EFFECT OF SOWING DATE AND POPULATION DENSITY ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF SESAME

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF SOWING DATE AND POPULATION DENSITY ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF SESAME"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of a piece of bona-fide research work successfully carried out by **C. M. REZAUL KARIM** bearing **Registration No. 07-02640** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated : 08/12/2008
Place : Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

MD. YOUSUF ALI

&

REHANA PARVIN

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The Author

ABSTRACT

The experiment was conducted at research field of Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2008 with a view to study the effect of date of sowing and population density on yield and yield contributing characters of sesame. The experiment consisted of four sowing dates (20 March, 30 March, 9 April and 19 April) and four population density levels (666666, 333333, 222222 and 166666 plants ha^{-1}). The experiment was laid out in a randomized complete block design with three replications. The result showed significant variations between date of sowing for all the crop characters viz. plant height, branches $plant^{-1}$, capsules $branch^{-1}$, total capsules $plant^{-1}$, effective capsules $plant^{-1}$, non-effective capsules $plant^{-1}$, length of capsule, filled seeds $capsule^{-1}$, unfilled seeds $capsule^{-1}$, 1000-seed weight, seed yield, seed/capsule wall ratio, stover yield, and harvest index. The highest seed yield (1.55 t ha^{-1}) was recorded from 20 March sowing. Population density had significant effect on all the parameters studied except unfilled seeds $capsule^{-1}$. The highest seed yield (1.54 t ha^{-1}) was recorded from 666666 plants ha^{-1}. The interaction between sowing date and population density exerted its significant effect on all the parameters studied except total capsules $plant^{-1}$. The highest seed yield (5.27 t ha^{-1}) of sesame was obtained from sowing March 20 along with 666666 plants ha^{-1}.

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ACRONYMS AND ABBREVIATIONS

AEZ	Agro-ecological Zone
B	Boron
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BINA	Bangladesh Institute of Nuclear Agriculture
CGR	Crop growth Rate
cm	Centimeter
CV	Co-efficient of variation
DAF	Days after flowering
DM	Dry matter
DAS	Days after sowing
EC	Emulsifiable Concentrate
et al.	and others
g	Gram
ha	Hectare
HI	Harvest Index
i.e.	that is
K	Potassium
kg	Kilogram
LAI	Leaf Area Index
LSD	Least significant difference
m	Meter
MP	Muriate of Potash
N	Nitrogen
NAR	Net Assimilation Rate
OST	Optimum sowing time
P	Phosphorus
RCBD	Randomized Complete Block Design
S	Sulphur
t ha^{-1}	ton per hectare
TSP	Triple Superphosphate
viz.	namely
%	Percentage
^0c	Degree Celsius

CHAPTER 1
INTRODUCTION

Chapter 1

INTRODUCTION

Sesame (*Sesamum indicum* L.), commonly known as 'Til', is an ancient and one of the important oil crops widely grown in different parts of the world. Among various oil crops grown in Bangladesh sesame ranks next to mustard in respect of both cultivated area and production (Alim, 1974). It belongs to the family Pedaliaceae. Sesame is grown almost all regions in Bangladesh occupying 4.22% of the total cropped area and contributes about 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. Because of its drought resistance ability, it can be cultivated as rainfed crop in upland condition. The crop is grown in both summer and winter seasons in Bangladesh. The summer sesame covers about two thirds of the total sesame area of Bangladesh (Kaul and Das, 1986; BARI, 1998). The climatic and edaphic conditions of Bangladesh are quite suitable for cultivation of sesame crop. Khulna, Jessore, Faridpur, Barisal, Patuakhali, Rajshahi, Pabna, Rangpur, Sylhet, Comilla, Dhaka and Mymensingh districts are the leading sesame producing areas of Bangladesh. The crop is cultivated either as a pure stand or as a mixed crop with aus rice, jute, groundnut, millets and sugarcane.

Sesame is a diversified crop with high class edible oil having versatile usage. Bangladesh faces an acute shortage of edible oil. As a result, she has to import edible oil from different countries of the world at the cost of huge amount of foreign exchange. 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 other 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 the oil, is used for its synergistic effect in pyrethrum, which increases the toxicity of insecticides (Hill, 1972).

The sesame oilcake is a very good cattle feed since it contains protein of high biological value and appreciable quantities of phosphorus and potash. The cake is also used as manure. It contains 6.2-6.3% N, 2.0-2.1% P_2O_5 and 1.1-1.3% K_2O (Chatterjee and Mondal, 1983). Sesame seed may be eaten fried mixed with sugar or in the form of sweetmeats. The use of the seeds for decoration on the surface of breads and cookies is most familiar to the Americans.

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, quality seed, weed control, proper fertilization, irrigation, method of sowing, optimum sowing time, seed rate, population density and time of harvest are indispensable. Yield decreases progressively with the delay in planting from optimum time of sowing.

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.

The effect of photoperiodism on sesame has been thoroughly studied, since this is a major factor influencing seed yield but no studies are reported regarding the optimum sowing date and population density. However, with a delay in date of sowing and consequent reduction in the maturity period occur in sesame (Dhawan *et al.*, 1979).

Population density has considerable effect on vegetative growth as well as on yield. It is one of the most important aspects of crop growing which can be manipulated to maximize yield (Babu and Mitra, 1989). Plant population closely relates to optimum spacing and also extraction of nutrients from the soil (Reddy *et al.*, 1978). The optimization of population density leads to both vegetative growth as well as yield (Hossain and Salahuddin, 1994).

It reveals that dates of sowing and population density are two important practices to improve the seed yield and quality of sesame. Sowing dates have 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 have great impact on different levels of population density.

Research works are limited on sowing dates and population density 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 necessary to find out appropriate sowing date and population density to obtain satisfactory yield and quality seed of sesame. Hence, the present study was undertaken to achieve the following objectives:

1. Identify the optimum date of sowing for maximizing the yield of sesame.
2. Determine the optimum population density for higher yield of sesame.
3. Find out the interaction between optimum date of sowing and population density for better performance of growing sesame in the farmers field level.

CHAPTER 2
REVIEW OF LITERATURE

Chapter 2

REVIEW OF LITERATURE

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

2.1 Effect of date of sowing

Local cultivators through farmers experience are planted in the optimum date of planting. The Rabi crop is mostly sown on flood free soils between August to October. The summer crop is sown with residual moisture in February to March on low to medium low lands. No specific studies so far been reported regarding the optimum sowing date of sesame in Bangladesh. However, the information obtained from foreign literature reveals that with a delay in time of sowing results consequent reduction in the maturity period.

Sarkar *et al.* (2007) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the period from February to June 1999 to investigate the effect of sowing date and time of harvesting on the yield and yield contributing characters of sesame seed (*Sesamum indicum* L.). The experiment consisted of three sowing dates viz., 26 February, 10 March and 22 March and four harvesting times viz., harvesting at 30, 35, 40 and 45 days after flowering (DAF). The highest plant height, number of branches plant^{-1}, capsules plant^{-1}, seeds capsule^{-1}, seed yield and stover yield were obtained from the crop sown on 26 February. The highest seed yield (1251.30 kg ha^{-1}) was obtained in 26 February sowing and reduced yield with delay in sowing.

KangBo *et al.* (2006) identified the effect of sowing dates on flowering and maturity of 20 sesame genotypes, some agronomic traits including days to flowering and days to maturity were investigated under five different sowing dates (25 April, 10 May, 25 May, 10 June and 25 June) in 2001-02 and in Suwon, Korea.

Plant height, days to flowering and days to maturity decreased significantly as sowing dates were delayed, but capsules and seed weight per plant showed highest values with 10 May sowing.

Ali *et al.* (2005) conducted field studies in Faisalabad, Pakistan, in 2003, to determine the effect of different sowing dates and row spacings on the growth and yield of sesame cv. 92006. Four sowing dates (8, 15, 22 and 29 July) were used. Effect of sowing dates was highly significant and maximum seed yield was produced when the crop was sown on 8 and 15 July due to higher number of capsules per plant and more seeds per capsule.

Avila and Graterol (2005) studied the effects of sowing date, row spacing and fertilizer rate on the growth and yield of sesame in Turen, Portuguesa State, Venezuela, during 1996-1997 and 1997-1998. Sowing dates (20 December and 27 December 1996 and 3 January 1997) were evaluated. The grain yields tended to decrease as the planting date was delayed in both seasons.

Mishra *et al.* (2005) conducted a field trial on sesame at Bijnor, Uttar Pradesh, India, sesame sown at different dates (10, 20 and 30 June and 10 July) and treated with varying levels of N fertilizer (0, 30, 60, 90 and 120 kg ha^{-1}). Grain yield increased in earlier sown crops. Sowing on 20 June was found optimum for sesame.

Thanki *et al.* (2004) carried out field trials on sesame in India, with or without biofertilizer, seeds were sown on 10, 17 or 24 February. Sowing in 17 February gave the highest plant height (104 cm) and pooled yield (1290 kg ha^{-1}). The number of capsules and branches per plant, and test weight were highest with 17 February sowing although differences among sowing dates were not significant.

Rahman *et al.* (2003) conducted an experiment on the sandy soil of Assiut, Egypt in 2001 and 2002 to investigate the effects of sowing dates (10 and 25 May, and 10 June) on the performance of sesame cv. Giza 32. Plants sown on 10 May showed the maximum height (178.99 cm). The height of the first branch and the number of branches per plant were highest in plants sown on 25 May, while the height of the first capsule was highest in plants sown on 10 June. The highest seed and oil yields were obtained in plants sown on 10 May.

DongKwan *et al.* (2002) carried out a study in Korea Republic to determine the differences in the growth, grain yield, and seed quality of sesame in response to different sowing dates (9 May and 8 June) and between polyethylene vinyl house and outdoor cultures. In vinyl house culture, sesame plants sown on 8 June had longer capsule setting period, more capsules per plant, higher 1000-grain weight, and higher percent ripened grain at the upper part of the capsule settings than those sown on 9 May. In outdoor culture, sesame plants, which were sown on 9 May, had more effective branch numbers and capsule numbers per plant than those sown on 8 June.

Rai *et al.* (2002) conducted a field experiment during the rainy season in Tikamgarh, Madhya Pradesh, India, to determine the effect of sowing dates on the crop yield of sesame cultivars TC-25, TKG-9, TKG-21, JT-7, and N-32. The crop was sown during 23 July, 30 July, 6 August, and 13 August. Sowing in 23 July recorded significantly higher grain yield than the subsequent sowing dates. Delay in sowing dates resulted in subsequent decrease in grain yield, but the differences were not apparent among the cultivars.

Rao and Rao (2001) conducted a field experiment in Andhra Pradesh, India, during the rabi season (January-March), using sesame cv. Madhavi to determine the best sowing date. Treatments comprised: two sowing dates (first and third weeks of January). Sowing sesame on first week of January resulted in the highest seed yield (820.08 kg ha^{-1}).

Bahale *et al.* (2001) studied to determine the appropriate sowing time, in vertisols to sustain or maximize the productivity of rainfed sesame in northern Maharashtra, India. Treatments comprised: 3 sowing dates-optimum sowing time (OST; twenty-sixth meteorological weeks), and delayed sowings (10 and 20 days after OST). The OST produced significantly higher grain yield (mean of 1185 kg ha^{-1}) and given significantly more gross monetary returns with the highest benefit: cost ratio (4.52) than the rest of the delayed sowing times.

Patra (2001) observed ten sesame cultivars (Vinayak, Usha, Kanak, OTM 10, OTM 11, Uma, Kalika, Krishna, B 67 and Balangir Local) were sown on 2 different dates (25 June and 15 July) during the rainy seasons, in Orissa, India. Higher capsules per plant were obtained in the 25 June sowing compared to the 15 July sowing.

SungWoo *et al.* (2001) investigated in field experiments of delayed sowing on growth, flowering date and yield of sesame cv. Yangbaeckkae in Korea Republic. The yield was decreased by 7, 24, 40, 57 and 74%, respectively, as sowing date was delayed by 5, 15, 26, 36 and 46 days when compared to 15 May standard sowing date under the culture mulched with black polyethylene film. The number of capsules per plant and length of stem bearing capsule were greatly decreased, while plant height, stem diameter, and days to flowering were not significantly affected by delayed sowing date. The yield was decreased by 7.7, 8.3, 9.2, 10.1 and 11.2%, respectively, as flowering date was delayed by 1, 2, 3, 4 and 5 days when compared to 3 July normal flowering date of Yangbaeckkae when it was sown on 15 May. The number of capsules per plant and length of stem bearing capsules were greatly decreased, but plant height and harvest index were not significantly affected by delay in flowering date.

Chakraborty *et al.* (2001) conducted a field experiment in India on an Entisol (alluvial, sandy loam) in summer to assess the yield of sesame for various dates of sowing. The number of seeds per capsule of sesame was highest in the crop sown on 19 February, although up to the 18 April sowing there was no significant variation. There was no appreciable variation in thousand-seed weight with date of sowing. Crops sown on 19 February and 1 March produced statistically similar yields. The average reduction in yield of sesame was 78.5 and 213%, respectively, for crops sown on 10 February and 28 April, compared with the crop sown on 19 February.

Ba-Angood *et al.* (2000) studied two local cultivars of sesame in Yemen for eight different sowing dates. The results have shown that early sowing in August and September gave higher yields compared to February and October sowing dates.

Jain *et al.* (1999) conducted trials under rainfed conditions at Jalgaon, Nagpur (Maharashtra) and Shillongani (Assam), sesame was sown at the normal date or 10 or 20 days later on flat beds or furrows. Delayed sowing decreased yield at all sites.

Tiwari *et al.* (1999) conducted an experiment during kharif at Tikamgarh, Madhya Pradesh, India, 5 sesame cultivars were sown at the onset of the monsoon (13-16 July) or 1 or 2 weeks later. Seed yield was greatest with sowing at the onset of monsoon and sowing 1 week later, while net returns and cost: benefit ratio decreased with delay in sowing.

Ieda *et al.* (1999) observed in plot trials, sesame was sown on 8 or 9 dates between 20 April and 27 July. Yields increased with delay in sowing from 20 April to 4 May then decreased with further delay. Yield on the main stem showed a similar pattern to total yield but yields on the side branches increased slightly with delay in sowing from 20 April to 18 May and 1 June. There after decreased slowly with further delay in sowing. The sesame seed content decreased with delay in sowing from 20 April to 18 May then increased with further delay in sowing.

