EFFECT OF PLANT SPACING AND NITROGEN ON THE GROWTH AND YIELD OF OKRA

BY

MD. NURE NAJMUL HUDA
Reg. No. 00967

A Thesis
Submitted to the Department of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University, Dhaka,
In partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE, 2008

APPROVED BY:

Prof. M. A. Mannan Miah
Dept. of Horticulture and Postharvest technology
Sher-e-Bangla Agricultural University, Dhaka
Supervisor

Prof. Md. Ruhul Amin
Dept. of Horticulture and Postharvest technology
Sher-e-Bangla Agricultural University, Dhaka
Co-Supervisor

Prof. Md. Ruhul Amin
Chairman
Examination Committee

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

PABX: +88029144270-9
Fax: +88029112649

Ref:

Date: 30.06.08

CERTIFICATE

*This is to certify that the thesis entitled, "**Effect of Plant Spacing and Nitrogen on the Growth and Yield of Okra**" submitted to the Department of **Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka,** impartial of the fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the results of a piece of bona fide research work carried out by **Md. Nure Najmul Huda, Roll No. 130, Registration no. 00967,** 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, received during the course of this investigation has been duly acknowledged.

Dated: 30 June 2008
Dhaka, Bangladesh

(Prof. M. A. Mannan Miah)
Dept. of Horticulture & Postharvest Technology
Sher-e-Bangla Agricultural University,
Dhaka-1207.
Supervisor

DEDICATED TO MY

BELOVED PARENTS

&

DEPARTED GRANDPARENTS

ACKNOWLEDGEMENTS

At first, the author gratefully expresses his sincere gratitude to almighty Allah, who kindly enabled him to complete this research work and preparation of this thesis.

The author would like to express his heartfelt respect and deepest sense of gratitude to his honorable Supervisor, Professor M. A. Mannan Miah, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his guidance, encouragement, valuable suggestions and kind advice during the research work and preparation of the thesis.

The author feels proud to express his sincere appreciation and profound respect to Professor Md. Ruhul Amin, Co-supervisor and Chairman, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his valuable and helpful suggestions during the research work and co-operation in preparing the thesis.

The author also likes to record special word of gratefulness to Professor A. K. M. Mahtab Uddin, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka.

The author takes an opportunity to express his cordial thanks and sincere gratitude to all the respectable teachers and staff of the Department of Horticulture and Postharvest Technology of Sher-e-Bangla Agricultural University, Dhaka.

Finally, his sincere and deepest appreciation to Pintu vai, Hashi vabi, Nehal babu, Lucky apu, Forhan vai, Parom babu and his friends Jahangir, Miru, Iqbal, Rokib and Rashed vai who inspired best of their prayer, great sacrifice, all time encouragement and blessings in carrying out the higher study.

The Author

EFFECT OF PLANT SPACING AND NITROGEN ON THE GROWTH AND YIELD OF OKRA

By

MD. NURE NAJMUL HUDA

ABSTRACT

An experiment was conducted to study the effect of plant spacing and nitrogen on the growth and yield of okra at the central farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to July 2007. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. This experiment was conducted with two factors; Factor A: Spacing (3 levels) i.e. S_1=75 cm x 20 cm, S_2=75 cm x 40 cm, S_3=75 cm x 60 cm and Factor B: Nitrogen (4 levels) i.e. N_0=control, N_1=50 kg N/ha, N_2=100 kg N/ha, N_3=150 kg N/ha. In case of plant spacing, the highest yield (8.20 t/ha) was recorded from the spacing S_2 and the lowest yield (6.84 t/ha) was from S_1. In case of nitrogen, the highest yield (8.25 t/ha) was obtained from N_3 and the lowest yield (5.72 t/ha) was from N_0. For combined effect, the highest yield (9.86 t/ha) was observed from the treatment combination of S_2N_3 which was similar (9.85 t/ha) to S_2N_2. Though the highest yield was recorded from S_2N_3 but on the basis of benefit cost ratio (BCR), the best (2.53) outcome was obtained from the treatment combination of S_2N_2. It may be concluded that 75cm x 40 cm spacing with 100 kg N/ha is the best for growth and yield of okra.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

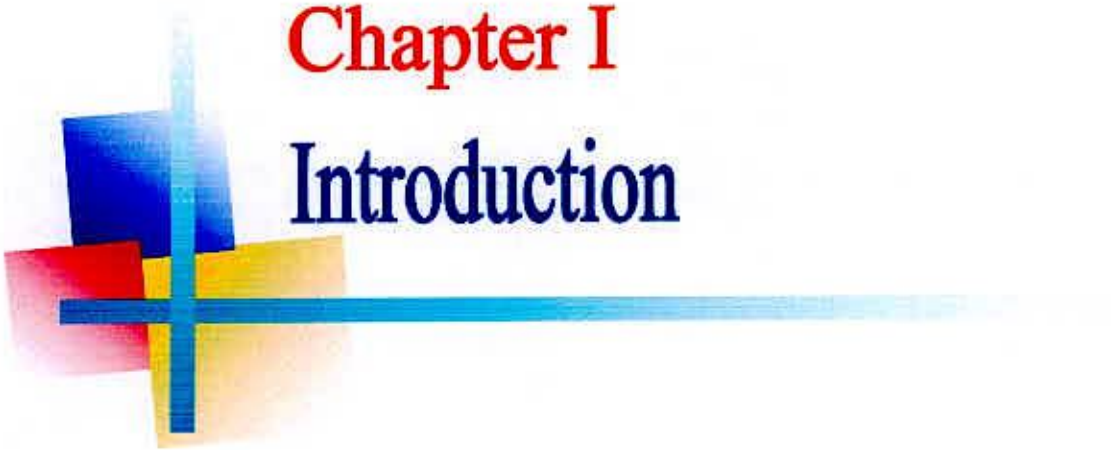
LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

Agril.	=	Agriculture
@	=	At the rate of
^{0}C	=	Degree Celsius
AEZ	=	Agroecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
BCR	=	Benefit cost ratio
CEC	=	Cation Exchange Capacity
cm	=	Centimeter
CPE	=	Cumulative Pan Evaporation
cv.	=	Cultivar
DAS	=	Days after sowing
Dept.	=	Department
DMRT	=	Duncan's Multiple Range Test
EC	=	Emulsifiable Concentrate
et al.	=	And others
Fig.	=	Figure
FYM	=	Farm Yard Manure
g	=	Gram
ha	=	Hectare
HI	=	Harvest Index
Hort.	=	Horticulture
i.e.	=	That is
J.	=	Journal
K	=	Potassium
Kg	=	Kilogram
L	=	Litre
LAD	=	Leaf Area Duration
LAI	=	Leaf Area Index
LSD	=	Least Significant Difference
mg	=	Milligram
ml	=	Milliliter
MP	=	Muriate of Potash
N	=	Nitrogen
NS	=	Non-Significant
P	=	Phosphorous
PM	=	Poultry Manure
ppm	=	Parts per million
RCBD	=	Randomized Complete Block Design
Res.	=	Research
S.	=	Soil
Sci.	=	Science
SRDI	=	Soil Sources and Development Institute
t/ha	=	Ton per hectare
TSP	=	Triple Super Phosphate
VC	=	Vermicompost
Viz.	=	Namely



Chapter I

Introduction

CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop in Bangladesh belongs to the Malvaceae family and it also known as Lady's finger. Locally it is known as 'Derosh' or 'Bhendi'. It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the World (Thakur and Arora, 1986). It grows year round in our country but commercially cultivated mainly in summer.

The popularity of okra is increasing day by day in our country because it is a nutritious and delicious vegetable, fairly rich in vitamins and minerals (Rashid, 1976). 100g edible portion of pod contains vitamin A 0.01mg, vitamin C 18mg, Calcium 90mg, Thiamine 0.07mg, Riboflavin 0.08mg and Niacin 0.08mg which are higher than that of many vegetables (Rashid, 1990). The pods also have some medicinal value and mucilaginous preparation from the pod can be used as a plasma replacement or blood volume expander.

In Bangladesh, vegetable production and supply is not uniform through the year round. It is abundant in winter but scanty in summer. Successful okra production may contribute partially in solving vegetable scarcity of summer season. The total vegetable production around 30% is produced during Kharif season and 70% is produced in Rabi season (Anon, 1993). So as a vegetable, okra can get an important in summer production. Total production of okra is about 24000 metric tons produced from 7287.50 hectare of land in the year 2005 and the average yield is about 3.29 t/ha (BBS, February-2005) which is very low compared to that of other developed countries where the yield is as high as 7.0-12.0 t/ha (Yamaguchi, 1998). Because of less production and unequal supply of vegetable, the present consumption is only about 50g/day/person; with potato and sweet potato, it is 70g/day/person which was the lowest among the countries of South Asia and South-East Asia (Rekhi, 1997). But the daily requirement was 285g of

vegetable for an adult person (Ramphal and Gill, 1990). Therefore, there is a big gap between the requirements and supply of vegetables in Bangladesh.

Successful production of okra depends on various factors. Among of these, controlling standard plant spacing and use of proper doses of fertilizer specially nitrogen fertilizer is the most important factor for quality green pod production of okra.

Adjustment of proper plant spacing in the okra field is important to ensure the maximum utilization of solar energy by the crop and reduce evaporation of soil moisture. Nutrient availability in the soil also depends on plant spacing. So, optimum plant spacing should be maintained to exploit the maximum natural resources such as nutrients, sunlight, soil moisture etc. and to ensure satisfactory yield. Plant spacing also directly affect the quality, proper growth of the plant, the pods as are desired as well as yield (Singh and Kanwar, 1995).

Nitrogen is the key element to the vegetative growth of plants. It plays an important role to build up of protoplasm and protein which induce cell division and initiate meristematic activities when applied optimum quantity. Majanbu *et al.* (1985) reported that nitrogen application significantly increased pod weight, pod diameter, number of pods per plant and number of seeds per pod in okra.

Considering the above mentioned facts and based on the prior observation, an investigation was undertaken to find out the standard plant spacing and optimum dose of nitrogen on the growth and yield of okra:

1. to determine the appropriate plant spacing for the growth and yield of okra.
2. to determine the optimum levels of nitrogen for the growth and yield of okra.
3. to determine the combined effect of plant spacing and nitrogen levels which would be the best for the growth and yield of okra.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

In Bangladesh, okra is a very important vegetable crop. Its growth and yield are greatly influenced by plant spacing and different levels of nitrogen. Appropriate doses of these are related to the best growth and yield of okra. But very little studies have been done on this crop under the agroecological condition of Bangladesh particularly in respect of plant spacing and different levels of nitrogen. A brief review of the relevant information available in the literature pertaining to the study is discussed below.

Bajpai *et al.* (2004) carried out an experiment with okra cv. Parbhani Kranti in Kanpur, India, consisting of three spacing i.e. 20cm x 15cm (S_1), 30cm x 15cm (S_2) and 45cm x 15 cm (S_3) and three sowing dates i.e. 5 February (D_1), 20 February (D_2) and 5 March (D_3). Plant populations per plot, number of leaves per plant, plant height, plant diameter, flowering date, fruiting date, number of fruits per plant, pod length, pod diameter data were recorded. The plant population and growth were highest in S_2D_2 treatment.

Yadav *et al.* (2004) conducted an experiment during kharif 2001 at Jobner, India to study the effects of different levels of organic manures and N fertilizer (urea) on the growth and yield of okra cv. Varsha Upahar. The treats consisted of 100% recommended dose of N, 75% N as urea + 25% N as Farm Yard Manure (FYM), Poultry Manure (PM) or Vermicompost (VC), 50% N as urea + 50% N as FYM, PM or VC, 25% N as urea + 75% N as FYM, PM or VC and 100% N as VC. The treatment involving 50% N as urea + 50% N as FYM, PM or VC recorded the highest yield (90.61 q/ha).

Effect of row spacing on growth and yield of okra was studied by Leghari *et al.* (2003) on clay loam soil at Latif Experimental Farm, Sindh Agriculture University, Tandojam Pakistan. The results exhibited that all the yield

components and yields were significantly affected by plant spacing. Number of pods and pod yield per plant also revealed significant response to row spacing only. Results also demonstrated that plants grown at 30 cm plant spacing with 50 cm row spacing produced taller plants and maximum branches. Maximum pods and pod yield/plant were produced by 50 cm inter spacing with 60 cm intra spacing. But higher pod yield per unit area was recorded under lowest inter and intra row spacing i.e. 30 cm plant to plant and 50 cm row to row spacing under agro- climatic conditions of Tandojam.

A study was undertaken by Shanke *et al.* (2003) during summer 1998 to assess the seed yield potential and other growth characters of okra cv. Parbhani Kranti under 5 levels of N (0, 50, 75, 100 and 125 kg/ha) and 4 levels of P (0, 25, 50 and 75 kg/ha) with agroclimatic conditions of Akola, Maharashtra, India. There was a linear increase in plant height with the application of N and P. The tallest plant (68.88 cm) was recorded under 125 kg N/ha and the shortest (54.90 cm) under no N. A similar trend was observed in respect of P application. The interaction effect between N and P was found to be significant, indicating maximum plant height with higher N and P levels. The number of fruits per plant increased significantly with an increase in N level. The highest number of fruits (5.78) was observed with 125 kg N/ha. Full fruit length and weight were also found highest (15.61 and 19.6 cm, respectively) in this treatment. The effect of application of P was also observed significant for fruit length, fruit number per plant and fruit weight, the highest values for these parameters being recorded at 75 kg P/ha. The maximum seed yield per plot (0.330 kg) was observed with the highest levels of N and P.

Gowda *et al.* (2002) was conducted a study in the summer season in 1999 in Bangalore, Karnataka, India to investigate the effects of different fertilizer levels (N:P:K at 125: 75: 60, 150:100:75 and 175:125: 100 kg/ha) on okra cultivars Arka Anamika, Varsha and Vishal. Dry matter accumulation and nutrient (N, P and K) accumulation increased with increasing fertilizer levels.

The highest fertilizer level resulted in the highest nutrient uptake. Varsha showed the highest nutrient uptake and accumulation in leaves and fruits at the highest level of fertilizer.

