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Effect of boron and molybdenum on yield and yield attributes of summer green gram (*Vigna radiata* L.) under medium black calcareous soils

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Abstract
A experiment was conducted during summer 2016 at J.A.U., Junagadh to assess the effect of four levels of boron and four levels of molybdenum on growth and yield of summer green gram (*Vigna radiata* L.). The result revealed that the yield and yield attributes significantly influenced by the various levels of boron and molybdenum. Application of boron @ 2 kg ha^{-1} was observed superior over rest of the levels in increasing branches per plant (4.50), seeds per pod (6.50) and seed yield (7.96 g plant^{-1}) and straw yield (16.85 g plant^{-1}). In case of nodules per plant and dry nodule weight were significantly observed higher with 6 kg B ha^{-1}. The application of molybdenum @ 0.75 kg ha^{-1} produced significantly higher on pods per plant, seeds per pod, nodules per plant of summer green gram. Interaction effect of boron and molybdenum found significant effect in respect of yield.

Keywords: boron, growth and yield, green gram, molybdenum

Introduction

Green gram (*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. India shares about 35-37% and 27% of the total area and production of pulses, respectively in the world. The calorific value of green gram is 334 calories per 100 g. and its chemical composition is as follows: crude protein 24.0%, fat 1.3%, carbohydrate 56.6%, minerals 3.5%, lysine 0.43%, methionine 0.10% and tryptophan 0.04% (Kachroo, 1970) [6]. It also plays an important role in maintaining and improving the fertility of soil through its ability to fix atmospheric nitrogen in the soil by root nodules. Nodule formation on the roots of green gram through *Rhizobium* bacteria, fix about 35 kg ha^{-1} atmospheric nitrogen (Yadav, 1992) [14]. The straw and husk yields are used as fodder for cattle. It is good green manure and erosion resisting cover crop. The crop also improves soil fertility by symbiotic fixation of atmospheric nitrogen.

Boron is very important in plant metabolism through acting activity of certain enzyme, cell division, carbohydrate transport, and calcium and potassium uptake and protein synthesis, ultimately it may enhance in pod and seed formation. Similarly, the molybdenum also playing important role in structural interring of cell wall and cell membrane and synthesis of protein as well as nitrogen fixation. Molybdenum is required for the formation of the nitrate reductase enzyme and in the legume it plays an additional role in symbiotic nitrogen fixation. Thus, the application of B and Mo not only increased the yield but also improved the quality of green gram.

Materials and Methods

A pot experiments was conducted during summer- 2016, to study the “Effect of boron and molybdenum on summer green gram (*vigna radiata* L.) Under medium black calcareous soils” at the Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University Junagadh. The soil of the experimental plot was silty clayey in texture and alkaline in reaction with $pH_{2.5}$8.0, $EC_{2.5}$ 0.58 dS m^{-1}, $CaCO_3$ 31.05% and CEC 36.2 C mol kg^{-1}. The soil was medium in available nitrogen(242 kg ha^{-1}), medium in available phosphorus (39.20 kg ha^{-1}), high in available potassium (298 kg ha^{-1}), sulphur (29.50 kg ha^{-1}), iron (3.25 mg kg^{-1}),zinc (0.55 mg kg^{-1}), manganese (5.20 mg kg^{-1}), copper (1.25 mg kg^{-1}), boron (0.80 mg kg^{-1}) and molybdenum (0.06 mg kg^{-1}).Completely randomized design with total sixteen treatments replicated thrice was employed in this study. Application of boron and molybdenum with the source of boric acid (B-17%) and ammonium molybldate (Mo-54%) respectively. The different boron level B_0=0 kg ha^{-1}, B_1=2 kg ha^{-1}, B_2=4 kg ha^{-1}, B_3=6 kg ha^{-1} and different molybdenum levels Mo_0=0 kg ha^{-1}, Mo_1=0.75 kg ha^{-1}, Mo_2=1.50 kg ha^{-1}, Mo_3=2.25kg ha^{-1}. A stock solution of the known concentration was prepaid using all the sources in mineralized water. From the stock solution a series of working solutions were prepared as per the level of the boron and molybdenum and sprayed by the hand sprayer on the soil. The soil was then well mixed up. The required quantity of N @ 20 kg/ha, and P @ 40 kg/ha P_2O_5 applied to all the pots as basal dose through urea and DAP and also mixed in the soil. observations were plant height, number of branches per plant, number of pods per plant, number of nodules per plant, while, nodule weight per plant were recorded at 45 DAS, number of seeds per pod, root: shoot ratio, seed yield and straw yield were recorded. The statistical analysis of data of the characters studied by the investigation through the procedure appropriate to the design of the experiment and significance of difference tested by the 'F' test (Panse and Sukhatme, 1985) [10].

