Effect of Phosphorus, Molybdenum and Cobalt Nutrition on Yield and Quality of Mungbean (*Vigna radiata* L.) in Acidic Soil of Northeast India

T. Alben Awomi[1], A. K. Singh[1], Manoj-Kumar[2 *], L. J. Bordoloi[2]

ABSTRACT

Phosphorus (P), molybdenum (Mo) and cobalt (Co) deficiencies often reduce crop productivity and quality on acidic soils, with the legumes being more susceptible. A field experiment was conducted to evaluate the effect of P, Mo and Co nutrition on crop growth, yield and quality of mungbean grown in a acidic soil (pH 4.5) of northeast India. Increasing doses of nutrients significantly increased the growth, yield attributes, yield and quality traits of mungbean. Application of 60 kg P_2O_5/ha resulted in maximum growth attributes and number of nodules, leading to 36.5, 19 and 7.5% higher grain yield (426 kg/ha) over control (272 kg/ha), 20 (345kg/ha) and 40 kg P_2O_5 (394 kg/ha) treatments, respectively. Mungbean showed maximum growth and yield with application of 1.5 kg Mo/ha; the yield was 31.9 and 5.4% higher than the control (272 kg/ha) and 0.75 kg Mo/ha (378 kg/ha) treatments, respectively. The grain yield at 1.0 kg Co/ha (395 kg/ha) was 31and 3 % higher than that in control and 0.5 kg Co/ha treatment, respectively. Protein content, protein yield and NPK uptake increased with increasing levels of P, Mo and Co application. We conclude that P, Mo and Co application can significantly improve yield and quality of mungbean in acidic soils of northeast India.

Keywords: Micronutrient deficiency, Northeast India, Pulse productivity, Soil acidity

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one of the protein rich major pulse crops grown in India. It has special importance in intensive crop production system of the country for its short growing period. Although grain legumes are a major source of protein and iron for the rural poor, their production is not keeping pace with the rising demand. Mungbean is a popular pulse in the diet and consumed in combination with cereals because it is easily digestible, free from flatulence, rich in protein (20-24%) and iron (6mg/100 g of dry seed), and easy to cook (Thirumaran and Seralathan 1988). Sprouted mungbean contains ascorbic acid (vitamin C) and the increased amount of riboflavin and thiamine. Being a short duration crop, it fits well in many intensive crop rotations, prevents soil erosion, fixes atmospheric nitrogen (N) through *Rhizobial* symbiosis and helps in improving soil fertility.

Pulses are generally grown in soils with low fertility or with application of low quantities of organic and inorganic plant nutrients, which has resulted in deterioration of soil health and low crop productivity (Kumpawat 2010). Mungbean contributes 14% in total pulse area and 7% in total pulse production in India. The low productivity of mungbean may be due to nutritional deficiency in soil and imbalanced external fertilization. The productivity of mungbean can be increased by inoculation with *Rhizobium* culture and phosphate-solubilizing bacteria. For legume, N is more useful because it is the main component of amino acid and protein. Like other leguminous crops, N requirement is substantially fulfilled from symbiotic N fixation through *Rhizobium*. The N fixation process is influenced by many factors, and P availability is one of them. Rhizobial activities and N fixation is depressed without adequate P supply. P promotes early root formation and the formation of lateral, fibrous and healthy roots, which is

[1]School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland -797106
[2]ICAR Research Complex for NEH Region, Umiam, Meghalaya -793 103
* Corresponding author's E-mail: mkumar_iari@yahoo.co.in

