in the post harvest soil (Table 3). Available MO content was significantly reduced at 60 kg S/ha. Application of P up to 26 kg/ha also resulted in significantly higher residual P in the soil. Available S and Mo contents were enhanced up to 13 kg P/ha, the higher level of P being at par. Application of Mo increased the available P and Mo content significantly. Sxp and SxPxMo interaction were also significant for available S, P and Mo contents. Maximum available P, S and Mo contents were recorded in $S_{30}P_{26}Mo_1$ treatment in the post harvest soil.

Thus, it could be inferred from the above discussion that the application of 30 kg S, 26 kg P and 1 kg Mo/ha was the most optimum dose to get maximum grain yield with high protein content and nutrient uptake by blackgram and nutrient build up in acidic Alfisol of Meghalaya.

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Table 1. Effect of sulphur, phosphorus and molybdenum on yield and protein content of blackgram (pooled of 2 years)

P levels (kg P/ha)	S and Mo levels (kg/ha)						
	S_0		S_{30}		S_{60}		Mean
	Mo_0	Mo_1	Mo_0	Mo_1	Mo_0	Mo_1	
			Grain yield (q/ha)				
P_0	5.25	5.42	8.75	9.54	7.62	7.20	7.30
P_{13}	8.12	9.20	10.75	11.91	11.08	10.87	10.32
P_{26}	9.08	10.42	11.37	13.91	13.17	12.80	11.79
Over all mean	S_0: 7.91	S_{30}: 11.04	S_{60}: 10.46	Mo_0: 9.46	Mo_1: 10.47		
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo
	1.3	1.3	2.25	1.00	NS	1.84	1.98
			Straw yield (q/ha)				
P_0	5.78	6.50	9.85	10.59	8.30	7.92	8.16
P_{13}	9.36	11.25	11.87	12.68	12.85	12.02	11.67
P_{26}	10.50	11.86	12.82	13.92	14.86	13.20	12.86
Over all mean	S_0: 9.21	S_{30}: 11.95	S_{60}: 11.52	M_0: 10.69	Mo_1: 11.10		
CD (P=0.05)	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo
			Protein content (%)				
	1.52	1.52	2.00	0.40	NS	1.96	2.05
P_0	20.08	21.87	22.37	24.31	24.62	25.25	23.08
P_{13}	21.90	23.62	24.81	26.12	25.19	26.25	24.65
P_{26}	22.00	23.75	25.49	26.25	25.50	27.87	25.14
Over all mean	S_0: 22.20	S_{30}: 24.89	S_{60}: 25.78	Mo_0: 23.55	Mo_1: 25.03		
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo
	1.51	1.51	2.60	1.23	2.10	2.10	3.69

Table 2. Effect of sulphur, phosphorus and molybdenum on nutrient uptake by blackgram grains (pooled of 2 years)

P levels (kg P/ha)	S and Mo levels (kg/ha)						
	S_0		S_{30}		S_{60}		Mean
	Mo_0	Mo_1	Mo_0	Mo_1	Mo_0	Mo_1	
	N uptake by grain (kg/ha)						
P_0	16.85	18.97	31.32	37.11	30.02	29.08	27.22
P_{13}	28.42	34.78	42.68	49.78	44.65	45.65	41.00
P_{26}	31.96	39.60	46.39	58.42	53.73	57.09	47.86
Over all mean	S_0: 28.43	S_{30}: 44.28	S_{60}: 43.37		Mo_0: 36.22	Mo_1: 41.16	
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo:
	4.23	4.23	7.35	3.46	NS	NS	1.04
	P uptake by grain (kg/ha)						
P_0	0.39	0.59	1.39	1.52	2.05	2.21	1.36
P_{13}	1.30	1.75	1.72	2.26	2.17	2.06	1.70
P_{26}	1.45	1.98	2.16	3.77	2.47	2.28	2.35
Over all mean	S_0: 1.24	S_{30}: 2.13	S_{60}: 2.04	Mo_0: 1.57	Mo_1: 2.05		
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo:
	0.34	0.34	0.60	0.28	NS	NS	0.86
	S uptake by grain (kg/ha)						
P_0	0.89	0.75	2.63	2.19	2.28	1.86	1.77
P_{13}	1.86	1.84	2.79	2.94	4.56	3.80	2.96
P_{26}	2.81	2.08	2.51	3.90	6.23	5.73	3.88
Over all mean	So: 22.20	S30: 24.89	S60: 25.78		Mo0: 23.55	Mo1: 25.03	
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo:
	1.51	1.51	2.60	1.23	2.10	2.10	3.69
	Mo uptake (g/ha)						
P_0	5.05	8.97	9.30	17.62	11.88	12.84	10.94
P_{13}	8.80	17.68	12.36	23.16	19.99	19.57	16.93
P_{26}	13.26	18.34	14.55	24.59	18.04	18.52	17.88
Over all mean	S_0: 12.02	S_{30}: 16.93	S_{60}: 16.80		Mo_0: 12.58	Mo_1: 17.92	
CD (P=0.05)	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo:
	1.92	1.92	NS	1.54	2.69	2.69	4.69

Table 3. Effect of sulphur, phosphorus and molybdenum on soil available nutrients (kg/ha) after harvest of blackgram

	S and Mo levels (kg/ha)						
P levels	S_0		S_{30}		S_{60}		Mean
(kg P/ha)	Mo_0	Mo_1	Mo_0	Mo_1	Mo_0	Mo_1	
	Available S						
P_0	4.93	7.39	8.00	9.93	10.21	8.39	8.14
P_{13}	7.39	9.74	12.54	14.93	14.90	13.74	12.21
P_{26}	7.44	9.74	14.93	16.93	15.39	14.93	13.23
Over all mean	S_0: 7.7	S_{30}: 12.88	S_{60}: 12.93		Mo_0: 10.64	Mo_1: 11.75	
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo:
	1.88	1.88	3.25	NS	NS	2.65	4.60
	Available P						
P_0	7.16	8.44	10.08	13.6	11.48	14.00	10.72
P_{13}	11.48	12.32	11.00	15.12	13.52	14.84	13.05
P_{26}	13.56	14.00	16.52	19.04	16.52	18.20	16.31
Over all mean	S_0: 11.16	S_{30}: 14.15	S_{60}: 14.76	Mo_0: 12.37	Mo_1: 14.35		
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo:
	1.58	1.58	2.74	1.29	NS	2.24	3.88
	Available Mo						
P_0	0.02	0.06	0.04	0.08	0.06	0.04	0.04
P_{13}	0.04	0.06	0.06	0.08	0.04	0.04	0.06
P_{26}	0.04	0.08	0.08	0.10	0.08	0.04	0.06
Over all mean	S_0: 0.04	S_{30}: 0.08	S_{60}: 0.04		Mo_0: 0.04	Mo_1: 0.06	
CD *(P=0.05)*	S:	P:	SxP:	Mo:	SxMo:	PxMo:	SxPxMo:
	0.004	0.004	0.007	0.003	NS	NS	0.01