EFFECT OF DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS ON YIELD AND YIELD ATTRIBUTES OF SESAME (*Sesamum indicum*)

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of different levels of nitrogen and phosphorus on yield and yield attributes of sesame (*Sesamum indicum*)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY**, embodies the result of a piece of bona fide research work carried out by Kaniz Fatima, Registration No. 00508 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 25/06/07
Dhaka, Bangladesh

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Abstract

An experiment was carried out to investigate the effect of nitrogen and phosphorus on the yield and yield attributes of sesame cv. BARI Til-2 at the Field Laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207. The experiment comprised four levels of nitrogen viz. no nitrogen (N_0), 30 kg N ha^{-1} (N_1), 45 kg N ha^{-1} (N_2), 60 kg N ha^{-1} (N_3) and four levels of phosphorus viz. no phosphorus (P_0), 60 kg P_2O_5 ha^{-1} (P_1), 70 kg P_2O_5 ha^{-1} (P_2) and 80 kg P_2O_5 ha^{-1}(P_3). The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. Results revealed that nitrogen significantly increased yield and yield contributing characters of sesame. Among the four levels of nitrogen the second highest level i.e. 45 kg N ha^{-1} performed best in obtaining the highest values in almost all the parameters such as Number of branches $plant^{-1}$(2.29), Number of capsule $plant^{-1}$(33.82), length of capsule (2.32 cm), Number of seeds $capsule^{-1}$(65.02), seed yield $plant^{-1}$(4.179), seed yield ha^{-1}(1316.67 kg). Phosphorus also showed significant effect on yield and yield attributes of sesame. Like nitrogen phosphorus at the second highest level i.e. 70 kg P_2O_5 ha^{-1}produced the highest values in all the studied parameters except the height of plant. The lowest values in the studied parameters were obtained from the control treatment. Combined effect of nitrogen and phosphorus also showed significant effect on yield and yield attributes except number of capsules $plant^{-1}$ and 1000 seed weight. Nitrogen at the rate of 45 kg ha^{-1} with 70 kg P_2O_5 ha^{-1} produced the highest values in the studied parameters and in the interaction effect lowest values were obtained from the control treatment combination.

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ACRONYMS

%	=	Percent
°C	=	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.	=	and others
etc.	=	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
L_n	=	Natural logarithum
LYV	=	Low Yielding variety
m^2	=	meter square
mm	=	millimeter
N	=	Nitrogen
N_0	=	Number
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

Sesame (*Sesamum indicum* L.) belongs to the family Pedaliaceae. It is an important oil crop, extensively grown in different parts of the world. Locally it is known as 'Til' which is one of the oldest cultivated oil crops. It is basically a crop of the tropics and sub-tropics. It ranks 4th among the oil crops in the world. The world production of sesame is 2.9 million mt (FAO, 2003). India is the world's major sesame producer with a third of the world average and approximately a quarter of the total production (Balasurbramanian and Palaniappan, 1999). The leading sesame producing countries are India, Sudan, Nigeria, Uganda, Egypt, Pakistan, USA, China, Chad, Morocco and Bangladesh. The total area of sesame cultivation is 690 thousand acres and production is 21 thousand mt (BBS, 2004). In Bangladesh, it ranks third in terms of area and fifth in terms of production among the oil crops (BBS, 2003). In Bangladesh, the crop can be cultivated both in *kharif* and autumn seasons but two third of sesame is produced in *kharif* seasons of the year. Faridpur, Khulna, Pabna, Barisal, Comilla, Rajshahi, Jessore, Feni, Rangpur, Sylhet and Mymensingh are the leading sesame producing areas of Bangladesh (BARI, 1999). The national average seed yield is 616 kg ha^{-1} (FAO, 1988), which is too low compared to other sesame producing countries of the world. The potential yield (1200-1400 kg ha^{-1}) of sesame is much higher than the average yield.

Sesame is rich in oil (42-45%), 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 is the second largest source of edible oil in Bangladesh (Kaul, 1986). The oil is odourless, colorless and remains liquid at low temperature. In Japan, it is an important domestic and commercial cooking oil and has many additional uses. In Bangladesh and in various parts of Indian subcontinent, sesame seeds are used in baking and sweet making in many forms. It also meets the other purpose such as margarine manufacture, use as lubricant for vehicle, disposing agent with insecticide, soap, paint, perfumery industry and in pharmaceuticals as an ingredient of drugs. Sesame oil is also used as hair oil in Bangladesh.

Bangladesh is highly deficit in edible oil. A large number of oil seed crops are grown in the country but the level of yield is generally low. Every year a large amount of foreign currency is being drained out for importing oil. 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 day by day due to rapid growth of population. Until the production is maximized in the country this condition will continue. Sesame is water sensitive but drought tolerant crops. It can be grown successfully in sandy to silty textured soil under rainfed condition. Yield of sesame is very low in Bangladesh in comparison to other countries. The main reasons for low yield of sesame in Bangladesh are various biotic and abiotic stresses, lack of high yielding varieties, lack of proper management and use of low levels of inputs. Poor photosynthetic efficiency and unfavorable partitioning of the photosynthates to the reproductive plant parts might be another reason for low yield. The yield difference between potential and actual yield indicates wide scope of increasing the productivity of sesame through adoption of high yielding varieties, crop rotation, application of fertilizer especially nitrogen and phosphorus.

Improved agronomic practices to raise the yield and quality of oil seed crops are required to be determined. Fertilizer dozes and seed rates for mustard and sunflower and phosphorus requirements for groundnut have been determined. However, research on sesame, soybean and other minor oil crops is till scanty in Bangladesh.

Nitrogen and phosphorus are two key nutrient elements to influence the seed yield. Nitrogen is one of the important nutrient elements 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 developing living tissues and thereby enhances the seed yield. But it is unfortunate that nitrogen content of Bangladesh soil is very low and supplementation of nitrogenous fertilizer is essential for better oil seed production.

Phosphorus is an important nutrient for all crops in general. It is a key constituent of ATP and it plays a significant role in the energy transformation in plants (Sankar *et al.* 1984) and also in various physiological processes (Sivasankar *et al.* 1982). Phosphorus plays a vital role in seed formation and its quality improvement. Sesame responds favorably to phosphorus application in a variety of soil. An adequate supply of phosphorus is needed during the growing period of sesame for maximizing yield (Esho and Shekin, 1993). Deshmukh *et al.* (1990) reported that phosphorus played a beneficial role in sesame growth by promoting root development and thereby ensuring a good seed yield.

However, systematic and comprehensive research effort on fertilization with nitrogen & phosphorus fertilizer to explore the yield potential in sesame is inadequate and sporadic. So an experiment was undertaken to investigate the effect of different level of nitrogen and phosphorus on the yield and yield attributes of sesame.

Objectives of the research:

i. To determine the optimum dose of nitrogen for sesame,

ii. To determine the optimum dose of phosphorus for sesame, and

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

Chapter 2

REVIEW OF LITERATURE

A huge number of research works have been carried out on various aspects of management practices for higher productivity of sesame. Still intensive research on improving its yield and quality is in progress. Yield and yield attributing characters of sesame are complex character and these 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 phosphorus fertilization are important for the production of sesame. The information available on this area generated from different studies have been reviewed in this chapter.

2.1 Effect of phosphorus

Plant nutrient especially phosphorus is a key input to increase productivity. Sesame responds favorably to phosphorus application in a variety of soil. Phosphorus application increases yield and yield attributing characters of sesame. Zaidi and Khan (1981) reported that seed yields of sesame were found to increase by 81, 106 and 175 kg ha^{-1} by the application of 183 kg super phosphate along with 72 kg urea and 165 nitrophos ha^{-1}respectively.

Seo *et al.* (1986) conducted a field trial with sesame and reported that seed yield (1.01 t ha^{-1}) was the highest with 80 kg P_2O_5 ha^{-1} along with 80 kg N and 180 kg K_2O ha^{-1}.

In India Jain *et al.* (1989) carried out a field experiment during the early rainy summer season. They found that increasing phosphorus rate from 0 to 15 and 30 kg P_2O_5 ha^{-1} increased average seed yields of sesame from 1.16 to1.43 t ha-1, respectively. Pauste and Maiti (1990) also obtained 725, 829, and 854 kg seed ha^{-1} with 0, 40 and 80 kg P_2O_5 ha^{-1}, respectively.

Deshmukh *et al.* (1990) carried out a field experiment in India on four phosphorus levels 0, 25, 50 and 75 kg ha^{-1} on sesame crop. They observed that rate of 75 kg P_2O_5 ha^{-1} significantly increased number of capsules $plant^{-1}$ and seed yield.

Prakasha and Thimmegowda (1992) conducted field trial with sesame grown with 25 and 50 kg P_2O_5 ha^{-1} during the early rainy season of 1987. They reported that application of 50 kg P_2O_5 ha^{-1} increased the number of capsules $plant^{-1}$, seeds $capsule^{-1}$ and seed yield. Maiti and Jana (1985) also found similar results.

In the study Ashok *et al.* (1992) opined that optimum phosphorus rate for sesame production appeared to be 50 kg P_2O_5 ha^{-1}. Dwivedi and Namdeo (1992) conducted an experiment in India on sesame with different rates of phosphorus 0, 15 and 30 kg P_2O_5 ha^{-1}. They stated that application of 30 kg P_2O_5 ha^{-1} increased seed yield significantly over no phosphorus application.

Behera *et al.* (1994) conducted a field trial on sesame growth with 0-45kg P_2O_5 ha^{-1}. They noticed that application of phosphorus up to 45 kg ha^{-1} increased number of capsules $plant^{-1}$ and seed yield significantly over the control. Application of 37.5 kg

P_2O_5 ha^{-1} increased yield attributes and yield of sesame in the experiment of Throve *et al.* (1997).

An experiment on sesame was conducted by Mahalonabis *et al.* (1999) with different phosphorus levels 0, 25 and 50 kg P_2O_5 ha^{-1}. They found that the dose of 50 kg P_2O_5 ha^{-1} was most effective in increasing the number of capsule $plant^{-1}$, seeds $capsule^{-1}$ and seed yield.

Kalita *et al.* (1994) conducted a field experiment at Gossaigaon, Assam in the 1988-90 winter seasons on sesame cv. TC 25. They stated that yield of sesame was highest with 40 kg P_2O_5.

In Bangladesh, Ali *et al.* (1997) carried out a field experiment during the *kharif* season. They responded that number of branches $plant^{-1}$, capsule $plant^{-1}$ and seed yield ha^{-1} were significantly improved by phosphorus application up to 60 kg P_2O_5 and it was statistically identical with 40 kg P_2O_5 ha^{-1}. Such type of variable response of sesame to phosphorus application has also been demonstrated by Sangar and Roy (1984).

Phosphorus plays a beneficial role in increasing the yield as well as oil in sesame. Pawar *et al.* (1993) reported that application of 60 kg P_2O_5 ha^{-1} increased seed oil content of sesame. Mankar *et al.* (1995) also reported that application of kg P_2O_5 up to 50 kg ha^{-1} increased the oil content in sesame seeds over the control. Thakur *et al.* (1998) noticed that addition of 30 kg P_2O_5 ha^{-1} resulted in significant increase in the seed oil yield of sesame.

2.2 Effect of nitrogen

Rahman *et al.* (2003) conducted an experiment on response of sesame to sowing dates, nitrogen fertilizer and plant population in sandy soil to investigate the effects of sowing dates (10 & 25 May and 10 June), N fertilizer rate (60,80 and 100 kg feedan^{-1} and plant population 70000, 35000, 235000 plants feddan^{-1}) on the performance of sesame cv.Giga32. The height of the first branch and first capsule as well as the length of the fruiting zone was highest at 60 kg N feddan^{-1}.

Malik *et al.* (2003) in a study observed the effects of different nitrogen levels (0, 40 and 80 kg ha$_{-1}$) on the productivity of sesame cv. TS-3 in Faisalabad, Pakistan under different plant geometries and shown that 80 kg N ha^{-1} produced the highest seed yield (.079 t ha^{-1}), 1000 seed weight (3.42 g) , oil content (45.88 %) and protein content.

Vijan *et al.* (1987) found that application of nitrogen at 40 kg ha^{-1} to sesame cv. C-6 increased seed yield from 0.73 to 0.98 t ha^{-1}, seed oil content from 48.1 to 56.3% and protein content from 19.4 to 20.9%, further increases in nitrogen rate to 120 kg ha^{-1} produced linear increase in protein contents but had no effect on other parameters.

Kumar and Prasad (1993) in a field trial found that seed yield of sesame increased with nitrogen fertilizer rate from 0.13 t ha^{-1} (without nitrogen) to 0.92 t ha$_{-1}$ with 90 kg N ha^{-1} but seed oil concentration was highest (47%) with 30 kg N ha^{-1} and after this oil content was in decreasing trend.

Kadam (1989) stated that application of nitrogen (of 0, 25 or 50 kg N ha^{-1}) to sesame cultivars increased seed yield with increasing nitrogen rates up to highest levels while seed oil content decreased.

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

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

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 ha-1 and found that 45 kg N ha^{-1} and 30 kg P ha^{-1} is suitable for optimum yield.