important for nodule formation and fixation of atmospheric N. Application of P along with *Rhizobium* inoculants has been reported to influence nodulation and N fixation in legume crops (Solaiman and Habibullah 1990). Since P deficiency results in reduced symbiotic N fixation, P fertilization usually result in enhanced nodule number and mass, as well as greater N_2 fixation activity per plant (Seraj and Gyamfi 2004). Mo plays a vital role in N fixation process by *Rhizobium* and is responsible for the formation of nodule tissue and increased N fixation (Sharma et al.1988). Mo is structural component of nitrogenase enzyme, which is important for N fixation by *Rhizobium* in the root-nodules of leguminous crops. Mo is also essential for absorption and translocation of Fe in plants. Significant increase in nodulation, N content and yield of soybean was reported by Laltlanmawia et al. (2004) by application of Mo in acid soils of Nagaland. Co is a constituent of cobalamine coenzyme and is required for formation of leghaemoglobin in N fixation. Bacteria on root nodules of legumes require Co to synthesize B_{12} and fix N from air. Co also promotes many developmental processes including stem and coleoptile elongation, opening of hypocotyls, hooks, leaf disc expansion, etc. (Kandil 2007). The specific cobalamine dependent enzyme systems in *Rhizobium,* which may account for the influence of Co on nodulation and Nfixation are: methionine synthase, ribonucleotidereductase and methylmalonyl co-enzyme A mutase (Das 2000). Under condition of Co deficiency, methionine synthesis is depressed which leads to lower synthesis of hemeprotein (iron porphyrins) in the bacteriods. Co seed treatment along with *Rhizobium* culture increased the yield of legumes to a great extent (Singh and Singh 2010). The soils of north-eastern India are highly acidic in nature which are low in available P and Mo, and have high phosphate fixation capacity. At low pH values, the $HMoO_4$ is absorbed by silicate clays and oxides of Fe and Al through ligand exchange with hydroxide ions on the surface of the colloidal particles. Since limited work has been carried out on P, Mo and Co nutrition of mungbean, the present investigation was undertaken to study the growth, yield and quality of mungbean as influenced by different levels of P, Mo and Co application in a typical acidic soil of northeast India.

MATERIALS AND METHODS

Field experiment was carried out in the experimental research farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland. The farm is located at an altitude of 310m with the geographical location of 25°45′45′v′′ N latitude and 93°53′04′′ E longitude. The soil of the experimental farm was sandy loam in texture with pH 4.5 and 13.0 g/kg organic carbon. The N, P_2O_5 and K_2O contents were 250.8, 17.9 and 165.3 kg/ha, respectively. The treatments comprised of four levels of P_2O_5 (0, 20, 40 and 60 kg/ha),three levels of Mo (0, 0.75 and 1.5 kg/ha) and Co (0, 0.5 and 1.0 kg/ha) along with common application of FYM @ 2t/ha before one month of sowing. *Rhizobium* @10 kg/ha as soil treatment, N @20 kg/ha (as urea) and K_2O @ 40 kg/ha (as muriate of potash) were applied at the time of sowing. The treatments were replicated thrice and the experiment was laid out in Randomized Block Design, with mungbean (Cv. K- 851) as the test crop. P, Mo and Co were applied through single super phosphate, ammonium molybdate and cobalt chloride, respectively. All the recommended cultural practices were followed during crop growth and the crop was harvested at maturity.

Five plants were selected randomly from each plot and tagged for recording plant height, number of branches/plant, dry weight/plant, number of nodules/plant, number of seeds/pod, number of pods/plant, seed yield and stover yield. Before sowing, composite soil sample (0-15 cm depth) representing the whole field was collected and the physical and chemical properties were determined. The soil sample was analyzed for pH in 1:2 soil water suspension using glass electrode and organic carbon by the Walkley and Black (1934). The soil samples were analyzed for available N (Subbiah and Asija 1956), available P (Bray and Kurtz 1945)and available K in 1N ammonium acetate (NH_4OAC) solution at pH 7.0 (Jackson1973). Seed and stover samples were oven-dried and grinded in Willey mill. Extract was prepared by digesting the samples with di-acid mixture (HNO_3 and $HClO_4$ in 4:1 ratio). Total N, P and K were determined as per standard procedure (Jackson 1973). Protein content was calculated by multiplying the N content with the conversion factor of 6.25. Statistical analysis of the datawas done as per the methodology described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Crop Growth

Application of P, Mo and Cohad significant influences on crop growth and development. Growth attributes, viz. plant height, number of branches/plant, dry weight/plant and number of nodules/plant were significantly influenced by different levels of P, Mo and Co application. P fertilization @ 60 kg/ha recorded maximum plant height and dry weight/plant which was significantly superior to other levels of P except 40 kg P_2O_5/ha. This result is in agreement with the previous findings of Singh and Hiremath (1990) and Mandal and Sikder (1999). The number of branches and nodules/plant were maximum with 60 kg P_2O_5/ha and significantly superior to other levels of P. This was due to possible beneficial effect of P fertilization on nodule development, energy transformation, metabolic process and root growth resulting in taller plant, more dry matter production and increased nodule numbers. These results are in conformity with the findings of Basu et al. (2003) and Bhattacharya and Pal (2001).