An experiment was conducted by Jalal-ud-Din *et al.* (2002) to observe Effect of different doses of nitrogen on the growth and yield of okra (*Abelmoschus esculentus* L.) under the agro-climatic conditions of Dera Ismail Khan in Pakistan. They used five different nitrogen doses viz. 50, 100, 150, 200 and 250 kg/ha along with a control (no nitrogen) treatment were kept in the study. All the parameters studied were significantly affected by different nitrogen levels. However, 150 Kg N/kg gave the best results. Minimum number of days for germination, flowering and fruit setting was also observed in the plots received nitrogen at the rate of 150 kg/ha. Maximum yield of pods (13.39 t/ha) was obtained from this level. Different parameters like plant height, pod length, pods per plant and weight of pods showed a favorable behavior under 150 kg N/ha, but above this particular dose, decline in the data of all the observations were noted. The control plots revealed the poorest findings compared to other treatments.

Field studies were conducted by Sajjan *et al.* (2002) in Bagalkot, Karnataka, India, to elucidate the effect of sowing date (15 June, 15 July (kharif), 15 November and 15 December (rabi)), spacing (60 x 20, 60 x 30 and 60 x 40 cm) and nitrogen rates (100, 125 and 150 kg/ha) on the yield attributes and seed yield of okra cv. Arka Anamika during the 1998 kharif season and 1998-99 rabi season. Sowing on 15 July coupled with 60 x 30 cm spacing and 150 kg N/ha recorded the highest yield attributes of branches per plant, fruits per plant, 100-seed weight, length and girth of fruits, processed seed recovery and processed yield (1139.7 kg/ha) in the kharif season. However, for the 15 November sowing, with the same spacing (60 x 30 cm) and nitrogen rate (150 kg N/ha), the highest seed yield of 745.3 kg/ha was recorded.

An experiment was conducted by Patton *et al.* (2002) to study the effect of different levels of nitrogen and phosphorus on growth, flowering and yield of okra cv. Arka Anamika grown under the foothills of Nagaland. Three doses of N (50, 100, and 150 kg/ha) and P (0, 60, and 90 kg/ha) were used. P as single superphosphate was applied along with half of the N (urea) rate during sowing. The remaining N was applied at 30 days after sowing. N at 150 kg/ha and P at 90 kg/ha gave the highest plant height (159.15 and 137.37 cm) and number of leaves per plant (24.98 and 23.57), the longest flowering duration (86.19 and 84.77 days), and the lowest number of days to flowering (40.93 and 41.48 days after sowing). N at 100 and 150 kg/ha resulted in the longest pods (15.81 and 16.72 cm) and the highest pod diameter (1.81 and 1.82), pod weight (19.74 and 20.19 g), pod number per plant (13.88 and 14.53), and pod yield per plant (274.14 and 293.75 g). P at 60 and 90 kg/ha recorded the highest pod length (15.06 and 15.27 cm), pod diameter (1.75 and 1.77 cm), seed number per pod (50.00 and 49.87), pod weight (18.75 and 18.63 g), and pod yield (248.35 and 252.00 g). In general, the interaction between N and P rates was not significant.

Amjad *et al.* (2001) conducted field experiment in Faisalabad, Pakistan with okra cultivar Sabz pari grown at the rate of 15, 30 or 45 cm; with a distance between rows of 60 cm. Phosphorous was applied at 0.33 or 66 kg/ha at the time of sowing. Phosphorous did not have any significant effect on days to first flowering and plant height at flowering, while these parameters were significantly affected by the planting geometry. Plants spaced at 30 and 45 cm took significantly lesser number of days to flower than those planted at 15 cm. However, plant height was maximum at 15 cm spacing, green pod length was maximum at plant spacing 45 cm. Number of green pods per plant and average weight per green pod were significantly affected by plant spacing. Both were highest with the widest spacing of 45 cm.

Gowda *et al.* (2001) was conducted a field experiment in Bangalore, karnataka, India during the 1999 summer season to determinate the response of okra

cultivars Arka Anamika, Varsha and Vishal to 3 NPK fertilizer rates (125:75:60 kg/ha, 150:100:75 kg/ha and 175:125:100 kg/ha). The highest dry matter production in leaves (20.40g), stems (35.17g), roots (18.03g), fruits (31.11g) and whole plants (104.71 g) were recorded with 175:125:100 kg NPK/ha treatments. Varsha recorded significantly higher dry matter production in leaves (17.48g), stems (31.44g), roots (17.61g), fruits (29.98g) and whole plants (96.51 g) compared with the other cultivars. In the interaction effect, the highest total dry matter production (1111.48 g/plant) was recorded in Varsha supplemented with 175:125:100 kg NPK/ha, which was at per with Arka Anamika supplemented with 175:125:100 kg NPK/ha. Comparative data on the effect of varying fertilizer rates, cultivars and their interaction on the length, diameter and yield of fruits are tabulated.

Rani *et al.* (1999) was conducted a field experiment in Bapatla, Andra Pradesh, India, during 20 March – 8 July 1997 studied the growth and development of 3 okra cultivars (Parbhani Kranti, Arka Anamika and Pusa Sawani) in response to 4 fertilizer levels (0-0-0, 50-25-25,100-50-50 and 150-75-75 kg N, P_2O_5 and K_2O/ha respectively). Results showed that leaf area, leaf area index (LAI) and leaf area duration (LAD) were significantly influenced at all stages by cultivars, fertilizer levels and their interaction effects. Among the cultivars, Pusa Sawani showed the maximum leaf area, LAI and LAD. However, Arka Anamika showed significantly superior performance with respect to plant height, number of leaves, number of nodes and yield per plant. The highest fertilizer level resulted in maximum leaf area, LAI and LAD, which gradually increased up to 60 days after sowing (DAS). Dry matter increased between stages and was influenced significantly by cultivars, fertilizer levels and their combinations. Crop growth (CGR) and relative growth rates were influenced by cultivars and fertilizers. Pusa Sawani supplied with the highest fertilizer level recorded the maximum CGR 60 DAS. Net assimilation rate (NAR) declined 60 DAS. Harvest index (HI) was also influenced by cultivars and fertilizer levels and their interactions. Arka Anamika, with a moderate vegetable growth and high

NAR, bad the highest HI values. Among the fertilizer levels, maximum HI was recorded by 100-50-50 kg NPK/ha.

Rain and Lal (1999) were conducted a field experiment in Bapalta, Andhra Pradesh, India, during 20 March – 8 July 1997 studied the growth and development of okra cultivars (Parbhani Kranti, Arka Anamika and Pusa Sawani) in response to 4 fertilizer levels (0-0-0, 50-25-25, 100-50-50 and 150-75-75 kg N, P_2O_5 and K_2O respectively). Results showed that leaf area, leaf area index (LAI) and leaf area duration (LAD) were significantly influenced at all stages by cultivars, fertilizer levels and their interaction effects.

In field trials in 1989-91 was conducted by Saimbhi *et al.* (1997) at Ludhiana and Jalandhar, India, to study the effect of plant spacing on fruit yield in okra. They were grown plants of okra cv. Punjab-7 in spring at 45 X 25, 45 X 20 or 45 X 15 cm on the flat or on ridges, while in the rainy season plants were grown on the flat at 3 row spacing (30, 45 or 60 cm) and 2 plant spacing (15 or 30 cm). Fruit yield increased as plant spacing decreased in both spring and rainy seasons. The highest fruit yields in spring (45 X 15 cm) and rainy season (30 X 15 and 45 X 15 cm) seasons were significantly higher than those at the recommended row and plant spacing (45 X 25 and 60 X 30 cm in spring and rainy seasons, respectively. The 45 X 15 cm spacing was considered most suitable for okra cultivation in both spring and rainy seasons, as a closer row spacing of 30 cm in the rainy season would make fruit picking difficult.

Kurup *et al.* (1997) reported that N rate up to 100 kg could increase the setting percentage, length and diameter of fruits, fruit number and weight per plant and the total pod yield of okra cv. Kiron.

An experiment was conducted by Somkuwar *et al.* (1997) in India to determine the effect of 3 levels of nitrogen (25, 50 and 75 kg/ha) on the growth of okra varieties Punjab 7, Parbhani Kranti and Sel 2-2. The results showed that fruit

yield per plant and yield per ha were increased with an increase in nitrogen concentration. Parbhani Kranti produced the highest fruit yield (171.11 kg) per plant and yield per ha (7770 kg) at 75 kg N/ha.

An experiment was conducted by Raghav (1996) to study influence of dates of sowing and plant spacing on the growth and yield of okra. In this study 4 sowing dates (21 Feb. or 1, 11 or 21 Mar.) and 3 plant spacing (15 X 30, 30 X 30 or 45 X 30 cm) on the growth and yield of okra cv. Pusa Sawani were investigated. Results from the 1992 and 1993 seasons were pooled. Plant height was greatest with sowing on 1 March and at the closest spacing. Green pod yield was highest with sowing on 1 March (5.73 t/ha) and at the widest spacing (4.76 t/ha).

An experiment was conducted by Birbal *et al.* (1995) to study the Effect of spacing and nitrogen on fruit yield of okra (*Abelmoschus esculentus* L. Moench.) cv. Varsha Uphar. Seeds of okra cv. Varsha Uphar were sown on a sandy loam soil at 30 X 30, 45 X 30, 45 X 45, 60 X 20 or 60 X 30 cm, with N applied at 0, 50, 100 or 150 kg/ha. The tallest plants (109.2 cm) were obtained with spacing at 30 X 30 cm. The number of branches/plant (2.5) was highest at 45 X 45 cm. Application of N at 100 and 150 kg/ha resulted in taller plants and more branches/plant than that at 0 and 50 kg/ha. Spacing did not affect the number of days to 50% flowering, but N at 100 and 150 kg/ha delayed it by 4.5 and 6.0 days, respectively, compared with no N. Number of fruits/plant, individual fruit weight and yield/plant were highest with 45 X 45 cm and 60 X 30 cm; these parameters were also increased by N at 100 kg/ha. Yield per hectare was highest (13.89 t/ha) with spacing at 60 X 20 cm; 45 X 30 cm gave a similar yield.

An experiment was conducted by Singh (1995) to study effect of various doses of nitrogen on seed yield and quality of okra (*Abelmoschus esculentus* L Moench). This trial was conducted during the kharif season in 1992 and 1993

and the plots of okra received 6 levels of nitrogen i.e., 0, 30, 60, 90, 120 or 150 kg/ha, with half applied before sowing and the rest applied 30 days after sowing. Plant height increased with increasing rate of N. Application of N at 90-150 kg/ha gave the highest number of pods/plant (12.7-14.0), pod length (16.7-17.6 cm), seed yield (17.5-19.0 q/ha) and 1000-seed weight (67.2-68.7 g). Seed germination rate was not affected by fertilizer application.

Arora *et al.* (1991) compared growth and yield of new okra cultivar, Punjab Padmini, with that of cv. Pusa Sawani grown under variable N (0, 30, 60 and 90 kg/ha) and P (0, 30 and 60kg/ha) fertilizer applications. They stated that plant height, number of fruits, fruit size and total green fruit yield were significantly increased by the application of 90 kg N/ha and 60 kg P_2O_5/ha.

Singh (1990) conducted an experiment to study the effect of spacing on okra. Okra seeds were sown at 40 x 20 cm, 40 x 30 cm, 50 x 20 cm, 50 x 30 cm, 40 x 40 cm and 50 x 40 cm spacing. He reported that the highest fruit yield (6037 kg/ha) with the closest spacing (40 x 20 cm) but the maximum fruit weight (35.58 g) and fruit length (19.06 cm) were recorded with the widest spacing (50 x 40 cm). In another experiment seeds of the okra cv. Pusa Sawani and Sel-2-2 were sown in early June, October and January to produce autumn, winter and summer crops respectively. The seeds were sown at 30 x 5 cm, 30 x 10 cm, 30 x 15 cm and 30 x 20 cm. The highest pod yield was obtained with the closest spacing and in the summer season (1.85 t/ha). The treatment had no appreciable effect on pod quality (Gadakh *et al.* 1990).

In a 2 year trails with the okra cv. Pusa Sawani in India Pandey and Singh (1989) found that seed yield (over 11q/ha) was the highest with plants spaced at 45 x 15 cm, receiving 100 kg N/ha and irrigated at 60 mm cumulative pan evaporation (CPE).

Lenka *et al.* (1989) invested a field trial with three replicates with N (as urea) applied at 4 levels (0, 50, 75 and 100 kg/ha), P_2O_5 at 2 levels (30 and 60 kg/ha) and K_2O at a constant 40 kg/ha. They stated that N and P significantly increased plant height, yield and yield attributes. Application of 100 kg N/ha and 30 kg P_2O_5/ha gave a satisfactory seed yield (7.60 q/ha).

Mondal *et al.* (1989) conducted an experiment to investigate the effect of dates and inter row spacing on the growth and yield of okra cv. Pusa Sawani. They obtained the highest number of fruits per plant and fruit yield per unit area when seeds were sown on 20 April. The closest spacing resulted in the lowest number of fruit and quality of fruit per plant but the highest fruit yield per hectare. The highest level of NPK and closer spacing gave the maximum yield of okra and number of fruits per plant increased with the increase of fertilizer levels and spacing (Abdul and Araf, 1986).

In an experiment Saha *et al.* (1989) studied the effect of plant spacing 80 x 10 cm, 80 x 20 cm and 80 x 40cm and picking interval (1, 3 and 5days) on the growth and yield of okra cv. Pusa Sawani at the Horticulture farm of Bangladesh Agricultural University, Mymensingh. The fresh weight of plant and number and weight of fruits per plant increased significantly with an increase in plant spacing. However, the yield per hectare decreased with the increasing plant spacing. The highest yield was obtained at spacing of 80 x 10 cm (7.15 t/ha) while the minimum yield recorded from wide spacing of 80 x 40cm (3.23 t/ha). Picking interval had no effect on the yield per hectare, but the fruit length was influenced significantly. Longer fruits (12.31 cm) were obtained at five days picking interval and a minimum length (9.39 cm) was obtained by picking interval on the yield and other yield components.

Khan and Jaiswal (1988) found significant effect on seed yield per hectare due to spacing, nitrogenous fertilizer and fruit pickings. They obtained the highest

seed yield (833-902 kg/ha) at close spacing (30 x 15 cm) with the highest amount of nitrogen (150 kg/ha) and edible pods picked twice.

Singh *et al.* (1988) investigated the effect of sowing dates and spacing on the yield and quality of okra seed. Four sowing dates (20 June to 4 August) and plant spacing were compared. The maximum seed yield was obtained when the crop was grown at 45 x 30 cm and sown on June 20 (1844.12 kg/ha).