Dwivedi and Namdeo (1992) observed in a field experiment in the monsoon season of 1987-89 on clay loam soil at Madhya Pradesh, India; seed yield of sesame cv. JT-7 increased with up to 30 kg N. after or before of this rate seed yield and economic returns decreased.

Shrivastava and Tripathi (1992) in a field experiment 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}.

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 60 kg N ha^{-1}. It was also observed that high dose of nitrogen increased the susceptibility of sesame plant to water stagnant.

Jadhav *et al*. (1992) stated that seed yield and protein content of sesame increased with increasing nitrogen rate up to 120 kg ha^{-1} in sesame variety cv. Punjab 1. But higher nitrogen dose increased the susceptibility to Fusarium.

Mondol *et al*. (1997) conducted a 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, dry matter accumulation, number of capsules $plant^{-1}$, number of capsules $plant^{-1}$, number of seeds $capsules^{-1}$, 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.

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, braches plant-1, capsule $plant^{-1}$, seeds $capsule^{-1}$, capsule length, 1000 seed weight and seed yield 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 60 kg ha^{-1}. Harvest index was not significantly affected by N application.

Ahmed *et al.* (2001) carried out a field experiment during the summer season of 1996-97 in Pakistan to study the response of sesame genotypes (92001 and TS3) to different rates of nitrogen (0, 40, 80 and 120 kg ha^{-1}). Application of nitrogen at 120 kg ha^{-1} significantly increased the seed and stalks yield, protein and oil content of cv. TS3 than in 92001.

Ravinder *et al.* (1996) stated that the seed yield of sesame was highest with 100 kg N ha^{-1}. Uptakes of nitrogen, phosphorus and potassium were positively correlated with yield.

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 plant height (74.3 cm), number of branches $plant^{-1}$ (4.50), number of capsules $plant^{-1}$ (39.0 cm) and 1000 grain weight (2.91 g). N at 45 kg ha^{-1} also recorded the highest values for seed yield (6.95 and 7.25 q ha^{-1}).

Om *et al.* (2001) conducted a field experiment in Uttar Pradesh, India with four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}) on sesame. They stated that application of 90 kg N ha^{-1} yielded highest number of capsules $plant^{-1}$, seeds $capsules^{-1}$, 1000 seed weight, seed yield, straw yield and harvest index.

Awad *et al.* (1997) observed that sesame cv. Giza 25 yielded significantly highest seed yield and oil yield with 45 kg N feddan^{-1} (1 feddan =0.42 ha).

Dixit *et al.* (1997) stated that the productivity of sesame cv. TC-25 and Rauss-17 significantly increased by nitrogen dose. Application of nitrogen up to 60 kg ha^{-1} increased seed yield significantly and gave highest net profit.

Sharma *et al.* (1996) in a field experiment observed that sesame cv. FC-25 produced higher plant height, number of capsule plant^{-1}, seed capsule^{-1}, seed yield and straw yield than TC-25 (329.2-259.2 kg). Mean seed yield increased up to 60 kg N ha^{-1}.

Tiwari and Namdeo (1997) observed that application of nitrogen at the rate of 90 kg ha^{-1} produced the highest seed yield. Seed oil content were also increased with increasing nitrogen rate.

Serala *et al.* (2002) conducted an experiment in Tirupati, Andhra Pradesh, India to determine the effects of nitrogen on the yield and yield components of sesame under dry land conditions. Nitrogen at 60 kg ha^{-1} recoded more number of capsule and seeds per capsule which was at per with 45 kg N ha^{-1} + Azospirillum treatment. The highest seed yield was obtained with application of 60 kg N ha^{-1}, which was at per with 45 kg N ha^{-1} + Azospirillum.

Patil *et al.* (1996) in a field experiment found that sesame cv. Padma produced highest mean seed yield and net returns at the rate of 50 kg N ha^{-1}.

Imayavaramban *et al.* (2002) evaluated the productivity of sesame as influenced by nitrogen level with or without Azospirillum inoculation in Tamil Nadu, India. They observed that application of an extra 25% of nitrogen than the recommended in combination with seed inoculation with Azospirillum significantly increased the seed yield, net income and benefit cost ratio.

Thakur *et al.* (1998) conducted an experiment at Raigarh, Madhya Pradesh in rainy seasons, sesame cv. Gujrat 1 was given 30, 45 or 60 kg N and 20, 30 or 40 kg P_2O_5 ha^{-1}. Seed yield and oil yields increased significantly with up to 45 kg N and 30 kg P_2O_5 ha^{-1}.

Sharma *et al.* (1993) in a field experiment in sesame cv. C7, TC 25, and Vinayak, used four levels of nitrogen (0, 15, 30 or 45 kg N ha^{-1}) in Diphu, Assam. They stated that seed yields increased with increasing N rate.

Allam (2002) in a field study evaluated the effects of gypsum (0, 500 and 1000 kg $feddan^{-1}$) and nitrogen (45, 60 and 75 kg $feddan^{-1}$) rates on sesame cv. Giza 32. Gypsum was applied during sowing and 55 days after sowing and nitrogen was applied after thinning and 3 weeks thereafter. He found that increasing gypsum and nitrogen rates increased plant height, length of fruiting zone, number of oil percentage of sesame. Seed yield and capsule length were highest with 60 and 75 kg N $feddan^{-1}$.

Seed yield per plant was positively correlated with plant height, fruiting zone, number of branches and capsule number. The number of capsules was positively correlated with the number of branches. Plant height showed a positive correlation with first capsule height, fruiting zone length, seed yield per plant $feddan^{-1}$ and seed index. First capsule height was positively correlated with seed index and seed yield feddan^{-1}. Capsule number was negatively correlated with seed index.

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 lower nutrient level.

Paul and Savithri (2003) undertook a study to evaluate the possibility of using biofertilizer either alone or as supplements to chemical fertilizer for sesame cv. Thalak 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 Azospirillum or Azotobacter each at 600 g ha^{-1} along with 25% or 50% nitrogen, either with or without lime at 600 kg ha^{-1} and an absolute control. The plots that received the recommended dose of nitrogen (30 kg N ha^{-1}) alone produced the tallest plants with the highest number of branches plant^{-1} and dry matter. The highest number of capsule plant$_{-1}$, number of seed capsule^{-1} and seed yield also found when 30 kg N ha^{-1} was applied.

Sujathamma *et al.* (2003) conducted an experiment on the direct and residual effects of N fertilizer in rice-groundnut-sesame cropping system and found that the 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 (30 kg N ha^{-1}). They found that, the number of capsule $plant^{-1}$, seed and stalk yield of sesame was highest in case of 60 kg N ha^{-1} (100% recommended dose) and application of nitrogen a green manure (50%) + FYM (50%) but highest number of seeds $capsule^{-1}$ and 1000 seed weight were obtained with the application of 100% of the recommended dose.

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}.

Tiwari *et al.* (2000) in a field experiment nitrogen (15, 30 or 60 kg ha^{-1}) and sulphur (0, 15 or 30 kg ha^{-1}) were applied to sesame varieties (TKG21, TKG22 and Rs226) in Madhaya Pradesh, India to investigate optimum dose of nitrogen and sulphur. They found that significant improvement in growth and yield (plant height, number of seeds $capsule^{-1}$, 1000 seed weight and straw yield) was observed for nitrogen at 60 kg ha^{-1} compared with 15 kg ha^{-1}.

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 yield and yield component values: plant height, number of branches $plant^{-1}$, number of capsule $plant^{-1}$, number of seed $capsule^{-1}$ increased with increasing nitrogen rate.

Parihar *et al.* (1999) in a field experiment on clay loam soil observed that yield of sesame (*S. indicum* L.) increased with increasing nitrogen rate up to 80 kg ha^{-1}.

Sumathi and Jaganadham (1999) stated that among four cultivars of sesame cv. Madhavi produced the highest seed yield in a trial. Seed yield of all varieties increased up to 60 kg N ha^{-1} and further increase in nitrogen rate the yield was not increased significantly.

Singh *et al.* (1997) in a field experiment on a sandy clay loam soil Madhya Pradesh, India found that sesame (cv. JT7) performed better in terms of mean seed yield and net returns with 10 t ha^{-1} poultry manure alone than 40, 80 or 120 kg N ha^{-1} or combination of 10 ton poultry manure with them.

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

On the basis of the findings presented in this review of literature, it is clear that seed yield and yield attributing characters of sesame is influenced by nitrogen and phosphorus fertilization.

Chapter 3

MATERIALS AND METHODS

The experiment was carried out during the period from mid August to mid November 2006 at the Agricultural Field Laboratory, Sher-e-Bangla Agricultural University, Dhaka. The experiment was designed to study the performance of sesame under different nitrogen and phosphorus level.

3.1 Description of the experimental site

3.1.1 Site and soil

The experiment was conducted at the Field Laboratory, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 that lies between $90^0 22'$ longitude and $23^0 41'$ N latitude at an altitude of 8.6 meters above the sea level. The land belongs to the Agro-ecological zone of ''Madhupur Tract'' (AEZ 28) of Nodda soil series. The topography is high and the soil texture is silty loam having P^H 5.47-5.63. The chemical and physical characteristics of the experimental soil have been presented in Appendix II.

3.1.2 Climate and weather

The climate of the locality is sub tropical. The climate is characterized by high temperature and heavy rainfall during *kharif* season (march-september) and scanty rainfall in rabi season. The prevailing weather data during the study period have been presented in Appendix ii.

3.2 Experimental design and layout

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

3.3 Planting Materials

The variety BARI Til-2 was used as the test crop. The seeds were collected from the Oil Seed Division of Bangladesh Agricultural Research Institute, Joydevpur, Gajipur. BARI Til-2 is a recommended variety of sesame, which was developed by the national seed board in 2001. It grows both in kharif and rabi season.

The salient features of the variety are:

- Plant height is 100-120 cm
- Leaves are green and broad, upper leaves are narrow
- Seeds are black colors
- Flowers are light rosy colors
- Soil salinity tolerance is medium (6-7 ds/m)
- Life cycle is 90-100 days
- Capsule $plant^{-1}$ are 60-70
- Seeds $capsule^{-1}$ are 60-70
- Average yield is 1200-1400 kg ha^{-1}

3.4 Treatments under study

There were two factors viz. Nitrogen and Phosphorus

A. Nitrogen level : 4

1. No nitrogen (N_0) i.e control
2. 30 kg N ha^{-1} (N_1)
3. 45 kg N ha^{-1} (N_2)
4. 60 kg N ha^{-1} (N_3)

B. Phosphorus level : 4

1. No phosphorus (P_0) i.e control
2. 60 kg P_2O_5 ha^{-1}(P_1)
3. 70 kg P_2O_5 ha^{-1}(P_2)
4. 80 kg P_2O_5 ha^{-1}(P_3)

Combination of the treatment

1. No nitrogen and no phosphorus i.e control (N_0P_0)
2. O kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} (N_0P_1)
3. O kg N ha^{-1} + 70 kg P_2O_5 ha^{-1} (N_0P_2)
4. O kg N ha^{-1} + 80 kg P_2O_5 ha^{-1} (N_0P_3)
5. 30 kg N ha^{-1}+ O kg P_2O_5 ha^{-1} (N_1P_0)
6. 30 kg N ha^{-1}+ 60 kg P_2O_5 ha^{-1} (N_1P_1)
7. 30 kg N ha^{-1}+ 70 kg P_2O_5 ha^{-1} (N_1P_2)
8. 30 kg N ha^{-1}+ 80 kg P_2O_5 ha^{-1} (N_1P_3)

9. 45 kg N ha^{-1}+ O kg P_2O_5 ha^{-1} (N_2P_0)

10. 45 kg N ha^{-1}+ 60 kg P_2O_5 ha^{-1} (N_2P_1)

11. 45 kg N ha^{-1}+ 70 kg P_2O_5 ha^{-1} (N_2P_2)

12. 45 kg N ha^{-1}+ 80 kg P_2O_5 ha^{-1} (N_2P_3)

13. 60 kg N ha^{-1}+ O kg P_2O_5 ha^{-1} (N_3P_0)

14. 60 kg N ha^{-1}+ 60 kg P_2O_5 ha^{-1} (N_3P_1)

15. 60 kg N ha^{-1}+ 70 kg P_2O_5 ha^{-1} (N_3P_2)

16. 60 kg N ha^{-1}+ 80 kg P_2O_5 ha^{-1} (N_3P_3)

3.5 Land preparation

The experimental land was first opened on 7 August, 2006 using a power tiller and subsequently three ploughing with country plough were done followed by laddering to obtain the desirable tilth. The land was prepared by removing all uprooted weeds, stubble and residues and trimming ails. The land was leveled by tractor drawn leveler.

3.6 Fertilizer application

Cowdung was applied at the rate of 10 t ha^{-1} during land preparation. Other fertilizers were applied at the rate of 50 K_2O, 110 kg S, 5 kg Zn and 10 kg B ha^{-1} in the form of muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Nitrogen and phosphorus was applied as per treatment in the form of urea and triple super phosphate. Half of the urea and all other fertilizers were applied during final land preparation. The remaining amount of urea was applied as top-dressing at 30 days after sowing.

