The Andhra Agric. J 64 (3): 578-582, 2017

Influence of Soil Applied Boron on Yield and Nutrient uptake of Black gram (*Vigna mungo* L.) grown in Calcareous soils

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ABSTRACT

A green house experiment with blackgram grown on boron (B) deficient calcareous soils was conducted at Agricultural College, Bapatla to study the influence of soil applied boron on yield and uptake of blackgram (var. PU-31) during 2015-16. Five soils with calcium carbonate content 1.08 (Soil I), 5.25 (Soil II), 10.37 (Soil III), 16.20 (Soil IV) and 17.75 (Soil V) per cent were collected from different sites of Sattenapalli mandal which falls under Krishna western delta system of Andhra Pradesh. The treatment comprised of four levels of boron viz. 0, 0.25, 0.50 and 0.75 mg B kg^{-1} supplied as boric acid laid out in completely randomized block design and replicated thrice. Different levels of boron had more influence on mean biomass production and seed yield. The mean total boron uptake at harvest varied from 38.73 to 67.14 µg pot^{-1} in blackgram. The highest mean seed yield of 1.67 g pot^{-1} was recorded by the addition of 0.75 mg B kg^{-1} followed by 0.25 mg B kg^{-1} (1.55 g pot^{-1}), and control (1.40 g pot^{-1}). Soil I (1.08% $CaCO_3$) which received B @ 0.25 mg kg^{-1} (B_1) was found sufficient to produce optimum seed yield of blackgram although maximum yield obtained with application of B @ 0.50 mg kg^{-1} soil (B_2) was on par with B_1 level. For all other soils having more than 1.08% $CaCO_3$ content, the yields were increased with increase in B doses.

Key words: *Boron content, Black gram, Calcareous soils, Seed yield, Soil applied Born.*

Due to intensive cropping and use of high yieldling varieties has caused depletion of soil fertility especially of micronutrients. Boron (B) is one of the most common deficiencies in soils of India. Its deficiency is found in nearly 30% of the soils of the country, which are highly calcareous, leached or sandy (Mondal *et al*., 1991; Sakal *et al*., 1996). Imbalance NPK fertilization also results in deficiency of boron in soils (Maji *et al*., 2013). Kaisher *et al.,* (2010) observed that soil applied boron at the rate of 5 kg B ha^{-1} had significant effect on yield and yield attributing characters of green gram. Shrila *et al*., (2013) reported that soil applied boron at the rate of 10 kg Borax ha^{-1} was found better than 5 kg Borax ha^{-1} for chickpea in soil of Pantnagar. Boron is mostly deficient in calcareous soils. Calcareous soils contain sufficient amount of calcium carbonate. Calcium carbonate is likely to decrease B-availability (Shaaban *et al.,* 2004, 2006). It acts as a sink for boron in the soil, where it adsorbs a great portion of the soluble boron on the surface of their particles (Forster, 1991). Singh and Nayyar (1999) reported that boron deficiency occurred in crop plants grown on light textured sandy, calcareous and soils with relatively low amount of organic matter. Keeping in view the factors influencing the boron availability and its significance in crop nutrition in calcareous soils it was programmed to investigate the effect of different levels of boron on yield and uptake of black gram in calcareous soils.

MATERIAL AND METHODS

Soils with low in boron and varying $CaCO_3$ content were collected to conduct the green house experiment. The calcareous soils collected from different location of Sattenapalli mandal were dried, ground and passed through a 2 mm stainless steel sieve. The physico-chemical characteristics of the soils are studied which is given in the Table 1.

Processed soil was taken in pots covered with high density polythene bags. The boron at different levels were supplied (0, 0.25, 0.50 and 0.75 mg kg^{-1}) soil through boric acid (Soil application). Each treatment was replicated thrice. Five seeds of black gram cv. PU 31 were sown at field capacity moisture level. After germination, the seedlings were thinned to three plants per pot and maintained up to harvesting stage. The pots were irrigated with distilled water as and when required.

The harvested plant samples were washed with acidified distilled water and distilled water thoroughly. The washed plant samples were then air dried by keeping them in paper bags and then oven dried at 65±2°C. Thereafter, the samples were weighed for biomass production and seed yield. Boron content in plant extract was determined by curcumin method as described by Tandon (1993) and uptake calculated as following. The statistical analysis of the data was done using a Completely Randomized Block Design and critical differences (CD) were computed at the 5 per cent probability level (Snedecor and Cochran, 1967).

