INFLUENCE OF NITROGEN AND PLANT POPULATION ON THE GROWTH AND YIELD OF SESAME

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CERTIFICATE

This is to certify that the thesis entitled, **"Influence of Nitrogen and Plant Population on the Growth and Yield of Sesame"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN AGRONOMY,** embodies the result of a piece of *bona fide* research work carried out by **MD. SARWAR HOSSAIN,** Registration No. **04-01234** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: 30/06/2009
Dhaka, Bangladesh

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Dedicated to
My Beloved Parents

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The Author

ABSTRACT

An experiment was conducted to assess the influence of four nitrogen levels and plant population on the growth and yield attributes of sesame at the agronomy research field of Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2009. The experiment was conducted in randomized complete block design comprising three replications. The treatments included four levels of nitrogen viz.0, 30, 45 and 60 kg ha^{-1} and four levels plant population density viz.166666, 222222, 333333 and 666666 plants ha^{-1}. Results indicated that different levels of N fertilizer and plant population had significant effects on yield and yield attributes of sesame. The addition of N levels resulted in the increasing of yield and yield attributes of sesame and the highest plant height (115.50 cm), branches $plant^{-1}$ (4.57), capsules $branches^{-1}$ (17.36), total capsules $plant^{-1}$ (80.32), number of effective capsules $plant^{-1}$ (76.47), capsule length (2.38 cm), seeds $capsule^{-1}$ (70.13), filled seeds $capsule^{-1}$ (68.31), 1000 seeds weight (3.46 g), seed yield (1.50 t ha^{-1}) and harvest index (24.45%) were obtained from 60 kg N ha^{-1}. On the other hand, increasing of plant population resulted increases in yield and yield attributes of sesame like plant height, unfilled seeds $capsule^{-1}$, seed yield, stover yield and harvest index. The highest seed yield of sesame plant (1.50 t ha^{-1}), stover yield (4.64 t ha^{-1}) and harvest index (24.45%) were found from 666666 plants ha^{-1} plant population. The combined effect of nitrogen levels and plant population had a significant effect on the plant parameters of sesame. The highest branches $plant^{-1}$ (5.12), capsules $branch^{-1}$ (19.07), total capsules $plant^{-1}$ (97.55), number of effective capsules $plant^{-1}$ (93.75), capsule length (2.79 cm), seeds $capsule^{-1}$ (84.63), filled seeds $capsule^{-1}$ (82.88), 1000 seeds weight (3.65 g) were recorded from 166666 plants ha^{-1} in combination with 60 kg N ha^{-1} applied but highest plant height (120.00 cm), seed yield (1.76 t ha^{-1}), stover yield (5.07 t ha^{-1}) and harvest index (25.73%) were obtained from the 666666 plants ha^{-1} in combination with 60 kg N ha^{-1} applied.

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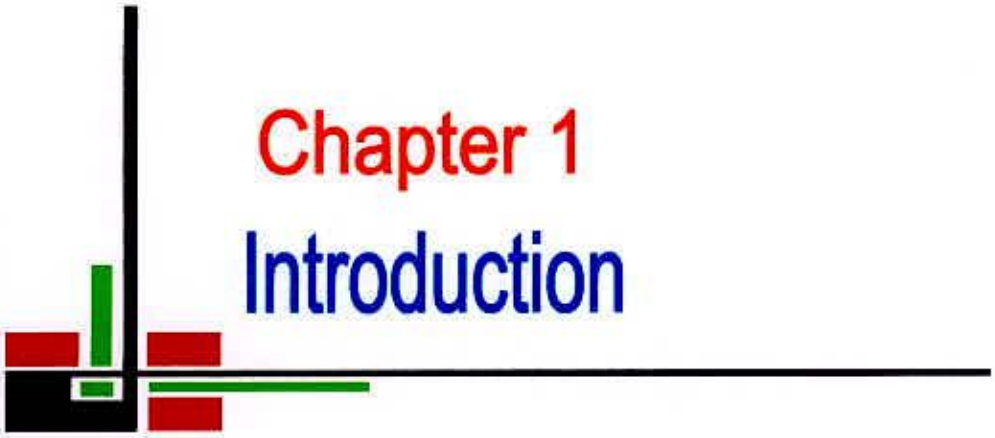
ACRONYMS AND ABBREBIATIONS

%	Percentage
°C	Degree Centigrade
AEZ	Agro- Ecological Zone
ANOVA	Analysis of variance
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
BRRI	Bangladesh Rice Research Institute
cm	Centimeter
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAT	Days After Transplanting
DMRT	Duncan's Multiple Range Test
e.g.	Example given
et al.	et alia (and others)
FAO	Food and Agriculture Organization
Fig.	Figure
g	Gram (s)
HI	Harvest Index
hr	Hour(s)
i.e.	That is
IFDC	International Fertilizer Development Centre
IRRI	International Rice Research Institute
K_2O	Potassium Oxide
kg	Kilogram (s)
lb	Pound
LSD	Least Significant Difference
m^2	Square meter
m^{-2}	Per square meter
mm	Millimeter
MP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Non Significant
P_2O_5	Phosphorus Penta Oxide
PU	Prilled Urea
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
t ha^{-1}	Ton per hectare
var.	Variety
Viz.	Namely
wt.	Weight



Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Sesame ((*Sesamum indicum* L.) is an important oil seed crop world wide and it yields a high quality, edible and odorless oil that serve as a good source of protein and fat for human and livestock. The crop is grown under a range of environments, which probably affects its performance. The environmental factors that influence sesame productivity include climatic factors such as temperature, rainfall and day length, soil types and management practices such as plant densities, fertilizers, time of sowing, irrigation, herbicides and fungicides, some of which may partially mitigate others.

Among the various oil crops grown in Bangladesh sesame ranks next to mustard in respect of both cultivated and production (Alim, 1974). Sesame is grown almost in all regions in Bangladesh occupying 4.22% of the total cropped area and contributes ab out 11% of the total oil seed production (BARI, 1998). In 2007-2008, the crop covered an area of about 83 thousand acres in Bangladesh with the production of 27 thousand metric tons (BBS, 2008).

Sesame is generally a photosensitive and short day plant due to its drought resistance ability, it can be cultivated in upland condition as rainfed crop. The crop is grown summer and winter seasons in Bangladesh (Kaul and Das, 1986; BARI, 1998). The climatic and edaphic conditions of Bangladesh are quite adaptable for cultivation of sesame crop. The most producing areas of sesame in Bangladesh are Khulna, Jessore, Faridpur, Barisal, Patuakhali, Rajshahi, Pabna, Rangpur, Sylhet, Comilla, Dhaka and Mymensingh.

Sesame is a diversified crop with high class edible oil having versatile usage. Bangladesh faces an acute shortage of edible oil. As a result, every year she has to import edible oil from different countries of the world at the cost of huge amount of foreign exchange. Bangladesh imported 376 thousand MT of oil from other countries costing an amount of Tk. 457 crores in 2002-2003 (BBS, 2004). Sesame oil is used mostly for edible purposes and in confectionery and for illumination.

Sesame is rich not only in oil (42-45%) but also in protein (20%) and carbohydrate (14-20%) (BARI, 1998). Sesame is also used for various purposes, such as in manufacture of margarine, paste (tahini), cake, and flour. Soap, paint, perfumery products and of pharmaceutical as an ingredients for drugs and as dispersing agent for different kinds of insecticides are obtained from sesame. Sesame seed contains antioxidants which inhibit the development of rancidity in the oil. Sesameolin a constituent of sesame oil is used for its synergistic effect in pyrethrum which increases the toxicity of insecticides (Hill, 1972).

The sesame oilcake is used for cattle feed as well as manure since it contains protein of high biological value and appreciable quantities of P and K. It contains N, P_2O and K_2O ranging from 6.2-6.2, 2.0-2.1, 1.1-1.3%, respectively (Chatterjee and Mondal, 1983).

Yield and quality seeds of sesame are very low in Bangladesh. Sesame yield is very low due to poor management practices (Rahman *et al.*, 1994). For successful production of crop many factors such as seed quality, weed control, proper fertilization, irrigation, methods of sowing, optimum sowing time, seed rate, plant population and time of harvest are indispensable. Yield decreases

progressively due to proper plant population and application of fertilizers especially nitrogen.

Left unchecked, world sesame production can decrease in the foreseeable future. This provides an opportunity for Bangladesh to produce larger quantities of high quality sesame seed to replace 'lost' of world sesame production.

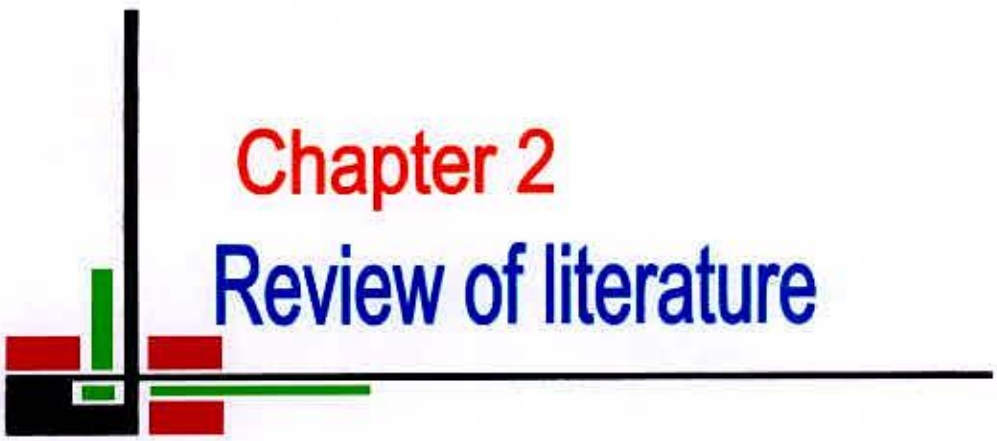
It reveals that nitrogen application and plant population are the two important practices to improve the seed yield and quality of sesame. Nitrogen levels have the direct influence on the seed yield of sesame and plant height, branches plant^{-1}, capsules plant^{-1}, seeds capsule^{-1}, seed yield and stover yield of sesame.

Plant population has considerable effect on vegetative growth as well as on yield of sesame. It is one of the most important aspects of crop growth which can be maintained to maximize the yield (Babu and Mitra, 1989). Plant population closely relates to optimum spacing and also extraction of nutrients from the soil and the optimization of plant population lead to both vegetative growth as well as yield (Hossain and Salahuddin, 1994).

The previous research works are limited on nitrogen levels and plant population in sesame. It is therefore, enough scope of conducting research with sesame cultivars for the improvement of its yield and quality under Bangladesh perspective. Extensive research works are necessity to find out the appropriate nitrogen levels and plant population to obtain satisfactory yield and quality seed of sesame.

Keeping the views like inter plant competition for optimum plant nutrients, sun light, moisture and aeration in mind, it may be required to find out a fair combination of plant population with nitrogen levels to achieve the maximum return of sesame yield under certain agroclimatic conditions. Hence, the present research work was undertaken to achieve the following objectives-

1. Find out the optimum nitrogen levels for the production of sesame
2. Determine the optimum plant population for higher yield of sesame
3. Find out the combination between nitrogen levels and plant population for better performance of sesame



Chapter 2
Review of literature

CHAPTER 2

REVIEW OF LITERATURES

Nitrogen levels and plant population play a significant role on the yield and yield contributing attributes of sesame crop. Relevant research information regarding the cultivar of sesame with nitrogen levels and plant population which are pertinent to the present experiment have been reviewed and presented in this chapter.

2.1. Effect of nitrogen levels

Chaubey *et al.*, (2003) conducted an experiment during the period of kharif season of 1997-98 and found that sesame yield and yield attributes were significantly increased with the application of different levels N (0, 15, 30, 45 and 60 kg ha^{-1}).

Malik *et al.*, (2003) observed that effect of different N levels (0, 40 and 80 kg ha^{-1}) on the productivity of sesame cv. TS-3 in Faisalabad, Pakistan under different plant geometrics and showed that 80 kg N ha^{-1} produced the highest seed yield (0.79 t ha^{-1}), 1000 seed weight (3.42 g), oil content (45.88%) and protein content.

Rahman *et al.*, (2003) conducted an experiment on the response of sesame to sowing dates, N 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 and 235000 plant $fedan^{-1}$ on the performance of sesame cv. Giga32. The highest of the first branch and first capsule as well as the length of the fruiting zone was highest at 60 kg N $fedan^{-1}$.

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 induced the recommended dose of inorganic N at 30 kg ha^{-1} alone, inoculation of Azospirillum or Azotobacter each at 600 kg ha^{-1} with 25% or 50% N, either with or without lime at 600 kg ha^{-1} and an absolute control. The plots that received the recommended dose of N (30 kg ha^{-1}) alone produced tales plants with the highest number of branches $plant^{-1}$ and dry matter. The highest number of capsule $plant^{-1}$, number of seeds $capsule^{-1}$ 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 ground sesame cropping system and found that the seed yield was highest with 60 kg N ha^{-1}. N was supplied to sesame at 0, 50 and 100% of the recommended rates of 60 kg ha^{-1} but in rice N was supplied as green manure (25%) + urea (75%), FYM (25%) + urea (75%), green manure (25%) + FYM (25%) + urea (50%), green manure (50%) or urea (100%), and incase of groundnut at 0, 50 and 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 the highest incase of 60 kg N ha^{-1} (100% recommended dose) and application of N as a green (50%) + FYM (50%) but highest number of seeds $capsule^{-1}$ and 1000 seed weight obtained with thee application of 100% of the recommended dose.

Allam (2002) evaluated the effect of gypsum (0, 500 and 1000 kg $feddan^{-1}$) and N (45, 60 and 75 kg $feddan^{-1}$) rates on sesame cv. Giza 32. Gypsum was applied during sowing and 55 days after sowing and N was applied after thinning and 3 weeks thereafter. He found that increasing gypsum and N rates

increased plat 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}

Kathiresan (2002) carried out an experiment to study the response of 2 cultivars (TMV-3 and TMV-4) of sesame at 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 period than lower nutrient level.

Pathak *et al.*, (2002) observed that the effect of N levels (0, 15, 30 and 45 kg ha^{-1}) on the growth and yield of sesame. They found that application of N 45 kg ha^{-1} produced the highest plant height (74.3 cm), number of branches pant^{-1}(4.50), number of capsules plant^{-1}(39.0) 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}).

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

Sarala *et al.*, (2002) conducted an experiment in Tirupati, Andhra Pradesh, India to determine the effects of N on the yield and yield components of sesame under dry land conditions. N at 60 kg ha^{-1} recorded more number of capsules and seeds per capsule which was at per 45 kg N ha^{-1} + Azospirillum

treatment. The highest seed yield was obtained with application of 60 kg B ha^{-1} which was at per with 45 kg N ha^{-1} + Azospirillum.

Ahmad *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 N (0, 40, 80 and 120 kg ha^{-1}). Application of N at 120 kg ha^{-1} significantly increased the seed and stalks yield, protein and oil content of cv. TS3 than in 92001.

Patra (2001) conducted a field trial of sesame cv. Kalika applying four levels of N (0, 30, 60 and 90 kg ha^{-1}) in Chiplima, Orissa, India. Plant height, branches $plant^{-1}$, seeds $capsule^{-1}$, capsule length, 1000 seed weight and seed yield significantly increased with increasing N rate up to 60 kg ha^{-1}. N uptake increased with increasing rates of N up to 90 kg ha^{-1} but oil content increased with increasing N rate up to 60 kg ha^{-1}. Harvest index was not significantly affected by N application.

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

Tiwari *et al.*, (2000) conducted an experiment N (15, 30 and 60 kg ha^{-1}) and S (0, 15 and 30 kg ha^{-1}) and found that optimum dose of N and S gave the improved growth and yield (plant height, number of seeds $capsule^{-1}$), 1000 seed weight and straw yield).

Mitra and Pal (1999) conducted a field experiment in West Bengal, India and observed that dry matter production plant^{-1}, number of capsule plant^{-1}, seeds capsule^{-1} and seed yield of sesame were significantly increased up to 100 kg N ha^{-1}. Further increase of N decreased the seed yield and yield contributing characters. For seed yield, the response to apply N 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}.

Subrahmaniyan and Arulmozhi (1999) conducted an experiment on sesame cv. VS 9104 and VR 11 with applying N (0, 35, 45 and 55 kg ha^{-1}) and found that yield and yield component, plant height, number of branches palnt^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1} increased with the increasing N rate.

Sumathi and Jaganadham (1999) stated that seed yield of sesame of four varieties increased up to 60 kg N ha^{-1} and further increase in N rate the yield was not increased significantly.

According to Thakur *et al.*, (1998) seed, oil and protein content of sesame increased significantly with application of N and P_2O_5. They applied 30, 45 and 60 kg N and 20, 30 and 40 kg P_2O_5 kg ha^{-1} and found that 45 kg N and 30kg P_2O_5 was suitable for obtaining optimum yield of sesame.

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

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

Mondol *et al.*, (1997) conducted an experiment with five levels of N 0, 30, 60, 90 and 120 kg ha^{-1} on sesame and observed that plant height, dry matted accumulation, number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, 1000 seed weight, seed yield and protein contents were increased significantly with increasing N rates but harvest index and oil content were not significantly affected.

Singh *et al.*, (1997) 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, 802 and 120 kg N ha^{-1} or combination of 10 t poultry manure with them.

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

Sharma *et al.*, (1996) observed that sesame cv. FC-25 produced the higher plant height, number of capsules $plant^{-1}$, 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} applying.

Kumar and Prasad (1993) in a field trial found that seed yield of sesame increased with N fertilizer rate from 0.13 t ha^{-1} (Without N) 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.

Dwivedi and Namdeo (1992) observed that 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.

