EFFECT OF NITROGEN ON GROWTH AND YIELD OF SESAME (*SESAMUM INDICUM* L.)

Examination Roll No. MS-020805

A thesis
Submitted to the Agrotechnology Discipline in partial fulfillment of the requirement for the degree of Master of Science in Agronomy

Agrotechnology Discipline
Khulna University
Khulna-9208

August, 2008

EFFECT OF NITROGEN ON GROWTH AND YIELD OF SESAME (*SESAMUM INDICUM* L.)

A Thesis
By

Examination Roll No. MS-020805

Certificate of Approval:

Dr. Md. Abdul Mannan
(Cosupervisor)

Dr. Md. Sarwar Jahan
(Supervisor)

Prof. Dr. Md. Yasin Ali
Chairman,
Examination Committee

**DEDICATED TO MY
BELOVED PARENTS AND CHILDREN**

EFFECT OF NITROGEN ON GROWTH AND YIELD OF SESAME (*SESAMUM INDICUM* L.)

ABSTRACT

A field experiment was conducted at Kismat Fultola village of Batiaghata upazila under Khulna district during Kharif-I (March-June) season, 2005 to evaluate the yield potential of a local variety of sesame under different nitrogen (N) levels. Four nitrogen levels *viz.* 0 kg N ha^{-1}, 50 kg N ha^{-1}, 100 kg N ha^{-1} and 150 kg N ha^{-1} were used as treatment variables in the experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Plant height, number of branches $plant^{-1}$, dry matter $plant^{-1}$, number of leaves $plant^{-1}$, number of capsules $plant^{-1}$, length of capsule, number of seeds $capsule^{-1}$, 1000-seed weight, seed yield, biological yield and harvest index were recorded from each replicated plot. Although plant height, branches $plant^{-1}$, capsules $plant^{-1}$, seeds $capsule^{-1}$, leaf $plant^{-1}$ and yield showed positive response to nitrogen application; but capsule length and diameter and 1000-seed weight were not significantly affected. Almost all the yield parameters were found maximum at 150 kg N ha^{-1} except capsule diameter and 1000-seed weight and the lowest in the control treatment (T_1). It was also revealed that application of 150 kg N ha^{-1} increased seed yield by 77% over the control. Higher dose of nitrogen enhanced the vegetative growth and development of yield attributes as indicated by higher dry matter production. Seed yield was well correlated to branch number, capsule number and harvest index.

ACKNOWLEDGEMENT

All praise and humble gratitude are due to the Almighty Allah who enabled the author to complete the research work and writing up the thesis in fulfilling the master of science degree successfully.

The author would like to express her heartfelt respect, deep sense of gratitude, immense indebtedness and deep appreciation to her respective adviser Dr. Manoranjan Kumar Mondal, Senior Agricultural Engineer of Bangladesh Rice Research Institute and Postdoctoral Fellow of the International Rice Research Institute for his worthy guidance, valuable suggestions, constructive criticism, encouragement and continuous supervision through out the research work and preparation of the thesis.

The author expresses her deep sense of gratitude, indebtedness and profound appreciation to her supervisor, Dr. Md. Sarwar Jahan, Associate Professor, Agro technology Discipline, Khulna University, Khulna, for his valuable intellectual guidance, scholastic supervision and suggestions during research and preparing this manuscript.

The author has much pleasure to express her deep sense of gratitude, immense indebtedness and deep appreciation to her respective cosupervisor Dr. Md. Abdul Mannan, Associate Professor, Agrotechnology Discipline, Khulna University, Khulna, for valuable suggestions, constructive criticism, encouragement and continuous supervision during research and preparing this manuscript.

The author extends her gratefulness to all teachers of the Agrotechnology Discipline, Khulna University, Khulna, for their encouragement, advice, suggestions and constructive criticism.

The author would like to express her special thanks to "Challenge Program for Water and Food funded project # 10" for giving financial support to conduct the research work in Khulna area. The author expresses her sincere thanks to Mr. Sanjoy, Data Collector of the project, for his help during the field research at Kismat Fultola, village.

The author is deeply indebted to the Staff of Soil Resource and Development Institute (SRDI), Daulatpur, Khulna and the Weather Station, Gollamari of the Khulna district for their cooperation to test the soil sample and to provide climatic information needed for the experiment.

The author fells pleasure to thankfully remember scientific staffs and laborers of "Challenge Program for Water and Food funded project # 10", Batiaghata, Khulna, for their valuable and sincere help in carrying out the research work.

The author expresses her boundless gratitude to her parents and other members of her family whose sacrifices, inspiration and continuous blessing opened the gate and paved the way for her higher studies.

The author also expresses her acknowledgement to Khulna University Library, Bangladesh Agricultural University Library, BSMRAU Library and BRRI Library, Seminar Library, Agrotechnology Discipline, Khulna University, Khulna, from where the author found valuable information to complete this research work.

August, 2008 The Author

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an economically important oilseed crop belonging to the family Pedaliaceae. Sesame is the second largest source of edible oil next to mustard in Bangladesh (Kaul and Das, 1986). Sesame seed contains on an average of 48% oil, which is embedded with 19.3% protein (Sharma and Chohan, 1983). Sesame oil is used for edible purpose, in confectionary, for illumination (Martin and Leonard, 1964), manufacture of soap, paint, margarine, pharmaceutical and perfumery products (Masefield, 1965; Tribe, 1967) and as synergist for pyrethrum to increasing the toxicity of the insecticide (Mellory, 1967). Sesame oil cake is a very good cattle feed as it contains protein of high biological value and appreciable quantities of calcium and phosphorus. The cake is also used as fertilizer (Cobley, 1967).

Annually Bangladesh is producing about 0.16 million tones of edible oil as against the requirement of 0.5 million tones (Wahhab *et al.*, 2002). To meet the demand, the country has to import oils and oilseeds to the tune of about 160 million US dollar every year (Anonymous, 1998). Therefore, it is an urgent need to take immediate actions for increasing the internal production to reduce the import and to save foreign exchange to some extent.

The climate of Bangladesh is suitable for cultivation of sesame. But the farmers of Bangladesh generally use traditional varieties and follow poor management practices for cultivation. As a result, the average yield level of sesame (500-600 kg ha^{-1}) in Bangladesh is quite low (Khaleque and Begum, 1991). Yield responses to fertilizer application are affected by crops agronomy and environment (Weiss, 1983). Poor yield of locally cultivated sesame might be related to poor soil fertility and improper crop management. Sesame seed production could be raised by 50% by way of proper fertilization (Pariacha *et al.*, 1988). Seed yield increased with an increased rate of N and K application (Mandal *et al.*, 1992).

It is noteworthy that sesame is the main and/or only crop during kharif season in saline areas including Khulna region (Jahan *et al.*, 2005). Jahan and Sultana (2007) reported that sesame cultivation is an integral part of the existing cropping patterns of this agriculturally problem area. Cultivation of sesame with inadequate or no fertilizer is the common practice in Bangladesh, which results in poor or low yield. Fertilizer is now one of the expensive inputs for crop production in Bangladesh. Among the nutrients, nitrogen stands prominent in raising sesame yields. Almost all the soils of Bangladesh are low in organic matter and hence of nitrogen (Ghose, 2003). Among many factors, deficiency of nitrogen is now considered as one of the major reasons for low yield of sesame in coastal region of Bangladesh.

Despite of versatile use of sesame and quite adaptability to the agro-environment of Bangladesh, the crop is still neglected both in the research and farmers level. Due to lack of improved production technologies, the crop has not yet received proper attention to the farmers. Development of appropriate package technologies is utmost necessary for horizontal and vertical expansion of the crop. Among different fertilizer nutrients, the importance of N, P, K and S on soil have been reported by several workers (Singh and Tiwari, 1985; Rahman, 1976). For the coastal region of Bangladesh, no trial has been carried out to determine the optimum dose of nitrogen for optimum yield of sesame.

Keeping the above facts in mind, the present study was undertaken with the following specific objective:

1. To determine the effect of nitrogen on the growth, yield components and yield of sesame.

CHAPTER II

REVIEW OF LITERATURE

Many research works have been done on different aspects of sesame, like population density, drainage spacing, fertilizer application at different stages of growth etc. in different parts of the globe. Considerable literatures in this regard are available. But there was no particular information based on the coastal area for local varieties and fertilizer response. A brief review of literature related to the present study has been presented in this chapter.

Plant height

Subrahmaniyan and Arulmozhi (1999) reported that each successive increase in dose of nitrogen up to 55 kg ha^{-1} significantly increased the plant height. Amin *et al.* (1996) observed that maximum plant height (81.3 cm) was obtained from 90 kg N ha^{-1} and the lowest plant height was recorded at zero N level. Nitrogen application along with line sowing method increased plant height significantly as recorded by Alom *et al.* (1999).

According to Sarder and Rosario (1995), the highest plant height was attained with 90 kg N ha^{-1} as furrow placement while no nitrogen treatment produced the shortest plant.

Sarker *et al.* (1989) conducted an experiment with mustard and observed that the plant height increased significantly with the increases in the level of nitrogen. They found that the application of 120 kg N ha^{-1} produced the tallest plants while the shortest was obtained in the control plots.

Leaf number

The Hindu, online edition of Indian's National Newspaper, 9th July 2000 reported that higher dose of fertilizers enhanced the vegetative growth of sesame. So, the leaf number increased with the increase rate of fertilizers. According to Subrahmaniyan and Arulmozhi (1999) higher dose of nitrogen enhances the vegetative growth and simultaneously increases the leaf number of plant.

Rahman *et al.* (1995) reported that leaf number decreased during pod maturity stage might be due to senescence of leaves associated with the remobilization of the stored metabolities from the leaf to the pod wall tissues. Similar results in chickpea were found by Prasad *et al.* (1978). They reported that with the onset of flowering and fruit development, there is a decline in vegetative dry weight. This is partly due to loss of leaves and petioles, and partly to the mobilization of the stored metabolities from the stem and the pod wall tissues.

Branching distribution

Subrahmaniyan and Arulmozhi (1999) noticed that each successive increase in dose of nitrogen up to 55 kg ha^{-1} significantly increased number of branches per plant. These observations are in line with Prakasha and Gowda (1992) who reported higher values of yield attributes with 60 kg N ha^{-1} in sesame.

