GROWTH AND YIELD RESPONSE OF SESAME TO THE NITROGEN LEVELS AND SPACING

BY

RIFAT TANJILA

REGISTRATION No. : 00952

A thesis

Submitted to the Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka-1207

In partial fulfill of the requirements

For the degree of

MASTERS OF SCIENCE

IN

AGRONOMY

SEMISTER: JANUARY-JUNE. 2008

Approved by:

....	....
Prof. Dr. Md. Fazlul Karim	**Prof. Md. Sadrul Anam Sardar**
Supervisor	**Co-supervisor**

....

Prof. Dr. Md. Jafar Ullah
Chairman
Examination Committee

CERTIFICATE

This is to certify that thesis entitled, **"Growth and Yield Response of Sesame to the Nitrogen Levels and Spacing"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfill of the requirements for the degree of **MASTERS OF SCIENCE IN AGRONOMY,** embodies the result of a piece of bona fide research work carried out by **Rifat Tanjila, Registration No. 00952** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 26/6/08
Place: Dhaka, Bangladesh

Prof. Dr. Md. Fazlul Karim
Supervisor

ACKNOWLEDGEMENTS

All praises due to Almighty Allah who enables the author to complete the study and submit this thesis. It is a matter of dignity and pride of the authoress to express heartiest gratitude and profound respect to her honorable teacher and research supervisor Prof. Dr. Md. Fazlul Karim, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his constant supervision, invaluable suggestion, scholastic guidance, constructive comments and encouragement during the research work and preparation of manuscript of the thesis.

The author expresses her deepest and endless gratitude to her co-supervisor Prof. Md. Sadrul Anam Sardar, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his sacrifices, help, and inspiration, encouragement in various ways during the study and preparation of manuscript of the thesis.

The author wishes to express her deepest gratitude, profound appreciation and immense indebtedness to the Departmental Chairman Prof. Dr. Md. Jafar Ullah, along with all the teachers and staff of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for the valuable teaching, sympathetic co-operation and inspiration throughout the course of this study and research work.

The author also expresses her thanks to Mr. Mirza Hasnuzzaman, Lecturer, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his sacrifice, help and encouragement in various ways during the study.

Heartiest thanks and gratitude are due to Farm Division of Sher-e-Bangla Agricultural University for their support to conduct the research.

The author would like to express cordial thanks to her husband, Sabbir Ahmed for his keen help as well as heartiest co-operation and encouragement.

The author expresses her sincere gratitude to her parents for their sacrifice, encouragement and good wishes which can never be forgotten.

May Allah bless and protect them all.

ABSTRACT

An experiment was conducted at the Agronomy Field, Sher-e-Bangla Agricultural University Dhaka during the period from April to June 2007. The experiment was designed to study the effect of different nitrogen level and spacing on growth and yield of sesame. The experiment consisted of four nitrogen levels viz. N_0 = 0, N_1 = 30, N_2 = 60 and N_3 = 90 kg ha^{-1} and four levels of spacing viz. S_1 = 30 cm x 5 cm; S_2 = 30 cm x 10 cm; S_3 = 40 cm x 5 cm and S_4 = 40 cm x 10 cm. The experiment was laid out in a split plot design with three replications. Sesame variety T-6 was used in the experiment. The result showed that nitrogen and spacing had significant influence on crop characters viz, plant height, number of leaves $plant^{-1}$, above ground dry weight, number of branches $plant^{-1}$, number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, 1000-seed weight, seed yield, stover yield, biological yield and harvest index. The highest seed yield (1102.00 kg ha^{-1}) was recoded from 30 kg N ha^{-1} and the yield decreased with further increase in nitrogen rates. Plant spacing of 30 cm x 10 cm (333333 plants ha^{-1}) influenced plants to have maximum seed yield (1010.00 kg ha^{-1}). Population either lower or greater then 333333 plants ha^{-1} gave lower yield. Optimum population for 30 cm x 10 cm nourished with 30 kg N ha^{-1} registered maximum seed yield (1405.00 kg ha^{-1}). It was evident that higher seed yield was obtained due to aggregation of yield components like capsules $plant^{-1}$, seeds $capsule^{-1}$and 1000-seed weight which farther justified with the increased value of harvest index.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICS

ACRONYMS

%	=	Percent
0C	=	Degree Celsius
AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
CEC	=	Cation Exchange Capacity
cm	=	centi-meter
CV%	=	Percentage of Co-efficient of variance
cv	=	Cultivar (s)
DAS	=	Days After Sowing
et al.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	gram (s)
HI	=	Harvest Index
hr	=	hour (s)
K_2O	=	Potassium oxide
kg	=	kilogram (s)
kg ha^{-1}	=	kilogram per hectare
m^2	=	meter square
N	=	Nitrogen
S	=	Spacing
NS	=	non Significant
P	=	phosphorus
P_2O_5	=	Phosphorus Penta Oxide
K	=	potassium
ppm	=	parts per million
RDA	=	Recommended Dietary Allowance
SA	=	Surface Area
SAU	=	Sher-e-Bangla Agricultural University
Var.	=	Variety

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Sesame (*Sesamum indicum* L.) is the most ancient oilseed crop and regarded as queen of oilseed by users because of the quality (fatty acid composition) of its oil and for its resistance to oxidation and rancidity even when stored at ambient air temperature. It ranks 4^{th} among the oil crops in the world. The world production of sesame is 2.9 million mt (FAO, 2003). The leading sesame producing countries are India, Egypt, Pakistan, USA, China, Sudan, Nigeria, Uganda, Chad, Morocco and Bangladesh. Sesame is the 2^{nd} important oil crop in Bangladesh in terms of area and production among the oil crops. The total area under sesame cultivation is 96 thousand acre and production is 37 thousand mt (BBS, 2007). It grows in both rabi and kharif-1 seasons but only kharf-1 covers about three-fourths of the total sesame area. Faridpur, Khulna, Pabna, Barisal Comilla, Rajshahi, Jessore, Feni, Rangpur, Sylhet and Mymensingh are the leading sesame producing areas of Bangladesh (BARI, 1999).

The seed contains all essential amino acids and fatty acids. Sesame is rich in oil (42-48%), protein (14-20%) and carbohydrate (20%) (BARI, 1994). The oil of sesame is mostly used for edible purpose due to its superior quality because it contains less amount of eurocic acid and high amount of linoleic acid which is beneficial for human health. Sesame oil is mainly used as cooking oil, particularly in south India. Sesame oil is also used as hair-oil in Bangladesh. It also meets the other purposes such as margarine manufacture, lubricant for vehicle, disposing agent with insecticide, soap, paint, perfumery industry and in pharmaceuticals as an ingredient of drugs. It is a good catch crop and can be grown as pure or mixed crop.

The oil cake is used as a valuable and nutritious feed for cattle, as it contains high amount of good quality protein. Sesame seed meal 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 6.2-6.3% N, 2.O-2.1% P_2O_5 and 1.1-1.3% K_2O (Chatterjee and Mondal, 1983). The cake is also used as manure (Coblev, 1967). Fried seed of sesame mixed with sugar or in the form of sweetmeat tiler khaja is a tasty food. The use of the seed for decoration on the surface of breads, biscuits and cookies is most popular to the people.

Bangladesh is not self-sufficient in edible oil and industrial oil and as a result huge amount of foreign currency is being drained every year for importing oil of both the categories. Bangladesh imported 376 thousand mt of oil from other countries costing an amount of Tk. 457 crores in 2002- 2003 (BBS, 2004). The acute shortage of edible oil in the country is increasing every year due to rapid growth of population. This condition will continue until its production is maximized in the country. Sesame an important oil crop in Bangladesh can play a vital role to fulfill the local demand of edible and industrial oil. There is a high prospect of sesame cultivation in Bangladesh.

Yield of sesame is very low in Bangladesh in comparison to other countries. The lower yield of sesame may be due to cultivation of low yielding varieties, improper management and traditional cultural practices. For successful production, balanced fertilization, weed control, irrigation and drainage, proper use of seed rate and method of sowing are indispensable.

The average yield in Bangladesh is 550 kg per hectare. Under improved management with optimum fertilization and spacing, per hectare yield may raise up to 1000 to 1200 kg. Kathiresan (2002) found that higher dose of nutrient significantly increase seed yield (1522 kg ha^{-1}). Nitrogen and spacing are two key factors known to influence the plant growth and seed yield of oil crop. Nitrogen is one of the important nutrient minerals that accelerate the growth of plant. It is also an important constituent of chlorophyll and takes part in protein synthesis. So nitrogen is essential for growth and development of living tissues and thereby enhances the plant growth, seed yield and oil content and protein content of oil seed. Mondol *et al.*, (1997) observed that plant height, dry matter accumulation, number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, 1000-seed weight, seed yield and protein yields were increased significantly with increasing nitrogen rates but harvest index and oil content were not significantly affected. But it is unfortunate that nitrogen content of Bangladesh soil is very low.

Spacing is an important factor that has profound effect on plant growth, yield and oil content of sesame. Narain and Srivestava (1962) found that the highest sesame seed tended to result from spacing of 15cm x 30cm. In broad sense, the functions of nitrogen and spacing are similar and they are synergistic. Maintain of proper spacing is essential for nutrient uptake, low weed infestation and it also reduces plant to plant competition for nutrient uptake, light interception etc.

Neither high yielding varieties nor nitrogen and proper spacing alone can improve the yield of sesame, but their appropriate combination can increase the yield to a desirable extent. As variety, nitrogen and proper spacing have significant role in increasing yield, oil content of sesame, conducting research in these lines are important for increasing yield of this crop. A study was, therefore, undertaken with the following objectives:

1. To assess the effect of nitrogen level on the growth and yield of sesame.

2. To determine the effect of spacing on the growth and yield of sesame.

3. To evaluate the combined effect of nitrogen level and spacing on the growth and yield of sesame.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

Seed yield, oil and protein content of sesame are greatly influenced by environmental factors like temperature, rainfall and humidity variety used and agronomic practices like fertilization, irrigation, seed rate, sowing time and spacing. Among the factors, nitrogen and spacing are important for the production of sesame. Many works on different aspects of sesame cultivation have been done for the improvement of yield of sesame. Research works related to the growth and yield response of sesame to the application of nitrogen level and spacing have been reviewed in this chapter.

2.1 Effect of nitrogen fertilizer

2.1.1 Plant height

Mondol *et al.*, (1997) conducted field trials at Kalyani, West Bengal with five levels of nitrogen (0, 30, 60, 90 or 120 kg ha^{-1}) on sesame and observed that plant height was increased significantly with increasing nitrogen rates.

Tiwari *et al.*,(2000) in a field experiment, nitrogen (15, 30 and 60 kg ha^{-1}) and sulphur (0, 15 and 30 kg ha^{-1}) were applied to sesame varieties (TKG21, FKG22 and Rs226) in Madhya Pradesh, India to investigate optimum dose of nitrogen and sulphur. They found that significant improvement in plant height was observed for nitrogen at 60 kg ha^{-1} compared with 15 kg ha^{-1}. Plant was statistically highest in cv. TKG 21 grown with 60 kg N ha^{-1} and 30 kg S ha^{-1}. Seed oil decreased and seed protein content increased significantly with increasing nitrogen, while sulphur application enhanced both seed oil and seed protein.

Patra (2001) in field trials in sesame cv. Kalika, used four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) in Chiplima, Orissa, India. He reported that plant height significantly increased with increasing nitrogen rate up to 60 kg ha^{-1}. Nitrogen uptake increased with increasing rates of nitrogen up to 90 kg ha^{-1} but oil yield increased with increasing nitrogen rate up to 60 kg ha^{-1}.

2.1.2 Number of branches

Subrahmaniyan and Arulmozhi (1999) conducted a field experiment at Vridhachalam, Tamil Nadu with sesame cv. VS 9104 and VRI 1. They apply nitrogen (0, 35, 45 or 55 kg ha^{-1}) and found that VS 9104 had a higher number of branches over VRI 1.

Patra (2001) conducted an experiment in sesame cv. Kalika, used four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) in Chiplima, Orissa, India. He reported that number of branches $plant^{-1}$ significantly increased with increasing nitrogen rate up to 60 kg ha^{-1}. Nitrogen uptake increased with increasing rates of nitrogen up to 90 kg ha^{-1} but oil yield increased with increasing nitrogen rate up to 60 kg ha^{-1}.

Pathak *et al.,* (2002) carried out an experiment and observed the effect of nitrogen level (0, 15, 30 and 45 kg ha^{-1}) on the growth and yield of sesame (*S. indicum*). They found that application of nitrogen at 45 kg ha^{-1} produced the highest number of branches $plant^{-1}$.

Kathiresan (2002) carried out an experiment to study the response of 2 cultivars (TMV-3 and TMV-4) of sesame (*S. indicum*) with different fertilizer levels (control, 100% recommended NPK of 35, 23 and 23 kg ha^{-1} and 150% recommended NPK of 52, 35 and 35 kg ha^{-1}) on a sandy-loam soil. Between the varieties TMV-4 produced significantly higher number of branches $plant^{-1}$, oil content and protein content.

2.1.3 Total dry matter production

Mitra and Pal (1999) in a field experiment in West Bengal India, observed that dry matter production plant^{-1} of sesame was significantly increased up to 100 kg N ha^{-1}. Further increase in nitrogen level decreased yield contributing characters. For seed yield, the response to apply nitrogen was shown to be quadratic in nature and maximum response (0.90 seed kg^{-1} N) was observed at 100 kg N ha^{-1}.

Subrahmaniyan and Arulmozhi (1999) conducted a field experiment at Vridhachalam, Tamil Nadu with sesame cv. VS 9104 and VRI 1. They apply nitrogen (0, 35, 45 or 55 kg ha^{-1}) and found that VS 9104 had dry matter production plant over VRI 1.

Singaravel and Govindasamy (1998) stated that cv. TMV-4 of sesame yielded greatest dry matter with application of 35 kg N + 20 kg humic acid ha^{-1}.

Mondol *et al.*, (1997) carried out a field experiment at Kalyani, West Bengal with five levels of nitrogen (0, 30, 60, 90 or 120 kg ha^{-1}) on sesame and observed that plant height, dry matter accumulation was increased significantly with increasing nitrogen rates but harvest index and oil content were not significantly affected.

2.2. Yield components

2.2.1 Number of capsule

Paul and Savitheri (2003) undertaken a study to evaluate the possibility of using biofertilizer either alone or as supplements to chemical fertilizers for sesame cv. Thilak grown in summer rice-fallow in Mannuth, Kerala, India, during January, April 1995. The treatments included the recommended dose of inorganic nitrogen at 30 kg ha^{-1} alone, inoculation of Agospirillum, Azotobacter each at 600 g ha^{-1} along with 25% or 50% nitrogen, either with or without time at 600 kg ha^{-1} and control. The better vegetative growth of plants in plots applied 30 kg N ha^{-1} alone resulted in a larger photosynthetic area and thereby highest number of capsules per plant

Sarala *et al.*, (2002) determine the effects of nitrogen on the yield and yield components of sesame varieties under dry land, condition. The number of capsules $plant^{-1}$ was highest in cv. Madhavi and VRI-I. Nitrogen at 60 kg ha^{-1} recorded more number of capsules which was at par with 45 kg N ha^{-1} + *Azospirillium* treatment (3 kg ha^{-1}).

Pathak *et al.*, (2002) in a field experiment observed the effect of nitrogen level (0, 15, 30 and 45 kg ha^{-1}) on the growth and yield of sesame (S. indicum). They found that application of nitrogen at 45 kg ha^{-1} produced the highest number of capsules $plant^{-1.}$

Sharma (1994) carried out a field experiment in the rainy season of 1985-86 at Diphu, Assam; sesame cv. TC.25, Madhavi and Gouri were given 0, 15. 30 or 45 kg N ha^{-1} and found that yield contributing characters were influenced with the application of nitrogen fertilizer.

Mondol *et al.,* (1997) in a field experiment observed at Kalyani, West Bengal with five levels of nitrogen (0, 30, 60, 90 or 120 kg ha^{-1}) on sesame and observed that, number of capsules $plant^{-1}$ was increased significantly with increasing nitrogen rates but harvest index and oil content were not significantly affected.

Patra (2001) carried out in field trials in sesame cv. Kalika, used four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) in Chiplima, Orissa, India. He reported that, capsules $plant^{-1}$ was significantly increased with increasing nitrogen rate up to 60 kg ha^{-1}.

Sarala *et al.,* (2002) determine the effects of nitrogen on the yield and yield components of sesame varieties under dry land condition. The number of capsules $plant^{-1}$ was highest in cv. Madhavi and VRI-l. Nitrogen at 60 kg ha^{-1} recorded more number of capsules which was at par with 45 kg N ha^{-1} + *Azospirillium* treatment (3 kg ha^{-1}).

2.2.2 Number of seeds per capsules

Mondol *et al.,* (1997) conducted field trials at Kalyani, West Bengal with five levels of nitrogen (0, 30, 60, 90 or 120 kg ha^{-1}) on sesame and observed that number of seeds $capsule^{-1}$ was increased significantly with increasing nitrogen rates.

Patra (2001) conducted a field experiment in sesame cv. Kalika, used four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) in Chiplima, Orissa, India. He reported that, number of seeds $capsule^{-1}$ was significantly increased with increasing nitrogen rate up to 60 kg ha^{-1}.