3.7 Germination test

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

3.8 Seed rate and sowing

The seeds were sown at the rate of 8 kg ha^{-1} by hand on 14 August 2006. Seeds were treated with vitavex-200 at the rate of 2.5 g kg^{-1} of seeds before sowing. Finally on prepared land, small furrows of approximately 5 cm depth were made by hand rake along the desired row just before sowing. Row to row distance was 30 cm. The recommended plant distance of 5 cm was maintained by thinning plants at 13 DAE. After placement of seeds in the furrow, seeds were covered with soil by hand.

3.9 Intercultural operations

3.9.1 Weeding and thinning

Two times weeding were done manually at 15 and 30 days after sowing using niri. Drainage operation for draining out of rain water was done as and when required for proper growth and development of crop.

3.9.2 Irrigation and drainage

One pre-sowing irrigation was done before 1 week of seed sowing for good germination. Further no irrigation was given as there was rainfall during experimentation. Sometimes there was excess water which was drained out.

3.9.3 Pest management

To protect the seedlings from the attack of cutworm and aphid a systemic insecticide Diazinon was applied at the rate of 2.5% liter water^{-1}.

3.10 General observation

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

3.11 Harvesting and sampling

The crop was harvested on 17 November 2006. The crop was harvested plot-wise when about 80% of the capsules became mature. Before harvesting ten plants are selected randomly from each plot and tagged. After harvesting, the plants were bundled, tagged properly and brought to the threshing floor. The bundles were dried in open sunshine for 3 days. The seeds and stover were then separated, cleaned and dried in the sun for 3 to 4 consecutive days for achieving safe moisture of seed.

3.12 Threshing, drying, cleaning and weighing

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

3.13 Collection of data

Data were collected from ten randomly selected plants from each unit plot on the following yield and yield attributes parameters.

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

3.14 Outline of the data recording

A brief outline of the data recording is given below-

Plant height (cm)

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

Number of branches plant^{-1}

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

Number of capsule plant^{-1}

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

Number of seeds capsule^{-1}

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

Length of the capsule (cm)

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

1000-seed weight (g)

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

Seed yield (kg ha^{-1})

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

Stover yield (kg ha^{-1})

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

Biological yield (kg ha^{-1})

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

Harvest index (%)

Harvest index was determined by the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.15 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique and the mean differences were compared by Least Significant Difference (LSD) using a computer operated programmed named MSTAT.

Chapter 4

RESULTS AND DISCUSSION

The experiment was conducted to evaluate the effect of nitrogen and phosphorus on yield and yield attributes of sesame. The parameters studied were plant height, no. of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, length of capsule, 1000 seed weight, seed yield plant^{-1}, stover yield, biological yield and harvest index. Results of the experiment have been presented in Tables 1 & 2. 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 appendix (IV & V).The results have been presented and discussed characterize as below

4.1 Plant height

4.1.1 Effect of nitrogen

The prime nutrient element nitrogen had a significant effect on plant height of sesame (Appendix IV). Plant height increased with the increased rate of nitrogen (Fig 1). The tallest plant of 117.68 cm was observed from 60 kg N ha^{-1} which was significantly different from second highest plant of 111.94 cm obtained from 45 kg N ha^{-1}. The lowest plant height of 98.49 cm was recorded from control. Increased height might be due to higher availability and uptake of nitrogen which progressively enhanced the vegetative growth of the plant. Similar effect of nitrogen on plant height was also observed by Pathak *et al.* (2002), Patra (2001) and Allam (2002).

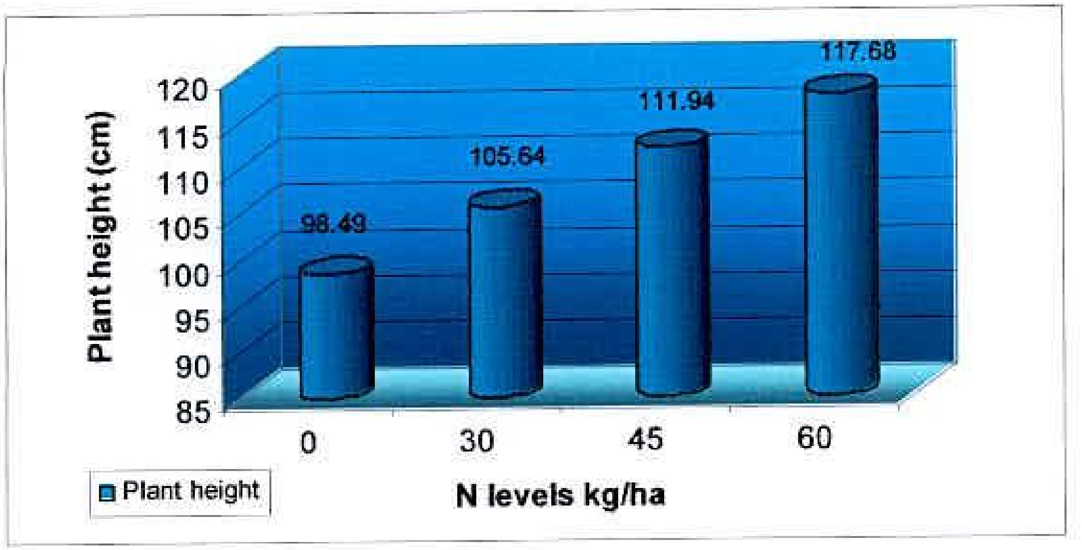


Fig. 1 Plant height of sesame at harvest as affected by different nitrogen levels (LSD 0.05= 1.57)

4.1.2 Effect of phosphorus

The level of phosphorus fertilizer had significant influence on plant height (Fig. 2). The tallest plant of 114.61 cm was observed from 80 kg P ha^{-1} which was significantly different from the second plant height of 112.38 cm obtained from the treatment P_2 (70 kg P_2O_5 ha^{-1}). Plants grown without phosphorus gave statistically the shortest plant height of 100.39 cm while treatment P_1 (60 kg P_2O_5 ha^{-1}) produced plant height of 106.4 cm which was statistically lower then that of P_2 treatment. Chaplot (1996) observed similar findings.

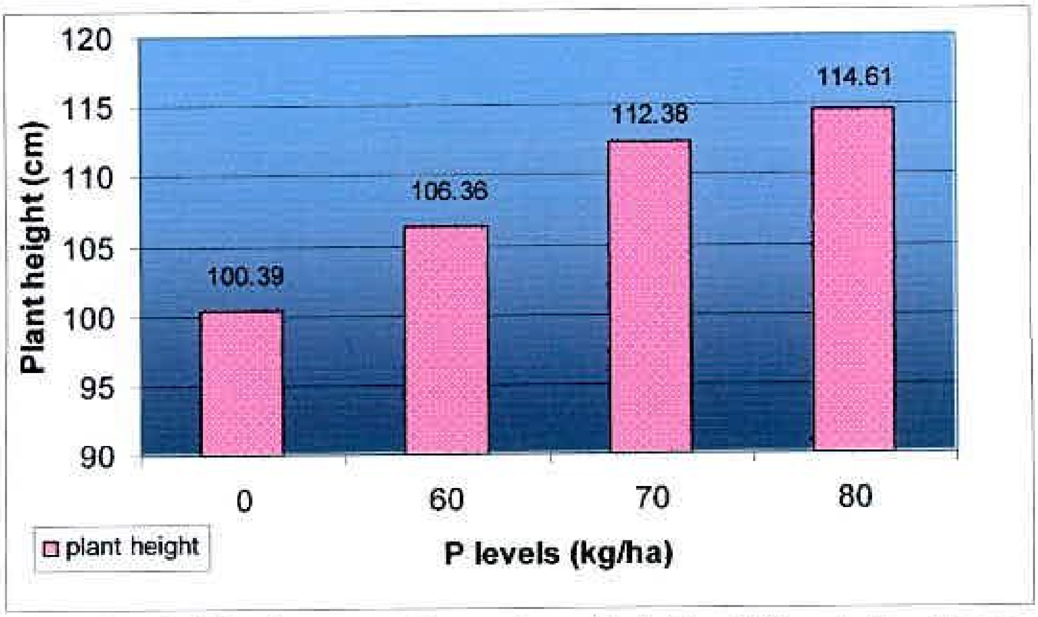


Fig. 2 Plant height of sesame at harvest as affected by different phosphorus levels (LSD 0.05 =1.57)

4.1.3 Combined effect of nitrogen and phosphorus

The interaction effect of different levels of nitrogen and phosphorus under study showed significant variation on height of sesame plants (Fig 3). Combination of 60 kg N ha^{-1} and 70 kg P_2O_5 ha^{-1} produced the tallest plant of 123.6 cm which was statistically similar to 122.9 cm (N_3P_3) and 120.5 cm (N_2P_3) but was significantly higher than the rest values of plant height. The treatment of (45 kg N x 70 kg P_2O_5) produced the plant height (117.6 cm) which was significantly lower than 123.59 cm, 122.94 cm and 120.54 cm but was similar to 120.20 cm and was higher than the rest treatments of different combinations. The lowest plant height (95.52 cm) was obtained from the treatment combination of control treatment T_1 (N_0P_0). Like individual effect of nutrient on plant height, combination of higher level of nutrients made tallest plant and control treatment combinations gave significantly the lowest plant height.

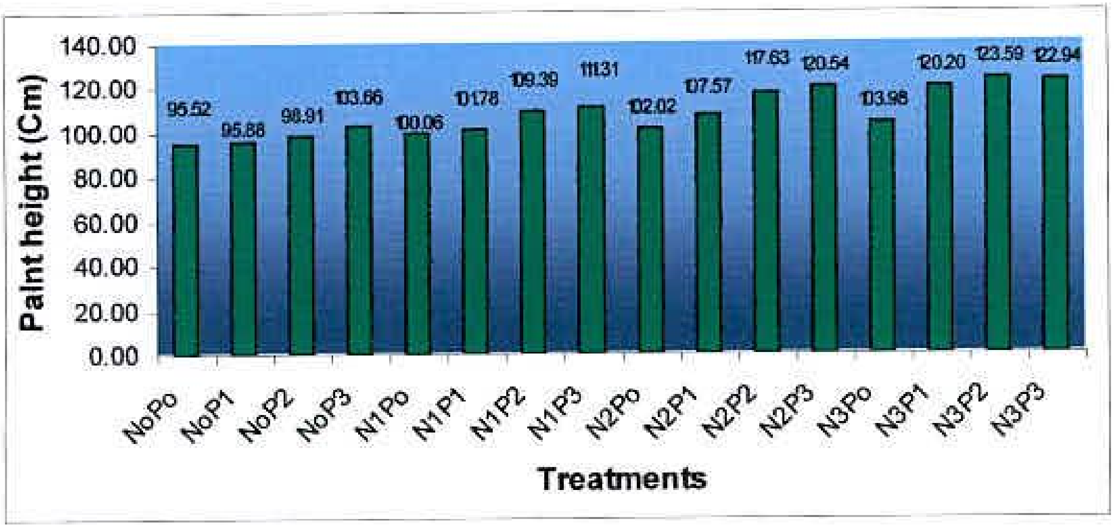


Fig. 3 Interaction effect of nitrogen and phosphorus levels on the plant height of sesame at harvest (LSD 0.05= 3.14)

4.2 Number of branches plant^{-1}

4.2.1 Effect of nitrogen

N fertilizer had a significant effect on number of branch plant^{-1}. The highest number of branch plant $^{-1}$ (2.29) was recorded from the treatment of nitrogen at 45 kg N ha^{-1} which was statistically similar with that of second highest (2.24) treatment of 60kg N ha^{-1}. The minimum number of branch plant $^{-1}$ was produced by control treatment (Fig. 4). It is evident from the result that application of nitrogen with increasing rates increased number of branch plant^{-1}. Sinharoy *et al.* (1990), Thakur *et al.* (1993), Mondol *et al.* (1997), Pathak *et al.* (2002), Patra *et al.* (2001) and Subrahmaniyan, Arulmozhj (1999) reported that 45 kg N ha^{-1} increased number of primary branches plant $^{-1}$.

