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# Effect of different sources of boron and it's doses on physico-chemical properties of soil and nutrients in soil

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**Abstract**
Boron management is challenging because the optimum B application range is narrow and optimum B application rates can differ from one soil to another. Among micronutrients, B deficiency is wide spread throughout India. Factor such as pH, texture, organic matter, temperature, moisture content and plant species influence B 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. Boron is retained in soils by adsorption onto minerals and humic particles and by forming insoluble 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 $kg^{-1}$. It is imperative that application of Zn and B containing fertilizers are needed to exploit the production potential of crops under cropping systems and also to mitigate the deficiencies of these nutrients. Addition of S + Zn + B in balanced fertilization schedule increased N, P and K utilization efficiency which highlights the role of micronutrients in increasing macronutrient use efficiency. Since, maize and black gram are the two important crops which are preferred much for its nutritional quality; 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 Green 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 $ha^{-1}$, $D_2$: 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 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. There was no significant effect of different sources and doses of boron on soil pH, EC, OC and available NPK. The different forms of boron increased over its initial status with the application of different sources and doses of boron but results did not vary significantly. While among different doses applied, application of 1.5 kg B $ha^{-1}$ was observed to be at par with the application of 2.0 kg B $ha^{-1}$ in increasing increasing the amount of boron in different available forms. It was found that foliar applications the best application methods for the boron.

**Keywords:** Physico-chemical properties, macro-nutrients, black gram, pH, EC, Organic carbon

## Introduction
Boron management is challenging because the optimum B application range is narrow and optimum B application rates can differ from one soil to another (Gupta, 1993; Marschner, 1995) [10, 16]. The boron content in the soil changes between 2 and 100 ppm (Swaine, 1955). 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 (Carlos, 2000) [5]. A tolerable boron concentration for plants in soils is approximately 25 ppm (Khan 2009) [14]. Generally speaking, there is more boron in the subsoil and deeper (Haas, 1992) [11]. 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 (Pandey and Gupta, 2013) [20].

At present about 33 % area at national level and 38% area in Bihar are B deficient (Singh, 2001) [23]. Boron is an essential micronutrient required for growth and development of vascular plants, diatoms and species of marine algal flagellates. Leguminous plants as well as cyanobacteria require B for $N_2$ fixation, as B plays a major role in nitrogen assimilation (Brown and Shelp, 1997) [4]. Boron (B), an essential micronutrient, plays an important role in cell wall structure, membrane stability, sugar transportation and phenol, carbohydrate, nucleic acid and IAA (Indol acetic acid) metabolism. In addition to its involvement in numerous metabolic processes, B has a great impact on productive structure development especially on micro-sporogenesis, pollen germination and seed development (Pandey and Gupta, 2013) [20]. Factor such as pH, texture, organic matter, tempeture, moisture content and plant species influence B 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 (Goldberg, 1997) [8]. 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 (Dobermann and Fairhurst, 2000) [7]. B deficiency symptoms in plants include dark green, leathery, downward cupping of leaves and dieback of shoot tips (Bell, 1997) [1]. Boron is retained in soils by adsorption onto minerals and humic particles and by forming insoluble precipitates. 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 $kg^{-1}$ (Takkar and Randhawa, 1978) [28].

## Materials and Methods

The study **"**Relative changes in Boron fractions in black gram rhizosphere**"** was carried out in 2018 in *kharif* season at BAC Farm, Sabour Bhagalpur. The details of the methods adopted for crop raising, materials used, and criteria adopted for the valuation of treatments during the course of investigation are presented in this chapter.

