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Interactive Effect of Cobalt, Boron and Molybdenum on Sulfur Uptake by Pea (*Pisum sativum* L.)

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Abstract

A pot experiment was conducted during the winter season of 2006-07 and 2007-08 to study the interactive effect of cobalt, boron and molybdenum on sulfur uptake by grain and straw in pea (*Pisum sativum* L.) at fertility levels F_1 (30 mg P_2O_5 + 20 mg S + 2.5 mg Zn, per kg soil) and F_2 (60 mg P_2O_5 140 mg S 15.0 mg Zn + 2 mg Col 1 mg Mo, per kg soil). Nitrogen 20 mg per kg and potassium (K_2O) 30 mg per kg were applied to all the pots at uniform rates. Folior application of boron was done after 45 and 60 days of sowing. The finding of the study reveals that treatment effect had significant superiority over control. Total uptake of sulfur by pea crop was found to be significantly enhanced by increasing levels of soil fertility. Cobalt, boron and molybdenum further enhanced it and remarkable effect was observed by their combined application. Interaction between fertility and micronutrient was also significant.
Key words : Micronutrient, Sulfur uptake, Grains, Straw, Pea.

Pulses, the cheapest source of protein alleviate various nutritional deficiencies besides helping in maintenance of soil health and sustenance of productivity of cropping system by increasing nutrient level. Pulses account for one fifth of total area under food grain crop and contribute about 1/12 of total food grain production in India with 35% of area and 27.1% of total production of world (1). Pea is highly nutritive and contains high proportion of digestive protein (28.5%), carbohydrates (62.1%), fat (1.8%) and minerals. Out of the total pulse area of 22.85 million ha in India peas are grown in 0.80 million ha with a production of 0.71 million tonnes and productivity of 895 kg per ha. Introduction of legume as a break crop in intensive rice-wheat system result in yield stability and restoration of soil fertility. A balanced nutrient supply is an important factor for complete growth and higher yield. Among micronutrients cobalt, boron and molybdenum are essential not only for plant growth but also for the growth of *Rhizobium*, promoting the biological nitrogen fixation. Cobalt forms Vitamin B_{12} during growth and development of symbiotic microorganism. It influences leghemoglobin metabolism and ribonucleotide reductase synthesis in *Rhizobium.* Boron boosts nodulation in legume, regulate water absorption and is essential for synthesis of ATP, DNA, RNA and pectins. It helps in absorption of nitrogen and is required for synthesis of amino acids and protein. It also regulates the carbohydrate required for synthesis of amino acids and protein. It regulates the carbohydrate metabolism and is required for the translocation of sugar and phosphorus. Molybdenum is pivotal for proper nodulation as it play an important role in nitrogenase and nitrate reductase activity involved in nitrogen fixation by root nodule bacteria of leguminous crop. Patnayak et al. (2) reported that use of cobalt as seed treatment at 0.008 mg/g of seed in green gram showed significant increase in nodule number, nodule weight and nitrogen concentration in nodule and leghaemoglobin content. Micronutrients also play a beneficial role in nutrition of microbial population of soil whose activity is directly related to productivity of crop. Study on integrated effect of various micronutrients at various soil fertility to promote sulphur fixation by legume is scare. Sulfur deficiency is becoming widespread due to continuous use of sulfur free fertilizers, coarse textured soil, low organic matter in soil, crop rotation including pulses and oil seeds, high yielding varieties, intensive multiple cropping

Table 1. Chemical analysis of the soil.

	Soil	2006-07	2007-08
1	pH	7.6	7.5
2	EC (milli mhos/cm)	0.28	0.39
3	$CaCO_3$ (%)	0.50	0.51
4	CEC mole (P+)/kg	12.75	12.72
5	Organic carbon (%)	0.34	0.36
6	Available N (kg/ha)	228	234
7	Available P (kg/ha)	19.0	19.5
8	Available K (kg/ha)	225	240
9	Available S (kg/ha)	15	18
10	Available Co (ppm)	0.1	0.1
11	Available B (ppm)	0.2	0.2
12	Available Mo (ppm)	0.08	0.08

system, high sulfur requiring crops leaching and erosion losses. Presently, sulfur deficiency is widespread in Indian soils and is on the rise. Singh (3) reported that addition of 40 kg/ha sulfur increased the pod yield of groundnut. The maximum yield was observed with sulfur application in soybean crop in medium block soil. Sulfur is the key nutrient responsible for higher productivity of soil seed and pulses in soils and responsible for synthesis of certain vitamin, protein, metabolism of carbohydrate and formation flavored compound in crucifers. Sulfur is a part every living cell, necessary for chlorophyll formation in plants leaves. It is a component of three essential amino acid viz. cystine, cysteine and methionine and promotes nodulation for biological nitrogen fixation in legume.

