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Influence of boron on growth attributes, yield of black gram and available boron status in *Typic chromustert*

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Abstract

A field experiment was carried out at farmer's field in Kalligudi block, Madurai district to evaluate the growth characters, available boron status and yield of black gram to soil and foliar applied boron in boron deficient calcareous soil. The experiment was outlined with thirteen treatments in a randomized block design with three replications. The results of the study revealed that the STCR based N, P₂O₅ and K₂O along with soil application of boron @ 1.5 kg ha⁻¹ and foliar application of borax @ 0.25 per cent at critical growth stages of the crop registered the highest plant height, root dry weight, number root nodules and the grain yield. From the findings of this experiment it was finally concluded that there is a need for application of boron for improving the productivity of black gram in calcareous soil.

Keywords: Boron, black gram, calcareous soil, growth, yield

Introduction

Black gram (*Vigna mungo*) is one of the most important highly remunerative legume crop introduced from India and cultivated throughout the Southern Asia. It is considered as the cheapest source of plant protein in poor man's diet. Black gram presumed considerable significance in the perspective of food, energy and nutritional security that contains about 24 per cent protein, 60 per cent carbohydrates, fat, minerals, amino acids such as methionine, cysteine, etc. It accounts for 10 per cent of country's total pulse production (Gowda *et al.*, 2013) [9]. Black gram plays a precise role in restoring soil fertility by fixing atmospheric nitrogen in the root nodules with the help of nodule producing bacteria *Rhizobium* sp.

The proper use of appropriate quantity of micronutrients with macronutrients is indispensable to orchestrate a wide range of physiological functions in plants and also aids in enhancing the quality and productivity. The potential B deficiency in soils of India was estimated as 33 per cent (Alloway 2008) [1]. Generally soils with calcareous nature, low organic matter, acid and coarse textured soils are highly prone to boron deficiency. Boron, an essential non metal micronutrient plays a decisive role in maintaining cell wall structure, cell division, membrane stability, nitrogen assimilation, sugar translocation, K⁺ transport, protein and sucrose synthesis, phenol, carbohydrate, nucleic acid and IAA metabolism (Singh *et al.*, 2014) [20]. It also plays a principle role in reproductive growth, microsporogenesis, pollen germination, pollen tube growth, pollination and seed set. Havlin *et al.* (1999) documented that due to shortage of boron, flowering and fruit development were highly restricted. In recent times, management of boron is a challenging aspect as the optimum level of B application range is narrow. Keeping these points in view, the present investigation was undertaken to interrogate the response of boron on growth parameters, yield of black gram and available boron status in boron deficient calcareous soil.

Materials and Methods

A field experiment was carried out during 2019 in a farmer's field in Vellakulam village, Kalligudi block, Madurai district, Tamil Nadu. The experiment was laid out in Randomized Block Design with 13 treatments replicated thrice. The experimental soil was sandy clay in texture with pH (8.54), EC (0.56 dSm⁻¹), organic carbon (4.2 g kg⁻¹), available N (202 kg ha⁻¹), available P (10.2 kg ha⁻¹), available K (584 kg ha⁻¹) and hot water soluble boron (0.25 mg kg⁻¹).

The treatments followed are as T₁ - Control, T₂ - Recommended N, P₂O₅ and K₂O (25:50:25 kg ha⁻¹), T₃ - N, P₂O₅ and K₂O on STCR basis, T₄ - T₃ + Soil application of Boron @ 0.5 kg ha⁻¹, T₅ - T₃ + Soil application of Boron @ 1.0 kg ha⁻¹, T₆ - T₃ + Soil application of Boron @ 1.5 kg ha⁻¹, T₇ - T₃ + Soil application of Boron @ 2.0 kg ha⁻¹, T₈ - T₄ + Foliar application of Borax @ 0.25% at 20 and 40 DAS, T₉ - T₄ + Foliar application of Borax @ 0.5% at 20 and 40 DAS, T₁₀ - T₅ + Foliar application of Borax @ 0.25% at 20 and 40 DAS, T₁₁ - T₅ + Foliar application of Borax @ 0.5% at 20 and 40 DAS, T₁₂ - T₆ + Foliar application of Borax @ 0.25% at 20 and 40 DAS, T₁₃ - T₆ + Foliar application of Borax @ 0.5% at 20 and 40 DAS. The black gram seeds (Vamban 8) were sown at a spacing of 30cm x 10cm. The source of N, P₂O₅, K₂O and B were urea, single super potash, muriate of potash and borax (10.5% boron) respectively. STCR based fertilizer doses were supplied in which N and K in 3 splits (basal, 20 DAS and 40 DAS) and P in single split (basal) and borax according to the treatment schedule. The biometric observations and yield parameters of test crop were recorded from each plot at respective growth stages. Similarly soil samples were collected at 20, 40 DAS and at post harvest stage and analysed for available boron content.