Mitra and Pal (1999) carried out in a field experiment in West Bengal, India, observed that number of seeds $capsul^{-1}$ was significantly increased up to 100 kg N ha^{-1}. Further increased in nitrogen rates then decreased the seed yield and yield contributing characters.

Sarala *et al.,* (2002) exposed the effects of nitrogen on the yield and yield components of sesame varieties under dry land condition. The number of seed capsule^{-1} was highest in cv. Madhavi and VRI-1. Nitrogen at 60 kg ha^{-1} recorded more number of seeds per capsule which was at per with 45 kg N ha^{-1} + *Azospirillium* treatment (3 kg ha^{-1}).

2.2.3 1000-seed weight

Subrahmaniyan and Arulmozhi (1999) conducted a field experiment at Vridhachalam, Tamil Nadu with sesame cv. VS 9104 and VRI 1. They apply nitrogen (0, 35, 45 or 55 kg ha^{-1}) and found that VS 9104 had higher a 1000-seed weight over VRI 1. Yield component values increased with increasing nitrogen rate in case of both varieties.

Mondol *et al.,* (1997) determined an experiment at Kalyani, West Bengal with five levels of nitrogen (0, 30, 60, 90 or 120 kg ha^{-1}) on sesame and observed that 1000-seed weight was increased significantly with increasing nitrogen rates. Om *et al.,* (2001) stated that application of 90 kg N ha^{-1} yielded maximum 1000-seed weight.

Pathak *et al.,* (2002) conducted a field experiment observed the effect of nitrogen level (0, 15, 30 and 45 kg ha^{-1}) on the growth and yield of sesame (*S. indicum*). They found that application of nitrogen at 45 kg ha^{-1} produced the highest 1000-grain weight.

Mondol *et al.,* (1997) in a field trial observed that 1000- seed weight was increased with increasing nitrogen rate up to 120 kg ha^{-1}.

2.2.4 Seed yield

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 as 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 (35 kg ha^{-1}). They found that, seed yield of sesame was highest in case of 60 kg N ha^{-1} (100% of recommended dose).

Kathiresan (2002) carried out an experiment to study the response of 2 cultivars (TMV-3 and TMV-4) of sesame (*S. indicum*) of different fertilizer levels (control, 100% recommended NPK of 35: 23: 23 kg ha^{-1} and 150% recommended NPK of 52:35:35 kg ha^{-1} on a sandy-loam soil. He found that higher dose of nutrient significantly increase seed yield (1522 kg ha^{-1}) during summer than the lower nutrient level. Between the varies TMV-4 produced significantly higher plant height, capsule bearing length, number of branches $plant^{-1}$, capsule length, seed $capsule^{-1}$, seed yield, oil content and protein content.

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

Kadam (1989) stated that application of nitrogen (0, 25, or kg N ha^{-1}) to sesame cultivars increased seed yield with increasing nitrogen rates up-to highest level while seed oil content decreased.

Gnanamurthy *et al.*, (1992) observed in a field trial in the kharif season in Vriddhachalam, India that seed yield increased with application of nitrogen up to 20 kg ha^{-1}.

Prakasha and Thimmegowda (1992) stated that seed yield of sesame cv. Kanakapura local grown on sandy loam soil increased with increasing nitrogen rate from 0 to 61 kg N ha^{-1}. It was also observed that high dose of nitrogen increased the susceptibility of sesame plant to water stagnant.

Shrivastava and Tripathi (1992) in a field trial at Raipur, Madya Pradesh, India observed that nitrogen rates (30, 60 or 90 kg ha^{-1}) increased the seed yield from 0.87 t ha^{-1} with 30 kg N ha^{-1} to 1.27 t ha^{-1} with 90 kg N ha^{-1}.

Dwivedi and Namdeo (1992) observed in a field experiment in the monsoon seasons o f 1987-89 on clay loam soil at Madhya Pradesh, India; seed yield of sesame cv. JT7 increased with up to 30 kg N and bellow or above this rate seed yield and economic returns decreased.

Seed oil and protein yields of sesame increased significantly with application of nitrogen and P_2O_5 (Thakur *et al.*, 1998). They applied 30, 45 or 60 kg nitrogen and 20, 30 or 40 kg P_2O_5 ha^{-1} and found that 45 kg N ha^{-1} and 30 kg P ha^{-1} is suitable for optimum yield.

2.3 Effect of spacing

The experiment on effect of spacing on sesame was scanty in Bangladesh. However, some review available in others countries here.

2.3.1 Plant height

Mazzani *et al.*, (1956) conducted an experiment with the branched sesame varieties, Inamar and Morada. These varieties were grown at 9 consisting varying from 36,630 to 200,000 plants ha^{-1}. It was found that closest spacing gave the height plant height. Spacing had significant effect plant height.

2.3.2 1000-seed weight

Ahuja *et al.*, (1971) found that, 1000- seed weight and content of oil and linoleic acid increased and protein and oleic acid contents decreased with increase in spacing.

2.3.3 Seed yield

Menon (1967) found that the highest sesame seed yields of 194.31 kg/ha were obtained from a spacing of 15 cm X 15 cm, followed by the yield of 180.56 kg/ha from a spacing of 15 cm X 22.5 cm; the lowest yield of 97.15 kg ha^{-1} was obtained from the widest spacing of 30cm X 30cm. The plant populations were 500000, 333333 and 111111 plants ha^{-1}, respectively.

Narain and Srivestava (1962) conducted an experiment to compare between row spacing of 30, 45 and 60 cm they found that the highest sesame seed yield obtained from the spacing of 15cm x 30cm or 30c m x 30 cm.

Olive and Cano (1958) conducted trails with the sesame varieties e.g. Venezuela 51, which had one central stem only, Venezuela 51 with few branches and Criolle with many branches. The row widths tested were 30, 60, and 90 cm; the spacing between hills was 10, 20 and 30 cm; and the number of plant per hill was 1, 2 and 3. The spacing of 30 cm x 10 cm gave the highest yields. Highly significant difference in yield was obtained according to varieties. The different spacing between hills and the different number of plants per hill gave similar yields.

Mcllroy (1967) and Masefield (1965) stated that between row spacings for sesame should be 22.5 cm to 30 cm and 35 cm respectively and 30 cm spacing between rows gave the height yield.

Martin (1964) and Collister (1965) recommended that sesame should be sown within the row spacings of 5 to 10 cm and 2.5 cm respectively and they observed that 10 cm spacing between row to row achieved height yields.

Department of agriculture, Nyasaland protectorate (1961) obtained sesame yield of 112 kg ha^{-1} when sown in 2 drills on ridges 90 cm apart.

It was observed from the report Irish Republic, Peru (1976) that, in trails with 23 sesame cultivars, the result showed that the row spacing of 100, 85 and 70 cm gave the height yield of 960, 1420 and 1800 kg ha^{-1} respectively.

On the basis of findings presented in this review of literature, it is clear that plant growth and seed yield of sesame can be greatly influenced by different level of nitrogen fertilizer and spacing.

Chapter 3

Materials and methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was carried out during the period from April to June 2007 at the Agronomy Field, Sher-e-Bangla Agricultural University Dhaka. The experiment was designed to study the effect of sesame under different nitrogen level and spacing.

3.1 Description o f the experimental site

3.1.1 Site

The experimental field was located at 90° 33' E longitude and 23° 71' N latitude at a height of 9m above the sea level. The land was medium high.

3.1.2 Climate

The climate of the experimental field was sub-tropical and was characterized by high temperature and heavy rainfall during kharif season (April -September) and scanty rainfall during rabi season (October-March) associated with moderately low temperature.

3.1.3 Soil

The land belongs to the Agro-ecological zone of "Madhupur Tract" (AEZ 28) of nodal soil series. The soil was sandy clay in texture and having soil pH varied from 5.55. The soil contains 36.9% sand, 26.04% silt and 36.66% clay. Organic matter content was very low (0.82%). and the physical and chemical properties of the experimental plot have been presented in Appendix I.

3.2 Plant materials

Sesame is a broad-leaved annual oilseed crop. It is herbaceous growing to a height of 0.5 to 2.0 meters with tap root system. The stem is erect, normally square in section. Stem color ranges from light green to almost purple, but the most common is darkish green, covered with short hairs. Leaves are green, broad, opposite, alternate or mixed. The inflorescence is raceme, flowers are two lipped with white color tubular corolla. Fruits are capsule, dehiscent. Seeds are oval shaped, black and sometimes creamy white. The variety T-6 used in the experiment as test crop.

3.3 Treatment

The experiment consisted of the following treatments -

Factor A: Nitrogen level

N_0 = No nitrogen
N_1 = 30 kg N ha^{-1}
N_2 = 60 kg N ha^{-1}
N_3 = 90 kg N ha^{-1}

Factor B: Spacing

S_1 = 30 cm x 5 cm
S_2 = 30 cm x 10 cm
S_3 = 40 cm x 5 cm
S_4 = 40 cm x 10 cm

3.4 Treatment combinations

The treatment combinations were as follows -

N_0S_1, N_0S_2, N_0S_3, N_0S_4; N_1S_1, N_1S_2, N_1S_3, N_1S_4; N_2S_1, N_2S_2, N_2S_3, N_2S_4; N_3S_1, N_3S_2, N_3S_3, N_3S_4

3.5 Experimental design and layout

The experiment was conducted in split plot design with 3 replications. The nitrogen level was placed in main plot and spacing in sub plot. The size of each plot is 4.5 m x 3.0 m. The spaces between blocks and between plots were 1.5m and 0.75m, respectively. The total number of plots was 48.

3.6 Collection of seeds

The seeds of cultiver T-6 were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.7 Land preparation

Ploughing and cross ploughing were done with country plough followed by laddering to obtain the desirable tilth. The land was prepared by removing weeds, stubble and crop residues and trimming ails. The layout was done as per experimental design. Each plot was fertilized with urea, triple super phosphate and muriate of potash.

3.8 Methods of fertilizer application

All the fertilizers except urea were applied during final land preparation. Urea was applied in two equal splits; first half was applied as basal dose and second half was applied after 30 days of sowing following nitrogen levels.

3.9 Fertilizer dose

The experimental plots were fertilized with triple super phosphate and muriate of potash at the rate of 120 and 50 kg ha^{-1}, respectively (BARI, 2006). Urea was applied as the sources of nitrogen, as per experimental treatment.

3.10 Sowing of seed

Seeds were sown continuously on April 10, 2007 in 2-2.5 cm deep furrows made by hand iron tine maintaining row spacing following treatment variables. After placement of seed in the furrow, seeds were covered with soil by hand. Four days after sowing the germination of seeds was satisfactory.

3.11 Weeding and thinning

Two weedings were done manually at 30 and 45 days after emergence of seedlings. Thinning was done during first weeding keeping a distance of 5 cm and 10 cm between plants according to treatment.

3.12 Pest management

The management was not taken as the crops were not infested.

3.13 Harvesting and processing

The crop was harvested plot-wise when about 80% of the capsules became mature (June 9, 2007). The duration of the crop was shortening as the crop was sown late and remains under rain water during flowering stage. The harvested crop was brought to the threshing floor and sun dried for 3 days. The seed and stover were then separated, cleaned and dried in the sun for 3 to 4 consecutive days for achieving safe moisture content of seed.

3.14 Sample collection and data recording

Ten plants were selected randomly from each plot at 30, 45 and 60 (at harvest) DAS to record data of the followings-

3.14.1 Growth parameters

- Plant height (cm)
- Number of leaves plant^{-1}
- Leaf dry wt. plant^{-1} (g)
- Stem dry wt. plant $^{-1}$ (g)
- Capsules dry wt. plant $^{-1}$ (g)
- Above ground dry wt. plant $^{-1}$ (g)

3.14.2 Yield parameters

- Number of branches plant^{-1}
- Number of capsules plant^{-1}
- Number of seeds capsule^{-1}
- 1000-grain weight (g)
- Seed yield (kg ha^{-1})
- Stover yield (kg ha^{-1})
- Biological yield (kg ha^{-1})
- Harvest index (%)

3.15 Out line of the data recording

A brief of the data recording has been given below -

3.15.1 Plant height (cm)

Plant height was measured from the base to the tip from plants and mean plant height was determined in cm.

3.15.2 Number of leaves plant^{-1}

Number of leaves was counted from selected plant samples. After that the mean value was recorded.

3.15.3 Stem dry weight plant^{-1} (g)

Collected stems from ten plants were oven dried maintaining a temperature of 80^0 C for 2 days until constant weight was reached and the dry weight was recorded with an electric balance and mean value was determined.

3.15.4 Leaves dry weight plant^{-1} (g)

Collected and counted leaves from ten plants were oven dried maintaining a temperature of 80^0 C for 2 days until constant weight was reached and the dry weight was recorded with an electric balance and mean value was determined.

3.15.5 Capsules dry weight plant^{-1} (g)

Collected capsules from ten plants were oven dried maintaining a temperature of 80^0 C for 2 days until constant weight was reached and the dry weight was recorded with an electric balance and mean value was determined.

3.15.6 Above ground dry weight plant $^{-1}$ (g)

Addition of leaf dry wt. plant^{-1} (g), stem dry wt. plant^{-1} (g) and capsules dry wt. plant^{-1} (g) is the above ground dry weight plant $^{-1}$.

3.15.7 Number of branches per plant^{-1}

Number of branches of ten plants was recorded from the selected plants and determined the mean value.

3.15.8 Number of capsules plant^{-1}

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

3.15.9 Number of seeds capsule^{-1}

From each treatment 20 capsules were randomly selected and all the seeds of them were counted. The number of seeds capsule^{-1} was determined by averaging the data.

3.15.10 1000-seed weight (g)

One thousand sun-dried seed were counted and then weight was recorded by means of an electrical balance.

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

The crop was harvested at full maturity from pre determined area of 2 m^2 from which seeds were separated out from the capsule, cleaned and dried in the sun to bring them at safety moisture content of seed and there after the weight of the seed was taken and converted to yield per hectare (kg ha^{-1}).

3.15.12 Stover yield (kg ha^{-1})

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

3.15.13 Biological yield (kg ha^{-1})

The summation of seed yield and above ground stover yield per hectare was the biological yield.

Biological yield = Seed yield + Stover yield

3.15.14 Harvest index (%)

Harvest index was determined by the following formula:

$$\text{Harvest index} = \frac{\text{Seed yield}}{\text{Biological yield}} * 100$$

3.16 Data analysis technique

Data recorded for different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done by the MSTAT-C program. Mean differences among the treatments were tested with Least Significant Difference method (LSD) at 5% level.

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to evaluate the effect of nitrogen and spacing on yield and yield attributes of sesame. The parameters studied were plant height, number of leaves plant^{-1}, stem dry weight plant $^{-1}$ (g), leaves dry weight plant^{-1} (g), above ground dry weight plant^{-1} (g), number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, 1000-grain weight (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%). The data of plant growth characters like plant height, number of leaves plant^{-1}, stem dry weight plant $^{-1}$ (g), leaves dry weight plant^{-1} (g) and above ground dry weight plant^{-1} (g) were recorded at 30, 45 and 60 (at harvest) days after sowing (DAS). Yields and yield attributes were taken at final harvest. Results of the experiment have been presented in figures and tables. The mean square values in respect of the above parameters together with the source of variation and their corresponding degrees of freedom have been presented in the appendices III, IV, V and VI. The results have been presented and discussed following plant characters as below.

4.1 Crop Growth Characteristics

4.2 Plant height

4.2.1 Effect of different level of nitrogen

The nitrogen had no significant effect on plant height of sesame but 90 kg ha^{-1} safer maturity (Fig. 1).

At 30 DAS, numerically the highest plant height was observed from N_1 (30 kg ha^{-1}), which was 35.17 cm and the lowest 32.17 was obtained from N_0 (0 kg ha^{-1}).

At 45 DAS, the maximum plant height was observed from N_1 (30 kg ha^{-1}), which was 46.97 cm and similar with N_2 (46.28 cm), N_3 (46.12 cm) and N_0 (39.40 cm).

At 60 (harvest) DAS, the highest plant height was obtained from N_1 (30 kg ha^{-1}), which was 83.46 cm and followed by N_0 (82.29 cm), N_2 (81.90 cm) and N_3 (79.78 cm). Numerically the lowest plant height was obtained from N_0 (no nitrogen) and it was 82.29 cm.

Plant height increased because of availability of optimum nitrogen to plant, which positively enhanced the vegetative growth of plant. Patra (2001) and Tiwari *et al.*, (2000) were observed that, 60 kg N ha^{-1} gave the maximum plant height.