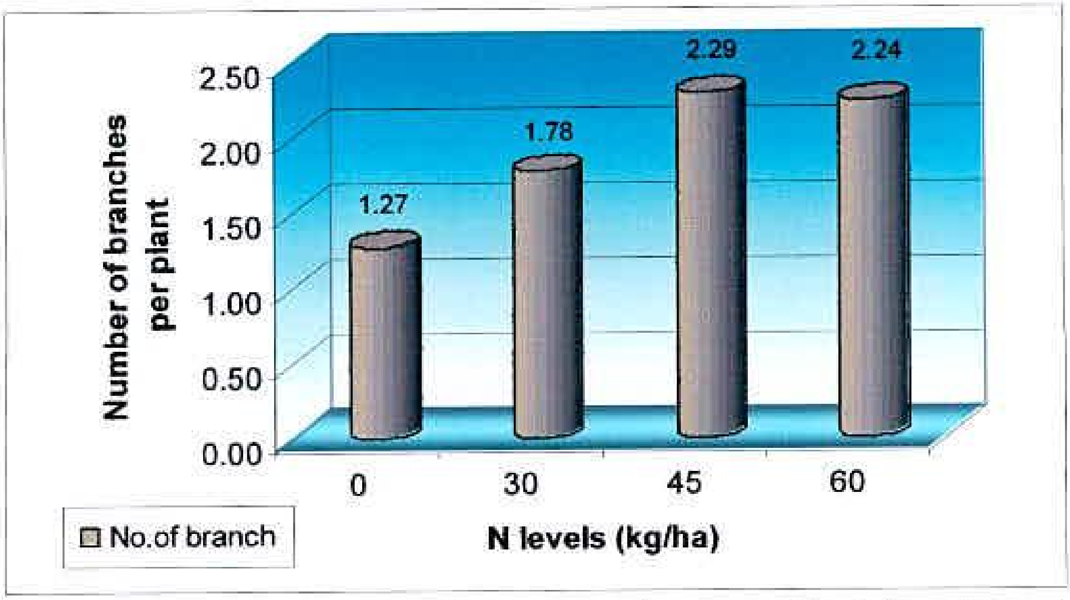


Fig. 4 Number of branches plant^{-1} of sesame at harvest as affected by different nitrogen levels (LSD 0.05=0.14)

4.2.2 Effect of phosphorus

Phosphorus had significant effect on number of branches plant^{-1}. The highest number of branches plant^{-1} (2.12) was recorded from the treatment of phosphorus at 70 kg P_2O_5 ha^{-1} which was statistically similar with that of second highest number of branches plant^{-1} (2.02) obtained from the treatment of 80 kg P_2O_5 ha^{-1}. The minimum number of branches plant^{-1} was produced by control treatment (Fig. 5). Ali. *et al.* (1997) in Bangladesh got the significant response of phosphorus application upto 60 kg P_2O_5 in branch plant^{-1}, capsule plant^{-1} and seed yield ha^{-1}. It is evident from the result that application of phosphorus with increasing rates increased branches plant^{-1}. Satyanarayan *et al.* (1996) also observed that with the increase of phosphorus yield and yield attributes of sesame increased.

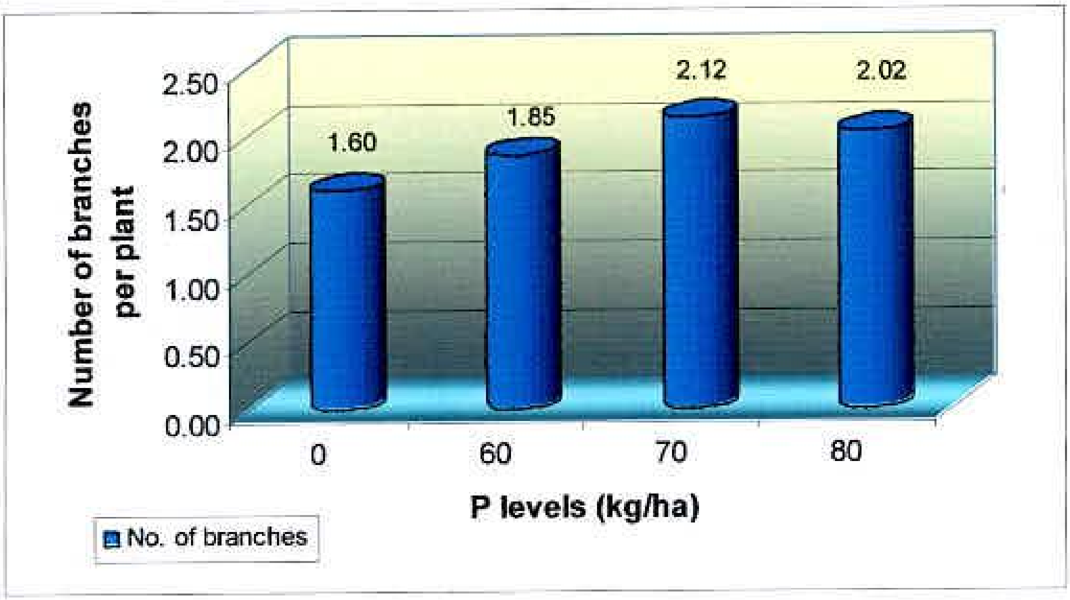


Fig. 5 Number of branches plant^{-1} at harvest as affected by different phosphorus levels (LSD 0.05 = 0.14)

4.2.3 Combined effect of nitrogen and phosphorus

Interaction effect of different levels of nitrogen and phosphorus under study caused significant variation in sesame plant on number of branches plant $^{-1}$ as revealed from (Appendix IV). It is revealed from the Fig. 6 that treatment of 30 kg N x 60 kg P_2O_5 produced the highest number of branches plant^{-1} (2.43) which was statistically similar to 45 kg N x 80 kg P_2O_5 (2.40), 60 kg N x 60 kg P_2O_5 (2.35), 60 N x 70 kg P_2O_5(2.33), 45 kg N x 60 kg P_2O_5 (2.28), 30 kg N x 70 kg P_2O_5 (2.23) and 70 kg N x 80 kg P_2O_5 (2.20) but was statistically higher than those of the rest combine treatments. The lowest number of branches plant^{-1} (1.033) was obtained from the treatment of control. It appears from the results of interaction effect that interaction among all high levels of nitrogen and phosphorus produced similar number of branches plant^{-1}.

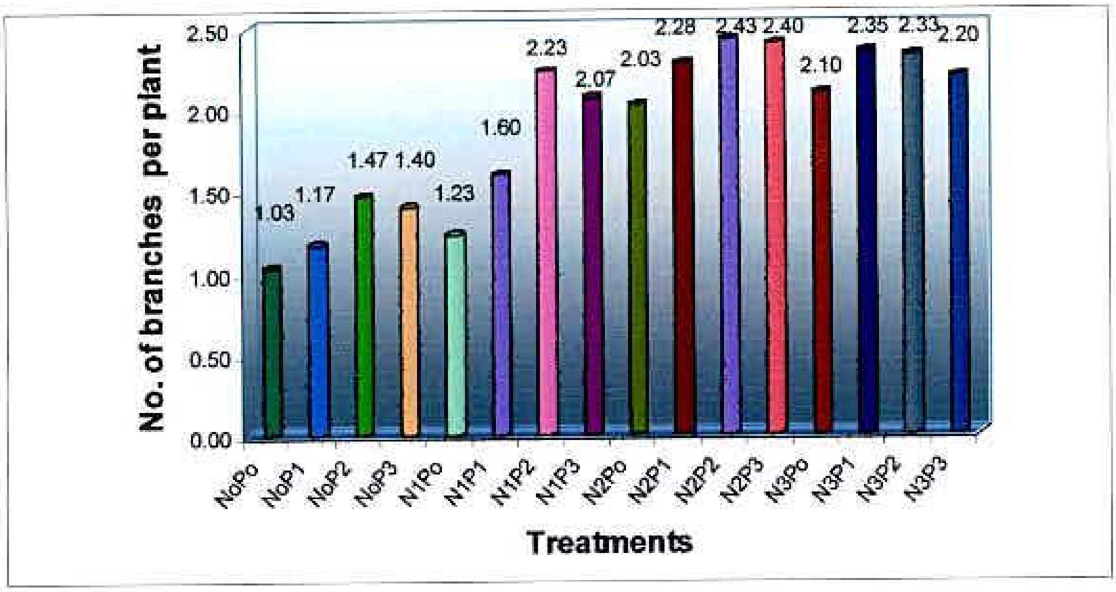


Fig. 6 Interaction effect of nitrogen and phosphorus levels on the number of branches plant^{-1} of sesame (LSD 0.05= 0.29)

4.3 Number of Capsules plant $^{-1}$

4.3.1 Effect of nitrogen

Level of nitrogen fertilizer significantly influenced the number of capsules plant^{-1} (Table 1). The highest number of capsules plant $^{-1}$ (33.82) produced by 45 kg N ha^{-1} was statistically similar with that of the second highest (33.03) number of capsules plant^{-1} obtained from the treatment of 60 kg N ha^{-1} while the lowest number (24.34) was produced from control treatment (N_0). The number of capsules 28.96 plant^{-1} obtained from the treatment of N_1 (30 kg N ha^{-1}) was statistically higher than that obtained from control (N_0) but lower than those obtained from N_2 and N_3 treatments. From the result it appears that capsules plant^{-1} increased due to the increased rate of nitrogen application upto certain level but excess application of nitrogen enhanced the vegetative growth instead of capsule formation. Allam (2002), Pathak *et al.* (2002), Patra (2001) and Mondol *et al.* (1997) stated that upto a certain extent increasing rate of N increased capsules plant $^{-1}$.

Table 1 Yield attributes of sesame cv. BARI Til-2 as affected by different nitrogen and phosphorus levels

Treatments		No. of capsules plant^{-1}	Length of capsules (cm)	Number of seeds capsules^{-1}	1000-Seed weight (g)
N Level	0	24.34	1.73	49.06	2.47
	30	28.96	2.09	60.72	2.74
	45	33.82	2.92	65.02	3.07
	60	33.03	2.92	63.43	3.06
P level	0	25.43	1.81	54.06	2.42
	60	28.90	2.37	59.67	2.90
	70	33.19	2.78	62.28	3.08
	80	32.63	2.70	62.22	2.94
LSD		1.28	0.13	1.58	0.16
CV(%)		5.09	6.50	3.17	6.93

4.3.2 Effect of phosphorus

Phosphorus had significant effect on the number of capsules plant^{-1} (Table 1). The highest number of capsules plant^{-1} (33.19) was produced by 70 kg P_2O_5 ha^{-1}. It was statistically similar with that of the second highest number of capsules plant^{-1} (32.63) of 80 kg P_2O_5 ha^{-1} while the lowest number (25.43) was produced from control treatment. Ali *et al.* (1997) reported that number of capsules plant^{-1} was significantly increased by phosphorus fertilizer application. The similar findings were also reported by Mahelonabis *et al.* (1992), Prakash and Thimegowda (1992) and Deshmukh *et al.* (1990).

4.3.3 Combined effect of nitrogen and phosphorus

Interaction effect between different levels of nitrogen and phosphorus under study caused no significant variation among the number of capsules plant^{-1} in sesame (Appendix IV) and (Fig. 7). Numerically, the highest number of capsules plant^{-1} (37.40) was observed in the treatment N_3P_2 (60 kg N x 70 kg P_2O_5) which was followed by N_2P_2 (37.10), N_2P_3 (36.58), N_3P_3 (35.45), N_2P_1 (33.12), N_1P_3 (32.25), N_1P_2 (31.23), N_1P_1 (28.10), N_0P_2 (27.04), N_0P_3 (26.23), N_1P_0 (24.25), N_0P_1 (23.32) and N_0P_0 (20.77) being the lowest.

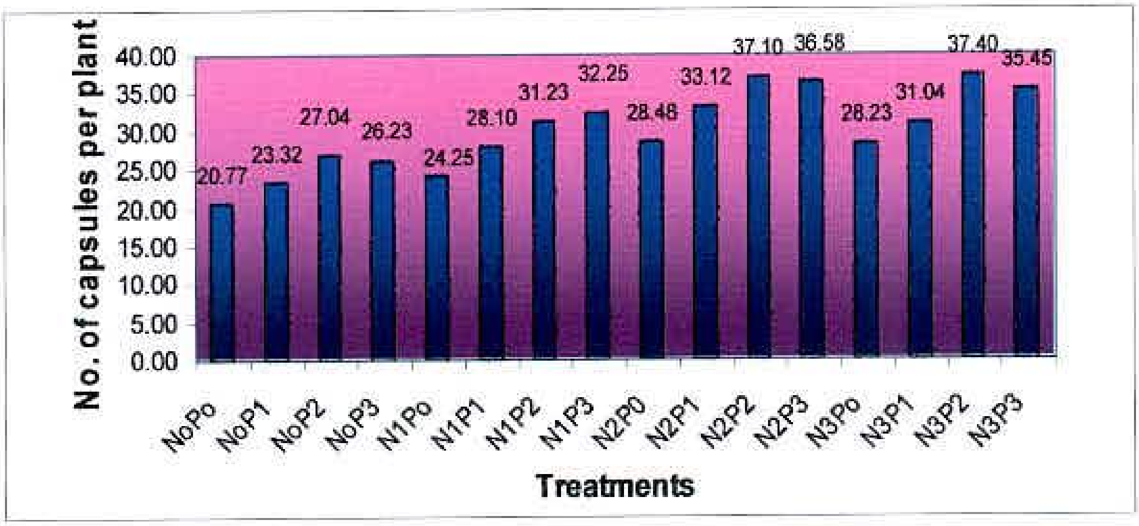


Fig. 7 Interaction effect of nitrogen and phosphorus on the number of capsules plant^{-1} of sesame (LSD = NS)

4.4 Length of capsule

4.4.1 Effect of nitrogen

Nitrogen had significant effect on the length of capsule Table 1). The longest capsule (2.92 cm) was produced by 45kg and 60kg N ha^{-1} which were significantly different from the second highest (2.09 cm) obtained from the treatment of 30 kg N ha^{-1}. The shortest length (1.73 cm) was found from control.