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

Shrivastava and Tripathi (1992) conducted a field experiment at Raipur, Madya Pradesh, India and observed that N rates 30, 60 and 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}.

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

Vijan *et al.*, (1987) found that application of N 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 N rate to 120 kg ha^{-1} produced linear increase in protein contents but had no effect on other parameters.

2.2. Effect of plant population

Plant population is the most critical for obtaining higher amount of sesame yield. Above or below the threshold level of plant population it would be lead to intra-species competition among plants for scarce resources which cause subnormal sesame seed yield. Hence, identification of optimum population for

each variety being tested becomes vital. Various reports indicated that the growth and yield attributes and yield of sesame were determined by plant densities. Adoption of suitable and optimum spacing would fulfill the objective of maximizing the yield of sesame.

Rahman and Bakhshandeh (2006) conducted an experiment and reported that rows were adopted at varying spaces of 37.5, 50 and 60 cm while the plants were arranged horizontally at 5, 10, 15 and 20 cm. In this way, the density of the plot was surveyed over an area ranging from 8300 to 53000 plants ha^{-1}. The maximum seed and oil yield was then estimated at a density of 200000 to 250000 plant ha^{-1}.

Adebisi *et al.*, (2005) studied an experiment to assess the impact of three population densities during two seasons on seed yield. Plant population of 166667 plants ha^{-1} gave 40% more yield that that of 266667 plants ha^{-1} and was the best for maximizing yield under rain-fed conditions.

Fard and Bahrani (2005) conducted an experiment in Iran, on the effect of different N rates (0, 60 and 90 kg ha^{-1}) and plant densities (10.0, 16.6 and 25.0 plants m^{-2}) on the yield and yield components of sesame. Plant density exhibited significant effect on seed yield, biological yield, harvest index, number of branches $plant^{-1}$ and number of capsules $palnt^{-1}$. Increasing the plant density increased the seed yield. Seed oil percentage was a stable yield component and was not affected by plant density.

Caliskan *et al.*, (2004) carried out an experiment on the effect of planting method (row and broadcast) and plant population (102000, 127500, 170000, 255000 and 510000 plant ha^{-1}) on the yield and yield components of sesame in

two consecutive years. Row planting had positive effects on the yield and yield components of the crop and produced 34% higher seed yield compared to broadcast planting in both the years. The plant population also significantly affected all growth and yield parameters. Plant height, branch number, capsule number, capsule length, seeds capsule^{-1}, seed weight, seed yield and protein content decreased, whereas seed yield, harvest index and oil content increased with increasing plant population. The highest seed yield was obtained from 510000 plant ha^{-1} with 1633 and 1783 kg ha^{-1}, respectively in two years.

Rahman *et al.*, (2003) conducted a study on the sandy soil of Assiut, Egypt in 2001and 2002 to investigate the effect of plant population (70000, 35000 and 23333 plants fed^{-1}) on the performance of sesame cv. Giza 32. The highest seed and oil yield (6.20 ard fed^{-1}) and 366.39 kg fed^{-1}) were obtained plants grown at 70000 population [1 fedan = 0.42 ha].

Olowe *et al.*, (2003) carried out a field experiment to determine the optimum populations of sesame (E8) intercropped with maize (SUWAN-1-SR). Sesame seed weight plnat^{-1} increased significantly ($p<0.05$) as its population reduced in the cropping system. Sesame at 75% population densities appeared optimal for intercropping with maize in the forest savanna transition zone of south western Nigeria.

Amabile *et al.*, (2002) conducted a study to determine the best row spacing and sowing density for sesame in the savannah area of the Federal District, Brazil. Sesame cv. CNPA-G3 was sown at densities of 80000, 100000 and 120000 plant ha^{-1}, combined to row spacing of 45, 60, 75 and 90 cm. Grain yield and other plant characteristics were not affected by row spacing and sowing density.

Imayavaramban *et al.*, (2002) investigated an experiment to find out the effect of varied plant populations and N rates on the productivity and economic returns in sesame cv. VRI 1. The highest plant population of 166666 ha^{-1} significantly recorded the maximum seed yield, net income and the benefit cost ration compared to lesser plant population viz. 166666 and 111111 plant ha^{-1}.

Basavaraj *et al.*, (2000) carried out field trials during the summer season in Karnataka, India to evaluate the performance of sesame varieties DS-1 (shy branching) and E-8 (branching) in rice fallows for plant population (3.33 and 6.66 lakhs ha^{-1}). Plant population of 6.66 lakhs ha^{-1} produced higher seed yield (1736 kg ha^{-1}) and net returns (Rs. 18871 ha^{-1}) than 3.33 lakhs ha^{-1} (1621 kg ha^{-1} and Rs. 17319 ha^{-1}, respectively) due to the increase in plant population per unit area.

Ricci *et al.*, (1999) studied seed yield on the effect of 3 plant densities (10, 15 and 20 plant m^{-2} of row) and of 2 drying processes (in the field and on the paved floor) of sesame cv. IAC-China. The results showed that the density of 20 plants m^{-2} of row resulted in highest yield ha^{-1}, while the density of 10 plants resulted in highest yield $plant^{-1}$.

Subrahmaniyan and Arulmozhi (1999) carried out an experiment and found that sesame cv. VS 9104 and VRI 1 were grown at densities of 111000 or 166000 plants ha^{-1} and given 0, 35, 45 or 55 kg N ha^{-1}. Yield parameters were generally highest with 111000 plants ha^{-1}, while 166000 plants ha^{-1} gave the highest seed yield.

Asaname and Ikeda (1998) observed that yield and its components were greater in higher density than in lower density. Increased yield depend on seed, pod and mode number m^{-2}.

Dixit *et al.*, (1997) carried out a field experiment during early rabi season at Powarkheda, Madhya Pradesh, India to assess the productivity of sesame cv. TC-25 and Rauss-17 sown at 333000, 444000 or 666000 plants ha^{-1} with application of 0-90 kg N ha^{-1}. Rauss-17 produced significantly higher yields (0.40 t ha^{-1}) and net profit than TC-25. Plant density had no significant effect on seed yield.

Moorthy *et al.*, (1997) conducted field trials at Cuttack, Orissa, India, sesame cv. Kalika was tested at different plant spacing ranging from 30 × 10 to 50 × 15 cm giving 133000-333000 plants ha^{-1}. Seed yield was highest at 30 × 15 cm spacing followed by the 40 × 10 cm spacing.

Balasubramaniyan (1996) carried out field trials during summer season on sandy loam soil. Two sesame genotypes were sown at 3.0, 4.5 or 6.0 x 105 plants ha^{-1} and were given 0, 30, 60 or 90 kg N ha^{-1}. The pre-release genotypes VS 350 yielded more (711 kg ha^{-1}) than cv. TMV (636 kg ha^{-1}) and matured 10-12 days earlier. Yield was not significantly affected by plant density.

Patil *et al.*, (1996) conducted a filed experiment at Maharashtra, India, sesame cv. Padma was grown at spacing of 30 x 10 cm (33 plants m^{-2}), 30 x 15 cm (22 plants m^{-2}), 45 × 10 cm (22 plants m^{-2}) and 45 × 15 cm (14 plants m^{-2}) and given 0-50 kg N ha^{-1}. Mean seed yield (0.58 t ha^{-1}) and net returns were highest at the 30 x 15 cm spacing (i.e. 22 plants m^{-2}) with 50 kg N.

Sharma *et al.*, (1996) conducted a field experiment at Hoshangabad, Madhya Pradesh, India, sesame cv. TC-25 and TKG-9 were grown at densities of 300000, 450000 or 600000 plants ha^{-1} and given 0-90 kg N ha^{-1}. Yield was not affected by plant density.

BINA (1993) reported that medium plant density (50 plants m^{-2}) produced significantly higher capsules $plant^{-1}$ on main stem compared to the other two plant densities of 25 and 75 plants m^{-2}. The highest yield was also obtained from 20 plants m^{-2}. In multi-location trial with plant population of sesame it was observed that the lowest plant density produced significantly higher number of capsules $plant^{-1}$ in branches but lower yield and the highest plant population (75 plants m^{-2}) produced the highest harvest index.

Ghosh and Patra (1993) carried out field trials in the dry season at West Bengalk, India. Sesame cv. B-67 (Tilottama) was grown on sandy loam soil at densities of 167000, 222000 or 333000 plants ha^{-1} and was given no fertilizer, 24 kg N + 4.5 kg P + 13 kg K ha^{-1} or 2, 3, 4 or 5 times these levels. Results indicated that increasing plant density was correlated with increases in LAI, crop growth rate and DM production but plant height was unaffected and degree of branching decreased with increasing density. Number of capsules $plant^{-1}$ decreased with increasing plant density whilst number and weight of seeds was unaffected. Seed yield increased with plant density.

Channabasavanna and Setty (1992) carried out an experiment with different plant densities (22, 33 and 66 plants m^{-2}) in sesame and observed that number of capsules $plant^{-1}$ differed significantly with varying plant density with the highest capsules $plant^{-1}$ were obtained at the lowest plant density.

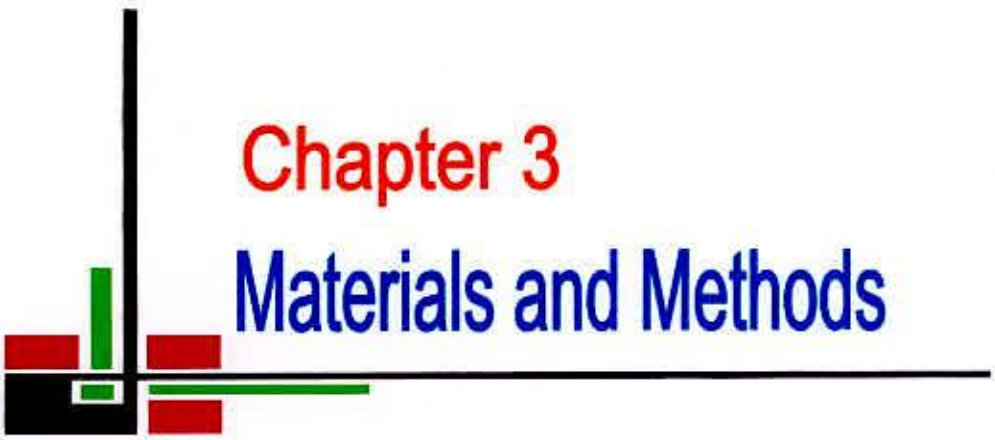
Ghungrade *et al.*, (1992) stated that wider spacing of 16 cm between rows produced maximum number of capsules plant^{-1} than narrower row spacing (25 cm × 20 cm). They also found that optimum density (20 plants m^{-2}) gave the better result.

Majumdar and Roy (1992) conducted an experiment in sesame with plant population (16, 22 and 33 plants m^{-2}) and observed that the 1000 seed weight was marginally improved by increasing spacing and decreasing plant height and the seed yields were significantly increased with increasing plant population.

Singh *et al.*, (1988) grown sesame with three plant densities (22, 33 and 66 plants m^{-2}) and observed that capsules plant^{-1} were decreased significantly with an increase in density from 33 to 50 plants m^{-2}. The lowest plant density (22 plants m^{-2}) gave the highest weight of 1000 seeds and it was decreased significantly with an increase in plant density from 33 to 50 plants m^{-2}.

Enyi (1973) observed that the total dry mass plant^{-1}, capsules weight plant^{-1}, stem weight plant^{-1}, shelling percentage, number of nodes plant^{-1}, number of node bearing capsules, filled capsules plant^{-1}, branches plant^{-1} and grain weight of branch decreased with increasing plant density.

On the basis of the findings presented in the review of literatures, it is clear that seed yield and yield attributing characters of sesame is influenced by N and plant population.



Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during March to July 2009. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recordings and their analyses.

3.1 Site description

The experiment was conducted at the research field of Agronomy Department, Sher-e-Bangla Agricultural University, Dhaka under the Agro-ecological zone of Madhupur Tract, AEZ-28. The land area was situated at 23°41′N latitude and 90°22′E longitude at an altitude of 8.6 meter above sea level.

3.2 Climate

The experimental area was under the sub-tropical that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif-1 season (March-July) associated with moderately low temperature during the rabi season (October-March).

3.3 Soil

The soil of the experimental field belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done from Soil Resources and Development Institute (SRDI), Dhaka.

3.4 Planting materials

BARI Til 3, a high yielding variety of sesame, developed by Bangladesh Agricultural Research Institute (BARI), Gazipur was used as a planting material. The seeds of this variety were collected from the research farm of Sher-e-Bangla Agricultural University, Dhaka.

3.5 Experimental treatments

The experimental treatments consisted of two factors i.e. nitrogen and plant population.

Factor A: Nitrogen level

Nitrogen levels	**Symbol used**
0 kg N (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

Factor B: Plant Population

Plants ha^{-1}	**Symbol used**
166666 (30 cm × 20cm)	P_1
222222 (30 cm × 15 cm)	P_2
333333 (30 cm × 10 cm)	P_3
666666 (30 cm × 5 cm)	P_4

3.6 Design and layout of the experiment

The experiment was laid out in a randomized completed block design (RCBD) comprising three replications. The size of each unit plot area was 3 × 2 m. The inter block and rows spaces were used as footpath and irrigation or drainage channels.

3.7. Conducting the experiment

3.7.1. Germination test

Before sowing of sesame seeds, germination test were made in the laboratory and germination percentage was counted over 92 using the following formula-

$$\textbf{Percentage of germination} = \frac{\text{Number of geminated Seeds}}{\text{Number of seed set for germination}} \times 100$$

3.7.2. Land preparation

The land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 6 operations of ploughing and harrowing with country plough and ladder. The stubble and weeds were removed. Experimental land was divided into unit plots following the design of experiment. The pots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly before planting.

3.7.3. Fertilizer application

Cowdung was applied at the rate of 10 t ha^{-1} during the land preparation. Other fertilizers were applied at the rate of 30, 25, 5, 0.34 and 1.8 kg ha^{-1} P, K, S, B and Zn, respectively where as 0, 30, 45 and 60 kg N ha^{-1} were applied at two installments.

3.7.4. Seed sowing

Seeds of sesame were sown on 21March, 2009 following line to line distance was 30 cm. Seeds were placed 2 cm depth and then rows were covered with loose soil properly. The seed rate was 8 kg ha-1.

3.7.5. Intercultural operations

The following intercultural operations were done for ensuring normal growth of the crop.

3.7.5.1. Weeding

During plant growth period two hand weeding were done using Nirani. First weeding was done at 20 days after sowing followed by second weeding at 30 days after first sowing.

3.7.5.2. Thinning

Thinning was done in all the unit plots with care so as to maintain a uniform plant population in each experimental plot. The job was done in twice times at 10 and 20 days after sowing of sesame seeds.

3.7.5.3. Irrigation and drainage

One pre sowing irrigation was done to maintain the equal seed germination of sesame. After sowing of seeds two irrigations were done during the life cycle of sesame. Excess water was drained out during the irrigation.

3.7.5.4. Plant protection measures

During the growth period some plants were infested by myriads and cutworm. It was controlled by spraying with Diazinon 60EC @ 1 L ha^{-1} at the time of infestation period.

3.8. General observation of the experimental field

The research field looked nice with normal green plants. The plants in the wider spacing appeared to be more vigorous and luxuriant than that of closer spacing. Field was observed time to time to detect visual difference among the treatment and any kind of infestation by weeds, insects and diseases so that considerable losses by pest was minimized.

3.9. Harvesting and threshing

The crop was harvested on 18 June, 2009. The crop was harvested plot wise when about 80% of the capsules became matured. Plants of 1 m^2 area from the

central part of the each plot were harvested and plants were tied into bundles and carried to the threshing floor. The bundles were dried in the open sunshine for three consecutive days. The seeds were separated from the pods by beating with the bamboo sticks and then cleaned, dried and weight. A weight of dry stover yields was also taken.

3.10. Collection of experimental data

The data were collected on different parameters of sesame plants. Ten plants were randomly selected from each plot excluding border plots outside the central 1 m^2 area which was kept for yield. The sample plants were uprooted carefully from the soil with khurpi so that no seeds were dropped into the soil and then cleaned, dried and the data in the following crop characters were collected from those sample plants-

1. Plant height (cm)
2. Branches $plant^{-1}$
3. Capsules $branch^{-1}$
4. Total capsules $plant^{-1}$
5. Number of effective capsules $plant^{-1}$
6. Number of non effective capsules $plant^{-1}$
7. Capsule length (cm)
8. Seeds $capsule^{-1}$
9. Filled seeds $capsule^{-1}$
10. Unfilled seeds $capsule^{-1}$
11. 1000 seeds weight (g)
12. Seed yield (t/ha^{-1})
13. Stover yield (t/ha^{-1})
14. Harvest index (%)

A brief outline of the above mentioned of the parameters data recording is given below-

3.10.1. Plant height

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

3.10.2. Branches plant^{-1}

The number of branches plant^{-1} was counted from preselected ten plants and mean values were taken.

3.10.3. Capsules branch^{-1}

The number of capsules branch^{-1} was counted from all the branches that were born on the preselected ten plants and values were taken.

3.10.4. Total capsules plant^{-1}

The number of total capsules plant^{-1} of preselected ten plants from each unit plot was obtained and mean number was determined. The mean number was expressed on per plant basis. The number of filled capsules plant^{-1} plus the number of unfilled capsules plant^{-1} gave the total number of capsules plant^{-1}. The total number of capsules plant^{-1} was calculated with the following formula:

Total Number of capsules plant^{-1} = Number of filled capsules plant^{-1} + number of unfilled capsules plant^{-1}.

3.10.5. Number of effective capsules plant^{-1}

The number of effective capsules plant^{-1} was counted from all the capsules that were born on all the preselected ten plants and mean values were taken.

