EFFECT OF NITROGEN AND BORON ON THE GROWTH AND YIELD OF SESAME

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CERTIFICATE

This is to certify that the thesis entitled, **"Effect of nitrogen and boron on the growth and yield of sesame"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY** embodies the result of a piece of *bona fide* research work carried out by **Sumaiya Sarkar, Registration No.01048** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by her.

Dated: June 26, 2008.
Place: Dhaka, Bangladesh

(Prof. Md. Sadrul Anam Sardar)
Supervisor

LIST OF ACRONYMS

%	Percent
^0C	Degree Celsius
AEZ	Agro-Ecological Zone
B	Boron
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
cm	Centi-meter
CV%	Percentage of Co-efficient of Variance
DAS	Days after sowing
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization
g	gram (s)
HI	Harvest Index
hr	hour (s)
K	Potassium
K_2O	Potassium Oxide
kg	kilogram (s)
kg ha^{-1}	kilogram per hectare
m^2	meter square
mm	milimeter
mt	metric ton
N	Nitrogen
NS	Non significant
P	Phosphorus
P_2O_5	Phosphorus Penta Oxide
ppm	Parts per million
SAU	Sher-e-Bangla Agricultural University
t	Ton
var.	Variety

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ABSTRACT

An experiment was carried out to investigate the effect of nitrogen and boron on the growth and yield of sesame cv. T-6 at the field laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207. The experiment comprised four levels of Nitrogen viz. 0, 30, 60 and 90 Kg N ha^{-1} and four levels of Boron viz. 0, 0.80, 1.60 and 2.40 Kg B ha^{-1}. The experiment was laid out in a Randomized Complete Block Design with three replications. Results revealed that nitrogen and boron had significant effect on growth, yield and yield parameters of sesame. Among the four levels of nitrogen 60 Kg N ha^{-1} performed the best in obtaining the highest values in almost all parameters such as plant height (110.04 cm) at 60 DAS, number of capsules $plant^{-1}$ (32.59), number of seeds $capsule^{-1}$ (69.65), 1000 seed weight (2.71g), seed yield ha^{-1} (1346.74 kg), stover yield ha^{-1} (5509.80 kg). Boron also showed significant effect on growth and yield of sesame. Boron at 1.60 Kg ha^{-1} produced the highest value in all parameters except number of leaves $plant^{-1}$. The lowest value in the studied parameters was obtained from the control treatment. In respect of the interaction 60 Kg N ha^{-1} along with 1.60 Kg B ha^{-1} gave the tallest plant (117.08 cm) at 60 DAS and produced the highest number of capsules $plant^{-1}$ (36.05), capsule length (2.42 cm), 1000 seed weight (2.87 g), seed yield ha^{-1} (1628.91kg) and harvest index (21.83%).

CHAPTER 1

INTRODUCTION

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Sesame (*Sesamum indicum*) is one of the most important oil crops under the Pedaliaceae family. It is locally known as "Til". In cultivable area and production it occupies second position as oil crop in Bangladesh followed by rape and mustard (BARI, 2001). It ranks 4^{th} among the oil crop in the world. The world production of sesame is 2.9 million mt (FAO, 2003). Sesame is a drought resistant annually cultivated herb which can be easily grown under rain fed upland condition. It has been grown all over the world. The tropics and subtropics of Asia, Africa, East and Central America are the major production areas of it.

Sesame is a versatile crop with high quality edible oil having diversified usage. Due to varietal difference it contains 37 to 63% oil (BINA, 2004), 14 to 20% carbohydrate and 20% protein (BARI, 2001). It also contains 0.156 to 0.288% S, 1.12 to 1.151% reducing sugar, 5.62 to 7.25% total sugar, 0.82 to 1.4 % Ca, 0.41 to 0.71% P, 0.4 to 0.95% K and 40.4 to 52.7% protein on oil free basis (Dhindsa and Gupta, 1973). It also contains more than 80% unsaturated fatty acid which is useful for human body including large amount of olic and linoleic acid (BINA, 2004). Sesame oil is also used as hair oil in Bangladesh. It also meets the purposes such as in margarine manufacture, use as lubricant for vehicle, disposing agent with insecticide, soap, paint, perfumery industry and in pharmaceutical as an ingredient oil drugs. Sesame Olin, a component of the oil has synergistic effect with pyrethrum and increase the toxicity (Mellroy, 1967). These sesame oilcake is a very good cattle feed since it contains high amount of good quality protein. Sesame seed meal is rich in minerals and contains available fatty acids and amino acids which may be a good feed of fish and animal (Nwokolo, 1987). Sesame oilcake contains 6.2 to 6.3% N, 2.0 to 2.1% P_2O_5 and 1.1 to 1.3% K_2O (Chakraborty *et al.*, 1984).The cake is also used as manure (Cobley, 1967). Fried seed of sesame mixed with sugar or in the form of sweetmeat 'tiller khaja' is a tasty food. The use of the seed for decoration on the surface of breads, 'nimkies', biscuits and cookies is most popular to the Americans.

Bangladesh faces an acute shortage of edible oil. The total production of edible oil in the country is not sufficient to meet its requirement. The area and production of oil seed crops in Bangladesh during 2002-03 were 46,000 acre and 24, 000 metric tons respectively (BBS, 2004). This production only ensures 4g per capita. People can consume only 10 g of oil day^{-1} summing local production and foreign import. But the expert says, an adult should consume 22g oil day^{-1} for better health. So at present the country is experiencing 70% oil deficit (Wahhab, 2002).

In view of population growth, the requirement of edible oil that the production of edible oil should be increased considerably to fulfill the increasing demands. The production may be increased either by increasing cropping area under oil crop or increasing yield per unit area. But in the present condition, scope of expansion of oil crop area is narrow. So there is a general consensus that increasing yield per unit area is most reasonable way to increase total production.

The practice of intensive cropping with modern varieties causes a marked depletion of inherent nutrient reserves in soil of Bangladesh. Deficiency of primary nutrient especially nitrogen has been reported since a long time. Every year a large amount of nitrogen is lost by different processes such as leaching, volatilization, de-nitrification etc. So as an accelerating factor for production, nitrogen should be added for better production. Besides primary nutrient some micronutrient deficiency viz B, Zn and Mo have also appeared in some soils and crops (Khanam *et al.,* 2001;. Islam *et al.*, 1999 and Jahiruddin *et al.*, 1995). Ahmed and Hossain (1999) stated that Bangladesh had one million hectare of land which had been boron deficient. This element deficiency is usually observed in light textured and high P^H soils.

Sesame can play an important role to fulfill the local demand of edible oil, because the climate of our country is suitable for sesame production. Bangladesh produced 22 thousand metric tons of sesame from 36.84 thousand hectare of land every year. (BBS, 2004). As sesame is short duration and photo insensitive crop with wider adaptability, it can be cultivated in both Rabi and kharif-1 seasons but two third area is produced in kharif-1 season of the year. Yield of sesame per unit area in our country is very low compared to other sesame producing countries. The average production of sesame in farmers level is only 0.55 ton/ha (BARI, 1998). The main reasons for poor yield are lack of modern varieties, production inputs, improper management practices and cultural operations.

Nitrogen is one of the accelerating factors of crop production. As an essential of protein it is needed for growth and development of all living tissues. It is an important constituent of chlorophyll, the green pigment of healthy tissues. Nitrogen is one of the dominant factors for yield of sesame (Tiwari *et al.*, 1994).

Boron deficiency may also be one of the factors responsible for such low yield (Srivastava *et al.*, 1996). Besides this different combinations of nitrogen and boron may have a great importance. But studies on this discipline are very limited. Hence the present experiment was undertaken to study the effect of nitrogen and boron on sesame using the cultivar 'T-6' with the following objectives:

i. To determine the effect of rate of nitrogen on yield and yield parameters of sesame,

ii. To determine the effect of boron on yield and yield components of sesame, and

iii. To determine the interaction effect of nitrogen and boron on yield and yield components of sesame.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Sesame is one of the most important oil yielding crops in Bangladesh. It may play an important role to mitigate edible oil demand of people. But the production of the crop is still low compared to other sesame producing countries of the world due to various reasons. Among the reasons, fertilizer management is one of the key factors, which directly control yield. Nitrogen and boron are two vital elements for growth and yield of sesame along with essential elements. In this chapter it was tried to review the effect of nitrogen and boron fertilizer on growth and yield of sesame.

2.1 Effect of nitrogen on growth and yield of sesame

Auwalu *et al.* (2007) conducted a field experiment and observed that the effect of nitrogen level (0, 30, 60 kg ha^{-1}) on the productivity of vegetable sesame (S radiatum). They suggested that the farmers should grow vegetable sesame during rainy season and apply 30 kg N/ha in a single dose 2 weeks after sowing. It also produced high total marketable yield.

Chang *et al.* (2005) carried out a field experiment during 2004 in Pakistan to study the response of sesame (S-18 and S-20) to different rate of nitrogen (0, 40, 70, 100, 130 and 160 kg ha^{-1}). Application of nitrogen at 130 kg ha^{-1} significantly increased the seed yield of CV. S-20 than S-18.

Naugraiya and Jhapatsingh (2004) conducted a field experiment in Chhattisgarh and reported that the role of nitrogen resulted significant increase in growth and yield attributes with high values under 60 kg N ha^{-1}.