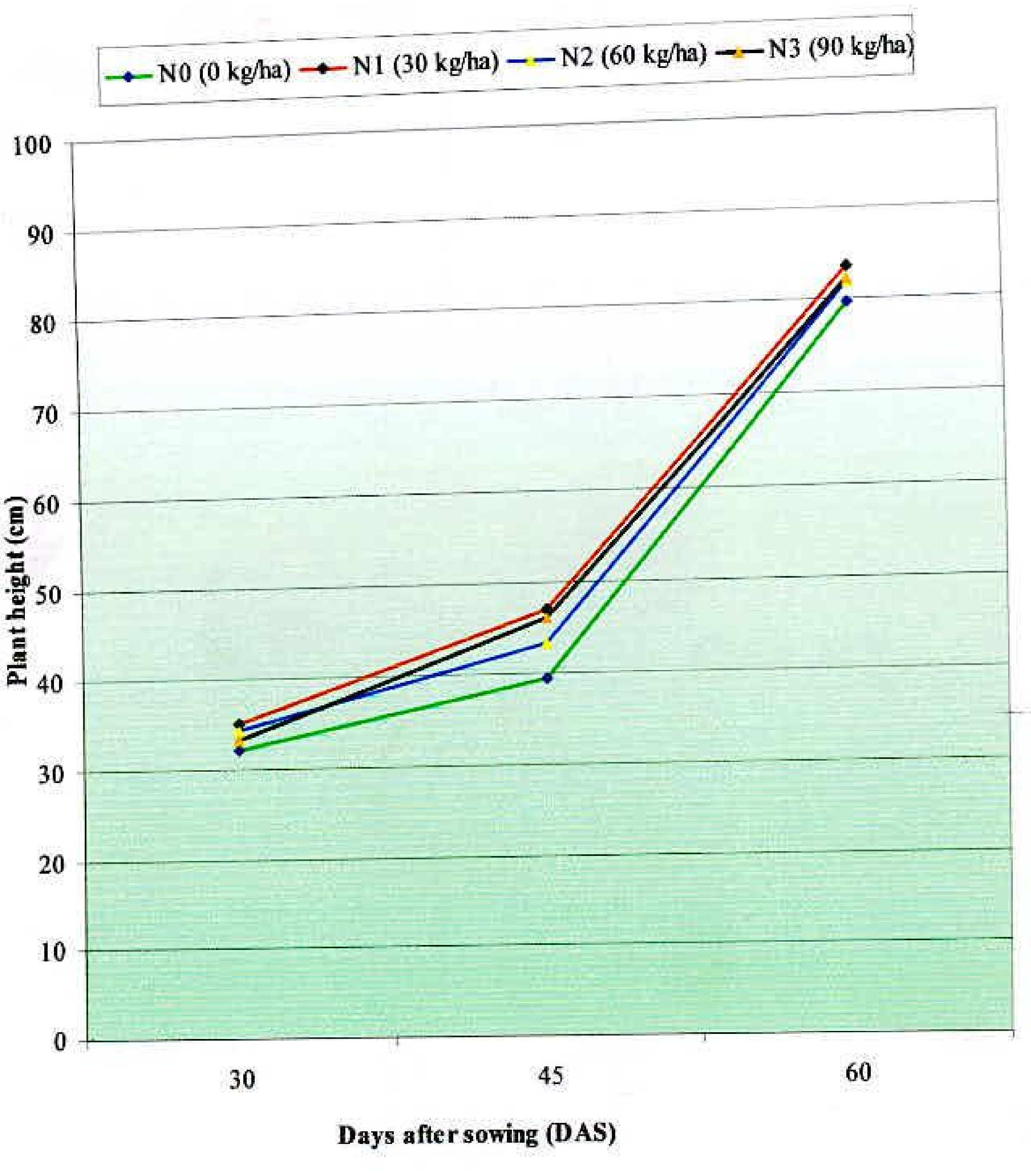

Fig.1 Plant height of sesame cv. T-6 at different ages as affected by nitrogen levels (LSD 0.05=6.61, 9.67 & 7.94 at 30, 45 and 60 DAS, respectively)

4.2.2 Effect of different spacing

Plant spacing had no significant effect on plant height of sesame at 30 and 60 (harvest) DAS but significant effect at 45 DAS (Fig 2).

At 30 DAS, numerically the highest plant height was observed from S_2 (30 cm x 10 cm), which was 36.25 cm and lowest was obtained from S_1 (30 cm x 5 cm) which was 30.45 cm.

At 45 DAS, maximum plant height 49.93 cm was observed from S_2 (30 cm x 10 cm) plant spacing which was statistically higher then other treatments. The lowest plant height obtained from S_1 (30 cm x 5 cm) plant spacing, which was 41.21 cm and followed by 41.94 and 42.70 cm, which was obtained from the spacing of S_3 (40 cm x 5 cm) and S_4 (40 cm x 10 cm), respectively.

At 60 (harvest) DAS, numerically the highest plant height was observed from S_2 (30 cm x 10 cm), which was 83.68 cm and followed by 82.48, 81.09 and 80.18 cm from S_3 (40 cm x 5 cm), S_4 (40 cm x 10 cm) and S_1 (30 cm x 5 cm), respectively.

Spacing of 30 cm x 10 cm gave the height plant height due to high light interception, less weed infestation and high nutrient uptake by optimum plant population. Martin (1964) found that closest plant spacing gave the height plant height.

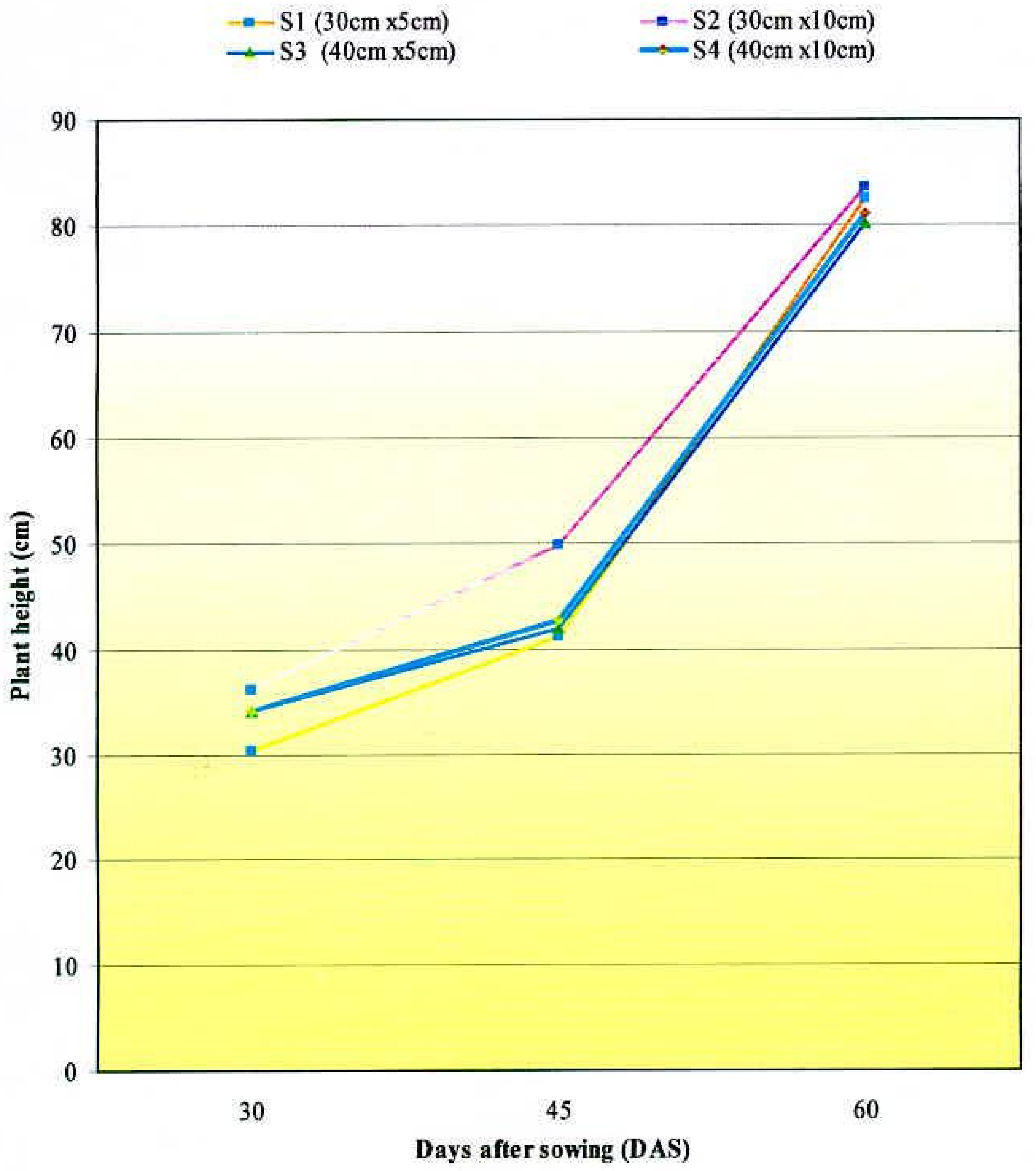

Fig. 2 Plant height of sesame cv. T-6 at different ages as affected by different spacing (LSD 0.05=5.15, 5.53 & 6.72 at 30, 45 and 60 DAS, respectively)

4.2.3 Combined effect of nitrogen and spacing

Table 1 showed that the combined effect of nitrogen and spacing had no significant effect on plant height of sesame at 30 and 60 (harvest) DAS but significant effect at 45 DAS.

At 30 DAS, numerically the highest plant height was observed from N_1S_2 (30 kg N ha^{-1} and 30 cm X 10 cm), which was 38.36 cm. The minimum plant height (27.33 cm) was obtained from N_1S_1 (30 kg N ha^{-1} and 30 cm X 5 cm) plant spacing.

At 45 DAS, the highest plant height was observed from N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm), which was 52.05 cm and followed by N_2S_2 (51.23 cm), N_3S_2 (50.93 cm), N_2S_4 (49.31 cm), N_3S_1 (47.75 cm), N_1S_4 (46.78 cm), N_1S_3 (45.53 cm), N_0S_2 (45.51 cm), N_2S_3 (45.40 cm) and N_1S_1 (43.50 cm). The maximum population with no nitrogen (N_0S_1) gave lowest value of plant height 35.03 cm and followed by N_3S_4 (37.12 cm), N_3S_3 (37.33 cm), N_0S_4 (37.58 cm), N_2S_1 (38.55 cm) and N_0S_3 (39.47 cm).

At 60 (harvest) DAS, numerically the highest plant height was observed from N_1S_2 (30 kg ha^{-1} and 30 cm x 10 cm), which was 87.50 cm.

Table 1. Plant height of sesame cv.T-6 at 30, 45 and 60 (harvest) DAS as affected by different nitrogen level and spacing

Treatment	Plant height (cm)		
	30 DAS	45 DAS	60 DAS (at harvest)
N_0S_1	29.82	35.03	77.06
N_0S_1	30.87	45.51	80.76
N_0S_3	37.19	39.47	87.33
N_0S_4	30.8A	37.58	80.8
N_1S_1	27.32	43.50	81.26
N_1S_2	38.36	52.05	87.50
N_1S_3	37.91	45.53	77.66
N_1S_4	37.07	46.78	82.73
N_2S_1	32.34	38.55	85.86
N_2S_2	34.64	51.23	85.36
N_2S_3	38.04	45.40	79.3
N_2S_4	32.3	49.31	84.93
N_3S_1	32.3	47.75	77.86
N_3S_2	33.16	50.93	81.06
N_3S_3	31.39	37.33	76.40
N_3S_4	36.44	37.12	83.76
$LSD_{0.05}$	NS	11.05	NS
CV (%)	20.22	14.92	9.74

NS = Non Significant

4.3 Number of leaves plant^{-1}

4.3.1 Effect of different level of nitrogen

The experimental result showed that the effect of nitrogen on number of leaves plant^{-1} of sesame had no significant effect at 45 DAS and 60 DAS of plant life cycle but significant effect at early vegetative stage (30 DAS) (Fig. 3).

At 30 DAS, the highest number of leaves plant^{-1} was observed from N_1 (30 kg ha^{-1}), which was 11.13 and followed by 10.95 and 10.49 obtained from the treatment of N_4 (40 cm x 10 cm) and N_3 (40 cm x 5 cm). The lowest number of leaves plant^{-1} was obtained from the treatment N_0 (no nitrogen).

At 45 DAS, numerically the maximum number of leaves plant^{-1} was observed from N_1 (30 kg ha^{-1}), which was 13.44 and similar with N_2 (13.13), N_3 (12.89) and N_0 (12.79).

At 60 (harvest) DAS, numerically the highest number of leaves plant^{-1} was observed from N_1 (30 kg ha^{-1}), which was 34.12 and followed by (30.04), (29.58) and (28.19) was observed from 90, 60 and 0 kg ha^{-1}, respectively.

Number of leaves per plant increased by reason of availability of nutrient to plant, which progressively enhanced the vegetative growth and produced much leaves plant^{-1}.

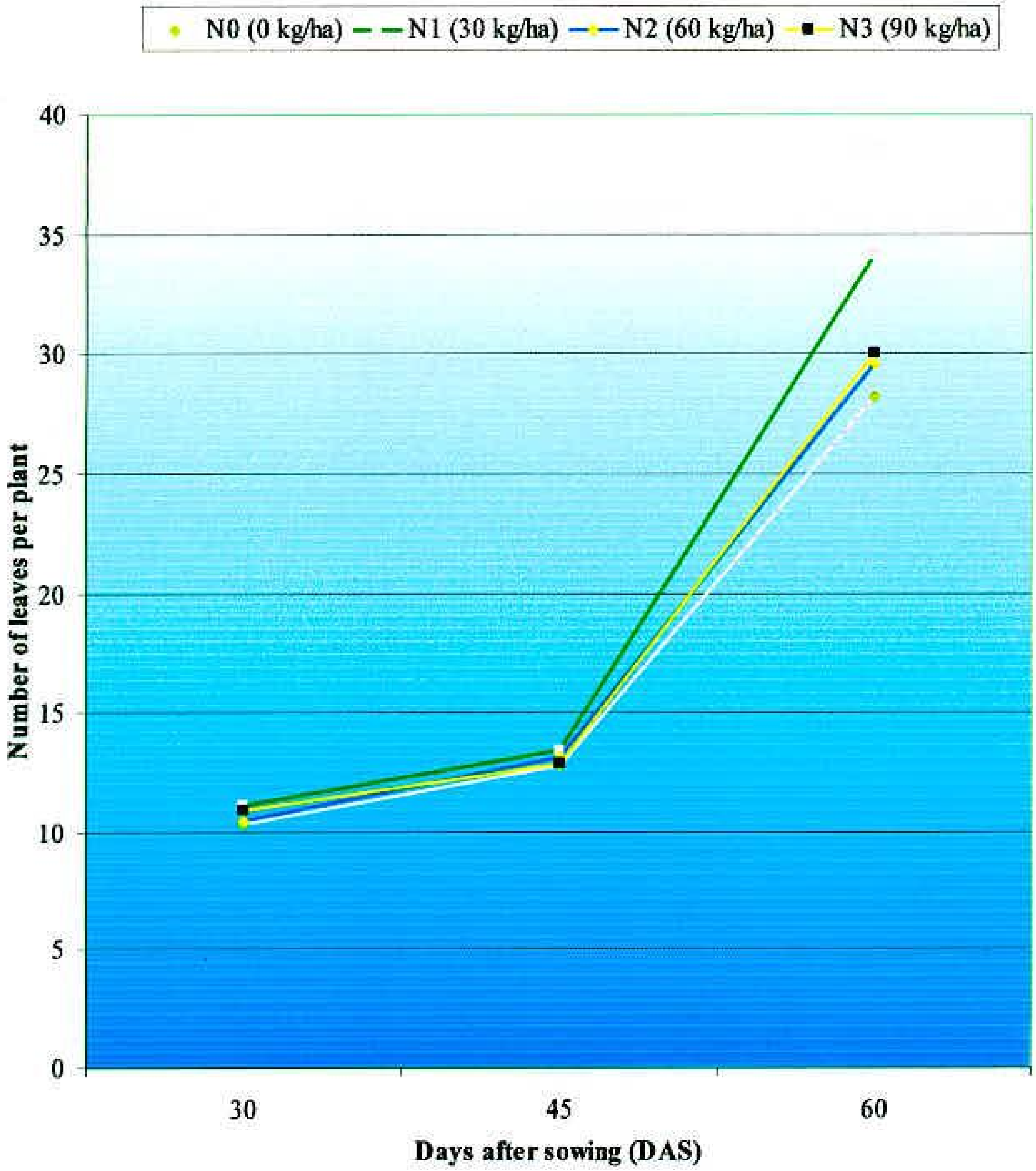

Fig. 3 Number of leaves per plant of sesame cv. T-6 at different ages as affected by nitrogen levels (LSD 0.05=0.68, 1.27 & 6.83 at 30, 45 and 60 DAS, respectively)

4.3.2 Effect of different spacing

The effect of spacing on number of leaves plant^{-1} of sesame had significant effect at early vegetative (30 DAS) stage and (45 DAS) stage but insignificant effect at maturity (60 DAS) stages of plant life cycle (Fig 4).

At 30 DAS, the maximum number of leaves plant^{-1} was observed from S_2 (30 cm x 10 cm), which was 11.18, followed by S_3 (10.91) and S_4 (10.79). The lowest number of leaves plant^{-1} 10.06 obtained from the closest plant spacing S_1 (30 cm x 5 cm).

At 45 DAS, the highest number of leaves plant^{-1} was observed from S_2 (30 cm x 10 cm) plant spacing which was 13.83 and statistically similar with 13.82 obtained from S_4 (40 cm x 10 cm) plant spacing. The lowest number of leaves plant^{-1} obtained from S_1 (30 cm x 5 cm) plant spacing, which was 12.13 and followed by 12.47 obtained from S_3 (40 cm x 5 cm) plant spacing.