### Climate and weather conditions

The cumulative rainfall recorded was 248.7 mm during the experimental period from August to November, 2018 which was 916.3 mm less than the normal rainfall (1165 mm) for this locality. Rainfall was a bit lower in early part of the crop season and very high in August. However, good drainage facilities of the experimental plot did not pose any problem due to stagnation of water. Relative humidity in the morning hours (7:00 am) and in the afternoon (2:00 pm) ranged between 82.6 to 91.6 and 56.9 to 77.7 per cent, respectively. Maximum and minimum temperature recorded for the same period varied in between 28.0 to 34.6 °C and 10.2 to 26.0 °C, respectively. Wind speed varied from 1.4 to 7.2 km $hr^{-1}$. The key factor influencing the relative duration of vegetative and reproductive growth is the "day length" which ultimately affect the dry matter and yield of the crop. The average duration of bright sunshine did not vary much and the values were 6.2 hours $day^{-1}$ during the entire Black gram growing period in 2018. Summing up the overall situation it may be said that the weather condition prevailing during *kharif* season of the year 2018 was congenial for raising a Black gram crop.

### 1. Collection of samples for laboratory work

Soil sample were 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. Methods of analysis

#### 2.1. Soil properties

**(i) Soil reaction**

Soil pH was determined in 1:2.5 soil to water suspension through pouring the combined electrode of a digital pH meter (Systronics pH meter model 335) as outlined by Jackson (1973) [12].

**(ii) Electrical conductivity**

Electrical conductivity of soil samples was measured in 1:2.5 soil to water extract using conductivity bridge (Elico conductivity meter model 180) as described by Jackson (1973) [12] under suitable measuring conditions. The results were expressed in terms of $dSm^{-1}$ at 25 ˚C.

**(iii) Organic carbon**

Easily oxidizable organic carbon content of soil samples was determined by Walkley and Black's wet oxidation method. In this method, take 1 g of processed soil sample was taken into 500 ml dry conical flask then Add 10 ml of $K_2Cr_2O_7$ and 20 ml of conc. $H_2SO_4$. Swirl a little and keep it for 30 minutes to cool the content, than add slowly 200 ml of distilled water and 10 ml of orthophosphoric acid or 1 g sodium fluoride then add 1 ml of diphenylamine indicator. Take 0.5 N ferrous ammonium sulphate solution in 50 ml burette and then titrate the contents until green colour starts appearing.

**(iv) Available nitrogen (N)**

The mineralizable available N content of the soil was determined by alkaline permanganate method as outlined by Subbiah and Asija (1956) [26]. Available nitrogen content in soil before and after black gram harvest was examined. The easily mineralizable N is reckoned by using alkaline $KMnO_4$ which oxidizes the organic matter present in soil and hydrolyses the liberated ammonia which is condensed and absorbed in boric acid. The content is titrated against standard acid. This method has been mostly adopted for the estimation of available nitrogen content in the soil due to its rapidness and consistency. The process of oxidative hydrolysis requires undifferentiated heating temperatures for better result. (Nitrogen Analyzer – Kel Plus-Elite EX (VA) is used for the estimation of available nitrogen.

**(v) Available phosphorus ($P_2O_5$)**

Available phosphorus content in soil before and after black gram harvest was extracted by the method as suggested by Olsen (1954) [19]. The $NaHCO_3$ solution extracts P from Calcium phosphates, some P from Al and Fe phosphates. The soluble phosphate forms heteropoly complexes with molybdate ions librated from ammonium molybdate. The hetero polycomplexes gives faint yellow colour, which on reduction with ascorbic acid gives blue colour. The intensity of blue colour is directly proportional to the concentration of phosphate and read on colorimeter at wavelength of 760 nm using red filter. The conc. of P in soil extract is calculated from the standard curve prepared at same time.

**(vi) Available potassium ($K_2O$)**

Available potassium content in soil was extracted by the (Flame Photometer Elico CL 378) after 5 minutes shaking with 25 ml of 1 N ammonium acetate (Black, 1965) [3].

**(vii) Hot water extractable boron (HWEB)**

The Boron from the soil was extracted from soil with water (1:2) by refluxing for 5 minutes on Hot Plate-Unitech. (Berger and Troug 1939) [2]. The HWEB in the extractant was determined by spectrophotometer at 420 nm using Azomethine-H as indicator (John *et al.* 1975) [13].

