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Relative Change in Yields and Nutrient Uptake of Black Gram under Different Doses and Sources of Boron

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Authors' contributions

This work was carried out in collaboration among all authors. Authors RK and SS designed the study, performed the statistical analysis, wrote the protocol. Author SK wrote the first draft of the manuscript. Authors RP and Shabana managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The present study "Relative changes in Boron fractions in black gram rhizosphere" was contemplated with two objectives: 1) To find out the suitable source, dose and method of boron for black gram and 2) To study the changes in relative boron fractionation under black gram rhizosphere. To achieve the present objectives a field experiment was conducted with Greek gram var. IPU2-43 in factorial randomized block design with three sources, four doses and two methods of application of boron replicated thrice at Bihar Agricultural College Farm of BAU, Sabour during the year 2018-19. Three sources were: S_1: Borax, S_2: Solubor and S_3: Boric acid; Doses: D_1: 0.5 kg

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ha^{-1}, D_2: 1.0 kg ha^{-1}, D_3: 1.5 kg ha^{-1}, D_4: 2.0 kg ha^{-1}and methods: Soil and foliar application. Based on the findings of field experiment it can be concluded that the application of 1.5 kg B ha^{-1} (D_3) registered maximum seed yield of (8.27 q ha^{-1}), straw yield of (10.04 q ha^{-1}), nutrient uptake by grain (12.64 g ha^{-1}) and nutrient uptake by straw (16.95 g ha^{-1}) which was statistically at par with the application of 2.0 kg B ha^{-1} (D_4) and was found to be statistically superior over rest of the doses. Among the sources, the maximum seed yield (7.96 q ha^{-1}), straw yield (9.53 qha^{-1}), nutrient uptake by grain (12.42 gha^{-1}) and nutrient uptake by straw (16.36 gha^{-1})was found to be highest under the plots receiving 1.5 kg B ha^{-1} through foliar application of Solubor (S_2) and the lowest grain yield (7.88 qha^{-1}), straw yield (9.36 q ha^{-1}),nutrient uptake by grain (11.85 gha^{-1}) and nutrient uptake by straw (15.60 gha^{-1})was recorded from 0.5 kg B ha^{-1}(D_1) which was found statistical inferior over rest of the boron doses. Foliar application resulted in a better yield of straw as compared to soil application.

Keywords: Black gram; boron uptake; grain yield; straw yield.