At 60 DAS, numerically the maximum number of leaves plant^{-1} was observed from S_2 (30 cm x 10 cm), which was 32.97 followed by S_4 (31.87), S_3 (30.39), S_1 (26.70).

Spacing of 30 cm x 10 cm gave the higher number of leaves plant^{-1} due to high light interception, less weed infestation and high nutrient uptake that stimulate plant vegetative growth and produce maximum number of leaves plant^{-1}. Similar effect of spacing on number of leaves per plant was also observed by Menon (1967) and Olive *et al.*, (1958).

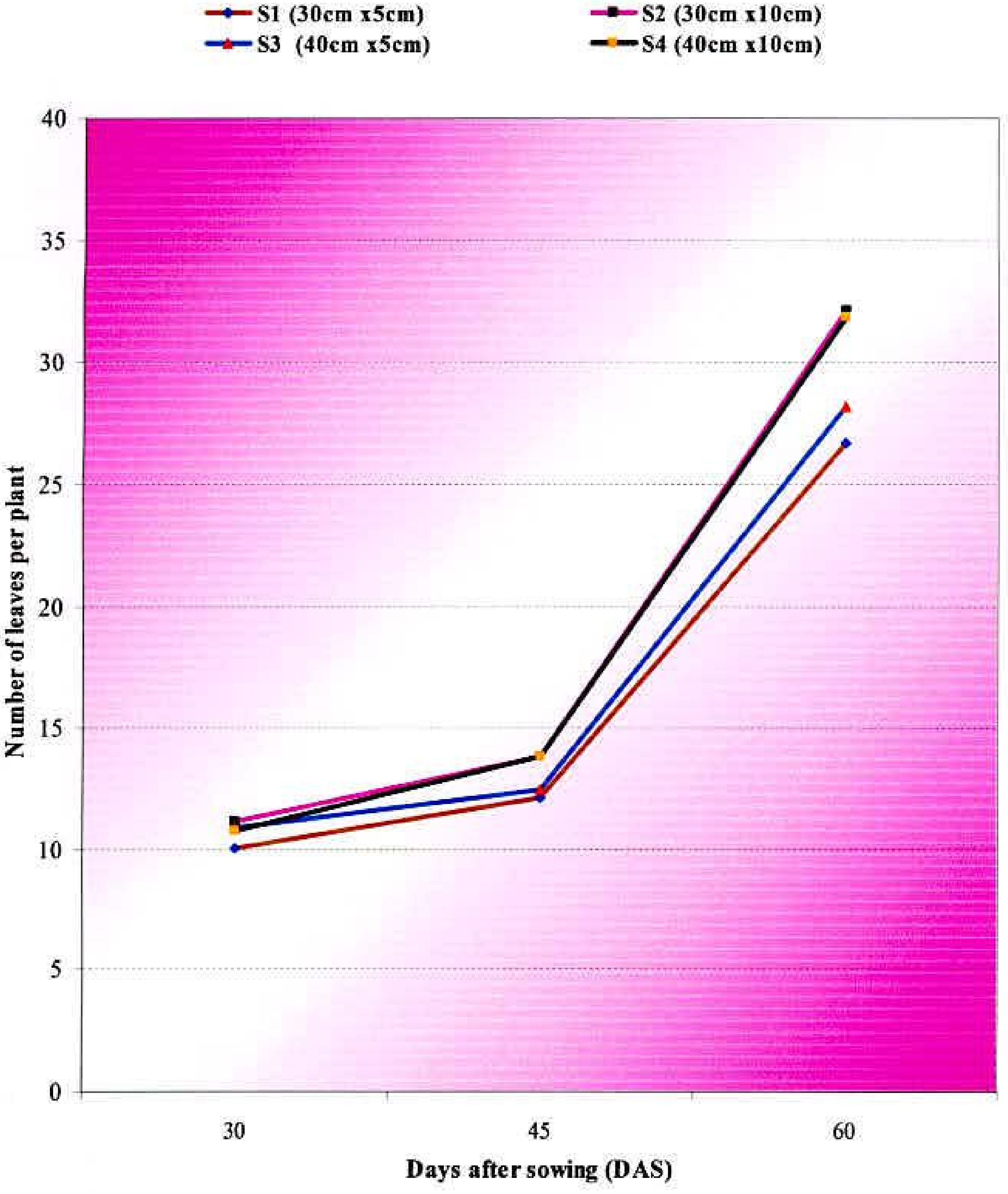

Fig. 4 Number of leaves per plant of sesame cv. T-6 at different ages as affected by different spacing (LSD 0.05=0.67, 1.02 & 7.28 at 30, 45 and 60 DAS, respectively)

4.3.3 Combined effect of nitrogen and spacing

The combined effect of nitrogen level and spacing showed significant variation on the number of leaves plant^{-1} at 30 and 45 DAS and no significant effect at 60 (harvest) DAS (Table 2).

At 30 DAS, the maximum number of leaves plant^{-1} was observed from the treatment combination of N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm), which was 11.93 and followed by N_3S_4 (11.70), N_1S_4 (11.57), N_0S_4 (11.40), N_2S_3 (11.13), N_1S_3 (11.13), N_3S_3 (11.07) and N_3S_2 (10.70). The maximum population with no nitrogen (N_0S_1) gave minimum number of leaves plant^{-1} 9.83 and followed by N_1S_1 (9.90) and N_2S_4 (10.03).

At 45 DAS, the highest number of leaves plant^{-1} was observed from N_1S_2 (30 kg ha^{-1} and 30 cm x 10 cm), which was 14.83 and followed by N_2S_4 (14.80), N_1S_4 (14.70), N_2S_2 (13.90), N_0S_2 (13.33), N_3S_1 (13.20), N_3S_2 (13.20) and N_0S_4 (13.07). The minimum number of leaves plant^{-1} was obtained from the treatment combination of N_0S_1 (11.67) and followed by N_2S_4 (11.81), N_2S_3 (12.00), N_0S_1 (12.30), N_3S_3 (12.40), N_0S_3 (12.47), N_1S_1 (12.57).

At 60 (harvest) DAS, numerically the highest number of leaves plant^{-1} was observed from N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm interaction), which was 38.40 and lowest was obtained from N_2S_2 (60 kg N ha^{-1} and 30 cm x 10 cm interaction) that was 23.93.

The combined result showed that (N_1S_2) treatment gave the highest number leaves plant^{-1} by reason of individual effect of nutrient along with spacing on plant at vegetative growth stage gave the maximum number leaves plant^{-1}.

Table 2. Number of leaves per plant of sesame cv.T-6 at 30, 45 and 60 (harvest) DAS as affected by different nitrogen level and spacing

Treatment	Number of leaves plant^{-1}		
	30 DAS	45 DAS	60 DAS (at harvest)
N_0S_1	9.83	11.67	30.07
N_0S_1	10.43	13.33	31.00
N_0S_3	10.30	12.47	29.23
N_0S_4	11.40	13.07	28.00
N_1S_1	9.90	12.57	26.27
N_1S_2	11.93	14.83	38.40
N_1S_3	11.13	12.30	33.47
N_1S_4	11.57	14.70	38.33
N_2S_1	10.17	11.81	23.93
N_2S_2	10.10	13.90	31.63
N_2S_3	11.13	12.00	30.13
N_2S_4	10.03	14.80	27.07
N_3S_1	10.33	13.20	26.53
N_3S_2	10.70	13.20	30.83
N_3S_3	11.07	12.40	28.73
N_3S_4	11.70	12.77	34.07
$LSD_{0.05}$	1.35	2.04	14.58
CV (%)	7.46	9.28	28.38

NS = Non Significant

4.4 Stem dry weight (gm)

4.4.1 Effect of different level of nitrogen

Different nitrogen level had significant influenced on stem dry weight of sesame at vegetative (30 DAS) and maturity (60 DAS) stages of plant life cycle (Table 3).

At vegetative stage (30 DAS), the highest stem dry weight 5.87 (gm) was produced by N_1 (30 kg N ha^{-1}), which was similar with the second highest stem dry weight 5.62 (g) and 5.34 (g) was obtained from the treatment 60 kg N ha^{-1} and 90 kg N ha^{-1}. The lowest stem dry weight 4.07 (g) was produced from control treatment (N_0).

At maturity stage (60 DAS), the highest stem dry weight 15.84 (g) was produced by the treatment N_1 (30 kg N ha^{-1}), which was statistically similar with N_3 (15.83 g) and N_2 (14.21 g). The lowest stem dry weight 13.06 (g) was produced from N_0 (no nitrogen) which was followed by N_2 (14.21 g).

Nitrogen level N_1 (30 kg N ha^{-1}) produce maximum stem dry weight at all stages because of that treatment produce maximum plant height, more number of leaves per plant and maximum number of branches per plant. Singaravel *et al.*, (1998) stated that at 35 kg N ha^{-1} produced highest stem dry weight and Mondol *et al.*, (1997) was observed that dry matter accumulation was increased significantly with increasing nitrogen rates.

4.4.2 Effect of different Spacing

Different spacing had significant influence on stem dry weight of sesame at vegetative (30 DAS) and maturity (60 DAS) stages of plant life cycle (Table 3).

At vegetative stage (30 DAS), the highest stem dry weight 6.18 (g) was produced by S_2 (30 cm x 10 cm) plant spacing, which was followed by S_4 (5.68 g) and S_3 (4.99 g). The lowest stem dry weight 4.05 (g) was produced from closest spacing S_1 (30 cm x 5 cm).

At maturity stage (60 DAS), the highest stem dry weight 16.46 (g) was obtained from S_2 (30 cm x 10 cm) plant spacing, which was statistically similar with the second highest stem dry weight 14.75 (g) was obtained from S_4 (40 cm x 10 cm) plant spacing. The lowest stem dry weight 13.61 (g) was produced from S_1 (30 cm x 5 cm) plant spacing, which was followed by S_3 (13.95 g) and S_4 (14.75 g).

Spacing of 30 cm x 10 cm produced highest stem dry weight due to the treatment produced maximum plant height more number of leaves per plant and maximum number of branches per plant. Similar result of spacing on stem dry weight was also found by Mazzani *et.al.* (1956).

Table 3. Stem dry weight of sesame cv. T-6 at different ages as affected by nitrogen levels and spacing

Treatment	Stem dry weight (g)	
Nitrogen level (kg ha^{-1})	**30 DAS**	**60 DAS (at harvest)**
N_0	4.07	13.06
N_1	5.87	15.84
N_2	5.62	14.21
N_3	5.34	15.83
$LSD_{0.05}$	1.73	3.33
Spacing		
S_1	4.05	13.61
S_2	6.18	16.46
S_3	4.99	13.95
S_4	5.68	14.75
$LSD_{0.05}$	1.44	2.64

NS= Non Significant

N_0 = No nitrogen

N_1 = 30 kg N ha^{-1}

N_2 = 60 kg N ha^{-1}

N_3 = 90 kg N ha^{-1}

S_1 = 30 cm x 5 cm

S_2 = 30 cm x 10 cm

S_3 = 40 cm x 5 cm

S_4 = 40 cm x 10 cm

4.4.3 Combined effect of nitrogen and spacing

Table 4 showed that the combined effect of nitrogen and spacing had significant effect on stem dry weight at 30 and 60 (harvest) DAS.

At 30 DAS, the uppermost stem dry weight 7.49 (g) was obtained from N_1S_2 (30 kg N ha^{-1} and 30 cm x10 cm), which was followed by N_1S_3 (6.89 g), N_3S_4 (6.42 g), N_3S_2 (6.33 g), N_2S_2 (6.21 g), N_2S_4 (6.14 g), N_1S_4 (5.30 g), N_2S_1 (5.10 g), N_2S_3 (5.04 g), N_0S_4 (4.86 g), N_0S_2 (4.69 g) and N_3S_1 (4.68 g). The lowest stem dry weight 2.60 (g) was obtained from the treatment combination of N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) which had followed by N_1S_1 (3.80 g), N_3S_3 (3.94 g) and N_0S_3 (4.11 g).

At 60 (harvest) DAS, combination of 30 kg N ha^{-1} and 30 cm x10 cm spacing (N_1S_2), produced the highest stem dry weight of 20.21 (g), which was followed by N_1S_2 (17.16 g), N_2S_2 (16.60 g), N_3S_2 (16.45 g) and N_1S_4 (14.97 g). The lowest stem dry weight 11.56 (g) was obtained from the treatment combination of 60 kg N ha^{-1} and 30 cm x 5 cm spacing (N_2S_1).

Stem dry weight increased by reason of individual effect of nitrogen and spacing on plant to accelerate cell division, cell elongation and thus stimulate plant vegetative growth consequently plant produced maximum stem dry weight. Similar finding was obtained by Singaravel and Govindasamy (1998).

Table 4. Stem dry weight of sesame cv.T-6 at different ages 30, 45 and 60 (harvest) DAS as affected by different nitrogen level and spacing

Treatment	Stem dry weight (g)	
	30 DAS	60 DAS (at harvest)
N_0S_1	2.60	13.13
N_0S_2	4.69	13.3
N_0S_3	4.11	12.98
N_0S_4	4.86	12.84
N_1S_1	3.80	14.91
N_1S_2	7.49	20.21
N_1S_3	6.89	17.16
N_1S_4	5.30	14.97
N_2S_1	5.10	11.56
N_2S_2	6.20	16.60
N_2S_3	5.04	14.68
N_2S_4	6.14	14.01
N_3S_1	4.69	14.85
N_3S_2	6.32	16.45
N_3S_3	3.95	14.85
N_3S_4	6.42	17.16
$LSD_{0.05}$	2.88	5.29
CV (%)	32.69	21.3

4.5 Leaves dry weight (g)

4.5.1 Effect of different level of nitrogen

The experimental result showed that the effect of nitrogen on leaves dry weight of sesame had significant effect at 30 DAS and no significant effect at 60 (harvest) DAS (Table 5).

At 30 DAS, the highest leaves dry weight 6.82 (g) was produced by N_1 (30 kg N ha^{-1}), which was statistically similar with that of the second highest leaves dry weight 6.35 (g) and 6.21 (g) was obtained from the treatment of N_3 (90 kg ha^{-1}) and N_2 (60 kg N ha^{-1}), respectively. The lowest leaves dry weight 5.43 (g) was produced from N_0 (no nitrogen) which was significantly lower then the highest.

At 60 (harvest) DAS, numerically the highest leaves dry weight 6.31 (g) was produced N_1 (30 kg N ha^{-1}) and the lowest 4.83 (g) was obtained from N_2 (60 kg N ha^{-1}).

The result showed that 30 kg N ha^{-1} produce maximum leaves dry weight due to the treatment produced maximum number of leaves per plant. Mita *et al.*, (1999) and Mondol *et al.*, (1997) also found alike result.

4.5.2 Effect of different Spacing

Plant spacing had significant influence on leaves dry weight at 30 and 60 (harvest) DAS (Table 5).

At 30 DAS, the highest leaf dry weight 7.33 (g) was produced by of S_2 (30 cm x 10 cm) plant spacing, which was statistically similar with the second highest leaf dry weight 6.92 (g) was obtained from S_4 (40 cm x 10 cm) plant spacing. The lowest leaf dry weight 4.93 (g) was produced from S_1 (30 cm x 5 cm) plant spacing, which was followed by 5.62 (g) was obtained from S_3 (40 cm x 5 cm) plant spacing.

At 60 (harvest) DAS, the highest leaf dry weight 7.35 (g) was produce by S_2 (30 cm x 10 cm) plant Spacing, which was statistically similar with 5.42 (g) and 4.61 (g) was obtained from the treatment of S_3 (40 cm x 5 cm) and S_4 (40 cm x 10 cm) plant spacing. The lowest leaf dry weight 3.91 (g) was produced from treatment S_1 (30 cm x 5 cm) plant spacing which was statically lower then all of the values of leaves dry weight.

The result showed that S_2 (30 cm x 10 cm) plant spacing produce maximum leaves dry weight due to the treatment produce maximum number of leaves per plant. Mazzani *et al.,* (1956) found similar result.

Table 5. Leaves dry weight of sesame cv. T-6 at different ages as affected by nitrogen levels and spacing

Treatment	Leaves dry weight (g)	
Nitrogen level (kg ha^{-1})	30 DAS	60 DAS (at harvest)
N_0	5.43	5.12
N_1	6.82	6.31
N_2	6.21	4.83
N_3	6.35	5.04
$LSD_{0.05}$	1.16	4.29
Spacing		
S_1	4.94	3.91
S_2	7.34	7.36
S_3	5.62	5.42
S_4	6.92	4.62
$LSD_{0.05}$	1.36	2.88

NS= Non Significant

N_0 = No nitrogen

N_1 = 30 kg N ha^{-1}

N_2 = 60 kg N ha^{-1}

N_3 = 90 kg N ha^{-1}

S_1 = 30 cm x 5 cm

S_2 = 30 cm x 10 cm

S_3 = 40 cm x 5 cm

S_4 = 40 cm x 10 cm

4.5.3 Combined effect of nitrogen and spacing

Combined effect of nitrogen and spacing showed significant variation on leaves dry weight among treatment combination at 30 and 60 (harvest) DAS (Table 6).

