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# EFFECT OF NITROGEN AND BORON ON AVAILABLE NUTRIENTS IN SESAME (*Sesamum indicum* L.) AND HARVESTED SOIL

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## A B S T R A C T

A field experiment was carried out at the Soil Science research field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh to study the nutrient uptake of sesame plant and available nutrient condition of soil after harvesting of sesame. Sesame variety BARI Til-3 was used as test crop. The experiment consisted of two factors. Factor A: Nitrogen levels ($N_{0-3}$): $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; Factor B: Boron levels ($B_{0-2}$): $B_0$: 0 kg B/ha (control), $B_1$: 2 kg B/ha, $B_2$: 3 kg B/ha. The experiment was carried out in two factors Randomized Complete Block Design (RCBD) with three replications. From the study, it was found that nutrient uptake of sesame plant and the nutrient concentration in post-harvested soil such as total N, available P, exchangeable K, available S and available B was increased with the increasing of nitrogen up to a certain level and boron supply. For the combined application of nitrogen and boron (60 kg N/ha and 3.0 kg B/ha) was found suitable to uptake maximum N, P, K, S and B by the sesame plant and to available the highest nutrient concentration in post-harvested soil.

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## INTRODUCTION

Sesame (*Sesamum indicum* L.) belongs to the family *Pedaliaceae* is one of the vital oil crops, which is widely grown in different parts of the world. It is grown for seed and oil for thousands of years and today its major production areas are the tropics and the subtropics of Asia, Africa, East and Central America. In Bangladesh, it is locally known as 'til' and is the second important produced edible oil crop (Mondal et al., 1997). Sesame is a versatile crop having diversified usage and contains 42-45% oil, 20% protein and 14-20% carbohydrate (BARI, 2012). In 2015-2016 the crop covered an area of 99,592 acres in Bangladesh with the production of 36,921 metric tons (BBS, 2017). The climate and edaphic conditions of Bangladesh are quite suitable for sesame cultivation. Yield and quality of sesame seeds are very low in Bangladesh. Deficiency of soil nutrient is now considered as one of the significant constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). To attain suitable production and quality yield for any crop it is necessary to apply proper management with ensuring the availability of an essential nutrient in proper doses. Generally, a considerable amount of fertilizer is required for the growth and development of sesame (Opena et al., 1988). Nitrogen is a structural constituent of chlorophyll and protein therefore, the adequate supply of nitrogen is beneficial for both carbohydrates and protein metabolism as it assists cell division and cell enlargement, resulting in more leaf area and thus ensuring good seed and dry matter yield (Ibrahim et al. 2014). On the other hand, excessive application of nitrogen is not only uneconomical, but it can prolong the growing period and delay crop maturity. Excessive nitrogen application causes physiological disorder (Obreza and Vavrina, 1993).

Boron is one of the crucial micronutrients required for plant growth and productivity. It plays a vital role in cell wall synthesis, RNA metabolism, and root elongation as well as phenol metabolism. Also, boron involved in pollen and tube growth (Srivastava and Gupta, 1996). Kalyani et al., (1993) noticed that boron applied as boric acid increased the plant height, relative growth rate, net assimilation rate and leaf area index. Boron is a micronutrient essential for healthy growth of pollen grains, sugar translocation and movement of growth regulators within the plant (Hamasa and Putaiah, 2012). Photosynthetic activity and metabolic activity enhanced with the application of boron (Sathya et al., 2009). Boron's involvement in hormone synthesis and translocation, carbohydrate metabolisms and DNA synthesis probably contributed to additional growth and yield (Kalyani et al., 1993). The objectives of this study were to find out the nutrient concentration in seeds and stover of sesame, and nutrient status of harvested soil due to the application of nitrogen and boron. Through this experiment farmers can get optimum dose of nitrogen and boron fertilizer for sesame cultivation.

## MATERIALS AND METHODS

### Study area and time

The experiment was conducted during the period from February to May 2016 at the research field of Soil Science of SAU. The location of the experimental site is located at $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and an elevation of 8.2 m from the sea level (Mostofa et al., 2019).

### Soil Condition and weather

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soil. A composite sample was made by collecting soil from the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, grounded and passed through 2 mm sieve and analyzed for significant physical and chemical parameters. The initial physical and chemical characteristics of the soil are presented in Table 1. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka (2016) are presented in Table 2.