Sarder and Rosario (1995) found that nitrogen placement had significant influence the number of branches, irrespective of rate, method of application of N fertilizer. N-treated plots had higher branch production compared to the no N plots. They showed that maximum number of branches was particularly observed from furrow placement at 90 kg N ha^{-1}, significantly exceeding all other rates and methods. Higher N rate (90 kg N ha^{-1}), when placed as surface band produced more branches than did by low N rate (60 kg ha^{-1}) with similar application method. The number of branches of sesame obtained from this experiment was comparable to that reported by Taylor and Chambi (1986) from row planting of sesame in Tanzania. They also noticed that in sesame, the number of branches per plant was found to be an important yield contributing character as capsule formation occurs at each leaf axile. As such, the number of capsules per plant was highly related to leaf number and thereby number of branches.

Alom *et al.* (1999) observed that application of nitrogen along with hand weeding at 20 days after emergence (DAE) significantly increased the number of branches per plant.

Sarker *et al.* (1989) studied on mustard and found that maximum primary branches were produced in plants irrigated at vegetative stage when 120 kg N ha^{-1} was applied. They also showed that plants though irrigated at vegetative, flowering and siliqua-filling stages did not produce more primary branches than non-irrigated ones when nitrogen was not applied. They observed that plants produced more primary branches with the increasing rates of nitrogen application even under non-irrigated condition. This indicates that available moisture present in soil was sufficient to help uptake of nitrogen which resulted in more primary branches.

Kolsarici and Eda (2002) reported that the highest numbers of branches per plant (7.60 and 7.73) were obtained with 50 cm row spacing and N doses of 120 and 160 kg ha^{-1} in safflower.

Plant population

Sardar and Rosario (1993) observed that placement of N fertilizer had greater effects on seedling emergence of sesame. The number of plants gradually decreased with increasing the rate of N and closer placement of seeds. Higher seedling emergence was recorded by no N and broadcast N plots, in contrast the lowest under furrow placement, regardless of N rate. However, N applied as broadcast and surface band did not affect seedling emergence significantly compared with broadcast N, furrow placement had 19 and 31 percent reduction in seedling emergence at 60 and 90 kg N ha^{-1}, respectively.

Dry matter accumulation and partitioning

Subrahmaniyan and Arulmozhi (1999) reported that higher dose of N enhanced the vegetative growth and development of yield attributes as indicated by higher dry matter production. Prakasha and Gowda (1992) also reported higher values of yield attributes with 60 kg N ha^{-1} in sesame.

According to Rahman *et al.* (1998), dry matter production varied significantly with different levels of nitrogen application. They reported that the rate of dry matter accumulation was similar in all the treatments up to 20 DAE, after which it showed significant variations due to different treatments. Tsiung (1978) also reported similar trend of results in respect of dry matter accumulation in mungbean irrespective of fertilizer management. Matsunaga *et al.* (1989) reported that dry matter of mungbean increased until the mid pod filling stage (56 DAS) and decreased rapidly after then, due to the rapid progress of reproductive growth.

In other study, Ali *et al.* (2005), showed that the highest dry matter was produced when they applied 125 kg Urea, 150 kg TSP and 50 kg MoP per hectare, respectively under control *i.e* when no salt were added. Babu and Thirumurugan (2001) observed decreased total dry matter (TDM) with the increase of salinity in sesame. Among the cultivars BINA TIL-1 produced the highest TDM while T-6 produced the lowest.

Number of capsules/plant

Amin *et al.* (1996) observed that the highest number of capsules $plant^{-1}$ was at 60 kg N ha^{-1} in combination with 30 kg P_2O_5, 20 kg K_2O and 10 kg S ha^{-1}. This was statistically identical with all the treatments where 30-90 kg N ha^{-1} was added. But capsule number was partially higher in presence of P, K and S with 60 kg N ha^{-1}.

According to Sarkar *et al.* (1989), significantly more siliqua were obtained in plants irrigated at flowering and siliqua filling stages when nitrogen was applied at 120 kg ha^{-1}. They also observed that the number of filled siliqua per plant was significantly increased with the increasing rates of nitrogen.

Sarder and Rosario (1993) reported that considering N placement and its rates, the highest number of capsules plant^{-1} was recorded from furrow placement at 90 kg N ha^{-1} which significantly exceeded the lower rate (60 kg N ha^{-1}) under same application method. The other two methods of N placement broadcast and surface band did not differ significantly from each other within or between N rates. However, the total number of capsules plant^{-1} obtained from their study was almost similar to that reported by Taylor and Chambi (1986) from broadcast planting of sesame. At 90 kg N ha^{-1}, furrow placement produced 32 and 13 percent more capsule than surface band and broadcast respectively. On the other hand, at 60 kg N ha^{-1}, this increase was 29 and 42 percent, respectively in surface band and broadcast application.

Subrahmaniyan and Arulmozhi (1999) observed that each successive increase in dose of N up to 55 kg ha^{-1} significantly increased total number of capsules plant^{-1}.

Capsule length and diameter

Sarkar *et al.* (1989) studied on the effect of nitrogen and irrigation at different growth stages on mustard and showed that the length of siliqua increased significantly with the increased levels of nitrogen. Relatively long siliqua was obtained in plants where nitrogen was applied at 80 and 120 kg ha^{-1}. The shortest siliqua were obtained in plants when nitrogen was not applied. These findings are in agreement with those of Singh and Yadava (1972) and Sen *et al.* (1977) who observed a similar trend of increase in the length of siliqua in mustard with the increased supply of nitrogen per hectare.

Number of seeds/capsule

Amin *et al.* (1996) found that the application of 30-90 kg N ha^{-1} with or without P, K and S fertilizer had no significant effect on number of seeds capsule^{-1} in sesame under rainfed condition. Absence of nitrogenous fertilizer gave the lowest seed number.

Sardar and Rosario (1993) found that there were no effects of tillage methods on number of seeds capsule^{-1} in sesame. Only N management had significant influence on seed number. The control treatment (no N) had the lowest number of seeds capsule^{-1}

which was significantly higher than broadcast and surface band methods at 60 kg and 90 kg N/ha, respectively. Up to 11 percent reduction in seed number capsule^{-1} occurred when N was applied compared to no nitrogen application. They revealed that the higher number of seeds was probably related to the lowest number of capsules plant^{-1}.

Sarkar *et al.* (1989) revealed that in general, the irrigated mustard plants produced more seeds per siliqua with increased levels of nitrogen. However maximum number of seeds per siliqua was produced in plants irrigated at flowering and siliqua filling stage when nitrogen was applied at 120 kg ha^{-1}. The non-irrigated plants also produced more seed per siliqua with the increasing rates of nitrogen. This indicates that available moisture present in soil was sufficient to produce more seeds in plants fertilized with adequate nitrogen.

1000-seed weight

Amin *et al.* (1996) reported that seed weight significantly differed at different fertilizer levels. The highest 1000 seed weight (3.20 g) was obtained from 60-60-20-10 of N, P_2O_5, K_2O and S kg ha^{-1} followed by 60-30-20-10 kg N, P_2O_5, K_2O and S ha^{-1}. But application of 60 kg N without any of the fertilizer P, K, and S, 1000 grain weight was reduced. This might be due to imbalanced fertilization in sesame.

Sarkar *et al.* (1989) observed that irrigated mustard plants produced heavier seeds of different rates of nitrogen in comparison to non-irrigated plants. The weight of 1000 seed increased with the increasing rates of nitrogen even in non-irrigated plants indicating that minimum level of available soil moisture might be enough to produce heavy seeds if the plants were fertilized with adequate nitrogen. The plants irrigated at flowering and siliqua filling stage with 40, 80 and 120 kg N ha^{-1} produced the heaviest seed in comparison to non-irrigated plants and plants irrigated at vegetative stage.

Sardar and Rosario (1993) showed that 1000-seed weight did not differ significantly either by tillage method or by N management and their interaction was also insignificant. Both seed number and seed weight of sesame were found fairly stable characters and considered as genetically controlled factors reported by Kumar and Sreedharan (1987). But Subrahmaniyan and Arulmozhi (1999) found that each successive increase in N dose up to 55 kg ha^{-1} increased seed weight of sesame.

Seed yield

Subrahmaniyan and Arulmozhi (1999) observed that application of 55 kg N ha^{-1} recorded significantly higher seed yield over lower levels of N proportionate to the favourable increase in yield attributes. The maximum yield was obtained with the highest N dose. These findings are in accordance with those of Balasubramganiyan *et al.* (1995).

Alom *et al.* (1999) observed that the treatment of hand weeding at 20 DAE along with fertilizer application irrespective of line or broadcast sowing recorded the highest seed yield due to reduced crop weed competition and also due to supply of sufficient nutrient which favourably influenced yield components and higher dry matter production in sesame.

Pariacha *et al.* (1988) reported that sesame seed production could be raised by 50 per cent by way of proper fertilization. Seed yield of sesame also increased with an increased rate of N and K application (Mandal *et al.*, 1992).

According to Sardar and Rosario (1993) placement of N fertilizer had a significant influence on seed yield though N rates of 60 kg and 90 kg ha^{-1} did not vary from each other at similar management practice. They also showed that almost an equal yield of sesame was obtained from both high and low N rates. It was possibly due to root damage by saturated soil water and higher N loss during surface drainage and by leaching. Taylor *et al.* (1986) reported a similar response of sesame to nitrogenous fertilizer from different sites in Tanzania.

Amin *et al.* (1996) reported that seed yield was significantly affected by fertilizer application. They observed that the highest seed yield (1035 kg ha^{-1}) was found from the treatment 60-30-20-10 followed by the treatment 60-45-20-10 of N, P_2O_5, K_2O and S kg

ha^{-1}. The lowest seed yield (425 kg ha^{-1}) was obtained from where no fertilizers were applied.

Sarkar *et al.* (1989) observed that the highest and the second highest yield of seed were obtained in plots fertilized with 120 and 80 kg N ha^{-1} but their difference was not significant. The lowest seed yield was obtained in plots where nitrogen was not applied at all. The yield of seed $plant^{-1}$ showed the similar trend as that of the yield of seed $plot^{-1}$ of various rates of nitrogen application. Yield of seed per plot was increased due to the improvement of yield components at increasing rates of nitrogen. The increased yield of seed in mustard due to increased rates of nitrogen has also been observed by many researchers (Vir and Verma, 1981; Mudhekar and Ahlwal, 1981; Garcia and Alcantra, 1983).

Split application of N and K as 50 percent as basal and 50 percent as top dressing on 20 DAS significantly increased the growth, yield characters and yield of sesame (Kannan, 1992).

In other study, Bhan (1979) reported that application of fertilizer gave good response when one hand weeding was done at 20 DAE. The results may appear due to competition between weed and crop plants for moisture and nutrients resulting a significant reduction in crop growth and yield components. The results confirm with the finding of Singh and Nema (1979) in which they stated that application of fertilizer only failed to enhance the seed yield of sesame.