At 30 DAS, the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x10 cm), produced the height leaves dry weight of 8.27 (g), which was followed by N_3S_4 (7.8 g), N_2S_4 (7.42 g), N_0S_4 (7.14 g), N_3S_2 (7.00 g), N_1S_4 (6.9 g), N_1S_3 (6.65 g), N_0S_2 (6.28 g), N_2S_2 (6.12 g), N_3S_3 (5.68 g), N_2S_3 (5.66 g) and N_2S_1 (5.5). The lowest leaves dry weight 3.82 (g) was obtained from the treatment combination of N_0S_1 (30 kg Nitrogen and 30 cm x 5 cm).

At 60 (harvest) DAS, combination of 30 kg N ha^{-1} and 30 cm x10 cm spacing (N_1S_2), produced the height leaves dry weight of 11.45 (g), which was followed by N_2S_1 (7.51 g), N_3S_2 (6.55 g), N_3S_3 (6.42 g), N_0S_3 (6.30 g) and N_1S_1 (5.73 g). The lowest leaves dry weight 2.34 (g) was obtained from the treatment combination of 90 kg N ha^{-1} and 30 cm x 5 cm (N_3S_1) which was statically similar with N_2S_1 (2.49 g), N_1S_4 (3.86 g), N_0S_2 (3.91 g), N_1S_3 (4.20 g), N_2S_4 (4.55 g), N_2S_3 (4.76 g), N_3S_4 (4.85 g), N_0S_1 (5.06 g), N_0S_4 (5.21 g) and N_1S_1 (5.73 g).

The treatment combination N_1S_2 gave the highest leaf dry weight by which was attributed to individual effect of nitrogen and spacing produce maximum number of leaves per plant. Subrahmaniyan and Arulmozhi (1999) were observed similar result.

Table. 6 Leaves dry weight of sesame cv.T-6 at different ages (30, 45 and 60 DAS) as affected by different nitrogen level and spacing

Treatment	Leaves dry weight (g)	
	30 DAS	60 DAS (At harvest)
N_0S_1	3.82	5.07
N_0S_2	6.29	3.91
N_0S_3	4.49	6.30
N_0S_4	7.14	5.21
N_1S_1	5.44	5.73
N_1S_2	8.27	11.45
N_1S_3	6.65	4.85
N_1S_4	6.92	3.86
N_2S_1	5.63	2.49
N_2S_2	6.12	7.51
N_2S_3	5.67	4.76
N_2S_4	7.42	4.55
N_3S_1	4.86	2.34
N_3S_2	7.01	6.56
N_3S_3	5.68	6.42
N_3S_4	7.87	4.85
$LSD_{0.05}$	2.72	5.76
CV (%)	25.98	64.18

4.6 Capsules dry weight (g)

4.6.1 Effect of different level of nitrogen

Nitrogen fertilizer had significant effect on capsules dry weight of sesame at 60 (harvest) DAS (Fig 5).

The peak value of capsules dry weight at the time of harvest (60 DAS) was observed by N_1 (30 kg N ha^{-1}) 15.32 (g), which was statistically similar with the second highest capsules dry weight 13.84 (g) was obtained from the treatment of N_3 (90 kg N ha^{-1}). The lowest capsules dry weight 10.73 (g) was produced from N_0 (0 kg N ha^{-1}), which was statistically similar with the intermediate capsules dry weight 10.83 (g) was obtained from N_2 (60 kg N ha^{-1}).

It was evident that N_1 (30 kg N ha^{-1}) treatment produced maximum capsules dry weight because the dose of nitrogen stimulate the growth of flower and capsule and thus produced maximum capsules per plant. The observation of Mondol *et al.*, (1997) was different from the present result. They stated that the dry matter accumulation was increased with increasing nitrogen rates.

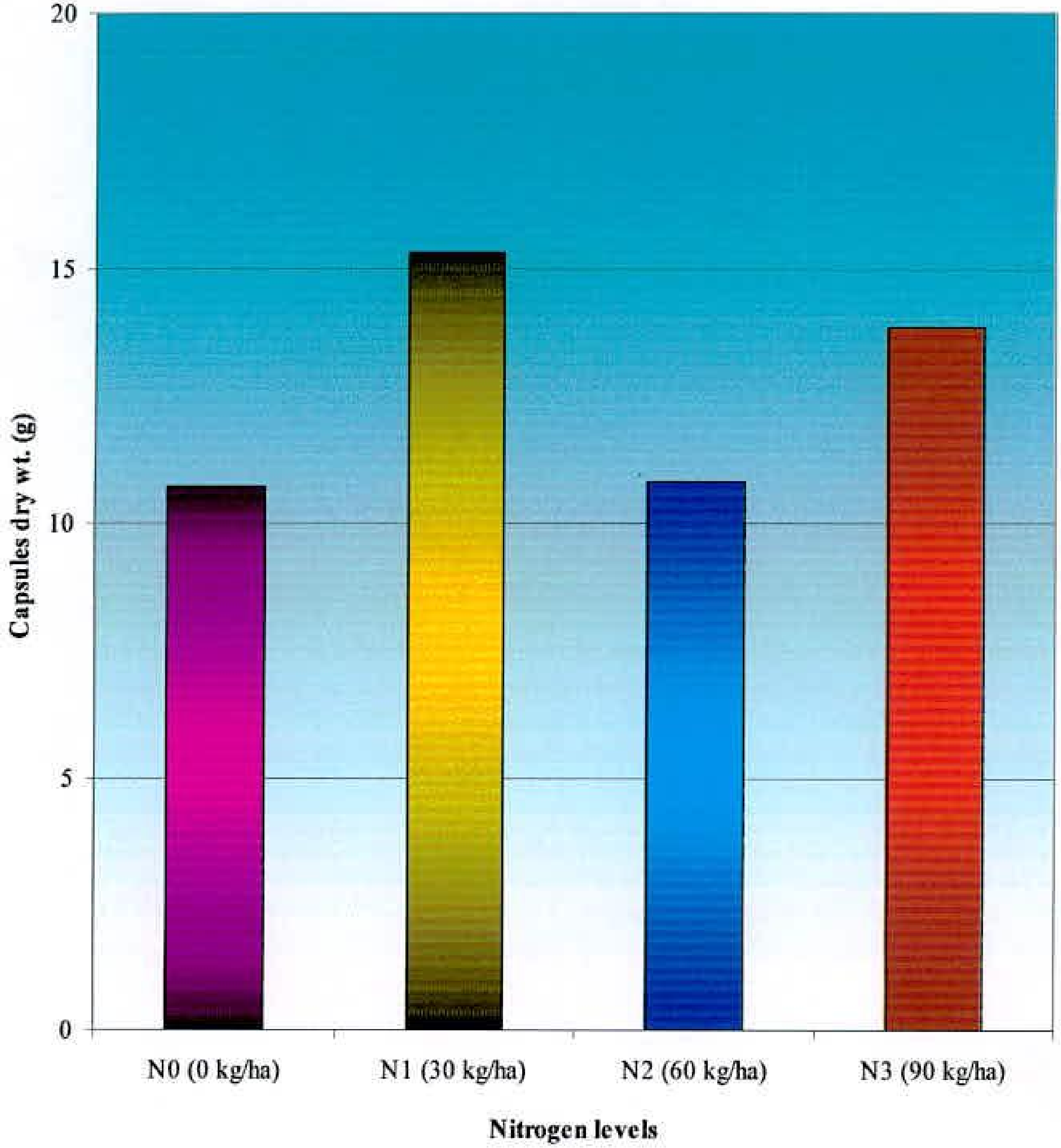

Fig. 5 Capsules dry weight of sesame cv. T-6 as affected by different level of nitrogen (LSD 0.05 = 1.95 at 60 DAS)

4.6.2 Effect of different Spacing

Spacing had no significant influenced on capsules dry weight at 60 (harvest) DAS (Fig 6).

Numerically the maximum value capsules dry weight 12.89 (g) was produced by S_2 (30 cm x 10 cm) plant spacing, which was followed by S_1 (12.89 g), S_4 (12.53 g) and S_3 (12.42 g) plant spacing respectively. Numerically the minimum value of capsules dry weight (12.42 g) was produced by S_4 (40 cm x 10 cm) plant spacing.

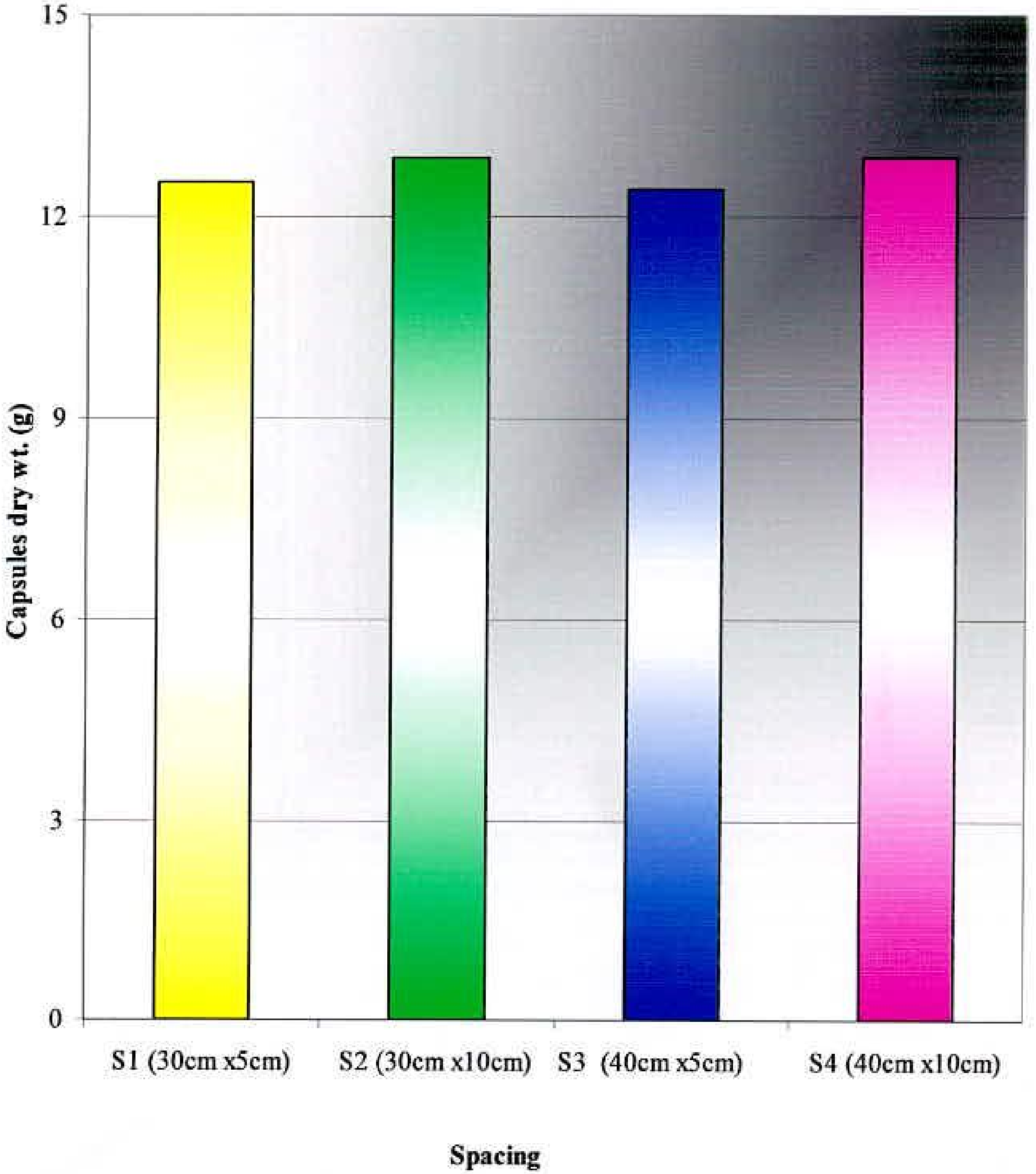

Fig. 6 Capsules dry weight of sesame cv. T-6 as affected by different spacing (LSD 0.05 = 3.56 at 60 DAS)

4.6.3 Combined effect of nitrogen and spacing

Combination of nitrogen level and spacing under study showed significant variation on capsules dry weight of sesame at the time of harvest (60 DAS) (Table 7).

The combination of N_1S_2 (30 kg N ha^{-1} and 30 cm x10 cm) spacing, produced the maximum capsules dry weight of 20.83 (g), which was followed by N_3S_4 (16.25 g), N_2S_1 (16.19 g), N_1S_4 (16.18 g) and N_3S_3 (15.56 g). The minimum capsules dry weight 7.00 (g) was obtained from N_2S_3 (60 kg N ha^{-1} and 40 cm x 5 cm).

The combination result showed that N_1S_2 treatment produced maximum capsules dry weight caused by individually N_1 (30 kg N ha^{-1}) and S_2 (30 cm x 10 cm) plant spacing stimulate the growth of flower and capsule and thus produced maximum capsules per plant Similar over view was found by Singaravel *et al.*, (1998).

Table 7. Capsules dry weight of sesame cv.T-6 at 60 (harvest) DAS as affected by different nitrogen level and spacing

Treatment	Capsules dry weight (g)
	60 DAS (at harvest)
N_0S_1	11.57
N_0S_1	9.78
N_0S_3	10.88
N_0S_4	10.71
N_1S_1	11.63
N_1S_2	20.83
N_1S_3	12.63
N_1S_4	16.18
N_2S_1	16.19
N_2S_2	9.63
N_2S_3	10.51
N_2S_4	7.00
N_3S_1	12.17
N_3S_2	11.31
N_3S_3	15.65
N_3S_4	16.25
$LSD_{0.05}$	7.12
CV (%)	33.33

4.7 Above ground dry weight (g)

4.7.1 Effect of different level of nitrogen

Different nitrogen level had significant influenced on above ground dry weight of sesame at early vegetative (30 DAS) and maturity (60 DAS) stages of plant life cycle (Table 8).

At early vegetative (30 DAS) stage, the highest above ground dry weight 12.69 (g) was obtained from N_1 (30 kg ha^{-1}), which was followed by N_2 (11.83 g) and N_3 (11.70 g). While the lowest above ground dry weight 9.50 (g) was produced by N_0 (no nitrogen).

At maturity (60 DAS) stage, the highest above ground dry weight 37.47 (g) was produced by N_1 (30 kg N ha^{-1}), which was statically similar with the second highest above ground dry weight 34.71 (g) was obtained from the treatment of N_3 (90 kg N ha^{-1}) while the lowest above ground dry weight 28.92 (g) was produced from N_0 (no nitrogen) which was followed by N_2 (29.04 g).

The result showed that 30 kg N ha^{-1} produce maximum above ground dry weight due to the treatment produced maximum stem dry weight (g), leaves dry weight (g) and capsules dry weight (g). Singaravel *et al.*, (1998) was observed that 35 kg N ha^{-1} produced maximum dry weight of sesame plant. Mitra and Pal (1999) were observed that dry matter production $plant^{-1}$ of sesame was significantly increased up to 100 kg N ha^{-1}.

4.7.2 Effect of different spacing

Plant spacing had significant effect on above ground dry weight of sesame at early vegetative (30 DAS) and maturity (60 DAS) stages of plant life cycle (Table 8).

At early vegetative (30 DAS) stage, the highest above ground dry weight 13.10 (g) was produced by S_2 (30 cm x 10 cm plant spacing), which was followed by the second highest above ground dry weight 13.02 (gm) was obtained from S_3 (40 cm x 5 cm plant Spacing). The lowest above ground dry weight 8.89 (g) was produced from treatment S_1 (30 cm x 5 cm plant spacing), which was followed by 10.62 (g) was obtained from (40 cm x 10 cm plant spacing).

At maturity (60 DAS) stage, the highest above ground dry weight 36.88 (g) produced by S_2 (30 cm x 10 cm plant spacing), which was followed by S_4 (31.90 gm) and S_3 (31.78 gm). The lowest above ground dry weight 29.57 (g) was produced by S_1 (30 cm x 5 cm plant spacing), which was significantly lower then all of the treatment.

The over view of this effect was S_2 (30 cm x 10 cm plant spacing) produced maximum above ground dry weight (g) because of the treatment produce maximum stem dry weight (g), leaves dry weight (g) and capsules dry weight (g). Cano and Lopez (1951) were observed comparable result.

Table 8. Above ground dry weight of sesame cv. T-6 at different ages as affected by nitrogen levels and spacing

Treatment	Above ground dry weight (g)	
Nitrogen level (kg ha^{-1})	30 DAS	60 DAS (at harvest)
N_0	9.5	28.92
N_1	12.69	34.71
N_2	11.83	29.04
N_3	11.7	37.47
$LSD_{0.05}$	2.68	6.72
Spacing		
S_1	8.98	29.58
S_2	13.1	36.88
S_3	10.62	31.9
S_4	13.02	31.78
$LSD_{0.05}$	2.627	6.113

NS= Non Significant

N_0 = No nitrogen

N_1 = 30 kg N ha^{-1}

N_2 = 60 kg N ha^{-1}

N_3 = 90 kg N ha^{-1}

S_1 = 30 cm x 5 cm

S_2 = 30 cm x 10 cm

S_3 = 40 cm x 5 cm

S_4 = 40 cm x 10 cm

4.7.3 Combined effect of nitrogen and spacing

Combination of nitrogen level and spacing under study showed significant variation on above ground dry weight of sesame at early vegetative (30 DAS) and maturity (60 DAS) stages of plant life cycle (Table 9).