4.4.2 Effect of phosphorus

Length of capsule differed significantly due to application of different levels of Phosphorus (Table 1). The longest capsule of (2.78 cm) was found by applying 70 kg P_2O_5 ha^{-1} which was statistically similar to that of 2.70 cm of 80kg P_2O_5 ha^{-1} but was significantly superior to 2.36 cm and 1.80 cm obtained respectively from 60 kg and 0 kg P_2O_5 ha^{-1} while 1.80 cm was significantly the lowest length.

4.4.3 Combined effect of nitrogen and phosphorus

Significant variation in the length of capsules was observed due to interaction effect of different levels of nitrogen and phosphorus (Appendix IV). The longest capsule (3.503 cm) was observed in the treatments combination N_2P_2 (45 kg N x 70 kg P_2O_5) which was statistically similar to N_2P_3 (3.40) while the later was similar to N_3P_2 (3.20) which was again similar to N_3P_3 (3.10). But N_3P_3 (3.10) was similar to N_3P_1 (2.87) and 2.87 was similar to N_2P_1 (2.63) and 2.63 was similar to N_3P_0 (2.53) and in that way N_3P_0 was similar to N_1P_3 and N_1P_3 was similar to N_1P_1 and N_1P_1 was similar to N_2P_0 while N_0P_0 produced the shortest length (1.20 cm) of capsule (Fig. 8)

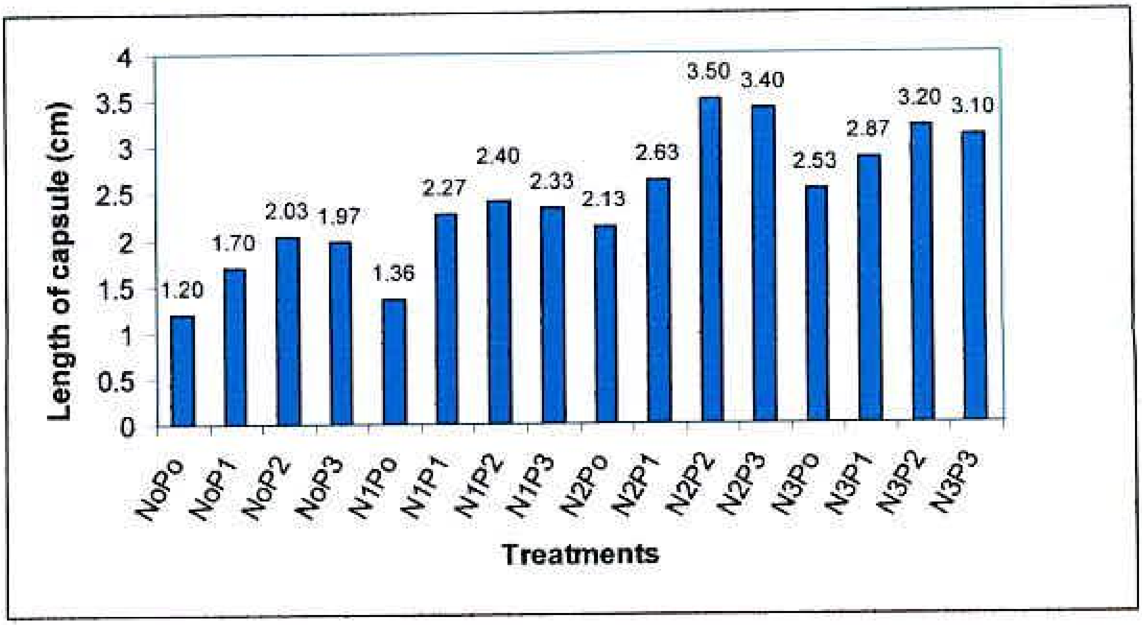


Fig. 8 Interaction effect of nitrogen and phosphorus levels on the length of capsule of sesame at harvest (LSD 0.05 = 0.06)

4.5 No. of seeds capsule^{-1}

4.5.1 Effect of nitrogen

Number of seeds capsule^{-1} was significantly influenced by the level of nitrogen (Table 1). The highest number of seeds capsule^{-1} (65.02) found from the application of nitrogen at 45 kg ha^{-1} was significantly different from the second highest number of seeds capsules^{-1} (63.43) obtained from the treatment of 60 kg N ha^{-1}. The lowest number of seeds capsule^{-1} was found from the control treatment. Similar findings were reported by Tiwari *et al.* (2002), Subrahmanyan and Arulmujhi (1999) and Chaubey *et al.* (2003).

4.5.2 Effect of phosphorus

Plants grown without phosphorus fertilizer gave the lowest number of seeds capsule^{-1} 54.06 (Table 1). Phosphorus fertilizer had a significant effect on number of seeds capsule^{-1}. The highest number of seeds capsule^{-1} (62.28) was recorded from the treatment of 70 kg P_2O_5 ha^{-1} which was statistically similar with that of 80 kg P_2O_5 ha^{-1} (62.22). Treatment P_2 (60 kg P_2O_5) produced 59.67 seeds capsule^{-1} which was statistically lower than those of treatments P_3 and P_4 but was superior to P_0 (54.06) obtained from the control treatment. Similar results were obtained from the reports of Deshmukh *et al.* (1990), Jain *et al.* (1989) and Seo *et al.* (1986).

4.5.3 Combined effect of nitrogen and phosphorus

Interaction effect of different levels of nitrogen and phosphorus under study showed significant variation on number of seeds capsule^{-1} at 1% level of probability (Appendix IV). It is observed from the (Fig.7) that interaction of treatments of N_2 (45 kg N) and P_3 (80 kg P_2O_5) showed the highest number of seeds capsule^{-1}(67.83) which was statistically similar to N_2P_2 (66.84), N_1P_2 (65.55), N_2P_1 (64.92) and N_3P_1 (64.76) while the last variable (64.76) was similar to N_1P_3 (63.76), N_1P_1 (61.94) and N_2P_0 (60.51) and again 60.51 was similar to N_3P_0 (59.33). Treatment (N_0P_2) produced 52.27 seeds capsule^{-1} which are similar to (N_0P_3) and (N_1P_0) producing respectively 52.11 and 51.62 seeds capsule^{-1} but was significantly higher than (N_0P_1) and (N_0P_0) while the later two are similar to each other. It appears from these findings that production of number seeds capsule^{-1} increased with the increase level of nutrients in interaction. These findings supported the findings of Satyanarayana, Vet *et al.* (1996), Ishwar singh *et al.* (1994), Behera *et al.* (1994).

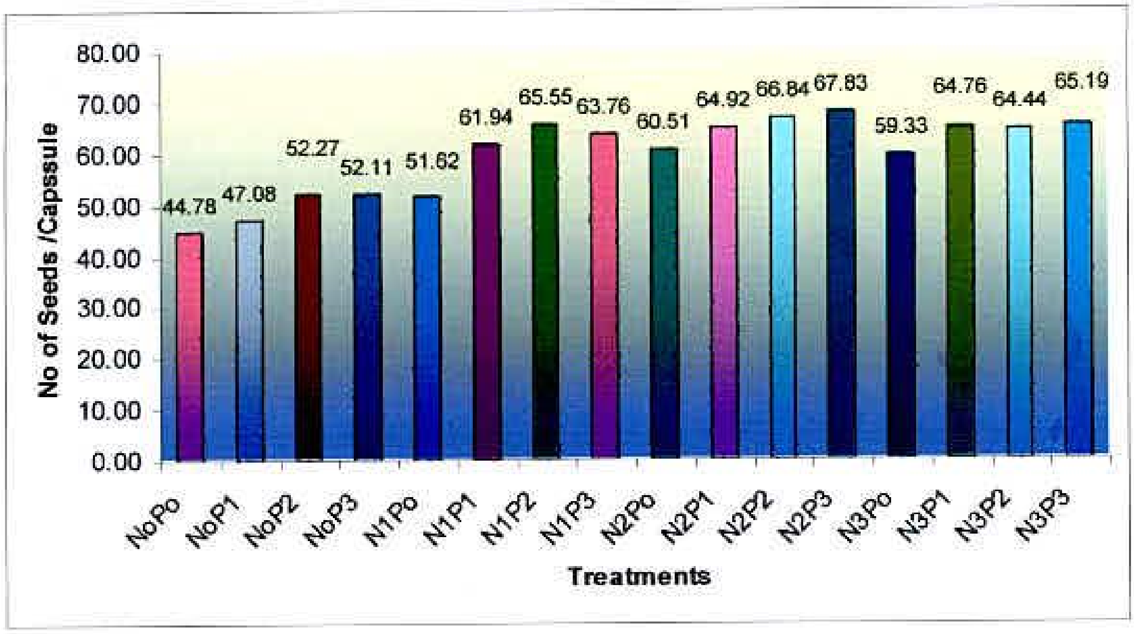


Fig. 9 Interaction effect of nitrogen and phosphorus on the number of seeds Capsule^{-1} of sesame (LSD 0.05 = 3.15)

4.6 1000-seed weight (g)

4.6.1 Effect of nitrogen

Weight of 1000-seed differed significantly due to application of different levels of nitrogen fertilizer (Table 1). The highest weight of 1000-seeds (3.07 g) was observed by applying nitrogen at 45 kg ha^{-1}, was statistically similar to that 1000-seed weight obtained from 60 kg N ha^{-1} but was higher than the weight (2.74g) obtained from the treatment of 30kg N ha^{-1}. The lowest 1000 seed weight (2.47g) was obtained from control. Pathak *et al.* (2002) also obtained highest 1000 seed weight at 45 kg N ha^{-1}.

4.6.2 Effect of phosphorus

Level of phosphorus fertilizer showed significant influence on 1000-seed weight (Table 1). It was observed that highest 1000-seed weight (3.08 g) was obtained from 70 kg P_2O_5 ha^{-1} which was statistically similar to that of 80 kg P_2O_5 ha^{-1}. The lowest 1000-seed weight was obtained from control treatment.

4.6.3 Combined effect of nitrogen and phosphorus

Interaction effect could not keep any significant effect on 1000 seed weight. Numerically the highest 1000 seed weight (3.34 g) was obtained from the interaction of N_2P_2 (45 kg x 70 kg P_2O_5) and it was followed by N_3P_2 (3.27 g), N_3P_3 (3.15 g), N_2P_3 (3.14 g), N_3P_1 (3.13 g), N_2P_1 (3.10 g), N_1P_2 (2.99 g), N_1P_3 (2.96 g), N_1P_1 (2.85 g), N_0P_2 (2.73 g), N_0P_1 (2.52 g), N_1P_0 (2.17 g) and N_0P_0 (2.15 g) being the lowest.

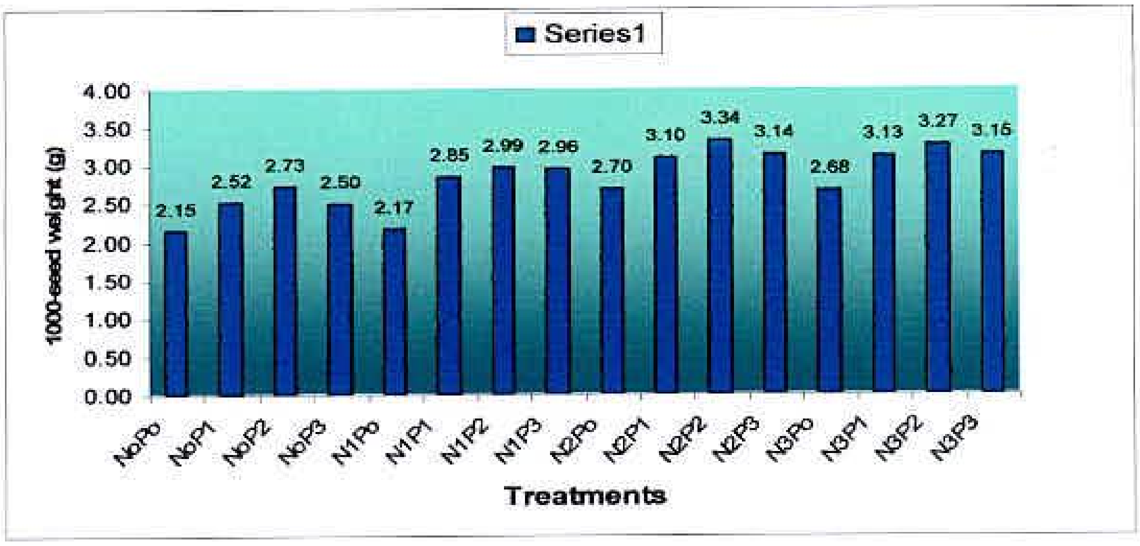


Fig. 10 Interaction effect of nitrogen and phosphorus on 1000-seeds weight of sesame (LSD 0.05= NS)

Table 2 Yield and harvest index of sesame cv. BARI Til-2 as affected by nitrogen levels, phosphorus levels and their combined effects

