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Effect of micronutrients on nodulation, growth, yield and nutrient uptake in black gram *(Vigna mungo L.)*

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ABSTRACT

A field experiment was conducted at Crop research centre, S.V.B.P. Univ. of Ag. & Tech. Meerut (U.P.) during Kharif season of 2014 to study the effect of micronutrients on growth, yield, quality and uptake of nutrients in black gram (Vigna mungo L. Hepper). The experiment has 8 treatments which were laid out in randomized block design with three replications. Results revealed that the tallest plants (57.6 cm), significantly higher nodules/plant (61.7), dry matter per plant (24.5 g), pods/plant (51.0) and test weight (43.2 g) were recorded with 100% NPK + 10 kg Fe + 1 kg Mo + 1 kg B ha^{-1} treatment over 100% NPK alone. Significant increase in grain (13.16 q ha^{-1}), straw (19.85 q ha^{-1}) and protein (304 kg ha^{-1}) yields were recorded with combined use micronutrients and NPK fertilizers (T_8) over 100% NPK alone (T_1). Use of 20 kg N+ 60 kg P_2O_5 + 40 kg K_2O + 10 kg Fe + 1 kg Mo + 1 kg B ha^{-1} increased the grain and straw yield of black gram by 51.6 and 29.3% over 100% NPK alone treatment. Among these micronutrients, application of NPK + 10 kg Fe ha^{-1} produced higher grain and straw yield than those of NPK + 1 kg Mo ha^{-1} and NPK + 1 kg B ha^{-1}. But statistically these micronutrients were at par in respect of grain and straw yield. Protein content in grain and straw of black gram increased with different combinations of micronutrients over 100% NPK alone. The maximum values of protein content (23.1%) were recorded with NPK + Fe + Mo + B (T_8) treatment. The highest uptake of N by grain and straw of black gram (48.5 and 33.3 kg ha^{-1}), P (3.2 and 3.3 kg ha^{-1}), K (9.5 and 33.7 kg ha^{-1}), Fe (100.6 and 277.8 g ha^{-1}), Mo (9.9 and 9.3 g ha^{-1}) and B (37.1 and 59.5 g ha^{-1}) was recorded with T_8 (NPK + Fe + Mo + B) and minimum under 100% NPK alone. Application of NPK + micronutrients significantly improved the status of available nutrients in post harvest soil.

Keywords: Micronutrients, growth, nodulation, yield, nutrient uptake, black gram

INTRODUCTION

The practice of intensive cropping with high yielding varieties for boosting food production caused nutrient depletion in soil, consequently macro and micronutrients deficiencies are reported in soils. Black gram (Vigna mungo L.Hepper), an important legume crop grown in western Uttar Pradesh, responds to micronutrients. Among various constraints leading to low productivity of pulses, inadequate and imbalanced plant nutrition assumes great significance. Boron, iron and Mo have a marked effect on plants. To increase or to sustain the productivity of black gram, there is a need for application of micronutrients (B, Fe and Mo) as the application of these micronutrients is not common with the introduction of high analysis fertilizer. Boron helps in the biosynthesis of protein in plant. It is associated with meristematic activity, auxin, cell well, maintaining correct water relations within the plant and sugar translocation. Boron is closely related to the functions that calcium performs in the plant. Molybdenum is an essential component of the enzyme nitrate reductase, which catalyzes the conversion of NO_3 to NO_2. It is also a structural component of enzyme nitrogenase which is actively involved in atmospheric N_2 fixation by root nodule bacteria of leguminous crops. Molybdenum acts in enzyme system which brings about oxidation-reduction reactions, especially the reduction of nitrate to ammonia prior to amino acids and protein synthesis in the cells of plant besides activator of dehydrogenases and co-factor in the synthesis of ascorbic acid. Molybdenum is considered as one of the constraints in the optimum nodulation of leguminous crops. Iron is a structural component of porphyrin molecules, cytochromes, hemes, hematin ferrichrome and leghemoglobin. These substances are involved in oxidation reduction reactions in respiration and photosynthesis. As much as 75% of cell Fe is associated with chloroplasts and up to 90% of Fe in leaves occurs with lipoprotein in chloroplast and mitochondria membranes. Iron is a constituent of nitrogenase the enzyme essential for N_2 fixation by rhizobia and other microorganisms. The alluvial soils of Meerut (western Uttar Pradesh) are poor in organic matter and deficient in micronutrients. Use of these micronutrients like B, Fe and Mo can increase the productivity of the crop. However, little work has been done on this aspect in black gram. Therefore, an experiment was conducted to study the effect of micronutrient along with NPK fertilizers on yield and uptake of nutrients in black gram.