Bennett *et al.* (1998) carried out experiment on sesame at Katherine, Northern Territory, Australia, on the effect of time of sowing on growth and development. In the experiment, sowing date (from 12 December 1995 to 6 February 1996) had no significant effect on time to reach various growth stages and on yield sesame. The initial advantage of rapid emergence of Yori 77 seedlings was lost as Edith developed a larger canopy after 6 weeks which was more efficient at light interception. After 6 weeks Yori 77 produced a larger plant than Edith, but did not produce a larger capsule plus seed biomass.

El-Serogy (1998) carried out an experiment in Mallawi, Egypt, to study the effects of sowing date (mid-April and late May) on the yield and yield components of sesame cv. Giza 32. Taller plants, lower stem height to the first capsule, and higher fruiting zone, number of capsules per plant, seed weight per plant, 1000-seed weight, seed yield per feddan, and oil percentage were obtained with early sowing (mid-April).

Paul *et al.* (1997) carried out an experiment on the effects of time of sowing on seed yield of sesame in West Bengal, India. The time of sowing had significance effects on plant height, number of branches, number of pods and yield.

XinTian *et al.* (1997) observed sowing date of 10-25 May after rainfall of at least 10 mm was recommended for sowing sesame in Henan Province, China. Growth using this sowing date was rapid. Transplanting sesame in early May at a plant density of 9000-10 000 plants/mu was also recommended. [1 mu = 0.067 ha.].

Thakur and Kaistha (1996) conducted a field experiment in India to study the effect of different sowing dates of sesame on the crop yield. Yield was lowest (1.05 q ha^{-1}) in late sown crops. One week delay in sowing after 1st June resulted in decrease in yield of 0.45 q ha^{-1} respectively.

JeongTaek *et al.* (1995) conducted field trials in Cheju Island; sesame was sown on various dates from 15 Apr. to 25 June. Delaying sowing decreased the period between sowing and emergence, flowering or maturity.

Chellaiah and Gopalaswamy (1995) studied field trial in the winter season at Tamil Nadu, India, sesame cv. SVPR1 was sown on 2, 9, 16 or 23 December. Seed yield decreased with delay in sowing date and it was not significantly affected by different irrigation treatments.

Nirval *et al.* (1995) conducted an experiment to see the response of sesame varieties to sowing dates. Sesame cultivars T-85 and JLT-7 were sown at the onset of monsoon or 10, 20 or 30 days later at plant densities of 111111, 148148 or 222222 plants ha^{-1}. Seed Yield was 351 kg ha^{-1} in cv. T-85 and 459 kg ha^{-1} in JLT-7. The yield decreased with delay in sowing after monsoon and it increased with increase in plant densities.

Jadhao *et al.* (1994) investigated the optimum sowing time for cultivation of summer sesame cv. L-38, in Akola, Maharashtra, India, under irrigated in sandy clay loam soil. The highest yield (0.755 t ha^{-1}) was achieved in sowing the crop in the 2 week, and next highest (0.731 t ha^{-1}) from sowing during the 1 week of February. An average yield of 0.548 t ha^{-1} was obtained for sowing in the 2 week sowing compared to 0.520, 0.396 and 0.313 t ha^{-1} for 1, 3 and 4 week.

Dhoble *et al.* (1993) studied with plant density in rainy season on sesame. In a field experiment at Parbhani, India, sesame cv. T-85 and JLT-7 were sown at onset of monsoon 10, 20 or 30 days later. The seed yield $plant^{-1}$ under each date for both cultivars decreased curvilinearly where as seed yield ha^{-1} increased asymptotically. Delaying in sowing decreased the seed yields of sesame.

Suryavanshi *et al.* (1993) carried out an experiment on the effect of sowing date and quality of sesame varieties. Information was presented on yields of grain, straw and percentage of oil and protein in the seed in 5 varieties of sesame grown under 4 sowing dates (10 June, 25 June, 10 July and 25 July). Early sowing produced 1309 kg seed ha^{-1}, 2215 kg straw ha^{-1} and 48.7 % oil and it gave better result than other sowing dates.

Chimanshette and Dhoble (1992) conducted an experiment to study the effect of sowing date and planting density on seed yield of sesame varieties under rained conditions. JTL7 sesame produced significantly higher yield (373 kg ha^{-1}) than 'T85' when sown at the onset of monsoon rain proved most advantageous than delayed sowing. The yield of sesame was decreased significantly as the sowing was delayed beyond onset of monsoon.

Baskaran *et al.* (1991) carried out an experiment on the effect of sowing time on yield of sesame in Tamil Nadu, India during the rainy, cold and summer seasons of 1987 and 1988. Sesame 'TMV4' sown on 1 June (rainy season) and 1 February (summer) produced significantly highest yield, 278 and 411 kg ha^{-1}, respectively.

Khan *et al.* (1991) conducted field trials at Oil Seeds Research Institute, Faisalabad during 1984-87 with sesame cv. P37-40 sown on 15 or 30 June, 15 or 30 July or 15 or 30 August. The crop sown during June exhibited maximum seed yield (1247 kg ha^{-1}) while 15 August sowing date showed maximum oil contents (54.81%).

Rani *et al.* (1991) analyzed the growth component, phytomass and yield as influenced by planting time in sesame in a field trial during summer season at Tirupati, India. The average seed yield of sesame cv. Madhavi and Gourii sown on 16 May, 15 July or 14 August were 58.6, 40.0, 11.7 and 29.8 g m^{-2}, respectively.

Sukhandi and Dhoble (1990) conducted field experiment during kharif season, Parbhani, India, revealed that the sowing of crops on 15 June or immediately after onset of monsoon rains proved to be significantly superior to later sowings.

Suryavansi *et al.* (1990) observed the effect of sowing dates on yield and yield attributes of 5 sesame cultivars. Delay in sowing from 10 June to 25 June, 10 July and 25 July decreased average seed yields from 1.13 to 0.179, 0.28 and 0.10 t ha^{-1}, respectively and also decreased number of capsules per plant and 1000-seed weight. Cv. L-30 sown on 10 June gave the highest yield of 1.61 t ha^{-1}.

2.2 Effect of population density

Plant population is most critical for obtaining higher yield in sesame. Above or below the threshold level of plant population it would lead to intraspecies 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 fulfil the objective of maximizing the yield of sesame (Kalaiselvan *et al*., 2001).

Rahnama and Bakhshandeh (2006) conducted an experiment in the Safi-Abad Agricultural Research Center, Khuzestan Province, Iran, to identify the optimal practice for cultivation of the uni-branched sesame. 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 83000 to 530,000 plants ha^{-1}. The maximum seed and oil yield was then estimated at a density of 200,000-250,000 plants ha^{-1}.

Adebisi *et al*. (2005) studied in an experiment to assess the impact of three population densities during two seasons on seed yield. Population density of 166667 plants ha^{-1} gave 40% more yield than that at 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 effects of different nitrogen (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 (*Sesamum indicum*). Plant density exhibited significant effects on seed yield, biological yield, harvest index, number of branches per plant and number of capsules per plant. 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 effects of planting method (row and broadcast) and plant population (102000, 127500, 170000, 255000 and 510000 plants ha^{-1}) on 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 around 34% higher seed yield compared to broadcast planting in both the years. The population density also significantly affected to all growth and yield parameters. Plant height, branch number, capsule number, capsule length, seeds per capsule, 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 plants 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 2001 and 2002 to investigate the effects of plant population (70000, 35000 and 23333 plants/fed) on the performance of sesame cv. Giza 32. The highest seed and oil yields (6.20 ard/fed and 366.39 kg/fed) were obtained plants grown at 70000 population. [1 feddan=0.42 ha.].

Olowe *et al.* (2003) carried out a field experiments in 1998 and 1999 at the Teaching and Research farm of University of Agriculture, Abeokuta, Nigeria during the late cropping season (June-November) to determine the optimum populations of sesame (E8) intercropped with maize (SUWAN-1-SR). Sesame seed weight per plant increased significantly ($P<0.05$) as its population reduced in the cropping systems. 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 plants 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 nitrogen 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 ratio compared to lesser plant population viz., 133333 and 111111 plants ha^{-1}.

Subrahmaniyan *et al.* (2001 a) carried out a field experiment during the rabi seasons, at Vridhachalam, Tamil Nadu, India, to study the response of five sesame genotypes, viz. YMV 3, TMV 4, TMV 6, VRI 1 and VS 9104, to two plant densities (111000 and 166000 plants ha^{-1}) and two NPK levels (100 and 150% of the recommended dose). Under a plant density of 111000 plants ha^{-1} (30x30 cm), yield parameters were significantly higher. However a plant population of 166000 plants ha^{-1} (30x20 cm) significantly recorded a higher seed yield of 768 kg ha^{-1}.

Subrahmaniyan *et al.* (2001 b) carried out a field experiment during summer, in Vridhachalam, Tamil Nadu, India, to study the response of three root rot resistant sesame cultivars viz., ORM 7, ORM 14 and ORM 17 in three spacing (30x10, 30x20 and 30x30 cm) and three NPK levels (100, 125 and 150 percent of the recommended dose). A favourable increase in the yield parameters was observed with a spacing of 30x30 cm i.e., 11 plants m^{-2}. However a spacing of 30x10 cm i.e., 33 plants m^{-2} significantly recorded a higher seed yield of 622 kg 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 lakh ha^{-1}). Plant population of 6.66 lakh ha^{-1} produced higher seed yield (1736 kg ha^{-1}) and net returns (Rs. 18871 ha^{-1}) than 3.33 lakh 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 effects of 3 plant densities (10, 15 and 20 plants per meter 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 per meter of row resulted in highest yield per hectare, while the density of 10 plants resulted in highest yield per plant.

Subrahmaniyan and Arulmozhi (1999) carried out a field study during summer at Vridhachalam, Tamil Nadu, India, 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.

Ramanathan and Chandrashekharan (1998) conducted a field experiment at Thanjavur during the summer (March-May) seasons, revealed that nipping of the terminal bud at 25 days after sowing significantly increased the seed yield (764 vs. 658 kg ha^{-1}) of sesame cv. TMV-4 in all years. Among the plant geometries, 45 cm x 15 cm (148148 plants ha^{-1}) was significantly superior to other spacings (30 cm x 30 cm and 45 cm x 30 cm).

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

Moorthy *et al.* (1997) conducted field trials at Cuttack, Orissa, India, sesame cv. Kalika, was tested at 6 different plant spacing ranging from 30 x 10 to 50 x 15 cm giving 133000-333000 plants ha^{-1}. Seed yield was highest at 30 x 15 cm spacing followed by the 40 x 10 cm spacing.

Dixit *et al.* (1997) carried out a field experiment during early rabi [winter] 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.

Sharma *et al.* (1996) conducted a field experiment at Hoshangabad, Madhya Pradesh, India, sesame cv. T.C.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.

Patil *et al.* (1996) conducted a field experiment at Maharashtra, India, sesame cv. Padma was grown at spacings of 30 x 10 cm (33 plants m^{-2}), 30 x 15 cm (22 plants m^{-2}), 45 x 10 cm (22 plants m^{-2}) and 45 x 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}) + 50 kg N.

Balasubramaniyan (1996) carried out field trials at Vridhachalam, Tamil Nadu, India 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 genotype VS 350 yielded more (711 kg ha^{-1}) than cv. TMV 3 (636 kg ha^{-1}), and matured 10-12 days earlier. Yield was not significantly affected by plant density.

Tiwari *et al.* (1994) conducted a field trial at Tikamgarh, Madhya Pradesh, India, during kharif [monsoon] season, sesame cv. TKG-9, TKG-21, JLSC-8 and JT-7 produced mean seed yields of 2.53, 2.80, 2.92 and 1.86 t ha^{-1}, respectively. Yield averaged 2.05 and 3.00 ton with spacings of 30 x 15 i.e., 22 plants m^{-2} and 10 x 10 cm i.e., 100 plants m^{-2}.

El-Ouesni *et al.* (1994) conducted field trials at Nobarya, Egypt, to study the effects were evaluated of 2 plant population densities (1 or 2 plants $hill^{-1}$) on the growth and yields of sesame cv. Giza 32. 1 plant $hill^{-1}$ resulted in the greatest crop plant height and seed yields of 134 cm and 11.58 g $plant^{-1}$, respectively.

Ghosh and Patra (1993) carried out field trials in the dry season at West Bengal, 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.

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 multilocation trial with population density of sesame, it was observed that the lowest plant density produced significantly higher number of capsules $plant^{-1}$ in branches but lower total yield and the highest plant population (75 plants m^{-2}) produced the highest harvest index.

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 x 20 cm). They also found that optimum density (20 plants m^{-2}) gave 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}.

In Sudan, Khidir (1981) reported that the optimum plant population is 21 plants m^{-2} for good yield of sesame.

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.

CHAPTER 3
MATERIALS AND METHODS

Chapter 3

MATERIALS AND METHODS

The experiment was conducted at the Agronomy research field of Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2008 to study the effect of date of sowing and population density on the yield of sesame cv. BARI Til-2. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analyses.

3.1 Experimental site

3.1.1 Location

The research work was carried out at the research field of Agronomy Department, Sher-e- Bangla Agricultural University, Dhaka. The experimental field was located at 90° 33' E longitude and 23° 71' N latitude at a height of 9 m above the sea level as showen in Appendix I.

3.1.2 Soil characteristics

The land belongs to the Agro-ecological zone "Madhupur Tract" (AEZ-28) having the red brown trace soils and acid basin clay of Nodda soil series. The soil of the experimental site was well drained and medium high. The physical and chemical properties of soil of the experimental site were examined prior to experimentation from 0-15 cm depth. The soil was sandy loam in texture and having soil pH varied from 5.45-5.61. Organic matter content was very low (0.83%). The physical composition such as sand, silt, clay content were 40%, 40% and 20%, respectively. The properties of soil of experimental soil have been presented in Appendix II.

3.1.3 Climate

The climate of the experimental field was sub-tropical and was characterized by high temperature, heavy rainfall during Kharif-I season (March - June) and scanty rainfall during Rabi season (October - March) associated with moderately low temperature. The monthly average temperature, humidity, rainfall and sunshine hours prevailed at the experimental area during the cropping season are presented in Appendix III.