Sujathamma *et al.* (2003) conducted an experiment on the direct and residual effects of N fertilizers on sesame in rice-groundnut- sesame cropping system and found that seed yield was highest with 60 kg N ha^{-1}. Nitrogen was supplied to sesame at 0, 50 or 100% of the recommended rates of 60 kg ha^{-1} but in rice nitrogen was supplied through green manure (25%) + urea (75%), FYM (25%) + urea (75%), green manure (25%) + FYM (25%) + urea (50%), green manure (50%) +FYM (50%) or urea (100%), and in case of groundnut at 0, 50, or 100% of recommended dose (30 kg N ha^{-1}). They found that, the number of capsules plant, seed and Stover yield of sesame was highest in case of 60 kg N ha^{-1} (100% of recommended dose) and application of nitrogen as green manure (50%) + FYM (50%) but highest number of seeds $capsule^{-1}$ and 1000-seed weight were obtained with the application of 100% of the recommended rate.

Rahman *et al.* (2003) conducted an experiment to investigate the effects of sowing date (10 and 25 May and 10 June), N fertilizer rate (60, 80 and 100 kg $feddan^{-1}$ and plant population 70,000, 35000 and 235000 plants $feddan^{-1}$) on the performance of sesame x cv. Giga 32. The height of the first branch and first capsule as well as the length of the fruiting zone was highest at 60 kg N $feddan^{-1}$ [1 feddan = 0.42 ha].

Malik *et al.* (2003) in a study observed the effects of different nitrogen levels (0,40 and 80 kg ha^{-1})on the productivity of sesame cv. TS-3 in Faisalabad, Pakistan under different plant geometries and shown that 80 kg N ha produced the highest seed yield, 1000-seed weight, oil content and protein content.

Pathak *et al.* (2002) evaluated the effect of nitrogen levels (0, 15, 30 and 45 kg ha^{-1}) on the growth and yield of sesame. N at 45 kg ha^{-1} recorded the highest mean values for plant height (74.3 cm), number of branches $plant^{-1}$ (4.50), number of capsules plant-1 (39.0) and 1,000 grain weight (2.91 g). N at 45 kg ha^{-1} also recorded the highest value for seed yield, net return and benefit cost ratio.

Wang *et al.* (2001) observed dynamics of the flowering rate of autumn season from early-blooming stage to final-flowering stage. Nitrogenous fertilizers applied in the flower-bud period made the autumn sesame enter flowering two days earlier and one day earlier into full bloom-stage compared with control. Its yield increased by 5.1%.

El-serogy (1998) evaluated the effect of nitrogen application such as 1-3 of N rate during sowing and 2/3 during thinning, 1-3 of the N rate during sowing, 1-3 during thinning and 1-3 at the set of flowering, full N rate during thinning, on the yield and yield components of sesame cv. Giga-32. Taller plant, lower stem height to the first capsule and higher fruiting zone, number of capsule $plant^{-1}$, seed weight $plant^{-1}$, 1000-seed weight and seed yield $feddan^{-1}$ (1 feddan = 0.42 ha) were obtained with application of 1-3 N at sowing, 1-3 at thinning at 1/3 at the onset of flowering.

Sumathi and Jaganadham (1999) conducted an experiment with 4 sesame cultivars which were given 0 to 90 kg N ha^{-1}. Seed yield increased with up to 60 kg N (388 kg ha^{-1}).

Allam (2002) evaluated the effect of N at 45, 60 and 75 kg $feddan^{-1}$ on sesame cv. Giza-32 was studied. N as ammonium nitrate was applied after thinning and 3 weeks thereafter increasing N rate increased plant height, length of fruiting zone, number of branches and capsules $plant^{-1}$. Seed index and capsule length were highest with 60 and 75 kg N $feddan^{-1}$.

Imayavaramban *et al.* (2002) reported that application of an extra 25% of nitrogen than the recommended in combination with seed inoculation with *Azospirillum* significantly recorded the maximum seed, net income, and benefit cost ratio in both both Rabi and kharif seasons.

Sarala *et al.* (2002) in an experiment of sesame which was given 6 fertilizer treatments such as no N (control) *Azorpirillum* (3 kg ha^{-1}) soil application; 60 kg N ha^{-1}, 30 kg N ha^{-1} + Azopirillum; 45 kg N ha^{-1} + *Azorpirillum*; 60 kg N ha^{-1}+ *Azorpirillum* N was applied at split doses (basal and top dressing 30 days after sowing). N at 60 kg ha^{-1} recorded more number of capsules and seed $capsule^{-1}$ which was as per with 45 kg N ha^{-1} +*Azorpirillum* treatment. The highest seed yield was obtained with application of 60 kg N ha^{-1}, which was as par with 45 kg N ha^{-1} + *Azorpirillum* and 30 kg N ha^{-1} + *Azorpirillum*.

Om *et al*. (2001) gave 0, 30, 60 and 90 kg N ha^{-1} and they obtained highest number of capsules $plant^{-1}$, seed $capsule^{-1}$, 1000 seed weight, seed yield, straw yield and harvest index from 90 kg N ha^{-1}.

Nageshwar *et al*. (1995) used 40, 80 and 120 kg N ha^{-1} in five selected varieties. Seed yield was the highest in 120 kg N ha^{-1} (1.82 t ha^{-1}) with net return highest.

Ashfaq *et al.* (2001) studied the response of 2 sesame genotypes (92001and TS3) to different rates of N and p (0, 40, 80 and 120 kg ha^{-1}) grain yield, yield components and harvest index increased with increasing N rates. The highest yields were obtained with 120 kg N and 40 kg ha^{-1} phosphorus, respectively.

Senlrilkumar *et al.* (2000) evaluated the effect of intra row spacing and nitrogen level with and without *Azospirillum* inoculation on growth and yield of sesame. Yield was hihest with 43.75 kg N ha^{-1} plus seed inoculation with *Azospirillum*.

Patra (2001) found out effects N on yield and yield attributes of sesame cv. Kalika. N was applied at 0, 30, 60 and 90 kg ha^{-1}, plant height, branches $plant^{-1}$, capsules $plant^{-1}$, seeds capsule, capsule length, 1000 seed weight and seed yield significantly increased with increasing N rates up to 60 kg N ha^{-1}.

Singaravel and Govindasamy (1998) conducted an experiment with sesame cv. TMV-4 which was given 35 kg N ha^{-1} and/or *Azospirillum* together with 0, 10, 20 or 30 kg humic acid/ha. Seed yield and dry matter production were greatest with N fertilizer+20 kg humic acid.

Mitra and Pal (1999) reported that the dry matter, number of capsules plant^{-1}, seeds capsule^{-1} and seed yield of sesame increased significantly up to 100 kg N ha^{-1}. Further increase in nitrogen depressed the seed yield and yield attributes.

Tiwari *et al.* (1999) reported sesame cv. Co-1, Tka-9 and Tka-21 producing mean seed yields of 3.71, 3.17 and 2.57 t ha^{-1} respectively, while N rates of 0, 30, 45, 60 and 75 kg ha^{-1} and produced mean yields of 1.66, 2.27, 3.17, 4.19 and 4.41 t ha^{-1}.

Shewal *et al.* (1995) observed that sesame cv. Tapi and Hawari gave highest seed yield of 541 kg ha^{-1} when 50 kg N ha^{-1} was applied.

Patil *et al.* (1996a) reported that sesame cv. Padma which was given 0-50 kg N ha^{-1} produced mean seed yield was 0.58 t ha^{-1} and a return was highest at 50 kg N ha^{-1}.

Dixit *et al.* (1997) assessed productivity of sesame cv. TC-25 and Rasua-17 with the application of 0 to 90 kg N ha$^{-1.}$ Application of up to 60 kg N ha^{-1} increase the seed yield significantly and gave the highest net profit.

Mondal *et al.* (1997) in a trial with sesame applied 0, 30, 60, 90 and 120 kg N ha^{-1}. Plant height, dry matter accumulation, number of capsules plant^{-1}, number of seeds capsules^{-1}, 1000 seed weight, seed yield, were all increased as nitrogen fertilizer rate was increased. However, harvest index was not significantly affected by N application.

Patil *et al.* (1996b) worked with two varieties of sesame treated with 0, 25 and 50 kg N ha^{-1} and obtained highest yield 732 kg ha^{-1} when it was treated with 50 kg N ha^{-1}. Ashok *et al.* (1996) obtained highest sesame seed yield when it was treated with 90 kg N ha^{-1} in 1990 and 60 kg N ha^{-1} in 1991.

Balasubramaniya (1996a) in a field experiment with sesame cv. TMV-4, and TMV-6 during 1992-93 which were given 0, 25 and 50 kg N ha^{-1}. Highest seed yield was 644 and 758 kg ha^{-1} when it was given 50 kg N ha^{-1}.

Majumdar *et al.* (1987) reported nitrogen application (60 kg ha^{-1}) to lateritic acidic soil increased the capsule number plant^{-1}, seed number capsule^{-1}, 1000 seed weight, plant height and seed yield.

Sinharoy *et al.* (1990) reported that application of 30 and 60 kg N ha^{-1} increased plant height and number of primary branches plant^{-1} and seeds capsule^{-1} and gave average seed yields of 651 and 801 kg ha^{-1}.

