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# Effect of Combined Application of Nitrogen and Boron on Yield Contributing Characters and Yield of Sesame (*Sesamum indicum* L.)

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### Authors' contributions

This work was carried out in collaboration among all authors. Author MS designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors PKK, MAR and RA managed the analyses of the study. Author MM managed the literature searches, performed the statistical analysis and reviewed the final draft of the manuscript. All authors read and approved the final manuscript.

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## ABSTRACT

Sesame is an important oilseed crop due to its different types of commercial application. The produced oil from sesame uses for food and beauty care product preparation due to its high nutritive value. However, the yield of sesame is comparatively low than other oilseed crops. Nitrogen and Boron are essential nutrients for plant development and growth. So, the combined application of nitrogen and boron can increase the yield of sesame. From these perspectives, an experiment was carried out to study the effect of nitrogen and boron application on yield contributing characters and yield of sesame. The experiment consisted of four Nitrogen doses ( $N_0$ : 0 kg N/ha (control),  $N_1$ : 50 kg

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N/ha, N<sub>2</sub>: 60 kg N/ha, N<sub>3</sub>: 70 kg N/ha) and three Boron doses (B<sub>0</sub>: 0 kg B/ha (control), B<sub>1</sub>: 2 kg B/ha, B<sub>2</sub>: 3 kg B/ha). It was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. Result demonstrated that combination of 60 kg N/ha and 3.0 kg B/ha were acceptable for getting better yield and maximum economic return from the studied parameters.

*Keywords: Boron; growth; nitrogen; sesame; yield.*

## 1. INTRODUCTION

Sesame (*Sesamum indicum* L.) belongs to the family Pedaliaceae is one of the important oil crops, which is widely grown in different parts of the world. It has been 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, locally it is known as "Til" and is the second important produced edible oil crop [1]. Sesame is a versatile crop having diversified usage and contains 42-45% oil, 20% protein and 14-20% carbohydrate [2]. In 2015-2016 the crop covered an area of 99,592 acres in Bangladesh with the production of 36,921 metric tons [3]. The climate and edaphic conditions of Bangladesh are quite suitable for sesame cultivation.

Sesame oil is generally used for edible purpose in confectionaries and illumination. It is also used for some other purposes, such as in the manufacture of margarine, soap, paint, perfumery products, drugs and as a dispersing agent for different kinds of insecticide. Sesamol, a constituent of the oil, is used for its synergistic effect in pyrethrum, which increases the toxicity of insecticides [4]. The sesame oilcake is an excellent cattle feed which contains protein of high biological value and appreciable quantities of phosphorus and potassium. The cake is also used as manure [5]. Sesame seed may be eaten fried mixed with sugar or in the form of sweetmeats. The use of the seeds for decoration on the surface of slices of bread and cookies is most familiar to the Americans. The crop is cultivated either as a pure stand or as a mixed crop with Aus rice, jute, groundnut, millets and sugarcane. Among the various oil crops grown in Bangladesh, sesame ranks next to mustard in respect of both cultivated area and production. The crop is grown in both Rabi and Kharif seasons in Bangladesh but the Kharif season covers about two-thirds of the total sesame area. Khulna, Faridpur, Pabna, Barishal, Rajshahi, Jashore, Cumilla, Dhaka, Patuakhali, Rangpur, Sylhet and Mymensingh districts are the leading sesame producing areas of

Bangladesh [6]. Yield and quality of sesame seeds are comparatively low in Bangladesh. The low yield of sesame in Bangladesh, however is not an indication of the low yielding potentiality of this crop but may be attributed to several reasons viz. unavailability of quality seeds of high yielding varieties, fertilizer management, disease and insect infestation and improper irrigation facilities. Deficiency of soil nutrient is now considered as one of the significant constraints to successful upland crop production in Bangladesh [7]. 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 [8].

Nitrogen is a structural component of chlorophyll and protein. An adequate supply of nitrogen is beneficial for both carbohydrates and protein metabolism as it promotes cell division and cell enlargement, resulting in more leaf area and thus ensuring good seed and dry matter yield [9]. A suitable supply of nitrogen is essential for vegetative growth and desirable yield [10]. On the other hand, excessive application of nitrogen is not economical and it prolongs the growing period and delays crop maturity. Excessive nitrogen application also causes physiological disorder [11].