3.10.6. Number of non effective capsules plant^{-1}

Capsules that have no seeds inside are termed as non effective capsules. The number of non effective capsules plant^{-1} was counted from all the capsules that were born on all the preselected ten plants and mean values were taken.

3.10.7. Capsule length

The length of capsule was determined by randomly preselected 10 capsules. The length of each capsule was measured using a measuring tape and finally plot wise average capsule length was determined.

3.10.8. Seeds capsule^{-1}

From each sample plant of ten sampled plants, 10 capsules were randomly selected and all the seeds of them were counted, the number of seeds capsule^{-1} was determined by averaging the data.

3.10.9. Filled seeds capsule^{-1}

The number of filled seeds was counted randomly taking ten capsules from each sample of each plot as per treatment and average values were taken.

3.10.10. Unfilled seeds capsule^{-1}

The number of unfilled seeds was counted randomly taking ten capsules from each sample of each plot as per treatment and average values were taken.

3.10.11. 1000 seeds weight

One thousand cleaned and dried sesame seeds were counted and then the data were recorded by means of an electrical balance and the weight was expressed in gram.

3.10.12. Seed yield

Weight of seeds of the demarcated area (1.0 m^2) at the centre of each plot was taken and then converted to the yield in t ha^{-1}.

3.10.13. Stover yield

The weight of stover yield was taken by subtracting the grain weight from the total weight. The biomass weight was calculated after threshing and separation of grain from the sample area and then expressed in t ha^{-1} in dry weight.

3.10.14. Harvest index

It is the ratio of economic yield to biological yield and was calculated with the following formula (Gardner *et al.*, 1985).

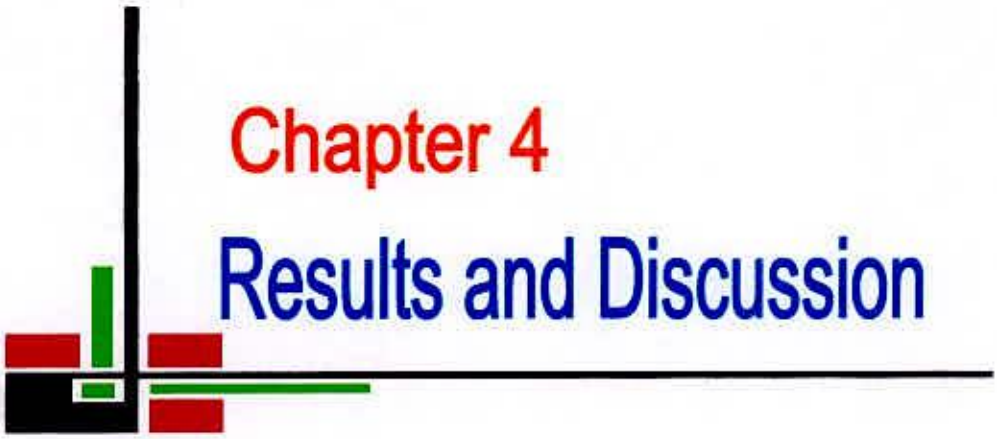
$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

The summation of economic yields and biomass yields were considered as biological yields. Biological yield was calculated by using the following formula-

Biological yield = Grain yield + stover yield (dry weight basis)

3.11. Statistical analysis of the data

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) at 5 % level of significance using the MSTAT computer package program.



Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Plant height

4.1.1. Effect of nitrogen levels

The present finding showed that plant height was significantly influenced by nitrogen levels as shown in Figure 1. The highest plant height (115.50 cm) was obtained from the higher dose of N application (60 kg N ha^{-1}) followed by (111.25 cm) from 45 kg N ha^{-1} applied and the shortest plant (104.50 cm) was recorded from 0 kg N ha^{-1} applied. It was observed that plant height increases with the increases of N levels. Similar results were reported by Allam (2002), Pathak *et al.*, (2002) and Pathak (2001).

4.1.2. Effect of plant population

The effect of plant population on plant height of sesame is presented in Figure 2. Plant height increased with the increases of plant population. The tallest plant (115.17 cm) was obtained from the highest plant population (666666 plants ha^{-1}) followed by 112.67 cm from the second highest plant population (333333 plants ha^{-1}) and the shortest plant (100.50 cm) was recorded from the lowest plant population (166666 plants ha^{-1}) preceded by 110.75 cm from (222222 plants ha^{-1}) plant population. Plant height increases with the increases of plant population. However, as plant population increases per unit area, appoint is reached at which each plant begins to complete for essential growth resources like nutrients, light and water. Mujaya and Yerokun (2003) reported that higher plant population gave the taller plant in sesame crop.

4.1.3. Combined effect of plant population and nitrogen levels

The interaction effect of plant population and nitrogen levels on plant height was found significant (Table 1). Combination of the highest plant population (666666 plants ha^{-1}) and higher dose of N application (60 kg N ha-1) gave the highest plant height (120.00 cm) followed by 118.00 cm from 333333 plants ha^{-1} in combination with 60 kg N ha^{-1} and the shortest plant was recorded from lower plant population in combination with 0 kg N ha-1 applied.

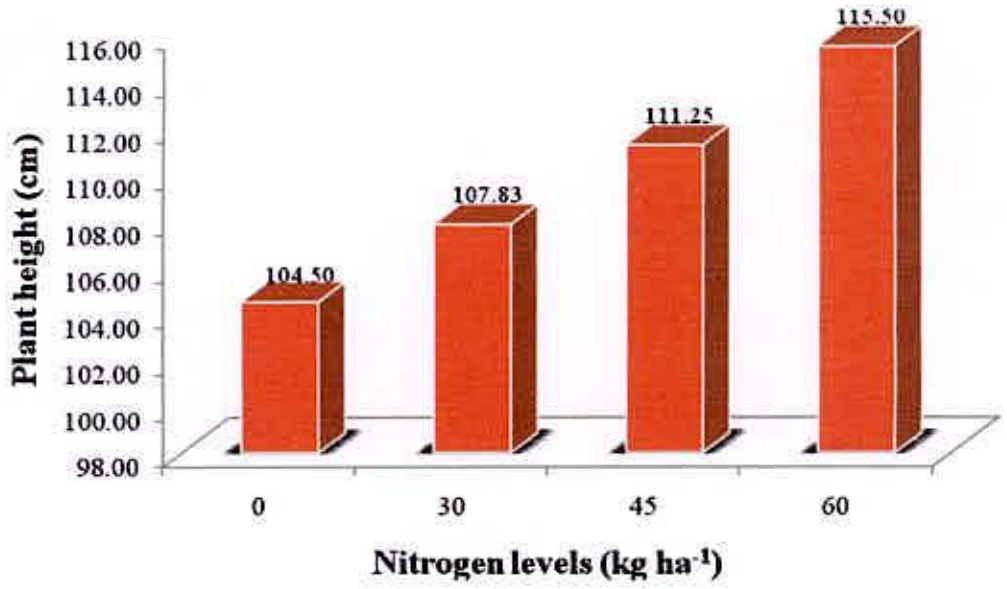


Fig.1. Effect of nitrogen levels on plant height (cm) of sesame (Sx= 0.6765)

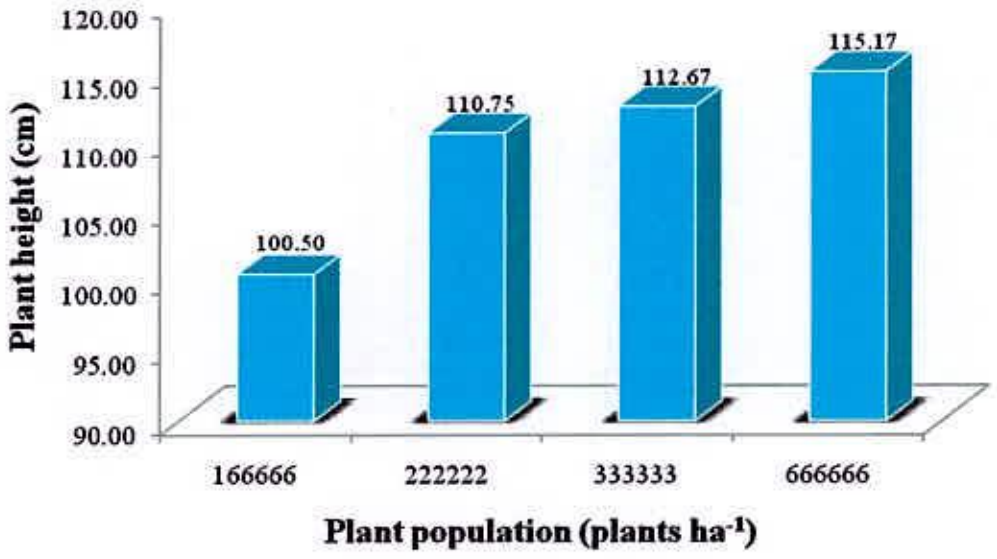


Fig.2. Effect of plant population on plant height (cm) of sesame (Sx = 0.6765)

4.2. Branches plant^{-1}

4.2.1. Effect of nitrogen levels

The effect of nitrogen levels on branches plant^{-1} of sesame is given in Figure 3. The varied levels of N had a significant role on branches plant^{-1}. The number of branches plant^{-1} increased with the increases of nitrogen levels. The highest (4.51) branches plant^{-1} was observed from the higher (60 kg N ha^{-1}) doses of N applied followed by (4.38) from the 45 kg N ha^{-1} and the lowest (3.51) branches plant^{-1} was found from the control treatment of 0 kg N ha^{-1} preceded by 3.98 in 30 kg N ha^{-1} applied. Pathak *et al.*, (2002); Patra *et al.*, (2001) reported that 45 kg N ha^{-1} increased number of primary branches plant^{-1}.

4.2.2. Effect of plant population

The effect of plant population on branches plant^{-1} of sesame is presented in Figure 4. The branches plant^{-1} decreased with the increases of plant population. The higher (4.55) number of branches plant^{-1} was obtained from the lower population (166666 plants ha^{-1}) followed by 4.35 in 222222 plant ha^{-1} and the lowest (3.18) branches plant^{-1} was found in the higher (666666) plant population ha^{-1}. Majumder and Roy (1992) reported that lowest plant population gave significantly increased number of branches plant^{-1}

4.2.3. Combined effect of plant population and nitrogen levels

The interaction effect of plant population and nitrogen levels on the branches plant^{-1} was found significant (Table 1). The interaction of the lowest plant population (166666 plants ha^{-1}) with the higher dose of nitrogen (60 kg N ha^{-1}) resulted in the highest branches plant^{-1} (5.12) followed by 4.95, 4.90 in combination of 166666 plants ha^{-1} with 45 kg N ha^{-1}, 222222 plants ha^{-1} with 60 kg N ha^{-1} and 333333 plants ha^{-1} with 60 kg N ha^{-1}, which were statistically identical. The lowest number of branches plant^{-1} (3.07) was recorded from the higher plant population (666666 plants ha^{-1}) in combination with 30 kg N ha^{-1} followed by 3.12 from 666666 plants ha^{-1}in combination with 0 kg N ha^{-1} and these also statistically similar.

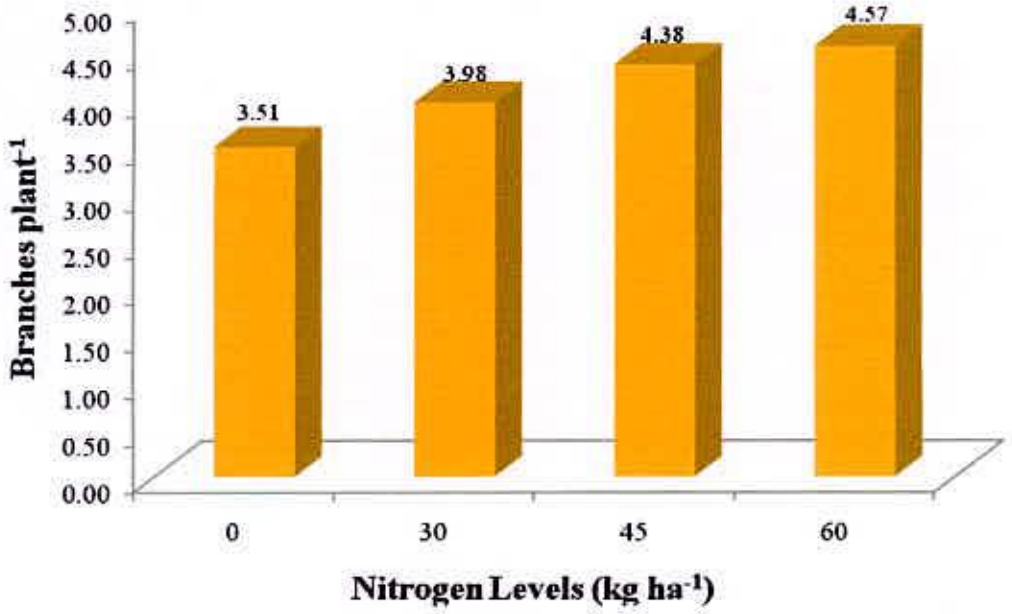


Fig.3. Effect of nitrogen levels on number of branches plant^{-1} of sesame (Sx = 0.0428)

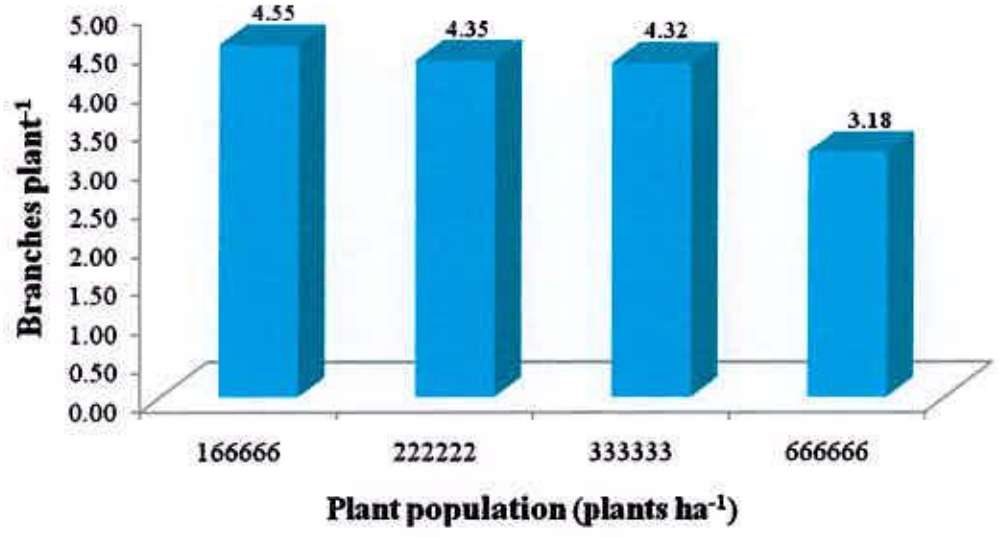


Fig.4. Effect of plant population on number of branches plant^{-1} of sesame (Sx = 0.0428)

4.3. Capsules branch^{-1}

4.3.1. Effect of nitrogen levels

The effect of nitrogen on capsules branch^{-1} of sesame is shown in Figure 5. The number of capsules branch^{-1} was significantly increased with the increasing levels of N. The highest capsules branch^{-1} 17.36, 16.03 was noted from 60 and 45 kg N ha^{-1} applied, respectively. The lowest (12.93) capsules branch^{-1} was recorded from the untreated plot (0 kg N ha^{-1}) preceded by 30 kg N ha^{-1} (14.63).

4.3.2. Effect of plant population

The effect of plant population on capsules branch-1 is shown in Figure 6. The maximum (17.28) amount of capsules was noted from the lower (166666 plant ha^{-1}) plant population followed by 15.45 from the 222222 plant ha^{-1} and the minimum (13.29) plant population was obtained from the higher plant population 666666 plant ha^{-1}. It was observed that capsules plant^{-1} decreased with the increases of population due to intra-specific competition among the plant population. The present study showed that lower number of plant population gave the higher number of capsules branch^{-1} but conflict with Fard and Bahrani (2005) they reported that higher number of plant population gave the higher number of capsules plant^{-1}.

4.3.3. Combined effect of plant population and nitrogen levels

The combined effect of plant population and nitrogen levels on capsules branch^{-1} of sesame showed significant variation and presented in Table 1. The highest number of capsules branch^{-1} (19.07) was recorded from the lower number of plant population (166666 plants ha^{-1}) with higher dose of N application (60 kg N ha^{-1}) followed by 18.37, 18.03, 17.00 from 222222 plants ha^{-1} with 45 kg N ha^{-1}, 166666 plants ha^{-1} with 45 kg N ha^{-1} and 333333 plants ha^{-1} with 60 kg N ha^{-1}, respectively and these were statistically identical. The lowest number of capsules branch^{-1} 10.67 and 12.83 were recorded both from the higher plant population in combination with 0 kg N ha^{-1} and 30 kg N ha^{-1} applied.