Results and Discussion

Effect of boron on growth parameters of black gram

Plant height

The plant height of black gram was positively influenced by soil and foliar application of boron (Table 1). The highest plant height of 64.6 cm was registered with the treatment receiving N, P₂O₅ and K₂O on STCR basis along with boron @ 1.5 kg ha⁻¹ as soil application + foliar application of borax @ 0.25% at 20 and 40 DAS (T₁₂) which was found to be statistically at par with T₁₃ (63.2 cm), while the lowest plant height was observed in the control. This momentous influence of boron fertilization on augmenting the plant height might be due to prominent role of boron on boosting up the carbohydrate metabolism, sugar transport, cell wall structure, protein metabolism, root growth and stimulating other physiological processes such as metabolic regulation, enzymatic process including photosynthesis, respiration and nitrogen fixation which resulted in better enhancement of growth characters. These results were in harmony with Kaisher *et al.* (2010)^[12], Patil *et al.* (2014)^[16] and Singh *et al.* (2014)^[20].

Root dry weight

The growth of plant root was highly restricted in boron deficient soil. The outcome of the experimental results confessed that the inclusion of boron along with macronutrients significantly increased the root dry weight of black gram (Table 1). Soil application of boron @ 1.5 kg ha⁻¹ and foliar application of borax @ 0.25% at 20 and 40 DAS along with N, P₂O₅ and K₂O on STCR basis achieved the highest root dry weight which could be ascribed due to absorption of boron by the roots that leads to increased physiological and biochemical activities of roots which resulted in more dry matter of root and the least was reported in unfertilized plot. The lowest root dry weight was noted with the control, where the insufficiency of boron suppresses the root elongation by limiting the cell enlargement and cell division in the growing zone of root tips. The outcome of the results were in conformity with Dell and Huang (1997)^[6], Carpena *et al.* (2000)^[4], Rosolem *et al.* (2008) and Padbhushan *et al.* (2019)^[14].

Number of nodules

Number of nodules in black gram was significantly influenced by application of boron. Soil and foliar application of boron markedly increased the nodule count per plant in the treatment receiving 1.5 kg B ha⁻¹ as soil application and 0.25% borax as foliar application along with N, P₂O₅ and K₂O on STCR basis (T₁₂) (Table 1). This consummate effect might be due to direct involvement of boron in nodulation, symbiotic nitrogen fixation in legume crops, buffering action and regulatory effect boron on other nutrients. Further, boron fertilization could have helped in retaining the cell wall and membrane integrity of nodules thereby expanding the nodulation. The results are in corroboration with Bolanas *et al.* (2001)^[3], Balachander *et al.* (2003)^[2], Shil *et al.* (2007)^[19] and Chaithra *et al.* (2018)^[5].

Hot water soluble B

A clear and significant relationship between applied B and soil B was observed on application of different doses of boron. As the initial status of available B was low in the soil, the soil application of 2.0 kg B ha⁻¹ enhanced the soil B status (Table 2). In calcareous soils, the application of boron at higher doses can meet out the adsorption of borate by Ca²⁺ and CaCO₃ requirement of boron for plant and thus increasing the B uptake in plants. As the dosage increased, the available B content in the soil was also increased. The increase in B concentration in soil might be due to concentration of boron in the soil solution which is generally controlled by boron adsorption reaction and directly increasing the water-soluble boron content which is readily available for plant growth. The results of present investigation are conformity with the results observed by Goldberg (1997)^[8], Haribhushan *et al.* (2008)^[10].