Boron is one of the essential micronutrients required for plant growth and productivity. It plays a vital role in cell wall synthesis, RNA metabolism, root elongation, phenol metabolism and helpful for pollen and tube growth [12, 13]. Mary et al. [14] observed that foliar application of boron was beneficial to increase the number of pods/branch, the number of seeds/plant and seed yield/plant. Kalyani et al. [15] observed that boron applied as boric acid was increased the plant height, relative growth rate, net assimilation rate and leaf area index. Boron is a micronutrient essential for the healthy growth of pollen grains, sugar translocation and movement of growth regulators within the plant [16]. Photosynthetic activity and metabolic activity enhanced with the

application of boron [17]. Boron's involvement in hormone synthesis, translocation, carbohydrate metabolisms and DNA synthesis probably contributed to higher growth and yield [15]. Deficiency of Boron causes severe reductions in crop yield, due to severe disturbances in B-involving metabolic processes, such as metabolism of nucleic acid, carbohydrate, protein and indole acetic acid, cell wall synthesis, phenol metabolism, membrane integrity and function [18,19].

Considering the facts as mentioned above and based on the previous observation, an experiment was undertaken to find out the optimum dose of nitrogen and boron for maximizing the yield contributing characters and yield of sesame.

## 2. MATERIALS AND METHODS

### 2.1 Location of the Experiment

The experiment was conducted during the period from February to May 2016 to find out the effect of nitrogen and boron on the growth and yield of sesame. The experiment was carried out in the research field of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The location of the experimental site is 23°74'N latitude and 90°35'E longitude and an elevation of 8.2 m from sea level [20].

### 2.2 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 Soils. 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 physical and chemical characteristics of the soil before seed sowing are presented in Table 1 and Table 2.

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October [21]. Details of the meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment were collected from the Bangladesh Meteorological Department, Dhaka (Table 3) [23].

**Table 1. Morphological characteristics of the experimental field**

Morphology	Characteristics
Locality	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace
Topography	Fairly level
Drainage	Well-drained
Flood level	Above flood level

Source: [22]

**Table 2. 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 <sup>-1</sup> )	0.12
Available P (mg kg <sup>-1</sup> )	19.85
Available S (mg kg <sup>-1</sup> )	14.40
Available B (mg kg <sup>-1</sup> )	6.25

**Table 3. 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 (°C)		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

### 2.3 Planting Material

Seeds of BARI Til-3 used as a test crop for the study and those were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur. BARI developed this variety and exposed for cultivation in the year of 2001 [2]. It is a non-hairy medium-sized plant with primary and secondary branches.

### 2.4 Experimental Treatment

The experiment consisted of two factors. Factor A: Levels of nitrogen (4 levels), N<sub>0</sub>: 0 kg N/ha (control), N<sub>1</sub>: 50 kg N/ha, N<sub>2</sub>: 60 kg N/ha, N<sub>3</sub>: 70 kg N/ha; Factor B: Levels of boron (3 levels), B<sub>0</sub>: 0 kg B/ha (control), B<sub>1</sub>: 2 kg B/ha, B<sub>2</sub>: 3 kg B/ha. There were 12 (4 × 3) treatment combinations such as N<sub>0</sub>B<sub>0</sub>, N<sub>0</sub>B<sub>1</sub>, N<sub>0</sub>B<sub>2</sub>, N<sub>1</sub>B<sub>0</sub>, N<sub>1</sub>B<sub>1</sub>, N<sub>1</sub>B<sub>2</sub>, N<sub>2</sub>B<sub>0</sub>, N<sub>2</sub>B<sub>1</sub>, N<sub>2</sub>B<sub>2</sub>, N<sub>3</sub>B<sub>0</sub>, N<sub>3</sub>B<sub>1</sub> and N<sub>3</sub>B<sub>2</sub>.

### 2.5 Experimental Design and Layout

The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments in each plot of each block. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. There were 36 plots altogether in the experiment. The size of the plot was 2.5 m × 1.5 m. The distance between two blocks and two plots were 50 cm each.

### 2.6 Fertilizer Application

Manures and fertilizers were applied to the experimental plot are presented in Table 4 [2]. The total amount of Cow dung, TSP, half of the MoP, total Zinc and Sulfur was applied as basal dose at the time of land preparation. The rest amount of MoP and the total amount of urea (as

per treatment) was applied in two installments at 15 and 30 days after seed sowing (DAS).

### 2.7 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.

### 2.8 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 collected in respect of the plant growth characters and yield of sesame.

#### 2.8.1 Plant height

The height of plants was recorded at 30, 40, 50, 60 DAS and harvesting time by using a meter scale. The height was measured from the ground level to the tip of an individual plant. Mean value of ten selected plants was calculated for each unit plot and expressed in centimeter (cm).

#### 2.8.2 Number of branches per plant

The number of branches per plant was counted and the data were recorded from randomly selected ten plants at 30, 40, 50, 60 DAS and harvesting time. Mean value from collected data was counted and recorded.

#### 2.8.3 Days required from sowing to harvest

The number of days required from sowing to harvest flower opening was recorded from ten randomly selected plants.