1. INTRODUCTION

Blackgram belongs to the family Fabaceae and the genus *Vigna*. Only seven species of the genus *Vigna* are cultivated as pulse crops, of which five are Asian species of subgenus Ceratotropis, *Vignamungo* (black gram), *V. radiata* (mungbean), *V. aconitifolia* (Mothbean), *V. angularis* (Azuki bean) and *V. umbellata* (Rice bean) and two African species of subgenus *Vigna*, *Vignaunguiculata* (Cowpea) and *V. subterranean* (The bambara groundnut) [1]. Blackgram (*Vignamungo* L. Hepper) is a member of the Asian *Vigna* crop group. It is a staple crop in the central and South East Asia; however, it is extensively used only in India and now grown in the Southern United States, West Indies, Japan and other tropics and subtropics [2]. Black gram (*Vignamungo* L.) is an important pulse crop of the tropic and sub-tropic area and has been identified as a potential crop in many countries. Black gram is commonly known as urd bean or mash. It is one of the important grain legumes and is an excellent source of easily digestible good quality protein [3]. In India black gram is shown in the area of 50.31 lakh ha with 32.84 lakh ton production and the productivity of 651 kg ha^{-1}(Ministry of Agriculture and Farmers Welfare [4] and in the Bihar the area under cultivation is 15.5 ('000) ha and productivity is 912 kg ha^{-1} [5]. About 33% area at national level and 38% area in Bihar are B deficient [6]. Leguminous plants, as well as cyanobacteria, require B for N_2 fixation, as B plays a major role in nitrogen assimilation [7]. Boron (B), an essential micronutrient, plays an important role in cell wall structure, membrane stability, sugar transportation and phenol, carbohydrate, nucleic acid and IAA (Indole acetic acid) metabolism. In addition to its involvement in numerous metabolic processes, B has a great impact on productive structure development especially on microsporogenesis, pollen germination and seed development [8]. Boron management is challenging because the optimum B application range is narrow and optimum B application rates can differ from one soil to another [9,10]. The boron content in the soil changes between 2 and 100 ppm [11]. Average boron is considered 30 ppm in soil depending on the main rock; boron content in the soil exhibits a large variation. Consequently, plants need trace amounts of boron but it becomes toxic at 2 ppm or greater for most plants [12]. A tolerable boron concentration for plants in soils is approximately 25 ppm [13]. Generally speaking, there is more boron in the subsoil and deeper (Haas, 1992). Among micronutrients, B deficiency is wide spread throughout India. Reasons behind the boron deficiency are - High soil pH, coarse texture, low organic matter and low moisture content [8]. Boron is very important in cell division, pod and seed formation. Factor such as pH, texture, organic matter, temp., moisture content and plant species influence boron adsorption, and thereby, plant B uptake. Coarse textured soils prone to leaching as a result of excessive rainfall in humid climate are generally associated with B deficiency [14]. Roots of many crops (Such as pulses and oilseeds) may beyond the surface layer to derive part of their nutrient requirements from the subsurface layer, therefore it is desirable to have information about the depth-wise distribution of available Boron content in the soil. Being a less mobile nutrient in plants, boron deficiency symptoms first appear on stem tips, young leaves, flowers and buds [15]. B deficiency symptoms in plants include dark green, leathery, downward cupping of leaves and dieback of shoot tips [16]. Boron is retained in soils by adsorption onto minerals and humic particles and by forming insoluble precipitates [14]. Total boron content in Indian soils has been reported to varying from 3.80 to 630 mg kg^{-1} and available boron from 0.04 to 7.40 mg kg^{-1} [17]. Application of Zn and B containing fertilizers must be needed to exploit the production potential of crops under cropping systems and also to mitigate the deficiencies of these nutrients.

2. EXPERIMENTAL DETAILS

Design- Factorial randomize block design
Number of plots – 36

Plot size- 3 m×3 m
Spacing – (30×10) cm
Test crop- Black gram
Variety- IPU2-43

2.1 Mode of Treatment Application

The source of fertilizers used was Urea (46% N) for nitrogen, DAP (18% N and 46% P_2O_5) for nitrogen and phosphorous and MOP (60% K_2O) for potassium. Application of half dose of nitrogen and total phosphorus and potash as a starter dose. experimental plot nutrient supplied through (S_1) borax & (S_3) boric acid, as basal respectively. For S_1 foliar application of solubor were applied at 50% vegetative stage.

2.2 Collection of Samples for laboratory Work

Soil sample was collected from BAC Sabour, Farm. Collected soil was completely air-dried in shade powdered in wooden mortar with pestle and sieved through 2 mm sieve for further analysis.

