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Influence of boron and FYM on boron concentration and dry matter yield of green gram (*Vigna radiata* L.)

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Abstract
A pot experiment was conducted during 2021 pre-*kharif* season to evaluate the effect of five levels of boron (viz., 0, 0.5, 1, 1.5 and 2 kg B ha^{-1}) and two levels of FYM (0 and 5 t ha^{-1}) on boron concentration and dry matter yield of green gram (var. DGGS-4) grown in an acid soil. Results revealed that irrespective of different treatments, there was an increasing trend of boron concentration and dry matter yield up to the harvest of the crop. Significantly higher boron concentration and dry matter yield were recorded in green gram grown in soil applied with boron over control at different crop growth stages. Irrespective of boron application, addition of FYM enhanced boron concentration as well as dry matter yield of the crop. Comparing among the different treatments, combined application of boron at 2 kg ha^{-1} and FYM at 5 t ha^{-1} significantly increased the boron concentration and dry matter yield at different crop growth stages. This shows higher efficiency of boron when applied in combination with FYM.

Keywords: boron, FYM, boron concentration, dry matter yield and green gram

Introduction
Green gram (*Vigna radiata* L.) is one of the most important and extensively cultivated pulse crops in India. It plays an important role in maintaining and improving soil fertility 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) [23]. India produces about 1.48 million tonnes of green gram annually from an area of around 3.18 million hectares with an average annual productivity of 469 kg ha^{-1}. Green gram output accounts for 10 to 12% of the total pulse production in India.

Boron is an essential micronutrient which is directly and indirectly involved in many important plant metabolic functions. Boron plays a vital role in transport of carbohydrates as well as in cell wall metabolism, permeability and stability of cell membranes and phenol metabolism. Deficiency of boron restricts stomata opening and transpiratory water loss and also leads to enhanced leakage of solutes across the plasma membrane. It also has an important role in improving the quality of produce (Mahajan *et al.*, 1994 and Noor *et al.*, 1997) [9, 14]. The application of boron through soil or foliar application was found to be beneficial in stimulating plant growth and yield (Nagula *et al.*, 2015) [13]. However, Boron is one of the most deficient micronutrient in soils of India. It is the second most deficient micronutrient in Indian soils after zinc presently (Sathya *et al.*, 2009) [18]. Its deficiency is found in nearly 30% of the soils of the country, which are highly calcareous, leached or sandy (Mondal *et al.*, 1991 and Sakal *et al.*, 1996) [12, 16]. Its deficiency is commonly observed in light-textured acidic soils, in soils with high amount of calcium carbonate ($CaCO_3$) or oxides and hydrous oxides of iron (Fe) and aluminium (Al), and in soils with low organic-matter content. Its availability is usually low in high rainfall areas with acidic soil environment. Under acid soil conditions, boron is more in water soluble and can therefore be leached below the root-zones of plants by rainfall.

Adoption of intensive cropping and use of high yielding varieties has caused depletion of soil fertility, especially micronutrients. Imbalance NPK fertilization also results in deficiency of boron in soils (Maji *et al.*, 2013) [10] thus causing adverse effect on soil health and ultimately on crop yield. Management of this micronutrient is critical because the range between deficiency and toxicity for B in soil is much narrower as compared to other nutrients. Keeping this in view a pot experiment was undertaken to study effect of boron and FYM on boron concentration and dry matter yield of green gram.

Materials and Methods

A pot experiment was conducted in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Iroisemba, Imphal during the pre-*kharif* season of 2021 in an acidic soil bearing the general characteristics as presented in Table 1. The soil sample was collected by taking multiple thin slices from the surface soil layer (0-20 cm depth) following the procedure as outlined by Jackson (1973) [7]. Five kg each of air dried soil was taken in a series of pots. The recommended dose of nitrogen, phosphorus and potassium for green gram were added at 20 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 20 kg K_2O ha^{-1} in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively to each pot as basal application. Different levels of boron in the form of borax (viz., 0, 0.5, 1, 1.5 and 2 kg B ha^{-1}) in combination with two levels of farmyard manure (FYM at 0 and 5 tonnes ha^{-1}) were mixed thoroughly with the soil according to different set of treatments. Four to five seeds of green gram were sown in each pot. After germination, by thinning out only one seedling per pot was maintained during the whole experiment. The soils were moistened to 60% of water holding capacity throughout the experiment.

The experiment was carried out under factorial randomized block design (FRBD) with ten treatment combinations replicated thrice.