**Table 4. Dose and method of application of fertilizers in sesame field**

Fertilizers and manures	Dose/ha	Application (%)		
		Basal	15 DAS	30 DAS
Cowdung	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	--	--

### 2.8.4 Length of capsule (cm)

The capsules from each randomly selected plant were measured using a centimeter scale and the mean value was calculated and was expressed in centimeter (cm).

### 2.8.5 Number of capsules per plant

The numbers of the capsule from ten randomly selected plants from each unit plot were counted and their mean values were recorded.

### 2.8.6 Seeds per capsule

Seeds per capsule were counted from ten randomly selected capsules as harvested from each unit plot.

### 2.8.7 Weight of 1000 seeds (g)

As per treatment combination, 1000 seeds were counted and weight was taken by a digital weighing machine and expressed in gram (g).

### 2.8.8 Seed yield

Mature capsule pods were harvested from each plot and seeds were separated from the capsule to measure weight. The seed yield per plot was finally converted to yield per hectare and expressed in ton per ha (t/ha).

### 2.8.9 Stover yield

Mature sesame plants were harvested from each plot. Seeds and Stover were separated and weight of stover was recorded. The Stover yield per plot was finally converted to Stover yield per hectare and expressed in ton per ha (t/ha).

## 2.9 Statistical Data Analysis

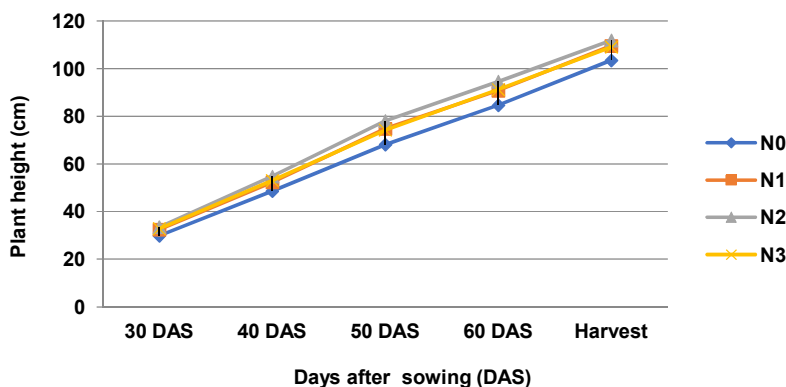
The data obtained for different parameters were statistically analyzed by using Statistix 10 [24] computer package program to find out the significant difference of different levels of nitrogen and boron. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) at 5% level of probability [25].

## 3. RESULTS AND DISCUSSION

### 3.1 Plant Height

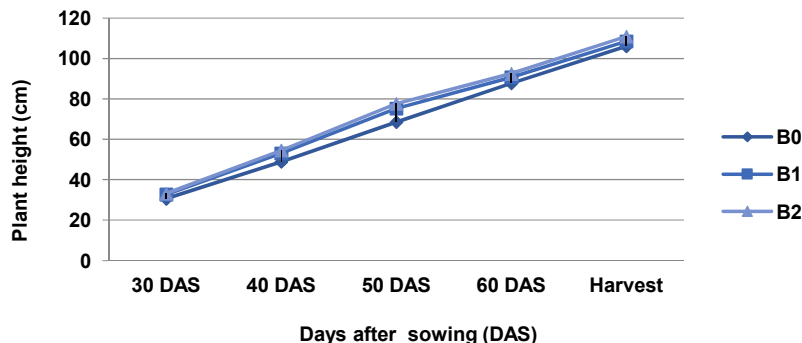
Plant height of sesame was shown statistically significant differences due to different levels of nitrogen. At 30, 40, 50, 60 DAS and at harvesting time, the tallest plant (33.49, 54.79, 78.07, 94.58 and 111.89 cm, respectively) were observed from N<sub>2</sub> (60 kg N/ha), which were statistically similar (32.87, 53.07, 74.23, 91.27 and 109.59 cm, respectively) to N<sub>3</sub> (70 kg N/ha), while the shortest plant (29.87, 48.61, 68.16, 84.62 and 103.46 cm, respectively) were observed from N<sub>0</sub> (0 kg N/ha) (Fig. 1).

Different levels of boron varied significantly in terms of plant height of sesame. At 30, 40, 50, 60 DAS and at harvesting time, the tallest plant (33.15, 54.54, 77.68, 92.46 and 110.93 cm, respectively) were recorded from B<sub>2</sub> (3.0 kg B/ha) which were statistically similar (32.77, 53.14, 75.23, 90.76 and 108.52 cm, respectively) to B<sub>1</sub> (2.0 kg B/ha), whereas the shortest plant (30.61, 48.90, 68.54, 87.74 and 106.04 cm, respectively) from B<sub>0</sub> (0 kg B/ha) (Fig. 2).