Rasgoti *et al.* (1987) conducted a trial for 3 years with the Sel. 6-2, planted at 45 x 40 cm, 60 x 40 cm and 75 x 40 cm spacing treated with at 45, 60 and 75 kg N/ha. They recorded the highest seed yield at 60 x 40 cm spacing receiving 60 kg N/ha (1184 kg/ha). They also found no appreciable effect on 1000 seed weight and germination percentage at different spacing.

In trails with okra CV. Pusa Sawani, N and K_2O were each applied at 0-120 kg/ha (Misra and Pandey, 1987). N at 80 kg/ha and K_2O at 40 kg/ha significantly increased the number of fruits/plant, 1000 seed weight and the seed yield. Application of N above 80 kg/ha and K_2O above 40 kg/ha adversely affected seed yield. Interaction effect was significant with 80 kg/ha N and 40 kg K_2O/ha giving the highest seed yield of 15.47 q/ha.

Majanbu *et al.* (1986) stated that the growth response and nutrient concentration in okra as influenced by four nitrogen rates (0, 25, 50 and 100 kg/ha) and three phosphorus rates (0, 13 and 26 kg/ha) were examined using two varieties (white Velvet and NHAE 47-4). They found that nitrogen application generally increased pod and shoot dry weights markedly. Leaf and primary branch production and plant height were also enhanced by nitrogen fertilization up to 100 kg/ha but no differential response of P was found.

Abdul and Aarf (1986) stated that in two trails, cv. Batrra was grown at spacing of 20, 30, 40, 50 and 60 cm with 5 levels of 100, 250, 300, 350 and

400 kg NPK/ donum (1338 m^2). The maximum yield (12.23 t/donum) was obtained with 400 kg NPK at 20 cm spacing. The numbers of pods/plant was increased slightly by increasing fertilizers levels and wider spacing to a maximum of 59, but there was no significant effect on average pod weight.

Palaniswamy *et al.* (1986) studied the influence of date of sowing and spacing on seed quality of okra cv. Pusa Sawani. The seeds were sown at monthly intervals between March and November with 60 x 30 cm, or 60 x 20 cm spacing. They obtained the best quality seed in March, April and May sowing.

Singh *et al.* (1986) conducted a two-year trial on the effect of planting dates and spacing on seed production of okra cv. Pusa Sawani. The seeds were sown on 15 and 30th day of June and July at 60 x 30 cm, 45 x 30 cm and 30 x 30 cm spacing. The seed yield in both the years was the highest (1.94-2.11 t/ha) in plots sown on 15 June with a plant spacing of 60 x 30 cm.

The response of okra (*Abelmoschus esculentus),* cultivars white velvet and NHAE 47-4 to fertilization in Northern Nigeria was examined using 0, 25, 50 and 100 kg N/ha and 0, 13 and 26 kg P/ha (Majanbu *et al.* 1985). Nitrogen application significantly increased green pod yield, pod diameter, number of fruits/plant, number of seed/pod and pod weight. Application of P also significantly increased green pod yield, pod number and number of seeds/pod. For optimum green pod yield of white velvet 35 kg N/ha was suggested while NHAE 47-4, N fertilization could be increased to 70 kg/ha. There was no differential response of cultivars to P fertilization for green pod yield; however, the application of 13 kg/ha enhanced the performance of both cultivars.

Plants of the okra cv. Pusa Sawani, receiving N at 25, 50, 75 or 100 kg/ha were picked at intervals of 2, 3 or 4 day. Plant receiving 75 kg N/ha gave the highest yield of 152.1 q/ha compared with 88.8 q/ha at 25 kg N/ha and 145.3 q/ha at

100 kg/ha (Tomar and Chauhan, 1982). Picking every 4 days higher yield than other 2 (2, 3 days) interval treatments.

In a 2 year trails with the okra cv. Pusa Sawani grown for seed production, seed quality was the best in plants spaced at 45 x 30 cm on plots receiving irrigation at 60 mm cumulative pan evaporation (CPE) and N at 100 kg/ha (Pandey and Singh, 1982).

Response of okra to varying levels of plant spacing (60 x 20, 60 x 30 and 60 x 40 cm) and graded levels of nitrogen (0, 50, 100 and 150 kg N/ha) and phosphorus (0, 30 and 60 kg P/ha) was studied on sandy loam soil poor in organic carbon, medium in available phosphorus and rich in available potassium during kharif season of 1972, 1974 and 1977 at the Indian Institute of Horticultural Research, Bangalore (Gupta *et al.*1981). They stated that the closest spacing (60 x 20 cm) gave consistently higher yields in all the years of study. Nitrogen phosphorus fertilization increased plant height, number of nodes per plant and pod size which finally contributed in increasing the pod yield. Application of 100 kg nitrogen and 60 kg phosphorus per hectare gave the highest yield as compared to other levels.

Mani and Ramanathan (1980) carried out an experiment to study the effect of nitrogen and potassium on the yield of okra. There were 5 levels of N (0, 20, 40, 60 and 80 kg/ha) and 5 levels of K_2O (0, 15, 30, 45 and 60 kg/ha). Nitrogen fertilization significantly increased yield. The highest N level (80 kg/ha) was increased yield by 149.2% over the control. Combined application of 80 kg N/ha with either 30 kg or 60 kg K_2O/ha produced maximum yields (17.2 t/ha and 17.5 t/ha respectively). Different K levels had no significant effect on yield in the absence of N.

Zanin and Kimoto (1980) reported an increased seed yield per unit area with application of higher dosages of fertilizers at closer spacing. Increased amount

of fertilizer increased the plant height, number of branches and number of fruits per plant through reduction in plant spacing reduced the number of branches and fruits per plant. They also found no effect of spacing and fertilizers on germination percentage.

An experiment was conducted by Chauhan and Gupta (1973) to find out the effect of NPK on the growth and yield of okra (*Abelmoschus esculentus)*. They found that plant height and girth, number of leaves and yield of green pod were increased by increasing application of N (22.5, 45.0 or 67.5 kg/ha), P at 22.5 or 45.0 kg/ha and K at 22.5 kg/ha had no effect on growth and yield. NPK applications, however, generally increased yields.

In a 2 year trails with okra the effects were assessed of N (as urea) at 40-120 kg/ha, P_2O_5 (as super phosphate) at 17.44-52.32 kg/ha and K (as muriate) at 24.9-74.7 kg/ha (Sharma and Shukla, 1973). The highest yields were obtained with N at 120, P_2O_5 at 34.88 and K at 49.8 kg/ha.

An experiment was conducted by Grewal *et al.* (1972 and 1973) to observe the effect of sowing dates, spacing and green pod picking on the yield and quality of okra seeds cv. Pusa Sawani. Seeds were sown on June 20, July 10 and 30 in rows at 30, 45 or 60 cm apart and 1, 2, 3 and 4 pickings and no picking of green pods were done. The earliest sowing date and closest spacing with no picking of greed pods resulted the highest seed yield, largest seed size and the highest percentage of germination. A gradual decline in these characters was recorded at delayed sowing, increased spacing and more picking of green pods. However, two pickings of green pods did not severely affect the seed yield and gave the highest profit.

Ahmed and Tullock-Reid (1968) studied the response of okra to nitrogen, phosphorus, potassium and magnesium fertilization at Trinidad on loam soil and

best yields were obtained with 112 kg N, 168 kg P, 280 kg K and 112 kg Mg per hectare.

In an investigation at the Punjab Agricultural University, Ludhiana, Singh and Korla (1967) was observed 113 kg N/ha to be an economic dose. It was also recommended that 62.5 kg N/ha is sufficient on soils of good fertility for both spring and rainy season crop (Anon, 1993). In Himachal Pradesh, NPK at the rate of 60, 50, 30 kg per hectare, respectively, were recommended for getting the best yield (Anon, 1978).

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in the execution of the experiment.

3.1 Experimental site

The experiment was carried out at the central farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April-July, 2007. The location of the site is 23.77° N and 90.34° E Latitude and at an attitude of 8.2m from the Sea level (Anon, 1989).

3.2 Climate

The experimental area was situated in the sub-tropical climate zone, which was characterized by heavy rainfall during the month of April to September (Kharif season) and scanty rainfall in the month of October to March (Rabi season). The weather data during the experimental period were collected from Bangladesh Metrological Department (Climate Division) Agargaon, Dhaka has been presented in Appendix II.

3.3 Soil

The experimental site was located in the Madhupur Tract (AEZ-28) and it was medium high land with adequate irrigation facilities. The soil was having a texture of silty loam with p^H and CEC were 5.6 and 2.64 meq/100g soil respectively. The analytical data of the soil sample collected from the experimental area were determined in Soil Resources and Development Institute (SRDI) Farmgate, Dhaka has been presented in Appendix I.

3.4 Plant Materials used in the Experiment

The variety 'BARI Dherosh-1' was used in the experiment. It is a high yielding variety and resistant to vein clearing mosaic disease. The seeds were collected

from Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Design of the Experiment

The experiment was conducted by Randomized Complete Block Design (RCBD) with three replications. Two factors were used in the experiment

Factor-A: Three plant spacing:

1. S_1: 75 cm x 20 cm
2. S_2: 75 cm x 40 cm
3. S_3: 75 cm x 60 cm

Factor-B: Four levels of nitrogen:

1. N_0: 0 kg N/ha (0 kg urea/ha)
2. N_1: 50 kg N/ha (108.70 kg urea/ha)
3. N_2: 100 kg N/ha (217.40 kg urea/ha)
4. N_3: 150 kg N/ha (326.10 kg urea/ha)

There 12 treatment combinations were given below:

S_1N_0	S_2N_0	S_3N_0
S_1N_1	S_2N_1	S_3N_1
S_1N_2	S_2N_2	S_3N_2
S_1N_3	S_2N_3	S_3N_3

3.6 Layout of the Experiment

The experimental plot was first divided into three blocks. Each block consists of 12 plots. Thus the total number of plot was 36. The size of a unit plot was 3.6m x 3m. A distance of 0.5m between the plots and 1.0m between the blocks was kept. Thus the total area of the experiment was 42.5m x 13.8m. A layout of the experiment has been shown in Fig. 1.

3.7 Land Preparation:

The experimental area was first opened on 30 March'07 by a disc plough to open it to direct sunshine to kill soil borne pathogen and soil inhabitant insects. It was prepared by several ploughing and cross ploughing with a power tiller followed by laddering to bring about a good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. The weeds, crops residues and stubbles were removed from the field. The basal doses of manure and fertilizers were applied and finally leveled. The soil of the plot was treated by Seven 50 WP @ 5 kg/ha to protect the young plants from the attack of mole cricket, ants and cutworm. According to the design and layout, the plots were prepared.

3.8 Application of manure and fertilizers

Cowdung : 10 t/ha

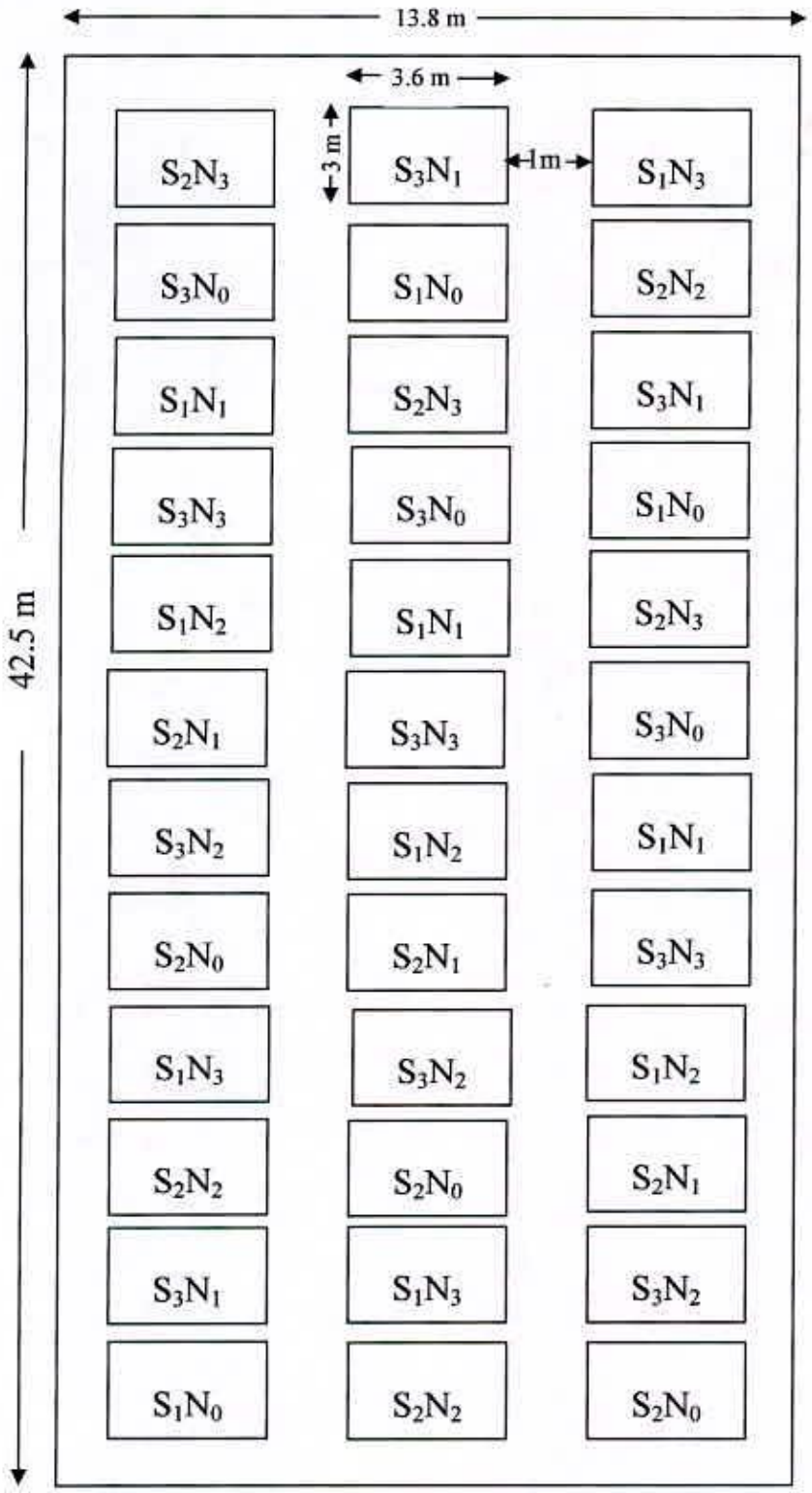
TSP : 100 kg/ha

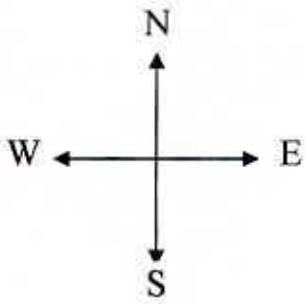
MP : 150 kg/ha

Urea : as per treatment levels

Full dose of Cowdung and TSP were applied in the field as basal dose during the final land preparation. Urea and MP were applied around the plants in three equal installments at 20 days interval as top dressing (Rashid, 1999).