Samui *et al.* (1990) found that dry matter production and N, P and K uptake in 3 sesame cultivars increased when 30 or 60 kg N ha^{-1} was applied.

Puste and Maiti (1990) obtained 632.772, 885 and 919 kg ha^{-1} yield when it was treated with 0, 40, 80 and 120 kg N ha^{-1}, respectively.

Pineda and Velasquezsilva (1987) conducted an experiment with 0, 50 and 100 Ib N/manzaha as urea of which 50% was applied at sowing and 50% at 45 days later. Posoltega application of 100 Ib N increased seed yield from 1.19 to 1.72 t manzana^{-1}. [1 manzana=0.7 ha].

Kandam (1989) observed 0.60, 0.69 and 0.61 (t ha^{-1}) seed when it was treated with 0, 25 and 50 kg N ha^{-1}. Seed yield increased with increasing N rates.

Seo *et al.* (1986) conducted an experiment with 0-180 kg N ha^{-1} and obtained highest yield 1.01 kg ha^{-1} when it was treated with 80 kg N ha^{-1}.

Vijan *et al.* (1987) applied 40 kg N ha^{-1} to sesame cv. C-6 and found increased seed yields from 0.73 to 0.98 t ha^{-1}, seed oil content of 48.1 to 56.3% and protein content from 19.4 to 20.9%.

Kamel *et al.* (1983) applied 0, 36 and 72 kg N ha^{-1} and reported that seed yield was highest with 72 kg N ha^{-1} application.

Chakraborty *et al.* (1984) reported that increasing nitrogen rates from 0 to 120 kg ha^{-1} in sesame increased seed yields from 238 to 990 kg ha^{-1}.

Satyanarayn (1978) applied 25 to 50 kg N ha to sesame and obtained highest yield when it was treated with 25 kg N under irrigated consideration.

Abdel-Rahman *et al.* (1980) grew sesame cv. Giza-25 with 0, 30 and 45 N feddan^{-1}, The highest seed yield (4.25 ardeb feddan^{-1}) and yield components were obtained when it was given 45 N feddan^{-1}, N application also increased plant height and number of effective capsules plant^{-1}.

Mehrotra *et al.* (1978) reported that average seed yield of sesame was increased from 400 to 760 kg ha^{-1} with increased rates of N from 0 to 30 kg ha^{-1}. Further increases in yield with 45 kg N ha^{-1} were not significant.

Velazquez *et al.* (1983) at Tapanatepae, sesame cv. Nardo was given 0 to 150 kg N ha^{-1}. The highest yield was obtained with 100 kg N ha^{-1} and the optimum economic treatment was 45.5 kg N ha^{-1}.

Ramakrishnan *et al.* (1994) used 5 sesame cultivars with 0-90 kg N ha^{-1}. Seed yield plant increases with upto 36 kg N ha^{-1}. They also reported that seed yield was positively correlated with number of branches, number of capsules plant^{-1}, number of seeds capsule^{-1} and 1000 seed weight. Number of seeds capsule^{-1} had the highest positive effect on seed yield followed by number of capsules plant^{-1}.

Chandrakar *et al.* (1994) reported that seed yield increased with increasing nitrogen rates (0, 50, 100 or 150 kg N ha^{-1}).

Rao *et al.* (1993) observed that seed yields increased with increasing nitrogen application from 0, 40 and 80 kg N ha^{-1}.

Rao *et al.* (1994) applied 0, 40 and 80 kg N ha^{-1} and reported that seed yield plant^{-1} was positively correlated within the order seeds plant^{-1} > capsules plant^{-1} > 1000 seed weight > leaf area plant^{-1} > branches plant^{-1} > capsule length> plant height.

Tiwari *et al.* (1994) conducted a field experiment with no fertilizer, 60 kg N ha^{-1}, 60 kg N + 30 kg P + O or 20 kg N or 60 kg N + 30 kg P + 20 kg + 25 kg Zn. Mean seed application of 60 kg N + 30 kg P + 20 kg K.

Ishwar *et al.* (1994) reported that sesame given 0, 30 and 60 kg N ha^{-1} gave mean seed yield of 470, 531 and 590 kg ha^{-1}.

Pawar *et al.* (1993) used 0, 40, 80 or 120 kg N ha^{-1} in sesame. Seed yield increased up to 120 kg N ha^{-1}.

Sharma and Kewat (1994) carried out a field trial with Sesame cv. N-32 which was given 0-60 kg N ha^{-1} applied 50% basal + 50% at 40 day after sowing (DAS), 50% at 15 (DAS) + 50% at 40 DAS or 50 % basal + 50% at 15 DAS. Seed yield increased significantly up to 40 kg N ha^{-1} and was highest with 50% at 15 DAS + 50% at 40 DAS.

El-Ouesni *et al.* (1994) conducted an experiment with 15, 30 and 45 kg N feddan^{-1} and obtain greatest crop plant height and seed yield of 134 cm and 11.58 g plant^{-1} respectively when it was treated with 45 kg N feddan^{-1} [1 feddan = 0.42 ha].

Satyanarayana *et al.* (1996) found that Sesame cv. Rajeshwari was grown in 0, 50 or 100 kg N ha^{-1}. Seed yield was highest 923 kg ha^{-1} (1992) and 884 kg ha^{-1} (1993) and mean seed yield was highest with 100 kg N ha^{-1} (870 kg).

Dutta *et al.* (1996) observed that sesame cv. Rama was given 0, 60 or 120 kg N ha^{-1}. The application of 120 kg N ha^{-1} gave highest seed yield and was the highest gross return.

Balasubramaniyan (1996b) grew sesame at 0, 30, 60 and 90 kg N ha^{-1}. Yield was significantly affected by increasing nitrogen rates.

Sharma *et al.* (1996) applied 0-90 kg nitrogen to sesame cv. TC-25 and TKG-9. Mean seed yield increased with upto 60 kg N ha^{-1} (343 kg ha^{-1}).

Tiwari *et al.* (2002) in a field experiment nitrogen (15, 30 or 60 Kg ha^{-1}) and sulphur (0, 15 or 30 Kg ha^{-1}) to sesame varieties (TKG21, TKG 22 and Rs226) in Madhaya Pradesh, India to investigate optimum dose of nitrogen and sulphur. They found that significant improvement in growth and yield (plant height, number of seeds $capsule^{-1}$, 1000 seed weight and straw yield) was observed for nitrogen at 60 kg ha^{-1} compared with 15 kg ha^{-1}.

Chaubery *et at.* (2003) conducted a field trial in Uttar Pradesh, India during Kharif season of 1997-98 to study response of nitrogen on yield and yield attributes of sesame (*Sesamum indicum* cv. T-4). The yield and yield attributes of sesame were significantly increased with the application of different levels nitrogen (0, 15, 30, 45 and 60 Kg ha^{-1}).

2.2 Effect of boron on growth and yield of different crops

Sarkar and Saha (2005) in an experiment in West Bengal, India, found that sesame CV-B-67 produced 10.4% higher seed yield at the rate of 1 kg B ha-1 compared to the control.

Bennneti (1993) reported that sesame mineral composition and seed yield was affected by boron fertilizer application.

Sindoni *et al.* (1994) grew *Sesamum indicum* in Hoagland No. 2 with nutrient solution supplemented with 0.05 mg B/liter or throughout the growth or unfil 20-30 or 40-day old when B was either reduced to 0.05 mg/L or eliminated completely. Elimination of B at all ages reduced root and shoot dry weight but reduction of B supplementation significantly reduced dry weight only at 30 day. Reduction of B concentration significantly decreased seed production and concentration of B in leaves stems and pods. Seed weight was linearly and significantly correlated with concentration of B in pods.

Rahman *et al.* (1998) conducted an experiment on ground nut and observed that application of 1.6 kg B/ha increases seed yield by 23% over control. The result was in agreement with that of Deshmukh (1985) who reported 15-19% in croquet in yield of ground nut.

Li *et al.* (1992) carried out the field experiments where borax solution at 0.2% was sprayed at seedling and flowering growth stages. In the pot experiments boric acid at 0.7 ppm was given and in hydroponic experiments 0.01, 0.02, 0.2 and 2.0 ppm boric acid were applied. Average yield increase of 4.6-21.2%, 3.3-19.9% and 2.1-17.1% were obtained with B application for Zhongzhi 8, Golden Turkey and Qingma, respectively. Application rates higher than 0.20 ppm in the hydroponic experiments was detrimental, depressing growth or even causing death to the plant.

Patra (1998) observed significant yield increase of soybean by the application of B (2 kg ha^{-1}).

Wankhade *et al.* (1998) observed that application of B alone gave the highest soybean seed yield. They also reported that combined application of Fe + B or Zn + Fe + B greatly decreased soybean growth and yield.

Rerkasem and Jamjod (2001) reported that grain, set failure due to boron deficiency and induced sterility to the others and pollen was a cause of yield loss in wheat in many wheat growing areas of Asia.

Mondol (2000) conducted an experiment with 19 bread wheat varieties to determine the response of B (O and 12 kg sodium borate/ha) in west Bengal, India and reported that most of the varieties responded well to B for yield and important yield component characters.

Ramirez and Linares (1995) reported exposed sesame to 6.25 to 750 µg B $litre^{-1}$. Dry matter production of leaves, stems, and roots were severely decreased when B in the leaf tissue was below 21 µg g^{-1}.