**Table 1.** Initial physical and chemical characteristics of the soil (0-15 cm depth)

| Characteristics | Value |
|---|---|
| Mechanical fractions: | |
| % Sand (2.0-0.02 mm) | 18.60 |
| % Silt (0.02-0.002 mm) | 45.40 |
| % Clay (<0.002 mm) | 36.00 |
| Textural class | Silty Loam |
| Consistency | Granular and friable when dry |
| pH (1: 2.5 soil- water) | 5.8 |
| Organic Matter (%) | 1.187 |
| Total N (%) | 0.06 |
| Exchangeable K (mmol $kg^{-1}$) | 0.12 |
| Available P (mg $kg^{-1}$) | 19.85 |
| Available S (mg $kg^{-1}$) | 14.40 |
| Available B (mg $kg^{-1}$) | 6.25 |

**Table 2.** Monthly record of air temperature, relative humidity, rainfall and sunshine hours of the experimental site during the period from February to May 2016

| Month (2016) | *Air temperature (ºc) | | *Relative humidity (%) | Total Rainfall (mm) | *Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| February | 27.1 | 16.7 | 67 | 30 | 6.7 |
| March | 28.1 | 19.5 | 68 | 00 | 6.8 |
| April | 33.4 | 23.2 | 67 | 78 | 6.9 |
| May | 34.7 | 25.9 | 70 | 185 | 6.8 |

**Planting material**

Seeds of BARI Til-3 were used as a test crop for the study and those were collected from Bangladesh Agricultural Research Institute, Gazipur-1701. This variety was developed by BARI and released for cultivation in the year of 2001 (BARI, 2012). It is a non-hairy medium-sized plant with primary and secondary branches with the high potential plant.

**Experimental treatment**

The experiment consisted of two factors. Factor A: Levels of nitrogen (4 levels), $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; Factor B: Levels of boron (3 levels), $B_0$: 0 kg B/ha (control), $B_1$: 2 kg B/ha, $B_2$: 3 kg B/ha.

**Experimental design and layout**

The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. The size of the plot was 2.5 m × 1.5 m. The distance between two blocks and two plots was 50 cm each.

**Fertilizer application**

Manures and fertilizers that were applied to the experimental plot presented in Table 3 (BARI, 2012). The total amount of Cowdung, TSP, half of the MOP, total zinc and sulfur were applied as basal dose during the time of land preparation. The rest amount of MOP and the total amount of urea (as per treatment) were applied in two installments at 15 and 30 days after seed sowing.

**Crop Management**

All intercultural operations such as irrigation, thinning, gap filling, weeding and plant protection measures were taken as per when needed. The pods were harvested depending upon the attaining good sized and the harvesting was done manually. Enough care was taken during harvesting.

**Parameters determined**

The data were collected from the inner rows of plants of each treatment to avoid the border effect. In each unit plot, ten plants were selected at random for data collection. Data were recorded on the following parameters.

### Chemical analysis of seed and stover samples

**Collection and preparation of samples**

Seed and stover samples were collected after threshing and finely grounded by using a Wiley-Mill grinder to pass through a 60-mesh sieve. Then the plant samples were dried in an oven at 70 $^{0}$C for 72 hours and grounded by a grinding machine to pass through a 20-mesh sieve. Then the samples were analyzed for determination of N, P, K, S and B concentrations.

**Determination of N, P, K, S and B from samples**

N concentration of the sample was determined followed by the Micro Kjeldahl Method (Page et al., 1982). Phosphorous and Potassium concentration in samples was determined as described by Olsen et al., 1954 and Page et al., 1982. Sulphur concentration in samples was determined as described by Page et al., 1982 and Hunter, 1984. Boron concentration in samples was determined as described by Hunter, (1984).

### Chemical analysis of post-harvested soil

**Post-harvest soil sampling**

After harvesting of the sesame, soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in a plastic container to determine the physical and chemical properties of soil.

**Soil analysis**

Total N content of the soil was determined followed by the Micro Kjeldahl Method (Page et al., 1982). Soil pH, organic matter and Exchangeable K were measured as described by Page et al., (1982). Available P was measured as described by Olsen et al., 1954 and Page et al., 1982. Available B was measured as described by Hunter, (1984).

**Statistical analysis**

The data obtained for different parameters were statistically analyzed by using Statistix 10 (Statistix, 2013) computer package program to find out the significant difference of different levels of nitrogen and boron. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

### N, P, K, S and B concentration in seed and stover of sesame

**N, P, K, S and B concentration in seeds**

Statistically, significant variation was recorded for N, P, K, S and B concentration in seeds due to different levels of nitrogen. The maximum concentration in seed for N (0.55%), P (0.32%), K (0.55%), S (0.21%) and B (0.014%) were observed from $N_2$, whereas the minimum concentration in seed for N (0.39%), P (0.26%), K (0.43%), S (0.17%) and B (0.011%) were found from $N_0$ (Table 4).