Effect of boron on grain yield of black gram

The highest grain yield was recorded in the treatment supplied with soil application of 1.5 kg B ha⁻¹ and foliar application of borax @ 0.25% along with STCR based N, P₂O₅ and K₂O at critical stages of the crop growth (Table 3). Inclusion of boron results in quick availability of boron to crop during the entire crop growth. Therefore, about 38 per cent yield increase was observed in the T₁₂ on comparison with treatment supplied with STCR based N, P₂O₅ and K₂O alone. The improvement in seed yield might be attributed to the role of boron in stabilizing certain constituents of cell wall and plasma membrane, enhancement of cell division, tissue differentiation, sugar transport, maintenance of conducting tissue with regulatory effect on another element and metabolism of nucleic acids, carbohydrates, proteins, auxins and phenols. Also, this phenomenal increase in grain yield could be attributed to the functional role of boron in enhancing flower development, pollen grain formation, pollen tube growth, pollen viability for proper pollination and seed development, dry matter accumulation and efficiency of translocation of assimilates from vegetative organs to reproductive organs, leading to increased pods and higher seed yield. This result was in accordance with Marschner (1986), Praveena *et al.* (2018)^[17], Dixit *et al.* (2007)^[7] and Pandey and Gupta (2013)^[15].

Conclusion

From the experimental results, it is suggested that the growth parameters such as plant height, root biomass, number of nodules plant⁻¹ and grain yield of black gram were achieved highest with the inclusion of boron as soil and foliar application at critical stages of the crop. Available boron

status was higher with the soil application of boron @ 2 kg ha⁻¹. Based on the above findings, it is concluded that nutrient management with STCR based N, P₂O and K₂O together with optimum level of boron application in calcareous soil can augment the economic yield of black gram in terms of production as well as maintaining the soil health.

Table 1: Effect of different levels of boron on plant height, root dry weight and root nodules at harvest stage of black gram

Treatment	Plant height (cm)	Root dry weight (g plant ⁻¹)	Number of root nodules
T ₁	40.8	0.813	23.9
T ₂	44.0	0.926	26.9
T ₃	46.6	1.020	29.4
T ₄	49.2	1.108	31.3
T ₅	50.8	1.174	33.2
T ₆	55.6	1.298	37.6
T ₇	57.1	1.321	38.9
T ₈	52.3	1.198	34.3
T ₉	54.2	1.263	36.1
T ₁₀	58.8	1.421	41.3
T ₁₁	61.1	1.485	43.9
T ₁₂	64.6	1.578	47.5
T ₁₃	63.2	1.564	46.2
SEd	0.81	0.025	0.79
CD (p=0.05)	1.67	0.052	1.63

Table 2: Influence of different levels of boron on available B (mg kg⁻¹) status of soil at all growth stages

Treatment	Hot water soluble boron (mg kg ⁻¹)		
	20 DAS	40 DAS	Post harvest
T ₁	0.196	0.182	0.172
T ₂	0.182	0.175	0.164
T ₃	0.180	0.168	0.153
T ₄	0.415	0.361	0.336
T ₅	0.523	0.467	0.429
T ₆	0.657	0.594	0.543
T ₇	0.673	0.619	0.564
T ₈	0.420	0.368	0.340
T ₉	0.424	0.372	0.350
T ₁₀	0.540	0.475	0.435
T ₁₁	0.530	0.480	0.442
T ₁₂	0.640	0.615	0.552
T ₁₃	0.642	0.615	0.548
SEd	0.011	0.014	0.013
CD (p=0.05)	0.024	0.029	0.028

Table 3: Influence of different levels of boron on grain yield of black gram

Treatment	Grain Yield (kg ha ⁻¹)
T ₁	354
T ₂	647
T ₃	690
T ₄	738
T ₅	802
T ₆	874
T ₇	896
T ₈	794
T ₉	844
T ₁₀	935
T ₁₁	984
T ₁₂	1050
T ₁₃	1020
SEd	16.03
CD (p=0.05)	33.08

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