Singaravel *et al.* (2002) reported that the application of the recommended dose of NPK along with soil application of $ZnSO_4$ at 25 kg ha^{-1} + $MnSO_4$ at 5 kg ha^{-1} would be beneficial for increasing the productivity of sesame in vertisols.

Sharma and Verma (1982) also reported a significant increase in safflower yield due to and application of 60 kg N ha^{-1} compared with the other levels of N. Rajput *et al.*

(1992) reported that 40 and 60 kg N ha^{-1} were at par but produced significantly higher yield than the control and 20 kg N ha^{-1}.

The highest yield of sesame (1244 kg ha^{-1}) was obtained from 60 kg N ha^{-1} in combination with 30 kg P_2O_5, 20 kg K_2O and 10 kg S ha^{-1} as reported by Amin *et al.* (1996). They also showed that further increase in N rate from 60 to 90 kg ha^{-1} did not give any yield advantage. This might be due to its maximum vegetative tendency than capsule formation. But the application of 30 kg N ha^{-1} gave lower yield than 60 and 90 kg N ha^{-1}. Low organic matter content in the soil may be the reason for low yield at 30 kg N ha^{-1}. The highest seed yield in the treatment 60-30-20-10 kg N-P_2O_5-K_2O-S ha^{-1} respectively, was mostly contributed by number of pods $plant^{-1}$ and 1000 seed weight. This result is in agreement with that of Mitchell *et al.* (1974) who reported that combination of N, P and K increased the yield and yield components of sesame but application of single fertilizer element had no such effect. The effect of P in producing higher yield was quite evident in this study when the grain yield data were compared between 60-0-20-10 kg N-P_2O_5-K_2O-S ha^{-1} and any of the P combination with 60 kg N ha^{-1}. The results are in agreement with the findings of Kaul and Das (1986).

Subrahmaniyan and Arulmozhi (1999) reported that higher dose of N enhanced the vegetative growth and development of yield attributes as indicated by more number of branches and capsules $plant^{-1}$. These observation are in line with Prakasha and Gowda (1992) who reported higher values of yield attributes with 60 kg N ha^{-1} in sesame.

Straw yield

Sarkar *et al.* (1989) reported that the straw yield was not significantly influenced by the irrigation at different stages of growth, but increased when nitrogen was applied at 40, 80 and 120 kg ha^{-1}. They also showed the straw yield obtained in plots where nitrogen were applied at 40 kg ha^{-1} were significantly lower than that obtained in plots where nitrogen were applied at 80 and 120 kg ha^{-1}.

Alom *et al.* (1999) revealed that the yield contributing characters such as the highest plant height , branches plant^{-1}, capsules plant^{-1}, 1000- seed weight, seed yield and straw yield were recorded the management level where fertilizer was applied along with hand weeding at 20 DAE irrespective of sowing methods.

Harvest index

Sardar and Rosario (1993) observed that the lowest harvest index was produced in zero N treatment and the highest by furrow placement at 90 kg N ha^{-1}. They further reported that as to N management a progressive increase in harvest index was found starting from 0 to 90 kg N ha^{-1}.

CHAPTER III
MATERIALS AND METHODS

Location

A field experiment was conducted at Kismatfultola village of Batiaghata upazila under Khulna district during Kharif-I (March-June) season, 2005 to evaluate the effect of nitrogen on growth and yield performance of sesame. The experimental site was located at a latitude of 22°47′ N and longitude of 89°34′ E.

The experimental site belongs to the Agroecological Zone No. 13 (AEZ 13). The experimental field was medium high land of clay soil belonging to the soil physiographic unit of Ganges Tidal Flood Plain. The region is characterized by close network of interconnected tidal rivers, channels and creeks. In the southwest these channels are saline throughout the year, although less saline in the rainy season than the dry season. In the east, channels carry fresh water in the rainy season and salinity only affects in the dry season.

Climate

The experimental field was characterized by subtropical climate with moderately high temperature and heavy rainfall during the Kharif season (April-September) and scanty rainfall with moderately low temperature during the Rabi season (October-March). The monthly total precipitation, daily average maximum temperatures, humidity and sunshine hours received at the experimental site during the study period was presented in Appendix I.

Soil

The experimental field was medium high land with silty loam textured soil having pH value of 8.2, termed alkaline. Soil samples of 15 cm depth from surface were collected from the experimental field. The composition of soil sample was analyzed at the Soil Resource Development Institute (SRDI), Daulatpur, Khulna. The physical and chemical characteristics of the soil were presented in Appendix II.

Experimental materials

A traditional cultivar of sesame popularly cultivated by the farmers of Batiaghata area was used as the test variety. Four levels of nitrogen were used as experimental treatment. They were T_1 (0 kg N ha^{-1}), T_2 (50 kg N ha^{-1}), T_3 (100 kg N ha^{-1}) and T_4 (150 kg N ha^{-1}).

Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three (3) replications. Unit plot size was 5 m × 3 m.

Land preparation

The experimental field was ploughed with a country plough followed by harrowing to attain a desirable tilth. All weeds and stubbles of the previous crop were removed from the experimental field. The land was turn up by spade twice to ensure a good land preparation. Finally the land was leveled by a leveler.

Fertilizer application

Four levels of nitrogen were applied for sesame cultivation (T_1=0 kg N ha^{-1}, T_2=50 kg N ha^{-1}, T_3 = 100 kg N ha^{-1} and T_4= 150 kg N ha^{-1}). Half of different levels of urea was applied at the time of final land preparation. The rest part of urea was top-dressed during flower initiation. Comprehensive soil testing of the experimental area revealed deficiencies in phosphorus (P). That is why, phosphorus (P) in the form of Triple Super Phosphate (TSP) at the rate of 150 kg P/ha^{-1} was applied during final land preparation as basal dose.

Seed sowing

Seeds were subjected to germination test and were treated with Vitavex-200 @ 2.5 g kg^{-1} of seeds before sowing. Seeds were sown on 28 February, 2005 in line with the spacing of 30 × 10 cm.

Intercultural operations

The desired population density was maintained by thinning plants after emergence. Irrigation, mulching, weeding and plant protection measures etc. were performed as needed. In order to keep crop weed free two hand weedings were done: first weeding was done at 25 days after sowing (DAS) followed by second weeding at 45 DAS. One irrigation was applied 42 DAS during topdressing of urea. Sesame plants were invaded by the caterpillar. Then insecticide Diazinon was applied at 30 DAE at the rate of 1 ml L^{-1}.

DATA COLLECTION

A. Growth Parameters

Plant height

Plant height was measured at 7 days intervals from the base of the plant up to tip of the five sample plants and the means were calculated.

Leaf number

Leaf number was determined at 7 days interval of the five sample plants and the means were calculated.

Branching distribution

Number of branches was recorded at 7 days intervals from each of five sample plants from each treatment and then the means were calculated.

Dry matter accumulation and partitioning

Data on dry matter accumulation in different plant parts were recorded from five samples. Plants were separated into their component parts (leaf, stem, branch, flower and capsule). Plants were sampled four (4) times commencing from 30 DAE to 75 DAE. Sample plants were collected from second and third rows. The first rows were avoided from sampling to reduce the border effect. The plant parts were then dried in an oven to a constant weight in a drier at 70°C for 72 hours and weighed separately.

Harvesting

The crop harvested from an area of 1.0 m^2 from each plot at their full maturity, when 90% of the capsules turned yellow in color. The harvested crop of each plot was bundled separately, tagged properly and brought on the clean threshing floor. The bundles were dried in open sunshine, threshed and the seeds were cleaned. Seed and straw yield were recorded from each experimental unit. The seed and straw weight for each plot were recorded after proper sun drying. The seed yield was adjusted to 8% moisture content.

During harvesting randomly selected five (5) sample plants from each plot were cut from the basal portion carefully for collecting data on yield contributing characters.

Yield and Yield components

Plant height

Plant height was measured from the base of the plant up to the tip of the sample plants and the means were calculated.

Total weight of plant

At first, fresh weight of five (5) sampled plants from each plot were measured and the means were calculated. Secondly, the plants were then dried in an oven at 70° C for 72 hours and weighed and the means were calculated.

Number of branches/plant

Number of branches of five (5) plants selected randomly from each treatment was taken and branches of individual plant was then calculated.

Number of capsules/plant

The number of capsules from each plant from sampled five (5) plants were counted and was recorded.

Capsule length and diameter

At first, length was measured by a scale from capsule base to apex of five (5) capsules from each plant. Then average value was taken. Diameter was measured by the tape on three places of capsule, average of which was taken as the diameter of the capsule.

Number of seeds/capsule

A sub sample was taken from each sampled plant from each treatment and the capsules were split to count the seeds contained in each capsule, mean of five was taken as the number of seeds in a capsule.

Determination of seed yield/plant

Seed yield per plant was determined by multiplication of seed per capsule with total number of capsules in a plant. For total grain weight per plant, at first all capsules from one plant were separated. Then the capsules were sun dried and split to weigh for the total grain weight of a plant.

Crop cut information

An area of 1.0 m^2 were harvested from each plot to know the total plant per m^2 and total capsule per m^2 for seed yield computation.

1000 grain weight

1000 seeds were counted randomly from the filled seeds by hand from the seed stock of each plot and weighed by an electric balance. The moisture content was also measures with an electrical moisture meter from 5 to 8 seed of the sample. Grain moisture content was adjusted to 8% moisture content (MC) by using the following formula .

$$\text{1000 grain weight at 8\% MC} = \frac{(100\text{-sample of MC}) \times 1000 \text{ grain weight at sample MC}}{(100-8)}$$

Yield

An area of 1.0 m^2 were harvested from each plot for seed yield computation and was converted to 8% moisture content by using the following formula .

$$\text{Yield (kg/ha) at 8\% moisture content} = \frac{10\,(100\text{-sample of MC})}{(100-8)} \times \frac{\text{Yield (g)}}{\text{Area } (m^2)}$$

Determination of biological yield

Grain yield and stover yield were all together regarded as biological yield. Biological yield was calculated with the following formula.

Biological yield = Grain yield + Stover yield

Harvest index

It is the ratio of economic yield to biological yield and was calculated with the following formula –

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Statistical Analyses

Data recorded for different parameters were subjected to statistical analysis. All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjusted by Duncan's New Multiple Range Test (DMRT) using a computer operated program MSTAT-C. Functional relationships were developed between different growth and yield parameters using simple linear regression analysis.

CHAPTER IV

RESULTS AND DISCUSSIONS

The experiment was conducted in Kharif-1 season 2005 with a widely grown local sesame variety in the farmers field at Batiaghata Upazila. Four levels of nitrogen was applied *viz*, 0 kg, 50 kg, 100 kg and 150 kg N ha^{-1} to examine the effect of nitrogen levels on growth and yield of sesame in the salt affected areas of Khulna district. Data were collected as per methodology and analyzed statistically using single factor RCBD. Results for the effect of fertilizer treatments on different crop characters, yield components and yield soil have been presented and discussed in this chapter.