3.2 Planting material

BARI Til 2, a high yielding variety of sesame, developed by Bangladesh Agricultural Research Institute (BARI), Gazipur (released in 2001) was used as test material. The seeds of this variety were collected from the research farm of Sher-e-Bangla Agricultural University, Dhaka. The important characteristics of these variety is mentioned below :

BARI Til 2: Plants are of average 100-120 cm height. Leaves are darker green and rough. Stem contains 3–7 branches. Number of capsule plant^{-1} is 60–70 and seeds capsule^{-1} is 60–70. It grows both in Rabi and Kharif seasons but suitable for Kharif-1 season. Normally yield is 1200-1400 kg ha^{-1}. Seeds contain 42-50% oil and 25% protein.

3.3 Experimental treatments

The experiment consisted of two factors i.e., date of sowing and population density.

Factor A : Date of sowing

The following date of sowing levels was imposed in the experiment;

Sowing time	Symbol used
20 March	S_1
30 March	S_2
9 April	S_3
19 April	S_4

Factor B : Population density

The following population density levels were imposed in the experiment;

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

3.4 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. Each block was divided into 16 plots for accommodation of combination of sowing date and population density. The blocks and the unit plots were separated from each other with a distance of 100 cm and 50 cm, respectively. The total number of plots in the experiment was 48. The unit plot size was 3.5 m x 2.5 m. The inter block and inter row spaces were used as footpath and irrigation or drainage channels.

3.5 Conducting the Experiment

3.5.1 Germination test

Before sowing, germination test was carried out in the laboratory and percentage of germination was found to be over 95.

3.5.2 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. The first ploughing and the final land preparation were done on 9 March and 16 March 2008, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly before planting.

3.5.3 Fertilizer application

Urea, triple super phosphate (TSP) and muriate of potash (MP), Gypsum, Boric acid and Zinc Sulphate fertilizers were used as source of nitrogen (N), phosphorus (P), potassium (K), Sulphur (S), Boron (B) and Zinc (Zn), respectively.

Half amount of N and whole amount of P, K, S, B and Zn fertilizers were applied as basal dose during final land preparation. Rest amount of N was applied as top dressing at the time of 1st irrigation. The rate of N, P, K, S, B and Zn was 46, 30, 25, 4.9, 0.34 and 1.8 kg ha^{-1}, respectively.

3.5.4 Sowing of seeds

Seeds of sesame were sown on different dates as per treatment in lines 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}.

3.5.5 Emergence of seedlings

Seedling emergence started after 5 days and completed within 8 days of sowing. After establishment, keeping the healthy seedlings within a distance of 5 cm, 10 cm, 15 cm and 20 cm respectively as per treatment and the remaining seedlings were carefully uprooted by hand pulling.

3.5.6 Intercultural operations

3.5.6.1 Weeding

The experimental field was weeded single at 20 and 30 days after sowing. The weeding was done manually by using Nirani. Demarcation boundaries and drainage channels were also kept weed free.

3.5.6.2 Thinning

Thinning was done in all the unit plots with care so as to maintain a uniform plant population in each plot. Thinning was done twice; first thinning was done at 10 DAE (Days after emergence) and second thinning at 20 DAE.

3.5.6.3 Irrigation

Pre sowing irrigation was done to maintain equal germination. After sowing two irrigations were done during the life cycle. First and second irrigation were done at 12 and 22 DAE, respectively.

3.5.6.4 Drainage

Drainage operation for draining out of rainwater and excess irrigation water was done as and when required for proper growth and development of the crop.

3.5.6.5 Application of pesticides

The crops were attacked by myriads at the time of vegetative stage. It was controlled by spraying Dimacron 60 EC at the rate of 1litre ha^{-1}. Malathion 57 EC at the rate of 2 ml $litre^{-1}$ of water was sprayed to control hawkmoth and jute hairy caterpillar at the time of pod formation. Spraying was done in the afternoon while the pollinating bees were away from the field.

3.6 Determination of maturity

When the leaves, stems and capsules at the lower part of the plant became yellowish in color, then it was the perfect time for harvesting.

3.7 Harvesting and threshing

Harvesting was done on 16 June, 24 June, 30 June and 6 July, 2008 for 20 March, 30 March and 9 April and 19 April 2008 sowing, respectively. The harvested plants were tied into bundles and carried to the threshing floor. The crops were sun dried by spreading on the threshing floor. The seeds were separated from the pods by beating with bamboo sticks and later were cleaned, dried and weighed. The weights of the dry stover were also taken.

3.8. Collection of experimental data

For collecting data on different parameters, ten plants were selected from each plot excluding border plants outside the central 1 m^2 area, which was kept for yield data, were selected randomly. The sample plants were uprooted carefully from the soil with khurpi so that no seeds were dropped in the soil. Later they were cleaned, dried and the data in the following crop characters were collected from these sample plants:

1) Plant height (cm)
2) Branches $plant^{-1}$
3) Capsules $branch^{-1}$
4) Total capsules $plant^{-1}$
5) Effective capsules $plant^{-1}$
6) Non-effective capsules $plant^{-1}$
7) Capsule length (cm)

8) Filled seeds capsule^{-1}

9) Unfilled seeds capsule^{-1}

10) 1000-seed weight (g)

11) Seed yield (t ha^{-1})

12) Seed/capsule wall ratio

13) Stover yield (t ha^{-1})

14) Harvest index (%)

Data on the above mentioned crop characters were collected as follows:

3.8.1 Plant height (cm)

The heights of ten plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.8.2 Branches plant^{-1}

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

3.8.3 Capsules branch^{-1}

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

3.8.4 Total capsules plant^{-1}

Number of total capsules of preselected ten plants from each unit plot was noted and the mean number was recorded. The mean number was expressed on per plant basis.

3.8.5 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.

3.8.6 Non-effective capsules plant^{-1}

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.

3.8.7 Capsule length (cm)

The capsule length was measured from talking the three capsules of each of 10 randomly selected sample plants, talking one capsule from bottom, another from middle and the rest from the top of the plant and then averaged values were taken.

3.8.8 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 averaged values were taken.

3.8.9 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 averaged values were taken.

3.8.10 1000-seed weight (g)

One thousand cleaned, sun-dried seeds were counted randomly from each harvested sample and weighed by using a digital electric balance and the mean weight was expressed in gram.

3.8.11 Seed yield (t ha^{-1})

Weight of seed 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}.

3.8.12 Seed/capsule wall ratio

The seed capsule wall ratio was calculated from seed weight per unit area divided by capsule wall weight per unit area where seed moisture content was 8% and capsule was oven dry.

3.8.13 Stover yield (t ha $^{-1}$)

The weight of the plants containing grain was taken. By subtracting the grain weight from the total weight. The biomass weights were calculated after threshing and separation of grain from the sample area and then expressed in t ha^{-1} in dry weight basis.

3.8.14 Harvest index (%)

The harvest index was calculated on the ratio of grain yield to biological yield and expressed in terms of percentage. It was calculated by using the following formula-

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

The summation of grain 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)

3.9 Analysis of data

The data collected on different parameters were statistically analyzed by using the MSTAT-C computer package program developed by Russel (1986). Mean difference among the treatments were tested with Duncan's Multiple Range Test (Gomez and Gomez, 1984) at 5% level of significance.

CHAPTER 4

RESULTS AND DISCUSSION

Chapter 4

RESULTS AND DISCUSSION

Present experiment was conducted with different date of sowing and population density to study their effects on yield and yield contributing characters of sesame. The results regarding the effect of date of sowing and population density and their interactions on different crop characters and yield parameters are presented and discussed under separate heads and sub-heads as follows:

4.1 Plant height (cm)

4.1.1 Effect of date of sowing

It was observed that plant height was significantly influenced by date of sowing (Appendix IV and Fig. 1). The tallest plant (116.0 cm) was obtained from 20 March sowing which was statistically superior to 30 March sowing (108.0 cm) as well as 9 April sowing (102.5 cm). The shortest plant height (97.81 cm) was obtained from 19 April sowing. Increment in plant height was faster at 20 March sowing and then decreased up to 19 April sowing. Plant height was increased by 18.60% in 20 March sowing and 10.42% in 30 March sowing over 19 April sowing. Similar result was found by Mulkey *et al.* (1987) and Sarkar *et al.* (2007); they reported that delayed sowing affected plant height of sesame.

4.1.2 Effect of population density

Population density showed significant influence on plant height of sesame (Appendix IV). Plant height increased with the increasing population density (Fig. 2). The tallest plant of 114.2 cm was observed in 666666 plants ha^{-1} (30cm × 5cm) which was statistically superior to 333333 plants ha^{-1} (108.2 cm) as well as 222222 plants ha^{-1} (103.1 cm). The shortest plant height (98.88 cm) was recorded from 166666 plants ha^{-1}. Plant height was increased by 15.49% in 666666 plants ha^{-1} and 9.43% in 333333 plants ha^{-1} over 166666 plants ha^{-1}. However, as plant population increases per unit area, a point is reached at which each plant begins to compete for essential growth resources like nutrients, light and water. Mujaya and Yerokun (2003) stated that higher population density gave taller plants in sesame.

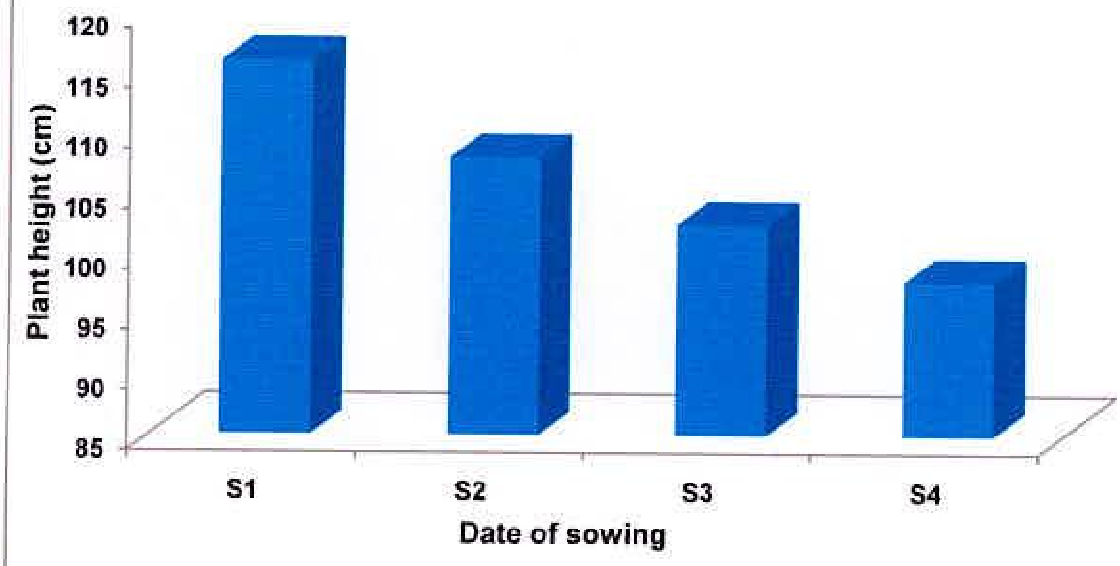

Figure 1. Effect of date of sowing on plant height of sesame

S_1 = 20 March sowing S_3 = 9 April sowing
S_2 = 30 March sowing S_4 = 19 April sowing

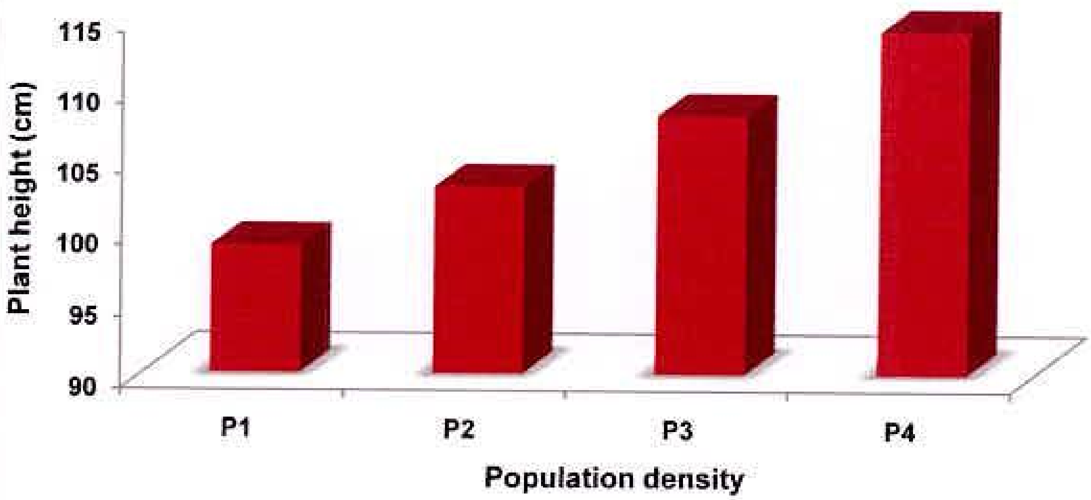

Figure 2. Effect of population density on plant height of sesame

P_1 = 166666 plants ha^{-1} P_2 = 222222 plants ha^{-1}
P_3 = 333333 plants ha^{-1} P_4 = 666666 plants ha^{-1}

4.1.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in plant height (Appendix IV and Table 3). Plant height was observed highest in combination with 20 March sowing and 666666 plants ha^{-1} (125.6 cm) followed by 20 March sowing and 333333 plants ha^{-1} (119.2 cm), 30 March sowing and 666666 plants ha^{-1} (117.2 cm) and 20 March sowing and 222222 plants ha^{-1} combination (112.9 cm). Combination of 19 April sowing with 166666 plants ha^{-1} resulted the shortest plant height (92.7 cm). Plant height was increased by 35.49% in 20 March sowing × 666666 plants ha^{-1}, 28.59% in 20 March sowing × 333333 plants ha^{-1}, 26.43% in 30 March sowing × 666666 plants ha^{-1} and 21.79% in 20 March sowing × 222222 plants ha^{-1} over the shortest plant height combination of 19 April sowing × 166666 plants ha^{-1}.