Layout of the experiment:





Plot size = 3.6 m × 3.0 m
Replication = 3
Number of Plot = 36
Plot spacing = 0.5 m
Between replication = 1.0 m
Total area = 42.5 m x 13.8 m

Factors A:

S_1 = 75 cm x 20 cm
S_2 = 75 cm x 40 cm
S_3 = 75 cm x 60 cm

Factors B:

N_0 = 0 kg N/ha (control)
N_1 = 50 kg N/ha
N_2 = 100 kg N/ha
N_3 = 150 kg N/ha

Fig. 1. Layout of the experimental plot

3.9 Seed sowing

Seeds were sown on 17 April'07. Before sowing seeds were soaked in water for 24 hours and then wrapped with a piece of thin cloth. Then the seeds were spread in polythene sheet for 2 hours to dry out the surface water of seed coat. This encourages the quick germination. Row-row and plant-plant distance were followed according requirements. Two to three seeds were sown in each pit and the seeds were covered with fine soil with hand.

3.10 Intercultural Operation

For better growth and development of the plant necessary intercultural operation were done through the cropping season. Stagnant water was effectively drained out at the time of heavy rain. Intercultural operation that were done as follows:

3.10.1 Thinning

Emergences of seedling were completed within 7 days and then keeping only one healthy seedling in each location, the others were thinned out.

3.10.2 Gap filling

Dead, injured and weak seedling were replaced by new vigor seedling from the block kept on the border line of the experimental site.

3.10.3 Weeding

The plants were kept under careful observation. Three times weeding were done during cropping period viz. 07 May, 27 May and 16 June for proper growth and development of plants.

3.10.4 Irrigation

Irrigation was given by observing the soil moisture condition and which was followed by weeding. Four times irrigation were done during crop period viz. 17 April, 07 May, 27 May and 16 June for proper growth and development of plants.

3.10.5 Plant Protection Measure

No major insects, pests and diseases were found to attack the crop during the growing season. Diazinon 60 EC@ 3.5 ml/L in water was sprayed at 10 days interval to keep the crop free from jassids.

3.11 Harvesting

Green pods were harvested at one day interval when they attained edible stage.

3.12 Data Collection

Ten (10) plants were randomly selected from each unit plot for the collection of data. The border plants in each plot were selected for the collection of growth data of okra and the other plants were selected for the collection of yield data of okra. Data were collected at 20, 40 and 60 DAS on the following parameters from the selected plants during the experiment:

i) Plant height

Plant height was measured in centimeter (cm) by a meter scale at 20, 40 and 60 DAS from the soil surface of stem up to the tip of the longest leaf. Average height was taken very carefully from the randomly selected plants.

ii) Plant diameter

Plant diameter was measured by a slide calipers. It was measured in centimeter (cm) at 20, 40 and 60 DAS at the thickened portion of the plant.

iii) Petiole length

Petiole length was measured in centimeter (cm) by a meter scale at 20, 40 and 60 DAS from the point of attachment of the leaf.

iv) Leaf length

Length of ten (10) leaves were measured in centimeter (cm) with the help of a meter scale from the base of the leaf which attached with petiole up to the point

of leaves and average leaf length were also recorded from the randomly selected plants.

v) Leaf breath

Ten (10) leaves of randomly selected plants were made detached and measured in centimeter (cm) by a meter scale at 20, 40 and 60 DAS from the middle of the leaves. Average leaf breath of 10 plants was recorded from randomly selected sample plants.

vi) Braches per plant

All the branches of each randomly selected sample plant were counted separately. This record was taken at 20, 40 and 60 DAS excluding the smallest young branches at the growing point of the plant. Average number of branches per plant was also recorded very carefully.

vii) Leaves per plant

Excluding young leaves from counting number of leaves per plant was counted at 20, 40 and 60 DAS. All the leaves of each plant were counted separately. Average number of leaf per plant was recorded very carefully.

viii) Green pods per plant

Mean number of green pods of selected sample plant from each plot was recorded.

ix) Green pod length

Excluding peduncle the length of ten (10) randomly selected pods was measured in centimeter (cm) by a meter scale and finally mean was calculated.

x) Green pod diameter

The diameter of green pods at middle position was measured by a slide calipers. This was measured in centimeter (cm).

xi) Green pod yield per plot

From each plot mean weight (gm) of edible green pods of 10 randomly selected plants was taken very carefully.

xii) Green pod yield per hectare

The green pod yield per hectare was calculated in metric ton by converting the total yield of per plot.

3.13 Economic analysis

Economic analysis were done in orders to compare the profitability of the treatment combination. All the non-materials and materials input cost and interest on running capital were considered for computing the cost of production. The interests were calculated for six months @ 13% per year. The price of okra at harvest was considered to be 18000 Tk/ton. The Benefit Cost Ratio (BCR) was calculated by the following formula:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income}}{\text{Total cost of production}}$$

3.14 Statistical analysis

The collected data on different parameters were statistically analyzed with the help of MSTAT program to find out the significance of variation resulting from the experimental treatments. The treatment means were separated by Duncan's Multiple Range Test (DMRT) at 5% level of significance for interpretation of the results (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to investigate the effect of plant spacing and nitrogen on the growth and yield of okra during the experimental period from April to July 2007. The results are presented in the table 1 to 9 and figure 2 to 9. The results of the present study have been presented and discussed in this chapter under the following headings:

4.1 Plant height

Significant variation was found on the plant height due to plant spacing at different days after sowing (Appendix III). The result revealed that plant height was decreased with increasing the plant spacing. At 20 DAS, the tallest (25.00cm) plant was observed at the closest spacing S_1 (75cm x 20 cm) which was followed (23.42cm) by the spacing S_2 (75cm x 40cm) and the shortest (21.67cm) plant was observed at the widest spacing S_3 (75cm x 60cm). At 40 DAS, the tallest (74.15cm) plant was noticed at the closest spacing S_1 (75cm x 20 cm) and the shortest (68.80cm) was at the widest spacing S_3 (75cm x 60cm) and at 60 DAS, the tallest (122.5cm) and the shortest (113.0cm) plant was recorded from the spacing S_1 (75cm x 20 cm) and S_3 (75cm x 60cm) respectively (Fig. 2). The overall result revealed tallest plant was found at the closest spacing but it was thin due to the competition of sunlight and other essential elements. Similar result was reported by Mondal and Mallik (1990) who obtained the tallest plant at the closer spacing at 30cm x 45cm.

The plant height was varied significant due to the application of different levels of nitrogen (Appendix III). It was the tallest (25.30cm) at 20 DAS, at the highest level of nitrogen N_3 (150 kg N/ha) which was followed (24.00cm) by the nitrogen level N_2 (100 kg N/ha) and the shortest (21.23cm) plant was obtained from the control treatment where the plot did not receive any nitrogen (N_0). At 40 DAS, the tallest (73.93cm) plant was observed at the highest level of nitrogen N_3 (150

kg N/ha) and the shortest (68.67cm) plant was at the control treatment (Fig. 3) and at 60 DAS, the tallest (126.00cm) and the shortest (107.3cm) plant was obtained from the highest level of nitrogen N_3 (150 kg N/ha) and at control condition respectively. Highest nitrogen level gave the highest plant. Because, nitrogen is the key factor for plant growth. It plays an important role in building protoplasm and protein which induce cell division. Singh *et al.* (1998) stated that the application of 90 kg N/ha increased plant height by 14.03% compared with the control.

Combined effect of plant spacing and nitrogen levels was observed significant in this respect of plant height at different days after sowing (Appendix III). At 20 DAS, the highest (27.70cm) plant was obtained from the treatment combination of S_1N_3 (75cm x 20cm and 150 kg N/ha) and the shortest (20.00cm) plant was at S_3N_0 (75cm x 60cm and control nitrogen). At 40 DAS, the highest (76.00cm) plant was found from S_1N_3 (75cm x 20cm and 150 kg N/ha) which followed (75.00cm) by at S_1N_2 (75cm x 20cm and 100 kg N/ha) and the lowest (66.00cm) was at S_3N_0 (75cm x 60cm and control nitrogen). At 60 DAS, the maximum (132.00cm) and the minimum (103.00cm) plant height was recorded from the treatment combination of S_1N_3 (75cm x 20cm and 150 kg N/ha) and S_3N_0 (75cm x 60cm and control nitrogen) respectively (Table 1).

4.2 Plant diameter

Plant diameter was significantly affected by plant spacing at 60 DAS and 40 DAS but insignificant at 20 DAS (Appendix III) and at 20 DAS, it was ranges from 0.34-0.35cm. At 40 DAS, the highest (1.71cm) plant diameter was recorded from the plant spacing S_3 (75cm x 60 cm) and the lowest (1.64cm) was from the spacing S_1 (75cm x 20cm) and at 60 DAS, the highest (2.47cm) and the lowest (2.24cm) was obtained from the spacing S_3 (75cm x 60 cm) and S_1 (75cm x 20cm) respectively (Fig. 4). The result showed that plant diameter was the highest at the highest plant spacing. Because at the highest plant spacing, a plant

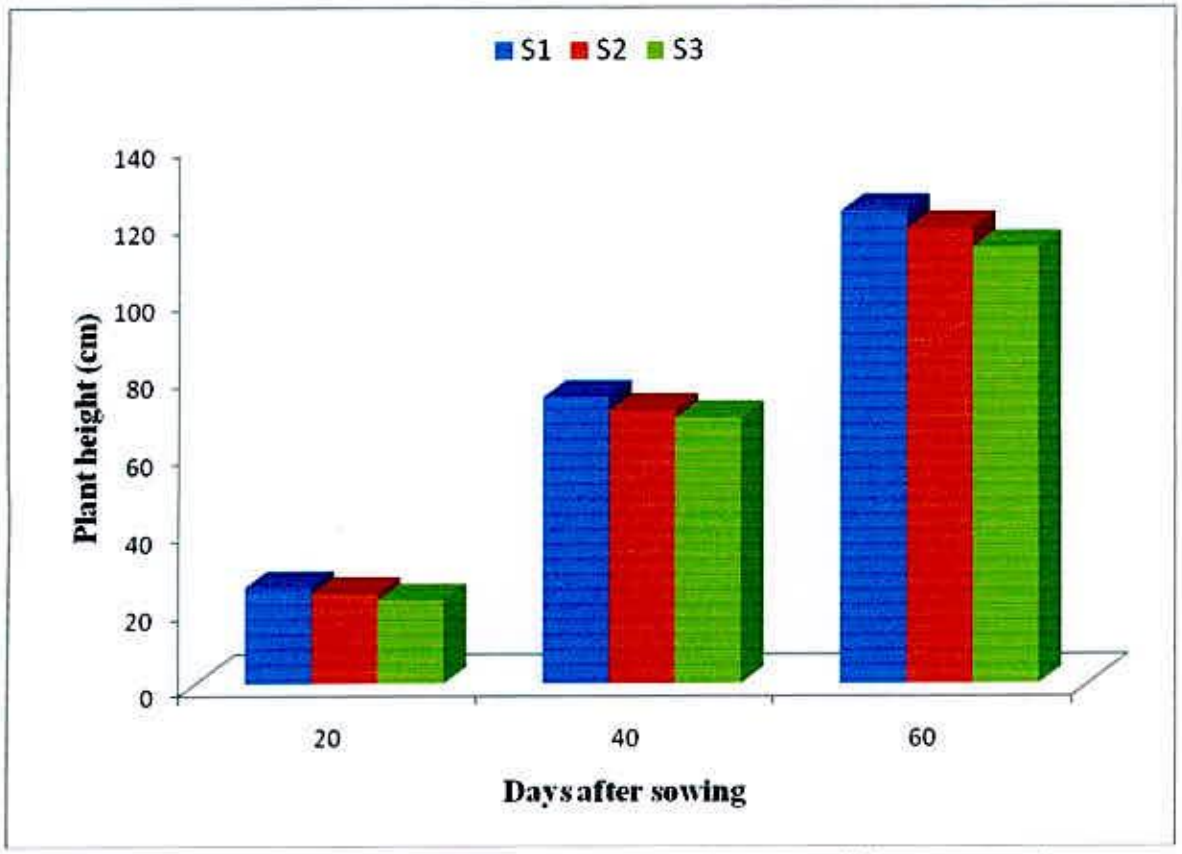


Fig 2. Effect of plant spacing on the plant height of okra at different growth stages

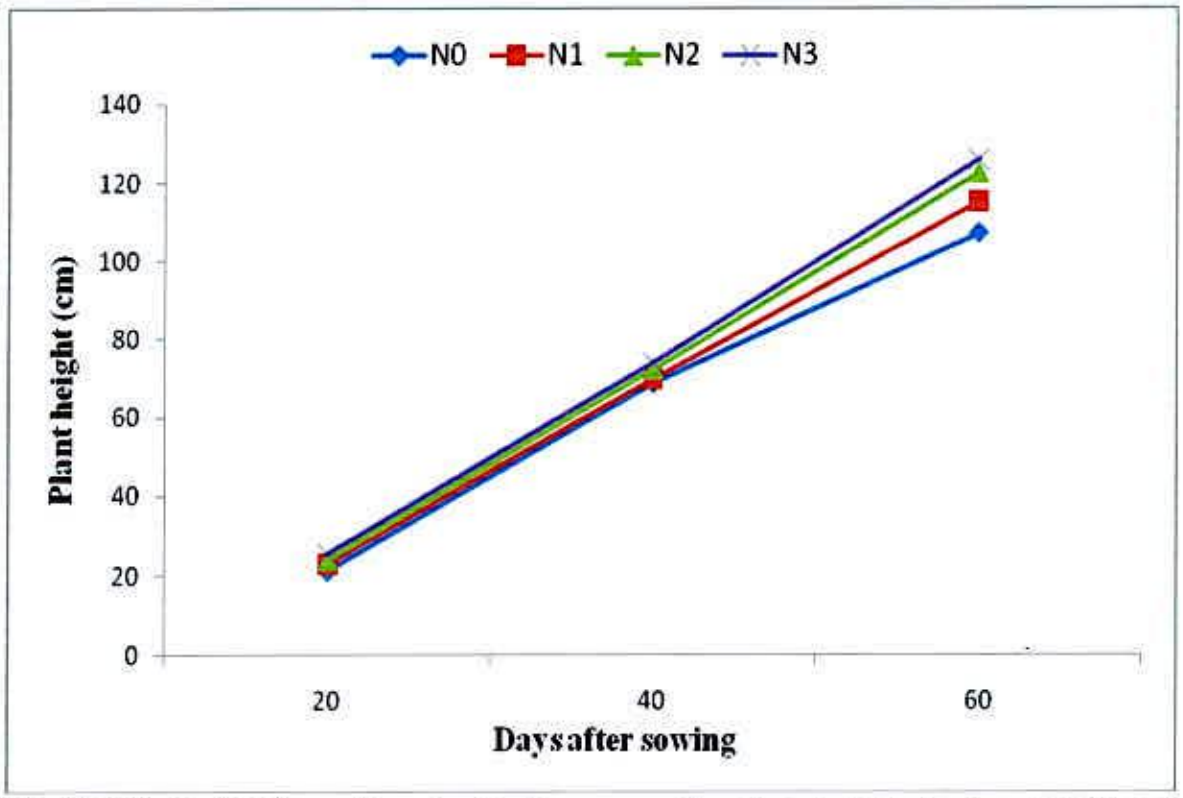


Fig 3. Effect of different levels of nitrogen on the plant height of okra at different growth stages

got more amount of light, nutrients and other essential elements than the closest spacing.