Liu *et al.* (2003) studied the effects of Mo and B, alone or in combination, on seed quality of pot growth soybean cultivars Zhechum 3, Zhechun 2, and 3811. Application of Mo and/or B increased the content of protein, in dispensable amino acids, total amino-acids (excluding praline), N, P, K and decrease the content of Ca and oil.

Hemantaranjan *et al.* (2000) stated that Soybean (*Glycine max* cv. PK-27) was sown in sandy loam soil and gave boron as boric acid at 50 and 100 ppm as foliar application and soil application individual and combined, plant height, root length, chlorophyll B content, total dry matter production and seed yield of soybean were higher at 50 than 100 ppm B. However chlorophyll a content was higher at 100 ppm.

Sakal *et al.* (1994) evaluated the direct and residual effect of varying levels of B (0, 8, 16, 32 and 64 kg Borax ha^{-1}) and FYM (0.25 and 5.0 t ha^{-1}) alone and in combinations on crops in maize and lentil cropping system. Increasing levels of B up to 16 kg borax ha^{-1} significantly increased and higher levels decreased the yield of first crop. Application of 16 kg Borax ha^{-1} in conjunction with 5t FYM ha^{-1} was an ideal combination which appreciably enhanced the cumulative grain yield response, and sustained the productivity of four crops in the cropping system.

Deasarker *et al.* (2001) conducted an experiment with soybean which was given 2, 4 and 6 kg B ha^{-1}. 2 kg B ha^{-1} was the best among the boron treatment for increasing row seed yield.

Millerand Donahue (1997) stated that Boron was essential for growth of new cells. Without adequate supply of boron, the number and retention of flowers reduces, and pollen tube growth is less consequently less fruit is developed.

Boron plays a vital role in the physiological processes of plants such as cell maturation, cell elongation and cell division, carbohydrate, protein and nucleic acid metabolism, cytokinin synthesis, acid and phenol metabolisms. The functions of B are primarily extra cellular and related to lignifications and xylem differentiation (Lewis, 1980), membrane stabilization (Pilbeam and Kirkby, 1983) and alteration of enzymatic reactions (Dugger, 1983).

The effect of boron on the development of the pollen grain of wheat was studied by Li *et al.* (1978) and Rerkasem *et al.* (1989). The process of fertilization involves the germination of the pollen grain and the growth of the pollen tube down the style into the ovary. In general, boron deficiency produces pollen grains that are small and that do not accumulate starch. Pollens that develop normally may still be affected by boron deficiency (Vaughan, 1977; Cheng and Rerkasem, 1993).

Rerkasem *et al.* (1989) reported that wheat grown in the low boron soils exhibited symptoms of male sterility, which included poorly developed anthers and nonviable pollen grains. Grain set failure lower seed yield and male sterility symptoms were associated with low boron concentration in the flag leaf. Failure in grain set up to 100%% of florets was frequently observed. They also reported that poor grain set in wheat depressed seed yield by 40-50% on Tropaqualf soils having low boron content (0.08-0.12 mg kg^{-1}).

Singh and Singh (1994) noted that green pod yield of French beans increased with increase in P application and with B application up to 1 kg B ha^{-1}. Application of more than 1 kg B ha^{-1} caused a toxic effect.

Talashikar and Chavan (1996) observed that pod production of groundnut was enhanced significantly with the addition of B 44 percent. The maximum pod and haulm yields were recorded in the treatment receiving B through boronated super phosphate along with application of FYM, N and P.

Srivastava *et al.* (1999) in a field study with B deficient soil grown chickpea cv. Kaliaka applying no fertilizer, complete fertilizer (P, K, S, B, Zn, Mo, Cu, Mn and Fe) or the complete fertilizer minus each of the trace elements observed that flower abortion was highest and no seed was produced in the treatment given no B.

Srivastava *et al.* (1999) observed that the average grain yield of chickpea and other legume crops was 0.1 t th^{-1} where B was not applied, while the yield was 1.4 t ha^{-1} where 0.5 kg ha^{-1} B was applied.

Hua and Yan (1998) observed that the addition of B promoted elongation of epicotyle and hypocotyle of mungbean and increased seedling height and dry weight in the Al treated plant.

Posypanov *et al.* (1994) observed that applying 1 kg B ha^{-1} to peas and soybeans and treating seeds with the equivalent of 50 g ammonium molybodate ha^{-1} increased nodule weight, atmospheric N_2 fixation and seed yield.

Mandal *et al.* (1991) noted that most of alluvial acidic soils responded to the application of B and Mo fertilizer and thereby increased the yield of pulse in the area.

Roy *et al.* (1992) observed that soil application of 20 kg borax ha^{-1} increased seed yield of lentil, while soil application of 3 kg sodium molybadate ha^{-1} gave only small (about 14%) increase.

Sinha *et al.* (1991) studied the response of five kharif crops, viz. onion, groundnut, maize, sweet potato and yard long bean as well as five rabi crops, viz mustard, onion, lentil, maize and sunflower to boron application on boron deficient calcareous soils under field condition. Boron was applied as borax @ 0, 1.5 and 2.5 kg B ha^{-1} . All the crops responded to boron, but the magnitude of yield response differed from crop to crop. The optimum level of B for kharif as well as rabi crops was 1.5 kg ha^{-1}.

Dwivedi *et al.* (1990) reported that B uptake $plant^{-1}$ had highly significant positive correlation with yield of lentil, soybean and pea was a reliable index for predicting crop response to B.

Galrao (1989) reported that yield of soybean was 2.38 t ha^{-1} for using B, whereas yield was 2.24 t ha^{-1} without B.

Buzetti *et al.* (1990) observed that soybean cv. Porana when treated with o, 0.2, 0.4, 0.6 or 0.8 ppm B pot^{-1}, DM and seed yield pot^{-1} increased up to approx. 0.3 ppm B and decreased at further higher B rates.

Howeler *et al.* (1978) also observed that yield of bean was nearly doubled with the application of 1 kg B ha^{-1}. Agarwala *et al.* (1981) reported that pollen producing capacity of anthers as well as the viability of the pollen grains is affected by B.

Sakal *et al.* (1988) reported on a coarse textured calcareous soil that was applied with 2.0 and 2.5 kg B ha^{-1} which then increased grain yield of black gram and chickpea by 63 and 38%, respectively.

Sakal *et al.* (1990) observed that seed yield of chickpea increased from 1.4 t ha^{-1} with no B to 1.49 t ha with 3 kg B ha^{-1}. The yield response of B application was greater on low B soils. It was concluded that on soils containing < 0.35 ppm B, 3 kg B ha^{-1} was optimum and on soils containing > 0.35 ppm B, 2 kg B ha^{-1} was optimum.

From the review of literature it was evident that plant height, number of branches plant, number of capsules plant, seed yield and Stover yield were influenced by different levels of nitrogen and boron application. Seed yield of sesame showed differential behavior due to different levels of applied nitrogen and boron in different parts of the globe. It is therefore, more researches on this aspect are necessary to arrive at a definite conclusion.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field at Sher-E-Bangla Agricultural University, Dhaka during the period from March to June, 2007. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout experimental design, planting materials, intercultural operations, data recording and their analysis.

3.1 Site description

The experiment was conducted in the Shere-E-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28 (Appendix I) during the Karif-1 season of 2007.

3.2 Climate and weather

The experimental area was under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (October March). The weather date during the study period of the experimental site is shown in Appendix II).

3.3 Soil

The farm belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above sea level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field for soil analysis with the cooperation of Soil Resources Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of each unit plot area was 3m x 2m. The adjacent blocks and adjacent plots were separated from one another by 1 m and 0.5 m, respectively.

3.5 Plant Materials

The variety T-6 was used as the test crop. The seeds were collected from the Oil Seed Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. T-6 is a recommended variety of sesame, which was developed by the Oil Seed Research Center of Bangladesh Agricultural Research Institute. It grows in both Rabi and kharif season but it is especially suitable for kharif season. It contains 42-45% oil and 20% protein (BARI, 1998). It produces very good edible oil with respect to value. The average yield of this variety of sesame in Bangladesh at the farmer's level is about 0.55 Kg ha^{-1})

Salient features: The salient features of the variety are [Mandal and Wahhab, 2001]:

1. Plant height is 100-120 cm.
2. Stem, leaf, branches and capsules are hairy
3. Flowers are white in color
4. Life cycle is 85-95 days.
5. Capsules per plant are 50-60
6. Seeds per capsule are 50-55
7. Seeds are black in color.
8. Average yield is 1200-1400 kg ha^{-1}.

3.6 Experimental treatment: Treatments were as follows:

Nitrogen level: 4

i) 0 kg N ha^{-1}

ii) 30 kg N ha^{-1}

iii) 60 kg N ha^{-1}

iv) 90 kg N ha^{-1}

Boron level: 4

v) 0 kg B ha^{-1}

vi) 0.8 kg B ha^{-1}

vii) 1.6 kg B ha^{-1}

viii) 2.4 kg B ha^{-1}

3.7 Land Preparation

The land was first opened on 28 March 2007 with a tractor drawn disc harrow and subsequently it was ploughed two times. Final land preparation was done by country plough on 2 April 2007. The land was finally prepared by four ploughing and cross-ploughing followed by laddering. The corners of the land were spaded and visible large clods were broken into small pieces. Weeds and stubble were removed from the field. The layout of the experiment was done in accordance with the design adopted. Finally, individual plot was prepared by using spade before sowing of seeds.