PLANT GROWTH CHARACTERS

Plant height

The plant height was measured at 15, 30, 45, 60 and 75 days after emergence (DAE). In all the sampling dates, T_4 produced the tallest plants (22.06 cm, 28.29 cm, 65.66 cm, 71.05 cm and 77.66 cm) followed by T_3, T_2 and T_1 (Table 1). The shortest plant was observed in T_1 at all sampling dates.

Plant height was significantly influenced by nitrogen application. The progressive increase of plant height was observed for all treatment up to 30 DAE (Table 1). Plant height increased sharply from 30 to 45 DAE, that the height of the plants become doubled within 15 days where after rate of increase was very slow. Each successive increase in dose of N up to 150 kg ha^{-1} significantly increased plant height. Here maximum plant height was observed with the highest dose of nitrogen (T_4) and lowest plant height was observed in the treatment with no N fertilizer (T_1). This finding is in accordance with that of Subrahmaniyan and Arulmezhi (1999).

Table 1. Effect of nitrogen on plant height at different growth stages of sesame in Batiaghata ,Khulna during Kharif-1 season 2005

Treatment	Plant height (cm) of sesame over time				
	15 DAE	30 DAE	45 DAE	60 DAE	75 DAE
T_1 = 0 kg N ha^{-1}	14.38 d	20.50 d	55.78 d	59.33 d	65.52 c
T_2 = 50 kg N ha^{-1}	18.19 c	24.37 c	57.23 c	62.57 c	76.00 b
T3 = 100 kg N ha^{-1}	19.46 b	26.38 b	64.18 b	69.06 b	76.64 b
T_4 = 150 kg N ha^{-1}	22.06 a	28.29 a	65.66 a	71.05 a	77.66 a
CV (%)	2.22	2.23	0.76	0.93	0.55
Level of significance	0.01	0.01	0.01	0.01	0.01

DAE = Days after emergence.

Leaf number

The number of leaf present in a plant was counted at 15, 30, 45 and 60 DAE. At 15 DAE, T_4 produced significantly higher number of leaf (16.80) than other treatments and was followed by T_2, T_3 and T_1 (Table 2). At 30 DAE, T_2 produced the highest leaf number followed by T_3, T_4 and T_1 which was significantly different from leaf number obtained in other treatments. At 45 DAE, T_4 showed the highest leaf followed by T_3, T_1 and T_2. The treatment difference was highly significant. At 60 DAE, T_1 produced the highest number of leaves and T_4 produced the lowest and the difference was highly significant.

At initial stages, T_4 showed the highest number of leaf, but at maturity T_4 represented the lowest number of leaf as plants of T_4 matured faster, usually leaves started to fall from the plant and followed by 100 kg N ha^{-1}, 50 kg N ha^{-1} and 0 kg N ha^{-1}. The progressive increase of leaf number was observed for all treatments up to 30 DAE. Then leaf number increased so rapidly from 30 to 45 DAE that the number of leaf increased more than three folds within 15 days where after rate of increase become very slow and finally started decrease during capsule maturity stage. That might be due to senescence of leaves associated with the remobilization of the stored metabolities from the leaf to the pod wall tissues. Similar results in chickpea were reported by Prasad *et al.* (1978). At maturity stage, each successive increase in dose of N up to 150 kg ha^{-1}, significantly decreased leaf number. Here maximum leaf number was observed with T_1 as the maturity of these plant became delayed and the lowest leaf number was observed with the highest dose of N fertilizer (Table 2).

Table 2. Effect of Nitrogen on leaf number at different growth stages of sesame in Batiaghata, Khulna during Kharif-1 season 2005

Treatment	Leaf number $plant^{-1}$ over time			
	15 DAE	30 DAE	45 DAE	60 DAE
$T_1 = 0$ kg N ha^{-1}	11.60 b	23.27 d	81.33 c	106.60 a
$T_2 = 50$ kg N ha^{-1}	12.26 b	29.60 a	66.07 d	104.33 b
$T_3 = 100$ kg N ha^{-1}	12.06 b	27.73 b	85.27 b	91.40 c
$T_4 = 150$ kg N ha^{-1}	16.80 a	24.87 c	86.00 a	83.33 d
CV (%)	5.15	2.29	0.43	0.92
Level of significance	0.01	0.01	0.01	0.01

DAE = Days after emergence.

Branching distribution

Number of branches per sesame plant differed significantly due to different levels of nitrogen application (Table 3). The development of branches in sesame started between 15 and 30 DAE and increased progressively up to 75 DAE. Sesame is indeterminate in growth habit and hence the vegetative and reproductive growth occur simultaneously up to 75 DAE.

It is evident from Table 3 that number of branches increased sharply from 30 to 45 DAE; branches became tripled within 15 days where after rate of increase was very slow. Each successive increase in dose of nitrogen up to 150 kg ha^{-1}

significantly increased branch number. At this stage maximum number of branches was found with the highest dose of nitrogen (150 kg ha^{-1}) and the lowest was observed in the treatment with no nitrogen application. The treatment difference was highly significant except T_1 and T_2. Higher dose of nitrogen enhanced the vegetative growth and development of yield attributes as indicated by more number of branches and capsules $plant^{-1}$. This observation are in line with Subrahmaniyan and Arulmozhi (1999) who reported higher values of yield attributes with 55 kg N ha^{-1} in sesame.

Table 3. Effect of nitrogen management on number of branches (primary & secondary) per plant in sesame

Treatment	Number of branches $plant^{-1}$ over time				
	15 DAE	30 DAE	45 DAE	60 DAE	75 DAE
$T_1 = 0$ kg N ha^{-1}	0.04 b	2.27 b c	6.93 b	7.33 c	7.66 c
$T_2 = 50$ kg N ha^{-1}	0.04 b	2.53 b	6.67 b	7.33 c	8.13 c
$T_3 = 100$ kg N ha^{-1}	0.67 a	2.93 a	8.27 a	8.33 b	9.00 b
$T_4 = 150$ kg N ha^{-1}	0.27 c	2.00 c	8.27 a	9.67 a	10.67 a
CV (%)	13.87	7.59	5.36	4.97	3.76
Level of significance	0.01	0.01	0.01	0.01	0.01

DAE = Days after emergence.

Dry matter accumulation and partitioning

The process of photosynthesis, mineral uptake, respiration and abscission usually determine the dry weight of plants. Photosynthesis is the main contributing factor in increasing plant dry matter (Evans and Ghobashi, 1983). Tanaka (1980) expressed total dry matter (TDM) as the product of average crop growth rate (CGR) and growth duration. Accumulation of TDM in sesame increased progressively over time attaining the highest at physiological maturity (Fig. 1). The rate of increase, however, varied depending on the growth stage.

There was significant variation in TDM accumulation among the different level of nitrogen treatments. Dry matter (DM) production was counted at 30 DAE (at vegetative stage), 45 DAE (at flowering stage), 60 DAE (at mid capsule formation stage) and 75 DAE (at maturity stage). Partitioning of DM showed that the highest DM was produced in stems, followed by leaf and petiole up to 45 DAE (Fig. 1). Later on, at 60 DAE and onward, the capsules produced the highest amounts of DM than the stem.

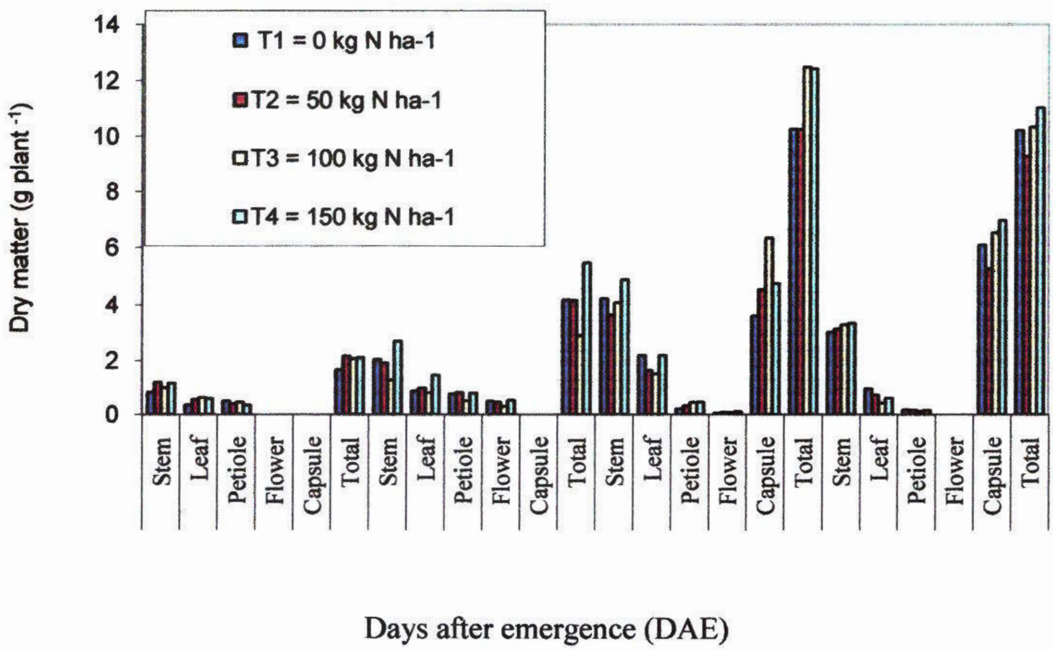

Fig. 1. Dry matter partitioning among stover (stem, leaf, petiole, flower and capsule) in sesame at different days as affected by nitrogen application

At 30 DAE, the stems produced about 1.0 g DM plant^{-1}, that doubled at 45 DAE and further increased two folds at 60 DAE (Fig. 1). The amount of DM was reduced to about 3.0 g plant^{-1} at 75 DAE. The DM production in leaf was less than 1.0 g plant^{-1} at 30 DAE, about 1.0 g plant^{-1} at 45 DAE and 2.0 g plant^{-1} at 60 DAE. It then reduced to about 1.0 g plant^{-1} at 75 DAE. The petiole and flower produced less than 1.0 g plant^{-1} DM at different growth phases of the plant.