2.3 Methods of Analysis

A field experiment was conducted with Greek gram var. IPU2-43 in factorial randomized block design with three sources, four doses and two methods of application of boron replicated thrice: Three sources were: S_1: Borax Soil application, S_2: Solubor Foliar application and S_3: Boric acid Soil application; Doses: D_1: 0.5 kg ha^{-1}, D_2: 1.0 kg ha^{-1}, D_3: 1.5 kg ha^{-1}, D_4: 2.0 kg ha^{-1}.The yield of clean and dry grains in the net plot was recorded in kg/plot and was later converted into q/ha to give the grain yield. The straw from each net plot was air-dried and weighted. The straw yield, thus converted in q/ha. Nutrient uptake by rice was calculated in kg/ha in relation to dry matter production (seed or straw).Boron content in plant samples were determined as per the method outlined by Jackson, [18]. One gm dry powdered plant samples were weighed in silica crucible and placed in muffle furnace for 1-3 hrs at 450-600°C and then cooled. The sample color was grayish or white. Then samples were wetted with 8-10 drops of deionized water and subsequently with 20 ml 0.1 N HCl with the help of a pipette into the crucible. Samples were then kept or reaction at room temperature for just about 50 to 60 minutes. Sporadically samples were stirred with the help of plastic or boron free glass rod to break up ash. Then these samples were filtered through whatman no. 1 filter paper. This filtrate was used for B determination. Colour was developed by pipetting 2 ml sample filtrate into test tube and added to it 2 ml of buffer-masking reagent and 1 ml Azomethine-H reagent. Samples were mixed up meticulously and thoroughly. Then samples were allowed to develop colour for 1 hr. After colour development, these samples were measured for their absorbance at 420 nm using a Spectrophotometer. Boron concentrations of sample were determined from the standard curve constructed by plotting absorbance versus concentration of standards in µg B/ml. [19]. Nutrient uptake by Black gram was calculated in kg/ha in relation to dry matter production (seed or straw).The experimental data recorded in respect of different observations in the present experiment were analyzed statistically with the help of following procedures for Factorial Randomized block design to test the significance of the overall differences among treatment by the F test and conclusion were drawn at 5% probability level [20].

3. RESULTS AND DISCUSSION

3.1 Grain Yield

Application of Solubor resulted in higher seed yield (7.96 q ha^{-1}) which was superior over the rest of the boron sources. Seed yield due to doses of boron was found significant at harvest stage of the crop. Application of 1.5 kg B ha^{-1} registered maximum seed yield of (8.27 q ha^{-1}) which was at par 2.0 kg B ha^{-1} and showed statistically superior over rest doses. The lowest seed yield (7.70 q ha^{-1}) was recorded from 0.5 kg B ha^{-1} which was showed statistical inferior over rest of the boron doses. This might be due to the enhanced vegetative growth; number of branches per plant provided more site for translocation of photosynthates and finally resulted in increment in yield attributes. The beneficial effect of boron on yield attributes might be due to flower development pollen grain formation, pollen tube growth, pollen viability for proper pollination and seed development. Similar results were obtained by (Pandey and Gupta) [8] in black gram.

3.2 Straw Yield

Sources of boron caused no significant variation in straw yield of black gram at harvest stage of the crop. However, application of Solubor found highest straw yield (9.53 q ha^{-1}) which was superior over the rest of the boron sources. Straw yield due to doses of boron were found significant at harvest stage of the crop. The increasing dose of boron showed the increment in straw yield of black gram up to 1.5 kg B ha^{-1}. Application of 1.5 kg B ha^{-1} registered maximum straw yield of (10.04 q ha^{-1}) which was at par 2.0 kg B ha^{-1} and statistically superior over rest of the doses. This might be due to quick availability of boron to crop during the entire growing period. Boron plays an important role in tissue differentiation and carbohydrate metabolism; it is also a constituent of cell membrane and essential for cell division, maintenance of conducting tissue with regulatory effect on another element. It is also necessary for sugar translocation in plant and development of new cell in meristematic tissue. The results confirm by the finding of Praveena et al. [21].

3.3 Boron Uptake by Grain

Boron uptake by plant in all case of sources of boron varied non-significantly. Solubor was found to have the highest boron uptake among the sources. As far as doses of boron was concerned, boron uptake increased with increasing in B doses resulting at 1.5 kg B ha^{-1} was found significant over rest of the boron doses. This increase may be the result of increased grain production with the addition B which enhances their availability in soil therefore; uptake was significantly higher by the application of different levels of boron. The interactive effect of boron and phosphorus, application on nutrient uptake showed a significant effect. The result was confirmed with the findings of (Kamboj and Malik) [22].