Methods

A pot experiment was conducted during winter season at agricultural research farm of Krishi Vigyan Kendra, Ghazipur, in 2006-07 and 2007-08. Certified seeds of pea variety Malviya-15 was used for the experiment. The pot experiment was conducted in a glass house, earthen pots are cleaned by fresh water and its outer and inner surfaces were colored by red and black paints respectively. The pots were filled with 10 kg field soil. Two fertility levels of soil F_1 and F_2 were maintained. Macronutrients, nitrogen at 20 mg/kg, potassium 30 mg (K_2O)/kg, and phosphorus 30 and 60 mg (P_2O_5) per kg and sulfur 20 and 40 mg per kg applied in F_1 and F_2 respectively. Micronutrient zinc 2.5 and 5 mg per kg, cobalt 0 and 2 mg per kg, molybdenum (ammonium molybdate) 0 and 1 mg/kg were applied at the time of sowing in F_1 and F_2 respectively. Foliar application of 0 and 0.3 mg/kg boron was done after 45 and 60 days of sowing. Weeding and irrigation was done as and when required.

Soil samples were taken from each earthen pot for analysis before cropping from depth of 0—15 cm. Collected soil samples were brought to the laboratory, air-dried, ground and passed through 2 mm mesh sieve for analysis. The samples were analyzed for various physico-chemical properties (4). The soil was alluvial sandy loam with slightly alkaline pH 7.6 and 7.5, low in organic content 0.34 and 0.36%, available nitrogen 228 and 234 kg/ha, phosphorus 19 and 19.5

Table 2. Effect of Co, B and Mo at different fertility status on uptake of S by grains of pea.

	Sulfur uptake (mg per pot)					
	2006-07			2007-08		
Micronutrients	F_1	F_2	Average	F_1	F_2	Average
Control	320.99	341.74	331.36	338.76	420.60	379.68
Co 2 ppm	497.13	530.59	513.86	547.95	641.41	594.68
B 0.3%	479.00	510.87	494.93	529.82	621.74	575.78
Mo 1 ppm	489.32	522.94	506.13	538.81	628.62	583.71
Co 2 ppm B 0.3%	504.38	536.78	520.58	557.01	652.14	604.58
Co 2 ppm + Mo 1 ppm	519.56	553.10	536.33	571.11	659.43	615.27
B 0.3% + Mo 1 ppm	497.20	528.33	512.76	549.34	637.93	593.63
Co 2 ppm + B 0.3% + Mo 1 ppm	535.26	566.60	550.93	589.16	676.23	632.69
Mean	459.47	491.19	475.33	504.91	595.61	550.26
Absolute control	258.62	–	–	279.69	–	–
Comparison between	SE ±		CD (P=0.05)	SE ±		CD (P=0.05)
Means of fertility	4.54		12.85	6.86		19.42
Means of micronutrients	4.54		12.85	6.86		19.42
Interaction F × M	6.42		18.17	9.71		27.46
Treatment vs Control	12.85		36.34	19.42		54.92

Table 3. Effect of Co, B and Mo at different fertility status on uptake of S by straw of pea.

Micronutrients	Sulfur uptake (mg per pot) 2006-07 F_1	F_2	Average	2007-08 F_1	F_2	Average
Control	313.92	333.76	323.84	330.65	410.32	370.49
Co 2 ppm	483.41	518.06	500.74	534.19	625.34	579.77
B 0.3%	465.82	498.37	482.09	516.63	606.18	561.41
Mo 1 ppm	475.59	510.13	492.86	525.37	612.82	569.09
Co 2 ppm + B 0.3%	489.33	523.00	506.16	543.06	635.81	589.43
Co 2 ppm + Mo 1 ppm	503.78	539.27	521.53	556.79	642.81	599.80
B 0.3% + Mo 1 ppm	482.07	515.14	498.60	535.63	621.85	578.74
Co 2 ppm + B 0.3% + Mo 1 ppm	516.63	552.28	534.45	574.37	659.19	616.78
Mean	447.43	479.68	463.56	492.35	580.74	536.55
Absolute control	252.22	–	–	272.47	–	–
Comparison between	SE ±		CD (P=0.05)	SE ±		CD (P=0.05)
Means of fertility	4.54		12.83	6.85		6.70
Means of micronutrients	4.54		12.83	6.85		6.70
Interaction F × M	6.42		18.15	9.69		9.48
Treatment vs Control	12.83		36.30	19.39		18.95

kg/ha and available potassium 225 and 240 kg/ha in 2006-07 and 2007-08 respectively (Table 1).