**Fig. 1. Effect of different levels of nitrogen on plant height of sesame**

Vertical bars represent LSD value. N<sub>0</sub>: 0 kg N/ha (control), N<sub>1</sub>: 50 kg N/ha, N<sub>2</sub>: 60 kg N/ha, N<sub>3</sub>: 70 kg N/ha



**Fig. 2. Effect of different levels of boron on plant height of sesame**  
Vertical bars represent LSD value. B<sub>0</sub>: 0 kg B/ha (control), B<sub>1</sub>: 2.0 kg B/ha, B<sub>2</sub>: 3.0 kg B/ha

**Table 5. Interaction effect of nitrogen and boron on plant height at different days after sowing (DAS) and harvest of sesame**

Treatments	Plant height (cm) at				
	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
N <sub>0</sub> B <sub>0</sub>	25.24 b	44.54 d	62.37 d	80.61 d	100.64 d
N <sub>0</sub> B <sub>1</sub>	30.87 a	48.50 cd	68.42 cd	81.37 d	100.87 cd
N <sub>0</sub> B <sub>2</sub>	33.49 a	52.79 a-c	73.70 bc	91.87 bc	108.88 a-c
N <sub>1</sub> B <sub>0</sub>	32.49 a	50.60 bc	71.21 bc	90.87 bc	107.27 a-d
N <sub>1</sub> B <sub>1</sub>	31.82 a	51.36 bc	74.08 bc	89.06 c	108.71 ab
N <sub>1</sub> B <sub>2</sub>	33.14 a	54.90 ab	79.07 ab	92.53 a-c	112.79 b-d
N <sub>2</sub> B <sub>0</sub>	31.70 a	48.23 cd	67.39 cd	90.94 bc	105.77 ab
N <sub>2</sub> B <sub>1</sub>	34.27 a	57.88 a	83.07 a	95.74 ab	113.47 a
N <sub>2</sub> B <sub>2</sub>	34.51 a	58.26 a	83.75 a	97.05 a	116.43 ab
N <sub>3</sub> B <sub>0</sub>	33.03 a	52.21 bc	73.17 bc	88.56 c	110.49 ab
N <sub>3</sub> B <sub>1</sub>	34.11 a	54.80 ab	75.34 bc	96.85 a	111.02 ab
N <sub>3</sub> B <sub>2</sub>	31.48 a	52.19 bc	74.18 bc	88.41 c	105.63 b-d
LSD <sub>(0.05)</sub>	4.054	5.056	7.006	4.578	7.264
Significance level	*	*	*	**	*
CV (%)	7.44	5.72	5.61	4.99	3.95

In a column means having the similar letter (s) are statistically similar and those having a dissimilar letter (s) differ significantly. \*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability. N<sub>0</sub>: 0 kg N/ha (control), N<sub>1</sub>: 50 kg N/ha, N<sub>2</sub>: 60 kg N/ha, N<sub>3</sub>: 70 kg N/ha; B<sub>0</sub>: 0 kg B/ha (control), B<sub>1</sub>: 2.0 kg B/ha, B<sub>2</sub>: 3.0 kg B/ha.

Statistically, significant variation was recorded for the interaction effect of nitrogen and boron on plant height of sesame. At 30, 40, 50, 60 DAS and at harvesting time, the tallest plant (34.51, 58.26, 83.75, 97.05 and 116.43 cm, respectively) were observed from N<sub>2</sub>B<sub>2</sub> (60 kg N/ha and 3.0 kg B/ha) and the shortest plant (25.24, 44.54, 62.37, 80.61 and 100.64 cm, respectively) were found from N<sub>0</sub>B<sub>0</sub> (0 kg N/ha and 0 kg B/ha) treatment combination (Table 5).

It was revealed from the observed data that plant height was shown an increasing trend with the increase of the application of nitrogen nutrients up to a certain level then decreases. Nitrogen created a favorable condition for the growth of sesame with optimum vegetative growth and the ultimate results were the tallest plant. Nitrogen is

a structural component of chlorophyll and protein. Therefore, the adequate supply of nitrogen is beneficial for both carbohydrates and protein metabolism as it promotes cell division and cell enlargement, resulting in the tallest plant [9]. Auwalu et al. [26] reported that application of N significantly increased plant height. It was also found that with the increase of boron fertilizer, plant height increased up to the highest level [27].

### 3.2 Number of Branches per Plant

The number of branches per plant of sesame was found statistically significant differences due to different levels of nitrogen. At 30, 40, 50, 60 DAS and at harvesting time, the maximum number of branches per plant (2.64, 4.58, 6.76,

8.47 and 8.80, respectively) were observed from  $N_2$ , which were statistically similar (2.60, 4.16, 6.40, 8.04 and 8.27, respectively) to  $N_3$ , while the minimum number (2.22, 3.44, 5.91, 7.36 and 7.91, respectively) were observed from  $N_0$  (Fig. 3).

