

Effect of Cobalt, Boron and Molybdenum on Nitrogen 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 effect of cobalt, boron and molybdenum on nitrogen uptake by grain and straw in pea (*Pisum sativum* L.) at fertility level F₁ (30 mg P₂O₅ + 20 mg S + 2.5 mg Zn, per kg soil) and F₂ (60 mg P₂O₅ + 40 mg S + 5.0 mg Zn + 2 mg Co + 1 mg Mo, per kg soil). Nitrogen 20 mg per kg and potassium (K₂O) 30 mg per kg were applied to all the pots at uniform rates. Foliar application of boron was done after 45 and 60 days of sowing. The study reveals that treatment effect had significant superiority over control. Nitrogen uptake by pea crop was remarkably influenced by increasing levels of soil fertility. Increasing uptake was found to the extent of 45.4 and 60.5% at F₁ and F₂ levels of fertility over absolute control. Uptake of nitrogen was increased by 20.5, 16.6 and 17.4% over control with the application of cobalt, boron and molybdenum respectively. 68.6 percent increase in nitrogen uptake over absolute control was recorded with the addition of various nutrients in soil.

Key words : Micronutrients, Nitrogen uptake, Grains, Straw.

Nitrogen, one of major nutrient needed by the organisms for protein and nucleic acid synthesis. Although nitrogen is present in the atmosphere about 80% by volume but if it is to be absorbed by the plants, it is to be fixed in ammonium form. Nitrogen fixation is done efficiently by some specific microorganisms. The most common symbiont capable of fixing nitrogen are *Rhizobium* and leguminous plant. Field pea (*Pisum sativum* L.), a premium pulse crop, is one of the cheapest sources of dietary protein. Being an able symbiont for nitrogen fixation it improves soil fertility, useful in any viable cropping system and important for biogeochemical cycling of nitrogen and other nutrients. Among micronutrients, cobalt, boron and molybdenum are essential for the growth of *Rhizobium* and nitrogen fixation. An adequate boron boosts nodulation in legumes, regulates water absorption and is essential for synthesis of ATP, DNA, RNA and pectin. Boron helps in absorption of nitrogen and is required for synthesis of amino acids and protein. It regulates carbohydrates metabolism and is necessary for the translocation of sugar, phosphorus. An adequate availability of molybdenum in addition to cobalt and boron is pivotal

for proper nodulation and higher yield of pea, as it plays an important role for the activity of enzymes, viz. nitrogenase and nitrate reductase. Cobalt is essential for microorganism fixing atmospheric nitrogen. It forms vitamin B₁₂ during growth and development of symbiotic nitrogen fixing microorganisms. At present about 48.1% of Indian soils are deficient in diethylene-triamine penta acetate (DTPA) extractable zinc, 11.2% in iron, 7% in copper and 5.1% in manganese. Apart from the deficiency of these mi-

Table 1. Chemical analysis of the soil.

Soil	2006-07	2007-08
pH	7.6	7.5
EC (milli mhos/cm)	0.28	0.39
CaCO ₃ (%)	0.50	0.51
CEC mole (P+)/ kg	12.75	12.72
Organic carbon (%)	0.34	0.36
Available N (kg/ha)	228	234
Available P (kg/ha)	19.0	19.5
Available K (kg/ha)	225	240
Available S (kg/ha)	15	18
Available Co ppm	0.1	0.1
Available B ppm	0.2	0.2
Available Mo ppm	0.08	0.08

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

Micronutrients	Nitrogen uptake (mg per pot)					
	2006-07			2007-08		
	F ₁	F ₂	Average	F ₁	F ₂	Average
Control	2811.42	2975.71	2893.57	2909.25	3594.38	3251.82
Co 2 ppm	4174.78	4388.47	4281.62	4512.22	5204.27	4858.24
B 0.3%	4037.44	4240.67	4139.05	4376.71	5061.71	4719.21
Mo 1 ppm	4082.08	4308.12	4195.10	4407.50	5080.16	4743.83
Co 2 ppm + B 0.3%	4236.97	4435.44	4336.20	4587.02	5283.54	4935.28
Co 2 ppm + Mo 1 ppm	4280.28	4494.90	4387.59	4616.23	5255.44	4935.84
B 0.3% + Mo 1 ppm	4141.69	4337.69	4239.69	4485.27	5138.23	4811.75
Co 2 ppm + B 0.3% + Mo 1 ppm	4377.77	4550.09	4463.93	4725.13	5321.92	5023.53
Mean	3881.06	4092.35	3986.70	4180.38	4868.31	4524.34
Absolute control	2290.36	—	—	2468.65	—	—
Comparison between	SE ±	CD (P = 00.5)		SE ±	CD (P = 0.05)	
Means of fertility	37.01	104.67		56.44	159.64	
Means of micronutrients	37.01	104.67		56.44	159.64	
Interaction F × M	52.33	148.02		79.82	225.77	
Treatment vs control	104.67	296.05		159.64	451.53	