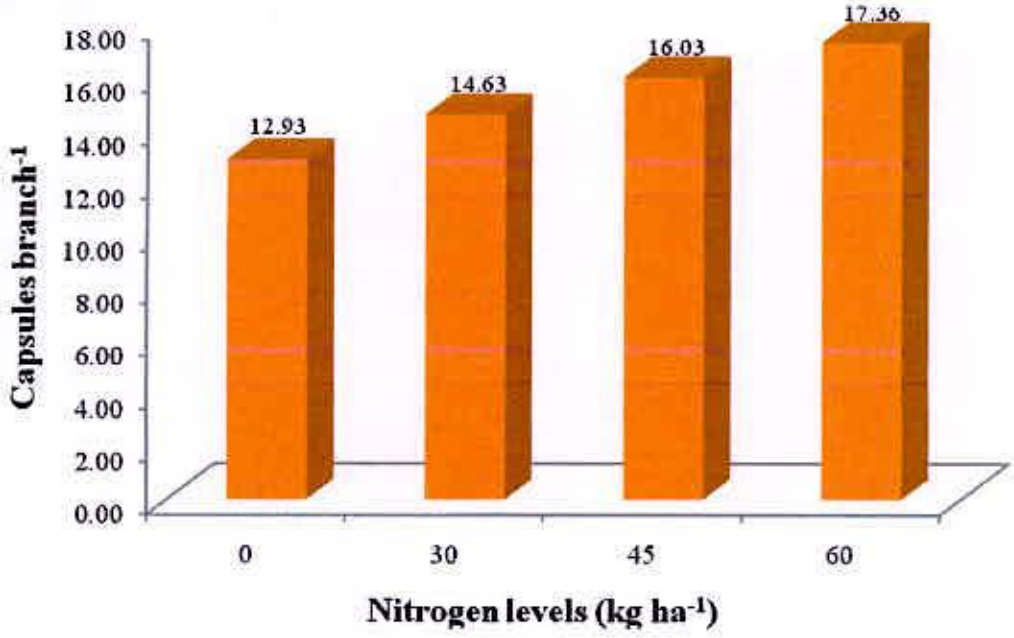


Fig.5. Effect of nitrogen levels on number of capsules branch^{-1} of sesame (Sx = 0.6175)

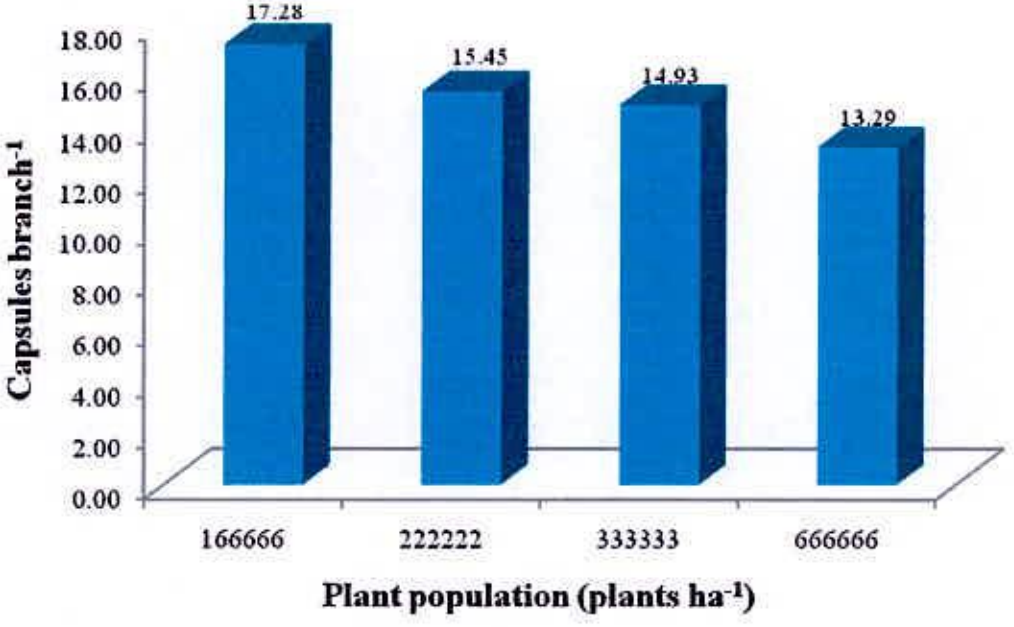


Fig.6. Effect of plant population on number of capsules branch^{-1} of sesame (Sx = 0.6175)

4.4. Total capsules plant^{-1}

4.4.1. Effect of nitrogen levels

The levels of different nitrogen had a significant effect on total capsules plant^{-1} on sesame crops and presented in Figure 7. The maximum number of capsules plant^{-1}were recorded from the higher doses of N ha^{-1} followed by 45 kg N ha^{-1}. The highest capsules plant^{-1} was 80.32 followed by 70.93 and the lowest was 45.76 preceded by 70.93 from the 60, 45, 30 and 0 kg N ha^{-1}, respectively.

4.4.2. Effect of plant population

The plant population had a significant effect on total capsules plant^{-1} of sesame and shown in Figure 8. The higher (79.38) number of capsules plant^{-1} was recorded in the lower (166666 plant ha^{-1}) plant population followed by 222222 plant ha^{-1} (68.15) and the lowest (42.54) was recorded from the higher (666666) number of plant population. The results agreed with Tomar *et al.*, (1992).

4.4.3. Combined effect of plant population and nitrogen levels

The combined effect of plant population and nitrogen levels on total number of capsules plant^{-1} of sesame showed significant variation and presented in Table 1. The highest number of total capsules plant^{-1} (97.55) was recorded from the lower number of plant population (166666 plants ha^{-1}) with higher dose of N application (60 kg N ha^{-1}) followed by 89.95, 89.23 and 83.13 from 222222 plants ha^{-1} with 60 kg N ha^{-1}, 166666 plants ha^{-1} with 45 kg N ha^{-1} and 333333 plants ha^{-1} with 60 kg N ha^{-1}, respectively and these were statistically identical. The lowest number of total capsules plant^{-1} 32.83 and 40.01 were recorded both from the higher plant population in combination with 0 kg N ha^{-1} and 30 kg N ha^{-1}.

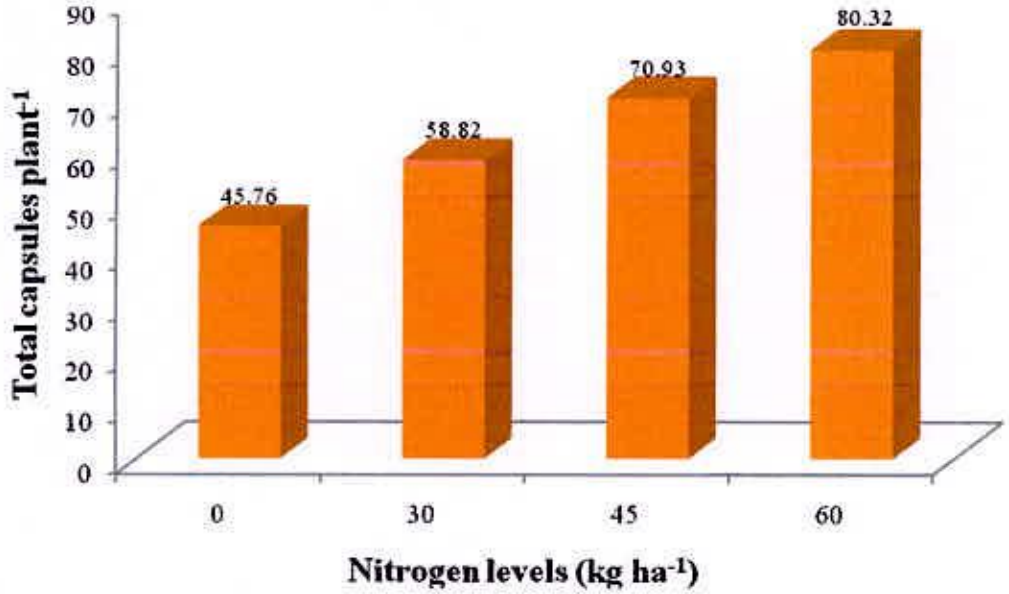


Fig.7. Effect of nitrogen levels on total number of capsules plant^{-1} of sesame (Sx = 2.7285)

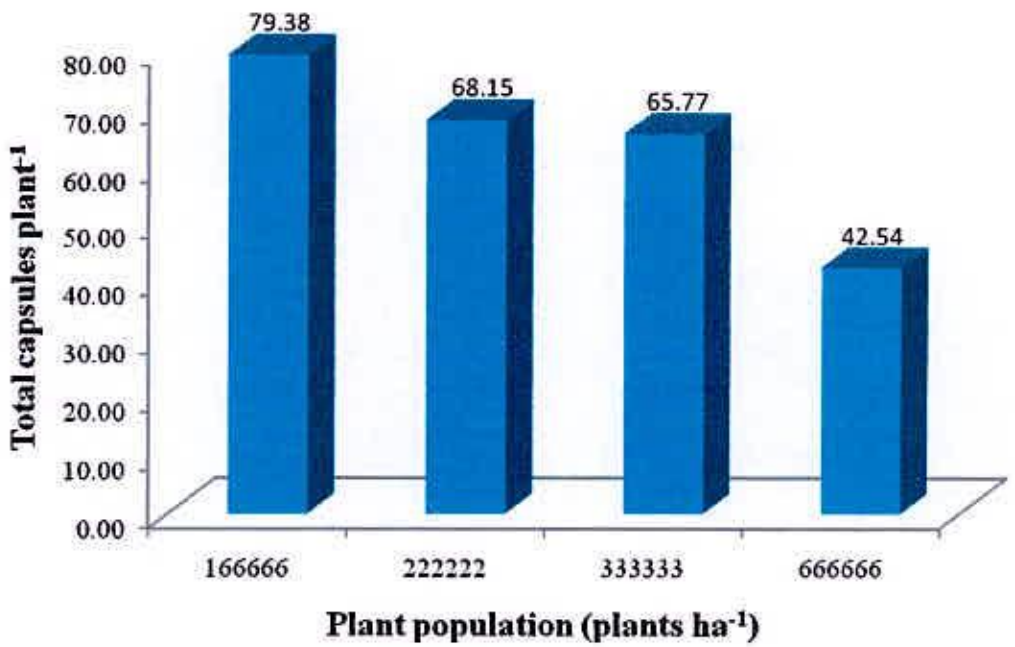


Fig.8. Effect of plant population on total number of capsules plant^{-1} of sesame (Sx = 2.7285)

Table 1. Combined effect of nitrogen levels and plant population on plant height, branches plant^{-1} capsules branch^{-1} and total capsules plant^{-1} of sesame

Combination Plant Population × N levels	Plant height (cm)	No. of branches plant^{-1}	No. of capsule branch^{-1}	Total no. of capsule plant^{-1}
$P_1 \times N_0$	93.33 h	3.700 g	15.67 a-d	58.17 de
$P_1 \times N_1$	97.00 h	4.433 de	16.33 a-d	72.57 bcd
$P_1 \times N_2$	103.70 g	4.950 ab	18.03 ab	89.23 abc
$P_1 \times N_3$	108.00 ef	5.117 a	19.07 a	97.55 a
$P_2 \times N_0$	106.00 fg	3.450 h	13.03 cde	44.91 efg
$P_2 \times N_1$	109.30 ef	4.233 ef	14.67 b-e	61.93 de
$P_2 \times N_2$	111.70 cde	4.810 bc	15.73 a-d	75.80 bcd
$P_2 \times N_3$	116.00 ab	4.900 ab	18.37 ab	89.95 ab
$P_3 \times N_0$	108.00 ef	3.817 g	12.33 de	47.13 efg
$P_3 \times N_1$	110.70 de	4.133 f	14.70 b-e	60.78 de
$P_3 \times N_2$	114.00 bcd	4.600 cd	15.67 a-d	72.03 cd
$P_3 \times N_3$	118.00 ab	4.900 ab	17.00 abc	83.13 abc
$P_4 \times N_0$	110.70 de	3.117 ij	10.67 e	32.83 g
$P_4 \times N_1$	114.30 bcd	3.067 j	12.83 cde	40.01 fg
$P_4 \times N_2$	115.70 bc	3.167 ij	14.67 b-e	46.67 efg
$P_4 \times N_3$	120.00 a	3.350 hi	15.00 a-d	50.65 ef
CV (%)	2.13	3.58	14.04	14.78
Sx Values	1.353	0.08563	1.235	5.457

Similar letters within the parenthesis do not differ significantly at 5% levels of significance according to Duncan's Multiple Range Test (DMRT)

P_1 = 166666 plants ha^{-1} N_0 = 0 kg N ha^{-1}

P_2 = 222222 plants ha^{-1} N_1 = 30 kg N ha^{-1}

P_3 = 333333 plants ha^{-1} N_2 = 45 kg N ha^{-1}

P_4 = 666666 plants ha^{-1} N_3 = 60 kg N ha^{-1}

4.5. Effective capsules plant^{-1}

4.5.1. Effect of nitrogen levels

The effect of nitrogen levels on sesame has a significant role and presented in Figure 9. The higher amount of N application gave the higher number of effective capsules plant^{-1}. The highest (76.47) number of effective capsules was recorded from 60 kg N ha^{-1} followed by 45kg N ha^{-1} (66.23) and the lowest (38.89) was obtained from the control plot 0 kg N ha^{-1}.

4.5.2. Effect of plant population

The number of effective capsules plant^{-1} of sesame is shown in Figure 10. The number of effective capsules plant^{-1} decreased with the increasing level of plant population ha^{-1}. The highest effective capsules palnt^{-1} was recorded from the lower (166666 plants ha^{-1}) plant population and the lowest was recorded from the higher (666666 plants ha^{-1}) plant population ha^{-1}. The maximum number of effective capsules palnt^{-1} was 74.54 followed by 63.64 and the lowest was 35.60. Increases of effective capsules due to wider plant spacing in rows and less inter plant competition in the community and the results agreed with Enyi (1973).

4.5.3. Combined effect of plant population and nitrogen levels

The interaction effect of plant population and nitrogen levels had a significant role on the number of effective capsules plant^{-1} and presented in Table 2. The highest number of effective capsules plant^{-1} 93.75, 86.95 and 84.91 was found from 166666, 222222 and 166666 plants ha^{-1}in combination with 60, 45 kg N ha^{-1}, respectively which were significantly similar. The lowest number of effective capsules 24.33, 32.71, 39.90 and 41.20 was recorded from 666666 and 333333 plants ha^{-1} in combination with 0, 30, 45 and 0 kg N ha^{-1}, respectively applied.

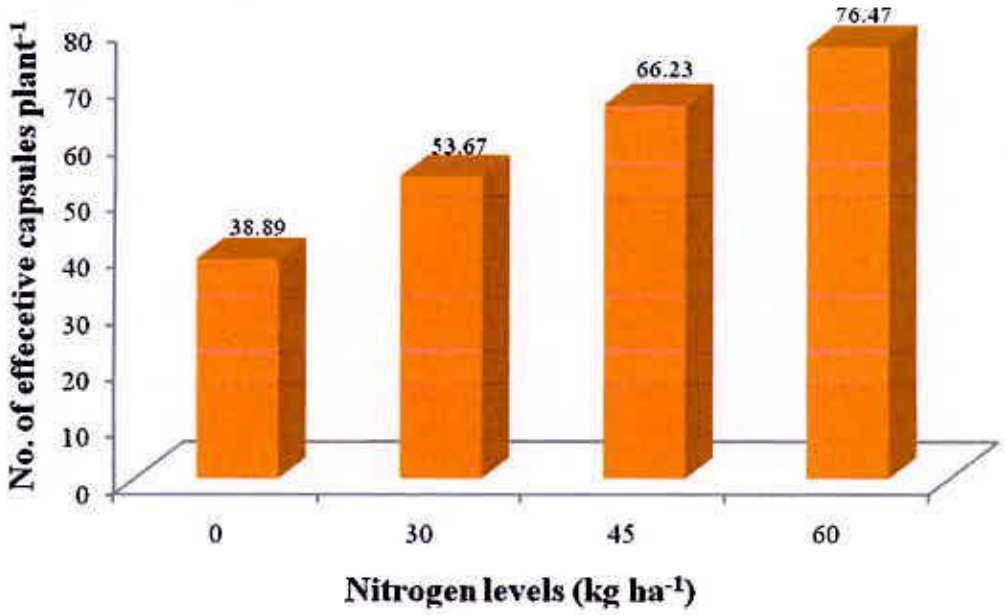


Fig.9. Effect of nitrogen levels on effective capsules plant^{-1} of sesame (Sx = 2.713)

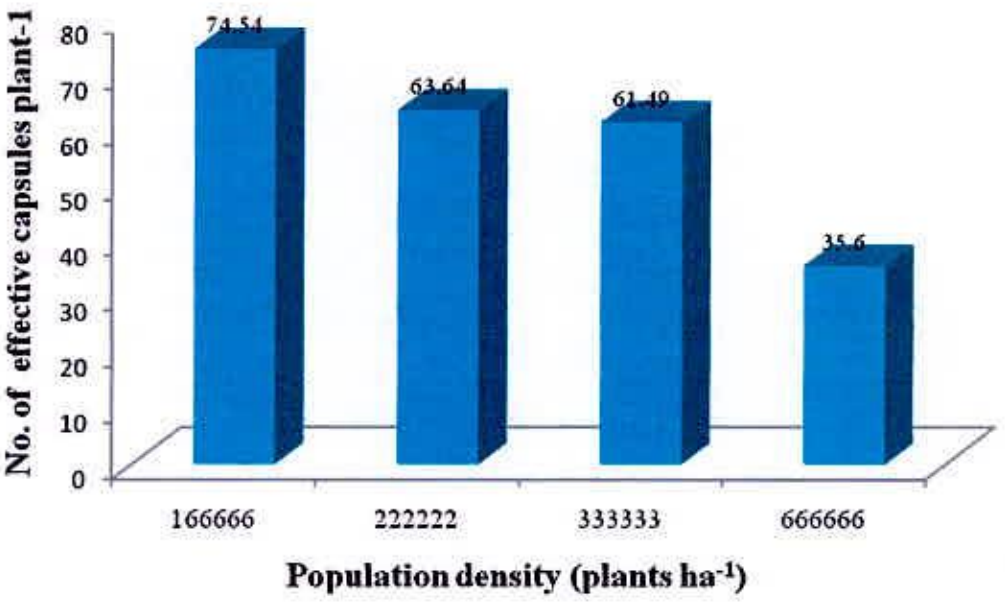


Fig.10. Effect of plant population on effective capsules plant^{-1} of sesame (Sx = 2.713)

4.6. Number of non effective capsules plant^{-1}

4.6.1. Effect of nitrogen

The effect of nitrogen on the non effective capsules plant^{-1}had a significant role and presented in Figure 11. The highest (6.87) number of non effective capsules plant^{-1} produced by 0 kg N ha^{-1} applied and the lowest (3.85) was obtained from the higher dose of N 60 kg N ha^{-1} applied preceded by 4.70 (45 kg N ha^{-1}). It was observed that the number of non effective capsule decreases with the increases of N rate ha^{-1} applied.