Different levels of boron varied significantly in terms of number of branches per plant of sesame. At 30, 40, 50, 60 DAS and at harvesting time, the maximum number of branches per plant (2.68, 4.28, 6.75, 8.47 and 8.72, respectively) were recorded from  $B_2$  which were statistically similar (2.57, 4.22, 6.58, 8.35 and 8.65, respectively) to  $B_1$ , whereas the minimum number (2.20, 3.80, 5.90, 7.03 and 7.50, respectively) from  $B_0$  (Fig. 4).

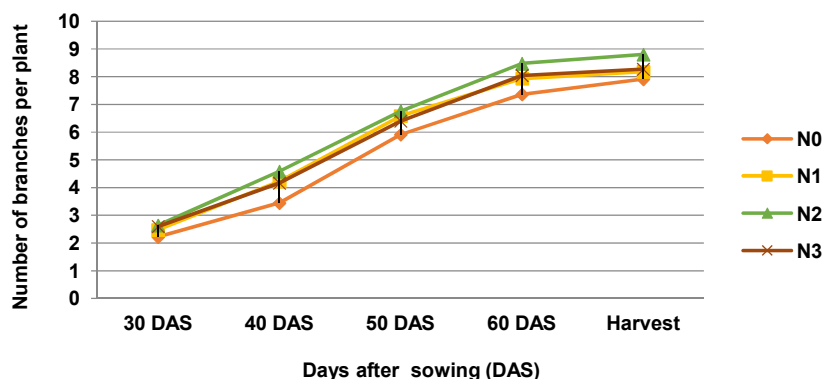
Statistically, significant variation was recorded due to the interaction effect of nitrogen and boron on plant height of sesame. At 30, 40, 50, 60 DAS and at harvesting time, the maximum number of

branches per plant (2.93, 4.93, 7.33, 9.13 and 9.47, respectively) were observed from  $N_2B_2$  and the minimum number (1.80, 3.07, 5.47, 6.20 and 7.27, respectively) were found from  $N_0B_0$  treatment combination (Table 6).

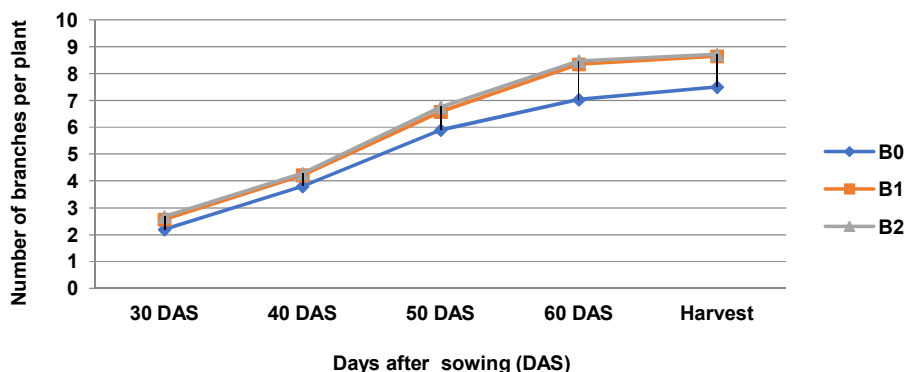
Auwalu et al. [26] reported that application of N significantly increased number of leaves per plant.

### 3.3 Days Required from Sowing to Harvest

Days required from sowing to harvest of sesame was shown statistically significant differences due to different levels of nitrogen. The minimum number of days required from sowing to harvest (93.78) were observed from  $N_2$ , which were statistically similar (96.00) to  $N_3$  and  $N_1$ , while the maximum number of days (97.78) were observed from  $N_0$  (Table 7).



**Fig. 3. Effect of different levels of nitrogen on number of branches per plant of sesame**  
Vertical bars represent LSD value.  $N_0$ : 0 kg N/ha (control),  $N_1$ : 50 kg N/ha,  $N_2$ : 60 kg N/ha,  $N_3$ : 70 kg N/ha



**Fig. 4. Effect of different levels of boron on number of branches per plant of sesame**  
Vertical bars represent LSD value.  $B_0$ : 0 kg B/ha (control),  $B_1$ : 2.0 kg B/ha,  $B_2$ : 3.0 kg B/ha

**Table 6. Interaction effect of nitrogen and boron on number of branches/plant at different days after sowing (DAS) and harvest of sesame**