Treatments		Seed yield Plot^{-1} (kg)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
N Level	0	1.14	952.78	1174.69	2285.50	41.68
	30	1.44	1197.92	1176.74	2441.68	48.85
	45	1.58	1316.67	1332.73	2491.36	52.62
	60	1.49	1237.50	1243.77	2414.24	51.11
P level	0	1.22	1015.28	1190.68	2295.95	44.13
	60	1.37	1137.50	1207.18	2386.90	47.50
	70	1.58	1313.20	1280.67	2503.87	52.10
	80	1.49	1238.89	1249.40	2446.07	50.53
LSD		0.05	39.68	29.96	48.82	0.98
Nitrogen x phosphorus						
N_0P_0		1.03	861.11	1128.77	2264.22	38.07
N_0P_1		1.14	950.00	1173.20	2304.82	41.22
N_0P_2		1.15	961.11	1132.72	2256.76	42.58
N_0P_3		1.25	1038.89	1193.88	2316.22	44.83
N_1P_0		1.14	952.78	1205.56	2228.95	42.75
N_1P_1		1.47	1222.22	1146.87	2484.24	49.18
N_1P_2		1.65	1375.00	1209.93	2580.57	53.27
N_1P_3		1.49	1241.67	1233.46	2472.98	50.21
N_2P_0		1.28	1063.89	1277.33	2273.82	46.78
N_2P_1		1.59	1322.22	1354.81	2509.09	52.68
N_2P_2		1.84	1536.11	1403.11	2664.89	57.63
N_2P_3		1.61	1344.45	1295.65	2517.65	53.39
N_3P_0		1.42	1183.33	1186.87	2416.80	48.93
N_3P_1		1.27	1055.56	1276.16	2249.44	46.92
N_3P_2		1.66	1380.56	1231.31	2513.28	54.91
N_3P_3		1.60	1330.56	1262.01	2477.43	53.70
LSD		0.09	79.36	59.93	97.64	1.97
CV (%)		4.05	4.05	2.92	2.43	2.43

4.7 Seed yield plot^{-1}

4.7.1 Effect of nitrogen

Level of nitrogen fertilizer showed significant influence on seed yield plot^{-1} (Appendix V). It was observed that highest seed yield plot^{-1} (1.58 kg) was obtained from 45 kg N ha^{-1} which was significantly different from that of 60 kg N ha^{-1}. Increased application of nitrogen fertilizer at 60 kg ha^{-1}decreased seed yield plot^{-1} (0.09 kg ha^{-1}). This was due to more vegetative growth, with excessive branches, less number of filled and more number of unfilled capsules. These findings were in agreement with those of Chauby *et al*. (2003), Pathak *et al*. (2002) and Thakur *et al*. (1998).

4.7.2 Effect of phosphorus

Phosphorus fertilizer had a significant effect on seed yield plot^{-1} (Appendix V). Highest seed yield plot^{-1} (1.58 kg ha^{-1}) was found from 70 kg P_2O_5 ha^{-1}, which was significantly different from that of 80 kg P_2O_5 ha^{-1}(P_4). The lowest seed yield plot^{-1} (1.22 kg ha^{-1}) was found from the control treatment (P_1). The treatment P_2 gave seed yield plot^{-1} 1.37 kg, which was statistically higher than the lowest one (Table 2). The nutrient phosphorus has a direct effect on the flowering and fruiting. So with the increase of phosphorus, number of capsules and seed yield plot^{-1} was increased but the increase occurred up to a certain level of Phosphorus after which the excess of phosphorus caused negative effect due to its harmful action. Behera *et al*. (1994) also reported that seed yield was significantly increased up to a certain level of phosphorus.

4.7.3 Combined effect of nitrogen and phosphorus

Seed yield of sesame varied significantly with the effect of interaction of varied level of nitrogen and phosphorus (Appendix V). From the (Table 2) it appears that treatment combination of N_2P_2 (45 kg N x 70 kg P_2O_5) produced significantly the highest yield (1.843 kg plot^{-1}) which was statistically superior to all other yields plot^{-1}. The second highest yield (1.657 kg plot^{-1}) was obtained from the treatment combination of N_3P_2 (60 kg N x 70 kg P_2O_5) which was similar to 1.650 kg plot^{-1}, 1.613 kg plot^{-1}, 1.597 kg plot^{-1}, and 1.587 kg plot^{-1} obtained respectively from the treatment combinations of N_1P_2 (30 kg N x 70 kg P_2O_5), N_2P_3 (45 kg N x 80 kg P_2O_5), N_3P_3 (60 kg N x 80 kg P_2O_5) and N_2P_1 (45 kg N x 60 kg P_2O_5) but was higher than 1.490 kg plot^{-1} obtained from the treatment combination of N_1P_3 (30 kg N x 80 kg P_2O_5). 1.490 kg plot^{-1} was similar to1.467 kg plot^{-1} and 1.420 kg plot^{-1} but was higher than 1.277 kg plot^{-1} while the later was similar to 1.267 kg plot^{-1} and 1.247 kg plot^{-1}. 1.153 kg plot^{-1} obtained from N_0P_2 was statistically lower than 1.247 kg plot^{-1} but was higher than 1.033 kg and was similar to 1.143 kg plot^{-1} and 1.140 kg plot^{-1}. The lowest yield 1.033 kg plot^{-1} was obtained from the N_0P_0 treatment combination. It appears from the results that level of individual nutrient effect on seed yield plot^{-1} was highly reflected in the combined nutrient effect.

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

4.8.1 Effect of nitrogen

The nutrient element nitrogen had a significant effect on seed yield (Appendix V). The highest seed yield (1316.67 kg ha^{-1}) was obtained from 45 kg N ha^{-1} which was significantly different from 1238 kg ha^{-1} and 1198 kg ha^{-1} obtained respectively from 60 kg N ha^{-1} and 30 kg N ha^{-1} while the later two were statistically similar. The lowest seed yield (952.78 kg ha^{-1}) was recorded from the control treatment (Table 2). Pathak *et al.* (2002) obtained highest seed yield at 45 kg N ha^{-1}. Patra (2001), Mitra and Pal (1999) reported that seed yield significantly increased with increasing N rates up to a certain level. Further increase in nitrogen depressed the seed yield because more vegetative growth than optimum.

4.8.2 Effect of phosphorus

Seed yield significantly increased with increasing phosphorus level (Appendix V). The highest seed yield (1313 kg ha^{-1}) was recorded from 70 kg P_2O_5 ha^{-1} which was significantly different from the second highest (1239 kg ha^{-1}) obtained from the treatment of P_3 (80 kg P_2O_5 ha^{-1}). The lowest seed yield (1015.28 kg ha^{-1}) was obtained from the control treatment while treatment P_2 (60 kg P_2O_5 ha^{-1}) gave statistically higher seed yield ha^{-1} (1138 kg ha^{-1}) than the lowest one (Table 2). From the result it appears that seed yield increased due to increased rates of phosphorus up to a certain level but excess application of phosphorus reduced the seed yield. Such findings were observed in the reports of Ali *et al.* (1997), Pauste and Chaiti (1990) and Seo *et al.* (1986).

4.8.3 Combined effect of nitrogen and phosphorus

The highest and lowest significant seed yield ha^{-1} as well as the other seed yield ha^{-1} in the middle position were obtained from the same treatment combinations as those were observed in seed yield $plot^{-1}$ treatment combinations.

The treatment combination of (N_2P_2) produced the highest seed yield plot^{-1} (1536.11 kg ha^{-1}) and treatment combinations of control i.e (N_0P_0) like individual treatment effect produced the lowest seed yield plot^{-1} (861.11 kg ha^{-1}) in the interaction effect. The highest seed yield ha^{-1} was 1536 kg which was significantly different from others. The second highest yield was 1381 kg ha^{-1}which was statistically similar to1375 kg ha^{-1}, 1344 kg ha^{-1}, 1331 kg ha^{-1} and 1322 kg ha^{-1}obtained respectively from (N_1P_2), (N_2P_3), (N_3P_3) and (N_2P_1) treatment combinations. The yield 1242 kg ha^{-1} obtained from(N_1P_3) was statistically lower than 1324 kg ha^{-1} yield but was similar to 1222 kg ha^{-1}yield and 1183 kg ha^{-1} yield obtained from (N_1P_1) and (N_3Po) respectively but was higher than 1064 kg ha^{-1} yield of N_2Po while the later yield similar to 1056 kg ha^{-1} yield of N_3P_1 and 1039 kg ha^{-1} of (NoP_3) but was higher than 961.11 kg ha^{-1} yield of NoP_2, 950.0 kg ha^{-1} yield of NoP_1 and 861.11 kg ha^{-1} yield of NoPo and the last one being lowest.

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

4.9.1 Effect of nitrogen

Nitrogen had a significant effect on stover yield. The highest stover yield (1333 kg ha^{-1}) was recorded from the treatment of 45 kg N ha^{-1} which was significantly different from the second highest (1242 kg ha^{-1}) treatment of 30 kg N ha^{-1}. The lowest stover yield (1175 kg ha^{-1}) was obtained from the control (Table 2). The results indicated that stover yield was directly proportional to nitrogen fertilization and this might be due to luxuriant vegetative growth of plants with increased application of nitrogen which tended to enhance dry matter production and finally stover yield. These results were in consistent with the results obtained by Tiwari *et al.* (2000) and Om-Prakash *et al.* (2001).

4.9.2 Effect of phosphorus

Phosphorus had a significant effect on stover yield (Table 2). The highest stover yield (1280.67 kg ha^{-1}) was obtained from the treatment of 70 kg P_2O_5 which was significantly different from the second highest (1249 kg ha^{-1}) obtained from the treatment of 60 kg P_2O_5 ha^{-1}. The lowest stover yield (1190.68 kg ha^{-1}) was recorded from the control treatment which was statistically similar to that of 80 kg P_2O_5 ha^{-1}.

4.9.3 Combination effect of nitrogen and phosphorus

It was observed that combined effect of nitrogen and phosphorus did not show any significant differences to produce stover yield. The application rate of N 45 kg ha^{-1} and P_2O_5 70 kg ha^{-1} produced highest stover yield 1403.11 kg ha^{-1} which was statistically similar to 1354.82 kg ha^{-1}, 1295.65 kg ha^{-1}, 1277.33 kg ha^{-1}, 1276.16 kg ha^{-1} obtained from N_2P_1, N_2P_3, N_2P_o, N_3P_1 respectively and control treatment produced the lowest stover yield 1128.77 kg ha^{-1} (Table 2).

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

4.10.1 Effect of nitrogen

The difference between the fertilizer application of N in respect of biological yield was found to be statistically significant (Table 2). Higher biological yield (2491 kg ha^{-1}) was recorded from the treatment of 45 kg N ha^{-1} which was significantly different from the second highest biological yield of 2442 kg ha^{-1} obtained from the treatment of N_2 (30 kg ha^{-1}) while 2414 kg ha^{-1} obtained from N_4 treatment was statistically lower than that of N_2 but was higher than that of the control treatment (2286 kg ha^{-1}) which was the lowest biological yield.

4.10.2 Effect pf phosphorus

Application of phosphorus fertilizer exerted significant influence on the biological yield of sesame (Table 2). The highest biological yield (2503.87 kg ha^{-1}) was obtained with 70 kg P_2O_5 kg ha^{-1} which was significantly different from the treatment of 80 kg P_2O_5 ha^{-1} which gave biological yield 2446 kg ha^{-1}. From the result it was evident that biological yield increased with phosphorus fertilizer application up to a certain level. Further increase in phosphorus fertilizer tended to decrease the biological yield. Plants grown without of phosphorus fertilizer had the lowest biological yield.

4.10.3 Combined effect of nitrogen and phosphorus

Biological yield in sesame also significantly varied due to variation in the nitrogen and phosphorus level combinations (Appendix V). Like individual effect of nutrient application and combined effect of different nitrogen and phosphorus level on seed yield plot^{-1}, yield ha^{-1} (Table 2), the treatment combination of N_2P_2 also produced the highest biological yield ha^{-1} (2665 kg) which was similar to 2581 kg ha^{-1} but was higher than all the rest biological yield ha^{-1} obtained from different levels of nitrogen and phosphorus combinations in the experiment. The next highest biological yield (2581 kg ha^{-1}) obtained from N_1P_2 was identical to 2518 kg ha^{-1} of N_2P_3, 2513 kg ha^{-1} of N_3P_2, 2509 kg ha^{-1}of N_2P_1, 2484 kg ha^{-1}of N_1P_1, 2477 kg ha^{-1} of N_3P_3 and 2473 kg ha^{-1} of N_1P_3 while the last one 2473 kg ha^{-1} biological yield was similar to 2417 kg ha^{-1}of N_3Po biological yield but was statistically higher than 2316 kg ha^{-1}(NoPo), 2305 kg ha^{-1} (NoP_1), 2274 kg ha^{-1} (N_2Po), 2264 kg ha^{-1} of NoPo, 2257 kg ha^{-1} of NoP_2, 2249 kg ha^{-1}of N_3P_1 and the last and the lowest 2229 kg ha^{-1} of N_1Po biological yield. Unlike the effect of nutrient combination on aforesaid parameter, here the lowest reading was found from N_1Po instead of NoPo.

4.11 Harvest index

4.11.1 Effect of nitrogen

Level of nitrogen application significantly influenced on the harvest index (Table 2). The highest harvest index (52.62) was recorded from the treatment of nitrogen at 45 kg N ha^{-1} which was significantly different from the harvest index 51.11, 47.50 and 44.13 obtained from the treatment of N_4, N_2 and N_1 while the last one (control) was the lowest. From the result it appears that harvest index increased with the increased rate of nitrogen application up to certain level. Excess application of nitrogen reduced harvest index. Similar effect of nitrogen on harvest index was also observed by Om *et al.* (2001) and Ashfaq *et al.* (2001).