N, P, K, S and B concentration in seeds showed statistically significant variation due to different levels of boron. The maximum concentration in seeds for N (0.56%), P (0.31%), K (0.51%), S (0.20%) and B (0.014%) were recorded from $B_2$ and the minimum concentration in seeds for N (0.39%), P (0.27%), K (0.46%), S (0.18%) and B (0.009%) from $B_0$ (Table 4).

**Table 3.** Dose and method of application of fertilizers in sesame field

| Fertilizers and Manures | Dose/ha | Application (%) | | |
|---|---|---|---|---|
| | | Basal | 15 DAS | 30 DAS |
| Cow dung | 10 tonnes | 100 | -- | -- |
| Urea | As per treatment | -- | 50 | 50 |
| TSP | 150 kg | 100 | -- | -- |
| MoP | 50 kg | 50 | 25 | 25 |
| Zinc Sulphate | 5 kg | 100 | -- | -- |
| Sulfur | 10 kg | 100 | -- | -- |
| Boron | As per treatment | 100 | -- | -- |

**Table 4.** Effect of nitrogen and boron on N, P, K, S and B concentrations in seeds of sesame

| Treatments | Concentration (%) in seeds | | | | |
|---|---|---|---|---|---|
| | N | P | K | S | B |
| **Levels of nitrogen** | | | | | |
| $N_0$ | 0.39 c | 0.26 c | 0.43 c | 0.17 c | 0.011 b |
| $N_1$ | 0.51 b | 0.29 b | 0.48 b | 0.19 b | 0.012 ab |
| $N_2$ | 0.55 a | 0.32 a | 0.55 a | 0.21 a | 0.014 a |
| $N_3$ | 0.51 b | 0.31 a | 0.48 b | 0.19 b | 0.012 ab |
| $LSD_{(0.05)}$ | 0.031 | 0.010 | 0.031 | 0.010 | 0.003 |
| **Levels of boron** | | | | | |
| $B_0$ | 0.39 c | 0.27 c | 0.46 b | 0.18 b | 0.009 b |
| $B_1$ | 0.52 b | 0.30 b | 0.49 a | 0.19 a | 0.014 a |
| $B_2$ | 0.56 a | 0.31 a | 0.51 a | 0.20 a | 0.014 a |
| $LSD_{(0.05)}$ | 0.027 | 0.009 | 0.027 | 0.009 | 0.003 |
| Significance level | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| CV (%) | 7.19 | 4.14 | 6.20 | 6.19 | 7.35 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; B0: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

**Table 5.** Interaction effect of nitrogen and boron on N, P, K, S and B concentrations in seeds of sesame

| Treatments | Concentration (%) in seeds | | | | |
|---|---|---|---|---|---|
| | N | P | K | S | B |
| $N_0B_0$ | 0.30 e | 0.24 g | 0.39 f | 0.16 f | 0.007 c |
| $N_0B_1$ | 0.38 d | 0.26 f | 0.41 ef | 0.17 ef | 0.012 a-c |
| $N_0B_2$ | 0.49 c | 0.28 de | 0.49 cd | 0.19 cd | 0.014 ab |
| $N_1B_0$ | 0.38 d | 0.27 ef | 0.47 c-e | 0.18 c-e | 0.010 bc |
| $N_1B_1$ | 0.56 ab | 0.30 bc | 0.47 c-e | 0.18 c-e | 0.013 a-c |
| $N_1B_2$ | 0.59 ab | 0.29 cd | 0.49 cd | 0.20 b-d | 0.013 a-c |
| $N_2B_0$ | 0.44 c | 0.28 de | 0.51 b-d | 0.20 b-d | 0.010 bc |
| $N_2B_1$ | 0.60 ab | 0.31 b | 0.56 ab | 0.21 ab | 0.016 ab |
| $N_2B_2$ | 0.61 a | 0.34 a | 0.58 a | 0.22 a | 0.017 a |
| $N_3B_0$ | 0.44 c | 0.30 b-d | 0.47 c-e | 0.18 c-e | 0.009 bc |
| $N_3B_1$ | 0.55 b | 0.31 bc | 0.52 bc | 0.20 bc | 0.014 ab |
| $N_3B_2$ | 0.55 b | 0.31 b | 0.45 de | 0.18 de | 0.013 a-c |
| $LSD_{(0.05)}$ | 0.054 | 0.017 | 0.054 | 0.017 | 0.005 |
| Significance level | 0.05 | 0.05 | 0.01 | 0.05 | 0.01 |
| CV (%) | 7.19 | 4.14 | 6.20 | 6.19 | 7.35 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; $B_0$: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