Total DM production at 30 DAE was about 2.0 g plant^{-1}in almost all the treatments (Fig. 1 and Table 4). But slightly lower amounts was produced in T_1. At this stage T_2, T_3 and T_4 produced statistically similar DM but significantly different than T_1 at 5% level of significance. At 45 DAE, total DM produced in T_1 and T_2 was about 4.0 g plant^{-1}, T_3 produced about 3.0 g plant^{-1} and it was about 5.5 g plant^{-1} in T_4 and was significantly different that other treatments. It is not clear why T_3 produced lower amounts of DM at 45 DAE compared to other treatments. But at 60 DAE, T_3 and T_4 produced statistically similar amounts of DM (7.2 g plant^{-1}) and was significantly higher than that produced in T_1 and T_2. Total DM production at 75 DAE was lower than that produced at 60 DAE. It was about 10 g plant^{-1} in T_1 and T_3, 9.8 g plant^{-1} in T_2 and 11 g plant^{-1} in T_4. The treatment difference was highly significant except T_1 and T_3 (Table 4).

Table 4. Total dry matter partitioning at different stages of sesame as affected by nitrogen
application

Treatment	Dry matter production (g/plant)			
	30 DAE	45 DAE	60 DAE	75 DAE
T_1 = 0 kg N ha^{-1}	1.68 b	4.18 b	10.26 b	10.21 b
T_2 = 50 kg N ha^{-1}	2.16 a	4.16 b	10.24 b	9.27 c
T_3 = 100 kg N ha^{-1}	2.08 a	2.88 c	12.46 a	10.32 b
T_4 = 150 kg N ha^{-1}	2.11 a	5. 48 a	12.41 a	11.03 a
CV (%)	8.20	10. 65	3.68	3.10
Level of significance	0.05	0.01	0.01	0.01

DAE = Days after emergence.

At vegetative stage, T_3 produced the highest dry matter which was followed by T_1, T_4 and T_2 (Fig. 1). At flowering stage, T_4 produced the highest dry matter followed by T_2, T_3 and T_1 respectively. During capsule formation stage, T_2 showed the highest dry-matter production followed by T_4, T_1, and T_3. At full maturity stage, T_4 produced the highest dry matter which followed by T_3, T_2 and T_1 respectively.

A sharp increase in dry matter production occurred for all treatment up to 60 DAE (Fig. 2). Dry matter production increased so rapidly from 45 to 60 DAE that TDM production become tripled within 20 days where after rate of increase was very slow and finally started decline due to leaves and flowers senescence. The plant with the highest N dose has accumulated more dry matter than with lower dose. TDM production increased with the increasing rate of nitrogen.

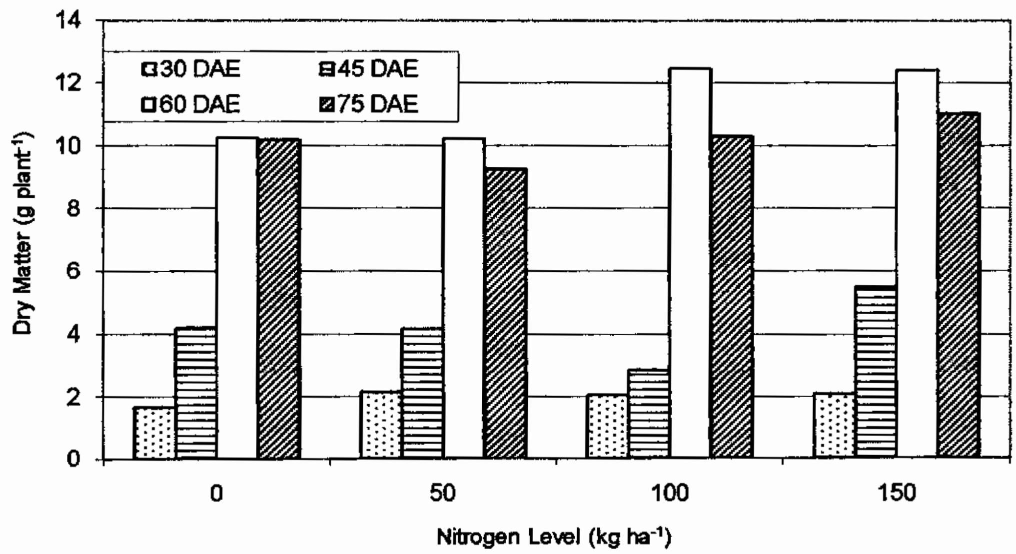

Fig. 2. Dry matter partitioning at different days of sesame under different nitrogen levels

YIELD AND YIELD ATTRIBUTES

Plant height

The average plant height of all treatment ranged from 65.53 to 77.66 cm (Table 7). Among the different level of treatments the highest plant height was observed in T_4 treatment (77.66 cm) followed by T_3 (76.97 cm), T_2 (76.01 cm) and T_1 (65.53 cm), respectively. The plant height increased significantly with the increase in the level of nitrogen (Table 7). The application of 150 kg N ha^{-1} produced the tallest plants while the shortest one was obtained in the control plots (0 kg N ha^{-1}). There is a linear relationship of plant height with increase in N dose. The plant height of T_4 and T_3 were statistically similar as well as plant height of T_2; but T_1 produced statistically shorter plants than T_4, T_3 and T_2 treatments. These results are in agreement with those of Ali *et al.* (1976), Mudhekar and Ahlawal (1981) and Khan and Agarwal (1985).

Dry matter production

The highest TDM was produced under treatment T_4 and the lowest under control (T_1). Among the different level of treatments, T_2 and T_3 produced statistically similar dry matter with that of T_1. It was observed that each successive increase in dose of N up to 150 kg ha^{-1} significantly increased dry matter production (Table 7). Higher dose of nitrogen enhanced the vegetative growth and development of yield attributes as indicated by higher dry matter production and more number of branches and capsules $plant^{-1}$. This observations are in line with Prakasha and Gowda (1992) who reported higher values of yield attributes with 60 kg N ha^{-1} in sesame.

Number of branches per plant

Table 5 shows that T4 produced the highest (4.11 branches $plant^{-1}$) number of primary branches per plant followed by T_1, T_3 and T_2, which was significantly different at

1% level of significance. T_3 and T_1 produced statistically similar number of primary branches per plant and the lowest number of primary branches per plant was produced by T_3. In case of secondary branches, T_4 also produced the highest number (0.9 plant^{-1}) of branches per plant that was significantly different than any other treatment. The lowest secondary branch was produced by T_1 (0.40 branch plant^{-1}). T_1 and T_3 produced statistically similar number of secondary branches per plant. Total branches plant^{-1} ranged from 4.20 to 5.01 (Table 5). The highest number of total branches plant^{-1} was produced by T_4 and was significantly different from those produced by T_1, T_2 and T_3 (Table 5). Numerically T_2 produced the lowest number of branches but was statistically similar to T_1 and T_3. It was observed that plants produced more branches with the increasing rates of nitrogen application. The number of branches of sesame obtained from this experiment was comparable to that reported Taylor and Chambi (1986) from row planting of sesame in Tanzania. In sesame, the number of branches plant^{-1} was found to be important yield contributing character as capsule (fruit) formation occurs at each leaf axile. As such, the number of capsules plant^{-1} was highly related to leaf number and thereby number of branches.

Table 5. Effect of nitrogen on the number of branches plant^{-1} in sesame as affected by different nitrogen levels

Treatment	Number of branches per plant		
	Primary	Secondary	Total
$T_1 = 0$ kg N ha^{-1}	3.80 a b	0.40 c	4.20 b
$T_2 = 50$ kg N ha^{-1}	3.33 c	0.53 b	4.00 b
$T_3 = 100$ kg N ha^{-1}	3.73 b	0.46 b c	4.20 b
$T_4 = 150$ kg N ha^{-1}	4.11 a	0.90 a	5.01 a
CV (%)	4.59	8.63	4.88
Level of significance	0.01	0.01	0.01

Number of capsules per plant

In the main stem, number of capsules/plant at different level of nitrogen application ranged from 13.33 to 19.20 (Table 6). The highest number of capsule plant^{-1} was produced by T_4 treatment followed by T_3, T_2 and T_1 which were statistically different from each other. Number of capsule plant^{-1} in primary branches ranged from 20.60 to 23.61. The highest number of capsule plant^{-1} was produced in control plots which was statistically similar to T_4 treatment but were significantly different from T_3 and T_2 treatment. The lowest number of capsule plant^{-1} was produced by T_2 treatment. Relatively less and a very few number of capsules plant^{-1} was observed in secondary branches that ranged from 0.53 to 1.20. The highest number of capsule was produced by T_2 treatment which was statistically similar to T_4 treatment but significantly different from T_3 and T_1 treatments. The lowest number of capsule was produced by T_3 treatment and was significantly different even from T_1.

The number of total capsules per plant ranged 37.74 to 43.77 (Table 6). The highest number of capsules plant^{-1} was produced by T_4 treatment, which was significantly different than other treatments at 1% level of significance. The lowest number of capsules plant^{-1} was showed by T_1 treatment which was statistically similar to that observed in T_2 treatment. Significantly more capsules were obtained in plants when nitrogen was applied at 150 kg ha^{-1} (Table 6). It was observed that each successive increase in dose of N up to 150 kg ha^{-1} significantly increased total number of capsules plant^{-1}. However, the total number of capsules plant^{-1} obtained from this study was similar to that reported by Sarder and Rosario (1993) from furrow placement at 90 kg N ha^{-1}.

Table 6. Effect of nitrogen on number of capsules/plant bearing on different branch of sesame

Treatment	Number of capsules per plant			
	Main stem	Primary branch	Secondary branch	Total
$T_1 = 0$ kg N ha^{-1}	13.33 d	23.61 a	0.800 b	37.74 c
$T_2 = 50$ kg N ha^{-1}	16.47 c	20.60 c	1.200 a	38.27 c
$T_3 = 100$ kg N ha^{-1}	17.53 b	22.67 b	0.533 c	40.73 b
$T_4 = 150$ kg N ha^{-1}	19.20 a	23.47 a	1.100 a	43.77 a
CV (%)	3.06	1.59	7.70	1.79
Level of significance	0.01	0.01	0.01	0.01

Length and diameter of capsule

Capsule length of the different N treatments ranged from 20.24 to 20.89 mm (Table 7). The highest length was produced by T_4 and the lowest is produced by T_1 treatment. There was no significant variation in respect of capsules length at different level of nitrogen application. Also there was no significant variation among different level of nitrogen application in respect of capsule diameter. Capsule diameter in different treatments ranged from 7.29 to 7.62 mm.