4.2 Branches $plant^{-1}$

4.2.1 Effect of date of sowing

The results showed that the number of branches $plant^{-1}$ was significantly influenced by date of sowing (Appendix IV and Table 1). The higher number of branches $plant^{-1}$ (4.63) was obtained from 20 March sowing which was statistically superior to 30 March sowing (4.43) as well as 9 April sowing (4.21). The lower number of branches $plant^{-1}$ (3.98) was obtained from 19 April sowing. It was found that the number of branches $plant^{-1}$ decreased after 20 March sowing up to 19 April sowing. Number of branches $plant^{-1}$ was increased by 16.33% in 20 March sowing and 11.31% in 30 March sowing over 19 April sowing. This lower branching in delayed sowing might be due to environmental effect. Similar result was found by Tilak *et al.* (1971) and Sarkar *et al.* (2007); they reported that delay in sowing decreased the number of branches $plant^{-1}$ of sesame.

4.2.2 Effect of population density

Number of branches $plant^{-1}$ differed significantly due to different population density (Appendix IV). Increase in population density gradually decreased the number of branches $plant^{-1}$ (Table 2). The highest number of branches $plant^{-1}$ (4.93) was observed in lowest population density (166666 plants ha^{-1}) which was statistically superior to 222222 plants ha^{-1} (4.49) as well as 333333 plants ha^{-1} (4.07).

The lowest number of branches plant^{-1} (3.67) was observed in highest population density (666666 plants ha^{-1}). Number of branches plant^{-1} was increased by 34.33% in 166666 plants ha^{-1} and 22.34% in 222222 plants ha^{-1} over 666666 plants ha^{-1}. Increase in population density increased intra-specific competition which eventually caused reduction in number of branches plant^{-1}. Similar phenomenon was observed by Channabasavanna and Setty (1992) and Majumder and Roy (1992); they reported that lowest plant density gave significantly increased number of branches plant^{-1}.

4.2.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in number of branches plant^{-1} (Appendix IV and Table 3). Number of branches plant^{-1} was observed highest in combination with 20 March sowing and 166666 plants ha^{-1} (5.50) followed by 30 March sowing and 166666 plants ha^{-1} (5.03), 9 April sowing and 166666 plants ha^{-1} (4.70) and 19 April sowing and 166666 plants ha^{-1} combination (4.47). Interaction of 9 April sowing with 666666 plants ha^{-1} resulted the lowest number of branches plant^{-1} (3.57). Number of branches plant^{-1} was increased by 54.06% in 20 March sowing × 166666 plants ha^{-1}, 40.90% in 30 March sowing × 166666 plants ha^{-1}, 31.65% in 30 March sowing × 166666 plants ha^{-1} and 25.21% in 19 April sowing × 166666 plants ha^{-1} over the lowest number of branches plant^{-1} combination of 9 April sowing × 666666 plants ha^{-1}.

4.3 Capsules branch^{-1}

4.3.1 Effect of date of sowing

The number of capsules branch^{-1} was significantly influenced by date of sowing (Appendix IV and Table 1). The higher number of capsules branch^{-1} (19.30) was obtained from 20 March sowing which was statistically superior to 30 March sowing (18.75) as well as 9 April sowing (17.84). The lower number of capsules branch^{-1} (16.78) was recorded from 19 April sowing. Number of capsules branch^{-1} decreased after 20 March sowing up to 19 April sowing. Number of capsules branch^{-1} was increased by 15.02% in 20 March sowing and 11.74% in 30 March sowing over 19 April sowing. Similar result was found by Rahman *et al.* (2003) and Thanki *et al.* (2004); they reported that early sowing increased number of capsules branch^{-1} of sesame.

Table 1. Effect of date of sowing on yield contributing characters and yield components of sesame

Date of Sowing	Branches $plant^{-1}$ (no.)	Capsules $branch^{-1}$ (no.)	Total capsules $plant^{-1}$ (no.)	Effective capsules $plant^{-1}$ (no.)	Non-effective capsules $plant^{-1}$ (no.)	Filled seeds $capsule^{-1}$ (no.)	Unfilled seeds $capsule^{-1}$ (no.)	Seed/ capsule wall ratio	Harvest index (%)
20March	4.63a	19.30a	88.57a	82.68a	2.56d	71.77a	2.25c	5.26a	26.04a
30March	4.43b	18.75b	82.39b	79.04a	3.35c	67.77b	1.62d	4.89b	24.61b
9 April	4.12c	17.84c	72.95c	69.26b	3.69b	63.51c	2.59b	4.14c	23.36c
19 April	3.98d	16.78d	66.52d	59.80c	6.73a	58.22d	3.46a	3.68d	22.42d
$S_{\bar{x}}$	0.03162	0.09174	0.7059	1.572	0.06646	0.1897	0.03651	0.009129	0.2113
$P_{(0.05)}$	**	**	**	**	**	**	**	**	**
CV (%)	**2.59**	**1.75**	**3.15**	**7.49**	**5.64**	**1.01**	**5.17**	**0.76**	**3.04**

In a column figures with same letters or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT) at 5% level of significance.

4.3.2 Effect of population density

Population density showed significant influence on number of capsules branch^{-1} of sesame (Appendix IV). Number of capsules branch^{-1} increased with the increasing population density (Table 2). The highest number of capsules branch^{-1} (20.29) was observed in 666666 plants ha^{-1} which was statistically superior to 333333 plants ha^{-1} (18.62) as well as 222222 plants ha^{-1} (17.21). The lowest number of capsules branch^{-1} (16.55) was found from 166666 plants ha^{-1}. Number of capsules branch^{-1} was increased by 22.60% in 666666 plants ha^{-1} and 12.51% in 333333 plants ha^{-1} over 166666 plants ha^{-1}. Fard and Bahrani (2005) reported that higher population density gave higher number of capsules branch^{-1} in sesame.

4.3.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in number of capsules branch^{-1} (Appendix IV and Table 3). Number of capsules branch^{-1} was observed highest in combination with 20 March sowing and 666666 plants ha^{-1} (22.31) followed by 30 March sowing and 666666 plants ha^{-1} (20.81), 20 March sowing and 333333 plants ha^{-1} (19.88) and 30 March sowing and 333333 plants ha^{-1} combination (19.29). Combination of 19 April sowing with 166666 plants ha^{-1} resulted the lowest number of capsules branch^{-1} (15.51). Number of capsules branch^{-1} was increased by 43.84% in 20 March sowing × 666666 plants ha^{-1}, 34.17% in 30 March sowing × 666666 plants ha^{-1}, 28.18% in 20 March sowing × 333333 plants ha^{-1} and 24.37% in 30 March sowing × 333333 plants ha^{-1} over the lowest number of capsules branch^{-1} combination of 19 April sowing × 166666 plants ha^{-1}.

4.4 Total capsules plant^{-1}

4.4.1 Effect of date of sowing

The results showed that total capsules number plant^{-1} was significantly influenced by date of sowing (Appendix IV and Table 1). The highest capsules number plant^{-1} (88.57) was obtained from 20 March sowing which was statistically superior to 30 March sowing (82.39) as well as 9 April sowing (72.95). The lowest number of capsules plant^{-1} (66.52) was observed from 19 April sowing. Number of capsules plant^{-1} decreased after 20 March sowing up to 19 April sowing.

Number of capsules plant^{-1} was increased by 33.14% in 20 March sowing and 23.86% in 30 March sowing over 19 April sowing. Similar result was obtained by Tilak *et al.* (1971) and Sarkar *et al.* (2007); they reported that delay in sowing decreased the number of capsules plant^{-1} of sesame.

4.4.2 Effect of population density

Number of total capsules plant^{-1} was significantly influenced by population density of sesame (Appendix IV). Higher population density gave the lower number of capsules plant^{-1} (Table 2). The highest number of capsules plant^{-1} (82.09) was recorded in 166666 plants ha^{-1} which was statistically superior to 222222 plants ha^{-1} (77.45) as well as 333333 plants ha^{-1} (75.90) but result from 333333 plants ha^{-1} was statistically similar to 222222 plants ha^{-1} . The lowest number of capsules plant^{-1} (74.99) was found from 666666 plants ha^{-1}. Number of capsules plant^{-1} was increased by 9.47% in 166666 plants ha^{-1} and 3.28% in 222222 plants ha^{-1} over 666666 plants ha^{-1}. This increase in number of capsules plant^{-1} might be attributed to wider plant to plant spacing in rows and less inter or intra plant competition in the community. Similar trend in number of capsules plant^{-1} in sesame was reported by Tomar *et al.* (1992).

4.4.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed no significant variation in number of capsules plant^{-1} (Appendix IV and Table 3). Number of capsules plant^{-1} was observed highest in combination with 20 March sowing and 166666 plants ha^{-1} (95.07) followed by 20 March sowing and 666666 plants ha^{-1} (87.79) which was statistically similar to 30 March sowing and 166666 plants ha^{-1} (87.32) and 20 March sowing and 222222 plants ha^{-1} combination (85.93). Interaction of 19 April sowing with 666666 plants ha^{-1} resulted the lowest number of capsules plant^{-1} (62.82). Number of capsules plant^{-1} was increased by 51.34% in 20 March sowing × 166666 plants ha^{-1}, 39.75% in 20 March sowing × 666666 plants ha^{-1}, 39% in 30 March sowing × 166666 plants ha^{-1} and 36.79% in 20 March sowing × 222222 plants ha^{-1} over the lowest number of capsules plant^{-1} combination of 19 April sowing × 666666 plants ha^{-1}.

Table 2. Effect of population density on yield contributing characters and yield components of sesame

Population density	Branches plant^{-1} (no.)	Capsules branch^{-1} (no.)	Total capsules plant^{-1} (no.)	Effective capsules plant^{-1} (no.)	Non-effective capsules plant^{-1} (no.)	Filled seeds capsule^{-1} (no.)	Unfilled seeds capsule^{-1} (no.)	Seed/ capsule wall ratio	Harvest index (%)
166666 plants ha^{-1}	4.93a	16.55d	82.09a	78.25a	3.84c	68.46a	2.55	5.25a	23.25c
222222 plants ha^{-1}	4.49b	17.21c	77.45b	73.62b	3.83c	65.90b	2.49	4.70b	23.99b
333333 plants ha^{-1}	4.07c	18.62b	75.90bc	71.76b	4.15b	64.37c	2.45	4.27c	24.53ab
666666 plants ha^{-1}	3.67d	20.29a	74.99c	67.14c	4.52a	62.55d	2.43	3.75d	24.66a
$S_{\bar{x}}$	0.03162	0.09174	0.7059	1.572	0.06646	0.1897	0.03651	0.009129	0.2113
Significance level	**	**	**	**	**	**	NS	**	**
CV (%)	**2.59**	**1.75**	**3.15**	**7.49**	**5.64**	**1.01**	**5.17**	**0.76**	**3.04**

In a column figures with same letters or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT) at 5% level of significance.

4.5 Effective capsules plant^{-1}

4.5.1 Effect of date of sowing

It was observed that the number of effective capsules plant^{-1} was significantly influenced by date of sowing (Appendix IV and Table 1). The highest number of effective capsules plant^{-1} (82.68) was obtained from 20 March sowing which was statistically similar to 30 March sowing (79.04). The lowest number of effective capsules plant^{-1} (59.80) was observed from 19 April sowing. Number of effective capsules plant^{-1} decreased after 20 March sowing up to 19 April sowing. Number of effective capsules plant^{-1} was increased by 38.26% in 20 March sowing and 32.17% in 30 March sowing over 19 April sowing. This phenomenon was occured because plants obtained optimum temperature, moisture and sunshine for proper photosynthesis and partitioning to reach effective capsule. Similar result was obtained by Shubha (2006) who reported that delay in sowing decreased number of effective capsules plant^{-1} of sesame.

4.5.2 Effect of population density

Number of effective capsules plant^{-1} was significantly influenced by population density of sesame (Appendix IV). Higher population density gave the lower number of effective capsules plant^{-1} (Table 2). The highest number of effective capsules plant^{-1} (78.25) was recorded in 166666 plants ha^{-1} which was statistically superior to 222222 plants ha^{-1} (73.62) that is statistically similar to 333333 plants ha^{-1} (71.76). The lowest number of effective capsules plant^{-1} (67.14) was obtained from 666666 plants ha^{-1}. Number of effective capsules plant^{-1} was increased by 16.55% in 166666 plants ha^{-1} and 9.65% in 222222 plants ha^{-1} over 666666 plants ha^{-1}. This increase in number of effective capsules plant^{-1} might be attributed to wider plant spacing in rows and less inter or intra plant competition in the community. Similar trend in number of effective capsules plant^{-1} in sesame was reported by Enyi (1973).

4.5.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in number of effective capsules plant^{-1} (Appendix IV and Table 3). Number of effective capsules plant^{-1} was observed highest in combination with 20 March sowing and with 166666 plants ha^{-1} (91.80) which was statistically similar to 30

March sowing and 166666 plants ha^{-1} (83.46), 20 March sowing and 333333 plants ha^{-1} (83.28) and 20 March sowing and 222222 plants ha^{-1} combination (82.73). The lowest number of effective capsules $plant^{-1}$ (52.49) was obtained from 19 April sowing with 666666 plants ha^{-1} combination. Number of effective capsules $plant^{-1}$ was increased by 74.89% in 20 March sowing × 166666 plants ha^{-1}, 59% in 30 March sowing × 166666 plants ha^{-1}, 58.66% in 20 March sowing × 333333 plants ha^{-1} and 57.61% in 20 March sowing × 222222 plants ha^{-1} over the lowest number of effective capsules $plant^{-1}$ combination of 19 April sowing × 666666 plants ha^{-1}.

4.6 Non-effective capsules $plant^{-1}$

4.6.1 Effect of date of sowing

The results showed that the number of non-effective capsules $plant^{-1}$ was significantly influenced by date of sowing (Appendix IV and Table 1). The lowest number of non-effective capsules $plant^{-1}$ (2.56) was observed from 20 March sowing which was statistically different from 30 March sowing (3.35) as well as 9 April sowing (3.69). The highest number of non-effective capsules $plant^{-1}$ (6.73) was obtained from 19 April sowing. Number of non-effective capsules $plant^{-1}$ increased from 20 March sowing up to 19 April sowing. Number of non-effective capsules $plant^{-1}$ was reduced by 61.96% in 20 March sowing and 50.22% in 30 March sowing over 19 April sowing. Similar result was obtained by Shubha (2006) who reported that early in sowing reduced the number of non-effective capsules $plant^{-1}$ of sesame.