Interaction effect of nitrogen and boron showed statistically significant variation in terms of N, P, K, S and B concentration in seeds. The maximum concentration in seeds for N (0.61%), P (0.34%), K (0.58%), S (0.22%) and B (0.017%) were observed from $N_2B_2$, while the minimum concentration in seeds for N (0.30%), P (0.24%), K (0.39%), S (0.16%) and B (0.007%) were found from $N_0B_0$ treatment combination (Table 5).

**N, P, K, S and B concentration in stover**

Statistically, significant variation was recorded for N, P, K, S and B concentration in stover due to different levels of nitrogen. The maximum concentration in stover for N (0.51%), P (0.26%), K (1.55%), S (0.22%) and B (0.012%) were observed from $N_2$, whereas the minimum concentration in stover for N (0.27%), P (0.19%), K (1.28%), S (0.15%) and B (0.008%) were found from $N_0$ (Table 6). N, P, K, S and B concentration in stover showed statistically significant variation due to different levels of boron. The maximum concentration in stover for N (0.43%), P (0.25%), K (1.56%), S (0.20%) and B (0.012%) were recorded from $B_2$ and the minimum concentration in stover for N (0.39%), P (0.19%), K (1.35%), S (0.18%) and B (0.009%) from $B_0$ (Table 6).

Interaction effect of nitrogen and boron showed statistically significant variation in terms of N, P, K, S and B concentration in stover. The maximum concentration in stover for N (0.54%), P (0.30%), K (1.67%), S (0.26%) and B (0.013%) were observed from $N_2B_2$, while the minimum concentration in stover for N (0.25%), P (0.15%), K (1.17%), S (0.13%) and B (0.006%) were found from $N_0B_0$ treatment combination (Table 7).

N, P, K, S and B concentration in sesame seed and stover increased with the increasing of the nitrogen level up to 60 kg N/ha; thereafter N, P, K, S and B concentration decreased in seed and stover with increasing nitrogen level (Kumawat et al., 2000; Shehu, 2014). In case of boron, the concentration of N, P, K, S and B in seed and stover increased with the increasing of boron level. Boron has positive effect on nutrient uptake by plant and improves nutrient use efficiency, nutrient demand and supply (Bariya et al., 2014). A positive relationship was observed with nitrogen and boron while up taking mineral nutrients (N, P, K, S and B). Boron concentration was higher in seeds than stover and its concentration in seed increase with increasing boron application (Bubarai et al., 2017).

**Table 6.** Effect of nitrogen and boron on N, P, K, S and B concentrations in stover of sesame

| Treatments | Concentration (%) in stover | | | | |
|---|---|---|---|---|---|
| | N | P | K | S | B |
| **Levels of nitrogen** | | | | | |
| $N_0$ | 0.27 c | 0.19 c | 1.28 c | 0.15 c | 0.008 b |
| $N_1$ | 0.43 b | 0.22 bc | 1.48 b | 0.19 b | 0.011 ab |
| $N_2$ | 0.51 a | 0.26 a | 1.55 a | 0.22 a | 0.012 a |
| $N_3$ | 0.45 b | 0.23 ab | 1.52 ab | 0.20 b | 0.011 ab |
| LSD $_{(0.05)}$ | 0.031 | 0.031 | 0.069 | 0.010 | 0.003 |
| Significance level | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Levels of boron** | | | | | |
| $B_0$ | 0.39 b | 0.19 b | 1.35 c | 0.18 b | 0.009 a |
| $B_1$ | 0.42 a | 0.24 a | 1.46 b | 0.20 a | 0.011 b |
| $B_2$ | 0.43 a | 0.25 a | 1.56 a | 0.20 a | 0.012 b |
| LSD $_{(0.05)}$ | 0.027 | 0.027 | 0.060 | 0.009 | 0.00 |
| Significance level | 0.05 | 0.01 | 0.01 | 0.05 | 0.001 |
| CV (%) | 7.42 | 9.87 | 4.64 | 10.86 | 4.98 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; $B_0$: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