At early vegetative (30 DAS) stage, the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x10 cm),was produced the maximum above ground dry weight of 15.77 (g), which was followed by N_3S_4 (14.28 g), N_2S_4 (13.56 g), N_1S_3 (13.54 g), N_3S_2 (13.33 g), N_2S_4 (12.32 g), N_1S_4 (12.23 g), N_0S_4 (12.00 g), N_0S_2 (10.98 g), N_2S_1 (10.74 g) and N_2S_3 (10.71 g) (Table-3). The lowest above ground dry weight 6.420 (g) was obtained from the treatment combination N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) which was followed by N_0S_3 (8.60 g), N_1S_1 (9.54 g), N_3S_1 (9.63 g), N_3S_3 (10.71 g), N_2S_3 (10.74 g) and N_2S_1 (10.98 g).

At maturity (60 DAS) stage, the treatment combination of N_1S_2 (30 kg N ha^{-1} and 30 cm x10 cm) was produced the maximum above ground dry weight 52.49 (g), which was statistically superior then all of the treatment combinations (Table-4). The lowest above ground dry weight 25.57 (gm) was obtained from the combination of treatment N_2S_4 (60 kg N ha^{-1} and 40 cm x 10 cm) which was followed by N_2S_1 (26.91 g), N_0S_2 (26.99 g), N_0S_4 (28.77 g), N_3S_1 (29.37 g), N_0S_1 (29.77 g), N_2S_3 (29.95 g), N_1S_3 (30.10 g), N_0S_3 (30.16 g), N_1S_1 (32.27 g), N_2S_2 (33.74 g), N_3S_2 (34.31 g), N_1S_4 (35.01 g) and N_3S_3 (36.92 g) respectively.

The combination results showed that N_1S_2 (30 kg N ha^{-1} and 30 cm x10 cm) treatment gave the highest above ground dry weight because the treatment produce maximum stem dry weight (g), leaves dry weight (g) and capsules dry weight (g). Subrahmaniyan *et al.*, (1999), Mita *et al.*, (1999) and Mondol *et al.*, (1997) found related result.

Table. 9 Above ground dry weight of sesame cv.T-6 at different ages (30, 45 and 60 (harvest) DAS) as affected by different nitrogen level and spacing

Treatment	Above ground dry weight (g)	
	30 DAS	60 DAS (At harvest)
N_0S_1	6.42	29.77
N_0S_2	10.98	26.99
N_0S_3	8.61	30.16
N_0S_4	12.00	28.77
N_1S_1	9.24	32.27
N_1S_2	15.77	52.49
N_1S_3	13.54	30.10
N_1S_4	12.23	35.01
N_2S_1	10.74	26.90
N_2S_2	12.32	33.74
N_2S_3	10.71	29.95
N_2S_4	13.56	25.57
N_3S_1	9.54	29.37
N_3S_2	13.33	34.31
N_3S_3	9.63	36.92
N_3S_4	14.28	38.25
$LSD_{0.05}$	5.25	12.23
CV (%)	27.27	22.3

4.8 Yield components

4.9 Number of branches plant^{-1}

4.9.1 Effect of different level of nitrogen

The nitrogen had significant effect on number of branches of sesame but it decreased with increased nitrogen rate (Table 10). The highest number of branches plant^{-1} (1.62) was obtained from the treatment N_1 (30 kg N ha^{-1}). The minimum number of branches plant^{-1} (1.28) was produced by the treatment N_0 (no nitrogen) which was similar with N_2 (1.33) and N_3 (1.33). Mondol *et al.*, (1997), Pathak *el al.*, (2002), Patra *et al.*, (2001) and Subrahmaniyan (1999) reported that 45 kg N ha^{-1} increased number of branches plant^{-1}.

4.9.2 Effect of different spacing

Plant spacing had no significant effect on number of branches plant^{-1} of sesame. Numerically the highest number of branches plant^{-1} (1.43) was observed from the treatment S_4 (40 cm x 10 cm) and lowest (1.32) from S_1 (30 cm x 5 cm).

4.9.3 Combined effect of nitrogen and spacing

Table 10 showed that the combined effect of nitrogen and spacing had significant influence on number of branches plant^{-1} of sesame. The highest number of branches plant^{-1} (1.80) was obtained by N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) which was followed by N_1S_1 (1.70), N_1S_4 (1.60), N_0S_3 (1.47), N_3S_4 (1.47) and N_2S_3 (1.43). The lowest number of branches plant^{-1} (1.13) was obtained from N_0S_1 (30 kg N and 30 cm x 5 cm).

It was evaluated that the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) produced maximum number of branches plant^{-1} because of combination stimulate plant to have more dry matter that partitioned in branches.

4.10 Number of capsules plant^{-1}

4.10.1 Effect of different level of nitrogen

Nitrogen fertilizer had no significant effect on number of capsules plant^{-1} of sesame (Table 10). Numerically the highest number of capsules plant^{-1} (20.92) was produced by N_1 (30 kg N ha^{-1}) and lowest from N_0 (17.83). Paul and Savitheri (2003) opined that at 30 kg N ha^{-1} gave the highest number of capsules plant^{-1} of sesame.

4.10.2 Effect of different spacing

Plant spacing had no significant effect on number of capsules plant^{-1} of sesame (Table 10). Numerically the highest (22.13) and lowest (18.51) number of capsules plant^{-1} were obtained from S_4 (40 cm x 10 cm) and S_3 (40 cm x 5 cm), respectively.

4.10.3 Combined effect of nitrogen and spacing

Combination of nitrogen level and spacing had significant effect on number of capsules plant^{-1} of sesame (Table 10). The highest number of capsules plant^{-1} (25.47) was observed by N_1S_2 (30 kg N and 30 cm x 10 cm) which was similar with N_1S_4 (25.13), N_3S_4 (24.60), N_2S_4 (23.27), N_0S_1 (22.13), N_3S_3 (21.57), N_3S_1 (19.93), N_2S_3 (19.53), N_2S_2 (18.50), N_0S_2 (17.20), N_1S_1 (16.60), N_0S_3 (16.47) and N_1S_3 (16.47). The lowest number of capsules plant^{-1} (14.40) was observed by N_3S_2 which was followed by N_0S_4 (15.50), N_2S_1 (15.93) N_1S_3 (16.47), N_0S_3 (16.47), N_1S_1 (16.60), N_0S_2 (17.20), N_2S_2 (18.50), N_2S_3 (19.53), N_3S_1 (19.93), N_3S_3 (21.57), N_0S_1 (22.13), and N_2S_4 (23.27).

4.11 Number of seeds capsules^{-1}

4.11.1 Effect of different level of nitrogen

The number of seeds capsules^{-1} of sesame was significantly affected by nitrogen level (Table 10). The highest number of seeds capsules^{-1} (57.69) was produced by the treatment N_1 (30 kg N ha^{-1}). The lowest number of seeds capsules^{-1} (49.20) was produced by the treatment N_0 (no nitrogen) which was similar with N_3 (49.74), N_2 (51.54). Result revealed that number of seeds capsules^{-1} decreased with increased in nitrogen level. Patra (2001) reported that number of seeds capsule^{-1} significantly increased with increasing nitrogen rate up to 60 kg N ha^{-1} in sesame.

4.11.2 Effect of different spacing

The number of seeds capsules^{-1} was varied significantly with different spacing management (Table 10). The highest number of seeds capsules^{-1} (55.11) was produced by S_2 (30 cm x 10 cm) plant spacing while the minimum number of seeds 48.72 was obtained from the treatment of S_3 (40 cm x 5 cm) spacing plot which was similar with S_4 (51.62) and S_1 (52.72) plant spacing.

4.11.3 Combined effect of nitrogen and spacing

Different combination of nitrogen level and spacing showed significant variation on number of seeds capsules^{-1} of sesame (Table 10). The highest number of seeds capsules^{-1} (59.70) was obtained by N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm plant spacing) which was similar with N_1S_4 (59.00), N_1S_1 (58.57), N_2S_2 (56.77), N_2S_1 (54.73), N_3S_2 (53.67) and N_1S_3 (53.50). The lowest number of seeds capsules^{-1} (45.23) was obtained from the treatment combination N_3S_3 (90 kg N and 40 cm x 5 cm) which was similar with N_2S_3 (45.83), N_0S_4 (48.00), N_0S_1 (48.17), N_2S_4 (48.82), N_3S_1 (49.40), N_0S_2 (50.30), N_0S_3 (50.33) and N_3S_4 (50.67).

4.12 1000-seed weight (g)

4.12.1 Effect of different level of nitrogen

Level of nitrogen fertilizer had no significant effect on 1000-seed weight of sesame (Table 10). Numerically the highest 1000-seed weight (3.55 g) was observed by the treatment N_1 (30 kg ha^{-1}) and lowest from N_0 (3.29 g). Pathak *et al.*, (2002) found that application of nitrogen at 45 kg ha^{-1} produced the highest 1000-grain weight but Om *et al.*, (2001) was stated that application of 90 kg N ha^{-1} produced maximum 1000-seed weight.

4.12.2 Effect of different spacing

Spacing had non significant influence on 1000-seed weight of sesame. Numerically the highest 1000-seed weight (3.58 g) was obtained from S_2 (30 cm x 10 cm) plant spacing and S_3 produced the lowest weight (3.23 g). Ahuja *et al.*, (1971) stated that 1000-seed weight increased with decrease in spacing.

4.12.3 Combined effect of nitrogen and spacing

The seed weight was varied significantly with the combine effect of nitrogen and spacing (Table 10). Treatment N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) influenced plant to have higher seed weight (3.91 g/1000 seed) and N_1S_3 (30 kg N ha^{-1} and 40 cm x 5 cm) could not influenced plant for its seed growth and development thus produced lower seed weight (2.95 g/1000 seed). Mondol *et al.*, (1997) observed that 1000- seed weight was increased with increasing nitrogen rate up to 120 kg ha^{-1}.

Table. 10 Yield contributing character of sesame (cv. T-6) and their combined effect as affected by nitrogen and spacing

Treatment	Number of branches $plant^{-1}$	Number of capsules $plant^{-1}$	Number of seeds $capsule^{-1}$	1000 - seed weight (g)
		Nitrogen level (kg ha^{-1})		
N_0	1.28	17.83	49.2	3.29
N_1	1.62	20.92	57.69	3.55
N_2	1.33	20.13	51.54	3.33
N_3	1.33	19.31	49.74	3.35
$LSD_{0.05}$	0.23	NS	3.67	NS
		Spacing level		
S_1	1.32	18.65	52.72	3.31
S_2	1.42 a	18.89	55.11	3.58
S_3	1.39	18.51	48.72	3.23
S_4	1.43	22.13	51.62	3.41
$LSD_{0.05}$	NS	NS	4	NS
		Nitrogen level x Spacing		
N_0S_1	1.13	22.13	48.17	3.36
N_0S_2	1.2	17.2	50.3	3.39
N_0S_3	1.47	16.47	50.33	3.77
N_0S_4	1.3	15.5	48	3.69
N_1S_1	1.7	16.6	58.57	3.28
N_1S_2	1.8	25.47	59.71	3.91
N_1S_3	1.37	16.47	53.5	2.95
N_1S_4	1.6	25.13	59	3.26
N_2S_1	1.2	15.93	54.73	3.34
N_2S_2	1.33	18.5	56.77	3.42
N_2S_3	1.43	19.53	45.83	3.09
N_2S_4	1.33	23.27	48.82	3.48
N_3S_1	1.23	19.93	49.4	3.27
N_3S_2	1.33	14.4	53.67	3.55
N_3S_3	1.3	21.57	45.23	3.11
N_3S_4	1.47	24.6	50.67	3.22
$LSD_{0.05}$	0.37	9.19	8.01	0.83
CV (%)	15.89	27.91	9.13	14.59

NS= Non Significant

N_0 = No nitrogen

N_1 = 30 kg N ha^{-1}

N_2 = 60 kg N ha^{-1}

N_3 = 90 kg N ha^{-1}

S_1 =30 cm x 5 cm

S_2 =30 cm x 10 cm

S_3 =40 cm x 5 cm

S_4 =40 cm x 10 cm

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

4.13.1 Effect different level of nitrogen

Level of nitrogen fertilizer showed significant influence on seed yield ha^{-1} (Table 11). It was observed that highest seed yield (1102.00 kg ha^{-1}) was obtained from the treatment N_1 (30 kg N ha^{-1}) which was similar with 60 kg N ha^{-1} (1034.00 kg) and 90 kg N ha^{-1} (947.30 kg). The lowest seed yield ha^{-1} was obtained from the control (631.80 kg ha^{-1}). Dwivedi *et al.*, (1992) and Kadam (1989) nitrogen 30 kg ha^{-1} that increased seed yield in sesame.

4.13.2 Effect of different spacing

Spacing had no significant effect on seed yield kg ha^{-1} of sesame (Table 11). Numerically the highest seed yield (1010.00 kg ha^{-1}) was found from S_2 (30 cm x 10 cm) plant spacing and lowest seed yield was obtained from S_4 (886.20 kg ha^{-1}). The over view of Ahuja *et al.*, (1971) was different from the present finding. They stated that seed yield increased with decrease in spacing.

4.13.3 Combined effect of nitrogen and spacing

Seed yield of sesame significantly influence by nitrogen level and spacing (Table 11). It appeared that the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) plant spacing, produced significantly the highest yield (1405.00 kg ha^{-1}) which was followed by N_3S_2 (1258.00 kg ha^{-1}), N_1S_1 (1208.00 kg ha^{-1}), N_2S_1 (1160.00 kg ha^{-1}), N_2S_3 (1118.00 kg ha^{-1}), N_2S_4 (1083.00 kg ha^{-1}) and N_1S_3 (1022.00 kg ha^{-1}). The lowest yield (459.90 kg ha^{-1}) was obtained from N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) treatment combination which was followed by N_0S_2 (604.40 kg), N_0S_3 (716.70 kg), N_0S_4 (746.10 kg), N_3S_1 (765.50 kg), N_1S_4 (771.60 kg), N_2S_2 (772.50 kg) and N_3S_3 (821.50 kg). The maximum seed was reflected from maximum dry matter production by the treatment N_1S_2. The dry matter partitioning was also ideal so the yield contributing character like capsules plant^{-1}, seeds capsules^{-1} and 1000-seed weight were increased. It was appeared that the treatment 30 kg N ha^{-1} along with 30 cm x 10 cm plant spacing favored plant to grow optimally for its production of dry matter and its ideal partition. On the other hand, plant grows poorly under no nitrogen and densely spaced conditions (N_0S_1).

4.14 Stover yield kg ha^{-1}

4.14.1 Effect of nitrogen

Level of nitrogen had significant effect on stover yield of sesame (Table 11). The highest stover yield (1128.00 kg) was recorded from the treatment N_2 (60 kg N ha^{-1}). The lowest stover yield (806.50 kg ha^{-1}) was obtained from the N_0 (no nitrogen) which was followed by N_1 (810.60 kg ha^{-1}) and N_3 (916.20 kg ha^{-1}).

4.14.2 Effect of spacing

Plant spacing had significant influence on stover yield of sesame (Table 11). The highest stover yield 995.00 kg ha^{-1} was obtained from the treatment of S_1 (30 cm x 5 cm) plant spacing which was similar with S_2 (950.60 kg ha^{-1}). The lowest stover yield 782.70 kg ha^{-1} was recorded from the S_4 (40 cm x 10 cm) plant spacing which was similar with to that of S_3 (933.20 kg ha^{-1}).

4.14.3 Combination effect of nitrogen and spacing

The combined effect of nitrogen and spacing had significant effect on stover yield (Table 11). The maximum stover yield (1427.00 kg ha^{-1}) was produced by N_3S_2 (90 kg N ha^{-1} and 30 cm x 10 cm) which was similar with N_3S_1 (1253.00 kg ha^{-1}) and N_2S_1 (1253.00 kg ha^{-1}. The lowest stover yield was obtained from the treatment N_0S_1 (500.60 kg ha^{-1}) which was similar with N_1S_4 (620.60 kg ha^{-1}), N_2S_2 (738.50 kg ha^{-1}), N_1S_2 (769.40 kg ha^{-1}) and N_2S_4 (774.10 kg ha^{-1}).

4.15 Biological yield kg ha^{-1}

4.15.1 Effect of nitrogen

The difference between the fertilizer applications of N in respect of biological yield kg ha^{-1} found to be statistically significant (Table 11). The highest biological yield (2076.00 kg ha^{-1}) was recorded from the treatment N_3 (90 kg N ha^{-1}) which was similar with biological yield (1950.00 kg ha^{-1}) and (1912.00 kg ha^{-1}) obtained from the treatment of N_2 (60 kg ha^{-1}) and N_1 (30 kg ha^{-1}), respectively. The lowest biological yield (1438.00 kg ha^{-1}) was obtained from the treatment N_0 (no nitrogen).