Treatments	Number of branches per plant at				
	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
N <sub>0</sub> B <sub>0</sub>	1.80 f	3.07 c	5.47 f	6.20 h	7.27 f
N <sub>0</sub> B <sub>1</sub>	2.20 e	3.33 c	6.07 c-f	7.80 ef	8.07 de
N <sub>0</sub> B <sub>2</sub>	2.67 a-d	3.93 b	6.20 c-e	8.07 de	8.40 cd
N <sub>1</sub> B <sub>0</sub>	2.33 de	4.20 b	6.33 c-e	7.20 g	7.40 f
N <sub>1</sub> B <sub>1</sub>	2.40 c-e	4.33 b	6.67 a-d	8.07 de	8.40 cd
N <sub>1</sub> B <sub>2</sub>	2.67 a-d	4.13 b	6.73 a-c	8.53 b-d	8.73 bc
N <sub>2</sub> B <sub>0</sub>	2.13 ef	3.93 b	5.80 ef	7.40 fg	7.67 ef
N <sub>2</sub> B <sub>1</sub>	2.87 ab	4.87 a	7.13 ab	8.87 ab	9.27 ab
N <sub>2</sub> B <sub>2</sub>	2.93 a	4.93 a	7.33 a	9.13 a	9.47 a
N <sub>3</sub> B <sub>0</sub>	2.53 a-e	4.00 b	6.00 def	7.33 fg	7.67 ef
N <sub>3</sub> B <sub>1</sub>	2.80 a-c	4.33 b	6.47 b-e	8.67 a-c	8.87 a-c
N <sub>3</sub> B <sub>2</sub>	2.47 b-e	4.13 b	6.73 a-c	8.13 c-e	8.27 c-e
LSD <sub>(0.05)</sub>	0.363	0.527	0.613	0.533	0.594
Significance level	**	*	*	*	*
CV (%)	8.64	7.61	5.64	3.97	4.23

*In a column means having the similar letter (s) are statistically similar and those having a dissimilar letter (s) differ significantly. \*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability. N<sub>0</sub>: 0 kg N/ha (control), N<sub>1</sub>: 50 kg N/ha, N<sub>2</sub>: 60 kg N/ha, N<sub>3</sub>: 70 kg N/ha; B<sub>0</sub>: 0 kg B/ha (control), B<sub>1</sub>: 2.0 kg B/ha, B<sub>2</sub>: 3.0 kg B/ha.*

Different levels of boron varied significantly in terms of number of days required from sowing to harvest. The minimum number of days required from sowing to harvest (94.33) were recorded from B<sub>2</sub> which were statistically similar (96.08) to B<sub>1</sub>, whereas the maximum number of days (97.25) from B<sub>0</sub> (Table 7).

Interaction effect of nitrogen and boron differed significantly on days required from sowing to harvest. The minimum number of days required from sowing to harvest (92.67) were observed from N<sub>2</sub>B<sub>2</sub> and the maximum number of days (99.00) were found from N<sub>0</sub>B<sub>0</sub> (Table 8).

### 3.4 Length of Capsule

Length of capsule of sesame was found statistically significant differences due to different levels of nitrogen. The longest length of capsules (3.46 cm) were observed from N<sub>2</sub>, which were statistically similar (3.33 cm and 3.28 cm) to N<sub>3</sub> and N<sub>1</sub>, while the shortest length of capsules (3.06 cm) from N<sub>0</sub> (Table 7).

Different levels of boron varied significantly in terms of length of capsule. The longest length of capsules (3.45 cm) were recorded from B<sub>2</sub> which were statistically similar (3.33 cm) to B<sub>1</sub>, whereas the shortest length of capsules (3.06 cm) from B<sub>0</sub> (Table 7).

Statistically, significant variation was recorded due to the interaction effect of nitrogen and boron on length of capsule. The longest length of capsules (3.77 cm) were observed from N<sub>2</sub>B<sub>2</sub> and the shortest length of capsules (2.83 cm) were found from N<sub>0</sub>B<sub>0</sub> treatment combination (Table 8).

### 3.5 Number of Capsules per Plant

Number of capsules per plant of sesame was found statistically significant differences due to different levels of nitrogen. The maximum number of capsules per plant (65.16) were observed from N<sub>2</sub>, which were statistically similar (63.78 and 63.40) to N<sub>3</sub> and N<sub>1</sub>, while the minimum number (57.78) were observed from N<sub>0</sub> (Table 7).

Different levels of boron varied significantly in terms of the number of capsules per plant. The maximum number of capsules per plant (65.50) were recorded from B<sub>2</sub> which were statistically similar (63.40) to B<sub>1</sub>, whereas the minimum number (58.68) from B<sub>0</sub> (Table 7).

Statistically, significant variation was recorded due to the interaction effect of nitrogen and boron on the number of capsules per plant. The maximum number of capsules per plant (69.33) were observed from N<sub>2</sub>B<sub>2</sub> and the minimum



number (53.73) were found from  $N_0B_0$  treatment combination (Table 8).

Prakash et al. [28] reported that application of a higher dose of N resulted in the highest number of capsules per plant.