**Table 7.** Interaction effect of nitrogen and boron on N, P, K, S and B concentrations in stover of sesame

| Treatments | Concentration (%) in stover | | | | |
|---|---|---|---|---|---|
| | N | P | K | S | B |
| $N_0B_0$ | 0.25 d | 0.15 c | 1.17 e | 0.13 h | 0.006 b |
| $N_0B_1$ | 0.26 d | 0.22 b | 1.26 de | 0.16 fg | 0.008 ab |
| $N_0B_2$ | 0.30 d | 0.22 b | 1.41 c | 0.15 g | 0.010 ab |
| $N_1B_0$ | 0.42 c | 0.21 bc | 1.41 c | 0.20 cd | 0.010 ab |
| $N_1B_1$ | 0.42 bc | 0.22 b | 1.40 c | 0.20 cd | 0.010 ab |
| $N_1B_2$ | 0.45 bc | 0.23 b | 1.61 a | 0.18 de | 0.012 ab |
| $N_2B_0$ | 0.46 bc | 0.19 bc | 1.35 cd | 0.18 ef | 0.011 ab |
| $N_2B_1$ | 0.52 a | 0.29 a | 1.64 a | 0.24 b | 0.012 ab |
| $N_2B_2$ | 0.54 a | 0.30 a | 1.67 a | 0.26 a | 0.013 a |
| $N_3B_0$ | 0.44 bc | 0.21 b | 1.46 bc | 0.20 cd | 0.010 ab |
| $N_3B_1$ | 0.48 ab | 0.24 ab | 1.54 ab | 0.20 c-e | 0.011 ab |
| $N_3B_2$ | 0.41 c | 0.25 ab | 1.55 ab | 0.21 c | 0.012 ab |
| LSD $_{(0.05)}$ | 0.054 | 0.054 | 0.120 | 0.017 | 0.005 |
| Significance level | 0.05 | 0.05 | 0.01 | 0.05 | 0.01 |
| CV (%) | 7.42 | 9.87 | 4.64 | 10.86 | 4.98 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; $B_0$: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

## Total N, pH, organic matter, available P, exchangeable K and available B in post-harvest soil

### Total N

Total N of post-harvest soil showed statistically significant differences due to different levels of nitrogen, boron and combined interaction. In case of nitrogen levels, the highest total N of post-harvest soil (0.073%) was observed from $N_2$ which were statistically similar to $N_1$ and $N_3$; and lowest (0.050%) was observed from $N_0$ (Figure 1). In case of boron levels, the highest total N of post-harvest soil (0.070%) was recorded from $B_2$ which was statistically similar to $B_1$ and lowest (0.058%) was recorded from $B_0$ (Figure 2). In the case of interaction, the highest total N of post-harvest soil (0.078%) was observed from $N_2B_2$ and lowest (0.041%) was observed from $N_0B_0$ (Figure 3).

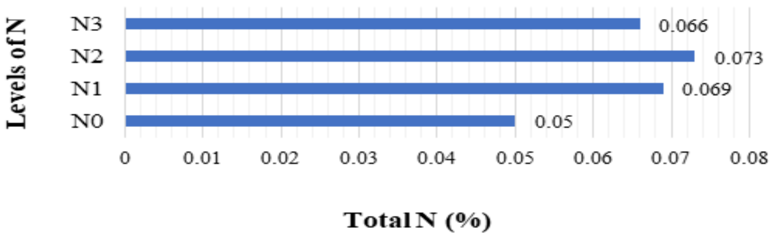


**Figure 1.** Effect of different levels of nitrogen on total N in post-harvest soil of sesame.
$N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha

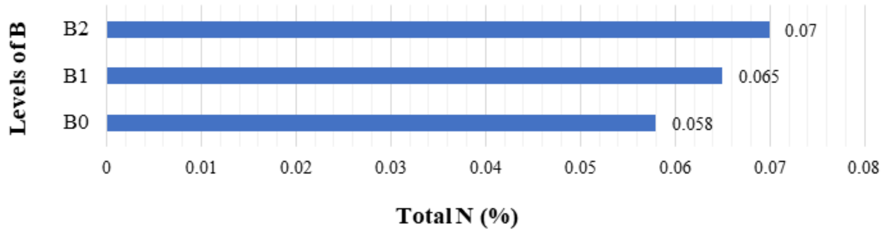


**Figure 2.** Effect of different levels of boron on total N in post-harvest soil of sesame
$B_0$: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