3.8 Fertilization

The plots were fertilized with triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 140, 45, 100 and 5 kg ha^{-1}, respectively (BARI, 1998). The whole amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied during final land preparation. Half of urea and whole of boric acid (as per experimental treatments) were applied at final land preparation. The rest half of urea for all treatments was top dressed at 30 days after sowing.

3.9 Germination Test

Before sowing, germination test of seed was done in Petridish in laboratory condition and the percentage of seed germination was found to be 95%.

3.10 Seed rate and sowing

The seed was sown at the rate of 8 kg ha^{-1} by hand on 3 April 2007. On finally prepared land, small furrows of approximately 5 cm depth were made by hand rake (Iron tine) along the desired row just before sowing. The rows were separated from each other by a distance of 30 cm. In each unit plot there were 8 rows. The distance between levees and first row was 15 cm. Seeds were placed approximately 5 cm apart in furrow and were covered with soil.

3.11 Intercultural operation

The experimental field was weeded on 15 and 30 days after sowing. Drainage operation for draining out of rain water was done as and when required for proper growth and development of crop. Thinning was done once 15 days after sowing to maintain optimum plant population. Pesticide was sprayed before flowering to keep the field insect free.

3.12 General observation

The experimental field was frequently visited to see any change in plant characters, pest and disease attack on crop. The general condition of the crop was good from beginning to the end. There was no infestation by any serious pest and disease.

3.13 Harvesting and sampling

The crop was harvested on 28 June 2007. The crop was harvested plot-wise when about 80% of the capsules became mature. Before harvesting ten plants were selected randomly from each plot and tagged. After harvesting, the plants were bundled, tagged properly and brought to the threshing floor. The bundles were dried in open sunshine for 3 days. The seeds and stover were then separated, cleaned and dried in the sun for 3 to 4 consecutive days for achieving safe moisture of seed.

3.14 Threshing, drying, cleaning and weighing

After threshing, the plants were brought to the threshing floor and sundried for consecutive three days. Threshing was done by beating with sticks and also hand shelling. The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.15 Collection of data

Data were collected from 10 (Ten) randomly selected plants from each unit plot on the following yield and yield attributes:

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Number of branches plant^{-1}
4. Number of capsule plant^{-1}
5. Number of seeds capsule^{-1}
6. Length of the capsule (cm)
7. 1000-seed weight (g)
8. Seed yield (kg ha^{-1})
9. Stover yield (kg ha^{-1})
10. Harvest index (%)

3.16 Outline of the data recording

A brief outline of the data recording is given below:

Plant height (cm)

The height of each sample plant was measured unit plot wise from the base of the plant to the tip at harvest and mean plant height was determined in cm.

Number of branches plant^{-1}

The number of braches plant^{-1} was counted from total branches of ten sampled plants and then averaged.

Number of capsule plant^{-1}

All the capsules borne on all ten sampled plants of each unit plot were counted to determine the average number of capsule pant^{-1}.

Number of seeds capsule^{-1}

From each sample plant of ten sampled plants, 5 capsules were randomly selected and all the seeds of them were counted, the number of seeds capsule^{-1} was determined by averaging the date.

Length of the capsule (cm)

Ten capsules were randomly selected from each sample plant of each unit plot. The length of each capsule was measured using a measuring tape and finally plot wise average capsule length was determined.

1000-seed weight (g)

One thousand sun dried seeds were counted and then data were recorded by means of an electrical balance.

Seed yield (kg ha^{-1})

The crop was harvested at full maturity, seeds were separated out from the capsule, cleaned and dried in the sun to bring them safety moisture content of seed and there after the weight of the seed was taken averaged and converted to yield kg ha^{-1}.

Stover yield (kg ha^{-1})

After separating the seeds from the crop, the stover was sun dried to constant weight and the stover yield was recorded in terms of kg ha^{-1}.

Harvest index (%) - Harvest index was determined by the following formula:

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.17 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique and the mean differences were compared by Least Significant Difference (LSD) using a computer operated program namely MSTAT. The means were compared at 5% level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to evaluate the effect of nitrogen and boron fertilization on growth and yield of sesame and the results obtained are discussed in this chapter. The characters studied were plant height, number of branches plant^{-1}, number of capsules plant^{-1}, number of main stem capsules plant^{-1}, number of branch capsules plant^{-1}, days after first flowering, seed yield plant^{-1}, 1000-seed weight, seed yield ha^{-1}, stover yield ha^{-1} and harvest index. Results of the experiment have been presented in Tables 1-9. The mean square values in respect of the above characters together with source of variation and their corresponding degrees of freedom have been presented in Appendices IV and V. The results have been presented and discussed character wise below.

4.1 - Effect of nitrogen on the growth and yield of sesame

4.1.1 Plant height

Plant height is one of the most important growth characteristics of sesame. The prime nutrient element nitrogen had a significant effect on plant height of sesame. The results showed that the plant height was significant at 20, 40 and 60 DAS. 60 kg N ha^{-1} gave the tallest plant height at 20, 40 and 60 DAS that were 45.64 cm, 88.03 cm and 110.04 cm which were statistically similar with those of 30 kg N ha^{-1}. The lowest plant height was recorded from control. (Table 1) Similar effect of nitrogen on plant height was also observed by Sinharoy *et al.*, (1990) and Patara (2001).

4.1.2 Number of leaves plant^{-1}

Leaves plant^{-1} are one of the most important character of sesame. Number of leaves plant^{-1} was not significant at 20 and 40 DAS. 60 kg N ha^{-1} produced the highest number of leaves per plant that was 11.32 and 15.51 at 20 and 40 DAS. The lowest number of leaves 10.37 and 14.36 from control at 20 and 40 DAS (Table 1).

Table 1. Growth of sesame cv. T-6 as affected by different nitrogen levels

Nitrogen level (Kg ha^{-1})	Plant height (cm) at different days after sowing			Number of leaves plant^{-1} at different days after sowing	
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS
0	41.83	83.12	103.90	10.37	14.36
30	44.18	86.60	108.25	10.68	14.79
60	45.64	88.03	110.04	11.32	15.51
90	44.37	84.07	105.08	10.85	15.19
$LSD_{(0.05)}$	1.998	3.757	4.671	NS	NS
CV%	5.44	5.27	5.24	9.70	12.5

NS – not-significant

4.1.3 Number of branches plant^{-1}

Nitrogen fertilizer had significant effect on number of branches plant^{-1}. The highest number of branches plant^{-1} (3.58) was recorded from the treatment at 90 kg N ha^{-1} which was significantly different from other treatments. The second branches plant^{-1} (3.17) obtained highest from the treatment 60 kg N ha^{-1} which was statistically similar to that of 30 kg N ha^{-1} while the minimum number of branches plant^{-1} was produced by control treatment. It appeared from the result that increasing rates of nitrogen application increased branches plant^{-1} (Table 2). Patra *et al*. (2001) also observed that with the increase of nitrogen yield attributes of sesame increased.

Table 2. Yield attributes of sesame cv. T-6 as affected by different nitrogen levels

Nitrogen level (Kg ha^{-1})	Number of branches $plant^{-1}$	Number of capsules $plant^{-1}$	Number of seeds $capsule^{-1}$	Capsule length (cm)	1000 seed weight (g)
0	2.83	28.02	63.54	2.29	2.33
30	2.92	30.97	69.22	2.35	2.62
60	3.17	32.59	69.65	2.36	2.71
90	3.58	32.30	68.37	2.32	2.61
$LSD_{(0.05)}$	0.3153	2.154	4.703	NS	0.09865
CV%	12.10	8.34	8.33	4.80	4.53

NS – not-significant

4.1.4 Number of capsules $plant^{-1}$

Level of nitrogen fertilizer significantly influenced on the number of capsules $plant^{-1}$ (Table 2). The highest number of capsules $plant^{-1}$ (32.59) was produced by 60 kg N ha^{-1} which was statistically similar with that of the second highest (32.30) number of capsules $plant^{-1}$ obtained from the treatment of 90 kg N ha^{-1} while the lowest number (28.02) was produced from control treatment. From the results it appeared that capsules $plant^{-1}$ increased due to the increased rate of nitrogen application up to certain level but excess application of nitrogen enhanced the vegetative growth instead of capsule formation (Allam, 2002 and Patra, 2001) reported similar results.

4.1.5 Number of seeds $capsule^{-1}$

Number of seeds $capsule^{-1}$ was significantly influenced by the level of nitrogen (Table 2). The highest number of seeds $capsule^{-1}$ (69.65) found from the application of nitrogen at 60 kg ha^{-1} was statistically similar with that of 30 kg N ha^{-1} (69.22) and 90 kg N ha^{-1} (68.37). The lowest number of seeds $capsule^{-1}$ was found from the control. Similar findings were reported by Patra (2001), Sarala *et al* (2002) and Sinharoy *et al* (1990).

4.1.6 Length of capsule (cm)

Nitrogen had no significant effect on the length of capsule (Table 2). The longest capsule (2.36 cm) was produced by 60 kg N ha^{-1}. The shortest length (2.29 cm) was found from control. Similar findings were reported by Patra (2001).