4.15.2 Effect of spacing

Plant spacing had no significant influence on the biological yield of sesame (Table 11). Numerically the highest biological yield (1961.00 kg ha^{-1}) was obtained from S_2 (30 cm x 10 cm) plant spacing, which was similar with S_1 (30 cm x 5 cm), S_3 (40 cm x 5 cm) and S_4 (40 cm x 10 cm) as the production were 1893.00, 1853.00 and 1696.00 kg ha^{-1}, respectively

4.15.3 Combined effect of nitrogen and spacing

Combination effect of nitrogen and spacing showed significant variation on biological yield among treatment combinations as imposed on of sesame (Table 11). The treatment combination of N_3S_2 produced the highest biological yield (2685.00 kg ha^{-1}), which was similar with the treatment N_2S_1 (2395.00 kg ha^{-1}). The second highest biological yield N_2S_1. (2395.00 kg ha^{-1}) was similar with N_1S_1 (2200.00 kg ha^{-1}), N_1S_2 (2174.00 kg ha^{-1}), N_2S_3 (2036.00 kg ha^{-1}) and N_3S_1 (2018.00 kg ha^{-1}). The lowest biological yield obtained from the treatment N_0S_1 (960.50 kg ha^{-1}) which was similar with N_1S_4 (1392.00 kg ha^{-1}). The combined result showed the N_3S_2 was produced maximum biological yield due to the treatment combination produce maximum stover yield.

4.16 Harvest index (%)

4.16.1 Effect of nitrogen

Level of nitrogen significantly influenced the harvest index of sesame (Table 11). The highest harvest index (57.13 %) was recorded from the treatment N_1 (30 kg N ha^{-1}), which was similar with N_2 (53.00 %). The lowest harvest index (44.15 %) was obtained from the treatment N_0 (no nitrogen), which was similar with N_4 (45.54 %) and N_2 (53.00 %). Similar effect of nitrogen on harvest index was observed by Om *et al.*, (2001).

4.16.2 Effect of spacing

Spacing had on significant effect on the harvest index of sesame (Table 11). Numerically the highest harvest index (52.76 %) was found from the treatment S_4 (40 cm x 10 cm) plant spacing and lowest from S_1 (46.68 %).

4.16.3 Combined effect of nitrogen and spacing

Harvest index had significantly varied with different combination of nitrogen and spacing (Table 11). Significantly the highest harvest index (61.62 %) was observed from the treatment combination N_1S_2 (30 k N ha^{-1} and 30 cm x 10 cm) and followed by N_2S_4 (57.47 %), N_1S_4 (55.63 %), N_2S_3 (54.81 %), N_1S_3 (54.66 %), N_1S_1 (53.64 %) and N_3S_4 (52.47 %). The lowest harvest index (37.85 %) was obtained from the treatment combination N_3S_1 (90 k N ha^{-1} and 30 cm x 5 cm) and followed by N_0S_2 (41.60 %), N_0S_3 (42.92 %), N_3S_3 (45.28 %), N_0S_4 (45.46 %), N_3S_2 (46.55 %), N_0S_1 (46.64 %) and N_2S_1 (48.59 %). The result showed that the N_1S_2 treatment combination was produced maximum harvest index as attributed to the maximum seed size and seed yield production.

Table 11. Yields and harvest index of sesame cv. (T-6) as affected by nitrogen, spacing and their combined effect

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
		Nitrogen level (kg ha^{-1})		
N_0	631.8	806.5	1438	44.15
N_1	1102	810.6	1912	57.13
N_2	1034	1128	1950	53
N_3	947.3	916.2	2076	45.54
$LSD_{0.05}$	175.5	204.3	309.1	8.36
		Spacing level		
S_1	898.5	995	1893	46.68
S_2	1010	950.6	1961	50.97
S_3	919.5	782.7	1853	49.42
S_4	886.2	933.2	1669	52.76
$LSD_{0.05}$	NS	161.4	232.4	NS
		Nitrogen level x Spacing		
N_0S_1	459.9	500.6	960.5	46.64
N_0S_2	604.4	867.8	1472	41.6
N_0S_3	716.7	963.4	1680	42.92
N_0S_4	746.1	894.1	1640	45.46
N_1S_1	1208	991.9	2200	53.64
N_1S_2	1405	769.4	2174	64.6
N_1S_3	1022	860.6	1882	54.66
N_1S_4	771.6	620.6	1392	55.63
N_2S_1	1160	1235	2395	48.59
N_2S_2	772.5	738.5	1511	51.14
N_2S_3	1118	917.5	2036	54.81
N_2S_4	1083	774.1	1857	57.47
N_3S_1	765.5	1253	2018	37.85
N_3S_2	1258	1427	2685	46.55
N_3S_3	821.5	991.3	1813	45.28
N_3S_4	944.1	842.2	1786	52.47
$LSD_{0.05}$	413.9	322.8	464.7	13.29
CV (%)	21.69	20.93	14.83	15.68

NS= Non Significant

N_0 = No nitrogen

N_1 = 30 kg N ha^{-1}

N_2 = 60 kg N ha^{-1}

N_3 = 90 kg N ha^{-1}

S_1 =30 cm x 5 cm

S_2 =30 cm x 10 cm

S_3 =40 cm x 5 cm

S_4 =40 cm x 10 cm

Chapter 5

Summary and conclusion

SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from April 2007 to June 2007 to study the effect of different levels of nitrogen and spacing on the growth and yield of sesame (cv. T-6). The experiment consisted of four levels of nitrogen viz 0, 30, 60 and 90 kg ha^{-1} and four levels of spacing viz. 30 cm x 5 cm; 30 cm x 10 cm; 40 cm x 5 cm and 40 cm x 10 cm as treatment. The experiment was laid out in a split plot design with three replications. The unit plot size was 4.50 m x 3.00 m. The land was fertilized with urea, triple super phosphate and muriate of potash. The rate of TSP and MP (120 and 50 kg ha^{-1}) was followed from recommended of BARI (2006). All the fertilizers except urea were applied during final land preparation. Urea was applied in two equal splits; first half was applied as basal dose and second half was applied after 30 days of sowing following treatment variables. The rate of TSP and MP was followed from recommended of (BARI, 2006). Thinning and weeding were done at 30 and 45 days after emergence of seedlings. Data on various plant characters like growth and yield contributing characters as recorded at different ages of plant and analyzed statistically and mean differences among the treatments were tested with Least Significant Difference (LSD) method at 5% level of probability.

Experimental results revealed that the crop growth characters including plant height (cm), no of leaves $plant^{-1}$, stem dry weight (g), leaves dry weight (g), capsules dry weight (g) and above ground dry weight (g) were recorded at different ages of plant life cycle. Plant height (cm), no of leaves $plant^{-1}$ were recorded at 30, 45 and 60 (harvest) DAS and stem dry weight (g), leaves dry weight (g) and above ground dry weight (g) were recorded at 30 and 60 (harvest) DAS and capsules dry weight (g) were recorded at 60 (harvest) DAS.

The highest plant height 35.17 cm, 46.97 cm and 83.46 cm was observed with N_1 (30 kg ha^{-1}) at 30, 45 and 60 (harvest) DAS. The highest number of leaves $plant^{-1}$ 11.13, 13.44 and 34.12 was observed with N_1 (30 kg ha^{-1}) at 30, 45 and 60 (harvest) DAS. The highest stem dry weight 5.87 g and 15.84 g was obtained by N_1 (30 kg ha^{-1}) at 30 and 60 (harvest) DAS. The highest leaves dry weight 6.82 g and 6.31 g was observed with N_1 (30 kg ha^{-1}) at 30 and 60 (harvest) DAS. The highest capsules dry weight 15.32 g was observed with N_1 (30 kg ha^{-1}) at 60 (harvest) DAS. The highest above ground dry weight 12.69 g and 37.47 g was observed with N_1 (30 kg ha^{-1}) at 30 and 60 (harvest) DAS.

The lowest plant height 32.11 cm, 39.40 cm and 82.29 cm was obtained by N_0 (no nitrogen) at 30, 45 and 60 (harvest) DAS. The lowest number of leaves $plant^{-1}$ 10.36, 12.79 and 28.19 was observed with N_0 (no nitrogen) at 30, 45 and 60 (harvest) DAS. The lowest stem dry weight 4.07 g and 13.06 g was observer with N_0 (no nitrogen) at 30 and 60 (harvest) DAS. The lowest leaves dry weight 5.43 g was observed with N_0 (no nitrogen) at 30 DAS and 4.83 g was observed with N_2 (30 kg ha^{-1}) at 60 (harvest) DAS. The lowest capsule dry weight 10.73 g was observed with N_0 (no nitrogen) at 60 DAS. The treatment N_0 (no nitrogen) produced lowest above ground dry weight 9.50 g and 28.92 g at 30 and 60 (harvest) DAS.

The highest plant height 36.25 cm, 49.93 cm and 83.68 cm was obtained by S_2 (30 cm x 10 cm) plant spacing at 30, 45 and 60 (harvest) DAS. The highest number of leaves $plant^{-1}$ 11.18, 13.83 and 32.97 was obtained by S_2 (30 cm x 10 cm) plant spacing at 30, 45 and 60 (harvest) DAS. The highest stem dry weight 6.18 g, 16.46 g was obtained by S_2 (30 cm x 10 cm) plant spacing at 30 and 60 (harvest) DAS. The highest leaves dry weight 7.13 g, 7.35 g was obtained by S_2 (30 cm x 10 cm) plant spacing at 30 and 60 (harvest) DAS. The highest capsules dry weight 12.89 g was obtained by S_2 (30 cm x 10 cm) plant spacing at 60 (harvest) DAS. The highest above ground dry weight 13.11 g, 36.88 g was obtained by S_2 (30 cm x 10 cm) plant spacing at 30 and 60 (harvest) DAS.

The lowest plant height 30.45 cm, 41.21 cm and 80.18 cm was observed with S_1 (30 cm x 5 cm) at 30, 45 and 60 (harvest) DAS. The lowest number of leaves plant^{-1} 10.06, 12.13 and 26.70 was observed with S_1 (30 cm x 5 cm) at 30, 45 and 60 (harvest) DAS. The lowest stem dry weight 4.05 g and 13.61 g was observer with S_1 (30 cm x 5 cm) at 30 and 60 (harvest) DAS. The lowest leaves dry weight 4.93 g and 3.91 g was observed with S_1 (30 cm x 5 cm) at 30 and 60 (harvest) DAS. The minimum value of capsule dry weight 12.42 g was obtained by S_4 (40 cm x 10 cm) at 60 DAS. The treatment S_1 (30 cm x 5 cm) produced lowest above ground dry weight 8.89 g and 29.57 g at 30 and 60 (harvest) DAS.

The highest plant height 38.36 cm, 52.05 cm and 87.50 cm was obtained by the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) at 30, 45 and 60 (harvest) DAS. The highest number of leaves plant^{-1} 11.93, 14.83 and 38.40 produced by the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) at 30, 45 and 60 (harvest) DAS. The highest stem dry weight 7.49 (g) and 20.21 (g) produced by the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) at 30 and 60 (harvest) DAS. The highest leaves dry weight 8.27 (g) and 11.45 (g) produced by the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) at 30 and 60 (harvest) DAS. The highest capsules dry weight 20.83 (g) was obtained by the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) at 60 (harvest) DAS. The highest above ground dry weight 15.77 (g) and 52.49 (g) was obtained by the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) at 30 and 60 (harvest) DAS.

The lowest plant height 27.33 cm produced by N_1S_1 (30 kg N ha^{-1} and 30 cm x 5 cm) at 30 DAS, 35.03 cm produced by N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) at 45 DAS and 76.40 cm was observed with N_3S_3 (90 kg N ha^{-1} and 40 cm x 5 cm) at 60 (harvest) DAS, respectively. The lowest number of leaves plant^{-1} 9.83 and 11.67 was observed with the treatment combination N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) at 30 DAS and 45 DAS and the lowest number of leaves plant^{-1} 23.93 was observed with the treatment combination N_2S_1 (60 kg N ha^{-1} and 30 cm x 5 cm) at 60 (harvest) DAS. The minimum stem dry weight 2.60 (g) was observed with N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) at 30 DAS and 11.56 (g) was observed with the treatment combination of N_2S_1 (60 kg N ha^{-1} and 30 cm x 5 cm) at 60 (harvest) DAS. The lowest leaves dry weight 3.82 (g) was obtained by the treatment combination of N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) at 30 DAS and at 60 (harvest) DAS the lowest leaves dry weight

2.34 (g) was obtained by the treatment combination of N_3S_1 (90 kg N ha^{-1} and 30 cm x 5 cm),the minimum capsules dry weight 7.00 (g) was obtained from N_2S_3 (60 kg N ha^{-1} and 40 cm x 5 cm). The lowest above ground dry weight 6.42 (g) was obtained from the treatment combination N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) at 30 DAS and the treatment combination N_2S_3 (60 kg N ha^{-1} and 40 cm x 5 cm) produced the minimum above ground dry weight at 60 (harvest) DAS and that was 25.57 (g).

The yield contributing characteristic like number of branches $plant^{-1}$, number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, 1000-seed weight seed yield kg ha^{-1}, stover yield kg ha^{-1}, biological yield kg ha^{-1} and harvest index (%) were recorded at 60 (harvest) DAS.

Level of nitrogen fertilizer had influence on crop yield contributing characteristic, crop yield and harvest index. The highest number of branches $plant^{-1}$ 1.62 was observed with the treatment N_1 (30 kg N ha^{-1}). The highest number of capsules $plant^{-1}$ 20.92 was observed with the treatment N_1 (30 kg N ha^{-1}). The highest number of seeds $capsule^{-1}$ 57.69 was observed with the treatment N_1 (30 kg N ha^{-1}) and the maximum 1000-seed weight 3.55 g was observed with the treatment N_1 (30 kg N ha^{-1}). The treatment N_1 (30 kg N ha^{-1}) produced highest seed yield (1102.00 kg ha^{-1}) but highest stover yield (1128.00 kg ha^{-1}) produced by the treatment N_2 (60 kg N ha^{-1}). The treatment N_3 (90 kg N ha^{-1}) produced highest biological yield (2076.00 kg ha^{-1}).the maximum harvest index was observed with N_1 (30 kg N ha^{-1}) and that was 57.13 %.

The treatment N_1 (30 kg N ha^{-1}) produced minimum number of branches $plant^{-1}$ (1.28), minimum number of capsules $plant^{-1}$ (17.83), lowest number seeds $capsule^{-1}$ (49.20), and lowest 1000-seed weight (3.29). The treatment N_1 (30 kg N ha^{-1}) produced lowest seed yield (631.80 kg ha^{-1}), lowest stover yield (806.50 kg ha^{-1}) and lowest biological yield (1438.00 kg ha^{-1}) produced by the treatment N_1 (30 kg N ha^{-1}). The lowest harvest index (44.15 %) was obtained with the treatment N_1 (30 kg N ha^{-1}).

highest number of branches $plant^{-1}$ 1.43 was observed with the treatment S_4 (40 cm x 10 cm) plant spacing. The treatment S_2 (30 cm x 10 cm) plant spacing produced highest number of capsules $plant^{-1}$ and that was 22.13. Highest number of seeds $capsule^{-1}$ (55.11) produced by the treatment S_2 (30 cm x 10 cm) plant spacing. The maximum 1000-seed weight (3.58 g) was observed with the treatment S_2 (30 cm x 10 cm) plant spacing. The highest seed yield (1010.00 kg ha^{-1}) produced by the treatment S_2 (30 cm x 10 cm) plant spacing but the highest stover yield (995.00 kg ha^{-1}) was observed with the treatment S_1 (30 cm x 5 cm) plant spacing. The treatment

S_1 (30 cm x 5 cm) plant spacing produced highest biological yield (1961.00 kg ha^{-1}) but the maximum harvest was observed with S_3 (40 cm x 5 cm) plant spacing and that was 52.76 %.

The minimum number of branches $plant^{-1}$ (1.32) was observed with the treatment S_1 (30 cm x 5 cm) plant spacing. The treatment S_3 (40 cm x 5 cm) plant spacing produced lowest number of capsules $plant^{-1}$ (18.51), lowest number seeds $capsule^{-1}$ (48.72), and lowest 1000-seed weight (3.23 g). The lowest seed yield (886.20 kg ha^{-1}) was observed with the treatment S_4 (40 cm x 10 cm) plant spacing, but the treatment S_3 (40 cm x 5 cm) plant spacing produced lowest stover yield (782.70 kg ha^{-1}) and lowest biological yield (1853.00 kg ha^{-1}). The lowest harvest index (46.68 %) was obtained by the treatment S_1 (30 cm x 5 cm) plant spacing.

The combination of nitrogen and spacing had a great influence on yield contributing characteristic, crop yield and harvest index. The combination of N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) produced maximum number of branches $plant^{-1}$ and that was (1.8). The highest number of capsules $plant^{-1}$ 25.47 was observed with N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm). The highest number of seeds $capsule^{-1}$ 59.70 was observed with N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm). The combination of N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) produce maximum 1000-seed weight and that was 3.9 (g). The highest seed yield (1405.00 kg ha^{-1}) was obtained by the treatment combination N_1S_2 (30 kg N ha^{-1} and 30 cm x 10 cm) but highest stover yield (1427.00 kg ha^{-1}) was obtained by the treatment combination N_3S_2 (90 kg N ha^{-1} and 30 cm x 10 cm). The treatment combination of N_1S_2 produced the highest biological yield (2831.00 kg ha^{-1}) and this treatment combination produced the maximum harvest index and that was 64.60 %.