MATERIALS AND METHODS

A field experiment with black gram was conducted at the crop Research Centre, S.V.B.P. University of Agriculture & Technology, Meerut (U.P.) during Kharif season of 2014. Geographically it is located at 24^o $04^/$ N latitude and 77^0 $42^/$ E mean sea level. The climate of the region is subtropical and semi arid characterzed with hot summer (max temp. 45^o C) and extremely cold winters (min. temp.3^0 C). The soil was sandy loam in texture and alkaline in reaction (pH 8.0). The status of organic carbon available N, P, K, S, Fe, B and Mo was 3.7 g kg^{-1}, 150, 11.2 and 170 kg ha^{-1} 4.5, 0.60 and 0.03 mg kg^{-1}, respectively. There were 8 treatments viz. T_1 RD of NPK (20 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}), T_2 NPK + 10 kg Fe ha^{-1}, T_3 NPK + 1 kg Mo ha^{-1}, T_4 NPK + 1 kg B ha^{-1}, T_5 NPK + 10 kg Fe + 1 kg Mo ha^{-1}, T_6 NPK + 10 kg Fe + 1kg B ha^{-1}, T_7 NPK + 1 kg Mo + 1 kg B ha^{-1} and T_8 NPK + 10 kg Fe + 1 kg Mo + 1 kg B ha^{-1}.The design was randomized block design involving three replications. The black gram (Var.Vallabh-1) was sown in first week of July using 20 kg seed ha^{-1} The recommended doses of N,P and K were 20, 60 and 40 kg ha^{-1}, respectively. Growth and yield attributes were recorded at harvest. The crop was harvested at physiological maturity and grain and stover yields were recorded.. Grain and straw samples were digested in di-acid mixture (HNO_3 $HClO_4$, 10:1 by volume) and the digest was analysed for P by vanado molybdate yellow colour method, K by flame photometer, Mo by thiocyanate method, B by azomethine – H method and Fe by atomic absorption spectrophotometer. Nitrogen in grain and straw was determind by micro-Kjeldahl method and the protein content was calculated from the N content multiplied by 6.25. The protein yield was calculated by multiplying grain yield with protein content in grain. Soil samples collected after harvest were analysed for available N (Subbiah and Asija 1956), available P (Olson et al. 1954), available K (Jackson 1973). Soil available B was extracted with boiling water in 1:2 suspension for 5 minutes (Berger and Truog 1944) and estimated using azomethine-H reagent as suggested by John et al. (1975). Available Mo was extracted with Grigg reagent (Grigg 1953) and determined by thiocynate method. Iron was expected with DTPA (Lindsay or Norvell 1978) and determined by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Growth and yield attributing characters