**(viii) Boron fractionation procedure and colorimetric estimation**

For Boron fractionation study procedure outlined by Datta et *al.* (2002) [6] was followed where the soil was subjected to sequential extraction procedure as follows. Duplicate samples for each treatment were taken for fractionation study.

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 significant of the overall differences among treatment by the F test and conclusion were drawn at 5% probability level Gomez KA, Gomez AA (1988) [9]. The analysis of variance table present study is given below:

## Results and Discussion

### 3.1. Effect of different sources of Boron and its different doses on physico-chemical properties of soil

#### 3.1.1 Soil reaction (pH)

The data presented in Table 1 on the effect of different sources of Boron and their different doses on soil pH was found to be non-significant. There was an overall increase in soil pH from initial soil 7.65 to 7.69. Different sources decreased soil pH from 7.63 to 7.58 while different doses decreased it from 7.67 to 7.52 and interaction between the different treatment combinations decreased it from 7.69 to 7.51 and was found to be non-significant. Above findings are in accordance with those reported by Ram *et al.* (2014) [21] who found that pH of post-harvest soil did not vary significantly with the application of S, Zn and B. Fageria *et al.* (2002) also reported that higher the soil pH lower the boron availability.

**Table 1:** Effect of different sources of Boron and its different doses on pH of the soil

| Sources / Doses | $S_1$ Borax Soil application | $S_2$ Solubor Foliar application | $S_3$ Boric acid Soil application | Mean |
|---|---|---|---|---|
| $D_1$ 0.5 kg $ha^{-1}$ | 7.65 | 7.59 | 7.69 | 7.64 |
| $D_2$ 1.0 kg $ha^{-1}$ | 7.67 | 7.69 | 7.65 | 7.67 |
| $D_3$ 1.5 kg $ha^{-1}$ | 7.66 | 7.51 | 7.65 | 7.61 |
| $D_4$ 2.0 kg $ha^{-1}$ | 7.55 | 7.51 | 7.51 | 7.52 |
| Mean | 7.63 | 7.58 | 7.62 | |

| Sources | S Em (±) | C.D (P=0.05) |
|---|---|---|
| S | 0.10 | NS |
| D | 0.12 | NS |
| S×D | 0.20 | NS |

#### 3.1.2 Electrical conductivity (EC ds $m^{-1}$)

A perusal of data on soil EC presented in table 2 revealed that EC of soil was found to be non-significant owing to sources and doses of boron However, EC was found towards decreasing trend on application of increasing boron doses over initial status. Among sources of boron, Solubor showed relatively more decline in soil EC rather than Borax and Boric acid. Ram *et al.* (2014) [21] found that EC of post- harvest soil was non-significantly affected by the application of S, Zn and B. Rathiya *et al.* (2018) [22] also reported that there is no any significant effect on EC by the application of boron.

**Table 2:** Effect of different sources of Boron and its different doses on EC (ds$m^{-1}$) of the soil

| Sources / Doses | $S_1$ Borax Soil application | $S_2$ Solubor Foliar application | $S_3$ Boric acid Soil application | Mean |
|---|---|---|---|---|
| $D_1$ 0.5 kg $ha^{-1}$ | 0.28 | 0.31 | 0.29 | 0.29 |
| $D_2$ 1.0 kg $ha^{-1}$ | 0.27 | 0.29 | 0.28 | 0.28 |
| $D_3$ 1.5 kg $ha^{-1}$ | 0.26 | 0.28 | 0.28 | 0.27 |
| $D_4$ 2.0 kg $ha^{-1}$ | 0.25 | 0.27 | 0.26 | 0.26 |
| Mean | 0.27 | 0.29 | 0.28 | |

| Sources | SEm (±) | C.D (P=0.05) |
|---|---|---|
| S | 0.01 | NS |
| D | 0.01 | NS |
| S×D | 0.02 | NS |

#### 3.1.3 Organic carbon

A perusal of data on organic carbon content in soil presented in Table 3 shows that variations in organic carbon of soil were found non-significant due to different sources and doses of boron. Among the sources, Borax had lowest value (0.45%) of organic carbon and Boric acid showed the highest (0.49%). There was increase in organic carbon with the application of boron up to 1.5 kg B $ha^{-1}$ and thereafter slight reduction in its value. Ram *et al.* (2014) [21] found that organic carbon of post -harvest soil did not significantly vary with the application of S, Zn and B. Rathiya *et al.* (2018) [22] also found that there was no any significant effect on organic carbon by the application of boron.