Number of seeds capsule^{-1}

The number of seeds capsule^{-1} was significantly influenced by nitrogen application (Table 7). Number of seed capsule^{-1} ranged from 55.92 to 61.12. The highest number of seed capsule^{-1} was obtained from T_3 treatment (61.12) followed by T_4, T_2 and the lowest number coming from T_1 treatment (55.92). Among the different treatments T_3 and T_4 showed statistically similar results which were different from T_2 and T_1. These results showed that the maximum number of seeds capsule^{-1}were produced in plants when nitrogen was applied at 100 kg ha^{-1}. Absence of nitrogenous fertilizer gave the lowest seed number.

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

Treatment	Plant height (cm)	Dry matter (g plant^{-1})	Branches plant^{-1}	Capsules plant^{-1}	Capsule length (mm)	Capsule diameter (mm)	Seeds/ capsule	Seed weight (g plant^{-1})	1000-seed weight (g)	Seed Yield (kg ha^{-1})	Biologic al yield (kg ha^{-1})	Harves t index
T_1	65.53c	15.88 c	4.20 b	37.74 c	20.24	7.43	55.92 c	6.33 c	2.75	1358 c	8266 a	0.16d
T_2	76.01b	16.85 b	3.86 c	38.27 c	20.37	7.58	58.53 b	7.57 b	2.53	1364 c	6987 c	0.19c
T_3	76.97b	16.31bc	4.20 b	40.73 b	20.62	7.62	61.12 a	7.34 b	2.71	1925 b	7609 b	0.25b
T_4	77.66a	19.07 a	5.01 a	43.77 a	20.89	7.28	60.75 a	8.42 a	2.74	2406 a	8202 a	0.29a
CV (%)	0.86	1.83	4.45	1.79	2.18	3.44	0.47	3.76	4.55	1.62	3.03	3.70
Level of significance	0.01	0.01	0.01	0.01	NS	NS	0.01	0.01	NS	0.01	0.01	0.01

Legend: T_1=0 kg N ha^{-1},
T_2= 50 kg N ha^{-1}
T_3=100 kg N ha^{-1},
T_4=150 kg N ha^{-1}
NS=Not significant,

Seed weight

Nitrogen application had a highly significant effect on total seed weight per plant which ranged from 6.33 to 8.42 g plant^{-1} (Table 7). The highest seed weight came from T_4 treatment (8.42 g) and the lowest from the T_1 treatment (6.33 g). These results showed that there was no significant difference between T_3 and T_2 treatments. The highest seed weight plant^{-1} was obtained in plots when it was fertilized with 150 kg N ha^{-1}. The lowest seed weight plant^{-1} was obtained in plots where nitrogen was not applied.

1000 seed weight

The weight of 1000 seed did not differ significantly due to effect of nitrogen management (Table 7). The highest weight of 1000 seeds (2.75 g) was observed from no nitrogenous fertilizer treated plants and the lowest (2.53 g) was recorded from 50 kg N ha^{-1} treated plants (Table 7). Both seed number and seed weight of sesame were found fairly stable characters and considered as genetically controlled factors (Kumar and Sreedharan, 1987). Seed weight was almost constant though growth and development of sesame was affected by varying levels and placement of N under tillage and minimum tillage soil environment.

Seed yield

Nitrogen application had significant influence on seed yield, which ranged from 1358 to 2406 kg ha^{-1} (Table 8). The highest seed yield was obtained from T_4 treatment and the lowest from where nitrogen was not applied. The result showed that statistically T_1 and T_2 produced similar seed yield which was significantly different from T_3 and T_4 treatment (Table 8). The highest rate of nitrogen application produced significantly higher seed yield that other treatments, which revealed that higher N dose enhanced the vegetative growth and development of yield attributes as indicated by more number of branches and capsule plant^{-1} leads to more yield. These findings are in accordance with those of Subrahmaniyan and Arulmozhi (1999).

Biological yield

Biological yield ranged from 6987 to 8266 kg/ha (Table 8). The highest biological yield obtained from T_1 which was statistically similar to that of T_4. Biological yield of T_2 and T_3 was significantly lower than the other two treatments. Even the yield between T_2 and T_3 was statistically different.

Harvest index

The harvest index was significantly influenced by different levels of N application and ranged from 16.45 to 29.38% (Table 8). The highest was produced by T_4 and the lowest by T_1 treatment. It was observed that as to nitrogen management, a progressive increase in harvest index was found as starting from 0 to 150 kg N ha^{-1}. The findings were similar to that obtained by Sarder and Rosario (1993).

Relationship between seed yield and plants population

Seed yield of sesame had liner relationship (Fig. 3) with the plant population density. Yield of sesame increased with the increase of population density and can be expressed by the following equation:

Seed yield = 183.94 (plants/m^{-2}) – 6636.7 --------- R^2=0.89

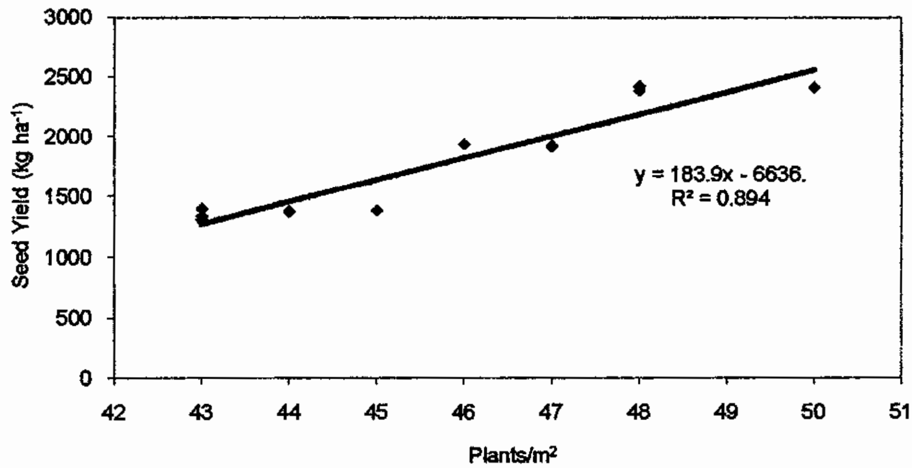

Fig. 3. Relationship between seed yield and plant/m^2 in sesame

Relationship between seed yield and branch per plant

The number of branches/plant influenced the yield of sesame (Figs. 4-6). The number of secondary branches/plant showed more correlation with the yield than the primary branches (Figs. 4 and 5). But strong relations were observed between total branching and yield of sesame (Fig. 6).

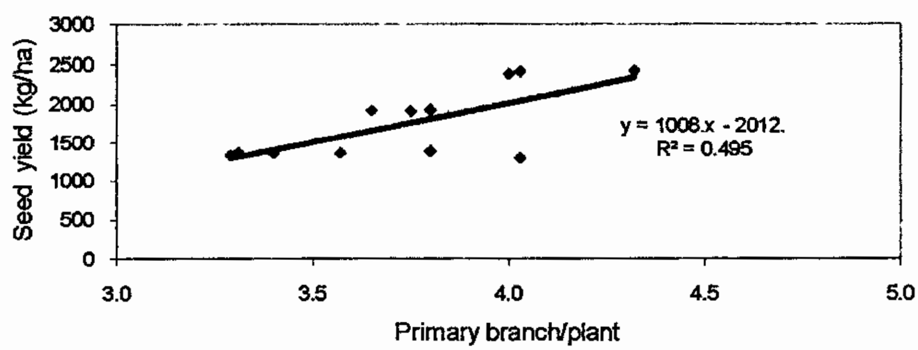

Fig. 4. Relationship between seed yield and primary branch/plant in sesame

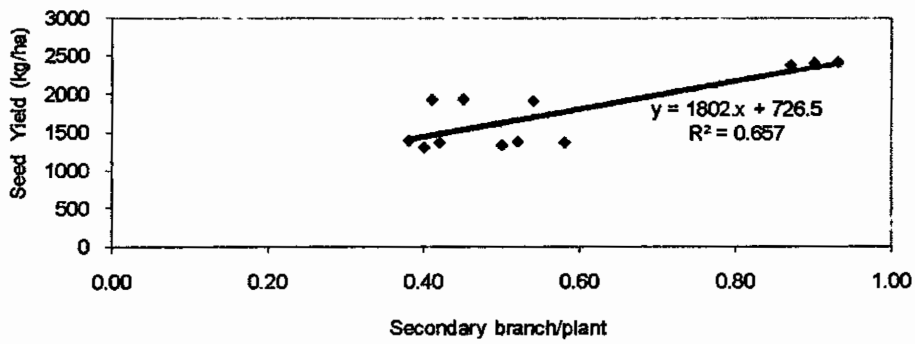

Fig. 5. Relationship between seed yield and secondary branch/plant in sesame

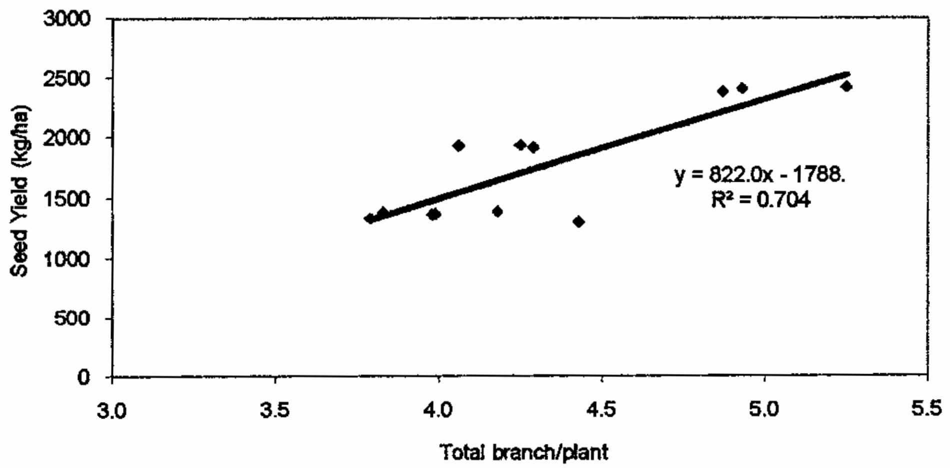

Fig. 6. Relationship between seed yield and total branch/plant of sesame

The relations between the yield of sesame and number of primary, secondary and total branches/plants can be expressed by the following equation:

For Primary Branch: SYPB = 1008.1(PB) – 2012.9 ------- $R^2 = 0.4958$

For Secondary Branch: SYSB = 1802.8(SB) +726.54 ----- $R^2 = 0.6576$

For Total Branch: SYYB = 822.06(TB) – 1788.8 --------- $R^2 = 0.7042$

Where,

SYPB = Seed yield and primary branch/plant (PB).

SYSB = Seed yield and secondary branch/plant (SB).

SYTB=Seed yield and total branch/plant (TB).