4.1.7 1000 seed weight (g)

Weight of 1000 seed differed significantly due to application of different levels of nitrogen (Table 2). The highest weight of 1000 seeds (2.71 g) observed by applying nitrogen at 60 kg ha^{-1} which was statistically similar to the 1000 seed weight (2.62 g) obtained from 30 kg N ha^{-1}. The lowest 1000 seed weight (2.33 g) was obtained from control. Patra (2001), Tiaearietat and Majumdar *et al* (1987) also obtained the highest 1000 seed weight at 60 kg N ha^{-1} in sesame.

4.1.8 Seed yield (kg ha^{-1})

Seed yield was significantly influenced by different levels of nitrogen (Table 3). The highest seed yield (1346.74 kg ha^{-1}) was recorded from the treatment of 60 kg N ha^{-1}. The lowest seed yield (959.91 kg ha^{-1}) was obtained from control. Patra (2001) and Sinharoy *et al*. (1990) reported similar results.

Table 3. Yield and harvest index of sesame cv. T-6 as affected by different nitrogen levels

Nitrogen level (Kg ha^{-1})	Yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	HI (%)
0	959.91	3774.30	20.28
30	1265.42	5251.42	19.42
60	1346.74	5509.80	19.64
90	1264.69	5264.04	19.37
$LSD_{(0.05)}$	65.14	195.0	NS
CV%	6.47	7.72	6.35

NS – not-significant

4.1.9 Stover yield (Kg ha^{-1})

Nitrogen had a significant effect on stover yield. The highest stover yield (5509.80 Kg ha^{-1}) was recorded from the treatment of 60 kg N ha^{-1}. The lowest stover yield (3774.30 Kg ha^{-1}) was obtained from control (Table 3). These results were consistent with the results obtained by Tiwari *et al.* (2000).

4.1.10 Harvest index (%)

Nitrogen fertilizer had no significant effect on harvest index (Table 3). The highest harvest index (20.28%) was found in control and lowest (19.37%) at 90 kg N ha^{-1}. Mondal *et al. (1997)* observed the similar results.

4.2 Effect of boron on the growth and yield of sesame

4.2.1 Plant height (cm)

The plant height was significantly influenced by boron fertilizer (Table 4) at 20, 40 and 60 DAS. The application of 1.6 kg B ha^{-1} gave the highest plant height at 20, 40 and 60 DAS and that was 45.39cm, 89.55 cm and 111.94 cm, respectively. The shortest plant was recorded from control. Levis (1980) stated that B plays an important role in the physiological process such as cell elongation, cell division etc which ultimately helped to make the plant taller.

Table 4. Growth of sesame cv. T-6 as affected by different Boron levels

Boron level (Kg ha^{-1})	Plant height (cm) at different days after sowing			Number of leaves $plant^{-1}$ at different days after sowing	
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS
0.0	41.04	82.17	102.71	10.62	14.45
0.8	43.77	85.83	107.29	10.71	14.99
1.6	45.39	89.55	111.94	11.21	15.61
2.4	45.82	84.27	105.33	10.68	14.80
$LSD_{(0.05)}$	1.998	3.757	4.671	NS	NS
CV%	5.44	5.27	5.24	9.70	12.5

NS – not-significant

4.2.2Number of leaves $plant^{-1}$

Number of leaves $plant^{-1}$ was not significant at 20 and 40 DAS. Use of 1.6 kg B ha^{-1} produced the highest number of leaves $plant^{-1}$ that was 11.21 and 15.61 at 20 and 40 DAS, respectively. The lowest number *of* leaves $plant^{-1}$ which were 10.62 and 14.45 from control at 20 and 40 DAS, respectively (Table 4).

4.2.3 Number of branches $plant^{-1}$

Level of boron had significant effect on the number of branches $plant^{-1}$. The highest number of branches $plant^{-1}$ (3.50) was observed in (1.6) kg B ha^{-1} and lowest number of branches $plant^{-1}$ (2.92) was obtained in control (Table 5).

4.2.4Number of capsules $plant^{-1}$

Level of boron had significant effect on number of capsules $plant^{-1}$ which was statistically different from each other. The highest number of capsules $plant^{-1}$ (33.64) obtained from application of 1.6 kg B ha^{-1} as revealed from table 5 which was statistically similar to the number of capsule $plant^{-1}$ (32.95) obtained from 2.40 Kg B h^{-1}. The lowest numbers of capsules $plant^{-1}$ were obtained from control.

4.2.5 Length of capsule (cm)

Boron had significant effect on the length of capsule (Table 5). The longest capsule (2.38 cm) was produced at 1.6 kg B ha^{-1}, which was statistically similar with the length of capsule (2.37cm) obtained from 2.4 kg B ha^{-1}. The shortest length of capsule (2.20 cm) was obtained from control.

Table 5. Yield attributes of sesame cv. T-6 as affected by different Boron levels

Boron level (Kg ha^{-1})	Number of branches $plant^{-1}$	Number of capsules $plant^{-1}$	Number of seeds $capsule^{-1}$	Capsule length (cm)	1000 seed weight (g)
0.0	2.92	26.94	62.21	2.20	2.51
0.8	3.08	30.35	67.95	2.36	2.57
1.6	3.50	33.64	73.53	2.38	2.68
2.4	3.00	32.95	67.10	2.37	2.52
$LSD_{(0.05)}$	0.3153	2.154	4.703	0.0154	0.09865
CV%	12.10	8.34	8.33	4.80	4.53

4.2.6 Number of seeds $capsule^{-1}$

Plants grown without boron fertilizer gave the lowest number of seeds $capsule^{-1}$ (62.21). Boron fertilizer had a significant effect on number of seeds $capsule^{-1}$. The highest number of seeds $capsule^{-1}$ (73.53) was recorded from the treatment of 1.6 kg B ha^{-1} (Table 5). Miller and Donahue (1997) observed that without adequate supply of boron less fruits were developed.

4.2.7 1000 seed weight (g)

Thousand seed weight of sesame was significantly increased by different boron level. However, application of 1.6 kg B ha^{-1} gave significantly the highest seed weight (2.68). The control of course gave the lowest 1000 seed weight (2.51g) which was statistically similar with 0.8 and 2.4 kg B ha^{-1}.

4.2.8 Seed yield (Kg ha^{-1})

Seed yield was significantly affected at different level of boron. The highest seed yield (1446.21 Kg ha^{-1}) was recorded from 1.6 kg B ha^{-1} which was significantly different from the second highest (1235.48 Kg ha^{-1}) obtained from 2.4 kg B ha^{-1}. The lowest seed yield (939.37 Kg ha^{-1}) was obtained from the control (Table 6). Rahman *et al.* (1998) reported the similar result. Wankhade *et al.* (1998) reported that B deficiency gave the lowest soybean seed yield.

4.2.9 Stover yield (Kg ha^{-1})

It was observed that level of B had significant effect on stover yield of sesame. The highest stover yield (5442.29 Kg ha^{-1}) was obtained from 1.6 kg B ha^{-1} treatment. The second highest stover (5322.40 Kg ha^{-1}) was obtained from 2.4 kg B ha^{-1} which was statistically similar to that of 1.6 kg B ha^{-1}. The lowest yield was obtained (4191.56 Kg ha^{-1}) from control treatment. From table 6 it was observed that stover yield increased up to 1.6 kg B ha^{-1} but further increase of B 2.4 kg B ha$^{-1)}$ decreased the stover yield of sesame.

Table 6. Yield and harvest index of sesame cv. T-6 as affected by different Boron levels

Boron level (Kg ha^{-1})	Yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	HI (%)
0.0	939.37	4191.56	18.31
0.8	1170.34	4847.31	19.45
1.6	1446.21	5442.29	20.99
2.4	1235.48	5322.40	18.84
$LSD_{(0.05)}$	65.14	195.0	1.038
CV%	6.47	7.72	6.35

4.2.10 Harvest index (%)

Boron level showed significant difference in harvest index. The highest harvest index (20.99%) was obtained from 1.6 kg B treatment. The lowest harvest index (18.31%) was obtained from 0 kg B treatment.

4.3 Effect of interaction of N and B on the growth and yield of sesame

4.3.1 Plant height

The effect of interaction of nitrogen and boron on the height of plant was not statistically significant at 20, 40 and 60 DAS (Table 7). The highest plant height (47.70 cm, 93.67cm, 117.08 cm) was obtained in the interaction of 60 kg N ha^{-1} and 1.6 kg B ha^{-1} at 20, 40 and 60 DAS, respectively.

4.3.2 Number of leaves $plant^{-1}$

The effect of interaction of nitrogen and boron on number of leaves $plant^{-1}$ was not significant (Table 7). But the highest number of leaves was produced $plant^{-1}$ that was 12.00 and 16.12 at 20 and 40 DAS from the interaction of 30 kg N and 1.6 kg B. The lowest number of leaves was obtained from control.