ronutrients, deficiencies of boron and molybdenum have also been reported in some areas (1). In Indo-Gangetic plains, the prevalent rice-wheat 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 practices from a shrinking land re-

source base has resulted in further depletion of micronutrient reserves (2). Introduction of legume as break crop in intensive rice-wheat system is expected to bring about yield stability and restoration of soil fertility (3, 4). Pea crop has been tried successfully in different locations for this purpose. However, among many factors that govern its success, supply of balanced nutrient, is of prime importance. Review of pre-

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

Micronutrients	Nitrogen uptake (mg per pot)					
	2006-07			2007-08		
	F ₁	F ₂	Average	F ₁	F ₂	Average
Control	1928.42	2046.84	1987.63	1984.72	2458.78	2221.75
Co 2 ppm	2927.98	3126.16	3027.07	3168.38	3716.76	3442.57
B 0.3%	2824.15	2999.58	2911.86	3066.35	3590.86	3328.60
Mo 1 ppm	2835.40	3034.75	2935.07	3066.75	3583.25	3325.00
Co 2 ppm + B 0.3%	2973.60	3168.70	3071.15	3231.65	3798.09	3514.87
Co 2 ppm + Mo 1 ppm	2998.30	3201.75	3100.02	3246.47	3758.33	3502.40
B 0.3% + Mo 1 ppm	2874.49	3064.48	2969.49	3127.91	3642.06	3384.99
Co 2 ppm + B 0.3% + Mo 1 ppm	3051.41	3249.33	3150.37	3321.23	3822.29	3571.76
Mean	2704.64	2883.53	2794.09	2912.48	3430.95	3171.71
Absolute control	1554.25	—	—	1676.12	—	—
Comparison between	SE ±	CD (P = 0.05)		SE ±	CD (P = 0.05)	
Means of fertility	28.26	79.93		40.29	113.95	
Means of micronutrients	28.26	79.93		40.29	113.95	
Interaction F × M	39.97	113.04		56.98	161.15	
Treatment vs control	79.93	226.08		113.95	322.30	

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

Micronutrients	Nitrogen uptake (mg per pot)					
	2006-07			2007-08		
	F ₁	F ₂	Average	F ₁	F ₂	Average
Control	4739.84	5022.55	4881.19	4893.98	6053.17	5473.57
Co 2 ppm	7102.76	7514.62	7308.69	7680.59	8921.03	8300.81
B 0.3%	6861.58	7240.25	7050.92	7443.06	8652.57	8047.81
Mo 1 ppm	6917.48	7342.87	7130.18	7474.25	8663.41	8068.83
Co 2 ppm + B 0.3%	7210.57	7604.13	7407.35	7818.67	9081.63	8450.15
Co 2 ppm + Mo 1 ppm	7278.57	7696.65	7487.61	7862.70	9013.77	8438.24
B 0.3% + Mo 1 ppm	7016.18	7402.18	7209.18	7613.18	8780.29	8196.74
Co 2 ppm + B 0.3% + Mo 1 ppm	7429.18	7799.41	7614.29	8046.37	9144.21	8595.29
Mean	6585.71	6975.88	6780.79	7092.86	8299.26	7696.06
Absolute control	3844.62	—	—	4144.77	—	—
Comparison between	SE ±		CD (P = 0.05)	SE ±		CD (P = 0.05)
Means of fertility	64.69		182.97	96.30		272.39
Means of micronutrients	64.69		182.97	96.30		272.39
Interaction F × M	91.48		258.75	136.20		385.22
Treatment vs control	182.97		517.51	272.39		770.44