The sulfur uptake by grain and straw were expressed in mg per pot in relation to dry matter production and phosphorus content was calculated by using formula

$$\text{Sulfur uptake (mg/pot)} = \frac{\text{Sulfur content in dry matter (\%)} \times \text{yield of dry matter}}{100} \times 1000$$

Results and Discussion

Data on sulfur uptake by grain in pea are presented in Table 2, which shows that treatment effect has significant superiority over absolute control. Treatment showed 50.23 and 60.78% more sulfur uptake per pot by grain than absolute control during 2006-07 and 2007-08 respectively. Data reveal that fertility level showed significant impact on sulfur uptake by grain per pot during both the years of study.

Table 4. Effect of Co, B and Mo at different fertility status on total uptake of S by of pea.

Micronutrients	Sulfur uptake (mg per pot) 2006-07 F_1	F_2	Average	2007-08 F_1	F_2	Average
Control	634.91	675.50	655.20	669.41	830.93	750.17
Co 2ppm	980.54	1048.65	1014.60	1082.14	1266.75	1174.45
B 0.3%	944.82	1009.23	977.03	1046.45	1227.92	1137.18
Mo 1 ppm	964.90	1033.07	998.99	1064.17	1241.43	1152.80
Co 2 ppm + B 0.3%	993.71	1059.78	1026.74	1100.07	1287.95	1194.01
Co 2 ppm + Mo 1 ppm	1023.34	1092.37	1057.86	1127.90	1302.24	1215.07
B 0.3% + Mo 1 ppm	979.27	1043.46	1011.37	1084.97	1259.77	1172.37
Co 2 ppm + B 0.3% + Mo 1 ppm	1051.89	1118.88	1085.38	1163.53	1335.42	1249.47
Mean	906.90	970.87	938.89	997.26	1176.35	1086.81
Absolute control	510.85	–	–	552.16	–	–
Comparison between	SE ±		CD (P=0.05)	SE ±		CD (P=0.05)
Means of fertility	9.06		25.64	13.56		38.37
Means of micronutrients	9.06		25.64	13.56		38.37
Interaction F × M	12.82		36.25	19.18		54.26
Treatment vs Control	25.64		72.51	38.37		108.52

The F_2 fertility level recorded 6.69 and 18.09% more sulfur uptake by grain than F_1 level in 2006-07 and 2007-08 respectively.

The significant impact of micronutrients was also observed at the both fertility doses during both the years of study. Sulfur uptake by grain increased by 55.07, 49.36, 52.74, 57.10, 61.85, 54.74 and 66.26% during 2006-07 and by 56.62, 51.64, 53.73, 59.23, 62.04, 56.52 and 66.63% during 2007-08 by the application of Co, B, Mo, Co + B, Co + Mo, B + Mo, Co + B + Mo, over control.

Data on sulfur uptake by straw per pot are presented in Table 3. The data show that treatment effect was significantly superior over absolute control. Treatment showed 50.24 and 60.94% more sulfur than absolute control during 2006-07 and 2007-08 respectively. Fertility effect was also significant and application of F_2 level of phosphorus : sulfur : zinc per kg soil caused 7.19 and 18.08% more sulfur per pot than F_1 level of phosphorus : sulfur : zinc per kg soil appplication during 2006-07 and 2007-08 respectively. Application of micronutrients also showed significant impact on sulfur uptake by straw of pea per pot. Increased uptake of sulfur per pot over control due to application of Co, B, Mo, Co+B, Co+Mo, B+Mo, Co+B+Mo was 54.62, 48.68, 52.19, 56.29, 61.04, 53.96 and 65.03% during 2006-07 and 56.48, 51.53, 53.60, 59.09, 61.89, 56.20 and 66.47% respectively during 2007-08. Total sulfur uptake by crop per pot as influenced by micronutrients under different fertility levels along with absolute control are presented in Table 4. The data on treatment effect showed significant superiority over absolute control. Treatment removed 50.24 and 60.86% more sulfur per pot than absolute control during 2006-07 and 2007-08 respectively. At F_2 fertility level 7.04 and 18.09% more sulfur uptake was recorded than F_1 level during 2006-07 and 2007-08 respectively. The significant impact of micronutrient was also observed at both fertility doses during both the years. Total sulfur uptake increased by 54.85, 49.11, 52.47, 56.70, 61.45, 54.36 and 65.65% during 2006-07 and by 56.55, 51.88, 53.67, 59.16, 61.97, 56.28 and 56.55% during 2007-08 by the application of Co, B, Mo, Co+B, Co+Mo, B+Mo, Co+B+Mo over control.

These results corroborate with the findings of Singh et al. (5) who reported that the uptake of N, P, K and S increased with the rate of S application in pea. Sharma and Kamath (6) also reported increased sulfur uptake by the application macronutrients.

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