4.6.2 Effect of population density

Population density showed significant influence on number of non-effective capsules $plant^{-1}$ of sesame (Appendix IV). Higher population density gave the higher number of non-effective capsules $plant^{-1}$ (Table 2). The lowest number of non-effective capsules $plant^{-1}$ (3.83) was obtained from 222222 plants ha^{-1} which was statistically similar to 166666 plants ha^{-1} (3.84) followed by 333333 plants ha^{-1} (4.15). The highest number of non-effective capsules $plant^{-1}$ (4.52) was observed in 666666 plants ha^{-1}. Number of non-effective capsules $plant^{-1}$ was decreased by 15.27% in 222222 plants ha^{-1} and 15.04% in 166666 plants ha^{-1} over 666666 plants ha^{-1}. This phenomenon might be occured due to greater competition for nutrients between high population densities per unit area.

Table 3. Interaction effect of date of sowing and population density on yield contributing characters of sesame

Interaction (Sowing date × Population density)	Plant height (cm)	Branches plant^{-1} (no.)	Capsules branch^{-1} (no.)	Total capsules plant^{-1} (no.)	Effective capsules plant^{-1} (no.)	Non-effective capsules plant^{-1} (no.)	Capsule length (cm)
S_1P_1	106.5f	5.50a	17.09h	95.07a	91.80a	3.27hi	2.66ef
S_1P_2	112.9d	4.80c	17.91e-g	85.93bc	82.73a-c	3.20hi	2.73d
S_1P_3	119.2b	4.30de	19.88c	85.48bc	83.28ab	2.20j	2.87b
S_1P_4	125.6a	3.93f	22.31a	87.79b	72.89c-f	1.57k	3.09a
S_2P_1	100.7h	5.03b	17.27h	87.32b	83.46ab	3.87d-f	2.63fg
S_2P_2	103.2g	4.67c	17.62f-h	82.19cd	78.73b-d	3.47f-h	2.63fg
S_2P_3	111.0e	4.20e	19.29d	80.97d	77.77b-d	3.20hi	2.69de
S_2P_4	117.2c	3.80f	20.81b	79.07de	76.20b-e	2.87i	2.80c
S_3P_1	95.70i	4.70c	16.31i	76.66ef	72.70c-f	3.97de	2.50i
S_3P_2	100.5h	4.30de	17.38gh	74.73f	70.93d-g	3.80ef	2.53hi
S_3P_3	103.5g	3.90f	17.99ef	70.17g	66.47e-h	3.70e-g	2.58gh
S_3P_4	110.1e	3.57g	19.70cd	70.26g	66.96e-h	3.30gh	2.65ef
S_4P_1	92.70j	4.47d	15.51j	69.30g	65.07f-h	4.26d	2.36k
S_4P_2	95.63i	4.20e	15.94ij	66.96gh	62.10gh	4.87c	2.42j
S_4P_3	99.20h	3.87f	17.32h	67.00gh	59.54hi	7.48b	2.44j
S_4P_4	103.7g	3.37h	18.35e	62.82h	52.49i	10.33a	2.51i
$S_{\bar{x}}$	0.5145	0.06325	0.1835	1.412	3.143	0.1329	0.01826
Significance level	**	**	**	NS	**	**	**
CV (%)	**0.84**	**2.59**	**1.75**	**3.15**	**7.49**	**5.64**	**0.98**

In a column figures with same letters or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT) at 5% level of significance.

S_1= 20 March sowing
S_2= 30 March sowing
S_3= 9 April sowing
S_4= 19 April sowing
P_1= 166666 plants ha^{-1}
P_2= 222222 plants ha^{-1}
P_3= 333333 plants ha^{-1}
P_4= 666666 plants ha^{-1}

4.6.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in number of non-effective capsules plant^{-1} (Appendix IV and Table 3). Number of non-effective capsules plant^{-1} was recorded lowest in combination with 20 March sowing with 666666 plants ha^{-1} (1.57) followed by 20 March sowing and 333333 plants ha^{-1} (2.20), 30 March sowing and 666666 plants ha^{-1} (2.87) which was statistically similar to 20 March with 222222 plants ha^{-1} (3.20) and 30 March sowing with 333333 plants ha^{-1} (3.20). The highest number of non-effective capsules plant^{-1} (10.33) was obtained from 19 April sowing and in combination with 666666 plants ha^{-1} combination. Number of non-effective capsules plant^{-1} was reduced by 84.80% in 20 March sowing × 666666 plants ha^{-1}, 78.70% in 20 March sowing × 333333 plants ha^{-1}, 72.22% in 30 March sowing × 666666 plants ha^{-1} and 69.02% in 20 March sowing × 222222 plants ha^{-1} over the highest number of non-effective capsules plant^{-1} in combination of 19 April sowing × 666666 plants ha^{-1}.

4.7 Capsule length (cm)

4.7.1 Effect of date of sowing

It was observed that the length of capsule was significantly influenced by date of sowing (Appendix IV and Fig. 3). The highest capsule length (2.84 cm) was obtained from 20 March sowing which was statistically superior to 30 March sowing (2.69 cm) as well as 9 April sowing (2.56 cm). The lowest capsule length (2.43 cm) was obtained from 19 April sowing. Capsule length decreased after 20 March sowing then up to 19 April sowing. Capsule length was increased by 16.87% in 20 March sowing and 10.70% in 30 March sowing over 19 April sowing. Similar trend in capsules length of sesame was reported by Shubha (2006).

4.7.2 Effect of population density

Capsule length was significantly influenced by population density of sesame (Appendix IV). Capsule length increased with the increasing population density (Fig. 4). The tallest capsule length (2.76 cm) was observed in 666666 plants ha^{-1} which was statistically superior to 333333 plants ha^{-1} (2.64 cm). The shortest capsule length (2.54 cm) was recorded from 166666 plants ha^{-1} which was statistically similar to 222222 plants ha^{-1} (2.58 cm). Capsule length was increased by 8.66% in 666666 plants ha^{-1} and 3.94% in 333333 plants ha^{-1} over 166666 plants ha^{-1}.

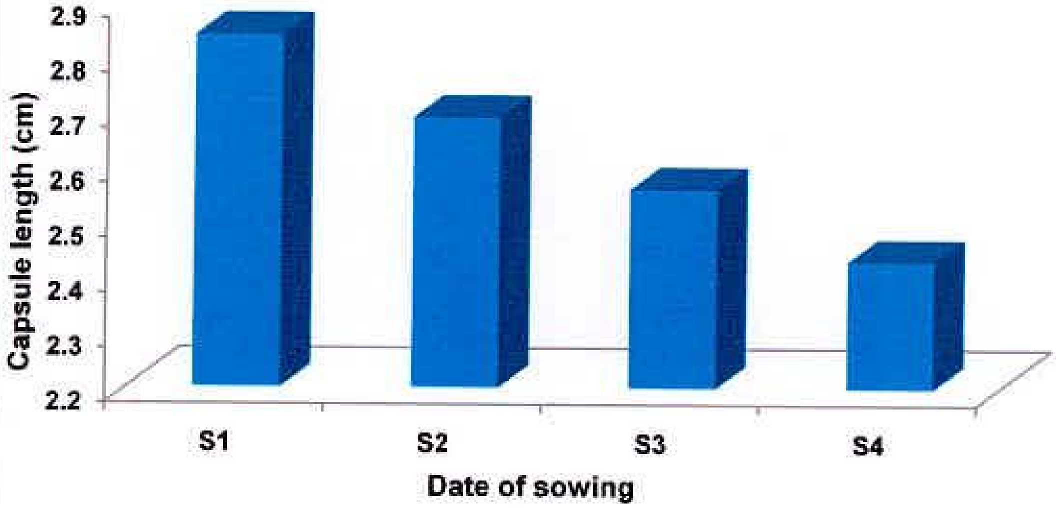

Figure 3. Effect of date of sowing on capsule length of sesame

S_1 = 20 March sowing S_3 = 9 April sowing
S_2 = 30 March sowing S_4 = 19 April sowing

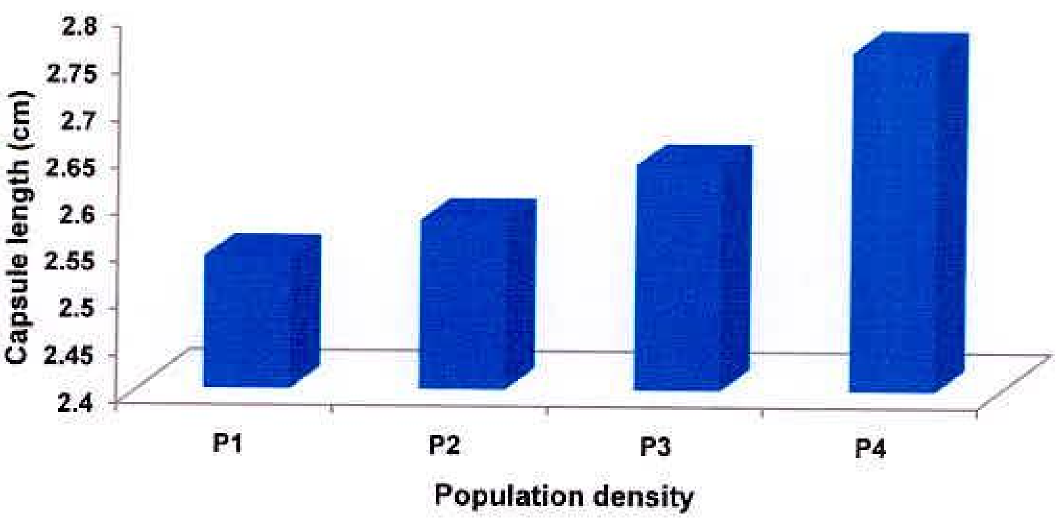

Figure 4. Effect of population density on capsule length of sesame

P_1 = 166666 plants ha^{-1} P_2 = 222222 plants ha^{-1}
P_3 = 333333 plants ha^{-1} P_4 = 166666 plants ha^{-1}

4.7.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in capsule length (Appendix IV and Table 3). Capsule length was observed highest in combination with 20 March sowing along with 666666 plants ha^{-1} (3.09 cm) followed by 20 March sowing and 333333 plants ha^{-1} (2.87 cm), 30 March sowing and 666666 plants ha^{-1} (2.80 cm) and 20 March sowing and 222222 plants ha^{-1} (2.73 cm). Interaction of 19 April sowing with 166666 plants ha^{-1} resulted the shortest capsule length (2.36 cm). Capsule length was increased by 30.93% in 20 March sowing × 666666 plants ha^{-1}, 21.61% in 20 March sowing × 333333 plants ha^{-1}, 18.64% in 30 March sowing × 666666 plants ha^{-1} and 15.68% in 20 March sowing × 222222 plants ha^{-1} over the shortest capsule length combination of 19 April sowing × 166666 plants ha^{-1}.

4.8 Filled seeds capsule^{-1}

4.8.1 Effect of date of sowing

The results showed that the number of filled seeds capsule^{-1} was significantly influenced by date of sowing (Appendix V and Table 1). The highest number of filled seeds capsule^{-1} (71.77) was observed from 20 March sowing which was statistically superior to 30 March sowing (67.77) as well as 9 April sowing (63.51). The lowest number of filled seeds capsule^{-1} (58.22) was obtained from 19 April sowing. Number of filled seeds capsule^{-1} decreased after 20 March sowing up to 19 April sowing. Number of filled seeds capsule^{-1} was increased by 23.27% in 20 March sowing and 16.40% in 30 March sowing over 19 April sowing. This phenomenon might be occured because plants obtained optimum temperature, moisture and sunshine for proper photosynthesis and partitioning to reach filled seed. Similar result was obtained by Shubha (2006) who reported that early in sowing increased number of filled seeds capsule^{-1} of sesame.

4.8.2 Effect of population density

Population density showed significant influence on number of filled seeds capsule^{-1} of sesame (Appendix V). Higher population density resulted the lower number of filled seeds capsule^{-1} (Table 2).

The highest number of filled seeds capsule^{-1} (68.46) was recorded in 166666 plants ha^{-1} which was statistically superior to 222222 plants ha^{-1} (65.90) as well as 333333 plants ha^{-1} (64.37). The lowest number of filled seeds capsule^{-1} (62.55) was obtained from 666666 plants ha^{-1}. Number of filled seeds capsule^{-1} was increased by 9.45% in 166666 plants ha^{-1} and 5.36% in 222222 plants ha^{-1} over 666666 plants ha^{-1}. This increase in number of filled seeds capsule^{-1} might be attributed to wider plant spacing in rows and less inter or intra plant competition in the community. Similar trend in number of filled seeds capsule^{-1} in sesame was reported by Begum (2002).

4.8.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in number of filled seeds capsule^{-1} (Appendix V and Table 4). Number of filled seeds capsule^{-1} was observed highest in 20 March sowing along with 166666 plants ha^{-1} (75.31) followed by 20 March sowing and 222222 plants ha^{-1} (72.23), 20 March sowing and 333333 plants ha^{-1} (70.47) which was statistically similar to 30 March sowing and 166666 plants ha^{-1} (70.26). The lowest number of filled seeds capsule^{-1} (54.97) was obtained from 19 April sowing with 666666 plants ha^{-1}. Number of filled seeds capsule^{-1} was increased by 37% in 20 March sowing × 166666 plants ha^{-1}, 31.40% in 20 March sowing × 222222 plants ha^{-1}, 28.20% in 20 March sowing × 333333 plants ha^{-1} and 27.82% in 30 March sowing × 166666 plants ha^{-1} over the lowest number of filled seeds capsule^{-1} combination of 19 April sowing × 666666 plants ha^{-1}.

4.9 Unfilled seeds capsule^{-1}

4.9.1 Effect of date of sowing

It was observed that the number of unfilled seeds capsule^{-1} was significantly influenced by date of sowing (Appendix V and Table 1). The lowest number of unfilled seeds capsule^{-1} (1.62) was recorded from 30 March sowing which differed statistically from 20 March sowing (2.25) as well as 9 April sowing (2.59). The highest number of unfilled seeds capsule^{-1} (3.46) was obtained from 19 April sowing. Number of unfilled seeds capsule^{-1} was reduced by 53.18% in 30 March sowing and 34.97% in 20 March sowing over 19 April sowing. Similar result was obtained by Shubha (2006) who reported that early in sowing reduced the number of unfilled seeds capsule^{-1} of sesame.