### 3.6 Number of Seeds per Capsule

Number of seeds per capsule of sesame was found statistically significant differences due to different levels of nitrogen. The maximum number of seeds per capsule (57.11) were observed from  $N_2$ , which were statistically similar (54.56 and 55.78) to  $N_3$  and  $N_1$ , while the minimum number (50.00) were observed from  $N_0$  (Table 7).

Different levels of boron varied significantly in terms of the number of seeds per capsule. The maximum number of seeds per capsule (56.25) were recorded from  $B_2$  which were statistically similar (54.58) to  $B_1$ , whereas the minimum number (52.25) from  $B_0$  (Table 7).

Statistically, significant variation was recorded due to the interaction effect of nitrogen and boron on the number of seeds per capsule. The maximum number of seeds per capsule (59.33) were observed from  $N_2B_2$  and the minimum number (48.33) were found from  $N_0B_0$  treatment combination (Table 8).

### 3.7 Weight of 1000 Seeds

Weight of 1000 seeds of sesame was shown significant differences due to different levels of nitrogen. The highest weight of 1000 seeds (12.12 g) was observed from  $N_2$ , which were statistically similar (11.86 g and 11.74 g) to  $N_3$ , while the lowest weight (11.25 g) from  $N_0$  (Table 7).

Different levels of boron varied significantly in terms of weight of 1000 seeds. The highest weight of 1000 seeds (12.19 g) was recorded from  $B_2$  which were statistically similar (12.08 g) to  $B_1$ , whereas the lowest weight of 1000 seeds (10.96 g) from  $B_0$  (Table 7).

Statistically, significant variation was recorded due to the interaction effect of nitrogen and boron on the weight of 1000 seeds. The highest weight of 1000 seeds (12.93 g) were observed from

$N_2B_2$  and the lowest weight of 1000 seeds (10.27 g) was found from  $N_0B_0$  treatment combination (Table 8).

### 3.8 Seed Yield

Seed yield of sesame was shown statistically significant differences due to different levels of nitrogen. The highest seed yield (1.51 t/ha) was observed from  $N_2$ , which was closely followed (1.42 t/ha and 1.39 t/ha) by  $N_3$  and  $N_1$  and they were statistically similar, while the lowest seed yield (1.09 t/ha) was observed from  $N_0$  (Table 7).

Different levels of boron varied significantly in terms of seed yield. The highest seed yield (1.40 t/ha) was recorded from  $B_2$  which were statistically similar (1.37 t/ha) to  $B_1$ , whereas the lowest (1.30 t/ha) from  $B_0$  (Table 7).

Statistically, significant variation was recorded due to the interaction effect of nitrogen and boron on seed yield. The highest seed yield (1.59 t/ha) was observed from  $N_2B_2$  and the lowest seed yield (1.03 t/ha) were found from  $N_0B_0$  treatment combination (Table 8).

Shilpi et al. [29] reported that application of 60 kg nitrogen might be considered to be optimum for getting a higher yield of sesame.

### 3.9 Stover Yield

Stover yield of sesame was shown statistically significant differences due to different levels of nitrogen (Table 7). The highest stover yield (2.91 t/ha) was observed from  $N_2$ , which was closely followed (2.77 t/ha and 2.67 t/ha) by  $N_3$  and  $N_1$  and they were statistically similar, while the lowest stover yield (2.01 t/ha) was observed from  $N_0$  (Table 7).

Different levels of boron varied significantly for stover yield. The highest stover yield (2.69 t/ha) was recorded from  $B_2$  which were statistically similar (2.66 t/ha) to  $B_1$ , whereas the lowest (1.42 t/ha) from  $B_0$  (Table 7).

Statistically, significant variation was recorded due to the interaction effect of nitrogen and boron on stover yield. The highest stover yield (3.13 t/ha) was observed from  $N_2B_2$  and the lowest stover yield (1.83 t/ha) were found from  $N_0B_0$  treatment combination (Table 8).

