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Interactive Effect of Cobalt, Boron and Molybdenum on Phosphorus 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 pea crop (*Pisum sativum* L.) at fertility level 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 + 40 mg S + 5.0 mg Zn per kg soil) on phosphorus uptake by grain, phosphorus uptake by straw and total phosphorus uptake by crop. The finding reveals that total uptake of phosphorus by pea crop was significant and is enhanced with the increasing level of soil fertility. Micronutrient application remarkably enhanced phosphorus uptake ; 68.6% increase in phosphorus uptake over absolute control was recorded with the addition of various nutrients in soil.
Key words : Micronutrient, Phosphorus uptake, Grains, Straw.

To fulfill the food and nutrition demand of growing population we need to improve the soil fertility and soil productivity. This can be achieved by adopting good management package and practices. Pulses are the rich source of protein and are major component of human meals in India. Pulses help in improving the soil health and nitrogen status by fixing the atmospheric nitrogen. In rice-wheat cropping system, introduction of legume crop i.e. pea, as a break crop, improve the yield stability and restoration of soil fertility. In India pea are grown in 0.80 million ha area with a production of 0.71 million tones and the productivity of 895 kg/ha. This is comparatively less than developed countries due to inadequate management of balanced nutrient status, lack of high yielding disease and pest resistant varieties, water management, weed management. Among the factors that affect the productivity of pea, supply of balanced nutrient may play an important role in minimizing the present gap between yield achieved and yield achievable. It is observed that the cobalt, boron and molybdenum promotes root growth and more number of symbiotic *Rhizobium* bacteria. Boron helps in the translocation of sugar synthesized by leaves through photosynthetic activity resulting increased number of nodules and better development of nodules. Cobalt increases the synthesis of vitamin B_{12} in microorganism, promoting their efficiency of atmospheric nitrogen fixation. Molybdenum being constituent of nitrogenase enzyme, acts as catalyst enhancing the rate of atmospheric fixation by *Rhizobium* bacteria. Among macronutrients phosphorus is an important constituent of energy molecules and nucleic acids. It promotes the growth of root systems hence it helps in providing suitable site for nodulation. Thus its promotes the biological nitrogen fixation and plays its role by providing energy needed for nitrogen fixation, nucleic acid synthesis and seat of biological nitrogen fixation. At present about 48.1% of Indian soils are deficient in deithylene-triamine

Table 1. Chemical analysis of the soil.

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

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

	Phosphorus uptake (mg per pot)					
	2006-07			2007-08		
Micronutrients	F_1	F_2	Average	F_1	F_2	Average
Control	376.89	413.10	395.00	419.71	525.37	472.54
Co 2ppm	582.26	613.73	598.00	624.64	731.27	677.96
B 0.3 %	564.76	592.57	578.66	607.36	712.85	660.11
Mo 1 ppm	569.80	598.87	584.34	611.95	713.88	662.92
Co 2 ppm + B 0.3%	592.54	626.16	609.35	635.03	743.79	689.41
Co 2 ppm + Mo 1 ppm	599.21	628.64	613.92	640.22	739.08	689.65
B 0.3% + Mo 1 ppm	578.83	604.31	591.57	621.66	721.89	671.78
Co 2 ppm + B 0.3% + Mo 1 ppm	616.16	644.57	630.37	655.23	752.00	703.61
Mean	539.90	570.02	554.96	582.12	687.48	634.80
Absolute control	304.82	–	–	359.56	–	–

Comparison between	SE ±	CD (P = 0.05)	SE ±	CD (P = 0.05)
Means of fertility	5.20	14.72	8.72	24.66
Means of micronutrients	5.20	14.72	8.72	24.66
Interaction F × M	7.36	20.82	12.33	34.88
Treatment vs Control	14.72	41.63	24.66	69.76

penta acetate (DTPA) extractable zinc, 11.2% in iron, 7% in copper and 5.1% in manganese. Apart from the deficiency of these micronutrients, deficiencies of boron and molybdenum have also been reported in some areas (1). In Indo-Gangetic plains, the prevalent rice-when system, has resulted in over- exploitation of the natural soil resource base, which is further enhanced by imbalanced use of various inputs. Continued emphasis on maximization of food grain production without appropriate management practice from a shrinking land resource base has resulted in further depletion of micronutrient reserves (2). Introduction of legume as a break crop in intensive rice-wheat system is expected to bring about yield stability and res-

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

	Phosphorus uptake (mg per pot)					
	2006-07			2007-08		
Micronutrients	F_1	F_2	Average	F_1	F_2	Average
Control	274.18	310.71	292.44	324.40	402.75	363.57
Co 2 ppm	474.93	498.43	486.68	515.80	603.88	559.84
B 0.3%	459.90	482.39	471.14	499.90	586.66	543.28
Mo 1 ppm	465.08	490.34	477.71	504.31	588.11	546.21
Co 2 ppm + B 0.3%	483.31	507.75	495.53	525.14	615.04	570.09
Co 2 ppm + Mo 1 ppm	487.01	516.66	501.83	529.14	610.58	569.86
B 0.3% + Mo 1 ppm	473.01	499.69	486.35	513.96	596.70	555.33
Co 2 ppm + B 0.3% + Mo 1 ppm	499.32	535.10	517.21	543.49	623.63	583.56
Mean	435.81	460.28	448.04	476.43	562.04	519.24
Absolute control	213.65	–	–	262.88	–	–