There was a significant effect of nitrogen levels on the plant diameter at 60 DAS but insignificant at 20 and 40 DAS (Appendix III). At 20 DAS, it was ranges from 0.33-0.36cm and at 40 DAS, 1.65-1.72cm. At 60 DAS, the maximum (2.48cm) plant diameter was obtained from the highest level of nitrogen N_3 (150 kg N/ha) which followed (2.43cm) by the nitrogen level N_2 (100 kg N/ha) and the minimum (2.22cm) plant diameter was recorded from the control nitrogen N_0 (Fig. 5). Majanbo *et al.* (1976) observed that plant diameter was enhanced by nitrogen fertilization up to 100kg N/ha.

Plant diameter was insignificantly affected by the combined affection of plant spacing and different levels of nitrogen at 20 DAS and 40 DAS but significant at 60 DAS (Appendix III). At 20 DAS, it was ranges from 0.32-0.38cm and at 40 DAS, it was 1.62-1.74cm. But at 60 DAS, the highest (2.52cm) plant diameter was recorded from the combination of the highest plant spacing and highest nitrogen level S_3N_3 (75cm x 60cm and 150 kg N/ha) and the lowest (1.96 cm) was from S_1N_0 (75cm x 20cm and control nitrogen) (Table 1).

4.3 Branches per plant

Number of branches per plant was significantly affected by different plant spacing (Appendix IV). At 20 DAS, no branches were found but at 40 DAS, the maximum (3.52) number of branches per plant was recorded from the widest spacing S_3 (75cm x 60cm) which was followed (3.13) by the spacing S_2 (75cm x 40cm) and the minimum (2.08) was at the closest spacing S_1 (75cm x 20cm). At 60 DAS, it was the highest (4.12) at the spacing S_3 (75cm x 60cm) and the lowest (2.27) was at the spacing S_1 (75cm x 20cm). The resulted showed that maximum branching was recorded at the highest spacing (Fig. 6). It was so, due to that at the highest plant spacing, a plant got more space to express itself and lower competition with another plants for the essential elements. Zanin and Kimoto

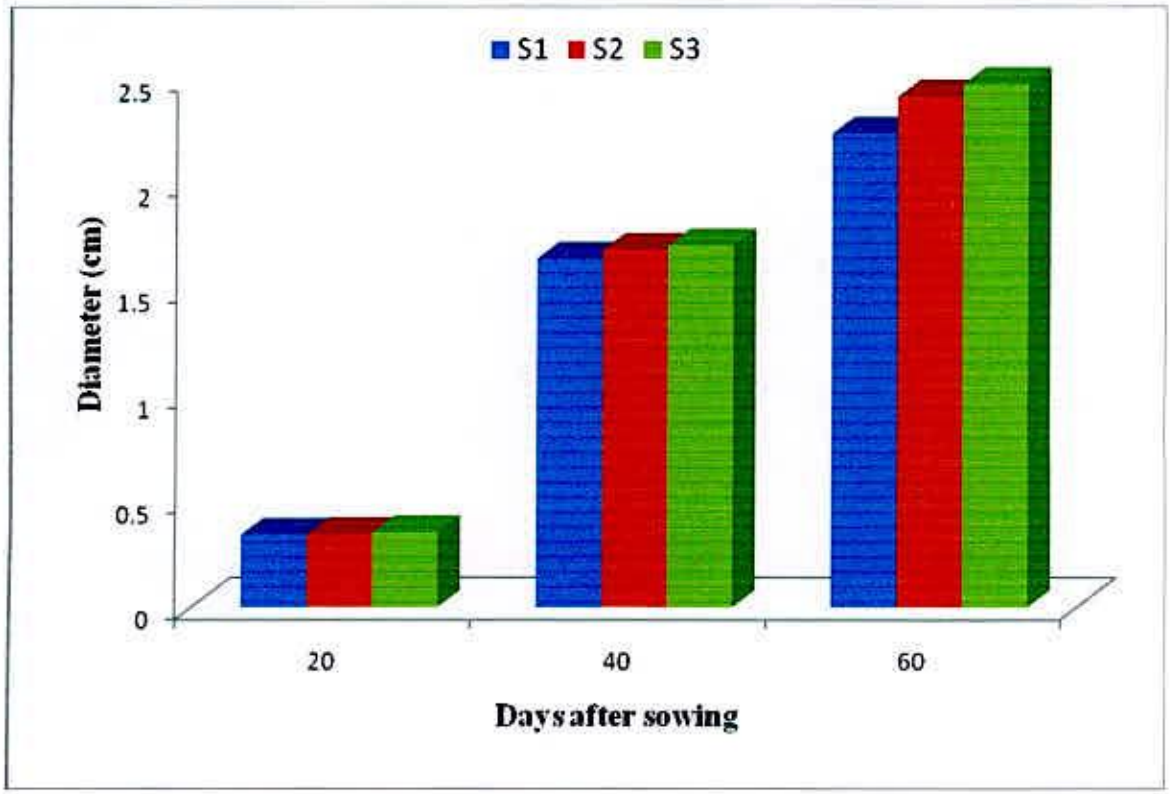


Fig 4. Effect of plant spacing on the plant diameter of okra at different growth stages

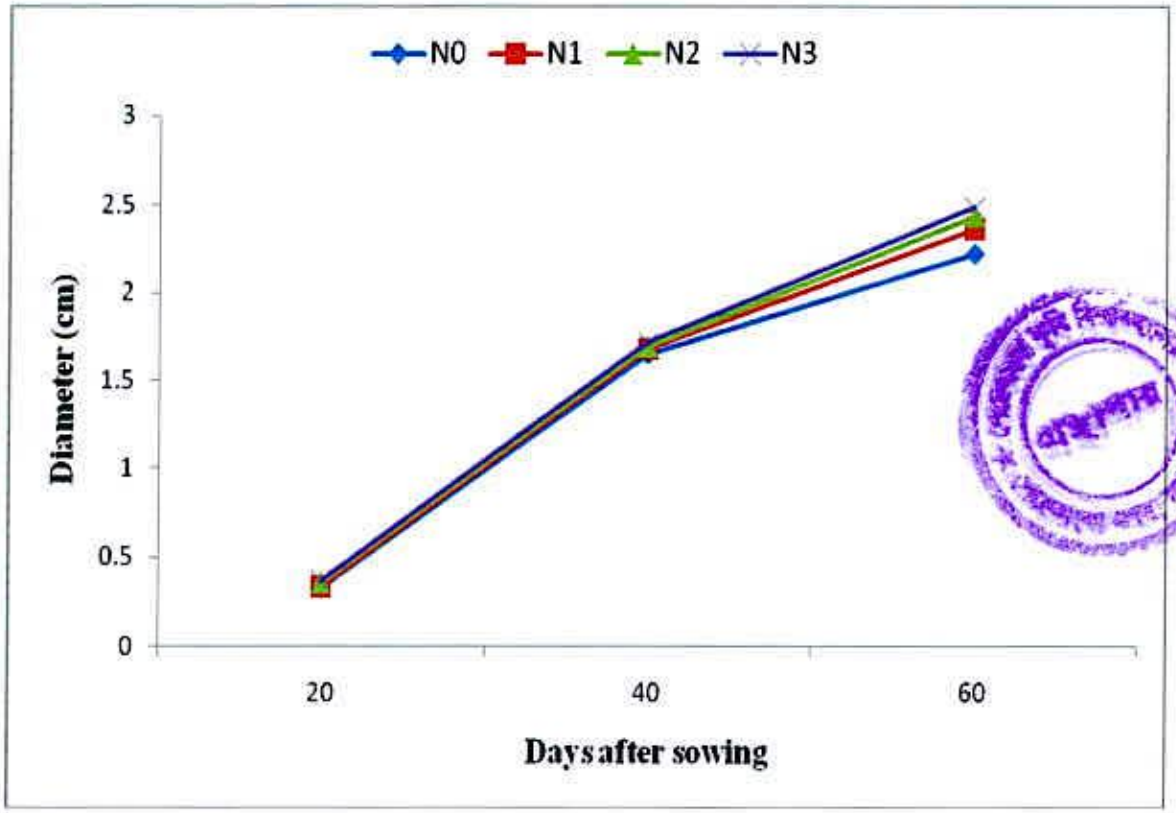


Fig 5. Effect of different nitrogen levels on the plant diameter of okra at different growth stages

Table 1. Combined effect of plant spacing and different levels of nitrogen on the plant height and plant diameter of okra at different growth stages

Treatment Combination	Plant height (cm)			Plant diameter (cm)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1N_0	22.30 cd	72.00 abc	112.0 cde	0.32	1.62	1.96 c
S_1N_1	24.00 bc	73.60 ab	118.0 bcd	0.34	1.64	2.20 bc
S_1N_2	26.00 ab	75.00 a	128.0 ab	0.35	1.65	2.34 ab
S_1N_3	27.70 a	76.00 a	132.0 a	0.36	1.68	2.46 a
S_2N_0	21.40 cd	68.00 cde	107.0 de	0.32	1.64	2.30 ab
S_2N_1	23.30 bcd	68.90 cde	117.0 bcd	0.34	1.69	2.42 ab
S_2N_2	24.00 bc	72.00 abc	122.0 abc	0.36	1.70	2.46 a
S_2N_3	25.00 abc	74.00 ab	126.0 ab	0.36	1.72	2.48 a
S_3N_0	20.00 d	66.00 e	103.0 e	0.33	1.68	2.40 ab
S_3N_1	21.50 cd	67.00 de	111.0 cde	0.35	1.70	2.47 a
S_3N_2	22.00 cd	70.40 bcd	118.0 bcd	0.36	1.72	2.51 a
S_3N_3	23.20 bcd	71.80 abc	120.0 abcd	0.38	1.74	2.52 a
$LSD_{0.05}$	3.269	3.855	12.24	0.053	0.107	0.2512
CV (%)	7.35	5.47	6.14	10.33	7.95	6.26

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

S_1= 75 cm x 20 cm,
S_2= 75 cm x 40 cm,
S_3= 75 cm x 60 cm

N_0= 0 kg N/ha,
N_1= 50 kg N/ha,
N_2= 100 kg N/ha,
N_3= 150 kg N/ha

(1980) also reported that the number of branches per plant decreased with increasing plant density.

Number of branches per plant was significantly increased with increasing nitrogen levels (Appendix IV). Because, nitrogen plays an important role in building up of protoplasm and protein which induce cell division and initiate meristematic activities. The result showed that no branches were found at 20 DAS but at 40 DAS, the highest (3.60) number of branches per plant was obtained from the highest level of nitrogen N_3 (150 kg N/ha) that was followed (3.37) by at N_2 (100 kg N/ha) and the lowest (2.10) was at the control nitrogen N_0 where the plots were not receive any nitrogen. Maximum (4.07) number of branches per plant at 60 DAS was recorded from the highest level of nitrogen N_3 (150 kg N/ha) and the lowest (2.70) was obtained from the control treatment (Fig. 7). Majanbu *et al.* (1986) observed that the branch production was enhanced by nitrogen fertilization up to 100kg/ha.

There was a significant combined effect of plant spacing and different levels of nitrogen on the number of branches per plant at different days after sowing (Appendix IV). The result revealed that no branches were found at 20 DAS but at 40 DAS, the highest (4.30) number of branches per plant was recorded from the treatment combination of S_3N_3 (75cm x 60cm and 150 kg N/ha) which was followed (4.10) by at S_3N_2 (75cm x 60cm and 100 kg N/ha) and the lowest (1.40) number of branches per plant was at S_1N_0 (75cm x 20cm and control nitrogen). At 60 DAS, maximum (4.80) and minimum (1.60) number of branches per plant was obtained from the combination S_3N_3 (75cm x 60cm and 150 kg N/ha) and S_1N_0 (75cm x 20cm and control nitrogen) respectively (Table 2).