The whole plant samples were collected on 15^{th}, 30^{th}, 45^{th}, 60^{th} days after sowing (DAS) and at harvest by destructive method of sampling. The collected plant samples were washed properly with tap water and then finally rinsed with deionized water. The plant material was then dried at 60 ˚C for 48 hours to a constant dry weight in a hot air oven and dry matter yield was recorded at each stage. The dried plant samples of each treatments were powdered in stainless steel grinder and kept for dry ashing in a muffle furnace at 550 ˚C for 5 hours and ash was extracted in 10mL 0.36N H_2SO_4 for 1 hour at room temperature as outlined by Gaines and Mitchell (1979) [5]. The plant boron concentration was determined colorimetrically by using azomethine- H method at 420 nm wavelengths. Textural analysis of the soil samples were carried out by using hydrometer method (Bouyoucos, 1962) [1]. The soil pH was determined in 1:2.5 soil: water suspension ratio described by Jackson (1973) [7]. Available nitrogen was determined by the alkaline potassium permanganate method (Subbiah and Asija, 1956) [21]. Available phosphorus content was determined spectrophotometrically by using the method described by Bray and Kurtz (1945) [2]. Available potassium of the soil was extracted by 1N NH_4OAc and determined flame photometrically (Jackson, 1973) [7]. The organic carbon present in the soil samples was determined by rapid titration method as described by Walkley and Black (1934) [11].

All the data pertaining to the investigation was statistically analysed through analysis of variance technique for comparing the treatments effects (Gomez and Gomez, 1984) [6]. The significance of various effects was tested at 5% level of probability.

Table 1: General characteristics of the soil used in the experiment

Soil characteristics	Results
Textural class	Clay
Sand (%)	28.20
Silt (%)	22.50
Clay (%)	49.30
pH (1:2.5 soil : water ratio)	4.70
EC (1:2.5 soil : water ratio, dSm^{-1})	0.31
CEC [cmol(p+)kg^{-1}]	12.80
Organic carbon (%)	1.65
Available nitrogen (kg ha^{-1})	263.42
Available phosphorus(kg ha^{-1})	25.76
Available potassium (kg ha^{-1})	211.37

Result and Discussion

Effect of Boron and FYM on boron concentration in green gram

Data presented in Table 2 represent the changes in the amount of boron concentration in green gram grown in soil applied with boron and FYM. Results showed that irrespective of different treatments there was an increasing trend of plant boron concentration with crop growth till harvest. When compared with untreated control, significantly higher boron was accumulated in plants grown in soil added with boron at 2 kg ha^{-1} at different stages of crop growth. This is at par with the findings of Sharma *et al.* (1999); Mandal and Das (2011); Sarkar and Devi (2020) and Das *et al.* (2020) [19, 11, 17, 4]. Further study revealed enhanced boron accumulation with increasing levels of boron application up to 2 kg ha^{-1} in each successive sampling days. Comparatively higher plant boron content at different green gram growth stages was found in FYM added soil over the untreated one. Critical analysis of the data revealed that the interactive effect of boron and FYM levels had significant influence on boron concentration during the whole experiment. Statistically higher boron content in plant was observed in soil applied with boron at 2 kg ha^{-1} in combination with FYM at 5 t ha^{-1} followed by boron at 2 kg ha^{-1} in combination with FYM at 5 t ha^{-1} from 30^{th} DAS onwards till harvest.

Effect of Boron and FYM on dry matter yield of green gram

The changes in the dry matter yield of green gram as affected by different levels of applied boron and FYM are presented in Table 3. An increasing trend of dry matter yield up to harvest was observed in green gram irrespective of different levels of boron and FYM. Similar result was recorded by Sarkar and Devi (2020) and Das *et al.* (2020) [17, 4]. In general, significantly higher dry matter yield of green gram was observed in soil treated with boron over control from 30^{th} DAS onwards till harvest. Dry matter yield increased significantly with increasing levels of boron application. Comparing among the different boron treatments significantly higher dry matter yield was recorded in soil treated with 2 kg ha^{-1} followed by 1.5 kg ha^{-1}, 1 kg ha^{-1} and 0.5 kg ha^{-1}. Similar reports on enhanced dry matter yield due to boron application were given by Chaudhury and Debnath (2006); Mandal and Das (2011), Padbhushan and Kumar (2015), Janaki *et al.*

(2018) and Sidhu and Kumar (2018) [3, 11, 15, 8, 20]. Boron application at 2 kg ha^{-1} was adequate to cause significantly higher increase in dry matter yield regardless of stage of crop growth. Further study revealed that, irrespective of different boron levels, application of FYM at 5 t ha^{-1} resulted significantly enhanced dry matter yield at all stages of crop growth. The combined application of boron and FYM had a beneficial effect on the dry matter yield. Further critical analysis of the interaction effect of boron and FYM revealed that statistically higher dry matter yield was recorded in green gram grown in soil applied with boron at 2 kg ha^{-1} in combination with FYM at 5 t ha^{-1} followed by 1.5 kg B ha^{-1} + 5 t ha^{-1} FYM.