4.6.2. Effect of plant population

The plant population showed variation on the number of non effective capsules plant^{-1} presented in Figure 12. The highest (6.94) number of non effective capsules per plant was recorded from the higher plant population (666666). It was observed that after decreasing (666666 plant ha^{-1}) plant population the number of non effective capsules plant^{-1}gradually increased.

4.6.3. Combined effect of plant population and nitrogen levels

The effect of plant population and nitrogen levels had a significant role on non-effective capsules plant^{-1} and presented in Table 2. The higher number of non-effective capsules plant^{-1} 8.50 and 7.30 were recorded both from the higher plant population (666666 plants ha^{-1}) in combination with 0 and 30 kg N ha^{-1} nitrogen application which was statistically similar. The lowest number of non-effective capsules plant^{-1} (3.00) was obtained from 222222 plants ha^{-1} in combination with 60 kg N ha^{-1} applied preceded by 3.42 and 3.57 both from 333333 plants ha^{-1} with 45 and 60 kg N ha^{-1} applied and those were statistically identical.

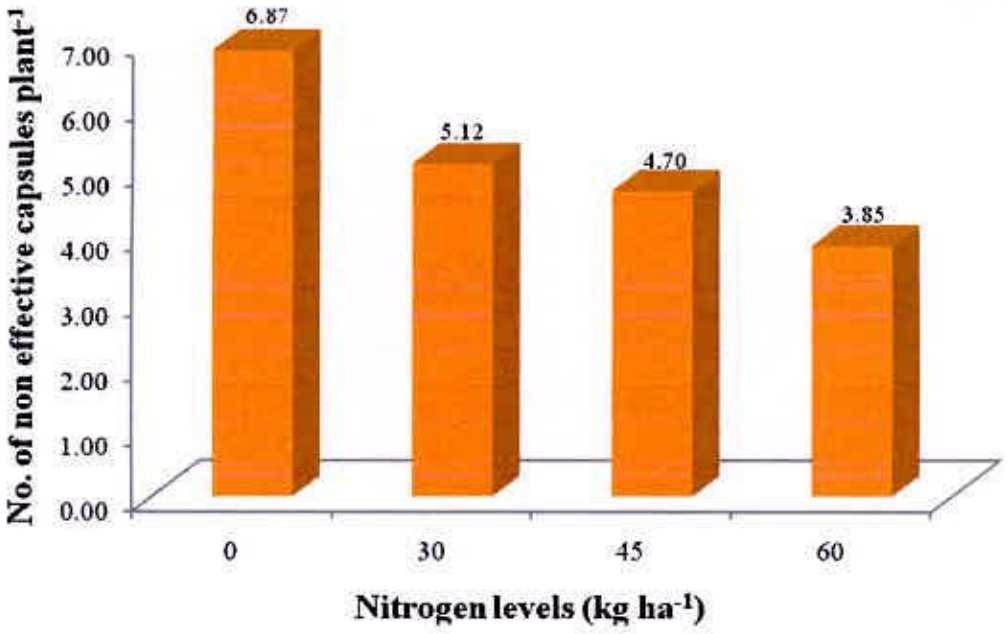


Fig.11. Effect of nitrogen levels on non effective capsules plant^{-1} of sesame (Sx = 0.2254)

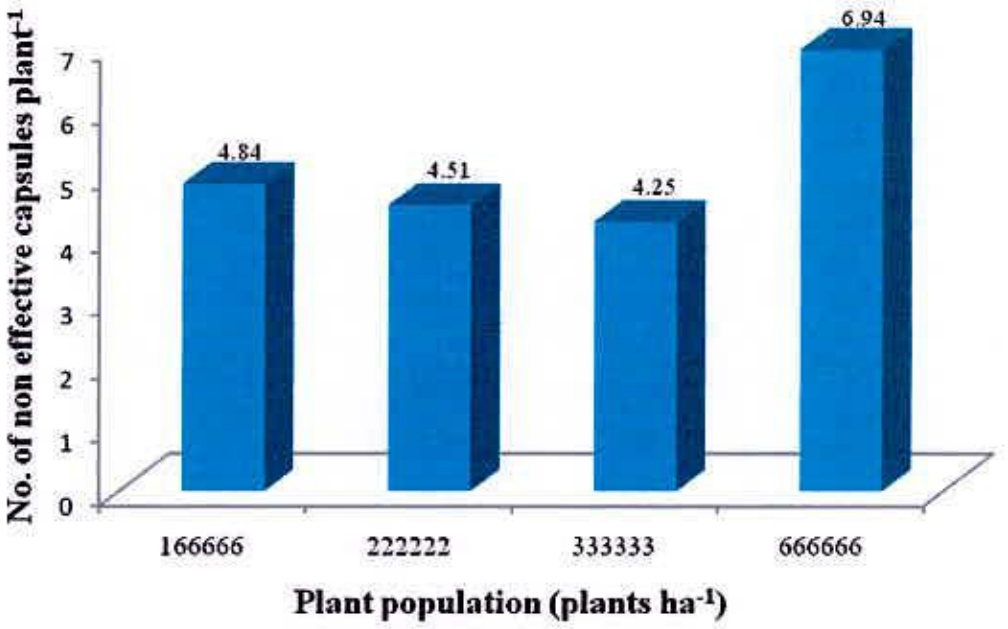


Fig.12. Effect of plant population on non effective capsules plant^{-1} of sesame (Sx = 0.2254)

4.7. Capsule length

4.7.1. Effect of Nitrogen

The levels of different N application had a significant effect on the capsule length of sesame (Figure 13). The longest (2.38) capsule length was obtained form 60 kg N ha^{-1} followed (2.25) by 45kg N kg ha^{-1} and the shortest (1.99) was obtained from 0 kg N ha^{-1} applied preceded by (2.13) 30kg N ha^{-1}.

4.7.2. Effect of plant population

The capsule length was significantly influenced by plant population and shown in Figure 14. The capsule length increased with the decreases of plant population ha^{-1}. The longer (2.52) capsule length was recorded from the lower (166666) plant population followed by 2.30 from 222222 plant ha^{-1} plant population and the shorter (1.88) was obtained from the higher (666666 plant ha^{-1}) plant population.

4.7.3. Combined effect of plant population and nitrogen levels

The combined effect of plant population and nitrogen levels on capsule length showed significant variation presented in Table 2. The highest capsule length (2.79 cm and 2.61 cm) were obtained from the lowest plant population (166666 plants ha^{-1}) in combination with 60 and 45 kg N ha^{-1}, respectively followed by 2.56 cm from second lowest plant population (222222 plants ha^{-1}) with maximum amount of N (60 kg N ha^{-1}) application. The lowest capsule length (1.79 cm) was noted from the higher amount of plant population (666666 plants ha^{-1}) in combination with 0 kg N ha^{-1}.

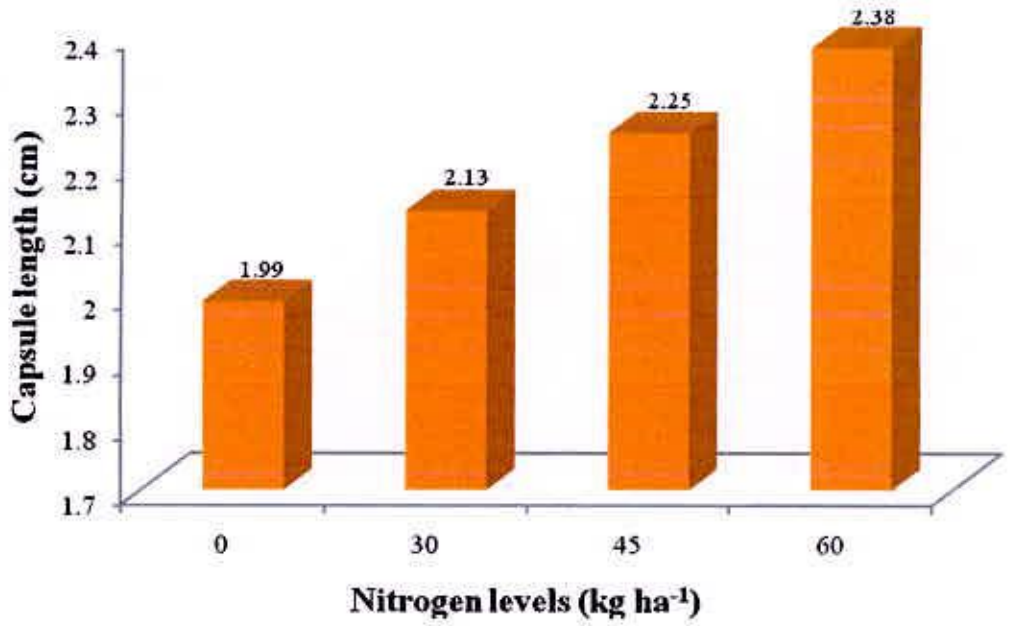


Fig.13. Effect of nitrogen levels on capsule length (cm) of sesame (Sx = 0.00913)

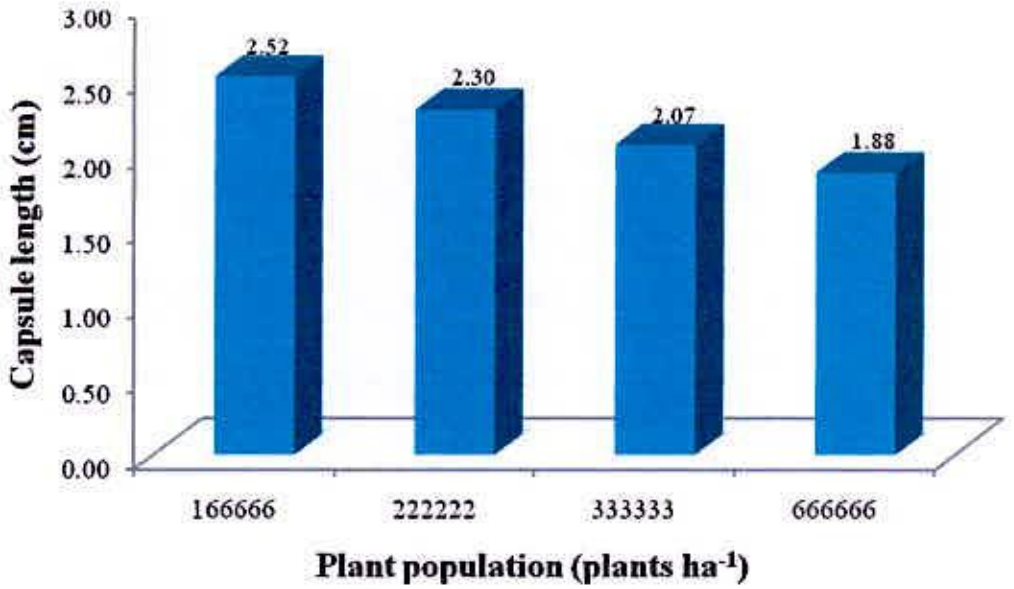


Fig.14. Effect of plant population on capsule length (cm) of sesame (Sx = 0.00913)

Table 2. Combined effect of nitrogen levels and plant population on number of effective and non effective capsules plant^{-1} and capsule length of sesame

Combination Plant population × N levels	Number of effective capsules plant^{-1}	Number of non-effective capsules plant^{-1}	Capsule length (cm)
$P_1 \times N_0$	52.03 f-i	6.13 bc	2.27 d
$P_1 \times N_1$	67.47 def	5.10 cd	2.41 c
$P_1 \times N_2$	84.91 abc	4.32 de	2.61 b
$P_1 \times N_3$	93.75 a	3.80 de	2.79 a
$P_2 \times N_0$	38.00 ijk	6.92 b	2.01 g
$P_2 \times N_1$	57.93 efg	4.00 de	2.25 d
$P_2 \times N_2$	71.66 b-e	4.13 de	2.38 c
$P_2 \times N_3$	86.95 ab	3.00 e	2.56 b
$P_3 \times N_0$	41.20 g-k	5.93 bc	1.93 h
$P_3 \times N_1$	56.58 e-h	4.07 de	2.06 fg
$P_3 \times N_2$	68.46 c-f	3.57 e	2.11 f
$P_3 \times N_3$	79.72 a-d	3.42 e	2.18 e
$P_4 \times N_0$	24.33 k	8.50 a	1.79 i
$P_4 \times N_1$	32.71 jk	7.30 ab	1.80 i
$P_4 \times N_2$	39.90 h-k	6.77 b	1.91 h
$P_4 \times N_3$	45.45 g-j	5.20 cd	2.01 g
CV (%)	15.98	5.41	1.75
Sx Values	5.426	0.4509	0.01826

Similar letters within the parenthesis do not differ significantly at 5% levels of significance according to Duncan's Multiple Range Test (DMRT)

P_1 = 166666 plants ha^{-1} N_0 = 0 kg N ha^{-1}

P_2 = 222222 plants ha^{-1} N_1 = 30 kg N ha^{-1}

P_3 = 333333 plants ha^{-1} N_2 = 45 kg N ha^{-1}

P_4 = 666666 plants ha^{-1} N_3 = 60 kg N ha^{-1}

4.8. Seeds capsule^{-1}

4.8.1. Effect of nitrogen levels

The effect of nitrogen levels on seeds capsule^{-1} of sesame shown in Figure 15. The highest number of seeds capsule^{-1} (70.13) was recorded in the highest N application (60 kg N ha^{-1}) followed by (65.01) in 45 kg N ha^{-1} and the lowest number of seeds capsule^{-1} (55.86) was obtained from the control plot (0 kg N ha^{-1}) preceded by 30 kg N ha^{-1} (61.95).

4.8.2. Effect of plant population

The effect of seeds capsule^{-1} of sesame plant showed significant variation shown in Figure 16. The highest (74.32) seeds capsule^{-1} was recorded from the lower (166666 plant ha^{-1}) plant population followed by the second lowest (222222 plant ha^{-1}) plant population and the lowest (53.61) was recorded from the highest (666666) plant population preceded by 333333 plant ha^{-1} (60.03). It noted that increasing the plant population decreases the seeds capsule^{-1}. The reduction might be due to extreme limitation of spacing and leaves (sink) for the formation and development of capsules.

4.8.3. Combined effect of plant population and nitrogen levels

The combined effect of plant population and nitrogen levels on seeds capsule^{-1} showed significant variation presented in Table 3. The highest number of seeds capsule^{-1}(84.63 and 81.12) were obtained from the lowest plant population (166666 plants ha^{-1}) in combination with 60 and 45 kg N ha^{-1}, respectively followed by 74.18 from second lowest plant population (222222 plants ha^{-1}) with maximum amount of N (60 kg N ha^{-1}) application. The lowest number of seeds capsule^{-1} (50.48) was noted from the higher amount of plant population (666666 plants ha^{-1}) preceded by 51.76, 52.43 and 53.36 in combination with 0, 30, 45 kg N ha^{-1} applied, respectively and those were statistically similar.