All the growth attributes were significantly increased with increasing levels of Mo. Application of 1.5 kg Mo/ha produced the tallest plants with the highest number of branches, number of nodules and dry weight per plant. Similar findings for beneficial effects of applied Mo were reported by Yakubu et al. (2010). Application of 1.0 kg Co/ha resulted in significantly better growth and yield responses (except dry weight/plant) compared to control and 0.5 kg Co/ha. This can be attributed to improved nodulation and high population of *Rhizobia* in the rhizosphere subsequent to Co application (Jena et al. 1994).

Yield and yield attributes

The application of P@60 kg/ha gave the maximum number of pods/plant, number of grains/pod and grain yield, with the responses being weaker at lower doses of P, and the control plot showing the poorest response. Basu et al. (2003) and Bhattacharya and Pal (2001) also observed significant increase in yield by increased application of P in groundnut and green gram, respectively. The yield attributes recorded maximum values with 1.5 kg Mo/ha and were on par with 0.75 kg/ha. The highest grain yield was recorded under 1.5 kg Mo/ha, which was 31.9 and 5.4% higher over control and 0.75 kg Mo/ha, respectively. Mo might have enhanced the activity of nitrogenase, thereby increasing the N supply to plants throughbiological N fixation, resulting in better growth and increased yield (Biswaset al. 2009). Application of 1.0 kg Co/ha recorded maximum number of grains/pod and number of pods/plant, which was significantly superior to other levels of Co application. The grain and straw yield increased significantly with increasing Co levels. Crop fertilized with 1.0 kg Co/ha produced 31.1 and 3.3%higher grain yield over control and 0.5 kg Co/ha, respectively. These findings are in agreement with the findings of Ibrahim et al. (1989). Co addition increased the nodule formation of root and atmospheric N fixation by microorganisms which increased the N content in faba bean plants (Abd El-Moezand Gad 2002). Das (2000) suggested that there are three specific cobalamine-dependent enzyme systems in *Rhizobium* which may account for influence of cobalt on methionine synthase, ribonucleotide reductase and methylmalonyl coenzyme A mutase.

Nutritional Quality

Protein content and protein yield was significantly influenced by application of varying levels of P. Maximum protein content (25.2%) and protein yield (107.6 kg/ha) was recorded under 60 kg P_2O_5/ha. Sharma et al. (2001) reported similar observations with application of 60 kg P_2O_5/ha. The nutrient (N, P and K) uptake by crop was significantly influenced by increasing levels of P (Table 2). Nutrient uptake was recorded maximum with 60 kg P_2O_5/ha and it was significantly superior to its lower level and control. This was mainly due to higher biological production under these treatments which increased the nutrient uptake. Similar result was observed by Khan et al. (2002) who reported increased P uptake in inoculated mungbean with increasing rates of P_2O_5 up to 75 kg/ha. Jain et al. (2007) reported increased P concentration in soil solution subsequent to P fertilization in P deficient soil which resulted in greater utilization of P by mungbean. Application of 1.5 kg Mo/ha recorded maximum protein content and protein yield. N, P and K uptake by crop was significantly influenced by increasing levels of Mo. Nutrient uptake was recorded maximum at the highest dose of Mo, and was significantly superior to its lower level and control. This was in conformity with the study of Laltlanmawia et al.

(2004) wherein enhancement in P content of soybean with increasing levels of Mo was reported. Application of 1.0 kg Co/ha recorded maximum protein content and protein yield. N, P and K uptake by crop was significantly influenced by increasing levels of Co. Significant increase in N and protein content of green gram due to seed treatment with Co was reported by Pattanayak et al.(2000) and Singh and Singh (2010). Nutrient uptake was recorded maximum with 1.0 kg Co/ha and it was significantly superior to its lower level and control. These results are in agreement with those found by Jena et al. (1994), Castro et al. (1996), Abd El-Moez and Gad (2002) and Basu et al. (2006).