Result and Discussion

Data for different attributes are presented in table 1 to 5. Statistical analyses of the data revealed significant effect of B, Mo and their interaction on different growth and yield attributes of mungbean in the experimental soil.

Seed and straw yield

The application of boron at 2.0 kg ha^{-1} produced significantly the highest seed yield (7.96 g $plant^{-1}$), which was statistically at par with boron applied @ 4.0 kg ha^{-1} (7.91 g $plant^{-1}$). Similarly, the significantly highest straw yield was registered at application of boron @ 2.0 kg ha^{-1} (16.85 g $plant^{-1}$) followed by boron at 4.0 kg ha^{-1} (15.69 g $plant^{-1}$) and 6.0 kg ha^{-1} (16.19 g $plant^{-1}$) and found statistically at par with each other. While, Significantly maximum seed yield (7.92 g $plant^{-1}$) was obtained with molybdenum applied at 1.50 kg ha^{-1}. The interaction effect of boron and molybdenum on seed yield was found significant on seed yield. Maximum seed yield (8.58g $plant^{-1}$) was recorded under B_2Mo_2 treatment combination (Saha *et al.*1996) [12].

No. of branches per plant

The application of B @ 2.0 kg ha^{-1} significantly increased the number of branches per plant to the tune of 13.92 per cent over control. The maximum no. of branches per plant (4.50) was observed under B_1 level, which was statistically at par with B_2 and B_3 level. The reason for increase in this yield attribute to the important role of boron in plant metabolism and translocation of photosynthates from source to sink (Mandal and Sinha, 1997) [9].

No. of pods per plant

The no. of pods per plant was significantly increased from 8.08 to 11.67 under different treatments of boron. The application of boron at 4 kg ha^{-1} produced significantly the highest pods per plant (11.67), which was statistically at par with B3 level (11.08). The lowest pods per plant (8.08) was recorded under B_0 level. Similarly, the application of Mo @ 0.75 kg ha^{-1} recorded significantly higher number of pods per plant (11.33). The interaction effect of boron and molybdenum on no. of pod per plant was found significant. Maximum pods per plant (14.33) were recorded under B_2Mo_3 treatment combination which was remain at par with treatment combination of B_3Mo_1.

Number of seeds per pod

Boron and molybdenum produced significantly effect on number of seeds per pod. The application of boron at 2.0 kg ha^{-1} produced significantly the highest no. of seeds per pod (6.50) over that of remaining all treatments. While, the maximum no. of seeds per pod (6.12) was observed under application of Mo @ 0.75 kg ha^{-1} which was remaining at par with Mo_2 in respect of seeds per pod.

Number of nodules per plant

The boron application @ 6.0 kg ha^{-1} significantly increased the number of nodules per plant (10.39) to the extent of 21.09 per cent over to control at 45 DAS. While, the application of molybdenum @ 0.75 kg ha^{-1} significantly increased the number of nodule per plant to the extent of 9.66 per cent than that of control at 45 DAS. The combined application of boron @ 6.0 kg ha^{-1} and Mo @ 0.75 kg ha^{-1} resulted significantly higher value (12.44) of nodules per plant followed by B_2Mo_1 (11.56) than remaining treatment combinations of boron and molybdenum.

Nodule weight

The application of boron, molybdenum and their interaction effect found significant on nodule weight per plant. Boron applied at 6.0 kg ha^{-1} registered maximum nodule weight (0.150 g $plant^{-1}$) while, the lowest (0.078 g $plant^{-1}$) at B_0 level (no boron). Significantly higher nodules weight (0.122 g $plant^{-1}$) was registered under application of Mo at 1.5 kg ha^{-1}, it was remain at par with Mo applied at 2.25 kg ha^{-1}. While, Significantly higher value of nodules weight (0.200 g $plant^{-1}$) was recorded with treatment combination of B_3Mo_3.

Working with different crops other researchers have also reported increased yield of different crops with application of B (Islam *et al.*, 2006 & Srinivasan *et al.*, 2008) [4, 13], (Kaisher *et al.*, 2010) [7]. While, Mo (Bhattacharyya *et al.*, 2001, Biswas *et al.*, 2010 & Kumar *et al*, 2010) [2, 8, 3] and combined appication of B & Mo (Balachandar *et al.*, 2003, Jain *et al.*, 2007, Patra and Bhattacharya 2009) [1, 5, 11].