Nutrient uptake (µg pot^{-1}) = Nutrient content (ppm) X dry matter yield (g pot^{-1})

RESULTS AND DISCUSSION

Biomass production and seed yield

Soil applied B at 0.25 mg kg^{-1} was adequate to cause significant increase in biomass production and seed yield of blackgram regardless of type of soils over control although increased non-significantly with further application of B (Table 2). Highest mean biomass (3.89 g pot^{-1}) and seed yield (2.14 g pot^{-1}) by blackgram was observed at 0.50 mg B kg^{-1} of soil while lowest (3.24g and 1.40 g pot^{-1}) was in B_0 (control), respectively. The improvement in biomass production can be attributed to the role of B in stabilizing certain constituents of cell wall and plasma membrane, enhancement of cell division, tissue differentiation (Marschner, 1986). The improvement in seed yield could be ascribed to boron as it was directly linked with process of fertilization, pollen producing capacity of anther, viability of pollen grains, pollen germination and pollen tube growth (Agarwal *et al*., 1981; Vaughan, 1997). Similar results were reported by Kaisher *et al*. (2010) in greengram. Among different soils, the maximum mean seed yield (1.99 g pot^{-1}) biomass (4.90 g pot^{-1}) was recorded in S_1 with low calcium carbonate content (1.08% $CaCO_3$) which was on par with the S_2 (5.25% $CaCO_3$). These results were accordance with the findings of Padbhushan and Kumar (2014).

Maximum biomass production (4.90 g pot^{-1}) and seed yield (2.14 g pot^{-1}) were recorded under interaction of 0.50 mg B kg^{-1} of soil (B_2) for S_1 - soil (1.08% calcium carbonate) and minimum yields were observed under interaction of 0 mg B kg^{-1} of soil (B_0) for S_5 - soil (17.75% calcium carbonate). The treatment S_1B_3 (S_1 soil which containing 1.08% CaCO3 that received B @ 0.75 mg kg^{-1}) showed a toxic effect and resulted in decrease in biomass production (4.66 g pot^{-1}) and seed yield (2.01 g pot^{-1}). The decrease in biomass production with increasing B might be due to the toxicity effect of higher dose of B application in soil. The detrimental effects of the highest B application on biomass production were also observed by Raza *et al.* (2014) in wheat crop grown in calcareous soils of Pakistan. The similar trends were observed by Ziaeyan and Rajaie (2009) under high calcium carbonate soil fertilized with B application.

Boron content and uptake

Boron content of blackgram decreased significantly with increase in calcium carbonate content of soils. Maximum boron content (19.50 ppm) in blackgram was observed in S_1 (1.08% $CaCO_3$) and minimum (8.75 ppm) was observed in S_5 soil (17.75% $CaCO_3$) (Table 3). At varied levels of calcium carbonate content of soils, per cent decrease over S_1 was 7.02, 34.97, 46.97 and 55.12 at S_2, S_3, S_4 and S_5, respectively. In calcareous soils apart from the B adsorption on the finer particles of $CaCO_3$, the excess Ca interfered in the B nutrition of crops. The occurrence of free Ca ions restricted B availability in soils. The co-precipitation of B with $CaCO_3$ can occur in calcareous soils which would affect the B distribution in the liquid phase of soil (Keren and Bingham, 1985). There was an interaction between B availability and the presence of Ca ions. High levels of Ca at high pH reduced the absorption of B by plants (Mortvedt *et al*., 1999). Maximum B uptake (90.07 µg pot^{-1}) in blackgram was observed in S_1 soil which contained 1.08% $CaCO_3$ while minimum (23.84µg pot^{-1}) was observed in S_5 soil (containing 17.75% $CaCO_3$). The decrease in B uptake with increase calcium carbonate content of soil might be due to decreased availability of B in soil (Shaaban *et al*., 2006).

Boron content of blackgram increased progressively at varied levels of boron and the difference recorded over control (B_0) was significant. Maximum boron content (16.19 ppm) of blackgram was recorded in B_3 (0.75 mg B kg^{-1}soil) level while minimum boron content (11.47 ppm) of blackgram was recorded in control (B_0).

Table 1. Physico-chemical characteristics of soils used for pot culture experiment .

Characteristics		Soil I	Soil II	Soil III	Soil IV	Soil V
$CaCO_3$ (%)		1.08	5.25	10.37	16.20	17.75
Bulk density (Mg m^{-3})		1.52	1.32	1.55	1.42	1.45
Textural class*		Clay	Clay	Clay	Clay	Clay
pH $_{1:2.5}$		8.06	8.17	8.43	8.45	8.52
EC $_{1:2}$ (dS m^{-1})		0.21	0.23	0.56	3.12	0.98
Organic carbon (%)		0.71	0.69	0.51	0.34	0.21
Available B (mg kg^{-1})		0.64	0.41	0.22	0.20	0.12
Available macronutrients (kg ha^{-1})	N	288.16	261.12	200.98	192.12	181.89
	P_2O_5	75.24	36.00	25.97	22.81	12.23
	K_2O	455.44	411.64	499.23	709.43	534.26
	S*	16.67	16.21	16.01	8.23	8.12
DTPA-micronutrients (ppm)	Zn	0.62	0.56	0.42	0.35	0.29
	Fe	22.95	12.57	4.48	4.21	4.11
	Mn	8.31	5.81	3.01	2.42	1.98
	Cu	1.56	1.52	1.47	0.20	0.18

Table 2. Effect of B application on biomass production and seed yield (g pot^{-1}) at harvest in different calcareous soils.