4.4 Leaves per plant

It was observed that plant spacing had a significant effect on the number of leaves per plant at 40 and 60 DAS but insignificant at 20 DAS (Appendix IV) and in here, it was varied from 6.89-7.39 (Fig. 8). At 40 DAS, the highest (40.95)

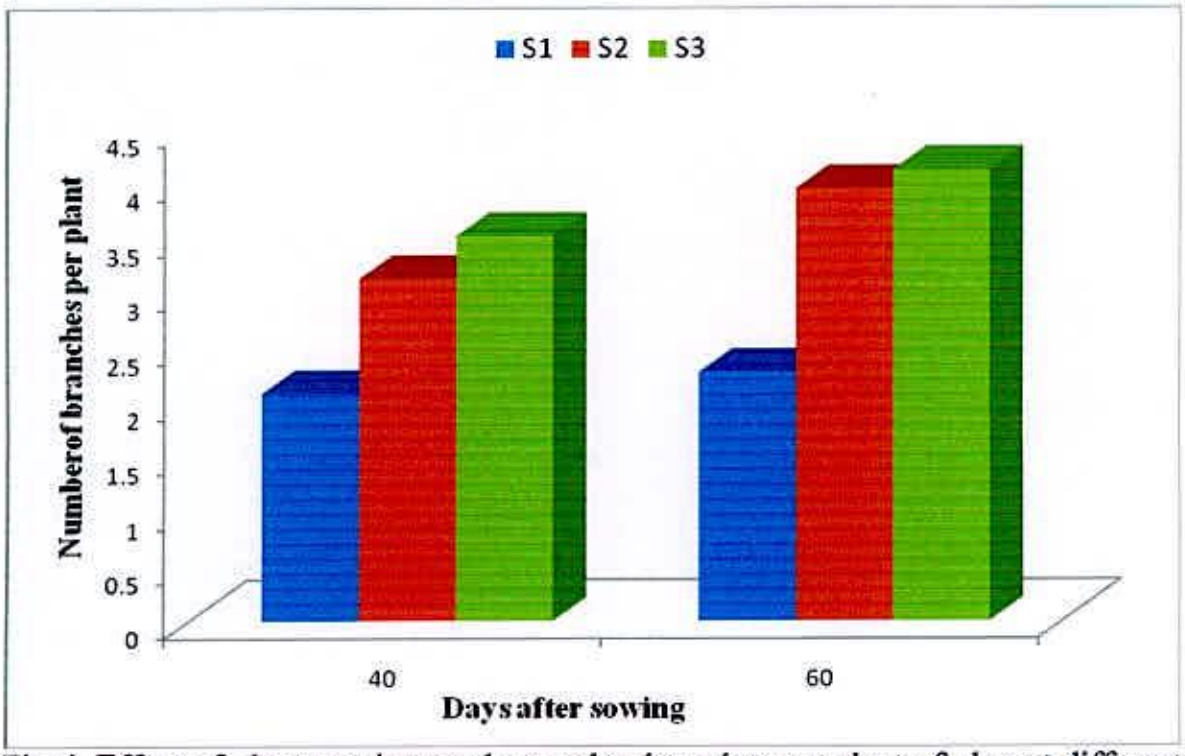


Fig 6. Effect of plant spacing on the number branches per plant of okra at different growth stages

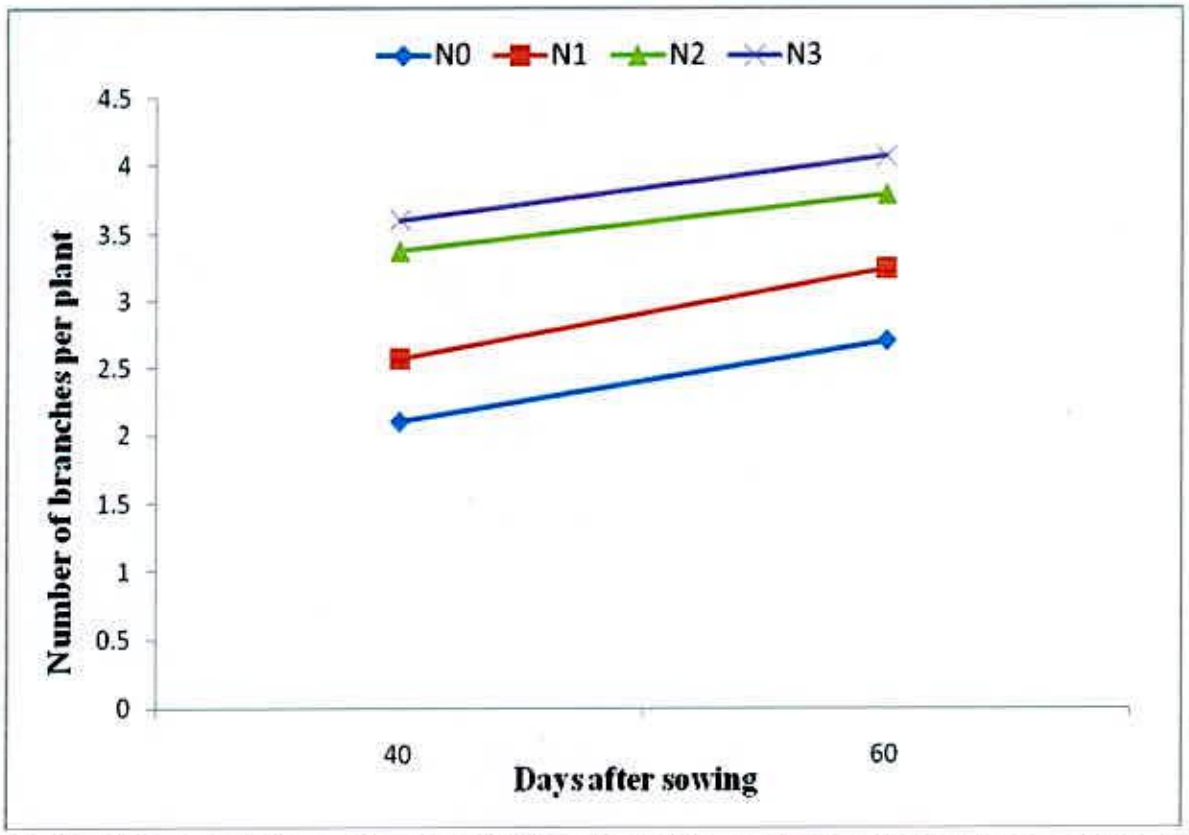


Fig 7. Effect of different levels of nitrogen on the number of branches per plant of okra at different growth stages

number of leaves per plant was found at the widest spacing S_3 (75cm x 60cm) which was followed (39.97) by the spacing S_2 (75cm x 40cm) and the lowest (30.58) was at the closest spacing S_1 (75cm x 20cm). At 60 DAS, it was the maximum (52.55) at the spacing S_3 (75cm x 60cm) and the minimum (35.63) was at the spacing S_1 (75cm x 20cm). Though the number of branches per plant was increased with increasing plant spacing, so automatically leaves per plant was increased with increasing plant spacing. Zanin and Kimoto (1980) also reported that the number of leaves per plant decreased with increasing plant density.

Application of different levels of nitrogen had significant effect on the total number of leaves per plant at different day levels (Appendix IV). At 20 DAS, it was the highest (7.59) at the higher level of nitrogen N_3 (150 kg N/ha) which was followed (7.42) by at N_2 (100 kg N/ha) and the lowest (6.55) was at the control treatment. At 40 DAS, the highest (42.97) number of leaves per plant was recorded from the highest level of nitrogen N_3 (150 kg N/ha) and the lowest (29.23) was at control condition and at 60 DAS, the maximum (54.57) and the minimum (37.57) numbers of leaves per plant was obtained from the nitrogen level N_3 (150 kg N/ha) and at the control level of nitrogen (N_0) respectively (Fig. 9). It was view that nitrogen application enhanced the branched production, so number of leaves per plant was increased with increasing nitrogen level. Majanbu *et al.* (1986) observed that the leaves production was enhanced by nitrogen fertilization up to 100kg/ha.

The combined affection of plant spacing and different levels of nitrogen on the number of leaves per plant was found significant at 40 DAS and 60 DAS but insignificant at 20 DAS (Appendix IV). At 20 DAS, it was varied from 6.05-7.78 and at 40 DAS, it was observed that the treatment combination S_3N_3 (75cm x 60cm and 150 kg N/ha) gave the highest (46.30) and S_1N_0 (75cm x 20cm and control) gave the lowest (22.00) number of leaves per plant (Table 2). At 60 DAS, the highest (63.30) and the lowest (29.00) number of leaves per plant was

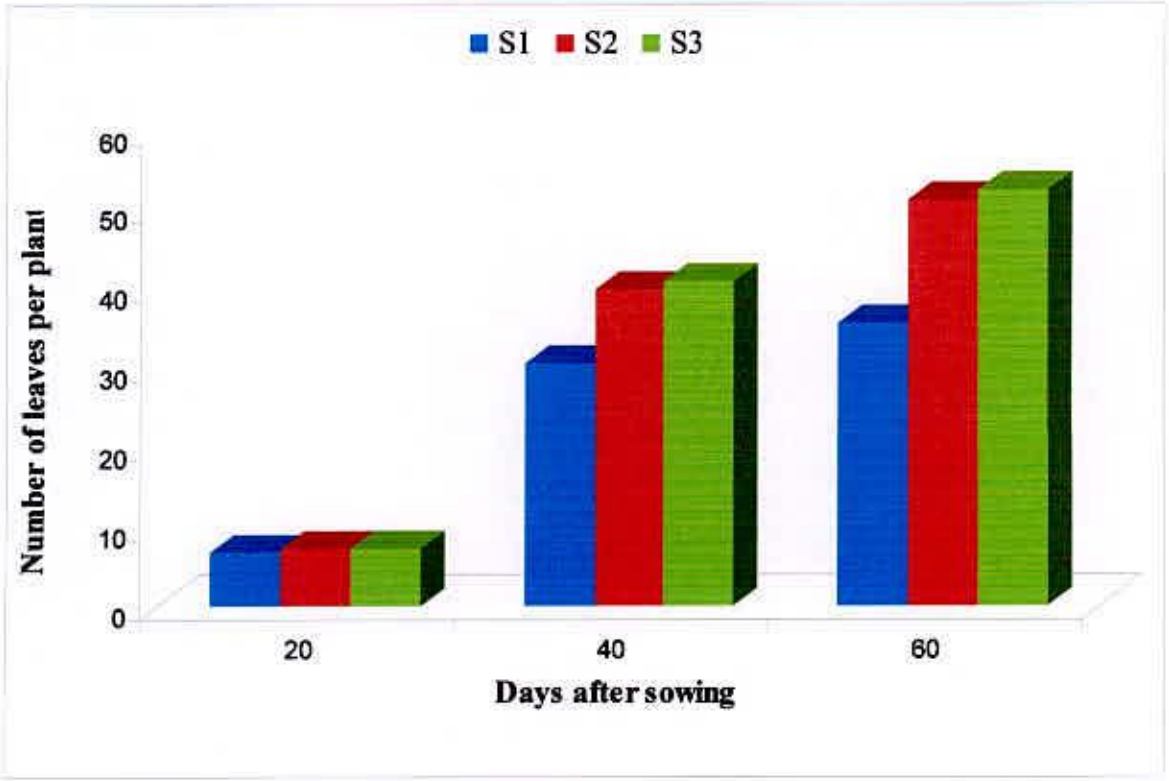


Fig 8. Effect of plant spacing on the number of leaves per plant of okra at different growth stages

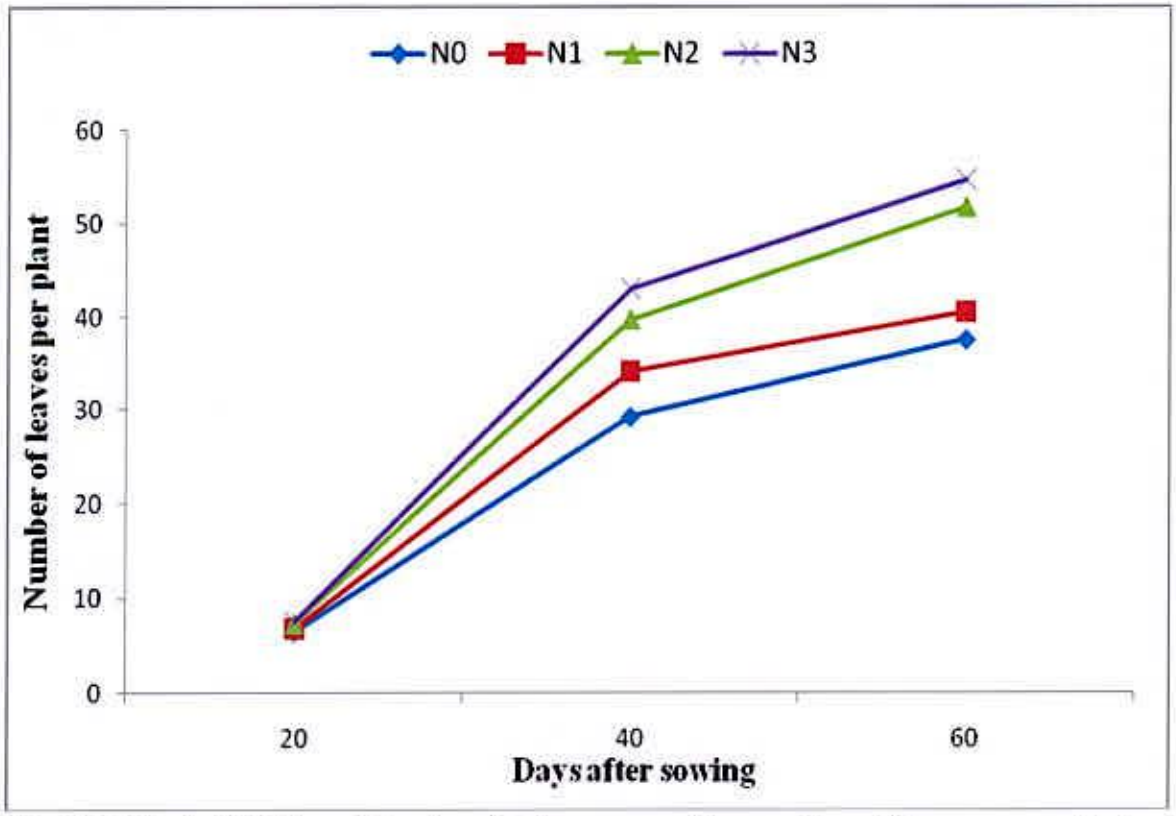


Fig 9. Effect of different levels of nitrogen on the number of leaves per plant at different growth stages

Table 2. Combined effect of plant spacing and nitrogen levels on the number of branches and leaves per plant of okra at different growth stages

Treatment Combination	Number of branches/plant		Number of leaves/plant		
	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1N_0	1.40 e	1.60 e	6.05	22.00 h	29.00 h
S_1N_1	1.80 de	2.20 de	6.03	28.70 g	32.00 h
S_1N_2	2.42 cde	2.51 de	7.16	35.20 e	39.00 g
S_1N_3	2.70 bcd	2.78 cd	7.43	36.40 de	42.50 ef
S_2N_0	2.40 cde	3.20 bcd	6.76	32.70 f	44.00 de
S_2N_1	2.72 bcd	3.80 abc	7.23	36.00 de	46.80 d
S_2N_2	3.60 abc	4.20 ab	7.45	43.00 b	56.00 c
S_2N_3	3.80 ab	4.62 a	7.56	44.20 b	58.20 bc
S_3N_0	2.50 cde	3.30 bcd	6.83	33.00 f	39.70 fg
S_3N_1	3.20 abc	3.72 abc	7.28	37.70 d	43.00 e
S_3N_2	4.10 a	4.65 a	7.66	40.80 c	60.20 b
S_3N_3	4.30 a	4.80 a	7.78	46.30 a	63.30 a
$LSD_{0.05}$	1.074	1.005	1.382	1.748	3.039
CV (%)	11.77	7.21	11.49	6.83	7.89

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

S_1= 75 cm x 20 cm,
S_2= 75 cm x 40 cm,
S_3= 75 cm x 60 cm

N_0= 0 kg N/ha,
N_1= 50 kg N/ha,
N_2= 100 kg N/ha,
N_3= 150 kg N/ha

recorded from the treatment combination S_3N_3 (75cm x 60cm and 150 kg N/ha) and S_1N_0 (75cm x 20cm and control) respectively.