Table 7. Growth of sesame cv. T-6 as affected by different N and B levels

Interaction (NitrogenXBoron) (Kg ha^{-1})	Plant height (cm) at different days after sowing			Number of leaves $plant^{-1}$ at different days after sowing	
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS
0 X0.0	40.01	78.67	98.33	10.40	13.92
0 X 0.8	39.17	83.27	104.08	10.37	14.51
0 X 1.6	42.87	85.60	107.00	10.23	14.67
0 X 2.4	45.26	84.93	106.17	10.47	14.33
30 X 0.0	40.67	84.40	105.50	10.13	13.85
30 X 0.8	43.62	87.60	109.50	10.20	14.28
30 X 1.6	45.45	90.27	112.83	12.00	16.12
30 X 2.4	46.98	84.13	105.17	10.40	14.89
60 X 0.0	41.80	85.20	106.50	11.33	15.19
60 X 0.8	46.60	84.87	106.08	11.33	15.87
60 X 1.6	47.70	93.67	117.08	11.40	15.96
60 X 2.4	46.46	88.40	110.50	11.20	15.03
90 X 0.0	41.69	80.40	100.50	10.60	14.84
90 X 0.8	45.68	87.60	109.50	10.93	15.31
90 X 1.6	45.53	88.67	110.83	11.20	15.68
90 X 2.4	44.57	79.60	99.50	10.67	14.93
$LSD_{(0.05)}$	NS	NS	NS	NS	NS
CV%	5.44	5.27	5.24	9.70	12.5

NS – not-significant

4.3.3 Number of branches plant^{-1}

The effect of interaction of level of nitrogen and boron fertilizer was also found statistically significant on number of branches plant^{-1} (Table 8). The highest number of branches plant^{-1} (4.00) was recorded from the interaction of both 60 Kg N ha^{-1} with 1.6 Kg B ha^{-1} and 90 Kg N ha^{-1} with 0.8 Kg B ha^{-1}. The interaction effect of 90 Kg N ha^{-1} with 0 and 1.6 Kg B ha^{-1} recorded statistically the similar number of branches plant^{-1} as that of the highest number. The control B with the N of 30 Kg N ha^{-1} produced the lowest number of branches plant^{-1}(2.33).

Table 8. Yield attributes of sesame cv. T-6 as affected by interaction of different N and B levels

Interaction (NitrogenXBoron) (Kg ha^{-1})	Number of branches plant^{-1}	Number of capsules plant^{-1}	Number of seeds capsule^{-1}	Capsule length (cm)	1000 seed weight (g)
0 X0.0	2.67	24.32	54.61	2.15	2.30
0 X 0.8	2.67	27.55	60.78	2.32	2.30
0 X 1.6	3.00	30.33	73.95	2.33	2.38
0 X 2.4	3.00	29.87	64.81	2.35	2.34
30 X 0.0	2.33	26.81	63.75	2.23	2.55
30 X 0.8	3.00	29.35	70.13	2.38	2.68
30 X 1.6	3.33	33.28	72.89	2.40	2.80
30 X 2.4	3.00	34.44	70.13	2.38	2.43
60 X 0.0	3.00	28.43	66.51	2.23	2.60
60 X 0.8	2.67	31.20	71.40	2.39	2.69
60 X 1.6	4.00	36.05	73.53	2.42	2.87
60 X 2.4	3.00	34.67	67.15	2.39	2.69
90 X 0.0	3.67	28.20	63.96	2.20	2.59
90 X 0.8	4.00	33.28	69.49	2.33	2.60
90 X 1.6	3.67	34.90	73.74	2.38	2.65
90 X 2.4	3.00	32.82	66.30	2.37	2.61
$LSD_{(0.05)}$	0.6306	NS	NS	NS	NS
CV%	12.10	8.34	8.33	4.80	4.53

NS – not-significant

4.3.4 Number of capsules plant^{-1}

The number of capsules plant^{-1} was not significantly affected by different combination of nitrogen and boron levels (Table 8). But among the different combinations, the interaction of 60 kg N ha^{-1} and 1.6 kg B ha^{-1} gave the highest number of capsules plant^{-1} (36.05). The lowest number of capsules plant^{-1} was obtained from the control treatment.

4.3.5 Length of capsule (cm)

Interaction effect of different levels of nitrogen and boron under study showed no significant effect on length of capsule. It was observed from Table 8 that interaction of treatment of 60 kg N ha^{-1} and 1.6 kg B ha^{-1} gave the longest capsule (2.42 cm). The shortest length of capsule (2.15 cm) was obtained from control.

4.3.6 Number of seeds capsule^{-1}

Interaction effect could not exert any significant effect on number of seeds capsule^{-1}. The highest number of seed capsule^{-1} (73.95) was obtained from the interaction of 0 Kg N and 1.6 kg B (Table 8). The lowest number of seed capsule^{-1} (54.61) was obtained from control.

4.3.7 1000 seed weight (g)

1000 seed weight was not statistically different due to various combination of nitrogen and boron fertilization. But the highest 1000 seed weight (2.87 g) was obtained from the interaction of 60 kg N ha^{-1} and 1.6 kg B ha^{-1}. The lowest 1000 seed weight was obtained from the control.

4.3.8 Seed yield (Kg ha^{-1})

It was found that seed yield was not significant due to nitrogen and boron interaction (Table 9). The interaction of 60 kg N ha^{-1} and 1.6 kg B ha^{-1} gave the highest seed yield ha^{-1} (1628.91 Kg) and the lowest yield (663.50 Kg) was recorded from the control treatment.

4.3.9 Stover yield (Kg ha^{-1})

Stover yield did not vary with different combinations of nitrogen and boron in sesame. From Table 9, it was found that the highest stover yield (5991.78 Kg ha^{-1}) was found in the interaction of 30 kg N ha^{-1} and 1.6 kg B ha^{-1} and the lowest stover yield (2961.01 Kg ha^{-1}) was obtained from the no nitrogen and no boron interaction treatment.

Table 9. Yield and harvest index of sesame cv. T-6 as affected by interaction of different N and B levels

Interaction (NitrogenXBoron) (Kg ha^{-1})	Yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	HI (%)
0 X0.0	663.50	2961.01	18.31
0 X 0.8	845.22	3764.39	18.34
0 X 1.6	1187.20	4267.73	21.76
0 X 2.4	1131.73	4104.05	21.62
30 X 0.0	952.99	4498.69	17.48
30 X 0.8	1205.81	4661.20	20.55
30 X 1.6	1492.76	5991.78	19.94
30 X 2.4	1410.11	5854.00	19.41
60 X 0.0	1075.91	5005.60	17.69
60 X 0.8	1312.26	5461.43	19.37
60 X 1.6	1628.91	5833.29	21.83
60 X 2.4	1367.88	5738.87	19.25
90 X 0.0	1025.07	4300.93	19.25
90 X 0.8	1318.08	5502.21	19.33
90 X 1.6	1475.97	5676.34	20.64
90 X 2.4	1239.63	5592.67	18.14
$LSD_{(0.05)}$	130.30	390.10	2.075
CV%	6.47	7.72	6.35

4.3.10 Harvest index (%)

The effect of interaction of nitrogen and boron fertilizer on harvest index was statistically significant (Table 9). The highest harvest index (21.83%) was observed from the interaction of 60 kg N ha^{-1} and 1.6 kg B ha^{-1} and the lowest harvest index (17.48%) was obtained from the interaction of 30 kg N ha^{-1} and 0 kg B ha^{-1} combination of fertilizer.

From the results of the experiment it can be concluded that appropriate dose of nitrogen and boron fertilizer are required for better yield and yield attributes of sesame. On the other hand, both excess and low doses are responsible for yield depression. The results revealed that fertilization with the interaction of 60 kg N ha^{-1} and 1.6 kg B ha^{-1} gave the highest yield of sesame. However, the present research work needs to be repeated in the forthcoming years on other agro-ecological zones of the country to confirm its fitness.

CHAPTER 5

SUMMARY AND CONCLUSION

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The experiment was carried out at the Agronomy field Laboratory, Sher-E-Bangla Agricultural University, Dhaka during the period from March to June, 2007. Sesame cv. T-6 was used as the test crop in the study. The experiment consisted of four levels of nitrogen viz., 0, 30, 60 and 90 Kg ha-^{1} and four levels of boron viz., 0, 0.8, 1.6 and 2.4 kg ha^{-1}. The experiment was laid out in a randomized complete block design, with three replications. The unit plot size was (3m X 2m). There were 16 treatment combinations in the experiment. Each plot was fertilized with 140, 45, 100 and 5 kg ha^{-1} of TSP, MP, gypsum and $ZnSO_4$, respectively. Nitrogen and boron were applied in the form of urea and boric acid as per experimental treatments. TSP, MP, gypsum, $ZnSO_4$, boron and half of urea was applied as basal dose. The rest of urea was top dressed 30 days after sowing.

The data collected were plant height, number of branches plant^{-1}, number of capsules plant^{-1}, length of capsule, number of seeds capsule^{-1}, seed yield plant^{-1}, 1000 seed weight, seed yield (Kg ha^{-1}), stover yield (Kg ha^{-1}) and harvest index. All data were statistically analyzed and mean differences were adjudged by LSD.