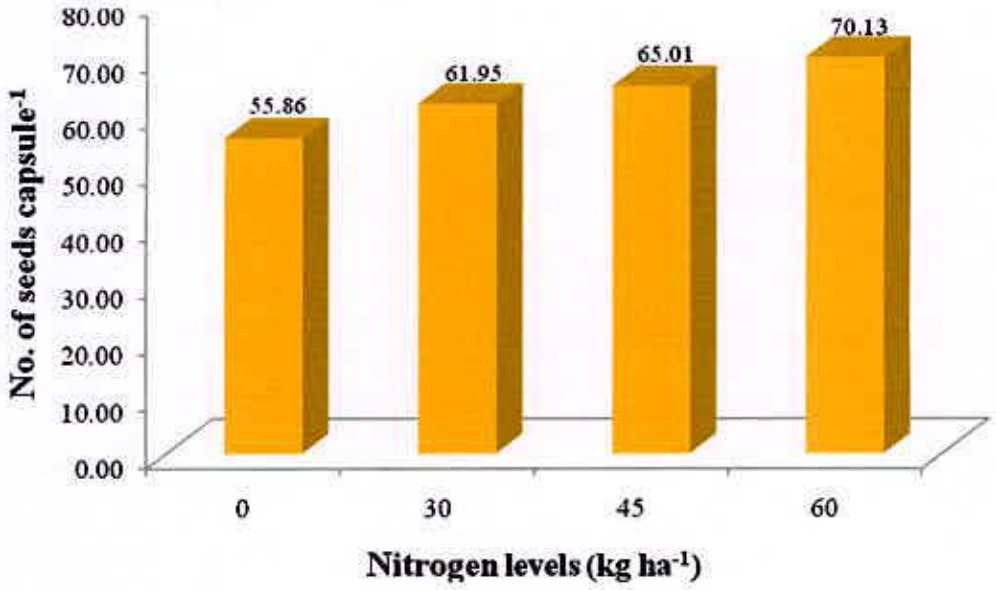


Fig.15. Effect of nitrogen levels on number of seeds capsule^{-1} of sesame (Sx = 0.03764)

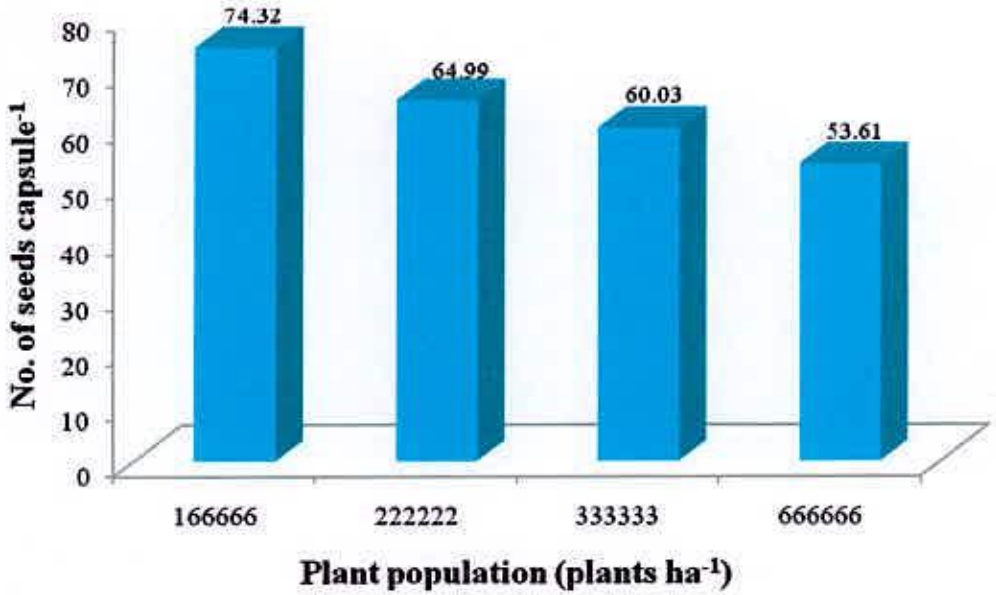


Fig.16. Effect of plant population on number of seeds capsule^{-1} of sesame (Sx = 0.03764)

4.9. Filled seeds capsule^{-1}

4.9.1. Effect of nitrogen levels

The number of filled seeds capsule^{-1} was significantly influenced by different nitrogen levels shown in Figure 17. The lowest filled seeds capsule^{-1} (53.49) was obtained from the control plot 0 kg N ha^{-1} preceded by 59.20 from 30 kg N ha^{-1} and the higher amount of filled seeds capsule^{-1} (68.31) was obtained from the higher amount of N application (60 kg N ha^{-1}). It was reveled that higher doses of N application increases the filled seeds capsule^{-1}.

4.9.2. Effect of plant population

The number of filled seeds capsule^{-1} was significantly influenced by plant population and presented in Figure 18. The highest filled seeds capsule^{-1} (72.71) was obtained in lowest plant population (166666 plants ha^{-1}) followed by 62.68 (222222 plants ha^{-1}) and the lowest filled seeds capsule^{-1} was recorded from the higher plant population (666666 plants ha^{-1}). It was reveled that higher plant population decreased the filled seeds capsule^{-1}. Similar result was recorded in number of filled seeds capsule^{-1} in sesame by Begum (2002).

4.9.3. Combined effect of plant population and nitrogen levels

The effect of plant population and nitrogen levels had a significant role on filled seeds capsules^{-1} presented in Table 2. The higher amount of filled seeds capsule^{-1} 82.88 and 79.10 were recorded both from the lower plant population (166666 plants ha^{-1}) in combination with 45 and 30 kg N ha^{-1} nitrogen application which was statistically similar. The lowest number of filled seeds capsule^{-1} (46.38) was obtained from the higher plant population 666666 plants ha^{-1} in combination with 0 kg N ha^{-1} preceded by 47.76 and 48.62 from 666666 plants ha^{-1} with 30 and 45 kg N ha^{-1} and those were statistically identical.

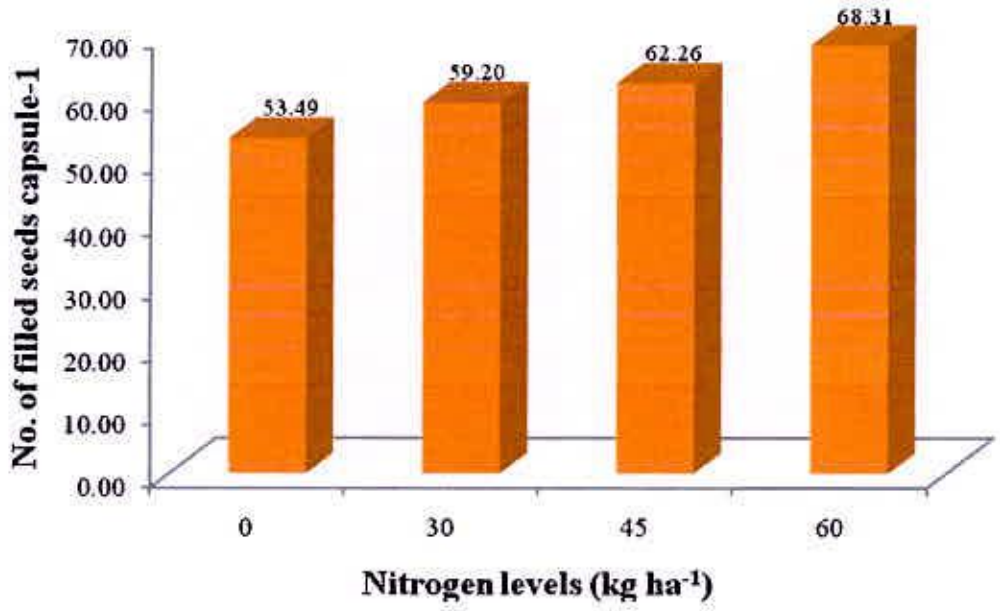


Fig.17. Effect of nitrogen levels number of filled seeds capsule^{-1} of sesame (Sx = 0.817)

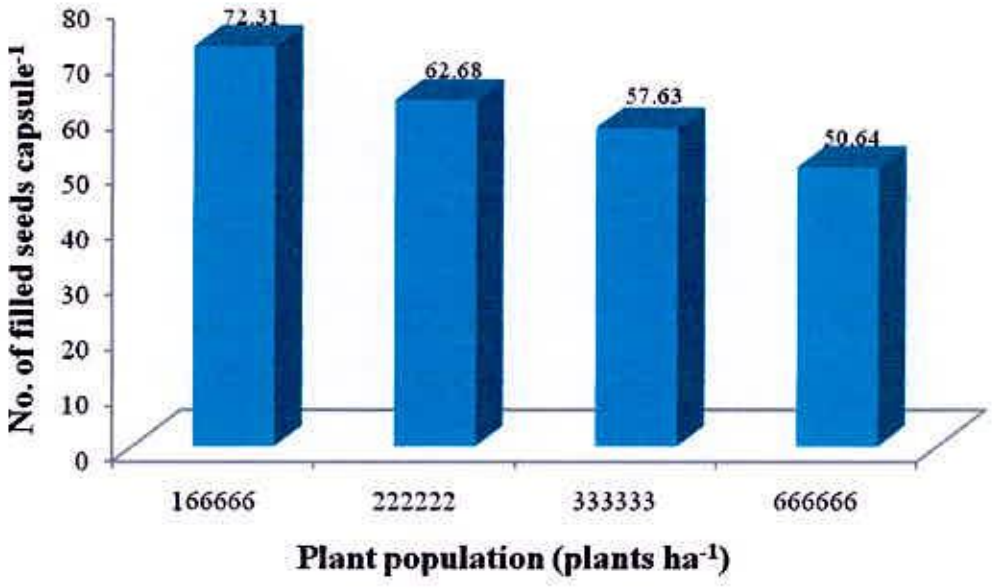


Fig.18. Effect of plant population on number of filled seeds capsule^{-1} of sesame (Sx = 0.817)

4.10. Unfilled seeds capsule^{-1}

4.10.1. Effect of nitrogen

The effect of nitrogen on unfilled seeds capsule^{-1} of sesame is shown in Figure 19. The number of unfilled seeds capsule^{-1} decreased with the increasing rate of N levels up to 60 kg N ha^{-1}. The highest number of unfilled seeds capsule^{-1} (4.48) was observed from 0 kg N ha^{-1} and the lowest unfilled seeds capsule^{-1} (4.19) was recorded from the control plot 6 0 kg N ha^{-1}.

4.10.2. Effect of plant population

The effect of plant population on the unfilled seeds capsule^{-1} of sesame is shown in Figure 20. The unfilled seeds capsule^{-1} increased with increases of plant population. The highest unfilled seeds capsule^{-1} (3.79) was obtained from 666666 plants ha^{-1} followed by 3.06 from 333333 plants ha^{-1} and the lowest unfilled seeds capsule^{-1} (2.02) was recorded from the lower plant population (166666 plants ha^{-1}).

4.10.3. Combined effect of plant population and nitrogen levels

The effect of plant population and nitrogen levels had significant role on unfilled seeds capsules^{-1} and presented in Table 2. The higher number of unfilled seeds capsule^{-1} (4.10) and 4.00 were recorded both from the higher plant population (666666 plants ha^{-1}) in combination with 0 and 30 kg N ha^{-1} application which were statistically similar followed by 3.86 and 3.82 from 333333 plants ha^{-1} with 0 kg N ha^{-1} and 666666 plants ha^{-1} with 45 kg N ha^{-1} applied. The lowest number of unfilled seeds capsule^{-1} (1.75) was obtained from the lower plant population 166666 plants ha^{-1} in combination with 45 kg N ha^{-1}.

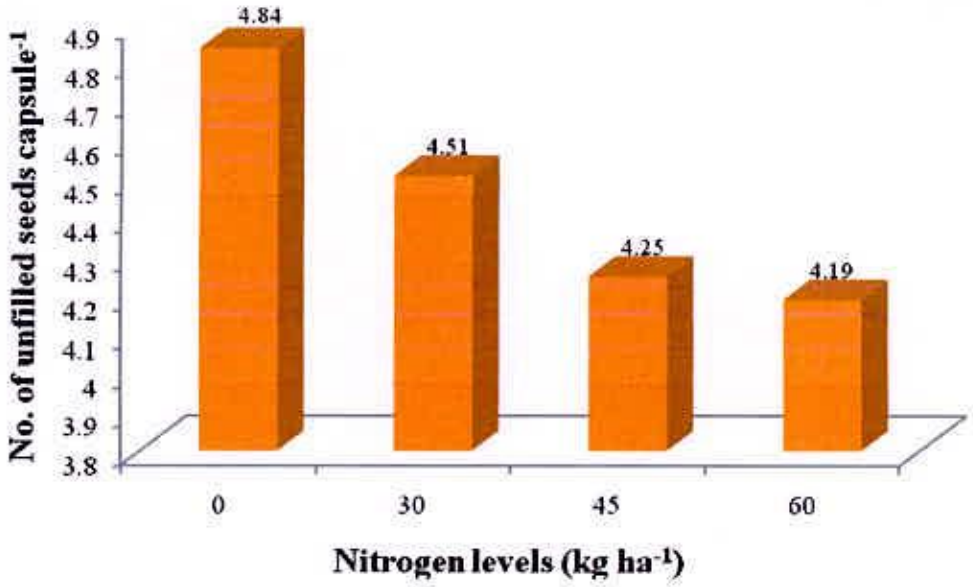


Fig.19. Effect of nitrogen levels on number of unfilled seeds capsule^{-1} of sesame (Sx = 0.0376)

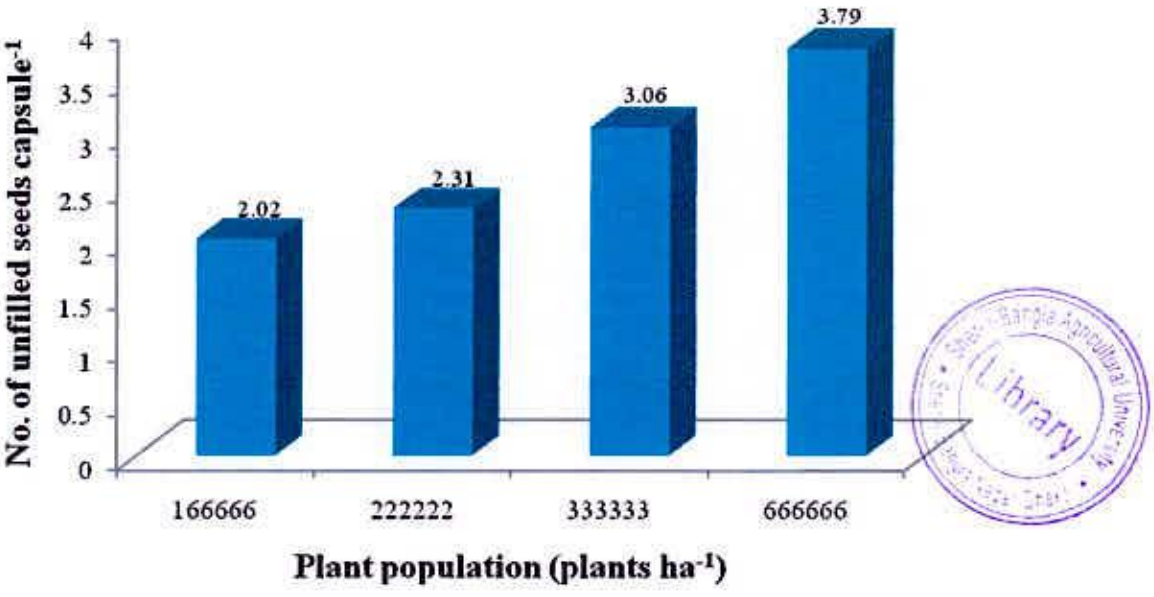


Fig.20. Effect of plant population on number of unfilled seeds capsule^{-1} of sesame (Sx = 0.0376)

Table 3. Combined effect of nitrogen levels and plant population on seeds capsule^{-1}, filled seeds and unfilled seeds capsule^{-1} of sesame

Combination Plant population × N levels	No. of seeds capsule^{-1}	No. of filled seeds Capsule^{-1}	No. of unfilled seeds capsule^{-1}
$P_1 \times N_0$	60.71 de	58.35 cd	2.36 ef
$P_1 \times N_1$	70.84 b	68.90 b	1.94 ghi
$P_1 \times N_2$	81.12 a	79.10 a	2.02 gh
$P_1 \times N_3$	84.63 a	82.88 a	1.75 i
$P_2 \times N_0$	58.90 e	57.09 d	1.81 hi
$P_2 \times N_1$	61.29 de	59.14 cd	2.15 fg
$P_2 \times N_2$	65.59 c	63.17 c	2.42 e
$P_2 \times N_3$	74.18 b	71.30 b	2.88 d
$P_3 \times N_0$	53.36 f	52.13 e	3.86 b
$P_3 \times N_1$	63.90 cd	61.01 cd	2.89 d
$P_3 \times N_2$	60.91 de	58.16 cd	2.75 d
$P_3 \times N_3$	61.96 cde	59.23 cd	2.73 d
$P_4 \times N_0$	50.48 f	46.38 f	4.10 a
$P_4 \times N_1$	51.76 f	47.76 ef	4.00 ab
$P_4 \times N_2$	52.43 f	48.62 ef	3.82 b
$P_4 \times N_3$	59.74 de	59.81 cd	3.23 c
CV (%)	3.75	4.65	4.71
Sx Values	0.07528	1.634	0.07528

Similar letters within the parenthesis do not differ significantly at 5% levels of significance according to Duncan's Multiple Range Test (DMRT)

P_1 = 166666 plants ha^{-1} N_0 = 0 kg N ha^{-1}

P_2 = 222222 plants ha^{-1} N_1 = 30 kg N ha^{-1}

P_3 = 333333 plants ha^{-1} N_2 = 45 kg N ha^{-1}

P_4 = 666666 plants ha^{-1} N_3 = 60 kg N ha^{-1}

4.11. Thousand seeds weight

4.11.1. Effect of nitrogen

The effect of 1000 seeds weight on sesame is shown in Figure 21. The highest 1000 seeds weight (3.46 g) was recorded in the highest dose of N application (60 kg N ha^{-1}) followed by 3.37 t ha^{-1} in the 45 kg N ha^{-1} applied and the lowest (3.16 g) was recorded from the control plot (0 kg N ha^{-1}) preceded by 3.30 g (30 kg N ah^{-1}). The result showed that increasing the N levels increases the 1000 seeds weight.

4.11.2. Effect of plant population

Thousand seeds weight was significantly influenced by plant population and shown in Figure 22. Thousand seeds weight decreased with the increases of plant population. The highest 1000 seed weight (3.48 g) was recorded from the lowest plant population (166666 plants ha^{-1}) followed by 3.33 g from the 222222 plants ha^{-1} and lowest weight (3.23 g) was obtained from the highest plant population (666666 plants ha^{-1}).

4.11.3. Combined effect of plant population and nitrogen levels

The effect of plant population and nitrogen levels had a significant role on 1000 seeds weight presented in Table 4. The highest 1000 seeds weight (3.65 g) was found from the lowest plant population (166666 plants ha^{-1}) with higher dose of 60 kg N ha^{-1} and the lowest (3.05) from 333333 plants ha^{-1} in combination with 0 kg N ha^{-1} preceded by 3.16, 3.18 and 3.19 from higher plant population with 0, 30 kg N ha^{-1} and from 222222 plants ha^{-1} with 0 kg N ha^{-1} applied respectively. Decreases in plants population increased intra specific completion which eventually caused reduction in yield attributes of sesame and the similar results were found by Roy *et al.*, (2009).