4.9.2 Effect of population density

Population density showed no significant variation on number of unfilled seeds capsule^{-1} of sesame (Appendix V). Higher population density gave the lower number of unfilled seeds capsule^{-1} (Table 2). The lowest number of unfilled seeds capsule^{-1} (2.43) was obtained from 666666 plants ha^{-1}. The highest number of unfilled seeds capsule^{-1} (2.55) was observed in 166666 plants ha^{-1} which was statistically similar to 333333 plants ha^{-1} (2.45) and 222222 plants ha^{-1} (2.49). Number of unfilled seeds capsule^{-1} was decreased by 4.71% in 666666 plants ha^{-1} and 3.92% in 333333 plants ha^{-1} over 166666 plants ha^{-1}.

4.9.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in number of unfilled seeds capsule^{-1} (Appendix V and Table 4). The lowest number of unfilled seeds capsule^{-1} (1.50) was obtained from 30 March sowing along with 166666 plants ha^{-1} which was statistically similar to 30 March sowing and 222222 plants ha^{-1} (1.60), 30 March sowing and 333333 plants ha^{-1} (1.67) and 30 March sowing and 666666 plants ha^{-1} (1.71). Number of unfilled seeds capsule^{-1} was recorded highest in combination with 19 April sowing and 166666 plants ha^{-1} (4.05). Number of unfilled seeds capsule^{-1} was reduced by 62.96% in 30 March sowing × 166666 plants ha^{-1}, 60.49% in 30 March sowing × 222222 plants ha^{-1}, 58.77% in 30 March sowing × 333333 plants ha^{-1} and 57.78% in 30 March sowing × 666666 plants ha^{-1} over the highest number of unfilled seeds capsule^{-1} produced by the combination effect of 19 April sowing × 166666 plants ha^{-1}.

4.10 1000-seed weight (g)

4.10.1 Effect of date of sowing

The results showed that 1000-seed weight was significantly influenced by date of sowing (Appendix V and Fig. 5). The highest 1000-seed weight (3.37 g) was obtained from 20 March sowing which was statistically superior to 9 April sowing (3.10 g) as well as 19 April sowing (2.99 g). The lowest 1000-seed weight (2.61g) was observed from 30 March sowing. 1000-seed weight was increased by 29.12% in 20 March sowing and 18.77% in 9 April sowing over 30 March sowing. 1000-seed weight was higher at early sowing and thereafter it was decreased due to delayed sowing.

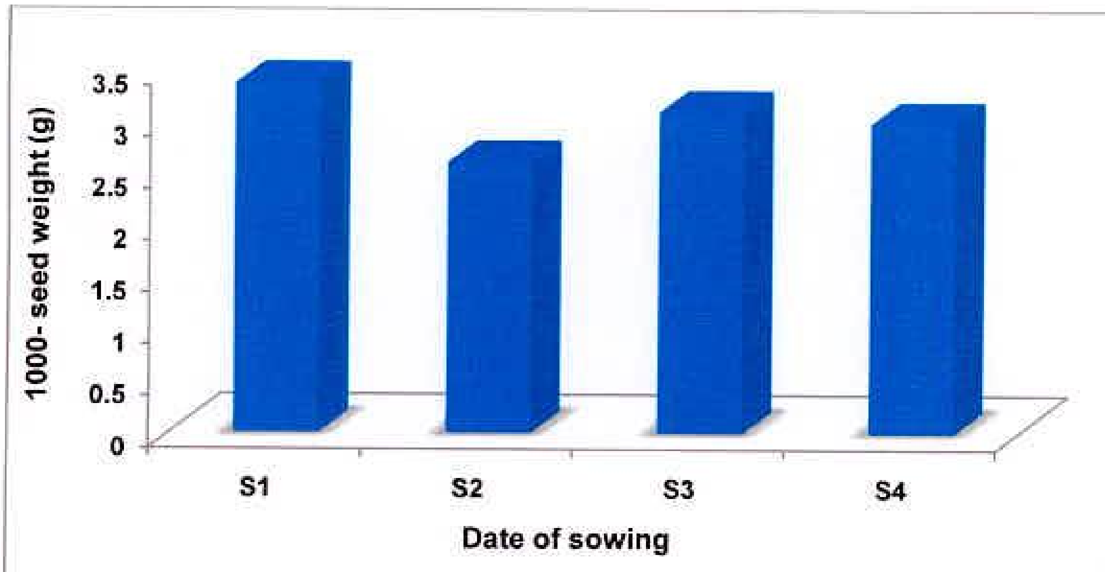

Figure 5. Effect of date of sowing on 1000-seed weight of sesame

S_1 = 20 March sowing S_3 = 9 April sowing
S_2 = 30 March sowing S_4 = 19 April sowing

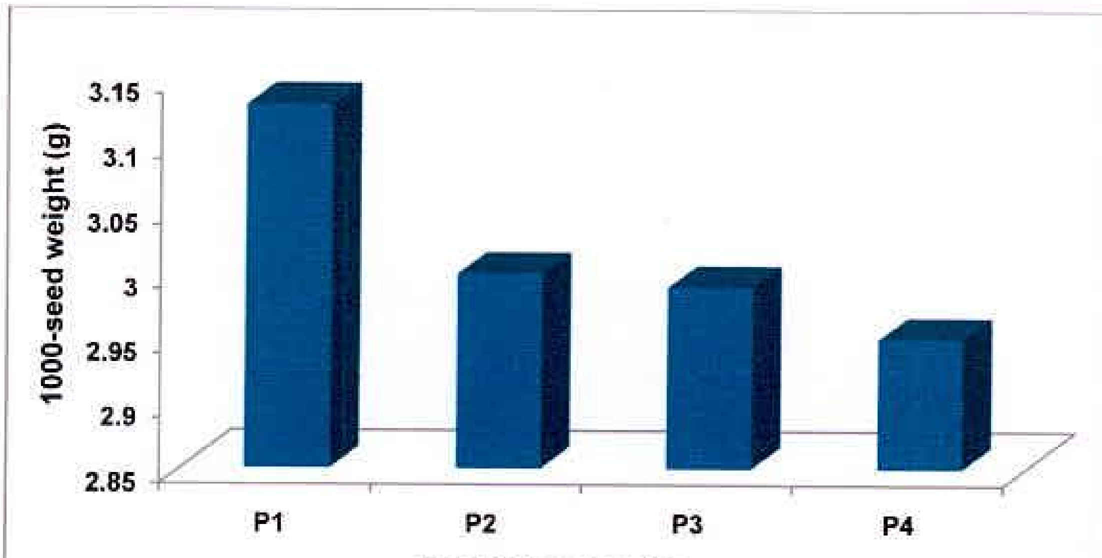

Figure 6. Effect of population density on 1000-seed weight of sesame

P_1 = 166666 plants ha^{-1} P_2 = 222222 plants ha^{-1}
P_3 = 333333 plants ha^{-1} P_4 = 666666 plants ha^{-1}

Similar results also reported by Ieda *et al.* (1999) and Shubha (2006); they reported that delay in sowing decreased 1000-seed weight of sesame.

4.10.2 Effect of population density

1000-seed weight was significantly influenced by population density of sesame (Appendix V). Increases in population density gradually decreased 1000-seed weight (Fig. 6). The highest 1000-seed weight (3.13 g) was recorded in the lowest population density (166666 plants ha^{-1}). The lowest 1000-seed weight (2.95 g) was obtained from highest population density (666666 plants ha^{-1}) which was statistically similar to 333333 plants ha^{-1} (2.99 g) and 222222 plants ha^{-1} (3.00 g). 1000-seed weight was increased by 6.10% in 166666 plants ha^{-1} and 1.69% in 222222 plants ha^{-1} over 666666 plants ha^{-1}. Increases in population density increased inter plant competition which eventually caused reduction in yield attributes. Similar result was found by Singh *et al.* (1988) who stated that the lowest plant density gave the highest 1000-seed weight of sesame.

4.10.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in 1000-seed weight (Appendix V and Table 4). Maximum 1000-seed weight was observed in combination with 20 March sowing and 166666 plants ha^{-1} (3.60 g) followed by 20 March sowing and 222222 plants ha^{-1} (3.38 g) which was statistically similar to 20 March sowing and 333333 plants ha^{-1} (3.29 g) and 9 April sowing and 166666 plants ha^{-1} combination (3.23 g). Interaction effect of 30 March sowing along with 222222 plants ha^{-1} resulted the lowest 1000-seed weight (2.59 g) which was statistically similar to 30 March sowing with 333333 plants ha^{-1} (2.62 g), 30 March sowing with 166666 plants ha^{-1} (2.62 g) and 30 March sowing with 666666 plants ha^{-1} (2.63 g). 1000-seed weight was increased by 39% in 20 March sowing × 166666 plants ha^{-1}, 30.50% in 20 March sowing × 222222 plants ha^{-1}, 27.03% in 20 March sowing × 333333 plants ha^{-1} and 24.71% in 9 April sowing × 166666 plants ha^{-1} over the lowest 1000-seed weight combination of 30 March sowing × 222222 plants ha^{-1}.

4.11 Seed yield (t ha^{-1})

4.11.1 Effect of date of sowing

Date of sowing exerted a significant effect on seed yield (Appendix V and Fig. 7). The highest seed yield (1.55 t ha^{-1}) was obtained from 20 March sowing which was statistically superior to 30 March sowing (1.33 t ha^{-1}) as well as 9 April sowing (1.13 t ha^{-1}). The lowest seed yield (0.94 t ha^{-1}) was recorded from 19 April sowing. Seed yield decreased after 20 March sowing up to 19 April sowing. Seed yield was increased by 64.89% in 20 March sowing and 41.49% in 30 March sowing over 19 April sowing. Similar result was found by Ashtana and Narain (1977) and Paul *et al.* (1997); they reported that highest seed yield was obtained when sown on February-March and yields were decreased with delay in sowing date of sesame. The higher seed yield produced in 30 March sowing was mainly due to production of higher number of branches plant^{-1}, higher number of capsules plant^{-1} and maximum number of seeds capsule^{-1}. The lower yield in late sowing might be attributed to lower number of capsules plant^{-1} and seeds capsule^{-1}. Unfavourable temperature and rainfall specially heavy shower during crop growing period might be the reasons for lower yield (Appendix III).

4.11.2 Effect of population density

Population density showed significant impact on seed yield of sesame (Appendix V). Seed yield increased with the increasing population density (Fig. 8). The highest seed yield (1.54 t ha^{-1}) was observed in 666666 plants ha^{-1} which was statistically superior to 333333 plants ha^{-1} (1.34 t ha^{-1}) as well as 222222 plants ha^{-1} (1.14 t ha^{-1}). The lowest seed yield (0.94 t ha^{-1}) was found from 166666 plants ha^{-1}. Seed yield was increased by 63.83% in 666666 plants ha^{-1} and 42.55% in 333333 plants ha^{-1} over 166666 plants ha^{-1}. The increase in seed yield with increasing population density might be attributed to higher number of plants ha^{-1}. Similar result was obtained by Tomar *et al.* (1992) who reported increase in seed yield with an increase in population density. Majumder and Roy (1992) observed increased seed yields with the increasing plant population.

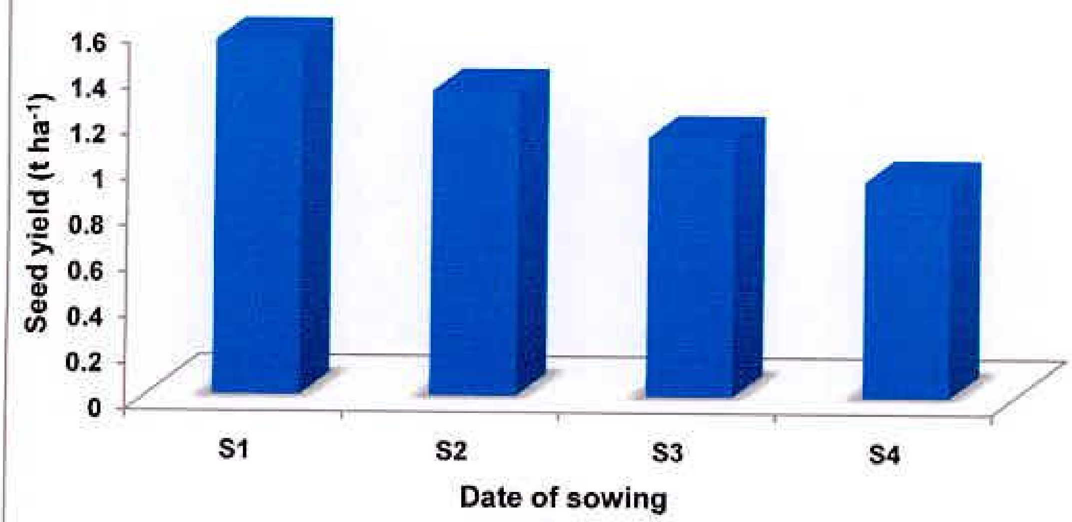

Figure 7. Effect of date of sowing on seed yield of sesame

S_1 = 20 March sowing S_3 = 9 April sowing
S_2 = 30 March sowing S_4 = 19 April sowing

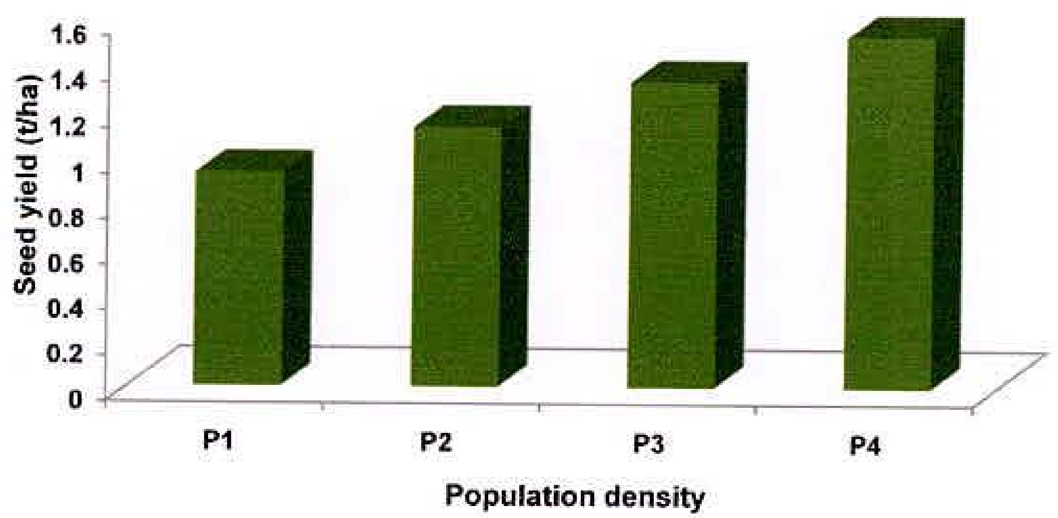

Figure 8. Effect of population density on seed yield of sesame

P_1 = 166666 plants ha^{-1} P_2 = 222222 plants ha^{-1}
P_3 = 333333 plants ha^{-1} P_4 = 666666 plants ha^{-1}

4.11.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in seed yield (Appendix V and Table 4). Seed yield was observed highest in combination with 20 March sowing and 666666 plants ha^{-1} (1.87 t ha^{-1}) followed by 20 March sowing and 333333 plants ha^{-1} (1.65 t ha^{-1}) which was statistically similar to 30 March sowing and 666666 plants ha^{-1} (1.63 t ha^{-1}), 20 March sowing and 222222 plants ha^{-1} (1.45 t ha^{-1}). Interaction of 19 April sowing along with 166666 plants ha^{-1} resulted the lowest seed yield (0.68 t ha^{-1}). Seed yield was increased by 175% in 20 March sowing × 666666 plants ha^{-1}, 142.65% in 20 March sowing × 333333 plants ha^{-1}, 139.71% in 30 March sowing × 666666 plants ha^{-1} and 113.24% in 20 March sowing × 222222 plants ha^{-1} over the lowest seed yield combination of 19 April sowing × 166666 plants ha^{-1}.