vious works reveals dearth of information on integrated effect of micronutrients on growth and yield performance of leguminous plants. Therefore it is of interest to see how an integrated application of boron, molybdenum and cobalt at graded soil fertility levels affects the nitrogen 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 were cleaned by fresh water and its outer and inner surfaces were colored by red and black paints respectively. The pots were filled 10 kg field soil. Two fertility levels of soil F₁ and F₂ were maintained. Macro nutrients, nitrogen 20 mg/kg, potassium 30 mg (K₂O)/kg, and phosphorus 30 and 60 mg (P₂O₅) per kg and sulfur 20 and 40 mg per kg were applied in F₁ and F₂ 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 F₁ and F₂ 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 (5). The soil was alluvial sandy loam with slightly alkaline pH, 7.6 and 7.5, low in organic carbon 0.34% and 0.36% available nitrogen, 228 kg/ha and 234 kg/ha, phosphorus 19 kg/ha and 19.5 kg/ha and available potassium 225 kg/ha and 240 kg/ha in 2006-07 and 2007-08 respectively (Table 1).

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

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

Results and Discussion

Data on nitrogen uptake by grain in pea are presented in Table 2, which shows that treatment effect had significant superiority over absolute control. Treatment showed 42.41 and 49.91% more nitrogen

uptake by grain per pot than absolute control during 2006-07 and 2007-08 respectively. The F_2 fertility level showed 5.45 and 16.61% more nitrogen uptake by grain 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. Nitrogen uptake by grain increased by 47.97, 43.04, 44.98, 49.85, 51.63, 46.52 and 54.27% during 2006-07 and 49.40, 45.12, 45.88, 51.76, 51.78, 47.97 and 54.48% during 2007-08 due to a application of Co, B, Mo, Co + B, Co+Mo, B+Mo, Co+B, Mo, over control.

Nitrogen uptake by straw of pea is presented in Table 3. The data show that treatment effect was significantly superior to absolute control. Treatment has 47.01 and 54.70% more nitrogen 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 removed 6.60 and 17.93% more nitrogen 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 nitrogen uptake by straw of pea per pot. Increased uptake of nitrogen per pot over control by the application of Co, B, Co+B, Co +Mo, B+Mo, Co+B+Mo was 52.30, 46.50, 47.67, 54.51, 55.97, 49.40 and 58.50% during 2006-07 and 54.95, 49.82, 49.66, 58.20, 57.64, 52.36 and 60.76% respectively during 2007-08.

Total nitrogen uptake by crop in pea is presented in Table 4. The treatment effect had significant superiority over absolute control ; 44.27 and 51.81% more nitrogen uptake per pot was observed in the treatment than absolute control during 2006-07 and 2007-08 respectively. An examination of data given in the table reveals that fertility level showed significant impact on total nitrogen uptake per pot during both the years of investigation. At F_2 fertility level 5.93 and 17.15% more nitrogen uptake was observed than at 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 nitrogen uptake increased by 49.73, 44.45, 46.07, 51.75, 53.39, 47.69 and 55.90% during 2006-07 and by 51.65, 47.03, 47.41, 54.38, 54.16, 49.75 and 57.03% during 2007-08 due to application of Co, B, Mo, Co+B, Co+Mo, B+Mo, Co+B+Mo over control. Total nitrogen uptake in-

crease was significant by the application of Co, B and Mo.

Nitrogen requirement of pulse crop is much higher as compared to cereals as these are rich in protein content, but these are mostly grown under deficient available soil nitrogen condition without supplying nitrogen through fertilizer. These have to depend upon acquisition of atmospheric nitrogen for meeting out their nitrogen requirement. It is therefore imperative to harness maximum atmospheric nitrogen through symbiotic microbial fixation by creating congenial and favourable condition for their efficient performance. Boron has been applied to enhance the translocation of sugar synthesized in leaves to the roots and nodules to be used as source of energy by symbiotic microbes. Similarly cobalt has been used to promote the synthesis of vitamin B_{12} by the symbiotic microbes and to enhance the efficiency of atmospheric nitrogen fixation. Molybdenum has acted as a catalyst in the process of reduction of atmospheric elemental nitrogen into NH_4^+ with the help of nitrogenase enzyme. All these nutrients management has helped to higher acquisition of atmospheric nitrogen in nodule by symbiotic microbes making it available to the plant and resulting into higher uptake by pea crop. These results corroborate with the finding of Subbian and Ramiah (6).

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