CONCLUSIONS

On the basis of the results of this study, we conclude that P, Mo and Co application can significantly improve yield and quality of mungbean in acidic soils of northeast India.

Table1: Effect of phosphorus, molybdenum and cobalt application on growth, yield attributes and yield of mungbean

Treatment	Plant height (cm)	No branches / plant	Dry weight (g/plant)	No of nodules / plant	No of pods /plant	Number of seed/pod	Seed yield (q/ha)	Stover yield (q/ha)
P_2O_5 level (kg/ha)								
0	51.6	19.7	15.7	21.3	15.0	8.6	2.4	3.8
20	51.9	20.7	15.5	28.2	20.6	10.9	3.2	3.8
40	53.5	23.2	18.1	28.4	24.1	11.2	3.4	4.3
60	55.1	24.5	18.9	31.7	24.3	11.6	3.5	4.5
CD (P=0.05)	6.51	4.01	0.87	1.35	1.31	0.43	0.08	0.08
Mo level (kg/ha)								
0	50.4	23.1	15.7	25.6	16.3	11.0	2.6	3.8
0.75	51.0	21.5	17.4	27.1	21.9	11.2	3.3	3.9
1.5	56.0	24.1	17.6	31.7	24.1	11.3	3.3	4.6
CD (P=0.05)	6.51	4.01	0.87	1.35	1.31	0.43	0.08	0.08
Co level (kg/ha)								
0	50.4	23.1	15.7	25.6	16.3	11.0	2.6	3.8
0.5	51.2	22.7	15.6	27.1	22.8	10.8	3.2	4.1
1.0	55.8	22.9	19.4	31.7	23.2	11.7	3.4	4.2
CD (P=0.05)	6.51	4.01	0.87	1.35	1.31	0.43	0.08	0.08

Table 2: Effect of phosphorus, molybdenum and cobalt application on seed quality and nutrient uptake by mungbean

Treatment	Protein content (%)	Protein yield (kg/ha)	Total nutrient uptake by crop (kg/ha)		
			N uptake	P uptake	K uptake
P level (kg/ha)					
0	21.1	57.8	17.6	2.1	11.8
20	31.9	82.3	29.1	2.3	14.1
40	34.7	96.0	35.4	2.6	16.2
60	33.8	107.7	39.8	3.0	17.2
CD (P=0.05)	0.77	4.0	2.82	0.19	0.88
Mo level (kg/ha)					
0	34.7	57.8	27.2	1.3	12.5
0.75	32.8	91.6	32.9	2.4	14.8
1.5	35.4	99.0	37.2	2.3	16.9
CD (P=0.05)	0.77	2.8	2.82	0.19	0.88
Co level (kg/ha)					
0	34.7	57.8	27.2	1.3	12.5
0.5	32.5	92.9	32.7	2.4	15.5
1.0	35.7	97.6	37.3	2.8	16.2
CD (P=0.05)	0.77	2.8	2.82	0.19	0.88

Therefore, P and micronutrient fertilization (particularly Co and Mo) needs to be promoted in the acidic soils of northeastern India for improved yield and nutritional qualities of legumes.

REFERENCES

Abd El-Moez MR, Gad SN (2002). Effect of organic cotton compost and cobalt application on cowpea plants growth and mineral composition. Egyptian J Appl Sci 17: 426-440

Basu M, Mondal P, Datta A, Basu TK (2003). Effect of cobalt, *Rhizobium* and *Phosphobacterium* inoculations on growth attributes of summer groundnut (*Arachishypogaea* Linn.). Environ Ecol 21: 813-816

Basu M, Bhadoria PBS, Mahapatra SC (2006). Influence of microbial culture in combination with micronutrient in improving the groundnut productivity under alluvial soil of India. Acta Agric Slovenica (Europe) 7: 435-444

Bhattacharyya J, Pal AK (2001). Effect of *Rhizobium* inoculation, phosphorus and molybdenum on the growth of summer greengram (*Vigna radiata* L. Wiczek). J Interacademicia 5(4): 450-457

Biswas PK, Bhowmick MK, Bhattacharya A (2009). Effect of molybdenum and seed inoculation on nodulation, growth and yield in urdbean [*Vigna mungo* (L.) Hepper]. J Crop Weed 5(1): 147-150