4.12 Seed/capsule wall ratio

4.12.1 Effect of date of sowing

The results showed that the seed/capsule wall ratio was significantly influenced by date of sowing (Appendix V and Table 1). The highest seed/capsule wall ratio (5.26) was observed from 20 March sowing which was statistically superior to 30 March sowing (4.89) as well as 9 April sowing (4.14). The lowest seed/capsule wall ratio (3.68) was recorded from 19 April sowing. It was found that the seed/capsule wall ratio decreased after 20 March sowing up to 19 April sowing. Seed/capsule wall ratio was increased by 42.93% in 20 March sowing and 32.88% in 30 March sowing over 19 April sowing. This phenomenon might be the better assimilate translocation from the source to the developing seeds.

4.12.2 Effect of population density

Seed/capsule wall ratio was significantly influenced by population density (Appendix V). Increases in population density gradually decreased the seed/capsule wall ratio (Table 2). The highest seed/capsule wall ratio (5.25) was observed in lowest population density (166666 plants ha^{-1}) which was statistically superior to 222222 plants ha^{-1} (4.70) as well as 333333 plants ha^{-1} (4.27). The lowest seed/capsule wall ratio (3.75) was observed in highest population density (666666 plants ha^{-1}).

Seed/capsule wall ratio was increased by 40% in 166666 plants ha^{-1} and 25.33% in 222222 plants ha^{-1} over 666666 plants ha^{-1}. This indicates that inter and intra plant competition due to high population density reduced the assimilate translocation towards developing seeds rather than capsule wall which ultimately resulted in a lower value of seed/capsule wall ratio.

4.12.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation on seed/capsule wall ratio (Appendix V and Table 4). Seed/capsule wall ratio was observed highest in combination with 20 March sowing and 166666 plants ha^{-1} (6.12) followed by 30 March sowing and 166666 plants ha^{-1} (5.61), 20 March sowing and 222222 plants ha^{-1} (5.55) and 30 March sowing and 222222 plants ha^{-1} (5.08). Interaction of 19 April sowing along with 666666 plants ha^{-1} resulted the lowest seed/capsule wall ratio (3.08). Seed/capsule wall ratio was increased by 98.70% in 20 March sowing × 166666 plants ha^{-1}, 82.14% in 30 March sowing × 166666 plants ha^{-1}, 80.19% in 20 March sowing × 222222 plants ha^{-1} and 68.94% in 20 March sowing × 222222 plants ha^{-1} over the lowest seed/capsule wall ratio combination of 19 April sowing × 666666 plants ha^{-1}.

4.13 Stover yield (t ha^{-1})

4.13.1 Effect of date of sowing

Date of sowing exerted a significant effect on stover yield (Appendix V and Fig. 9). The highest stover yield (4.41 t ha^{-1}) was obtained from 20 March sowing which was statistically superior to 30 March sowing (4.13 t ha^{-1}) as well as 9 April sowing (3.69 t ha^{-1}). The lowest stover yield (3.20 t ha^{-1}) was recorded from 19 April sowing. Stover yield significantly decreased after 20 March sowing up to 19 April sowing. Stover yield was increased by 37.81% in 20 March sowing and 29.06% in 30 March sowing over 19 April sowing. From the results it was observed that early sowing produced taller plants and more number of branches that resulted greater stover yields. This was again might be the production of maximum number of branches and increased vegetative growth of plant for favourable weather conditions. Similar result was also found by Suryavanshi *et al.* (1993) and Sarkar *et al.* (2007); they reported that delay in sowing reduced stover yield of sesame.

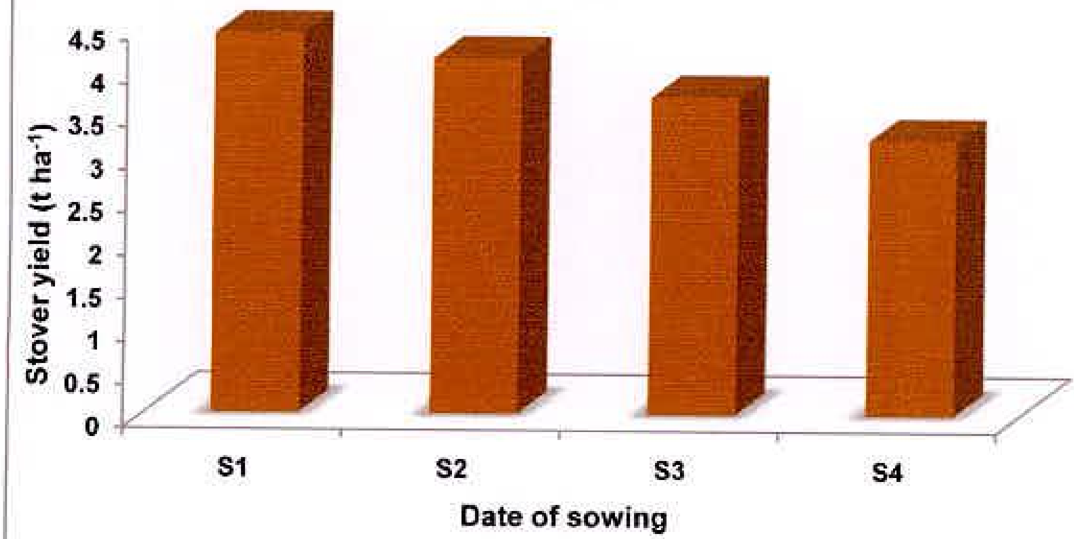

Figure 9. Effect of date of sowing on stover yield of sesame

S_1 = 20 March sowing S_3 = 9 April sowing
S_2 = 30 March sowing S_4 = 19 April sowing

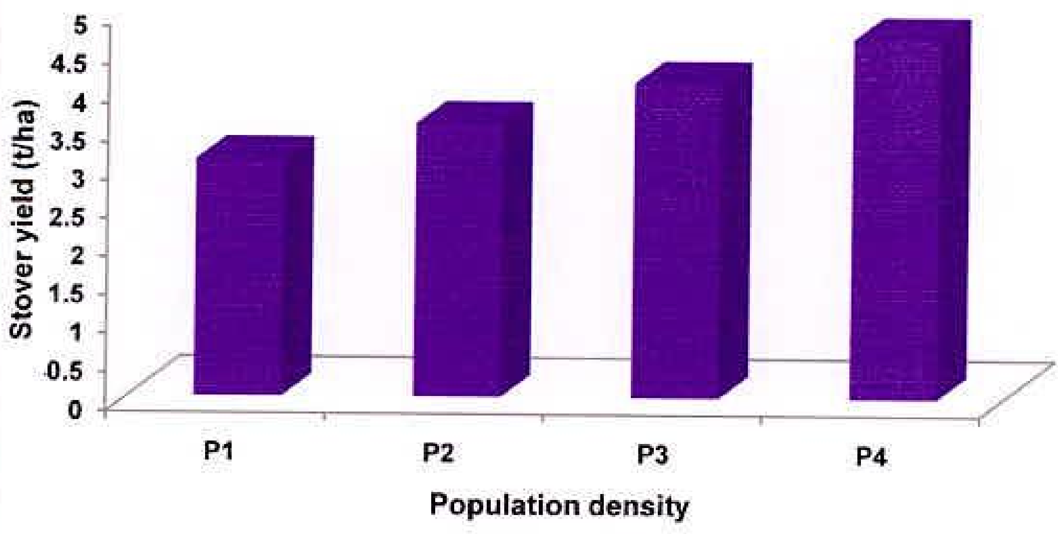

Figure 10. Effect of population density on stover yield of sesame

P_1 = 166666 plants ha^{-1} P_2 = 222222 plants ha^{-1}
P_3 = 333333 plants ha^{-1} P_4 = 666666 plants ha^{-1}

4.13.2 Effect of population density

Population density showed significant impact on stover yield of sesame (Appendix V). Stover yield increased with the increasing population density (Fig. 10). The highest stover yield (4.68 t ha^{-1}) was observed in 666666 plants ha^{-1} which was statistically superior to 333333 plants ha^{-1} (4.10 t ha^{-1}) as well as 222222 plants ha^{-1} (3.56 t ha^{-1}). The lowest stover yield (3.09 t ha^{-1}) was found from 166666 plants ha^{-1}. Stover yield was increased by 51.46% in 666666 plants ha^{-1} and 32.69% in 333333 plants ha^{-1} over 166666 plants ha^{-1}. The increase in stover yield with increasing population density might be attributed to higher number of plants ha^{-1}. Similar result was obtained by Tomar *et al.* (1992) who reported that increase in stover yield with an increase in population density.

4.13.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in stover yield (Appendix V and Table 4). Stover yield was observed highest in combination with 20 March sowing and 666666 plants ha^{-1} (5.27 t ha^{-1}) followed by 30 March sowing and 666666 plants ha^{-1} (5.01 t ha^{-1}), 20 March sowing and 333333 plants ha^{-1} (4.70 t ha^{-1}) and 9 April sowing along with 666666 plants ha^{-1} (4.59 t ha^{-1}). Interaction of 19 April sowing along with 166666 plants ha^{-1} resulted the lowest stover yield (2.66 t ha^{-1}). Stover yield was increased by 98.12% in 20 March sowing × 666666 plants ha^{-1}, 88.35% in 30 March sowing × 666666 plants ha^{-1}, 76.69% in 20 March sowing × 333333 plants ha^{-1} and 72.56% in 9 April sowing × 666666 plants ha^{-1} over the lowest stover yield combination of 19 April sowing × 166666 plants ha^{-1}.

4.14 Harvest index (%)

4.14.1 Effect of date of sowing

It was observed that the harvest index was significantly influenced by date of sowing (Appendix V and Table 1). The highest harvest index (26.04 %) was obtained from 20 March sowing which was statistically superior to 30 March sowing (24.61 %) as well as 9 April sowing (23.36 %). The lowest harvest index (22.42 %) was obtained from 19 April sowing. Harvest index decreased after 20 March sowing then up to 19 April sowing.

Harvest index was increased by 16.15% in 20 March sowing and 9.77% in 30 March sowing over 19 April sowing. Similar trend in harvest index of sesame was reported by Shubha (2006).

4.14.2 Effect of population density

The results showed that the harvest index was significantly influenced by population density of sesame (Appendix V). Harvest index increased with the increasing population density (Table 2). The highest harvest index (24.66 %) was observed in 666666 plants ha^{-1} which was statistically similar to 333333 plants ha^{-1} (24.53 %). The lowest harvest index (23.25 %) was recorded from 166666 plants ha^{-1}. Harvest index was increased by 6.06% in 666666 plants ha^{-1} and 5.51% in 333333 plants ha^{-1} over 166666 plants ha^{-1}. Similar results were observed by BINA (1993) who reported that the highest plant population produced the highest HI.

4.14.3 Interaction effect of date of sowing and population density

The interaction effect of date of sowing and population density showed significant variation in harvest index (Appendix V and Table 4). Harvest index was observed highest in combination with 20 March sowing and 666666 plants ha^{-1} (26.20 %) which was statistically similar to 20 March sowing and 222222 plants ha^{-1} (26.08 %), 20 March sowing and 333333 plants ha^{-1} (25.96 %), 20 March sowing with 166666 plants ha^{-1} (25.90 %) and 30 March sowing with 166666 plants ha^{-1} (25.13 %). Interaction of 19 April sowing along with 166666 plants ha^{-1} resulted the lowest harvest index (20.26 %). Harvest index was increased by 29.32% in 20 March sowing × 666666 plants ha^{-1}, 28.73% in 20 March sowing × 222222 plants ha^{-1}, 28.13% in 20 March sowing × 333333 plants ha^{-1} and 27.84% in 20 March sowing × 166666 plants ha^{-1} over the lowest harvest index combination of 19 April sowing × 166666 plants ha^{-1}.

Table 4. Interaction effect of date of sowing and population density on yield components of sesame

Interaction (Sowing date × Population density)	Filled seeds capsule^{-1} (no.)	Unfilled seeds capsule^{-1} (no.)	1000-seed weight (g)	Seed yield (t ha^{-1})	Seed/ capsule wall ratio	Stover yield (t ha^{-1})	Harvest index (%)
S_1P_1	75.31a	2.13h	3.60a	1.25d	6.12a	3.58i	25.90a
S_1P_2	72.23b	2.21gh	3.38b	1.45c	5.55c	4.10f	26.08a
S_1P_3	70.47c	2.30f-h	3.29bc	1.65b	4.95e	4.70c	25.96a
S_1P_4	69.08d	2.36e-g	3.20cd	1.87a	4.42g	5.27a	26.20a
S_2P_1	70.26c	1.50i	2.62g	1.03e	5.61b	3.23k	25.13ab
S_2P_2	68.57d	1.60i	2.59g	1.24d	5.08d	3.84h	24.41b
S_2P_3	66.76e	1.67i	2.62g	1.42c	4.71f	4.42e	24.35b
S_2P_4	65.49f	1.71i	2.63g	1.63b	4.15i	5.01b	24.55b
S_3P_1	67.47e	2.54de	3.23b-d	0.80f	4.93e	2.88m	21.71c
S_3P_2	64.18g	2.51d-f	3.01e	1.05e	4.43g	3.33j	23.90b
S_3P_3	61.73h	2.68d	3.02e	1.24d	3.86j	3.95g	23.96b
S_3P_4	60.64h	2.63d	3.13c-e	1.44c	3.33m	4.59d	23.89b
S_4P_1	60.80h	4.05a	3.08de	0.68g	4.35h	2.66n	20.26d
S_4P_2	58.61i	3.63b	3.04e	0.82f	3.74k	2.97l	21.57c
S_4P_3	58.52i	3.13c	3.03e	1.04e	3.56l	3.33j	23.88b
S_4P_4	54.97j	3.01c	2.83f	1.21d	3.08n	3.84h	23.98b
$S_{\bar{x}}$	0.3795	0.07303	0.05164	0.01826	0.01826	0.01826	0.4227
Level of significance	**	**	**	**	**	**	**
CV (%)	**1.01**	**5.17**	**2.92**	**1.99**	**0.76**	**0.72**	**3.04**

In a column figures with same letters or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT) at 5% level of significance.