Nitrogen had a significant effect on plant height, branches plant^{-1}, capsule pant^{-1}, number of seeds capsule^{-1}, 1000 seed weight, yield (Kg ha^{-1}), stover yield. Number of leaves plant^{-1}, capsule length and harvest index were not significantly affected by different levels of nitrogen. The nitrogen fertilizer at the rate of 60 kg N ha^{-1} gave the highest plant height (110.04cm) at 60 DAS and number of leaves plant^{-1} (15.51) at 40 DAS, the highest number of capsules plant^{-1} (32.59), length of capsule (2.36 cm), number of seeds capsule^{-1} (69.65) 1000 seed weight (2.71 g), seed yield (1346.74 Kg ha^{-1}) and stover yield (5509.80 Kg ha^{-1}). The lowest value of the above parameters viz. the plant height, (103.90cm) at 60 DAS, number of leaves (14.36) at 40 DAS, branches plant^{-1} (2.83), capsule plant^{-1} (28.02), seed capsule^{-1} (63.54), capsule length (2.29 cm), 1000 seed weight (2.33g), yield (959.91 Kg ha^{-1}), stover yield (3774.30 Kg ha^{-1}), from control treatment.

Boron had a significant effect on plant height, number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight, length of capsule, number of seeds capsule^{-1}, seed yield ha^{-1}, stover yield ha^{-1} and harvest index. But no significant effect on number of leaves plant^{-1}. The highest plant height (111.94 cm) at 60 DAS number of branch plant^{-1} (3.50) number of capsules plant^{-1} (33.64), seed yield (1446.21 Kg ha^{-1}), 1000 seed weight (2.51g), stover yield (5442.29 Kg ha^{-1}) and harvest index (20.99%) were obtained from 1.6 kg B ha^{-1}.

All the parameters studied except branches plant^{-1} and harvest index did not show significant influence with the interaction. The effect of nitrogen and boron levels, the highest number of capsules plant^{-1} (36.05), capsule length (2.42 cm), 1000 seed weight (2.87g), seed yield h^{-1} (1628.91 Kg) and harvest index (21.83%) were obtained in the interaction of 60 kg N ha^{-1} and 1.6 kg B ha$^{-1.}$ The corresponding lowest values of these characters were observed at control treatment.

From the results of the present study, It may be concluded that both nitrogen at the rate of 60 kg ha^{-1} and boron at the rate of 1.6 kg ha^{-1} had significant favorable effect for improving yield components and increasing yield of sesame cv. T-6, However, further study is necessary to confirm the results of the present study and draw a definite conclusion for recommendation.

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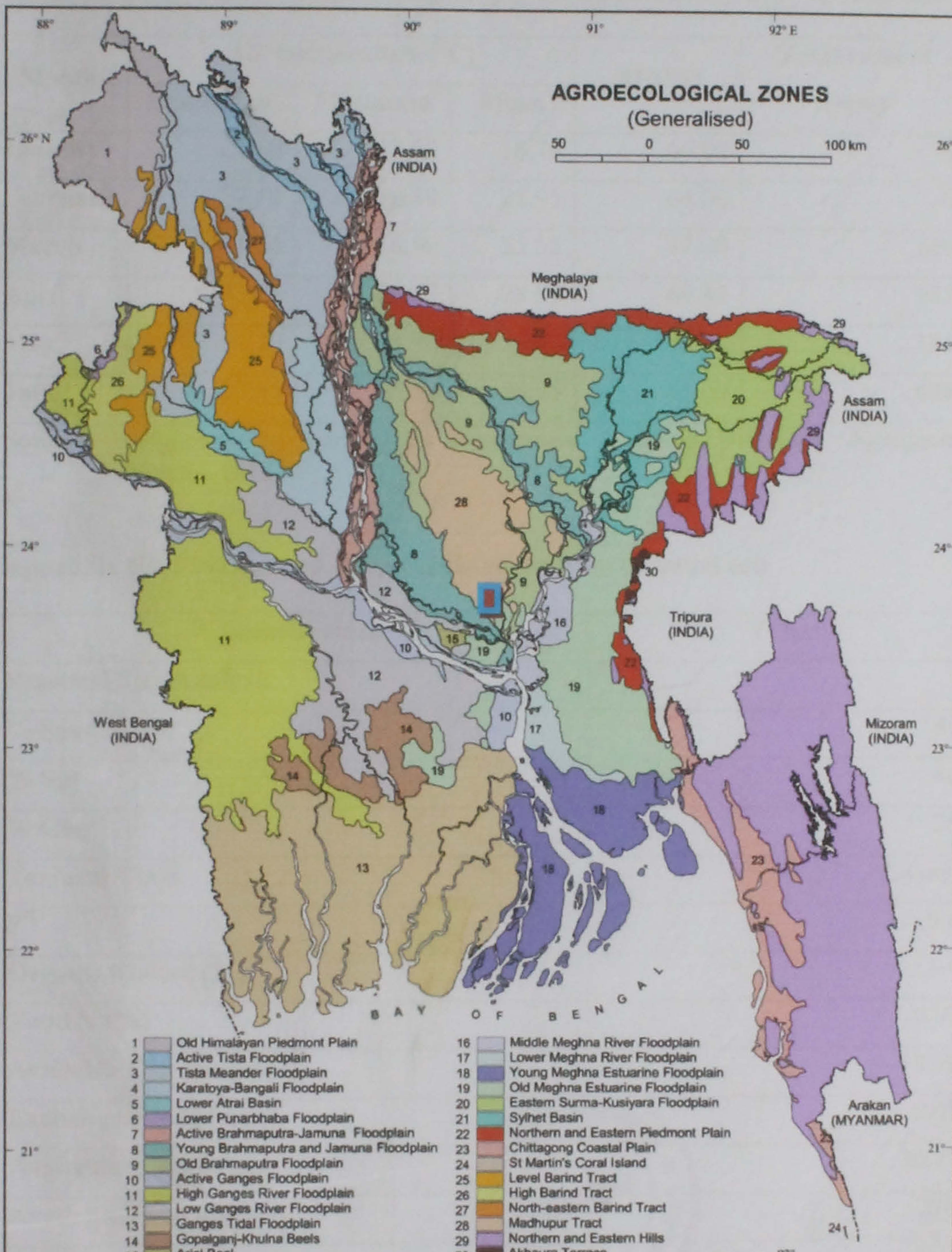
APPENDICES

Appendix I. The map showing experimental site under study



Experimental site under study

Appendix II. Monthly record of air temperature, relative humidity and total rainfall of the experiment site during the period from January 2007 to June 2007

Month	Air temperature (^0C)			RH(%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
January	24.60	12.50	18.70	66.00	0
February	27.10	16.80	21.95	64.00	0
March	31.50	16.90	25.55	47.00	160
April	33.74	23.87	28.81	69.41	185
May	34.70	25.90	30.30	70.00	185
June	32.40	25.50	28.95	81.00	628

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka – 1212.

Appendix III. Physical and chemical characteristics of initial soil

Characteristics	Value
Practical Size Analysis	
% Sand	40
% Silt	40
% Clay	20
Textural Class	Loamy
P^H	5.6
Organic Matter (%)	1.4
Total N (%)	0.07
Available P (μ gm/gm)	18.49
Exchangeable K (meq)	0.07
Available S (μ gm/gm)	20.82
Available Fe (μ gm/gm)	229
Available Zn (μ gm/gm)	4.48
Available Mg (μ gm/gm)	0.825
Available Na (μ gm/gm)	0.32
Available B (μ gm/gm)	0.94

Source: Soil Resources Development Institute (SRDI), Dhaka - 1207

Appendix IV. Summary of analysis of variance on effect of nitrogen and boron on growth of sesame cv. T-6

Source of variation	Degree of freedom	Mean Square				
		Plant height (cm)			Number of leaves plant^{-1}	
		20 DAS	40 DAS	60 DAS	20 DAS	40 DAS
Replication	2	2.949	0.106	0.126	0.033	0.075
Factor A (N)	3	30.348**	61.416*	95.963*	1.883 ^{NS}	2.990 ^{NS}
Factor B (B)	3	56.155**	161.550**	182.109**	0.889 ^{NS}	2.824 ^{NS}
N X B (AB)	9	6.701^{NS}	18.359 ^{NS}	28.685 ^{NS}	0.579 ^{NS}	0.505 ^{NS}
Error	30	5.740	20.309	31.382	1.098	1.731
Total	47					

*=significant at 5% level of probability
**= significant at 1% level of probability
NS = Not significant
N = Nitrogen
B = Boron

Appendix V. Summary of analysis of variance on effect of nitrogen and boron on yield and harvest index of sesame cv. T-6

Source of variation	Degree of freedom	Mean Square							
		Number of branch plant^{-1}	Number of capsule plant^{-1}	Number of seed capsules^{-1}	Length of capsule	1000 seed weight (g)	Seed yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	Harvest index (%)
Replication	2	0.188	2.590	12.903	0.000043	0.022	8528.466	20291.817	1.825
Factor A (N)	3	1.361**	52.450**	95.537*	0.012^{NS}	0.375**	355213.666**	7550623.917**	1.229^{NS}
Factor B (B)	3	0.806**	110.759**	258.009**	0.085**	0.070**	568682.131**	3867212.878**	16.763**
N X B (AB)	9	0.454**	3.196^{NS}	24.092^{NS}	0.00044^{NS}	0.018^{NS}	15829.581*	216215.332**	4.082*
Error	30	0.143	6.673	31.815	0.012	0.014	6104.439	54717.225	1.549
Total	47								

*=significant at 5% level of probability
**= significant at 1% level of probability
NS = Not significant
N = Nitrogen
B = Boron