Application of various treatments improved the plant height significantly over 100% NPK. Application of Fe, Mo and B applied alone or in combination with 100% NPK improved the plant height and tallest plants (57.6 cm) were recorded under T_8 (NPK + Fe + Mo + B) treatment. It seems possible that addition of micronutrients along with NPK might have provided the better nutrient supply to the black gram, which improved the plant height and dry matter/plant. The number of nodules / plant at 30 days of growth increased significantly with various treatments over 100% NPK alone (T_1). Application of Fe, Mo, and B along with NPK improved the number of nodules/plant. Among these treatments 100% NPK + Fe + Mo (T_5) and NPK + Fe + Mo + B (T_8), being at par, proved significantly superior to other treatments in respect of number of nodules / plant. This could be attributed to beneficial role of Mo in nodule formation (Lal *et al.* 2016). Yield attributes, viz., pods/plant and test weight of black gram increased lucidly with each treatment of micro-nutrients over 100% NPK (T_1).The maximum values of pods/plant (51.0) and test weight (43.2 g) were recorded with T_8 (NPK + Fe + Mo + B) treatment. Almost all the treatments of micronutrients proved superior to 100% NPK with respect of these yield attributes. These micronutrients (Fe, Mo and B) led to greater photosynthates production and vigorous growth. Further with efficient partitioning of accumulated photosynthates resulted in enhanced yield attributes at adequate supply of major and micro-nutrients. These results are in conformity with the findings of Kannah *et al.* (2014), Singh *et al.* (2014) and Kushwaha *et al.* (2009).

Table 1: Effect of micronutrients on growth yield and quality of black gram

Treatment	Plant height (cm)	Nodules / plant at 30 days	Dry matter / plant (g)	Pods / plant	Test Weight (g)	Yield ($q\ ha^{-1}$)	
						Grain	Straw
T_1 100% RD NPK	51.2	50.0	18.4	30.8	37.5	8.68	15.35
T_2 NPK+10kg Fe ha^{-1}	53.5	52.6	22.0	44.7	41.2	11.39	19.26
T_3 NPK+1kg Mo ha^{-1}	53.4	54.4	21.5	44.4	40.1	11.20	19.15
T_4 NPK+1kg B ha^{-1}	52.3	52.5	20.8	43.7	39.2	10.28	18.18
T_5 NPK+10 kg Fe+1kg Mo ha^{-1}	53.8	56.0	23.2	48.7	42.1	12.12	19.69
T_6 NPK+10 kg Fe+1kg B ha^{-1}	53.6	55.4	22.7	43.3	41.8	11.80	19.20
T_7 NPK + kg Mo+1kg B ha^{-1}	53.4	56.3	22.2	45.0	41.6	11.50	19.10
T_8 NPK + 10kg Fe + 1kg Mo + 1kg B ha^{-1}	57.6	59.7	24.5	51.1	43.2	13.16	19.85
CD(P=0.05)	0.94	1.45	1.21	2.46	2.38	1.47	1.78

Yield

The gram and straw yield of black grain ranged from 8.68 to 13.16 q ha^{-1} and from 15.35 to 19.85 q ha^{-1} respectively with various treatments, but the highest mean grain and straw yield was registered under complete treatment supplying 20 kg N + 60 kg P_2O_5 + 40 kg K_2O + 10 kg Fe + 1 kg Mo + 1 kg B ha^{-1} (T_8) in adequate and balanced amounts. The highest yield under this treatment may be ascribed to either direct or cumulative effect of supplied macro-and micronutrients on metabolic processes of black gram. Availability of nutrients, especially the micronutrients at optimum level has direct impact on accelerated cell division and enlargement, root growth and plant vigour which resulted in higher grain and straw production. Mevada *et al.*(2005) and Sharma *et al.* (2005) reported similar results. The 100% NPK (20 kg N + 60 kg P_2O_5 + 40 kg K_20 ha^{-1}) resulted in lower grain and straw yield than other treatments. Application of Fe, Mo and B in black gram had significant effect on grain and straw yield of black gram. Among these micronutrients, boron produced relative lower yields of black gram. But the difference in yield due to these micronutrients were statistically non-significant. The combined application of Fe + Mo along with 100% NPK proved superior to Fe + B and Mo + B in respect of grain and straw production (Yadav *et al.* 2002, Vyas *et al.* 2003, Singh et al 2014, Kannan *et al.* 2014 and Lal *et al.* 2016).