4.11.2 Effect of Phosphorus

Phosphorus had a significant effect on the harvest index of sesame (Table 2). The highest harvest index (52.10) was found from the treatment of 70 kg P_2O_5 ha^{-1} which was significantly different from (50.53) obtained from P_4 (80 kg P_2O_5 ha^{-1}). The lowest harvest index (44.13) was obtained from the control treatment. The harvest index (47.50) was statistically higher than that of control but lower than that of P_2 and P_1. Excess application of phosphorus fertilizer reduced the harvest index.

4.11.3 Combined effect of nitrogen and phosphorus

Harvest index also significantly varied with the variation in the interaction effect of studied levels of nitrogen and phosphorus in the experiment. Significantly the highest harvest index (57.63) was obtained from the treatment combination of N_2P_2 (45 kg N x 70 kg P_2O_5). The second highest harvest index 54.91 was obtained from N_3P_2 which was similar to harvest index 53.70, 53.39 and 53.27 respectively obtained from N_3P_3, N_2P_3 and N_1P_2 treatment combinations while the latter 3 harvest index each was similar to harvest index 52.68 but was higher than the rest harvest index 50.21, 43.18 and 46.92. The treatment N_3P_1 (60 kg N ha^{-1} x 60 kg P_2O_5) produced harvest index 46.92 which was similar to 46.78 while the latter was similar to 44.83 but was higher than 42.75 and again was similar to 42.58 and 41.22 while the above three were higher than 38.07. The lowest harvest index obtained from the control treatment.

Chapter 5

SUMMARY AND CONCLUSION

A field experiment was conducted at the Field Laboratory of Sher-e-Bangla Agricultural University during the period from mid August 2006 to mid November 2006 to study the effect of nitrogen and phosphorus on the yield and yield attributes of sesame of variety (BARI Til-2). The experiment consisted of four levels of nitrogen viz. 0, 30, 45 and 60 kg ha^{-1} and four levels of phosphorus viz. 0, 60, 70 and 80 kg ha^{-1} as treatment. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 6 m^2 (3 m x 2.0 m). Nitrogen and phosphorus in the form of urea and T.S.P. were applied as per experimental specification and M.P, Gypsum, Zinc Sulphate and Boric acid fertilizer were applied as 50, 110, 5 and 10 kg ha^{-1}, respectively. Half dose of urea and full dose of other fertilizers were applied during final land preparation. Thinning and weeding were done at 15 and 30 days after showing (DAS). Data on yield and yield attributes including various plant characters were recorded at harvest and analyzed statistically and mean difference were compared by L.S.D.

Experimental results revealed that the yield contributing characters including plant characters such as flowering habits, plant height, number of branches $plant^{-1}$, number of capsules $plant^{-1}$, capsule length, number of seeds $capsule^{-1}$ and seed yield $plot^{-1}$, seed yield ha^{-1} and 1000 seed weight were significantly influenced by different levels of nitrogen.

The highest number of branches plant^{-1}(2.29), number of capsules plant^{-1}(33.82), capsule length (2.92), number of seeds capsule^{-1}(65.02) and seed yield ha^{-1}(1316 kg) and 1000 seed weight (3.09) were obtained from 45 kg N ha^{-1} but the tallest plant was observed at 60 kg N ha^{-1}. The increase of nitrogen level beyond 45 kg could not influence in the improvement of yield attributes rather it caused declination in the most of the parameters studied. Lowest value of the above parameters viz. the number of branches plant^{-1} (1.27), number of capsules palnt^{-1}(24.34), number of seeds capsule^{-1}(49.06), capsule length (1.73 cm), seed yield ha^{-1}(952.78 kg) were obtained from the control treatment (O level). Phosphorus also at second highest level i.e. 70 kg P_2O_5 ha^{-1} showed the highest values of all the studied parameters such as number of branches plant^{-1}(2.12), number of capsule plant^{-1} (33.19), capsule length 2.78 cm, number of seeds capsules^{-1} 62.28, seed yield 1313.20 kg ha^{-1}and 1000 seed weight 3.08 g. The lowest corresponding values of the above parameters obtained from the control level of P_2O_5 were 1.6 number of branches plant^{-1}, 25.43 capsules plant^{-1}, 2.90 g 1000 seed weight and 952.78 kg ha^{-1}seed yield.

Interaction effect of 45 kg N ha^{-1} in combination with 70 kg P_2O_5 ha^{-1}produced the highest values of all the studied yield attributes such as number of branches plant^{-1} (2.43), number of capsules plant^{-1} (37.10), length of capsule (3.5 cm), number seeds capsules^{-1} (66.84), seed yield 1536.11 kg ha^{-1}and 1000 seeds weight (3.34 g), respectively while the corresponding lowest values of those parameters obtained from the control combination (N_0P_0) were 1.03, 20.77, 1.20 cm, 44.78, 861.11 kg ha^{-1} and 2.15 g ha^{-1}.

On the basis of the above findings of the experiment, it may be concluded that nitrogen at the rate of 45 kg N ha^{-1} in combination with phosphorus at the rate of 70 kg ha^{-1} is suggested to be applied in sesame production to obtaining higher vegetative growth and higher yield.

(Further study may be undertaken on a priority basis because the fertility status and performance of nitrogen and phosphorus fertilizer in Bangladesh soil may vary from place to place and season to season.)

REFERENCES

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.

Abdel-Rahman, K.A., Hussaballa, E.A., E.A., El-Morshidy, M.A. and Khalifa, M.A. (1980). Physiological response of sesame to sowing dates, nitrogen fertilizer and hill spacing. Res. Bull. Fac. Agric. Ain Shams Univ., Egypt, **1235**: 13.

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

Ashfaq, A., Abid, H., Mahaboob, A. and Mahammad, M. (2001). Yield and quality of two sesame varieties as affected by different rates of nitrogen and phosphorus. *Pakistan J. Agril. Sci.* **38** (12): 4-7.

Ali, M. H., Ullah, M. J., Bhuiyan, M. S. U. and Amin, A. K. M. (1997). Effect of nitrogen and phosphorus on the yield attributes and of sesame (*Sesamum indicum*). *Bangladesh J. Agril. Sci.* 24-32.

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

Ashri, A. (1998). Sesame Breeding. In : *Janick, J.* (ED.). Plant Breeding reviews. John Willey and Sons, Inc. P. 179-228.

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

BARI (Bangladesh Agricultural Research Institute). (2001). 'BARI Til-2' Bangladesh Agril. Res. Inst. Joydebpuur, Gazipur. Folder December 2001.

BARI (Bangladesh Agricultural Research Institute). (1994). "Til Fosaler Chash". Bangladesh Agril. Res. Inst. Joydebpur, Gazipur. Folder January 1994.

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). (2003). Year Book of Agricultural Statistics of Bangladesh. Statistics Division, Ministry of Planning, Govt. of the Peoples Republic of Bangladesh.

Behera, A. K., Mishra, S. K. and Sha, H. S. (1994). Response of summer sesame to row spacing and phosphorus. *Orissa J. Agril. Res.* **7**: 99-101.

Bhatol, D. P., Patel, N. A. and Pavaya, R. P. (1994). Effect of nitrogen, phosphorus and Zinc application on yield uptake of nutrients by groundnut. *Indian J. Agril. Res.* **28**: 209-213.

Chaplot, P. C., Jain, G. I. and Bansai, K. N. (1996). Effect of phosphorus and sulpher on the oil, yield and uptake of N, P and S in sesame. *Indian J. Trop. Agric.* **9** (3): 190-193.

Chaubey, A. K., Kaushik, M. K. and Singh, S. B. (2003). Response of Sesame (*Sesamum indicum*) to nitrogen and sulphur in light-textured entisol. *New Agriculturist*. **14** (1/2): 61-64.

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): 27-31.

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

Das, N. R. and Deb, N. (1995). Evaluation of productivity of some rainfed summer crops under different levels of NPK fertilizers. Advances in Agricultural Research in India **3**: 141-150.

Deshmukh, V. A., Chavan, D. A. and Sagave, G. T. (1990). Response of *sesamum* to nitrogen and phosphate. *Indian J. Agron*. **37**(4): 314.

El-Ouesni, F.E.M., Gaweesh, S.S.M. and Abd-El-Haleen A.K. (1994). Effect of plant population, density weed control nitrogen level on associated weeds, growth and yield of sesame plants. Bull. Fac. Agric. Univ. Cairo, Egypt. **45**(2): 371-388.

El-serogy, S.T. 1998. Effect of thinning time, nitrogen application and sowing dates on sesame yield under middle Egypt conditions. *Egyptian J. Agril. Res.* **76**(2): 639-649.

Esho, K.B. and Shekir, N.R. (1993). Effect of plant spacing and compound fertilizer NPK on growth and yield of egg plant. *Mesopotamia J. Agric*. **25**(3): 29-35.

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

FAO. (1988). Production Year Book. Food and Agriculture organization of the United Nation, Rome, Italy. **42**: 190-193.

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

Ishwar, S., Nagda, B. L. and Choudhury, L.S. (1994). Response of sesame (*Sesamum indicum*) varieties to nitrogen and phosphorus. Ann. Agril. Res. Rajasthan Agril. Univ., Indian **15**(2): 250-251.

Imamyavaramam, V., Singaravel, R., Thanunathan, K. and Manickam, G. (2002). Stidies on the effects of different plant densities and the levels of nitrogen on the productivity and economic returns of sesame. Crop Res. **24**(2): 314-316.

Jain, V.K., Y.S. Chauhan, M.P. Khandekar, R.P. Sharma and M.S. Yadav. (1989). Effect of nitrogen and phosphorus on growth and yield of linseed. *Indian J. Agron*. **34**(1): 122-124.

Jana, P.K., Barik, A., Ghatak, S., Mukherjee, A. K. and Sounda, G. (1991). Effect of nitrogen, phosphorus and potassium on yield and yield attributes of rainfed groundnut. *Indian J. Agric Sci*. **60**(1): 49-51.

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 sesamum. *J. Maharashtra Agril. Univ*. **14** (2): 227-228.

Kalita, M. C. (1994). Effect of phosphorus on growth and yield of sesame (*Sesamum Indicum*). *Indian J. Agron*. **39**: 3, 500-501.

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.

Kaul, A.K. and Das, M. L. (1986). Oilseeds in Bangladesh. Pub: Bangladesh. Canada Agric Sec. Team. Ministry of Agril. Govt. of the peoples Republic of Bangladesh, Dhaka. pp. 69.

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

Mahalonobis, D., Ghosh, M., Maiti, D. and Chakraborty, P. B. (1999). Response of groundnut *sesamum* intercroppimg to levels of nitrogen and phosphorus and their economics. *Environ and Ecol*. **17**(1): 116-119.

Maiti, D. and P.K. Jana. (1985). Effect of different levels of nitrogen and phosphorus on yield and yield attributes of sesame. *J. Oilseeds Res*. **2**: 252-269.

Majumdar, S.K., Barik, K.C., Bera, P.S. and Ghosh, D.C. (1987). Effect of molybdenum and boronon nitrogen application on sesame in acidic soil. *Indian Agriculturist*. **31**(3): 165-169.

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. *Int. J. Agric. and Biol*. **5**(4): 490-492.

Mankar, D. D., R.N. Satao, V. M. Selanke, and P.G. Ingole (1995). Effect of nitrogen and phosphorus on quality uptake and yield of sesame. *PKV Res J*. **19**(1): 69-70.

Mehrotra, O.N., Pal, M. and Saxena, K.K. (1978). Response of rainfed sesamum to nitrogen levels and plant densities in Mar soil of Bundelkhand region. *Indian J. agron*. **23**(2): 172-173.

Mitra, S. and Pal, A.K. (1999). Water use and productivity of 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). Effect of different irrigation levels and nitrogen doses on yield of sesame (*Sesamum indicum* L.). *Indian Agriculturist*. **41**(1): 15-21.

Muthusamy, A.M.P. Gomez and Javabalan, N. (1999). Effect of phosphorus nutrient on the growth of *sesamum indicum*. *J. Phytol. Res*. **12**: 1-2, 6.

Nageshwar, L., Sarwgi, S.K., Tripathi, R.S., Bhambri, M.C. and Lal, N. (1995). Effect of nitrogen, potassium and sulphur on seed yield, nutrient uptake, quality and economics of summer sesame (*Sesamum indicum*). *Indian J. Agron*. **40**(2): 333-335.

Om, P., Singh, B.P., Singh, P.K. and Prakash, O. (2001). Effect of weed control measures and nitrogen fertilization on yield and yield attributes of sesame (*Sesamum indicum*) under rainfed condition. *Indian. J. Agric. Sci*. **71**(9): 610-612.

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

Pathak, K., Barman, U., Kalita, M.K. and Hazarika, B.N. (2002). Effect of nitrogen levels on growth and yield of sesamum (*sesamum indicum*) in Barak Valley Zone of Assam. Adv. *Plant Sci.* **15**(1): 341-343.

Parihar, S.S., Pandey, D. and Shukla, 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**(1 & 2): 47-49.