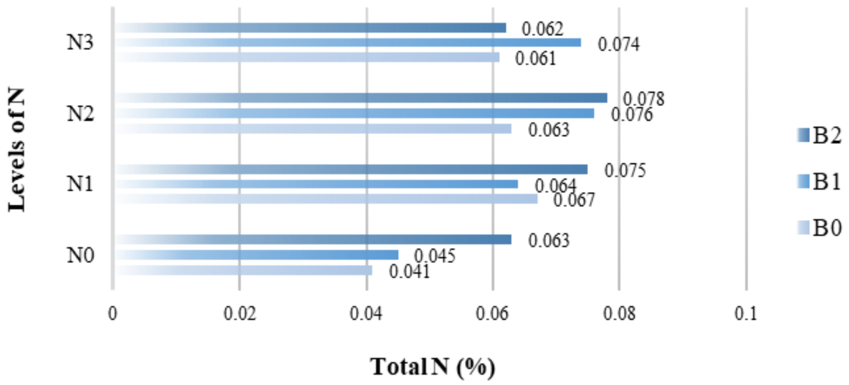


**Figure 3.** Interaction effect of different levels of nitrogen and boron on total N in post-harvest soil of sesame
$N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; $B_0$: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

**pH**

pH of post-harvest soil showed statistically non-significant due to different levels of nitrogen, boron and combined interaction (Table 8 and 9).

**Organic matter**

Organic matter of post-harvest soil showed statistically non-significant due to different levels of nitrogen, boron and combined interaction (Table 8 and 9).

**Available P**

Available P of post-harvest soil showed statistically significant differences due to different levels of nitrogen, boron and combined interaction. In case of nitrogen levels, the highest available P of post-harvest (34.98 ppm) were observed from $N_2$ which were statistically similar to $N_3$ and $N_1$; and lowest (27.25 ppm) was observed from $N_0$. In case of boron levels, the highest available P of post-harvest soil (32.51 ppm) was recorded from $B_2$ which were statistically similar to $B_1$ and lowest (29.47 ppm) was recorded from $B_0$ (Table 8). In the case of interaction, the highest available P of post-harvest soil (36.53 ppm) was observed from $N_2B_2$ and lowest (24.43 ppm) was found from $N_0B_0$ (Table 9).

**Table 8.** Effect of nitrogen and boron on pH, organic matter, available P, exchangeable K and available of post-harvest soil of sesame

| Treatments | pH | Organic matter (%) | Available P (ppm) | Exchangeable K (me %) | Available B (ppm) |
|---|---|---|---|---|---|
| **Levels of nitrogen** | | | | | |
| $N_0$ | 5.67 | 1.20 | 27.25 c | 0.129 b | 0.244 c |
| $N_1$ | 5.97 | 1.24 | 31.68 b | 0.138 ab | 0.263 b |
| $N_2$ | 6.00 | 1.29 | 34.98 a | 0.144 a | 0.277 a |
| $N_3$ | 5.87 | 1.27 | 32.64 ab | 0.139 ab | 0.265 b |
| $LSD_{(0.05)}$ | -- | -- | 2.35 | 0.010 | 0.010 |
| **Levels of boron** | | | | | |
| $B_0$ | 5.86 | 1.21 | 29.47 b | 0.130 b | 0.185 b |
| $B_1$ | 5.92 | 1.26 | 32.93 a | 0.140 a | 0.298 a |
| $B_2$ | 5.84 | 1.28 | 32.51 a | 0.143 a | 0.303 a |
| $LSD_{(0.05)}$ | -- | -- | 2.035 | 0.009 | 0.009 |
| Significance level | NS | NS | 0.01 | 0.01 | 0.01 |
| CV (%) | 5.09 | 7.59 | 7.60 | 4.47 | 3.20 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; $B_0$: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

**Table 9.** Interaction effect of nitrogen and boron on pH, organic matter, available P, exchangeable K and available of post-harvest soil of sesame