S_1= 20 March sowing
S_2= 30 March sowing
S_3= 9 April sowing
S_4= 19 April sowing
P_1= 666666 plants ha^{-1}
P_2= 333333 plants ha^{-1}
P_3= 222222 plants ha^{-1}
P_4= 166666 plants ha^{-1}

CHAPTER 5
SUMMARY AND CONCLUSION

Chapter 5

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The field experiment was conducted at the Agronomy research field of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from March to July 2008 to evaluate the effect of date of sowing and population density on the performance of yield and yield contributing characters of sesame. The experiment comprised of two factors such as (1) four levels of date of sowing viz. S_1 (20 March sowing), S_2 (30 March sowing), S_3 (9 April sowing) and S_4 (19 April sowing) and (2) four levels of population density viz. P_1 (166666 plants ha^{-1}), P_2 (222222 plants ha^{-1}), P_3 (333333 plants ha^{-1}) and P_4 (666666 plants ha^{-1}). BARI Til 2 cultivar was used in the experiment as test material.

The experiment was set up in Randomized Complete Block Design (RCBD) (factorial) with three replications. There were 16 treatment combinations. Each unit plot size was 3.5m x 2.5m. The experimental plot was fertilized at the rate of 46 kg, 30 kg, 25 kg, 4.9 kg, 0.34 kg and 1.8 kg ha^{-1} N, P, K, S, B and Zn, respectively. The whole amount of P, K, S, B, Zn and 50% of N were incorporated at the time of final land preparation. The remaining N was applied top dressing at 20 days after sowing.

Harvesting was done in four different times as the crop matured. The first sown 12 plots were harvested first on 16 June 2008. The second sown 12 plots were harvested on 24 June 2008. The third sown 12 plots were harvested on 30 June 2008 and last sown 12 plots were harvested on 6 July 2008.

The data were recorded on plant height, branches $plant^{-1}$, capsules $branch^{-1}$, total capsules $plant^{-1}$, effective capsules $plant^{-1}$, non-effective capsules $plant^{-1}$, capsule length, filled seeds $capsule^{-1}$, unfilled seeds $capsule^{-1}$, 1000-seed weight, seed yield, stover yield and harvest index. All the data were recorded and analyzed by using MSTAT-C software. The mean differences among the treatments were compared by DMRT test at 5% level of significance.

The results showed that the effect of date of sowing, population density and their interaction were significant in respect of yield and yield contributing attributes of sesame viz. plant height, branches plant^{-1}, capsules branch^{-1}, total capsules plant^{-1}, effective capsules plant^{-1}, non-effective capsules plant^{-1}, capsule length, filled seeds capsule^{-1}, unfilled seeds capsule^{-1}, 1000-seed weight, seed yield, seed/capsule wall ratio, stover yield and harvest index.

The highest plant height (116.0 cm), branches plant^{-1} (4.63), capsules branches^{-1} (19.30), total capsules plant^{-1} (88.57), effective capsules plant^{-1} (82.68), capsule length (2.48 cm), filled seeds capsule^{-1} (71.77), 1000-seed weight (3.37 g), seed yield (1.55 t ha^{-1}), seed/capsule wall ratio (5.26), stover yield (4.41 t ha^{-1}), harvest index (26.04 %) and the lowest non-effective capsules plant^{-1} (2.56) was obtained from 20 March sowing. But the lowest unfilled seeds capsule^{-1} (1.62) was recorded from 30 March sowing.

Population density had significant effect on all the parameters studied except unfilled seeds capsule^{-1}. The highest plant height (114.2 cm), capsules branches^{-1} (20.29), capsule length (2.76 cm), seed yield (1.54 t ha^{-1}), stover yield (4.68 t ha^{-1}), harvest index (24.66 %) and the lowest unfilled seeds capsule^{-1} (2.43) was obtained from 666666 plants ha^{-1}. But the highest branches plant^{-1} (4.93), total capsules plant^{-1} (82.09), effective capsules plant^{-1} (78.25), filled seeds capsule^{-1} (68.46), 1000-seed weight (3.13 g), seed/capsule wall ratio (5.25) and the lowest non-effective capsules plant^{-1} (3.84) was observed from 166666 plants ha^{-1}.

The interaction of date of sowing and population density exerted its significant effect on all the parameters studied except total capsules plant^{-1}. The highest plant height (125.6 cm), capsules branches^{-1} (22.31), capsule length (3.09 cm), seed yield (1.87 t ha^{-1}), stover yield (5.27 t ha^{-1}), harvest index (26.20 %) and the lowest non-effective capsules plant^{-1} (1.57) was recorded from 20 March sowing x 666666 plants ha^{-1}.

But the highest branches plant^{-1} (5.50), total capsules plant^{-1} (95.07), effective capsules plant^{-1} (91.80), filled seeds capsule^{-1} (75.31), 1000-seed weight (3.60 g), seed/capsule wall ratio (6.12) was found from 20 March sowing × 166666 plants ha^{-1} and the lowest unfilled seeds capsule^{-1} (1.50) was obtained from 30 March sowing × 166666 plants ha^{-1}.

From the results of the present study, it may be concluded that 20 March sowing gave the highest seed yield and seed yield increases with increased level of population density i.e. 666666 plants ha^{-1} and their combination gave the highest yield. To arrive at a definite conclusion however, further investigation is needed.

CHAPTER 6
REFERENCES

Chapter 6

REFERENCES

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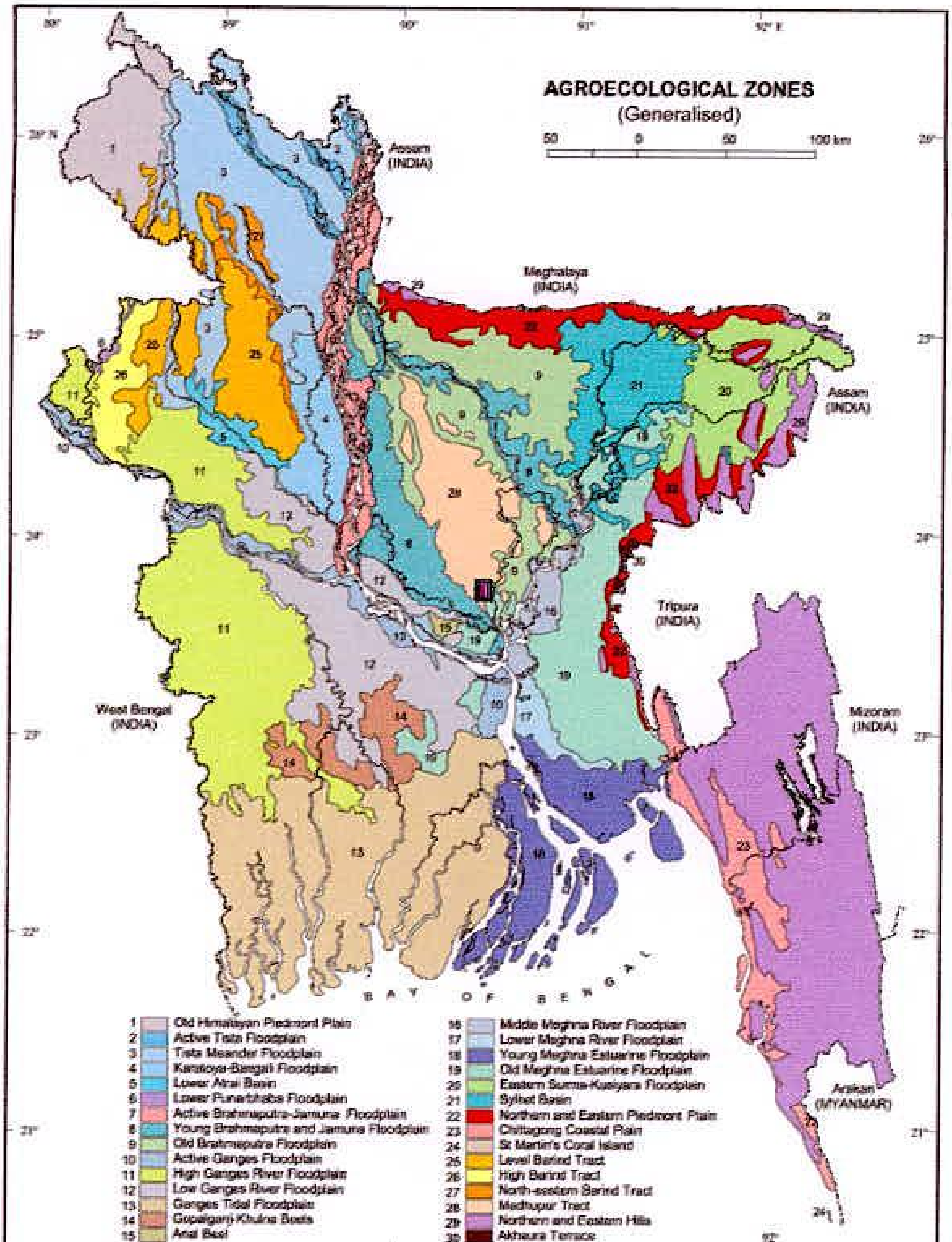
APPENDICES

APPENDICES

Appendix 1. Map showing the experimental site under study



The experimental site under study

Appendix II. The morphological characteristics, physical properties and chemical composition of soil of the experimental plot

A. Morphological characteristics of the soil

1.	Location	:	Agronomy Research field, SAU, Dhaka
2.	Soil tract	:	Madhupur Tract
3.	Land type	:	Medium high land
4.	General soil type	:	Red brown trace soils and acid basin clay
5.	Soil series	:	Nodda
6.	Agro-ecological zone	:	AEZ-28

B. Physical properties of the initial soil (0-15 cm depth)

	Constituents		Results
1.	Particle size analysis		
	i) Sand (2.00-0.02mm)	:	40%
	ii) Silt (0.02-0.002 mm)	:	40%
	iii) Clay (<0.002 mm)	:	20%
2.	Textural class	:	Sandy loam

C. Chemical composition of the initial soil (0-15 cm depth)

1.	pH	:	5.46 – 5.61
2.	Organic matter (%)	:	0.83
3.	Total N (ppm)	:	0.41
4.	Available P (ppm)	:	21
5.	Exchangeable K(me/100 g soil)	:	0.42
6.	Available S (ppm)	:	15.00
7.	Boron (ppm)	:	1.72
8.	Copper (μg/g soil)	:	3.56
9.	Iron (μg/g soil)	:	262.9
10.	Manganese (μg/g soil)	:	163.0
11.	Zinc (μg/g soil)	:	3.31

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

Appendix III. Monthly average air temperature, average relative humidity, total rainfall and total sunshine hours during the experimental period (March to July, 2008) at the experimental area (Sher-e-Bangla Agricultural University campus).

Month	Year	Monthly average air temperature (^{0}C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
March	2008	34.6	16.5	26.6	67	45	5.9
April	2008	36.9	19.6	29.2	64	91	8.5
May	2008	36.7	20.3	29.3	70	205	7.7
June	2008	35.4	22.5	28.7	80	577	4.2
July	2008	36.0	24.6	28.5	83	563	3.1

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

Appendix IV. Summary of analysis of variance (mean square) on yield contributing characters of sesame

Source of variance	Degrees of freedom	Mean squares value						
		Plant height (cm)	Branches plant^{-1} (no.)	Capsules branch^{-1} (no.)	Total capsules plant^{-1} (no.)	Effective capsules plant^{-1} (no.)	Non-effective capsules plant^{-1} (no.)	Capsule length (cm)
Replication	2	1.138	0.008	0.068	6.797	37.889	0.014	0.000
Date of sowing (S)	3	738.219**	1.061**	14.534**	1150.036**	1271.949**	40.175**	0.362**
Population density (P)	3	522.984**	3.529**	33.028**	119.532**	254.222**	1.255**	0.117**
S × P	9	9.111**	0.039**	0.762**	10.349 ^{NS}	22.879**	8.228**	0.012**
Error	30	0.794	0.012	0.101	5.980	29.642	0.053	0.001
CV (%)		**0.84**	**2.59**	**1.75**	**3.15**	**7.49**	**5.64**	**0.98**

** Significant at 1% level of probability
* Significant at 5% level of probability
NS = Non significant

Appendix V. Summary of analysis of variance (mean square) on yield components of sesame

Source of variance	Degrees of freedom	Mean squares value						
		Filled seeds capsule^{-1} (no.)	Unfilled seeds capsule^{-1} (no.)	1000-seed weight (g)	Seed yield (t ha^{-1})	Seed/ capsule wall ratio	Stover yield (t ha^{-1})	Harvest index (%)
Replication	2	1.662	0.021	0.003	0.000	0.001	0.000	0.092
Date of sowing (S)	3	405.068**	7.034**	1.172**	0.839**	6.110**	3.352**	29.464**
Population density (P)	3	75.122**	0.037 ^{NS}	0.078**	0.799**	4.911**	5.634**	4.917**
S × P	9	1.515**	0.242**	0.028**	0.002*	0.036**	0.049**	3.034**
Error	30	0.432	0.016	0.008	0.001	0.001	0.001	0.536
CV (%)		**1.01**	**5.17**	**2.92**	**1.99**	**0.76**	**0.72**	**3.04**

** Significant at 1% level of probability
* Significant at 5% level of probability
NS = Non significant