Table 1. Effect of different sources of boron and its different doses on grain yield (q ha^{-1}) of black gram

Sources / Doses	S_1 Borax soil application	S_2 Solubor foliar application	S_3 Boric acid soil application	Mean
D_1 0.5 kg ha^{-1}	7.70	7.65	7.76	7.70
D_2 1.0 kg ha^{-1}	7.84	7.89	7.83	7.85
D_3 1.5 kg ha^{-1}	8.26	8.41	8.14	8.27
D_4 2.0 kg ha^{-1}	7.71	7.89	7.90	7.83
Mean	7.88	7.96	7.91	
Sources	SEm (±)		C.D (P=0.05)	
S	0.12		NS	
D	0.14		0.40	
S×D	0.24		NS	

Table 2. Effect of different sources of boron and its different doses on straw yield (q ha^{-1}) of black gram

Sources / Doses	S_1 Borax soil application	S_2 Solubor foliar application	S_3 Boric acid soil application	Mean
D_1 0.5 kg ha^{-1}	9.08	9.12	9.17	9.13
D_2 1.0 kg ha^{-1}	9.34	9.42	9.29	9.35
D_3 1.5 kg ha^{-1}	9.91	10.25	9.96	10.04
D_4 2.0 kg ha^{-1}	9.09	9.34	9.31	9.25
Mean	9.36	9.53	9.43	
Sources		SEm (±)	C.D (P=0.05)	
S		0.20	NS	
D		0.23	0.67	
S×D		0.40	NS	

Table 3. Effect of different sources of boron and its different doses on boron uptake (g ha^{-1}) by grain of black gram

Doses \ Sources	S_1 borax soil application	S_2 solubor foliar application	S_3 boric acid soil application	Mean
D_1 0.5 kg ha^{-1}	11.26	11.70	11.48	11.48
D_2 1.0 kg ha^{-1}	11.73	12.27	11.93	11.98
D_3 1.5 kg ha^{-1}	12.54	12.88	12.49	12.64
D_4 2.0 kg ha^{-1}	11.88	12.82	12.23	12.31
Mean	11.85	12.42	12.03	
Sources		SEm (±)		C.D (P=0.05)
S		0.21		NS
D		0.24		0.71
S×D		0.42		NS

Table 4. Effect of different sources of boron and its different doses on boron uptake (g ha^{-1}) by straw of black gram

Doses \ Sources	S_1 Borax soil application	S_2 Solubor foliar application	S_3 Boric acid soil application	Mean
D_1 0.5 kg ha^{-1}	14.77	15.45	15.05	15.09
D_2 1.0 kg ha^{-1}	15.49	16.13	15.63	15.75
D_3 1.5 kg ha^{-1}	16.68	17.31	16.85	16.95
D_4 2.0 kg ha^{-1}	15.46	16.56	15.89	15.97
Mean	15.60	16.36	15.86	
Sources	SEm (±)		C.D (P=0.05)	
S	0.33		NS	
D	0.39		1.13	
S×D	0.67		NS	

3.4 Boron Uptake by Straw

Solubor Foliar application (S_2) was found to have the highest boron uptake (16.36 g ha^{-1}) among the sources and lowest boron uptake in straw was found with (S_1) borax soil application. Among the doses of boron higher value of boron uptake was recorded with (D_3) 1.5 kg B ha^{-1}which was significant over rest of the boron doses Foliar application is a most suitable method for the application of boron by which the boron uptake was found to be highest.

This might be due to the 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 plant vigour and enlargement root growth and cell division which resulted in higher straw production Mevada et al. [23], Sharma et al. [24] reported similar results.

4. CONCLUSION

Based on the findings of field experiment it can be concluded that the application of graded doses of boron enhanced the growth and yield as well as concentration and uptake of boron. Therefore, addition of boron fertilizer made more boron nutrient available to the black gram crop. Application of 1.5 kg B ha^{-1} was found to be best in terms of black gram yield and uptake. It was found that foliar applications the best application methods for the boron.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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