| Treatments | pH | Organic matter (%) | Available P (ppm) | Exchangeable K (me %) | Available B (ppm) |
|---|---|---|---|---|---|
| $N_0B_1$ | 5.98 | 1.16 | 29.60 bc | 0.129 bc | 0.268 d |
| $N_0B_2$ | 5.64 | 1.27 | 27.72 cd | 0.138 a-c | 0.300 bc |
| $N_1B_0$ | 5.96 | 1.28 | 26.67 cd | 0.134 a-c | 0.194 e |
| $N_1B_1$ | 5.94 | 1.21 | 32.41 ab | 0.136 a-c | 0.292 c |
| $N_1B_2$ | 6.00 | 1.24 | 35.96 a | 0.144 ab | 0.304 a-c |
| $N_2B_0$ | 5.92 | 1.19 | 33.37 ab | 0.128 bc | 0.196 e |
| $N_2B_1$ | 5.98 | 1.33 | 35.03 a | 0.150 a | 0.315 ab |
| $N_2B_2$ | 6.10 | 1.34 | 36.53 a | 0.152 a | 0.320 a |
| $N_3B_0$ | 5.98 | 1.23 | 33.42 ab | 0.137 a-c | 0.189 e |
| $N_3B_1$ | 6.00 | 1.33 | 34.67 a | 0.143 ab | 0.317 ab |
| $N_3B_2$ | 5.61 | 1.27 | 29.83 bc | 0.138 a-c | 0.290 c |
| $LSD_{(0.05)}$ | -- | -- | 4.070 | 0.017 | 0.017 |
| Significance level | NS | NS | 0.01 | 0.05 | 0.01 |
| CV (%) | 5.09 | 7.59 | 7.60 | 4.47 | 3.20 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. $N_0$: 0 kg N/ha (control), $N_1$: 50 kg N/ha, $N_2$: 60 kg N/ha, $N_3$: 70 kg N/ha; $B_0$: 0 kg B/ha (control), $B_1$: 2.0 kg B/ha, $B_2$: 3.0 kg B/ha

**Exchangeable K**

Exchangeable K of post-harvest soil showed statistically significant differences due to different levels of nitrogen, boron and combined interaction. In case of nitrogen levels, the highest exchangeable K of post-harvest soil (0.144 me%) was observed from $N_2$ which were statistically similar to $N_3$ and $N_1$; and lowest (0.129 me%) was observed from $N_0$. In case of boron levels, the highest exchangeable K of post-harvest soil (0.143 me%) was recorded from $B_2$ which were statistically similar to $B_1$, whereas the lowest (0.130 me%) was recorded from $B_0$ (Table 8). In the case of interaction, the highest exchangeable K of post-harvest soil (0.152 me%) was observed from $N_2B_2$ and the lowest (0.120 me%) was found from $N_0B_0$ (Table 9).

**Available B**

Available B of post-harvest soil showed statistically significant differences due to different levels of nitrogen, boron and combined interaction. In case of nitrogen levels, the highest available B of post-harvest (0.277 ppm) were observed from $N_2$ which was statistically similar to $N_3$ and $N_1$; and lowest (0.244 ppm) was observed from $N_0$. In case of boron levels, the highest available B of post-harvest soil (0.303 ppm) was recorded from $B_2$ which were statistically similar to $B_1$, and lowest (0.185 ppm) was recorded from $B_0$ (Table 8). In the case of interaction, the highest available P of post-harvest soil (0.320 ppm) was observed from $N_2B_2$ and the lowest (0.163 ppm) was observed from $N_0B_0$ (Table 9).

In post-harvest soil available total N and available B increased with the increasing of nitrogen level up to 60 kg N/ha thereafter decreased with increasing nitrogen level except available P and exchangeable K. In case of boron supply available total N, available P, exchangeable K and available B increased in soil with the increasing of boron level (Petridis et al., 2013). For soil pH and organic matter percentage, nitrogen and boron levels were found non-significant; but numerically both soil pH and organic matter percentage were increased with increasing nitrogen and boron level. Nitrogen was applied from the source of Urea, as a result Urea hydrolysis increased with the increasing Urea concentration up to a maximum was reached and soil pH was increased; thereafter with increasing Urea concentration (70 kg N/ha) hydrolysis decreased and ultimately soil pH was decreased (Cabrera et al., 1991).

## CONCLUSION

From the above experiment, it was found that combined application of Nitrogen and Boron @ 60 kg N/ha with 3.0 kg B/ha influenced the uptake of maximum nutrient by sesame plant (BARI Til-3) and also increased available nutrients of harvested soil.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with this research.