Conclusion

Based on the results as summarized above, it can be concluded that the application of boron @ 2 kg ha^{-1} enhanced the yield attributes, nodulation and yield of the summer green gram. Similarly, molybdenum application @ 1.5 kg ha^{-1} had also exhibited its superiority in respect of yield attributes, nodulation, and yield of summer green gram.

Table 1: Effect of boron and molybdenum on yield attributes of summer green gram

Treatments	Plant height (cm)	No. of branches $plant^{-1}$	No. of Pods $plant^{-1}$	No. of Seeds pod^{-1}	No. of Nodules $plant^{-1}$	Nodules weight (g $plant^{-1}$)	Seed yield (g $plant^{-1}$)	Straw yield (g plant-1)
B_0 = Control	45.65	3.95	8.08	5.22	8.58	0.078	6.46	14.81
B_1 = 2	46.33	4.50	9.25	6.50	7.25	0.076	7.96	16.85
B_2 = 4	45.60	4.23	11.67	6.03	9.06	0.130	7.91	15.69

B_3 = 6	45.58	4.42	11.08	5.42	10.39	0.150	6.85	16.19
S.Em.±	0.42	0.12	0.27	0.20	0.16	0.002	0.21	0.45
C.D. at 5%	NS	0.33	0.79	0.57	0.45	0.007	0.62	1.31
Mo_0 = Control	46.02	4.23	8.83	5.47	8.69	0.089	6.42	15.47
Mo_1 = 0.75	45.90	4.27	11.33	6.12	9.53	0.101	7.42	15.93
Mo_2 = 1.50	45.47	4.28	10.33	6.05	8.58	0.122	7.92	16.14
Mo_3 = 2.25	45.78	4.32	9.58	5.53	8.47	0.121	7.42	16.01
S.Em±	0.42	0.12	0.27	0.20	0.16	0.002	0.21	0.45
C.D. at 5%	NS	NS	0.79	0.57	0.45	0.007	0.62	NS
Interaction (BxMo)								
S.Em±	0.84	0.23	0.55	0.40	0.32	0.005	0.43	0.91
C.D. at 5%	NS	NS	Sig.	NS	Sig.	Sig.	Sig.	NS
C.V.%	3.19	9.36	9.45	11.89	6.20	7.95	10.17	9.91

Table 2: Interaction effect of boron and molybdenum on no. of pod per plant of summer green gram

Level of Boron	**Level of molybdenum**				
	Mo_0	**Mo_1**	**Mo_2**	**Mo_3**	**Mean**
B_0	6.67	8.33	10.00	7.33	8.08
B_1	7.33	11.33	10.33	8.00	9.25
B_2	9.67	12.00	10.67	14.33	11.67
B_3	11.67	13.67	10.33	8.67	11.09
Mean	8.84	11.33	10.33	9.58	
S.Em±	0.55		C.D. at 5%	1.57	

Table 3: Interaction effect of boron and molybdenum on no. of nodules per plant of summer green gram

Level of Boron	**Level of molybdenum**				
	Mo_0	**Mo_1**	**Mo_2**	**Mo_3**	**Mean**
B_0	8.11	7.56	8.89	9.78	8.59
B_1	7.56	6.56	7.78	7.11	7.25
B_2	10.00	11.56	7.56	7.11	9.06
B_3	9.11	12.44	10.11	9.89	10.39
Mean	8.70	9.53	8.59	8.47	
S.Em±	0.32		C.D. at 5%	0.91	

Table 4: Interaction effect of boron and molybdenum on nodules weight per plant (g $plant^{-1}$) of summer green gram

Level of Boron	**Level of molybdenum**				
	Mo_0	**Mo_1**	**Mo_2**	**Mo_3**	**Mean**
B_0	0.080	0.090	0.080	0.070	0.080
B_1	0.080	0.080	0.070	0.080	0.078
B_2	0.130	0.080	0.170	0.140	0.130
B_3	0.080	0.150	0.170	0.200	0.150
Mean	0.093	0.100	0.123	0.123	
S.Em±	0.005		C.D. at 5%	0.014	

Table 5: Interaction effect of boron and molybdenum on seed yield of summer green gram

Level of Boron	**Level of molybdenum**				
	Mo_0	**Mo_1**	**Mo_2**	**Mo_3**	**Mean**
B_0	6.02	6.56	6.75	6.52	6.46
B_1	7.41	8.08	7.95	8.38	7.96
B_2	7.57	8.21	8.58	7.27	7.91
B_3	4.69	6.83	8.39	7.50	6.85
Mean	6.42	7.42	7.92	7.42	
S.Em±	0.43		C.D. at 5%	1.23	

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