Levels of B (mg kg^{-1})	Biomass production						Seed yield					
	Soil I	Soil II	Soil III	Soil IV	Soil V	Mean	Soil I	Soil II	Soil III	Soil IV	Soil V	Mean
0	4.01	3.84	2.98	2.78	2.58	3.24	1.78	1.65	1.28	1.20	1.11	1.40
0.25	4.76	4.45	3.15	2.91	2.68	3.59	2.04	1.91	1.39	1.26	1.15	1.55
0.50	4.90	4.74	3.49	3.04	2.78	3.79	2.14	2.02	1.50	1.31	1.20	1.63
0.75	4.66	4.88	3.88	3.18	2.83	3.89	2.01	2.10	1.67	1.37	1.22	1.67
Mean	4.58	4.48	3.37	2.98	2.72		1.99	1.92	1.46	1.28	1.17	
	SEm	CD (0.05)		CV (%)			SED		CD(0.05)	CV (%)		
S	0.03	0.07		3.81			0.03		0.07	3.42		
B	0.02	0.07					0.02		0.06			
S×B	0.05	0.15					0.05		0.14			

This increase in available boron content of soil might be due increased level of boron application to the soil. The transpiration loss resulted in more movement of applied boron with water in the xylem then to phloem but due to phloem immobility of boron, there was more accumulation of boron in plant (Padbhushan and Kumar, 2014). Whereas, maximum B uptake (67.14 µg pot^{-1}) was observed at B_3 level while minimum B uptake (38.73 µg pot^{-1}) was observed at B_0 level. The experimental soils were low in available B (< 0.5 ppm) except S_1 and this might be one of the reasons for response to B levels. Similar favourable effect B on B uptake was reported by Shamsuddoha *et al.* (2011) in wheat crop.

Interaction effect between applied boron and soils increased the boron content in blackgram crop. Maximum boron content (22.63 ppm) in blackgram was recorded under the interaction of 0.50 mg B kg^{-1} (B_2) of soil for S_1 level (1.08% calcium carbonate) which was on par with S_1B_3 and S_2B_3. Minimum boron content (7.86 ppm) was observed under interaction of 0.00 mg B kg^{-1} (B_0) of soil for S_5 level (17.75% calcium carbonate)

Table 3. Effect of boron application on B content (mg kg^{-1}) and B uptake (µg pot^{-1}) of black gram at harvest in different calcareous soil.

Levels of B (mg kg^{-1})	B content						B uptake					
	Soil I	Soil II	Soil III	Soil IV	Soil V	Mean	Soil I	Soil II	Soil III	Soil IV	Soil V	Mean
0	15.14	14.16	11.18	8.98	7.86	11.47	60.66	54.42	33.32	24.98	20.28	38.73
0.25	17.10	16.08	12.15	9.86	8.56	12.75	81.00	71.51	38.22	28.72	22.93	48.48
0.50	22.63	20.14	13.20	10.78	8.82	15.11	110.81	95.46	46.03	32.82	24.54	61.93
0.75	23.13	22.12	14.19	11.72	9.76	16.19	107.82	107.91	55.12	37.23	27.62	67.14
Mean	19.5	18.13	12.68	10.34	8.75		90.07	82.33	43.17	30.94	23.84	
	SEm	CD(0.05)		CV (%)			SEm	CD (0.05)		CV (%)		
S	0.17	0.48		4.17			0.70	2.01		4.42		
B	0.15	0.43					0.63	1.80				
S×B	0.33	0.96					1.41	4.02				

which was on par with S_5B_1 and S_5B_2. These results were in accordance with the findings of Padbhushan and Kumar (2014).

Combined effect of boron application and soils showed increased B content and uptake significantly except at S_5 soil. Highest B uptake (110.81 µg pot^{-1}) by blackgram was recorded under the interaction of 0.50 mg B kg^{-1} (B_2) of soil for S_1 soil (1.08% calcium carbonate) which was on par with S_1B_3 and S_2B_3. Lowest B uptake (20.28 µg pot^{-1}) was observed in S_5 level (17.75% calcium carbonate) under no boron application. These results were in accordance with the Waghadhare *et al.* (2007) in calcareous inceptisols.

CONCLUSION

From the experiment application of B @ 0.25 mg kg^{-1} to the soils containing 1.08% $CaCO_3$ was proved to be sufficient to produce optimum yield of blackgram. For all other soils having more than 1.08% $CaCO_3$ content, the yields were increased with increase in B doses under study.

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(Received on 8.09.2016 and revised on 4.03.2017)