4.5 Petiole length

Plant spacing had an insignificant effect on the petiole length at all growth stage except 60 DAS (Appendix V). At 20 DAS, it was varied from 3.11-3.42cm and at 40 DAS, it was 23.27-24.25cm. At 60 DAS, the highest (30.24cm) petiole length was recorded from the widest plant spacing S_3 (75cm x 60cm) and the lowest (26.92 cm) was from the closest spacing S_1 (75cm x 20cm) (Table 3).

There was a significant variation on the petiole length due to different levels of nitrogen at different days after sowing (Appendix V). At 20 DAS, the highest (3.46cm) petiole length was obtained from the highest level of nitrogen N_3 (150 kg N/ha) which was similar (3.38cm) at N_2 (100 kg N/ha) and the lowest (2.73cm) was at the control treatment (N_0) where the plots were not receive any nitrogen. At 40 DAS, the highest (25.10cm) petiole length was recorded from the nitrogen level N_3 (150 kg N/ha) and the lowest (22.20cm) was from the control condition and at 60 DAS, the highest (29.89 cm) and the lowest (26.83cm) petiole length was recorded from N_3 (150 kg N/ha) and at control treatment respectively (Table 4). Sing (1995) reported that application of N up to 90-160 kg/ha gave the highest petiole length.

Combination of plant spacing and different levels of nitrogen had a significant effect on the petiole length of okra at different days after sowing (Appendix V). The result revealed that petiole length was gradually increased with the increasing plant spacing and nitrogen levels (Table 5). At 20 DAS, it was the maximum (3.82cm) at the treatment combination of S_3N_3 (75cm x 60cm and 150 kg N/ha) and the lowest (2.62cm) was at S_1N_0 (75cm x 20cm and control nitrogen). At 40 DAS, the highest (25.20cm) petiole length was recorded from S_3N_3 (75cm x 60cm and 150 kg N/ha) and the lowest (20.80cm) was from S_1N_0 (75cm x 20cm and control) and at 60 DAS, the highest (31.07 cm) and the lowest

(25.20 cm) petiole length was obtained from the combination of S_3N_3 (75cm x 60cm and 150 kg N/ha) and S_1N_0 (75cm x 20cm and control treatment) respectively.

4.6 Leaf length

The result showed that there was no affection in this respect of leaf length due to plant spacing at different days after sowing (Appendix V). At 20 DAS, the leaf length was varied from 6.67-7.35cm. At 40 DAS, it was from 19.33-20.25cm and at 60 DAS, 24.22-24.56cm (Table 3).

Significant variation was observed in respect of nitrogen levels on the leaf length at all growth stage except 20 DAS (Appendix V). At 20 DAS, leaf length was ranges from 6.63-7.46cm. At 40 DAS, the highest (20.77cm) leaf length was recorded from the highest nitrogen level of N_3 (150 kg N/ha) and the lowest (18.73cm) was from control treatment N_0. At 60 DAS, the highest (25.53cm) and the lowest (23.07cm) leaf length was obtained from the nitrogen level of N_3 (150 kg N/ha) and from the control level of nitrogen (N_0) respectively (Table 4).

Leaf length was significantly affected due to the combination of the plant spacing and different nitrogen levels at different days after sowing except 20 DAS (Appendix V). At 20 DAS, it was ranged from 6.20-7.8cm. At 40 DAS, the maximum (21.20cm) leaf length was obtained from the treatment combination of S_3N_3 (75cm x 60cm and 150 kg N/ha) and the minimum (18.20cm) was from S_1N_0 (75cm x 20cm and control nitrogen) and at 60 DAS, the highest (26.00cm) and the lowest (23.00cm) leaf length was found from the combination of S_3N_3 (75cm x 60cm and 150 kg N/ha) and S_1N_0 (75cm x 20cm and control condition) respectively (Table 5).

4.7 Leaf breadth

The result showed that plant spacing had an insignificant effect on the leaf breadth of okra at all day levels (Appendix V). At 20 DAS, it was recorded from

7.77-9.20cm, at 40 DAS, it was 24.93cm-25.88cm and at 60 DAS, 29.30cm-30.60cm (Table 3).

Leaf breadth was significantly affected by different levels of nitrogen at 60 DAS but insignificant at 20 and 40 DAS (Appendix V). At 20 DAS, Leaf breadth was ranges from 7.83-8.93cm and 40 DAS, it was from 24.43-26.40cm. Finally at 60 DAS, the maximum (31.03cm) leaf breadth was recorded from the highest level of nitrogen N_3 (150 kg N/ha) which was followed (30.03cm) by the nitrogen level of N_2 (100 kg N/ha) and the minimum (28.13cm) was from the control level of nitrogen (Table 4).

There was a significant combined affection due to plant spacing and nitrogen levels on the leaf breadth in all day levels except 20 DAS (Appendix V). At 20 DAS, it was recorded from 7.30-9.70cm. At 40 DAS, the highest (27.00cm) leaf breadth was obtained from the treatment combination of S_3N_3 (75cm x 60cm and 150 kg N/ha) and the shortest (24.00cm) was recorded from S_1N_0 (75cm x 20cm and control nitrogen) and at 60 DAS, the maximum (32.10cm) and the minimum (26.40cm) leaf breadth was recorded from S_3N_3 (75cm x 60cm and 150 kg N/ha) and S_1N_0 (75cm x 20cm and control nitrogen) respectively (Table 5).

4.8 Pods per plant

Number of pods per plant was significantly affected by plant spacing (Appendix VI). The highest (26.25) number of pods per plant was found at the widest spacing S_3 (75cm x 60 cm) and the lowest (9.00) was found at the closest spacing S_1 (75cm x 20cm). The highest number of pods per plant was found at the widest plant spacing, because at the widest plant spacing, a plant produced more branches than the closest spacing (Table 6). Similar result was found by Abdul and Araf (1986) and Palaniswarmy *et al.* (1986), who reported that number of pods per plant was increased with increasing the plant spacing.

Table 3. Effect of plant spacing on the petiole length, leaf length and leaf breadth of okra at different growth stages

Treatment	Petiole length (cm)			Leaf length (cm)			Leaf breadth (cm)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1	3.11	23.27	26.92 c	6.67	19.33	24.22	7.77	24.93	29.30
S_2	3.26	23.88	28.60 b	7.20	19.80	24.40	8.10	25.02	30.05
S_3	3.42	24.25	30.24 a	7.35	20.25	24.56	9.20	25.88	30.60
$LSD_{0.05}$	0.385	1.553	1.492	0.721	1.103	1.244	1.437	2.449	1.608
CV (%)	8.43	8.78	9.17	10.05	12.06	8.67	10.30	11.44	10.98

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

S_1= 75 cm x 20 cm

S_2 = 75 cm x 40 cm

S_3= 75 cm x 60 cm

Table 4. Effect of nitrogen levels on the petiole length, leaf length and leaf breadth of okra at different growth stages

Treatment	Petiole length (cm)			Leaf length (cm)			Leaf breath (cm)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
N_0	2.73 b	22.20 b	26.83 b	6.63	18.73 c	23.07 b	7.83	24.43	28.13 b
N_1	3.04 ab	23.33 ab	28.23 ab	6.96	19.33 bc	24.13 ab	8.16	25.10	29.40 ab
N_2	3.38 a	24.57 a	29.40 a	7.23	20.33 ab	25.00 a	8.50	25.17	30.03 ab
N_3	3.46 a	25.10 a	29.89 a	7.46	20.77 a	25.53 a	8.93	26.40	31.03 a
$LSD_{0.05}$	0.444	1.793	1.722	0.833	1.274	1.436	1.659	2.828	1.856
CV (%)	8.43	8.78	9.17	10.05	12.06	8.67	10.30	11.44	10.98

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

N_0 = 0 kg N/ha
N_1= 50 kg N/ha
N_2 = 100 kg N/ha
N_3= 150 kg N/ha

Table 5. Combined effect of plant spacing and nitrogen levels on the petiole length, leaf length and leaf breadth of okra at different growth stages

Treatment Combination	Petiole length (cm)			Leaf length (cm)			Leaf breadth (cm)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1N_0	2.62 d	20.80 b	25.20 c	6.20	18.20 b	23.00 b	7.30	24.00 b	26.40 c
S_1N_1	2.76 cd	22.40 ab	26.40 bc	6.50	18.80 ab	24.70 ab	7.60	25.01 ab	28.00 bc
S_1N_2	3.10 abcd	24.60 a	27.80 abc	6.90	20.00 ab	25.00 ab	7.90	24.50 b	29.20 abc
S_1N_3	2.65 d	25.30 a	28.30 abc	7.10	20.30 ab	25.40 ab	8.30	26.20 ab	29.60 abc
S_2N_0	2.73 cd	22.60 ab	26.30 bc	6.80	18.80 ab	23.20 ab	7.40	24.30 b	30.00 abc
S_2N_1	3.10 abcd	23.90 ab	28.20 abc	7.20	19.40 ab	24.00 ab	7.90	24.80 ab	30.40 ab
S_2N_2	3.55 abc	24.20 ab	29.60 ab	7.30	20.20 ab	25.00 ab	8.30	25.00 ab	30.60 ab
S_2N_3	3.68 ab	24.80 a	30.00 a	7.50	20.80 a	25.20 ab	8.80	26.00 ab	31.40 ab
S_3N_0	2.84 bcd	23.20 ab	29.00 ab	6.90	19.20 ab	23.00 b	8.80	25.00 ab	28.00 bc
S_3N_1	3.28 abcd	23.70 ab	30.10 a	7.20	19.80 ab	23.70 ab	9.00	25.50 ab	29.80 abc
S_3N_2	3.75 a	24.90 a	30.80 a	7.50	20.80 a	25.00 ab	9.30	26.00 ab	30.30 ab
S_3N_3	3.82 a	25.20 a	31.07 a	7.80	21.20 a	26.00 a	9.70	27.00 a	32.10 a
$LSD_{0.05}$	0.770	3.106	2.983	1.444	2.206	2.488	2.873	1.981	3.216
CV (%)	8.43	8.78	9.17	10.05	12.06	8.67	10.30	11.44	10.98

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

S_1= 75 cm x 20 cm,
S_2= 75 cm x 40 cm,
S_3= 75 cm x 60 cm

N_0= 0 kg N/ha,
N_1= 50 kg N/ha,
N_2= 100 kg N/ha,
N_3= 150 kg N/ha

Pods per plant were significantly affected by the different levels of nitrogen (Appendix VI). The highest (24.33) number of pods per plant was obtained from the highest level of nitrogen N_3 (150 kg N/ha) and the lowest was (13.67) from the control level of nitrogen N_0 (0 kg N/ha). Nitrogen application enhanced the branched production per plant, for which pods per plant were increased with increasing nitrogen levels (Table 7). Kurup *et al.* (1997) also reported that nitrogen rates up to 100 kg/ha could increase the pod number of okra per plant.

Combined effect due to plant spacing and different levels of nitrogen was found significant on the number of pods per plant (Appendix VI). The maximum (29.00) number of pods per plant was obtained from the treatment combination of S_3N_3 (75cm x 60cm and 150 kg N/ha) and the minimum (7.00) number of pods per plant was obtained from the combination of S_1N_0 (75cm x 20cm and the control nitrogen (Table 8).

4.9 Pod length

The effect of plant spacing on the pod length was found insignificant (Appendix VI). However, the longest (14.68cm) and the shortest (13.80cm) pod length were recorded from the spacing S_3 (75cm x 60 cm) and S_1 (75cm x 20cm) respectively (Table 6). Palaniswamy *et al.* (1986) reported that pod length increases with decreasing plant populations.

The effect of nitrogen levels on the pod length was found insignificant (Appendix VI). The longest (14.60cm) and the shortest (12.83cm) pod length was recorded from the nitrogen level N_3 (150 kg N/ha) and the control level of nitrogen N_0 (0 kg N/ha) respectively (Table 7). Kurup *et al.* (1997) reported that N rate upto 100 kg/ha could increase the pod length.

Pod length was varied significantly affected by the combined effect of the plant spacing and different levels of nitrogen (Appendix VI). The longest (15.40cm) pod length was recorded from the treatment combination of S_3N_3 (75cm x 60cm

and 150 kg N/ha) and the shortest length (12.20cm) was from S_1N_0 (75cm x 20cm and control nitrogen) (Table 8).

4.10 Pod diameter

Plant spacing effect on the pod diameter was found insignificant (Appendix VI). The highest (1.63cm) and the lowest (1.53cm) pod diameter were recorded from the spacing S_3 (75cm x 60 cm) and spacing S_1 (75cm x 20cm) respectively (Table 6).

Effect of nitrogen levels on the pod length was found insignificant (Appendix VI). The maximum (1.65cm) and the minimum (1.53cm) pod diameter was observed from the nitrogen level of N_3 (150 kg N/ha) and the control nitrogen (N_0) where no fertilizer were used respectively (Table 7).

The combined effect of plant spacing and different levels of nitrogen on the pod diameter was found insignificant (Appendix VI). The result showed that the pod diameter was ranges from 1.36-1.73cm (Table 8).

4.11 Yield per plot

Significant affection was observed on the yield per plot due to plant spacing (Appendix VI). The highest (8.86 kg) yield per plot was found from the spacing S_2 (75cm x 40 cm) and the lowest (6.86 kg) was from the widest spacing S_3 (75cm x 60 cm). All the treatments differed significantly with each other in respect of pod yield per plot (Table 6). It was due to that number of plants per plot and branching per plant was significantly affected by plant spacing.