Pawar, P.R., Patil, R.A., Khanuilkar, S.A., Mahadkar, U.K. and Bhagat, S.B. (1993). Effect of different levels of nitrogen and phosphorus on yield and quality of sesamum. *J. Maharatra Agril. Univ.* India. **18**(2): 310-311.

Pineda, M.F.W. and Velasquez Silva, J.M. (1987). Effects of rates of nitrogen and phosphorus on yield of sesame. Centro Experimental dal Algodon (Updated), Psoltega, Nicaragua:107-114.

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

Pauste, A.M. and Maiti, A. (1990). Response of fertilizer on seed yield of sesame (*Sesamum indicum*). *Environ. and Ecol.* **8** (3): 349-351.

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. Agrail. Sci.* **34** (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 fertilizer use efficiencies in summer sesame (*S. indicum* L.). *J. Oilseed Res.* **13**(2): 173-177.

Samui, R.C., Sinharoy, A., Ahasan, A.K.M.M. and Roy, B. (1990). Dry matter production, nutrient content and uptake of sesame varieties at different levels and sources of nitrogen application. *Environ. Ecol.* **8**(1A): 239-243.

Sankar, A.S., Reddy, P. R. Reddy and Rao I. V. S. (1984). Nodulation and nitrogen fixation in groundnut as affected by seed size and phosphorus. *Legume Res.* **7**:1-5.

Sarala, N.V., Jagannatham, A. and Rajan, M.S.S. (2002). Influence of nitrogen and azospirillum on yield attributes and yield of sesame under dry land condition. *J. Res. ANGRAU.* **30** (1) 87-89.

Sargar, R. L. and Roy, G. L. (1984). Fertilizer use at farmers level and its relationship with productivity of oilseed, wheat and potato. *J Maharastra Agril. Univ.* **9**: 234-235.

Satyanarayana, V., Ravinder, N., Rao, V.P. and Latchana, A. (1996). Influence of irrigation, nitrogen and phosphorus on yield and its components in sesame (*Sesamum indicum*). Ann. Agril. Res., Dept. Agron., Agril. Univ. Rajendranagar, Hydrabad, **17** (3): 286-291.

Satyanarayana, V. (1978). Effect of plant density, nitrogen and potassium on the yield of two gingelly (*Sesamum indicum* L.) varieties. Thesis Abst. **41**(1): 13.

Senlrilkumar, R., Imayavaramban, V., Thanunathan, K. and Manickam, G. (2000). Effect of intro row spacing and different levels of nitrogen in combination with Azospirillum inoculation on growth and yield of sesamum. Res. Crops **1**(3): 351-354.

Seo, G.S., Jo, J.S. and Choi, C.Y. (1986). The effect of fertilization level on the growth and oil quality in sesame. *Korean J. Crop Sci.* **31** (1): 24-24.

Sharma, N.N. and Kakati, N.N. (1993). Response of summer sesame (*Sesamum indicum*) to levels of nitrogen and spacing. *Indian J. Agron.* **38** (4): 659-661.

Sharma, P.B., Parashar, R.R., Ambawatia, G.R. and Pillai, P.V.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 nitrogen, 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. Oilseeds* Res. **15** (2): 366-367.

Singh, D., Jain, K.K. and Sharma, S.K. (2004). Quality and nutrient uptake in mustard as influenced by levels of nitrogen and sulpher. *J. Maharashtra Agril. Univ.* **29** (1): 87-88.

Singh, V., Chauhan, Y. S. and Tripathi, N. K. (1997). Comparative efficacy of levels of nitrogen and sulphur in production and biochemical values of til (*Sesamum indicum*) var. c-6. *Res. and Dev. Report.* **4**(2): 213-217.

Sinharoy, A., Samui, R.C., Ahasan, A.K.M.M. and Roy, B. (1990). Effect of different sources and levels of nitrogen on yield attributes and yield of sesame varieties. *Environ. and Ecol.* **8**(1A): 211-215.

Sivasankar, A., Reddy, P. R. and Singh, B. G. (1982). Nitrogen nutrient in groundnut. Effect of phosphorus on N_2- fixation and dry matter partitioning. *Legume Res.* **7**: 105.

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 Jaganadham, A. (1999). Effect of nitrogen levels on yield, dry matter and nitrogen uptake by sesame (*Sesamum indicum* L.) varieties. *J. Res. ANGRAU.* **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.

Tiwari, K.P, Namdeo, K. N. and Patel, S. B. (1998). Dry matter 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., Girish, J and Jha, G. (2002). Effect of nitrogen and sulpher on growth, yield and quality of sesame (*Sesamum indicum*) varieties. *Res. on Crops*. **1**(2):163-167.

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

Tiwari, K.P., Yadav, L.N., and Jain, R.K. (1999). Response of sesame (*Sesamum indicum* L.) genotypes to nitrogen levels under summer condition. *Crop. Res. Hisar*. **8**(2): 467-469.

UNDP and FAO (United Nations Development Programme and Food and Agriculture Organization). (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report-2, Agro-ecological Regions of Bangladesh. FAO-UNDP pp. 212-221.

Vandana, T. and Parkask, A. (1998). Influence of soil inoculation with V. A. myconliza and phosphorus solubilising microorganisms on growth and phosphorus uptake in *sesamum indicum*. *Intetrn J. Trop. Agric*. **16**:201-209.

Venkatesan, G., Elango, R. and Runachalam, L. (1983). Influence of spacing and nitrogen on the yield of sesamum. *Madras Agric. J*. **70**(7): 468-470.

Vijan, S., Crauran, Y.S. and Tripathi, N.K. (1987). Comparative efficacy levels of nitrogen and sulpher in production and biochemical values of til (*Sesamum indicum* L.). Res. & Dev. Repor. Coll; Agric. Gwalior, Indian, **4**(2): 213-217.

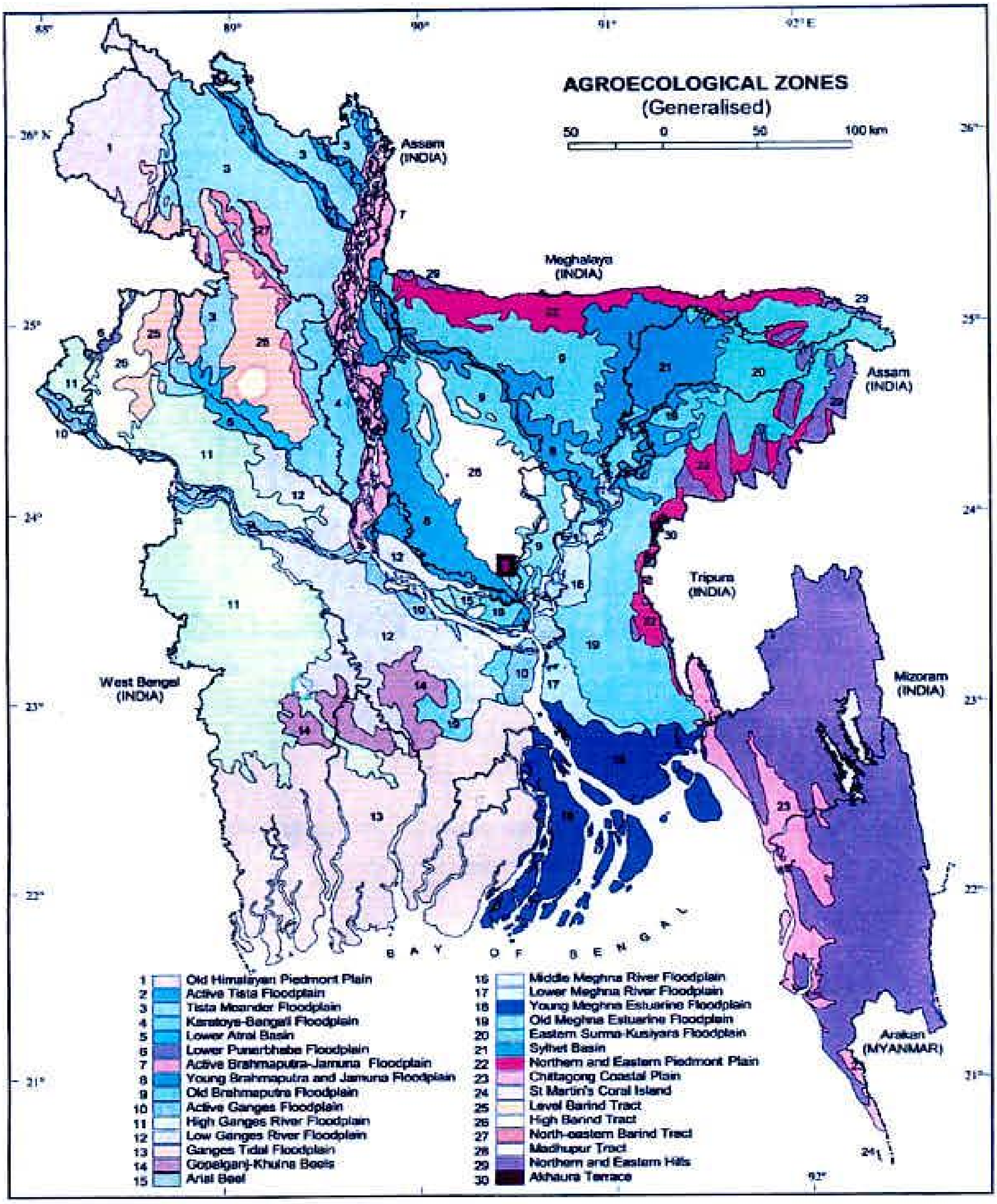
Wang, X., Gu, Z., Qiu, C., Wang, X.C. and Qui, C.X. (2001). Effect of nitrogenous fertilizer distribution and planting patterns on flowering rate of autumn sesame. *J. Hubai Agril. Coll*. **21**(3): 199-201.

Zhang, J and S. A. Barber. (1992). Maize root distribution between phosphorus fertilized and unfertilized *soil Sci. Soc. Am. J*. **56**: 819-822.

Zaidi, S. H. and Khan, A. A. (1981). Performance of four varieties of sesame and their response to fertilizer. *Pakistan J. Forest*. **31** (2): 61-66.

APPENDICES

Appendix 1. The map showing experimental sites under study



Experimental sites under study

Appendix II: Physical and chemical characteristics of initial soil (0-15 cm depth) before seed sowing

A. Physical composition of the soil

Soil separates	(%)	Methods employed
Sand	36.90	Hydrometer method (Day,1995)
Silt	26.40	-do-
Clay	36.66	-do-
Texture class	Clay loam	-do-

B. Chemical composition of the soil

Sl. No.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.82	Walkley and Black, 1947
2	Total N (kg/ha)	1790.00	Bremner & Mulvaney, 1965
3	Total S (ppm)	225.00	Bardsley and Lancster, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg/ha)	54.00	Bremner, 1965
6	Available P (kg/ha)	69.00	Olsen and Dean, 1965
7	Exchangeable K (kg/ha)	89.50	Pratt, 1965
8	Available S (ppm)	16.00	Hunter, 1984
9	PH (1:2.5 soil to water)	5.55	Jackson, 1958
10	CEC	11.23	Chapman, 1965

Appendix III: Monthly record of air temperature, rainfall and relative humidity during the period from July-December, 2006

Month	*RH (%)*	*Air temperature (^0C)*			*Rainfall (mm)*
		Max.	*Min*	*Mean*	
July	81	31.4	25.8	28.6	542
August	82	32.0	26.6	29.3	361
September	81	32.7	26.0	29.35	514
October	80	30.5	24.3	27.4	417
November	72	29.0	19.8	24.4	3
December	66	27.0	15.6	21.3	0

Source: Bangladesh Meterological Department (Climatic Division), Agargaon, Dhaka-1207.

Appendix IV. Summary of analysis of variance of yield attributes of sesame

Source of variation	d.f	Mean square					
		Plant height (cm)	Number of branches per plant	Number of capsules per plant	Length of capsules(cm)	Number of seeds per capsules	1000-seed weight (g)
R	2	5.752	0.001	2.028	0.014	2.924	0.092
N	3	817.680**	2.729**	227.595**	4.379**	625.575**	0.971**
P	3	490.864**	0.615**	156.776**	2.364**	178.894**	0.987**
N x P	9	41.544**	0.090**	2.058^{NS}	0.108**	11.372 **	0.021^{NS}
Error	30	3.545	0.031	2.341	0.025	3.575	0.039
Total	47						

Note: ** = Significant at 1% levels
NS = Non significant,
R = Replication, N = Nitrogen , P =Phosphorus

Appendix V. Summary of analysis of variance of different categories yield of sesame

Source of variation	d.f	Mean square				
		Seed yield (kg/plot)	Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
R	2	0.010	6928.818	1215.437	5490.749	5.282
N	3	0.426**	295514.742**	66487.828**	92513.290**	281.884**
P	3	0.289**	200364.972**	19979.101**	94568.753**	148.422**
N x P	9	0.042**	29167.760**	914.944^{NS}	31589.815**	12.480**
Error	30	0.003	2264.990	1291.662	3428.585	1.394
Total	47					

Note: ** = **Significant at 1% levels**

NS = Non significant,

R = Replication, N = Nitrogen , P =Phosphorus