Relationship between Seed yield and capsule/plant

Regression analysis indicated that yield of sesame is well correlated with the number of capsules in the main branch (Fig. 7), very weak relations found with the number of capsule produced in the primary whereas negative relationship was noticed with the capsules produced in the secondary branches respectively (Figs. 8 and 9). But when summed, total number of capsules/plant showed very strong relations with the yield of sesame (Fig. 10). The relationship can be expressed by the following equation:

For the main branch: SYMC = 169.74(MBC)—1060.4 ------ $R^2 = 0.7097$
For the primary branch: SYPBC = 153.76(PBC)—1709.5 --- $R^2 = 0.1937$
For the secondary branch: SYSBC = 40.804(SBC) +1800.2 --- $R^2 = 0.0006$
For total branch: SYTC = 172.81(TBC)—5171.6 ----- -------- $R^2 = 0.9375$

Where,

SYMC = Seed yield with capsules in main branches (MBC)
SYPBC = Seed yield with capsules in primary branches (PBC)
SYSBC = Seed yield with capsules in secondary branches (SBC).
SYTC = Seed yield with capsules in total branches (TBC)

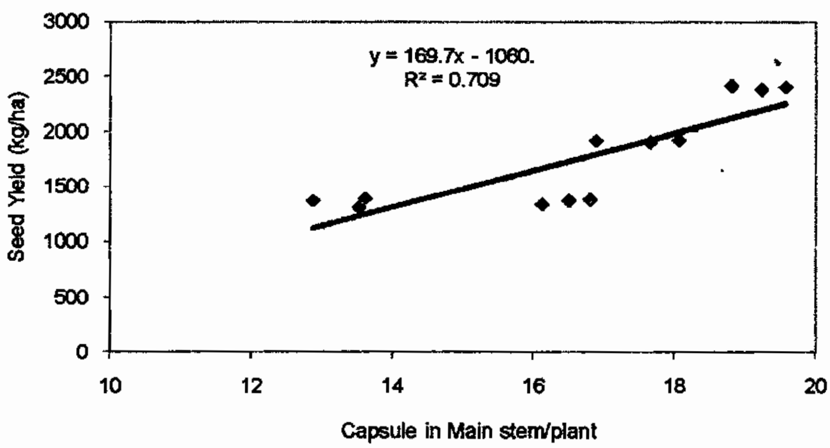

Fig. 7. Relationship between seed yield and capsule in main stem/plant in sesame

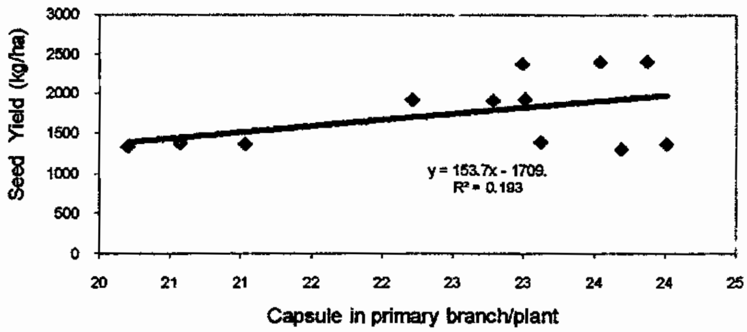

Fig. 8. Relationship between seed yield and capsule in primary branch/plant in sesame

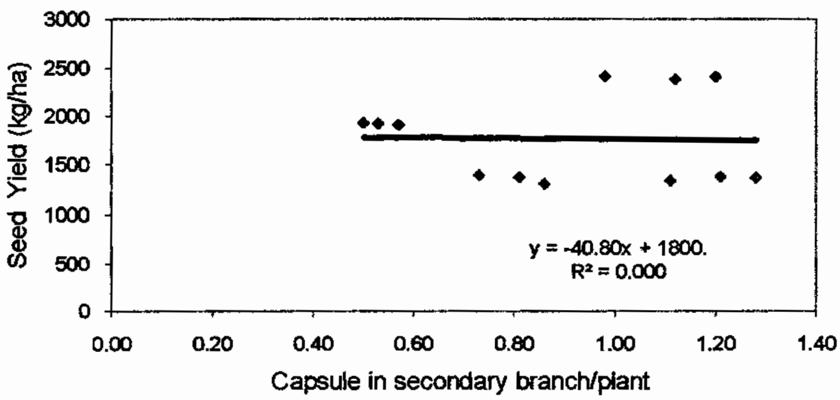

Fig. 9. Relationship between seed yield and capsule in secondary branch/plant in sesame

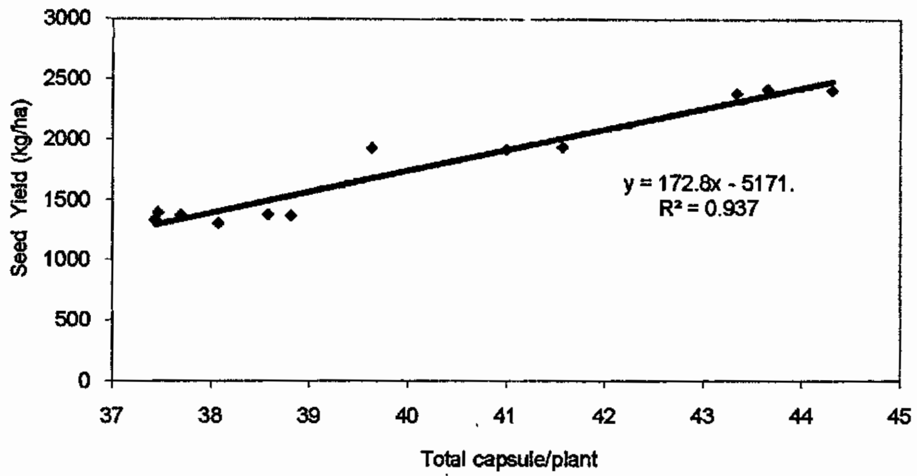

Fig. 10. Relationship between seed yield and total capsule/plant of sesame

Relationship between seed yield and harvest index

Harvest index and seed yield of sesame showed very strong relations and can be expressed by the following equation:

Seed yield = 8305.5(HI)—119.36 ------ $R^2 = 0.9257$

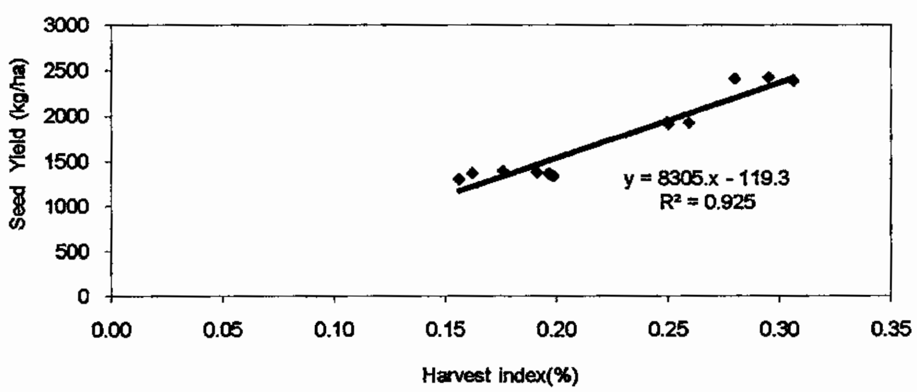

Fig. 11. Relationship between seed yield and harvest index of sesame

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted in Kharif-1 season, 2005 at Kismatfultola village of Batiaghata upazila under Khulna district with a local variety of sesame and four levels of nitrogen (0 kg N ha^{-1}, 50 kg N ha^{-1}, 100 kg N ha^{-1} and 150 kg N ha^{-1}) to find out the effect of nitrogen on the performance of sesame. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Plant height, number of branches $plant^{-1}$, dry matter $plant^{-1}$, number of leaves $plant^{-1}$, number of capsules $plant^{-1}$, length of capsule, number of seeds $capsule^{-1}$, 1000-seed weight, seed yield, biological yield and harvest index were recorded from each replicated plot.

The result showed that plant height, number of branches $plant^{-1}$, dry matter $plant^{-1}$, number of leaves $plant^{-1}$, number of capsules $plant^{-1}$, seed yield, biological yield and harvest index were significantly influenced by N treatments. But length and diameter of capsule, and 1000-seed weight did not influence due to N fertilizers application. Almost all the yield parameters were found maximum in the treatment T_4 where 150 kg N ha^{-1} was applied.

Higher dose of nitrogen enhanced the vegetative growth and development of yield attributes as indicated by higher dry matter (DM) production. There was significant variation in total DM accumulation among the different level of nitrogen treatments. Partitioning of DM showed that the highest DM was produced in stems, followed by leaf and petiole up to 45 DAE. Later on, at 60 DAE and onward, the capsules produced the highest amounts of DM than the stem. A sharp increase in DM production occurred for all treatment up to 60 DAE. DM production increased so rapidly from 45 to 60 DAE that total DM production become tripled within 20 days where after rate of increase was very slow and finally started decline due to leaves and flowers senescence. Total DM production at 75 DAE was lower than that produced at 60 DAE. The plant with the highest N dose has accumulated more DM than with lower dose. Total DM production increased with the increasing rate of nitrogen.

Nitrogen application had significant influence on seed yield. The highest seed yield was obtained from T_4 treatment where 150 kg N ha^{-1} was applied and the lowest from where nitrogen was not applied. The highest rate of nitrogen application produced significantly higher seed yield, which revealed that higher N dose enhanced the vegetative growth and development of yield attributes as indicated by more number of branches and capsule $plant^{-1}$ leads to more yield. Application of 150 kg N ha^{-1} increased seed yield by 77% over the control treatments. It was observed that plant population and main branches had strong relationship with the seed yield of sesame. The highest biological yield was obtained from 0 and 150 kg N ha^{-1} (T_1 and T_4) treatments. Biological yield of T_2 and T_3 was significantly lower than the other two treatments. The harvest index was significantly influenced by N application. The highest harvest index was produced when 150 kg N ha^{-1} was applied and the lowest in no N fertilizer condition. A progressive increase in harvest index was found as starting from 0 to 150 kg N ha^{-1}. Since the yield of sesame increased up to 150 kg N ha^{-1}, further study is needed with higher doses of N fertilizer to determine the optimum N dose for economically higher yield of sesame in coastal saline environments of Khulna area.

CHAPTER VI

REFERENCES

Ali, M. H., M. M. Karim and M. A. Khaleque, 1976. Effect of irrigation and nitrogen on mustard. Bangladesh J. Agric. 1: 5.

Ali, M. A., M. T. Islam and M. T. Islam, 2005. Effect of salinity on some morpho-physiological characters and yield in three sesame cultivars. J. Bangladesh Agril. Univ. 3 (2): 209-214.