Table 2: Effect of Boron and FYM on boron concentration (µg/g) in green gram

Treatments	15 DAS			30 DAS			45 DAS			60 DAS			HARVEST		
	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
B_1	1.43	1.29	1.36	1.57	2.71	2.14	3.72	4.66	4.19	4.94	6.31	5.62	5.55	6.59	6.07
B_2	1.89	1.62	1.75	2.47	3.32	2.89	5.52	6.39	5.95	6.60	10.16	8.38	7.30	10.25	8.78
B_3	2.43	2.15	2.29	3.56	4.35	3.95	6.24	8.64	7.44	8.75	10.51	9.63	10.29	10.72	10.50
B_4	2.92	3.18	3.05	4.29	4.95	4.62	8.15	9.65	8.90	9.59	10.66	10.12	10.55	11.00	10.78
B_5	3.27	4.64	3.95	4.78	5.30	5.04	8.37	10.64	9.50	9.84	11.18	10.51	10.67	11.44	11.06
Mean	2.39	2.57		3.33	4.12		6.40	8.00		7.94	9.76		8.87	10.00	
Source	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$
B	0.09		0.18	0.07		0.15	0.14		0.30	0.13		0.27	0.13		0.27
F	0.06		0.12	0.04		0.09	0.09		0.19	0.08		0.17	0.13		0.27
BXF	0.12		0.26	0.10		0.21	0.20		0.43	0.18		0.38	0.18		0.38

B_1 = Boron @ 0 kg ha^{-1}
B_2 = Boron @ 0.5 kg ha^{-1}
B_3 = Boron @ 1 kg ha^{-1}
B_4 = Boron @ 1.5 kg ha^{-1}
B_5 = Boron @ 2 kg ha^{-1}
F_1 = FYM @ 0 tonnes ha^{-1}
F_2 = FYM @ 5 tonnes ha^{-1}
SE(d) = Standard error of mean difference
$CD_{0.05}$ = Critical difference at 5% level of probability

Table 3: Effect of Boron and FYM on dry matter yield (g plant^{-1}) of green gram

Treatments	15 DAS			30 DAS			45 DAS			60 DAS			HARVEST		
	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
B_1	0.32	0.41	0.37	0.98	1.16	1.07	1.74	2.36	2.05	5.22	6.17	5.69	7.82	9.15	8.49
B_2	0.35	0.47	0.41	1.21	1.42	1.32	2.63	3.37	3.00	6.37	6.58	6.47	9.20	9.67	9.43
B_3	0.46	0.60	0.53	1.40	1.74	1.57	3.13	3.75	3.44	6.83	7.75	7.29	9.97	10.64	10.30
B_4	0.55	0.81	0.68	1.60	2.17	1.88	3.48	4.19	3.83	7.09	8.22	7.66	10.07	11.16	10.62
B_5	0.67	0.86	0.77	1.90	2.36	2.13	3.95	4.66	4.30	7.44	8.52	7.98	10.28	11.55	10.92
Mean	0.47	0.63		1.42	1.77		2.98	3.66		6.59	7.45		9.47	10.43	
Source	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$	SE(d)		$C.D_{0.05}$
B	0.025		0.054	0.013		0.027	0.019		0.040	0.021		0.045	0.023		0.050
F	0.016		0.034	0.008		0.017	0.012		0.025	0.013		0.028	0.015		0.031
BXF	0.036		0.076	0.018		0.039	0.027		0.057	0.030		0.064	0.033		0.070

B_1 = Boron @ 0 kg ha^{-1}
B_2 = Boron @ 0.5 kg ha^{-1}
B_3 = Boron @ 1 kg ha^{-1}
B_4 = Boron @ 1.5 kg ha^{-1}
B_5 = Boron @ 2 kg ha^{-1}
F_1 = FYM @ 0 tonnes ha^{-1}
F_2 = FYM @ 5 tonnes ha^{-1}
SE (d) = Standard error of mean difference
$CD_{0.05}$ = Critical difference at 5% level of probability

Conclusion

From the result of the experiment it is opined that application of boron at 2 kg ha^{-1} in combination with 5 tonnes ha^{-1} FYM enhanced boron concentration and dry matter yield of green gram throughout the entire growth stages. This shows that combined application of boron and FYM gives higher agronomic efficiency as compared to single application of boron.

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