Comparison between	SE ±	CD (P = 0.05)	SE ±	CD (P = 0.05)
Means of fertility	4.29	12.13	6.55	18.52
Means of micronutrients	4.29	12.13	6.55	18.52
Interaction F × M	6.07	17.16	9.26	26.18
Treatment vs Control	12.13	34.31	18.52	52.37

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

	Phosphorus uptake (mg per pot)					
	2006-07			2007-08		
Micronutrients	F_1	F_2	Average	F_1	F_2	Average
Control	651.08	723.81	687.44	722.10	896.83	809.46
Co 2 ppm	1057.18	1112.16	1084.67	1140.44	1335.14	1237.79
B 0.3%	1024.66	1074.95	1049.81	1107.26	1299.51	1203.39
Mo 1 ppm	1034.88	1089.22	1062.05	1116.27	1301.99	1209.13
Co 2 ppm + B 0.3%	1075.85	1133.91	1104.88	1160.17	1358.84	1259.50
Co 2 ppm + Mo 1 ppm	1086.21	1145.30	1115.76	1169.36	1349.65	1259.51
B 0.3% + Mo 1 ppm	1051.84	1104.01	1077.92	1135.62	1318.58	1227.10
Co 2 ppm + B 0.3% + Mo 1 ppm	1115.48	1179.67	1147.58	1198.71	1375.63	1287.17
Mean	975.71	1030.30	1003.00	1055.80	1245.61	1150.71
Absolute control	518.47	–	–	600.05	–	–

Comparison between	SE ±	CD (P = 0.05)	SE ±	CD (P = 0.05)
Means of fertility	9.45	26.73	14.47	40.92
Means of micronutrients	9.45	26.73	14.47	40.92
Interaction F × M	13.37	37.80	20.46	57.87
Treatment vs Control	26.73	75.61	40.92	115.74

toration of soil fertility (3, 4). Pea crop has been tried successfully in different locations for this purpose. Review of past works reveals dearth of information on integrated effect of micronutrients on growth and yield performance of leguminous plants. Present study was made to assess the effect of integrated application of boron, molybdenum and cobalt at graded soil fertility levels on phosphorus uptake by pea plants.

Methods

A pot experiment was conducted during winter season at agricultural research farm of Krishi Vigyan Kendra, Ghazipur, in the year of 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. Macro nutrients, 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 were 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 (5). 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 kg/ha and available potassium 225 and 240 kg/ha in 2006-07 and 2007-08 respectively (Table 1).

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

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

Results and Discussion

Data on phosphorus uptake by grain in pea are presented in Table 2, which shows that treatment effect has significant superiority over absolute control. Treatment showed 48.88 and 65.85% more phosphorus uptake per pot by grain than absolute control during 2006-07 and 2007-08 respectively. The F_2 fertility level recorded 5.66 and 18.12% more phosphorus uptake per pot by grain than F_1 level during 2006-07 and 2007-08 respectively.

The significant impact of micronutrients was also observed in the both fertility doses during both the years of study. Phosphorus uptake by grain increased by 51.39, 46.49, 47.93, 54.26, 55.42, 49.76 and 59.58% during 2006-07 and by 43.47, 39.69, 40.28, 45.89, 45.94, 42.16 and 48.89% during 2007-08 due to a application of Co, B, Mo, Co+B, Co + Mo, B + Mo, Co+B, Mo, over control.

Phosphorus uptake by straw of pea are presented in Table 3. It is obvious that treatment effect is significantly superior over absolute control. Treatment showed 71.18 and 61.47% more phosphorus uptake 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 5.76 and 18.10% more uptake of phosphorus per pot than F_1 level of phosphorus : sulfur : zinc per kg soil application during 2006-07 and 2007-08 respectively. Application of micronutrients also showed significant impact on phosphorus uptake by straw of pea per pot. Increased uptake of phosphorus per pot over control due to application of Co, B, Mo, Co+B, Co+Mo, B+Mo, Co+B+Mo was 66.42, 61.10, 63.35, 69.37, 71.60, 66.30 and 76.86% during 2006-07 and 53.98, 49.42, 50.23, 56.80, 64.16, 52.74 and 60.50% respectively during 2007-08.

Total phosphorus uptake by crop in pea is presented in Table 4. Data showed that treatment effect had significant superiority over absolute control. 58.07 and 56.79% more phosphorus uptake per pot was observed in the treatment than absolute control during 2006-07 and 2007-08 respectively.The fertility level showed significant impact on total phosphorus uptake per pot during both the years. At F_2 fertility level 5.71 and 18.11% more phosphorus 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 of study. Total phosphorus uptake increased by 57.78, 52.71, 54.49, 60.72, 62.32, 56.80 and 66.93% during 2006-07 and by 92.91, 48.66, 49.37, 55.59, 55.59, 51.59 and 59.01% during 2007-08 due to application of Co, B, Mo, Co+B, Co+Mo, B+Mo, Co+B+Mo over control.

Further, fertility level showed significant impact on phosphorus uptake by grain, straw and crop per pot during both the years. The F_2 fertility level removed more phosphorus than at F_1 level in both the years. The significant impact of micronutrients was also observed at both fertility doses during both the years. Total phosphorus uptake increased significantly due to application of Co, B and Mo. These results corroborate with the findings of Kumar et al. (6) who reported that application of P and Mo alone and in combination causes increase in the content uptake of Mo and P in lentil.

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