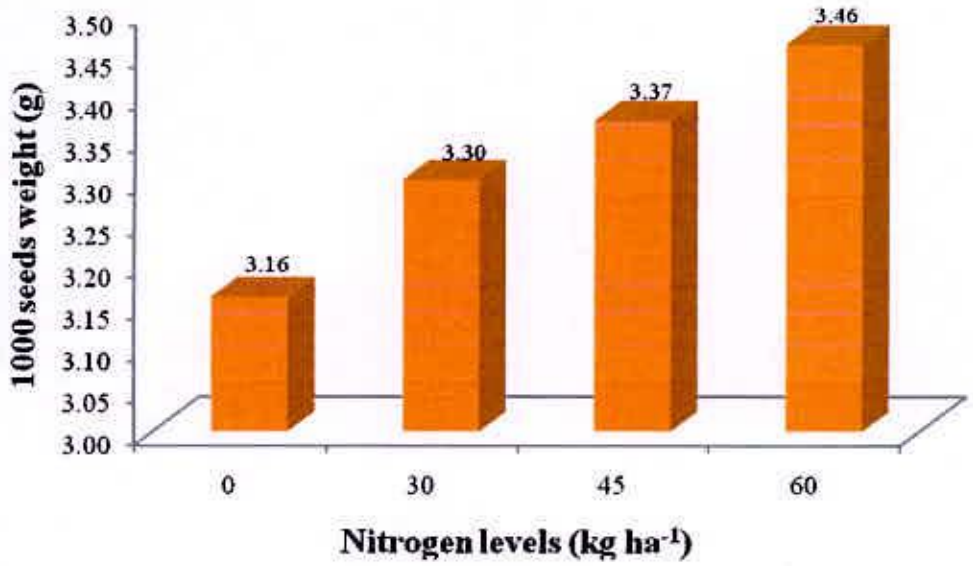


Fig.21. Effect of nitrogen levels on 1000 seeds weight (g) of sesame (Sx = 0.0129)

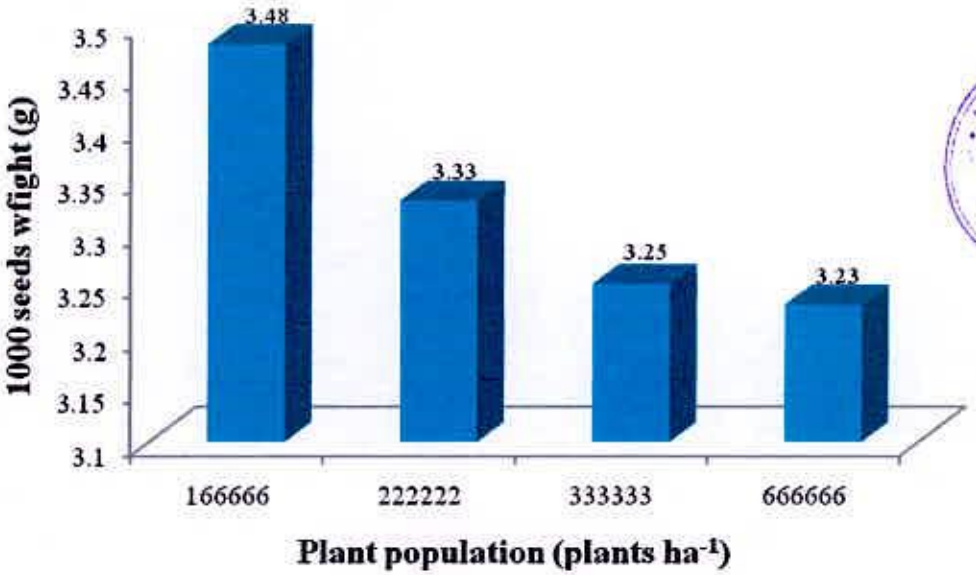


Fig.22. Effect of plant population on 1000 seeds weight (g) of sesame (Sx = 0.0129)

4.12. Seed yield

4.12.2. Effect of nitrogen levels

The varied nitrogen levels had significant effect on sesame yield shown in Figure 23. The maximum seed yield (1.50 t ha^{-1}) of sesame was obtained from the higher dose application of N ha^{-1} (60 kg N ha^{-1}) followed by 1.38 t ha^{-1} in 45 kg N ha^{-1} and the lowest seed yield (1.15 t ha^{-1}) was obtained from the control plot 0 kg N ha^{-1}. From the results it was observed that seed yield increased gradually with the increases of N dose ha^{-1} up to 60 kg N ha^{-1}. Om *et al.*, (2001) reported that increased amount of N application increased the yield of sesame.

4.12.1. Effect of plant population

Seed yield in sesame is the function of capsule length, capsule $plant^{-1}$ and seeds $capsule^{-1}$ (Figure 24). The highest seeds yield of sesame (1.53 t ha^{-1}) was noted form the highest plant population (666666 plants ha^{-1}) and the lowest yield (1.13 t ha^{-1}) was obtained from the lowest plant population preceded by (1.29 t ha^{-1}) form 222222 plants ha^{-1} (Figure 23). It was observed that the highest yield of sesame was recorded with increasing rate of plant population ha^{-1} and it found only in this parameter but others parameters did not show the same results due to plant population per square meter area's yield is higher than higher row spacing. The finding is also agreed with Majumder and Roy (1992), Tomar *et al.*, (1992) who's reported that seed yield increased with the increasing plant population.

4.12.3. Combined effect of plant population and nitrogen levels

The effect of plant population and nitrogen levels had a significant role on seed yield presented in Table 4. The highest seed yield (1.76 t ha^{-1}) was recorded from the higher plant population (666666 plants ha^{-1}) with higher amount of N application (60 kg N ha^{-1}) followed by 1.60 t ha^{-1} form the second highest plant population (333333 plants ha^{-1}) in combination with second highest N application (45 kg N ha^{-1}) and the lowest seed yield (1.04 t ha^{-1}) was obtained from the lowest plant population in combination with 0 kg N ha^{-1} applied. Seed yield of sesame was increased by 69.23, 53.85% both from higher plant population with 60 and 45 kg N ha^{-1} respectively over lower plant population in combination with 0 kg N ha^{-1}.

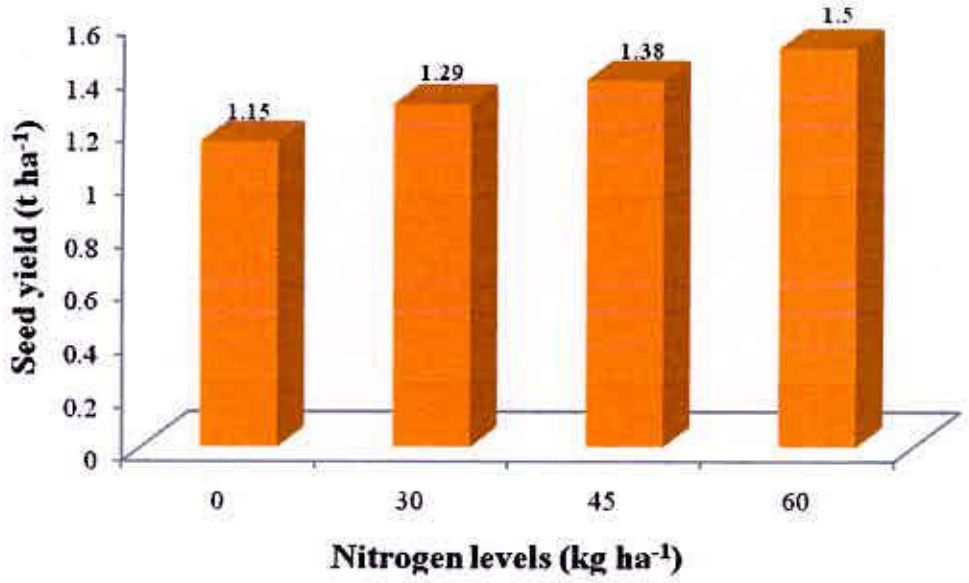


Fig.23. Effect of nitrogen levels on seed yield (t ha^{-1}) of sesame (Sx = 0.00913)

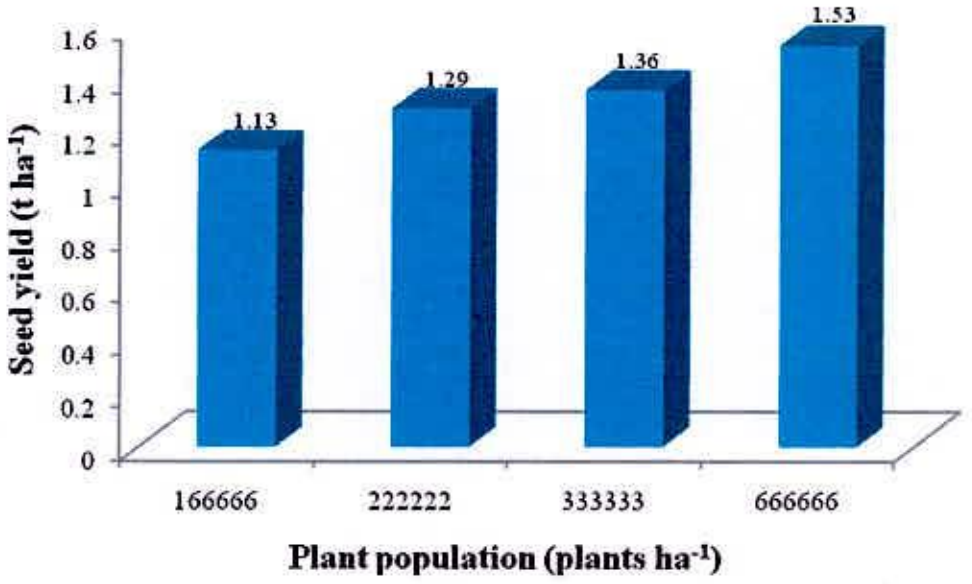


Fig.24. Effect of plant population on seed yield (t ha^{-1}) of sesame (Sx = 0.00913)

4.13. Stover yield

4.13.1. Effect of nitrogen levels

The effect of nitrogen levels on sesame stover yield is presented in Figure 25. The maximum stover yield (4.64 t ha^{-1}) was recorded from the higher dose of N (60 kg N ha^{-1}) application followed by 4.43 t ha^{-1} from the 45 kg N ha^{-1} and the minimum yield (3.80 t ha^{-1}) was noted from the control plot preceded by 4.17 t ha^{-1} from the 30 kg N ha^{-1}. The results showed that stover yield increased with the increasing level of N ha^{-1} applied. The results showed that stover yield directly proportional to N application and might be due to luxuriant vegetative growth of plants with increased application of N which tends to enhance dry matted accumulation and finally stover yield increased. Similar results were reported by Tiwari *et al.*, (2001).

4.13.2. Effect of plant population

Stover yield influenced by population presented in Figure 26. The higher stover yield (4.74 t ha^{-1}) was recorded from the 666666 plants ha^{-1} followed by 4.35 t ha^{-1} from the 333333 plants ha^{-1} and the lower amount of stover yield (3.79 t ha^{-1}) was obtained from the lower plant population (166666 plants ha^{-1}) preceded by 4.17 t ha^{-1} from the 222222 plants ha^{-1}. Tomar *et al.*, (1992) reported that increase in stover yield with an increasing plant population.

4.13.3. Combined effect of plant population and nitrogen levels

The effect of plant population and nitrogen levels had a significant role on stover yield of sesame presented in Table 4. The highest stover yield (5.07 t ha^{-1}) of sesame was obtained from the higher plant population (666666 plants ha^{-1}) in combination with higher dose of N application (60 kg N ha^{-1}) followed by (4.93 t ha^{-1}) from same highest plant population in combination with 45 kg N ha^{-1} applied. The lowest stover yield 3.58 and 3.66 t ha^{-1} was recorded both from the lower plant population in combination 0 and 30 kg N ha^{-1}respectively.

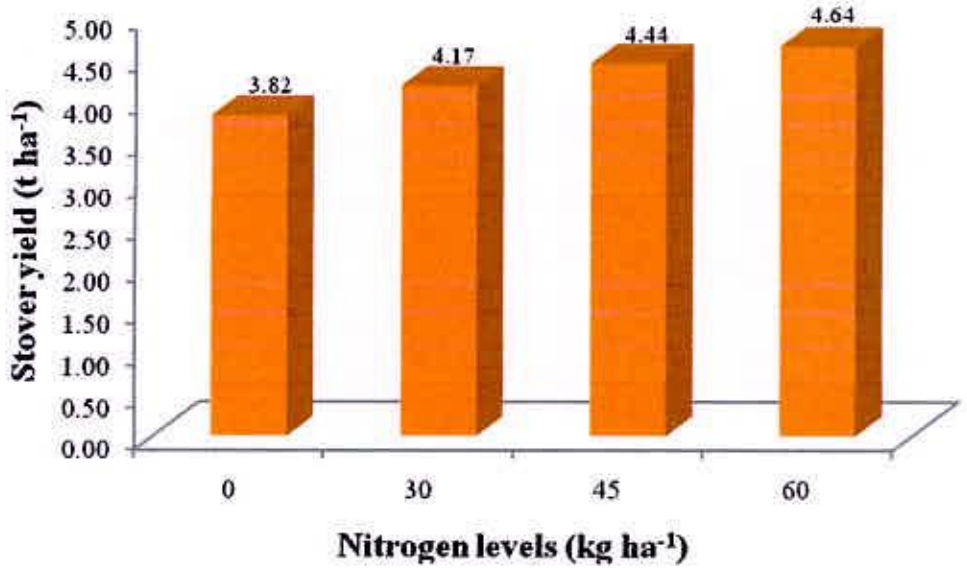


Fig.25. Effect of nitrogen levels on stover yield (t ha^{-1}) of sesame (Sx = 0.01825)

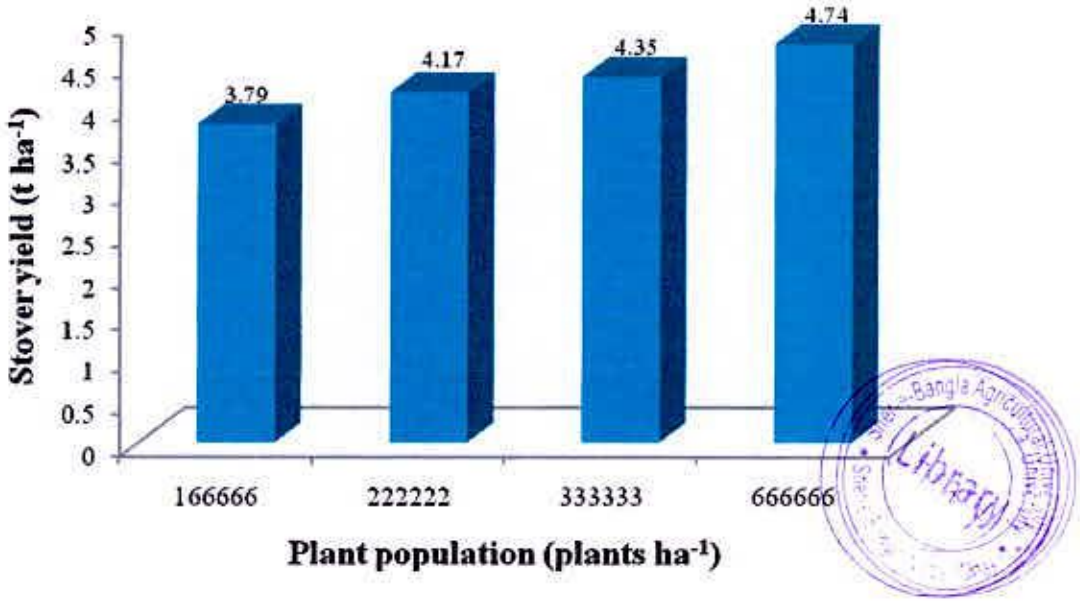


Fig.26. Effect of plant population on stover yield (t ha^{-1}) of sesame (Sx = 0.01825)

4.14. Harvest index

4.14.1. Effect of nitrogen levels

The harvest index influenced by application of nitrogen level is shown in Figure 27. The highest harvest index (24.45%) was recorded from the higher dose of N application (60 kg N ha^{-1}) followed by 23.71% from the 45 kg N ha^{-1} and the lowest harvest index (23.10%) was obtained from the control plot (0 kg N ha^{-1}). From the result it appears that harvest index increased with the increased rate of nitrogen application up to 60 kg N ha^{-1}. Excessive application of N may be enhanced the growth of sesame but harvest index might be reduced. The harvest index increased by 5.75% in 60 kg N ha^{-1} and 2.55% in 45 kg N ha^{-1} applied over 0 kg N ha^{-1} applied. The similar findings also reported by Ashfaq *et al.*, (2001) and Om *et al.*, (2001).

4.14.2. Effect of plant population

The present study showed that the harvest index was significantly influenced by plant population and harvest index increased with the increasing of plant population shown in Figure 28. The highest harvest index 24.37% was recorded from the higher plant population (666666 plants ha^{-1}) followed by 23.77% from the 333333 plants ha^{-1} and the lowest harvest index (22.99%) was recorded form the lowest plant population preceded by 23.69% from 222222 plants ha^{-1}. Harvest index increased by 6.00% in 666666 plants ha^{-1} and 3.39% in 333333 plants ha^{-1} over 166666 plants ha^{-1}. The findings are agreed with BINA (1993) who reported that the higher plant population gave the higher harvest index.

4.14.3. Combined effect of plant population and nitrogen levels

The effect of plant population and nitrogen levels had a significant role on harvest index of sesame presented in Table 4. The highest harvest index (25.73%) was obtained from the higher plant population (666666 plants ha^{-1}) in combination with higher amount of N application (60 kg ha^{-1}) followed by 24.56% from the (222222 plants ha^{-1}) and the lowest harvest index was obtained from the lower plant population in combination with 0 kg N ha^{-1} applied nitrogen. The harvest index increased by 14.51% in higher plant population in combination with 60 kg N ha^{-1} applied N over lower plant population (166666 plants ha^{-1}) in combination with 0 kg N ha^{-1}.