The lowest number of branches $plant^{-1}$ (1.13) was obtained by the treatment combination N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm). The lowest number of capsules $plant^{-1}$ (14.40) was observed by N_3S_2 (90 kg N ha^{-1} and 30 cm x 10 cm). The lowest number of seeds $capsules^{-1}$ (45.23) was obtained from the treatment combination N_3S_3 (90 kg N and 40 cm x 5 cm). The treatment combination N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) produced lowest 1000-seed weight ant that was (2.95 g). The treatment combination N_0S_1 (0 kg N ha^{-1} and 30 cm x 5 cm) produced lowest seed yield (459.90 kg ha^{-1}), lowest stover yield (500.60 kg ha^{-1}) and lowest biological yield (960.50 kg ha^{-1}). The lowest harvest index (37.85 %) was obtained by the combination N_3S_1 (90 kg N ha^{-1} and 30 cm x 5 cm).

On the basis of the above findings of the experiment, it may be concluded that nitrogen at the rate of 30 kg N ha^{-1} along with spacing 30 cm x 10 cm may be influential for growth, development and yield of sesame.

Further study may be undertaken in the different agro-ecological zone (AEZ) of Bangladesh to validate the present results in different environments.

References

REFERENCE

Ahmad, A., Hussain, A., Akhtar, M., Ehsanullah and Musaddique, M. 2001. Yield and quality of two sesame varieties as affected by different rates of nitrogen and phosphorus. *Pakistan J. Agril. Sci.* 38(1-2): 4-7.

Allam, A. Y. 2002. Effect of gypsum, nitrogen fertilization and hill spacing on seed and oil yields of sesame cultivated on sandy soils. *Assiut J. Agril. Sci.* 33(4): 1-16.

Anonymous. 1961. Sesame. Rep. Dep. Agric. Nyaseland. 1959-60. pt. 2, 1961. 39. (Field crop Abst. 15 (1): 60. 1962) .

Anonymous. 1976. Sesame *(sesamum indicum).* Rep. Irish Rep. Peru. (Field crop Abst. 29(1): 56. 1976).

Awad, S. G., Slimen, J. T., Shalaby, S. A. and Osman, A. 0. 1997. Response of sesame plant (S. indicum L) to NPK fertilizers on new reclaimed sandy soils. Annals Agril. Sci. 42(1):297-303.

BARI.1994. "Til Fosaler Chash". Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. Folder January 1994.

BARI.1999. "Til Fosaler Chash". Bidesh Agril.:Res. Inst. Joydebpur, Gazipur. Folder January 1999.

BARI (Bangladesh Agricultural Research Institute). 2006. *"Krishi Projokti Hatboi".* Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. Folder December 2001.p.122.

BBS (Bangladesh Bureau of Statistics). 2004. Statistical Yearbook of Bangladesh. Stat. Div. Minis. Planning, Govt. People's Repub. Bangladesh. p. 37, 52.

BBS (Bangladesh Bureau of Statistics). 2007. Statistical Yearbook of Bangladesh 2005. Stat. Div. Minis. Planning, Govt. People's Repub. Bangladesh. p. 149.

Chatterjee, R. and Mondal, B. 1983. Principles of Crop Production. West Bengal Stationary Book Board. p. 89.

Cobley, L. S. 1967. An Introduction to Botany of Tropical Crops. Longmans Green and Co. Ltd. Grosvener St. London. WI. p.105.

Cano. J. M, and Lopez, M. 1951. sesame aand its cultivation. Field crop Abst. 4(4) : 172. 1951.

Dixit, J. P. Rao, V. S.N. Ambabatiya, G. R. and Khan, R. A. 1997. Productivity of sesame cultivars sown as semi-rabi under various plant densities and nitrogen levels. Crop Res. 13(1):27-3 1.

Dwivedi, V. D. and Namdeo, K.N. 1992. Response of sesame (*Sesamum indicum)* to nitrogen and phosphate. Indian J. Agron. 37(3): 606-607.

FAO (Food and Agriculture Organization). 1998. FAO Production Yearbook. Food and Agriculture Organization of the United Nations. Rome. 52:101-107.

FAO (Food and Agriculture Organization). 2003. FAO Production Yearbook. Food and Agriculture Organization of the United Nations. Rome. 1999. 52: 341

Gnanamurthy, P. Xavier, H. and Balasubramaniyan, P..1992. Spacing and nitrogen requirement of sesame (Sesamum indicum). *Indian J. Agron.* 37(4): 858-859.

Imamyavarambam, V. Singaravel, R. Thanunathan, K. and Manickam, G. 2002. Studies on the effects of different plant densities and the levels of nitrogen on the productivity and economic returns of sesame. Crop Res. 24(2): 3 14-316.

Jadhav, A. S., Chavan, G. V. and Chavan, D. A. 1992. Response of summer sesame (*Sesamum indicum)* to nitrogen and phosphorus. *Indian J. Agron.* 37(3): 604-605.

Kadam, W.G. 1989. Effect of row spacing and nitrogen on yield of sesame. *J. Maharashtra Agril. Univ.* 14 (2): 227-228.

Kathiresan, G. 2002. Response of sesame (*Sesamum indicum)* genotypes to levels of nutrients and spacing under different seasons. *Indian J. Agron.* 47(4):537-540.

Kumar, A and Prasad, T. N. 1993, Response of summer sesame (*Sesamum indicum)* irrigation and nitrogen in calcareous soil. *Indian J. Agron.* 28(1):145-147

Malik, M.A., Saleem, M. F., Cheema, M. A. and Ahmed, S. 2003. Influence of different nitrogen level on productivity of sesame (*Sesamum Indicum* L.) under varying planting patterns. mt. *J. Agric. Biol.* 5(4): 490-492.

Martin. J.H.; 1964. and Collister (1965); principal of field crop production. 13th printing. The Macmillan Com. New York. P. 1040.

Mazzani, B. and Cobo, M. 1965 Effect of different plant densities on sum characters of branched varieties of sesame. Agron. Trop. Haracay 6(1): 3-14. [Field Crop Abst. 11(1): 52, 1958]

Mellroy, R.J.; 1967 and Masefield (1965);. An Introduction to TropicalCash Crops. Repr. 1967. Ibadan University Press.pp. 71-72.

Menon, E.P.;1967. Effect of varying spacing on yield of sesame. *Indian J. Agron.* 12 (3): 274-276. (Field Crop Abst. 22(1) : 80. 1969).

Mitra, S. and Pal, A. K. 1999. Water use and productivity or summer sesame as influenced by irrigation and nitrogen. *J. Indian Soc. Soil Sci.* 47(3): 400-404.

Mondal, D. K.; Sounda, G.; Panda, P. K.; Ghosh, P.; Maitra, S. and Roy, D. K. 1997. Effects of different irrigation levels and nitrogen doses on growth and yield of sesame (*Sesamum indicum L)* Indian Agriculturist. 41(I):15-21.

Nwokolo, E. 1987. Composition and availability of nutrients in some tropical grain and oil seeds. Nutri. Rep. int. 36(3): 63 1-640.

Narain, A. and Srivastave, R.N. 1962. A Note on Spacing trials of sesamum in *Indian J. Agron.* 7 (2): 133-135. Field crop Abst. 17(1): 56. 1976.

Olive, F.R and Cano, J.O, 1958. The influence of various spacing on the yield of different types of sesame Turrialba, 4(3-4): 143-146 Field Crop Abst. 9(1): 39. 1956

Om, P K, Singh, R S and Shulda, P C 2001 Effect of nitrogen on yield components and yield of sesame. *Indian J. Agril. Sci.* 41(3): 52-55.

Parihar, S. S.; Pandey, D. and Shukia, R. K. 1999. Response of summer sesame (*Sesamum indicum* L.) to irrigation schedule and nitrogen level in clay loam soil. Intl. *J. Trop. Agric.* 17(1-4): 189-193.

Pathak, A. B.: Shinidi, Y. M. and Jadhav, N.D. 2002. Influence of nitrogen levels and spacing on grain yield of sesame. *J. Maharashtra Agril. Univ.* 21(3):368-369.

Patil, R.K., Jadhav, K.S. and Panday, C. 1996. Yield and yield component of sesame as affected by variety and nitrogen. Indian Agriculturist. 39(1): 152-155.

Patra, A. K.; 2001. Yield and quality of sesame (*Sesamum indicum* L.) as influenced by N and P during post rainy season. Annal. Agril. Res. 22(2): 249-252.

Paul, I. K.; and Savithri, K.E. 2003. Effect of biofertilizer VS perfected chemical fertilization for sesame grown in summer rice fallow. *J. Trop. Agric.* 41(l&2): 47-49.

Prakasha, N. D. and Thimmegowda, S. 1992. Influence of irrigation, nitrogen and phosphorus level on sesame (*Sesamum indicum* L.). *Indian J. Agron.* 37(2):387-388.

Rahman, K. A., Allam, A. Y., Gala,A.H. and Bakry, B.A.2003.Response of sesame to sowing dates, nitrogen fertilization and plant populations in sandy soil. Assuit .*J. Agril. Sci.* 4(3):1-13.

Ravinder, N. Satyanarayana, V. Rao, V.P. Latchanna, A and Varaprasad, P.V. 1996. Influence of irrigation and nitrogen fertilization on seed yield, nutrient uptake and hrtilizer use efficiencies in summer sesame (*Sesamum indicum* L.). *J. Oilseed Res.* 13(2):173-177.

Serala, N.V. Gannathan, A. and Rajon, M. S. S. 2002. Influence of nitrogen and azospirillum on yield attributes and yield of sesame under dryland condition. *J. Res. ANGRAU.* 3 0(1)87-89.

Sharma, N. N. 1994. Response of sesame (*Sesamum indicum* L.) varieties to levels of nitrogen and spacing. Annal. Agril. Res. 15(1): 107-109.

Sharma, P.B. Prashar, K R.; Ambawatia, G. R. and Pillai, P. B. A. 1996. Response of sesame varieties to plant populations and nitrogen levels. *J. Oilseed Res.* 13(2): 214-225.

Shrivastava, G.K., Tripathi, R. S. 1992. Effect of irrigation, mulch and nitrogen levels on growth and yield of summer sesame *(Sesamum indicum). Indian J. Agron.* 37 (3): 602-604.

Singaravel, R. and Govindasamy, R. 1998. Effect of humic acid, nitrogen and biofertilizer on the growth and yield of sesame. *J. Oliseeds Res.* 15(2): 366-367.

Singh, A. and Meena, N.L 2003. Effects of nitrogen and sulphur levels on the oil and protein yield of mustard. Annals Agril. Res. 24(2): 368- 371.

Singh, V., Chauhan, Y. S., and Tripathi, N. K. and Singh, V. 1987. Comparative efficacy of levels of nitrogen and sulphur in production and biochemical values of til (*Sesamum indicum* L.)var. c-6. Res. Dev. Report. 4(2): 213-2 17.

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

Sujathamma, P., Reddy, D.S. and Reddy, B.S. 2003. Direct, residual and cumulative residual effect of nitrogen on yield parameter, yield and nitrogen uptake of sesame in rice-groundnut-sesame cropping system. Annal. Agril. Res. 24(3): 587-592.

Sumathi, V. and Jaganadhann. A. 1999. Effect of nitrogen levels on yield, dry matter and nitrogen uptake by sesame (*Sesamum indicum* L.) varieties. *J. Res. ANGRAL.* 27(3):63-66.

Thakur, D. S.; Patel, S. R., Nageshwar, L. and Lal, M. 1998. Yield and quality of sesame (*Sesamum indicum* L.) as influenced by nitrogen and phosphorus in light textured inceptisols. *Indian J. Agron.* 43(2): 325-328.

Throve, S. B.; Pathan, S. H. and Pol, P.S. 1997. Performance of sesame cultivar at different fertility levels under rainfed condition. *J. Oilseeds Res.* 14(1): 107-108.

Tiwari, K.P, Namdeo, K. N. and Patel, S. B.2000. Dry metter production and nutrient uptake of sesame *(S. indicum)* genotypes as influenced by planting geometry and nitrogen level. Crop Res. 12(3):291-293.

Tiwari, K.P, Namdeo, K. N., 1997.Response of sesame *(Sesamum indicum)* to planting geometry and nitrogen. *Indian J. Agron.* 42(2): 365-369.

Vijay, S. Chauhan, Y. S. Tripathi, N. K. and Singh, V. 1987. Comparative efficacy of levels of nitrogen and sulphur in production and biochemical values of Til (*Sesamum indicum* L.) var. C6. Res. and Dev. Repo. 4(2): 2 13-217.

Appendices

APPENDICES

Appendices I: Physical and chemical characteristic of initial soil (0-15 cm depth) before seed sowing

A. physical composition of soil

soil separates	%	Method employed
Sand	36.9	hydrometer method (Day, 2007)
Silt	26.4	-do-
Clay	36.33	-do-
Texture class	Sandy clay	-do-

B. Chemical composition of soil

Sl. No.	soil characteristics	Analytical data	Method employed
1	Organic carbon %	0.82	Walkey and Black 1947
2	Total N (kg/ha)	1790	Bremner and Lancster, 1965
3	Total S (ppm)	225	Bardsley and Lancster,1965
4	Total P (ppm)	840	Olsen and Sommers, 1982
5	Available N (kg/ha)	54	Bremner , 1965
6	Available P (kg/ha)	69	Olsen and Dean, 1982
7	Exchangeable k (kg/ha)	89.5	Pratt, 1965
8	Available S (ppm)	16	Hunter, 1984
9	pH (1:2.5 soil to water)	5.55	Jackson, 1958
10	CEC	11.23	Chapman, 1965

Appendices II: Monthly record of air temperature, rainfall and relative humidity during the period from April - June, 2007

Month	RH%	Air temperature (^{0}C)			Rainfall (mm)
		Max.	Min.	Mean	
April	83	30.5	25.5	29.5	630
May	84	33.5	24	28	520
June	82	31	23.5	27	465

Source: Bangladesh Meteorological Department (Climatic Division), Agargoan, Dhaka-1207.

Appendices III: Summary of analysis of variance of growth parameters of sesame

Source of variation	d.f.	Mean square				
		Plant height (cm) 30 DAS	Plant height (cm) 45 DAS	Plant height (cm) 60 DAS	Number of leaf per plant 30 DAS	Number of leaf per plant 60 DAS
R	2	20.069	139.862	97.711	1.878	284.098
N	3	294.848**	147.261**	28.359**	1.624^{NS}	77.892**
S	3	27.924**	50.011**	28.449**	0.912^{NS}	26.431**
N X S	9	69.864**	195.713**	47.775**	2.739^{NS}	89.61**
Error-I	6	43.83	93.049	63.154	0.474	46.85
Error-II	24	46.557	43.003	63.618	0.64	74.816
Total	47					

Note: ** = Significant at 1% levels,
NS= Non Significant,
R = Replication,
N = Nitrogen,
S = Spacing.

Appendices IV: Summary of analysis of variance of growth parameters of sesame

Source of variation	d.f.	Mean square						
		Stem	Leaf dry wt. at 30 DAS	Above ground dry wt. at 30 DAS	Stem dry wt. at 60 DAS	Leaf dry wt. at 60 DAS	Capsule dry wt. at 60 DAS	Above ground dry wt. at 60DAS
R	2	2.563	1.417	7.752	22.51	11.661	33.443	22.282
N	3	7.749**	3.97**	22.193**	21.906**	5.355**	62.072**	217.431**
S	3	2.316**	1.243**	47.778**	7.488**	26.573**	0.708**	114.443**
N X S	9	10.227**	14.958**	5.75**	22.048**	12.584**	38.684**	96.714**
Error-I	6	2.99	1.341	7.202	3.333	18.442	3.83	45.289
Error-II	24	2.919	2.6	9.719	9.849	11.688	17.868	52.63
Total	47							

Note: ** = Significant at 1% levels,
NS= Non Significant,
R = Replication,
N = Nitrogen,
S = Spacing.

Appendices V: Summary of analysis of variance of yield attributes of sesame

Source of variation	d.f.	Mean square			
		Number of branches per plant	Number of capsules per plant	Number of ds per see capsule	1000-seed weight (g)
R	2	0.114	34.714	8.94	0.107
N	3	0.288^{NS}	20.929**	182.242**	0.168
S	3	0.065^{NS}	49.989**	84.191**	0.256
N X S	9	0.029^{NS}	35.836**	19.707**	0.183
Error-I	6	0.051	17.578	13.484	0.267
Error-II	24	0.049	29.751	22.586	0.243
Total	47				

Note: ** = Significant at 1% levels,
NS= Non Significant,
R = Replication,
N = Nitrogen,
S = Spacing.

Appendices VI: Summary of analysis of variance of yield attributes of sesame

Source of variation	d.f.	Mean square			
		Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
R	2	100402.573	217220.132	564488.712	75.107
N	3	986464.208**	272628.032**	2240670.629**	235.728**
S	3	648.104**	101956.398**	423153.747**	36.211**
N X S	9	86233.789**	153024.252**	101028.543**	81.199**
Error-I	6	45830.567	41819.765	95770.801	70.093
Error-II	24	41921.095	36696.948	76056.009	62.164
Total	47				

Note: ** = Significant at 1% levels,
NS= Non Significant,
R = Replication,
N = Nitrogen,
S = Spacing.