Bray RH, Kurtz LT (1945). Determination of total, organic and available forms of phosphorus in soil. Soil Sci 59: 39-45

Castro A, Bouretto AE, Nakagawa J (1996). Treatments of seeds of *Phaseolus vulgaris* L. with cobalt. Revista Brasleira Sementes 16: 26-30

Das DK (2000). Micronutrients: their behaviour in soil and plants. Kalyani Publishers, UP, India

Gomez KA, Gomez AA (1984). Statistical procedure for agricultural research. John Wiley and Sons, New York

Ibrahim A, AbdSoel, El AS (1989). A possible role of cobalt in salt tolerance of plant. Egyptian J Soil Sci (Special Issue) 359-371

Jackson ML (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi

Jain AK, Kumar S, Panwar JDS (2007). Response of mungbean (*Vigna radiata*) to phosphorus and micronutrients on N and P uptake and seed quality. Legume Res 30 (3): 201–204

Jena PK, Karmakar S, Ghatak S, Barik A, Naybri A, Sounda G, Mukher AK, Saren BK (1994). Effect of cobalt and *Rhizobium* on yield, oil content and nutrient concentration in irrigated summer groundnut. Indian J Agric Sci 64(1): 630–632

Kandli H (2007). Effect of cobalt fertilizer on growth, yield and nutrient status of faba bean (*Vicia faba* L.) plants. J Appl Sci Res 3(9): 867-872

Khan MA, Aslam M, Tariq-Sultan, Mahmood IA (2002). Response of phosphorus application on growth and yield of inoculated and un-inoculated mungbean (*Vigna radiata*). Int J Agric Biol 4(4): 523-524

Kumpawat BS (2010). Integrated nutrient management in blackgram (*Vigna mungo*) and its residual effect on succeeding mustard (*Brassica juncea*) crop. Indian J Agric Sci 80 (1): 76-79

Laltlanmawia L, Singh AK, Sharma SK (2004). Effect of phosphorus and molybdenum on yield, protein content and nutrient uptake by soybean on acid soils of Nagaland. J Indian Soc Soil Sci 52(2): 199-202

Mandal R, Sikder BC (1999). Effect of nitrogen and phosphorus on growth and yield of mungbean grown in saline soil of Khulna, Bangladesh. J Phytopathol Res 12(1/2): 85-88.

Pattanayak SK, Dash D, Jena MK, Nayak RK (2000). Seed treatment of green gram with molybdenum and cobalt: effect on nodulation, biomass production and nitrogen uptake in an acid soil. J Indian Soc Soil Sci 48(4): 769-773

Serraj R, Gyamfi JA (2004). Role of symbiotic nitrogen fixation in the improvement of legume productivity under stressed environments. West African J Appl Ecol 6: 95-109

Sharma MS, Upadhyay MS, Tomar SS (1988). Water use efficiency of some rainfed crop on a Vertisol as influenced by soil micronutrients and straw mulching. J Indian Soc Soil Sci 33: 387-390

Singh PK, Singh AK (2010). Response of mungbean (*Vigna radiata* L. Wilczek) in relation to micronutrients content and yield as affected by sulfur and cobalt application. Environ Ecol 28(1B): 564-568

Singh BG, Hiremath SM (1990). Effect of phosphate fertilization on physiological aspects of mungbean. J Maharashtra Agric Univ 15(2): 176-178

Solaiman ARM, Habibullah AKM (1990). Response of groundnut to *Rhizobium* inoculation. Bangladesh J Soil Sci 21(1): 42-46

Subbiah BV, Asija GL (1956). A rapid procedure for determination of available nitrogen in soils.CurrSci25: 259-260

Thirumaran AS, Seralathan MA (1988). Utilization of mungbean. In: Shanmugasundaram S, McClean BT (eds)Proceedings of the second international mungbean symposium, Shanhua, Taiwan: The World Vegetable Center (AVRDC)

Walkley AJ, Black IA (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci 37: 29-38

Yakubu H, Kwari JD, Sandabe MK (2010). Effect of molybdenum fertilizer on N_2 fixation by some grain legume varieties in Sudano-Schelian zone of north eastern Nigeria. America-Euririan J Agric Environ Sci 8(1): 109-115