**Table 3:** Effect of different sources of Boron and its different doses on OC (%) of the soil

| Doses \ Sources | $S_1$ Borax Soil application | $S_2$ Solubor Foliar application | $S_3$ Boric acid Soil application | Mean |
|---|---|---|---|---|
| $D_1$ 0.5 kg $ha^{-1}$ | 0.44 | 0.45 | 0.50 | 0.46 |
| $D_2$ 1.0 kg $ha^{-1}$ | 0.44 | 0.46 | 0.52 | 0.47 |
| $D_3$ 1.5 kg $ha^{-1}$ | 0.52 | 0.44 | 0.49 | 0.48 |
| $D_4$ 2.0 kg $ha^{-1}$ | 0.40 | 0.52 | 0.45 | 0.46 |
| Mean | 0.45 | 0.47 | 0.49 | |

| Sources | SEm (±) | C.D (P=0.05) |
|---|---|---|
| S | 0.01 | NS |
| D | 0.01 | NS |
| S×D | 0.02 | NS |

### 3.2 Effect of different sources of Boron and its different doses on major macro nutrients in soil

#### 3.2.1 Available Nitrogen (N)

Perusal of data on available nitrogen in soil presented in Table 4.5 revealed that sources of boron did not show any significant change in available nitrogen content of soil. However, there was higher available N with the application of boric acid. As far as boron doses was concerned, it indicated increasing trend up to 1.0 kg B $ha^{-1}$, then after there was little reduction in its value but registered relatively higher than initial value. This might be due to the fact that black gram being a leguminous crop fixes the nitrogen biologically and thereby accorded increased content. The similar findings were observed by Singh (2017) was also reported that the interaction between boron and nitrogen was positive but statistically non-significant.

**Table 4:** Effect of different sources of Boron and its different doses on Available N of the soil

| Doses \ Sources | $S_1$ Borax Soil application | $S_2$ Solubor Foliar application | $S_3$ Boric acid Soil application | Mean |
|---|---|---|---|---|
| $D_1$ 0.5 kg $ha^{-1}$ | 205.44 | 202.54 | 216.85 | 208.28 |
| $D_2$ 1.0 kg $ha^{-1}$ | 205.68 | 203.70 | 218.21 | 209.20 |
| $D_3$ 1.5 kg $ha^{-1}$ | 195.30 | 214.20 | 214.20 | 207.90 |
| $D_4$ 2.0 kg $ha^{-1}$ | 203.06 | 209.38 | 207.10 | 207.43 |
| Mean | 202.37 | 207.46 | 214.09 | |

| Sources | SEm (±) | C.D (P=0.05) |
|---|---|---|
| S | 4.54 | NS |
| D | 5.24 | NS |
| S×D | 9.07 | NS |

#### 3.2.2 Available Phosphorus ($P_2O_5$)

The data on available phosphorus in soil illustrated in Table 5 showed that sources of boron did not make any significant effect on available phosphorous content in soil. Among the use of various sources the maximum value of available P was found with Solubor. As far as the doses of boron was concerned, their values was increasing with increasing doses of boron up to 1.5 kg B $ha^{-1}$ and it further decreased but observed remarkable increase over initial status in all treatments.