Table 2: Effect of micronutrients on uptake of NPK (kg ha^{-1}) and Fe, Mo and B (g ha^{-1}) by black gram

Treatment	Nitrogen		Phosphorus		Potassium		Iron		Molybdenum		Boron	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	25.1	19.8	1.7	2.1	3.5	21.1	60.7	190.1	3.5	3.2	12.5	36.0
T_2	39.8	30.8	2.8	2.4	6.8	30.8	85.4	262.0	5.7	4.8	20.5	46.4
T_3	38.7	30.2	2.5	2.7	5.6	28.8	79.0	240.8	7.6	7.0	19.1	47.8
T_4	32.8	27.3	2.3	2.7	4.9	26.0	73.0	230.7	4.6	4.3	25.2	50.5
T_5	44.0	21.8	2.5	3.1	7.7	32.0	92.0	271.8	6.4	7.3	23.4	52.3
T_6	41.3	30.5	2.9	3.1	6.7	29.8	89.2	262.7	6.1	5.4	26.9	49.5
T_7	39.9	30.1	2.8	3.0	6.2	29.0	81.4	249.2	7.9	7.0	27.1	47.3
T_8	48.5	33.3	3.2	3.2	9.5	33.7	100.6	277.8	9.9	9.3	37.1	59.5
CD(P=0.05)	5.65	5.38	0.49	0.11	0.92	5.19	11.02	43.3	1.07	1.09	3.84	10.03

Quality

There was a significant increase in protein content in grain and straw of black gram with different treatments over 100% NPK alone (Table 3). Protein content in grain and straw ranged from 18.0 to 23.1% and 8.1 to 10.4%, respectively. The maximum values of protein content in grain (23.1%) and straw (10.4%) were recorded in treatment having 20 kg N + 60 kg P_2O_5 + 40 kg K_2O + 10 kg Fe + 1 kg Mo + 1 kg B ha^{-1} and minimum in 100% NPK (18.1 and 8.1%). Protein yield in black gram grain ranged between 157.0 and 304.0 kg ha^{-1} where maximum protein yield (304.0 kg ha^{-1}) was recorded in T_8 treatment and minimum (157.0 kg ha^{-1}) in 100% NPK. This increase in protein yield in black gram grain may be attributed to increased grain yield and protein content in grain with ample supply of nutrients. Most of the treatments proved superior to 100% NPK in respect of protein yield which may be attributed to higher grain yield. Yadav *et al.* (2002) also reported similar results.

Uptake of nutrients

The average uptake of nutrients by black gram grain ranged from 25.1 to 48.5 kg ha^{-1} for nitrogen 1.7 to 3.2 kg ha^{-1} for phosphorus, 3.5 to 9.5 kg ha^{-1} for potassium, 60.7 to 100.6 g ha^{-1} for iron,3.5 to 9.9 g ha^{-1} for molybdenum and 12.5 to 37.1 g ha^{-1} for boron. The corresponding ranges of uptake of nutrients by straw were 19.8 to 33.3 kg ha^{-1} for N, 2.1 to 3.2 kg ha^{-1} for P, 21.1 to 33.7 kg ha^{-1} for K, 190.1 to 277.8 g ha^{-1} Fe, 3.2 to 9.3 g ha^{-1} for Mo and 36.0 to 59.5 g ha^{-1} for B. These results showed that the complete treatment (NPK + Fe + Mo + B, T_8) maintained higher uptake values of all the nutrients most probably owing to the higher yield recorded under this treatment (T_8) alone (T_1) recorded the lowest uptake values, which is again the reflection of the lowest yield recorded under this treatment. Application Fe and Mo alone and combined form (Fe + Mo) along with NPK improved their uptake by black gram but depressed the B uptake by the crop. Similarly application of Mo + B also increased their uptake by black gram. The combined application of these micronutrients (Fe + Mo, Mo + B + Fe + B) proved superior to their alone application with respect to their uptake of these nutrients by the crop.