**Table 7. Effect of nitrogen and boron on yield contributing characters and yield of sesame**

Treatments	Days from sowing to harvest	Length of capsule (cm)	Number of capsules per plant	Number of seeds per capsule	1000 seeds weight (g)	Seed yield (t/ha)	Stover yield (t/ha)
<b>Levels of nitrogen</b>							
N <sub>0</sub>	97.78 a	3.06 b	57.78 b	50.00 b	11.25 b	1.09 c	2.01 c
N <sub>1</sub>	96.00 ab	3.28 a	63.40 a	55.78 a	11.74 ab	1.42 b	2.67 b
N <sub>2</sub>	93.78 b	3.46 a	65.16 a	57.11 a	12.12 a	1.51 a	2.91 a
N <sub>3</sub>	96.00 ab	3.33 a	63.78 a	54.56 a	11.86 ab	1.39 b	2.77 b
LSD <sub>(0.05)</sub>	2.149	0.183	2.593	3.448	0.581	0.076	0.142
Significance level	**	**	**	**	*	**	**
<b>Levels of boron</b>							
B <sub>0</sub>	97.25 a	3.06 b	58.68 b	52.25 b	10.96 b	1.30 b	2.42 b
B <sub>1</sub>	96.08 ab	3.33 a	63.40 a	54.58 ab	12.08 a	1.37 a	2.66 a
B <sub>2</sub>	94.33 b	3.45 a	65.50 a	56.25 a	12.19 a	1.40 a	2.69 a
LSD <sub>(0.05)</sub>	1.861	0.158	2.246	2.986	0.503	0.066	0.123
Significance level	**	**	**	*	**	**	**
CV (%)	5.29	5.66	4.24	6.49	5.06	5.79	5.56

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly. \*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability. N<sub>0</sub>: 0 kg N/ha (control), N<sub>1</sub>: 50 kg N/ha, N<sub>2</sub>: 60 kg N/ha, N<sub>3</sub>: 70 kg N/ha; B<sub>0</sub>: 0 kg B/ha (control), B<sub>1</sub>: 2.0 kg B/ha, B<sub>2</sub>: 3.0 kg B/ha

**Table 8. Interaction effect of nitrogen and boron on yield contributing characters and yield of sesame**

Treatments	Days from sowing to harvest	Length of capsule (cm)	Number of capsules per plant	Number of seeds per capsule	1000 seeds weight (g)	Seed yield (t/ha)	Stover yield (t/ha)
N <sub>0</sub> B <sub>0</sub>	99.00 a	2.83 e	53.73 f	48.33 cd	10.27 e	1.03 g	1.83 e
N <sub>0</sub> B <sub>1</sub>	98.67 ab	3.08 de	56.33 ef	46.00 d	11.39 b-d	1.06 fg	1.97 e
N <sub>0</sub> B <sub>2</sub>	95.67 a-d	3.27 b-d	63.27 bc	55.67 ab	12.09 a-c	1.18 ef	2.23 d
N <sub>1</sub> B <sub>0</sub>	97.67 a-c	2.97 de	60.40 c-e	53.00 a-c	11.00 c-e	1.40 b-d	2.63 c
N <sub>1</sub> B <sub>1</sub>	95.67 a-d	3.21 cd	64.40 a-c	56.67 ab	12.01 a-c	1.38 b-d	2.63 c
N <sub>1</sub> B <sub>2</sub>	94.67 b-d	3.67 a	65.40 a-c	57.67 ab	12.22 a	1.48 a-c	2.75 bc
N <sub>2</sub> B <sub>0</sub>	93.33 d	3.15 c-e	58.20 d-f	53.33 a-c	10.76 de	1.45 a-c	2.53 c
N <sub>2</sub> B <sub>1</sub>	95.33 a-d	3.45 a-c	67.93 ab	58.67 ab	12.67 a	1.50 ab	3.07 a
N <sub>2</sub> B <sub>2</sub>	92.67 d	3.77 a	69.33 a	59.33 a	12.93 a	1.59 a	3.13 a
N <sub>3</sub> B <sub>0</sub>	99.00 a	3.29 b-d	62.40 cd	54.33 a-c	11.82 a-d	1.30 de	2.70 c
N <sub>3</sub> B <sub>1</sub>	94.67 b-d	3.59 ab	64.93 a-c	57.00 ab	12.24 ab	1.52 ab	2.97 ab
N <sub>3</sub> B <sub>2</sub>	94.33 cd	3.11 c-e	64.00 bc	52.33 bc	11.51 b-d	1.34 cd	2.63 c
LSD <sub>(0.05)</sub>	3.722	0.317	4.492	5.972	1.006	0.131	0.245
Significance level	*	**	*	*	*	*	**
CV (%)	5.29	5.66	4.24	6.49	5.06	5.79	5.56

In a column means having the similar letter (s) are statistically similar and those having a dissimilar letter (s) differ significantly. \*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability. N<sub>0</sub>: 0 kg N/ha (control), N<sub>1</sub>: 50 kg N/ha, N<sub>2</sub>: 60 kg N/ha, N<sub>3</sub>: 70 kg N/ha; B<sub>0</sub>: 0 kg B/ha (control), B<sub>1</sub>: 2.0 kg B/ha, B<sub>2</sub>: 3.0 kg B/ha

#### 4. CONCLUSION

From the research findings, it was found that application of Nitrogen and Boron can increase sesame yield. Combined application of 60 kg

N/ha and 3.0 kg B/ha can be more beneficial for the oilseed growers of Bangladesh to get the better yield up to 1.59 t/ha and economic return from the cultivation of sesame.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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