Alom M. S., M. Biswas, M. A. Hossain, A. B. M. Salahuddin and S. Hossain, 1999. Response of sesame to varying levels of management practices. Bangladesh J. Agril. Res. 24(2): 335-341.

Amin, M., M. M. Haque, M.A. Akhtaruzzaman, M. Shahjahan and M. N. Anwar, 1996. Effect of N P K and S on sesame under rainfed condition. Bangladesh J. Agril. Res. 21 (2): 306-311.

Anonymous,1998. Daily Janakantha of 23 January 2000, Dhaka, Bangladesh.

Anonymous, 2000. Fertilizer for sesame. The Hindu, Online edition of Indian's National Newspaper, Thursday, 07 September 2000.

Babu, S. and T. Thirumurugan, 2001. Effect of NaCl priming for increased salt tolerance in sesame (*Sesamum indicum* L.). J. Ecobiol. 13 (4): 309-311.

Balasubramaniyan, P., P. Gnanamurthy, and V. Dharmalingam, 1995. Response of irrigated sesame varieties to planting density and nitrogen. Sesamum Newsletter 10: 59-62.

BBS, 2004. Statistical Year Book of Bangladesh. Statistics Division, Ministry of Planning, Government of People's Republic of Bangladesh, Dhaka., Bangladesh, p. 57.

Bhan, S. 1979. Get better returns from sesame. Indian Farming (May). pp. 9-10.

Cobley, L. S. 1967. Fertilizer guide for tropical and sub-tropical farming. Congett and Huber, Zurich, Switzerland. p. 341.

Evans, E. and A. A. Ghobashi, 1983. Effect of leaf removal on the growth of winter oil seed rape (*Brassica napus* L.). P. 104-109. In: Proc. Intl. Rapeseed Conference, Paris, 17-19 May, 1983.

Garcia, R. R. and R. A. Alacantra, 1984. Effect of methods and rates of application of nitrogen fertilizer on *Brassica napus*. Field Crop. Abst. 37(4): 288.

Ghosh, R. K. 2003. Effect of nitrogen on the performance of local rice in coastal saline soil of Khulna region. Postgraduate thesis, Agrotechnology Discipline, Khulna University, Khulna.

Jahan, E. and Sultana, S. 2007. Response of sesame varieties to irrigation. Undergraduate thesis, Agrotechnology Discipline, Khulna University, Khulna.

Jahan, M. S., M. A. Hasan, and A. K. M. N. Islam, 2005. A study on the existing cropping patterns of Batiaghata upazila under Khulna district of Bangladesh. Journal of Subtropical Agricultural Research and Development, 3: 88-92.

Kaul, A. K. and M. L. Das, 1986. Oil Seeds in Bangladesh. BARI and FAO, Gazipur, Bangladesh, pp. 63-77.

Khaleque, M. A. and D. Begum, 1991. Area and production of oilseed crops, 1988-90. In fifteen years of oilseed research and development in Bangladesh. AST/CIDA, BARI, Gazipur, Bangladesh. p. 28.

Kannan, 1992. Studies on nitrogen and weed management in sesame. Unpublished M. Sc.(Ag) Thesis, Annamalai University, Annamalai Nagar, India.

Kolsarici, O and G. Eda 2002. Effects of different row distances and various nitrogen doses on the yield components of a safflower variety. Sesame and Safflower Newsletter No.17.

Krishnakumar, V. and C. Sreedharan, 1987. Evolving a suitable agrotechnique for rice-fallow-seame in sandy solitaries. Indian J. Agric. Res. 21(2): 88-92

Khan, G. M. and S. K. Agarwal, 1985. Influence of sowing method, moisture stress and nitrogen levels on growth components and seed yield of mustard. Indian J. Agril. Sci. 55(5): 324-327.

Mandal, S.S., D. Verma and S. Kuila, 1992. Effect of organic and inorganic sources of nutrients on growth and seed yield of sesame (*Sesamum indicum* L.). Sesame and Safflower Newsletter No. 17(2002).

Martin, J. H. and W. H. Leonard, 1964. Principles of Field Crop Production. Macmillan Co. New York, USA, pp. 1039-1040.

Masefield, G. B. 1965. A Handbook of Tropical Agriculture. Oxford Clarendon Press. p.51.

Matsunaga, R., A. Hamid and A. Hashem, 1989. Dry matter production and yield performance of summer and winter pulses in Bangladesh. J. Fac. Agr. Kyushu Univ., 33(3-4): 221-228.

Mitchell, G. A., F. T. Bingham and D. M. Yermanos 1974. Growth, mineral composition and seed characters of sesame as affected by nitrogen, phosphorus and potassium. Soil Sci. Soc. Am. Proc. 38 (6): 925-931.

Mellory, R. J. 1967. An Introduction to Tropical Cash Crop. Ibadan Univ., Ibadan. Nigeria, p. 71.

Mudhekar, N. I. and I. P. S. Ahlawal, 1981. Response of rape seed to plant density and fertilizer. Indian J. Agron. 26(2): 184-188.

Prakasha, N. D. and S. T. Gowda, 1992. Influence of irrigation, nitrogen and phosphorus level on sesame. Indian J. Agron. 37(2): 387-388.

Prasad, V. V. S., R. K. Pandey and M. C. Saxena 1978. Physiological analysis of yield variation in gram (*Cicer arietinum* L.) genotypes. Indian J. Plant Physio. 21: 228-234.

Pariacha, N.S., N.S. Aulakh, G.S. Bahl and H.S. Baddesha. 1988. Fertilizer use research in oilseed crops. Fertilizer News. 33: 15-22.

Rahman, M. M., M. M. Rahman and M. S. Alam 1998. Response of groundnut to phosphorus and boron nutrition. Bangladesh J. Agril. Res. 23 (2): 237-245.

Rahman, M.M., T. S. Hossen, A. A. A. Muhsi, M. A. Quadir, and J. Haider, 1995. Seasonal variations in some physiological characters of sesame (*Sesamum indicum* L.). Bangladesh Journal of Botany, 24: 47-51.

Rajput, R. I., O. P. Verma and D. S. Gautam 1992. Relative performance of safflower (*Carthamus tinctorius* L.) varieties with different levels of nitrogen under rainfed condition. Indian J. Agron. 37(2): 290-292.

Rahman, A. F. M. H. 1976. Effect of fertilization on some oilseeds and pulses. Proc. of the First National Workshop on Oilseeds and Pulses. BARC, Dhaka, Bangladesh, pp. 200-208

Subrahmaniyan, K. and N. Arulmozhi 1999. Response of sesame to plant population and nitrogen under irrigated condition. Indian J. Agron. 44(2): 413-415.

Sarder, N. A. and E. L. Rosario, 1993. Effect of tillage methods and N-management on the establishment of sesame grown after wet land rice. Bangladesh. J. Agril. Res. 18 (2): 172-179.

Sarder, N. A. and E. L. Rosario, 1995. Some growth parameters of sesame as affected by tillage methods and nitrogen management after wetland rice. Bangladesh J. Agril. Res. 20 (1): 11-17.

Sarker M. A. R., M. R. Ahsan, A. U. Sarker and S. M. A. Hossain, 1989. Effect of nitrogen and irrigation at different growth stages on mustard. Bangladesh J. Agril. Sci. 16 (2): 283-288

Sharma, V. D. and B. S. Verma, 1982. Effect of nitrogen, phosphorus and row spacing on yield, yield attributes and oil content of safflower under rainfed condition. Indian J. Agron. 27(1): 28-33.

Singh, B. P. and T. P. Yadava, 1972. Effect of plant population and fertilizer variation on yield and yield attributes of Indian rape (*Brassica campestris*). Indian J. Agril. Sci. 42(7): 596-600.

Singaravel, R., V. Imayavaramban, K. Thanunathan and V. Shanmughapriya, 2002. Effect of micronutrients on yield and nutrient uptake of sesame (*Sesamum indicum* L.) in a vertisol soil. Sesame and Safflower Newsletter No. 17 (2002).

Sen, H., P.K. Java and S.K. Das, 1977. Response of mustard variety varuna (*Brassica juncea*) to high doses of nitrogen. Indian Agriculturist 19 (4): 347-350.

Singh, M. and R. C. Tiwari, 1985. Response of oilseed and pulse crops to fertilizers in dry land agriculture. Proc. FAI-NRC Seminar, Varanasi, India, pp.147-159

Sharma, R. L. and B. P. S. Chohan, 1983. Heterosis and inbreeding depression in sesame. Madras Agric. J. 70(9): 561-566.

Singh, P. P. and V. P. Nema, 1979. Effect of seed rates, row spacing and fertilizer levels on the yield of sesame. Indian J. Agron. 17(4): 366-367.

Tribe, A. J. 1967. Sesame (A review article). Field Crop Abst. 20(3): 189-193.

Taylor, B. R. and J. Y. Chambi, 1986. Sesame agronomy in south-east Tanzania. I: Plant population and sowing methods. Experimental Agric. 22: 243-251.

Tanaka, A. 1980. Physiological examination of very high yielding rice crops. Research issues for ultra-high yielding rice crops. Secretariat of Research Council of Agriculture, Forestry and Fisheries (Mimeo). P. 64-74.

Taylor. B., R. D. Lamboll and E. Kafirul, 1986. Sesame agronomy in south-east Tanzania. III: The effect of nitrogen and phosphorus on seed yield and oil content. Experimental Agric. 22: 263-268

Tsiung, T. N. 1978. Responses of mungbean to sowing date in Sarawak. Proceedings of the international mungbean symposium, Univ. of the Philippines, Los Banos, Philippines, pp. 101-106.

Vir, P. and B. S. Verma, 1981. Effect of nitrogen, phosphorus and row spacing on yield, yield attributes and oil contents of rainfed mustard. Indian J. Agron. 26(1): 37-41.

Weiss, E.A. 1983. Oilseed Crops. Longman Group Limited. New York. p. 402.

Wahhab, M. A., M. R. I. Mondal, M. A. Akbar, M. S. Alam, M. Ahmed, and E. Begum 2002. Status of oil crop production in Bangladesh. Oilseed Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh, p 85.

Appendix 1. Weather data of the experimental site from January to June, 2005

Month	Precipitation (mm)	Daily Average Temperature (°C)		Daily Sunshine (hours)
		Maximum	Minimum	
January	015	25.2	13.5	7.23
February	000	30.0	17.3	8.73
March	148	32.6	22.1	7.83
April	047	34.9	25.2	9.53
May	215	35.1	25.3	8.73
June	103	34.9	27.3	4.83

Source: Bangladesh Meteorological Station, Gollamari, Khulna