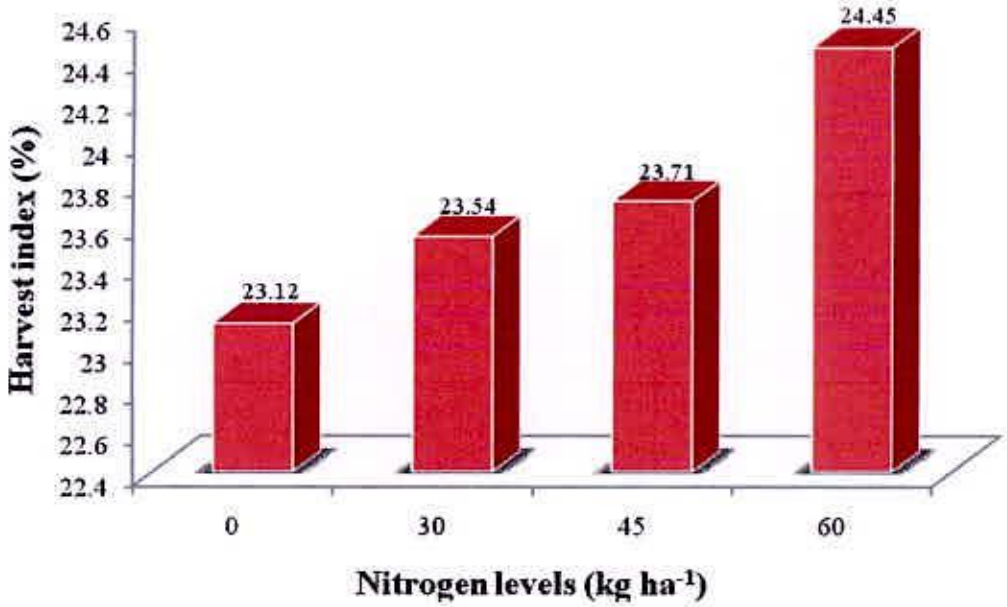


Fig.27. Effect of nitrogen levels on harvest index (%) of sesame (Sx = 0.15385)

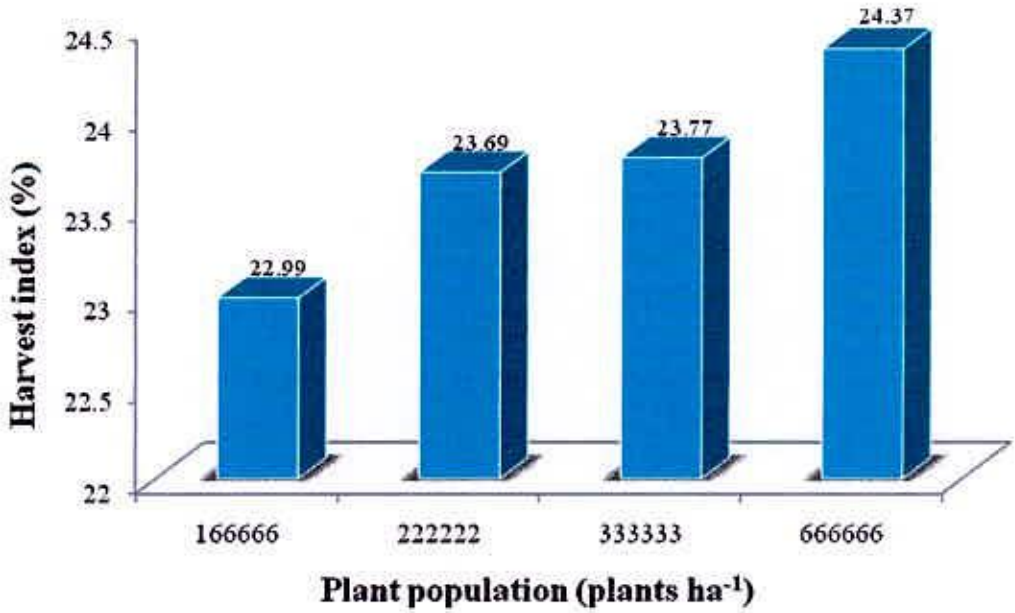


Fig.28. Effect of plant population on harvest index (%) of sesame (Sx = 0.15385)

Table 4. Combined effect of nitrogen levels and plant population on 1000 seeds weight, seed yield, stover yield and harvest index of sesame

Interaction Plant population × N levels	1000 seeds wt (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest Index (%)
$P_1 \times N_0$	3.24 ef	1.04 h	3.58 i	22.47 f
$P_1 \times N_1$	3.51b	1.11 g	3.66 hi	23.21 ef
$P_1 \times N_2$	3.53 b	1.14 g	3.81 g	23.08 ef
$P_1 \times N_3$	3.65 a	1.25 f	4.13 f	23.18 ef
$P_2 \times N_0$	3.19 f	1.10 g	3.68 hi	23.08 ef
$P_2 \times N_1$	3.28 de	1.25 f	4.09 f	23.44 def
$P_2 \times N_2$	3.37 c	1.34 e	4.32 e	23.69 b-e
$P_2 \times N_3$	3.46 b	1.45 d	4.59 d	24.56 b
$P_3 \times N_0$	3.05 g	1.14 g	3.73 gh	23.46 def
$P_3 \times N_1$	3.24 ef	1.33 e	4.26 e	23.75 b-e
$P_3 \times N_2$	3.33 cd	1.43 d	4.65 cd	23.54 cde
$P_3 \times N_3$	3.37 c	1.53 c	4.76 c	24.33 bcd
$P_4 \times N_0$	3.16 f	1.32 e	4.30 e	23.47 def
$P_4 \times N_1$	3.18 f	1.46 d	4.67 cd	23.76 b-e
$P_4 \times N_2$	3.23 ef	1.60 b	4.93 b	24.51 bc
$P_4 \times N_3$	3.34 cd	1.76 a	5.07 a	25.73 a
CV (%)	1.26	2.90	1.46	2.25
Sx Values	0.02582	0.01826	0.03651	0.3077

Similar letters within the parenthesis do not differ significantly at 5% levels of significance according to Duncan's Multiple Range Test (DMRT)

P_1 = 166666 plants ha^{-1} N_0 = 0 kg N ha^{-1}

P_2 = 222222 plants ha^{-1} N_1 = 30 kg N ha^{-1}

P_3 = 333333 plants ha^{-1} N_2 = 45 kg N ha^{-1}

P_4 = 666666 plants ha^{-1} N_3 = 60 kg N ha^{-1}

Chapter 5

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

The research experiment was conducted at the field research farm of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from 21 March to 18 July 2009 to determine 'Growth and Yield Performance of Sesame at varying plant population and nitrogen levels'. The field experiment comprised two factors namely plant population viz., 166666, 222222, 333333 and 666666 plants ha^{-1} and nitrogen levels viz., 0, 30, 45 and 60 kg N ha^{-1} and the BARI til-3 was used in the experiment as test materials.

The experiment was laid out in a Randomized Completely Block Design (RCBD) comprising three replication in sixteen treatments combination. The unit plot size was 3m x 2m and fertilizers were applied as per the recommended dose.

The data were recorded on the basis of sesame plant height, branches $plant^{-1}$ capsules $branches^{-1}$ total capsules $plant^{-1}$, number of effective capsules $plant^{-1}$, number of non effective capsules $plant^{-1}$, capsule length, seeds $capsule^{-1}$, filled seeds $capsule^{-1}$, unfilled seeds $capsule^{-1}$, 1000 seeds weight, seed yield, stover yield and harvest index (HI). Data were analyses using MSTAT-C software package program. The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) at 5 per cent levels of significance.

The present finding showed that plant population and nitrogen levels and their combined effect had a significant role to some extent on the yield and yield attributing characters of sesame.

The different levels of nitrogen had an impact on yield of sesame. Increasing rates of nitrogen resulted in the increasing of yield and yield attributes of sesame and gave the highest plant height, branches $plant^{-1}$, capsules $branches^{-1}$, total capsules $plant^{-1}$, number of effective capsules $plant^{-1}$, capsule length, seeds $capsule^{-1}$, filled seeds, 1000 seeds weight, seed yield and harvest index was obtained from 60 kg N

ha^{-1} to some extent of number of non effective capsules $plant^{-1}$ and unfilled seeds $capsule^{-1}$.

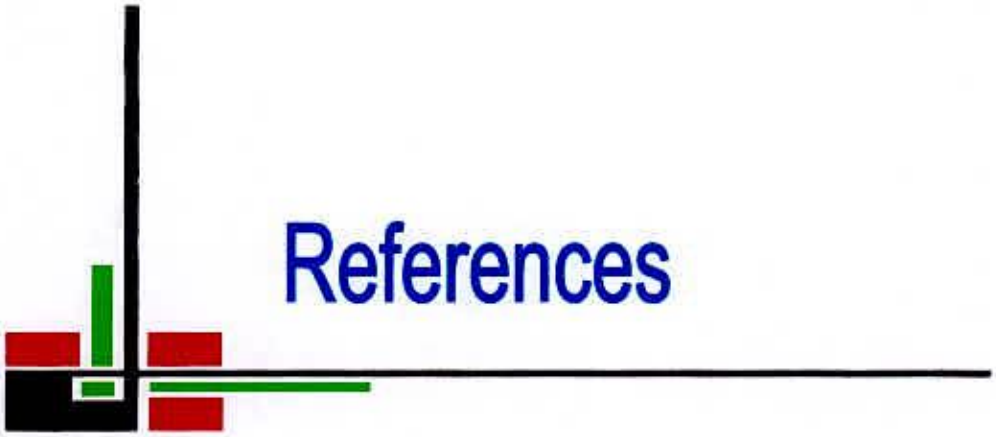
The plant population increases and resulted highest plant height, unfilled seeds $capsule^{-1}$, seed yield and harvest index but decrease the rest of parameter of sesame. The highest seed yield of sesame (1.50 t ha^{-1}), stover yield (4.64 t ha^{-1}) and harvest index (24.45%) were obtained from 666666 plants ha^{-1} plant population.

The combination of nitrogen levels and plant population had a significant effect on the plant parameters of sesame. The highest number of branches $plant^{-1}$ (5.12), capsules $branch^{-1}$ (19.07), total capsules $plant^{-1}$ (97.55), number of effective capsules $plant^{-1}$ (93.75), capsule length (2.79 cm), seeds $capsule^{-1}$ (84.63), filled seeds $capsule^{-1}$ (82.88), 1000 seeds weight (3.65 g) was recorded from 166666 plants ha^{-1} in combination with 60 kg N ha^{-1} applied but highest plant height (120.00 cm), seed yield (1.76 t ha^{-1}), stover yield (5.07 t ha^{-1}) and harvest index (25.73%) was obtained from the 666666 plants ha^{-1} in combination with 60 kg N ha^{-1}. The lowest yield attributes of sesame was obtained from 0 kg N ha^{-1} in combination with lower to higher plant population ha^{-1}.

At the end of the above results and discussion it ca be concluded that-

- Higher dose of N (60 kg N ha^{-1}) application gave the higher yield of sesame
- Higher plant population (666666 plants ha^{-1}) also gave the higher seed yield, stover yield and harvest index to some extent
- Higher levels of N application (60 kg N ha^{-1}) in combination with higher plant population (666666 plants ha^{-1}) gave the higher yield of sesame than the lower plant population (166666 plants ha^{-1})

Further study should be conducted at different agro-ecological zone of Bangladesh to reach the sound conclusion and recommendations.



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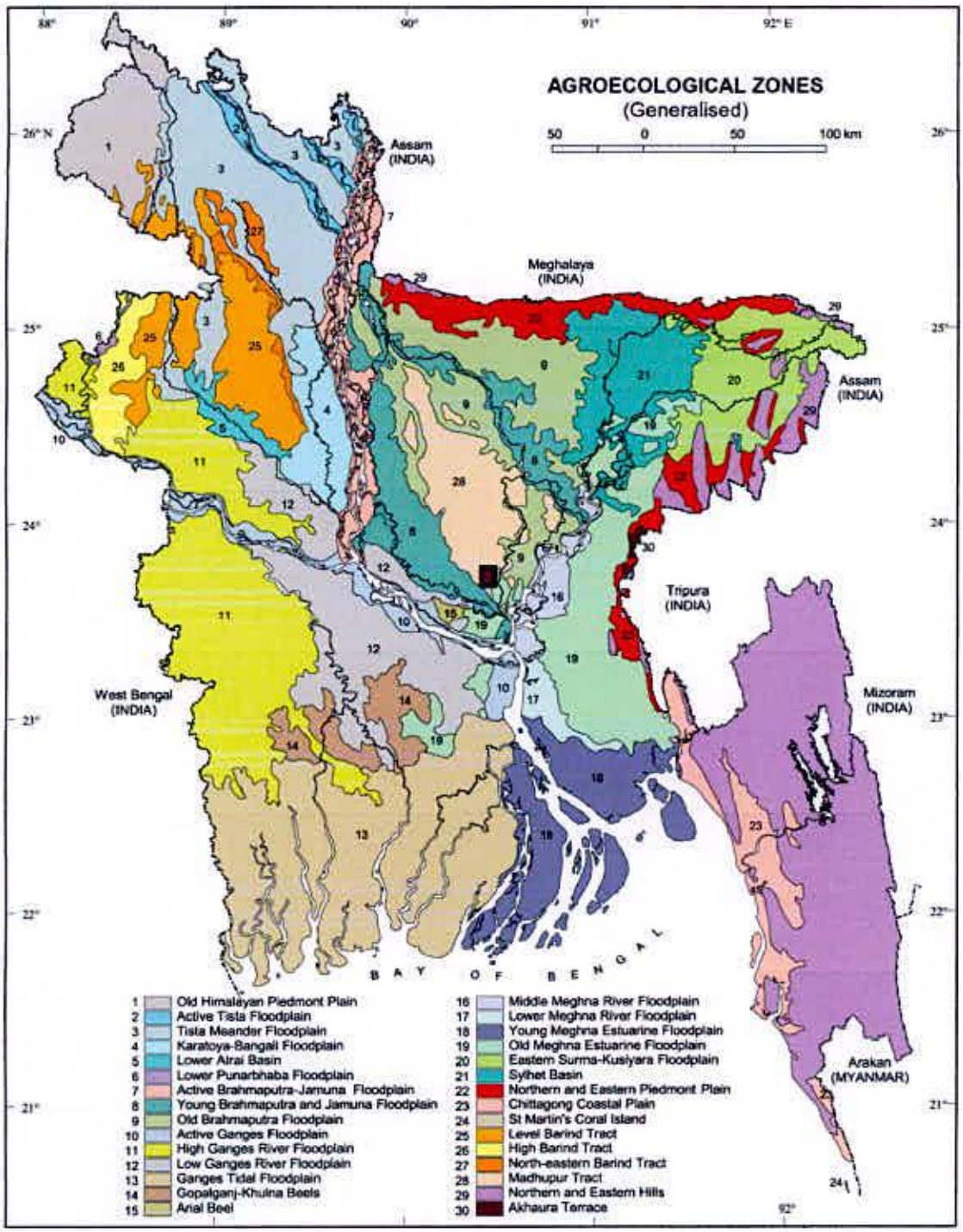
Appendices

APPENDICES

Appendix I. Map showing the experimental sites under study



■ **The experimental site under study**

Appendix II. Physiochemical characteristics of the initial soil

Characteristics	Value
Partical size analysis	
% Sand	26
% Silt	45
% Clay	29
Textural class	Silty clay
P^{H}	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

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

Appendix III. Summary of analysis of variance on yield attributes of sesame

Source of variance	Mean square						
	Degrees of freedom	Plant height (cm)	Branches plant^{-1}	Capsules branch^{-1}	Total capsules plant^{-1}	Number of effective capsules plant^{-1}	Number of non effective capsules plant^{-1}
Replication	2	65.333	0.010	4.577	8.424	15.440	1.369
Nitrogen	3	497.632**	2.646**	0.837**	2869.296**	3266.673**	18.111**
Plant population	3	266.188**	4.754**	43.323**	2695.233**	3159.971**	19.382**
Nitrogen × Plant population	9	5.743**	0.217**	1.714**	78.932**	79.418**	0.610**
Error	30	5.489	0.022	32.322	89.350	88.331	0.077
Total	47						
CV (%)		2.13	3.58	14.04	14.78	15.98	5.41

** Significant at 1% level of probability

* Significant at 5% level of probability

NS – Non Significant

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

Source of variance	Degrees of freedom	Capsule length (cm)	Seeds capsule^{-1}	Filled seeds capsule^{-1}	Unfilled seeds capsule^{-1}	1000 seeds weight (g)	Seed yield (t/ha^{-1})	Stover yield (t/ha^{-1})	Harvest index (%)
Replication	2	0.048	197.924	161.704	0.013	0.025	0.002	0.008	0.158
Nitrogen	3	0.924**	916.137**	996.504**	7.562**	0.161**	0.331**	1.862**	3.848**
Plant population	3	0.329**	426.937**	458.101**	0.329**	0.182**	0.256**	1.482**	3.700**
Nitrogen × Plant population	9	0.018**	58.308**	61.289**	0.603**	0.009 ^{NS}	0.006*	0.045**	0.459**
Error	30	0.001	5.632	8.009	0.017	0.002	0.001	0.004	0.284
Total	47								
CV (%)		1.75	3.75	4.65	4.71	1.26	2.90	1.46	2.25

** Significant at 1% level of probability

* Significant at 5% level of probability

NS – Non Significant