Table 3: Effect of micronutrients on quality of black gram and status of available N,P,K (kg ha^{-1}) and Fe, Mo and B (mg kg^{-1}) in post harvest soil

Treatments	Nitrogen	Phosphorus	Potassium	Iron	Molybdenum	Boron	Protein Content (%)		Protein Yield
							Grain	Straw	
T_1	118.5	10.0	160.0	4.0	0.02	0.55	18.1	8.1	157.0
T_2	160.6	11.5	166.5	5.5	0.02	0.60	21.3	10.0	242.6
T_3	162.0	12.3	168.0	4.1	-0.06	0.61	21.7	9.9	243.0
T_4	158.5	12.4	168.0	4.2	0.04	-0.88	20.0	9.4	205.6
T_5	160.3	12.5	169.0	-5.6	-0.07	0.64	22.5	10.1	272.7
T_6	155.8	12.1	165.0	-5.7	0.04	-0.90	21.9	9.9	258.4
T_7	159.5	12.1	168.0	4.7	-0.07	-0.92	21.7	9.9	249.5
T_8	163.8	12.7	171.0	-5.9	-0.08	-1.0	23.1	10.4	304.0
CD(P=0.05)	0.30	0.45	2.57	0.24	0.01	0.07	1.08	0.23	9.8

Available nutrients in soil

Incorporation of micronutrients along with NPK fertilizers enhanced the available N, P and K content in post harvest soil as compared to 100% NPK alone (Table 3).However, available N content decreased than that of initial value of Nwhich may be attributed to utilization of native N from the soil by the crop. The maximum values of available N (163.8 kg ha^{-1}), P (12.7 kg ha^{-1}) and K (171.0 kg ha^{-1}) were recorded with NPK + Fe + Mo + B (T_8) treatment. Combined application of Mo + Fe, Mo + B, Fe + B also improved the status of these nutrients in soil over 100% NPK alone (T_1) treatment. This may be attributed to the role of micronutrients (Mo) in nitrogen fixation. The highest build up of available Fe (5.9 mg kg^{-1}) was recorded with NPK + Fe + Mo + B (T_8) treatment which may be attributed to addition of Fe as iron fertilizer. All the treatments (T_2, T_5 and T_7) also improved the status of available iron in post harvest soil over the treatments having no iron (Table 3). The minimum amount of available Fe (4 mg kg^{-1}) was recorded with 100% NPK treatment (T_1). The residual available Mo ranged from 0.02 to 0.08 mg kg^{-1}. With the addition of NPK + Fe + Mo + B (T_8), available Mo increased by 0.06 mg kg^{-1} over 100% NPK alone. The reason for higher Mo content in the soil with T_8 treatment was that addition of Mo fertilizer to the soil improved the available of Mo in soil. Other treatments having Mo improved the status of available Mo in soil than those treatments having no molybdenum. Available boron status in post harvest soil ranged from 0.55 mg kg^{-1} at 100% NPK (T_1) to 1.0 mg kg^{-1} with NPK + Fe + Mo + B (T_8) treatment. Application of 20 kg N + 60 kg P_2O_5 +

40 kg K_2O + 10 kg Fe + 1 kg Mo + 1 kg B resulted in maximum amount of available B (1.0 mg kg^{-1}) in soil compared to other treatments. The minimum amount of available B in soil was noted under control (Kannan *et al.* 2014, Singh *et al.* 2014).

It could be concluded that the combined application of 10 kg Fe + 1 kg Mo + 1 kg B + 100% NPK is beneficial in increasing the status of available nutrients in soil besides crop yield, nutrient uptake and grain quality of black gram. Use of boron proved inferior to Fe and Mo in respect of yield, quality and uptake of nutrients. However, it proved superior to build up boron in post harvest soil.

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