**Table 5:** Effect of different sources of Boron and its different doses on Available Phosphorus of the soil

| Doses \ Sources | $S_1$ Borax Soil application | $S_2$ Solubor Foliar application | $S_3$ Boric acid Soil application | Mean |
|---|---|---|---|---|
| $D_1$ 0.5 kg $ha^{-1}$ | 20.90 | 21.44 | 20.12 | 20.35 |
| $D_2$ 1.0 kg $ha^{-1}$ | 2068 | 21.86 | 20.77 | 21.01 |
| $D_3$ 1.5 kg $ha^{-1}$ | 20.48 | 22.55 | 20.43 | 21.16 |
| $D_4$ 2.0 kg $ha^{-1}$ | 20.07 | 21.36 | 21.11 | 20.84 |
| Mean | 20.11 | 21.80 | 20.61 | |

| Sources | SEm (±) | C.D (P=0.05) |
|---|---|---|
| S | 0.24 | NS |
| D | 0.28 | NS |
| S×D | 0.48 | NS |

#### 3.2.3 Available Potassium ($K_2O$)

A perusal of data on available potassium content in soil as presented in Table 6 revealed that the effect of sources and doses of boron was found to be non-significant. However, there was increase in soil available potassium over the initial status. Boric acid showed the highest value among the sources of boron. The value of potassium content in soil enhanced with increasing B doses up to 1.5 kg B $ha^{-1}$ and further increase in dose led to sharp decrease in its content. However, it was found that there was remarkable increase over initial status in all the treatments. This decrease was might be due to the toxic concentration of boron in the soil at $D_4$ level of boron application (Mengel and Kirkby, 2001) [17].

**Table 6:** Effect of different sources of Boron and its different doses on available potassium (kg ha$^{-1}$) of the soil

| 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$^{-1}$ | 219.97 | 234.85 | 225.79 | 226.87 |
| $D_2$ 1.0 kg ha$^{-1}$ | 225.79 | 219.50 | 232.94 | 226.08 |
| $D_3$ 1.5 kg ha$^{-1}$ | 232.16 | 231.66 | 249.88 | 237.90 |
| $D_4$ 2.0 kg ha$^{-1}$ | 219.07 | 225.00 | 236.54 | 226.87 |
| Mean | 224.25 | 227.75 | 236.29 | |

| Sources | SEm (±) | C.D (P=0.05) |
|---|---|---|
| S | 3.49 | NS |
| D | 4.02 | NS |
| S×D | 6.97 | NS |

### 3.2.4 Available Boron ($H_3BO_3$)

A perusal of data on available boron in the soil illustrated in Table 7 shows that available boron in soil was not significantly affected due to sources of boron. However the highest boron content in soil was found with the application of Solubor as source. It was also observed that there was increase in available B content with the application of both sources and doses of B treated plots over the initial value. The different doses of boron significantly increased the available B status in soil with corresponding enhancement in their doses resulting in highest B content under 2.0 kg B ha$^{-1}$. The content at 1.5 kg B ha$^{-1}$ (0.57 mg kg$^{-1}$) was significantly higher than that at $D_1$ (0.47 mg kg$^{-1}$) and $D_2$ (0.50 mg kg$^{-1}$) but statistically at par with that under 2.0 kg B ha$^{-1}$ (0.62 mg kg$^{-1}$). However, the effect of interaction of doses and sources was found to be non-significant. This might be due to the application of different doses of boron fertilizer which easily comes into the available boron pool. Similar results were also reported by the Kumar *et al*. (2018) [15].

**Table 7:** Effect of different sources of Boron and its different doses on Available Boron (mg kg$^{-1}$) of the soil

| 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$^{-1}$ | 0.47 | 0.48 | 0.46 | 0.47 |
| $D_2$ 1.0 kg ha$^{-1}$ | 0.50 | 0.51 | 0.50 | 0.50 |
| $D_3$ 1.5 kg ha$^{-1}$ | 0.52 | 0.61 | 0.58 | 0.57 |
| $D_4$ 2.0 kg ha$^{-1}$ | 0.59 | 0.67 | 0.60 | 0.62 |
| Mean | 0.52 | 0.57 | 0.53 | |

| Sources | SEm (±) | C.D (P=0.05) |
|---|---|---|
| S | 0.02 | NS |
| D | 0.02 | 0.07 |
| S×D | 0.04 | NS |

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