## REFERENCE

1. Bangladesh Agricultural Research Institute (BARI), 2012. BARI Til-3. Oil seeds Research Centre. p. 16. Accessed 10 January 2016. Available: http://www.bari.gov.bd/
2. Bangladesh Bureau of Statistics (BBS), 2017. Yearbook of Agricultural Statistics-2016, Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People’s Republic of Bangladesh. p. 120. Accessed 17 February 2019. Available: www.bbs.gov.bd

3. Bariya H, S Bagtharia and A Patel, 2014. Boron: A Promising Nutrient for Increasing Growth and Yield of Plants. Nutrient Use Efficiency in Plants, 153–170.
4. Bubarai ML, AM Tahir and RI Solomon, 2017. The Micronutrients Boron Its Influence on Growth and Development of Plants and Factors Affecting Availability: A Review. Journal of Agriculture and Veterinary Science, 10(12): 10-13.
5. Cabrera ML, DE Kissel and BR Bock, 1991. Urea hydrolysis in soil: Effects of urea concentration and soil pH. Soil Biology and Biochemistry, 23(12): 1121–1124.
6. Gomez KA and AA Gomez, 1984. Statistical procedures for Agricultural Research. 2nd Edition. Jhon Wiley and Sons, New York. 139-180.
7. Hamasa A and ET Putaiah, 2012. Residual effect of zinc and boron on growth and yield of sesame. International Journal of Environmental Science, 3(1):167-172.
8. Hunter AH, 1984. Soil Fertility Analytical Service in Bangladesh. Consultancy Report BARC, Dhaka.
9. Ibrahim M, M Hussain, A Khan, Y Jamal, M Ali and MFA Malik, 2014. Effect of nitrogen and phosphorus on yield and yield components of Sesame. International Journal of Sciences: Basic and Applied Research, 18(1):95-101.
10. Islam JK and SP Noor, 1982. Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh. Pakistan Journal of Scientific Research, 34(3-4):113-119.
11. Kalyani, R. R., V. Sree Devi, N. R. Satyanarayana and M. K. Rao. 1993. Effect of foliar application of boron on crop growth and yield of sesame. Indian Journal of Plant Physiology, 4:223-226.
12. Kumawat SM, LL Dhakar and PL Maliwal, 2000. Effect of irrigation regimes and nitrogen on yield, oil content and nutrient uptake of soybean (*Glycine max*). Indian Journal of Agronomy, 45(2):361-366
13. Meteorological Department, Dhaka, Bangladesh. 2016. Accessed 13 September 2016. Available: http://www.bmd.gov.bd/
14. Mondal, D. K., G. Sounda, P. K. Panda, P. Ghosh, S. Maitra and D. K. Roy. 1997. Effect of different irrigation levels and nitrogen doses on growth and yield of sesame (*Sesamum indicum* L.). Indian Agriculturist, 41(1): 15-21.
15. Mostofa M, TS Roy, R Chakraborty, S Modak, PK Kundu, MS Zaman, M Rahman and M Shamsuzzoha, 2019. Effect of Vermicompost and Tuber Size on Processing Quality of Potato during Ambient Storage Condition. International Journal of Plant and Soil Science, 26(3): 1-18.
16. Obreza TA and CS Vavrina, 1993. Production of Chinese cabbage in relation to nitrogen source, rate, and leaf nutrient concentration. Commun. Soil Science and Plant Analysis, 24(13-14):1465-1479.
17. Olsen SR, C V Cole, FS Watanabe and L A Dean, 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Dept Agric Cir. 929.
18. Opena RT, CC Kuo and JY Yoon, 1988. Breeding and Seed Production of Root crops in the Tropics and Subtropics. Technology Bulletin, 17, AVRDC. 97.
19. Page AL, RH Miller and DR Keeney, 1982. Methods of analysis part 2, Chemical and Microbiological Properties, Second Edition American Society of Agronomy, Inc., Soil Science Society of American Inc. Madson, Wisconsin, USA. 403-430.
20. Petridis A, D Gasparatos, C Haidouti, C Paschalidis and P Zamanidis, 2013. Effects of Nitrogen and Boron Fertilization on Lettuce Mineral Nutrition in a Calcareous Soil. Communications in Soil Science and Plant Analysis, 44(1-4):733–740.
21. Sathya S and G J Pitchai. 2009. Indirani R. Boron nutrition of crops in relation to yield and quality review. Agriculture Reviews, 2:139-144.
22. Shehu HE, 2014. Uptake and Agronomic Efficiencies of Nitrogen, Phosphorus and Potassium in Sesame (*Sesamum indicum* L.). American Journal of Plant Nutrition and Fertilization Technology, 4(2): 41–56.
23. Srivastava PC and UC, Gupta, 1996. Trace Elements in crop production. Science Pub. Inc. Lebanon, NHO3766 USA. 366.
24. Statistix, R. 2013. Statistix 10 Analytical Software. Tallahassee, FL USA.