Different levels of nitrogen showed significant effect on the yield per plot (Appendix VI). The highest (8.90 kg) yield per plot was obtained from the highest level of nitrogen N_3 (150 kg N/ha) which was statistically similar (8.76 kg) to the nitrogen level N_2 (100 kg N/ha). The lowest (6.18 kg) yield per plot was recorded at the control nitrogen level N_0 (0 kg N/ha) (Table 7). Kurup *et al.*

(1997) also reported that nitrogen rates up to 100 kg/ha could increase the pods per plant as well as yield per plot of okra cv. Kiran.

There was significant combined variation due to effect of plant spacing and different levels of nitrogen on the yield per plot (Appendix VI). The highest (10.65 kg) and the lowest (5.97 kg) yield per plot was recorded from the treatment combination of S_2N_3 (75cm x 40cm and 150 kg N/ha) and S_3N_0 (75cm x 60cm and control level of nitrogen) respectively (Table 8).

4.12 Yield per hectare

The present study was revealed that there was a significant effect of plant spacing on pod yield per hectare (Appendix VI.). The highest (8.20 t/ha) yield per hectare was recorded from the spacing S_2 (75cm x 40 cm) and the lowest (6.35 t/ha) yield was recorded at the widest spacing S_3 (75cm x 60 cm). Number of plants per plot and branching per plant was significantly affected by plant spacing that's why the above result was found (Table 6).

Nitrogen levels significantly affected the yield per hectare (Appendix VI.). The result showed that the yield per hectare was increased with increasing the application of nitrogen levels (Table 7). It was due to that nitrogen levels increased the number of branches per plant. The highest (8.25 t/ha) yield was recorded from the highest level of nitrogen N_3 (150 kg N/ha) which was similar (8.11 t/ha) to the nitrogen level of N_2 (100 kg N/ha) and the lowest (5.72 t/ha) yield was obtained from the control level of nitrogen N_0 (0 kg N/ha) (Table 7). Kurup *et al.* (1997) reported that N rate up to 100 kg/ha could increase the total pod yield of okra per ha cv. Kiran.

Combined effect of plant spacing and different levels of nitrogen on the yield per hectare was found significant (Appendix VI.). The maximum (9.86 t/ha) yield per hectare was recorded from the treatment combination of S_2N_3 (75cm x 40cm and 150 kg N/ha) which was similar (9.85t/ha) to S_2N_2 (75cm x 40cm and 100 kg

Table 6. Effect of plant spacing on the number pods/plant, pod length, pod diameter, yield/plot and yield/ha of okra

Treatment	Pods/plant	Pod length (cm)	Pod diameter (cm)	Yield/plot (kg)	Yield (t/ha)
S_1	9.00 c	13.80	1.53	7.38 ab	6.84 b
S_2	21.00 b	14.33	1.57	8.86 a	8.20 a
S_3	26.25 a	14.68	1.63	6.86 b	6.35 c
$LSD_{0.05}$	2.296	1.784	0.214	1.538	0.249
CV (%)	7.46	10.25	7.06	8.58	6.10

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

S_1= 75 cm x 20 cm
S_2 = 75 cm x 40 cm
S_3= 75 cm x 60 cm

Table 7. Effect of nitrogen levels on the number of pods/plant, pod length, pod diameter, yield/plot and yield/ha of okra

Treatment	Pods/plant	Pod length (cm)	Pod diameter (cm)	Yield/plot (kg)	Yield (t/ha)
N_0	13.67 d	12.83	1.53	6.18 b	5.72 b
N_1	16.67 c	13.53	1.60	6.96 b	6.45 b
N_2	20.33 b	14.30	1.61	8.76 a	8.11 a
N_3	24.33 a	14.60	1.65	8.90 a	8.25 a
$LSD_{0.05}$	2.651	1.174	0.247	1.776	0.894
CV (%)	7.46	10.25	7.06	8.58	6.10

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

N_0 = 0 kg N/ha
N_1= 50 kg N/ha
N_2 = 100 kg N/ha
N_3= 150 kg N/ha

Table 8. Combined effect of plant spacing and nitrogen levels on the number pods/plant, pod length, pod diameter, yield/plot and yield/ha of okra

Treatment Combination	Pods/plant	Pod length (cm)	Pod diameter (cm)	Yield/plot (kg)	Yield (t /ha)
S_1N_0	7.00 g	12.20 e	1.36	6.52 b	6.04 bcd
S_1N_1	9.00 g	13.00 cde	1.41	6.96 b	6.46 bcd
S_1N_2	10.00 g	12.80 de	1.52	7.90 ab	7.33 bc
S_1N_3	10.00 g	13.20 cde	1.56	8.16 ab	7.57 b
S_2N_0	15.00 f	12.50 e	1.46	6.32 b	6.56 bcd
S_2N_1	20.00 de	13.40 cde	1.53	7.86 ab	7.89 bc
S_2N_2	23.00 bcd	14.80 ab	1.63	10.61 a	9.85 a
S_2N_3	25.00 bc	15.20 a	1.68	10.65 a	9.86 a
S_3N_0	19.00 ef	13.80 bcd	1.49	5.97 b	5.88 d
S_3N_1	21.00 cde	14.20 abc	1.58	6.18 b	6.02cd
S_3N_2	26.00 b	15.30 a	1.69	7.78 ab	7.21 bc
S_3N_3	29.00 a	15.40 a	1.73	7.90 ab	7.33 bc
$LSD_{0.05}$	4.592	1.124	0.428	3.076	1.582
CV (%)	7.46	10.25	7.06	8.58	6.10

Figures in a column having the same letter (s) do not differ significantly at 5% levels as per DMRT

S_1= 75 cm x 20 cm,
S_2= 75 cm x 40 cm,
S_3= 75 cm x 60 cm

N_0= 0 kg N/ha,
N_1= 50 kg N/ha,
N_2= 100 kg N/ha,
N_3= 150 kg N/ha

N/ha). The lowest (5.88t/ha) yield per hectare was recorded at combination of S_3N_0 (75cm x 60cm and at control level of nitrogen) (Table 8).

4.13 Cost and Return Analysis

The benefit cost ratio (BCR) analysis has been done very carefully and presented in the table 9 and appendix VII. The input cost (A), overhead cost (B) and outcome (yield) were calculated for all the treatments combination and it was calculated on the hectare basis. Incase of yield and the others material, the price was considered on the local market basis. The benefit cost ratio (BCR) analysis showed that the plant spacing and the nitrogen levels had a significant effect on the growth and yield of okra.

Due to the variation of the price of fertilizer, manure and others necessary materials, the total cost of production was varied from 68037.00Tk. to 71403.00Tk/ha. This highest (71403.00Tk/ha) cost of production was recorded from the treatment combination of S_1N_3 (75 cm x 20 cm and 150 kg N/ha) and the lowest (68037.00Tk/ha) was from the S_3N_0 (75 cm x 60 cm and control nitrogen). The highest (177480.00Tk/ha) gross return was obtained from the combination of S_2N_3 (75 cm x 40 cm and 150 kg N/ha) and the lowest (105840.00Tk/ha) was found from the treatment combination of S_3N_0 (75 cm x 60 cm and control condition).

The highest (2.53) benefit cost ratio (BCR) was found from the treatment combination of S_2N_2 (75 cm x 40 cm and 100 kg N/ha) and the lowest (1.56) was noted from the combination of S_3N_0 (75 cm x 60 cm and control nitrogen where the plots were not receive any nitrogen).

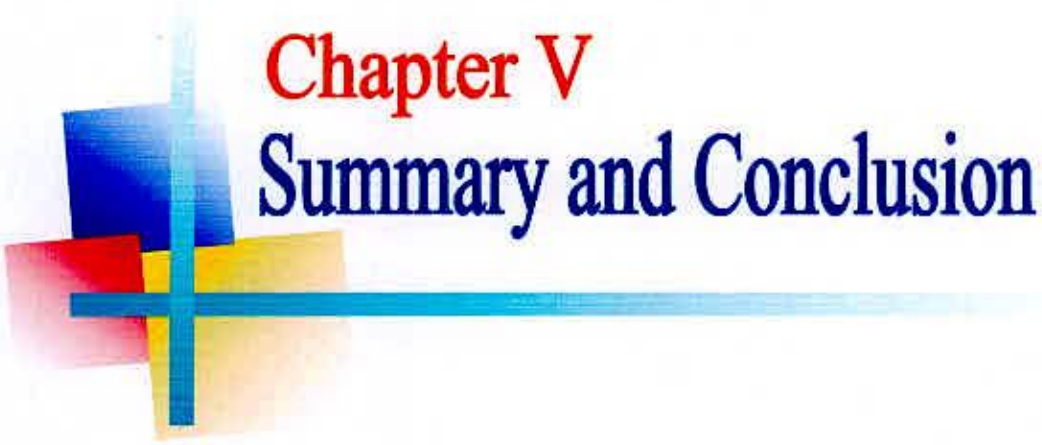
Table 9. Cost and Return analysis of okra as influenced by plant spacing and different levels of nitrogen

Treatment Combination	Marketable Yield (t/ha)	Gross Return (Tk./ha)	Total cost of production (Tk./ha)	Net Return (Tk./ha)	Benefit cost ratio (BCR)
S_1N_0	6.04	108720.00	68485.00	40235.00	1.59
S_1N_1	6.46	116280.00	69457.00	46823.00	1.67
S_1N_2	7.33	131940.00	70430.00	61510.00	1.87
S_1N_3	7.57	136260.00	71403.00	64857.00	1.91
S_2N_0	6.56	118080.00	68261.00	49819.00	1.73
S_2N_1	7.89	142020.00	69233.00	72787.00	2.05
S_2N_2	9.85	177300.00	70207.00	107093.00	2.53
S_2N_3	9.86	177480.00	71179.00	106301.00	2.49
S_3N_0	5.88	105840.00	68037.00	37803.00	1.56
S_3N_1	6.02	108360.00	69010.00	39350.00	1.57
S_3N_2	7.21	129780.00	69983.00	59797.00	1.85
S_3N_3	7.33	131940.00	70955.00	60985.00	1.86

Yield @ Tk.18000/ton

S_1= 75 cm x 20 cm,
S_2= 75 cm x 40 cm,
S_3= 75 cm x 60 cm

N_0= 0 kg N/ha,
N_1= 50 kg N/ha,
N_2= 100 kg N/ha,
N_3= 150 kg N/ha



Chapter V
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted to study the effect of plant spacing and nitrogen on the growth and yield of okra at the central farm of Sher-e-Bangla Agricultural University during the period from April to July'07. The experiment consists of two factors that are three plant spacing (S_1: 75 cm x 20 cm, S_2: 75 cm x 40 cm and S_3: 75 cm x 60 cm) and four levels of nitrogen (N_0: 0, N_1: 50, N_2:100 and N_3:150 kg N/ha).

Plant spacing and different levels of nitrogen significantly influenced most of the yield and yield contributing parameters that's are plant height, petiole length, leaf length, leaves breath, number of leaves, number of braches, number of pod per plant, yield per plot, yield per hectare which were studied at different growth stage (20 DAS, 40 DAS and 60 DAS).

Incase of the plant spacing, the result showed that the maximum (122.5cm) plant height was found from the spacing of S_1 (75 cm x 20 cm) and the petiole length (30.24cm), number of branches (4.12), number of leaves (52.55), number of pods (26.25) per plant, pod length (14.68cm) and pod diameter (1.63cm) was the highest at the widest spacing of S_3 (75 cm x 60 cm). The highest yield (8.86 kg) per plot and yield (8.20 t) per hectare was found from the spacing of S_2 (75 cm x 40 cm).

Incase of nitrogen level, the highest plant height (126.0cm), petiole length (29.89cm), leaf length (25.53cm), number of branches (4.07), number of leaves (54.67) was obtained with the application 150kg N/ha. The maximum number of pods (24.33) per plant, pod length (14.60cm), pod diameter (1.65cm), yield per plot (8.90 kg) and yield per hectare (8.25 t) was obtained from the highest level of nitrogen N_3 (150 kg N/ha).

Due to combined effect, the highest plant height (132.00cm) was recorded from the treatment combination of S_1N_3 (75 cm x 20 cm and 150 kg N/ha). The highest petiole length (31.07cm), leaf length (26.00cm), number of branches (4.80), number of leaves (63.30), number of pods (29.00) per plant, pod length (15.40cm), pod diameter (1.73cm) was the highest at the combination of S_3N_3 (75 cm x 60 cm and 150 kg N/ha).

Incase of yield, the highest (10.65 kg) yield per plot was noted from the treatment combination of S_2N_3 (75 cm x 40 cm and 150 kg N/ha) which was similar (10.61 kg) with of S_2N_2 (75 cm x 40 cm and 100 kg N/ha), the highest (9.86 t/ha) yield per hectare was found from the combination of S_2N_3 (75 cm x 40 cm and 150 kg N/ha) which was identical (9.85 t/ha) to with of S_2N_2 (75 cm x 40 cm and 100 kg N/ha).

Though the combination of the plant spacing S_2N_3 gave the highest (9.86 t/ha) yield per hectare but on the basis of the benefit cost ratio (BCR) the best (2.53) outcome was recorded from the combination of S_2N_2.

CONCLUSION:

Considering all the above, the following conclusions may be drawn:

i) Plant spacing and nitrogen had significant influence on the growth and yield of okra and S_2N_3 (75 cm x 40 cm and 150 kg N/ha) gave the highest yield but the highest economic return was found in S_2N_2 (75 cm x 40 cm and 100 kg N/ha), whereas economic return was decreased with excess use of nitrogen fertilizer. Hence, S_2N_2 was the best combination for okra production.

ii) The present study was conducted in an individual region, so further regional trials should be needed for appropriate plant spacing and nitrogen fertilizer recommendation of okra.

References

REFFERENCES

Abdul, K.S. and Aarf, L.S. 1986. Effect of plant spacing and fertilizer levels on the growth and yield of okra. *Iraqi J. Agril. Sci.,* **4** (2): 77-89.

Ahmed and Tullock-Reid. 1968. Studied the response of okra to nitrogen, phosphorus, potassium and magnesium fertilization for the best yield of okra. *Haryana J. Hort. Sci.,* **10** (1/2): 136-140.

Amjad, M., Sultan, M., Anjum, M.A. and Ayub, C.M. 2001. Response of okra to various doses of P and different spacing. *J. Res.,* **13** (1): 19-29.

Anonymous. 1978. Effect of NPK for getting the best yield of okra (*Abelmoschus esculentus* L.). *Gujrat Agril. Uni. Res. J.,* **13** (2): 8-11.

Anonymous. 1989. An Annual Weather Report, IPSA, Salna, Gazipur. Pp. 8-15.

Anonymous. 1993. Pod development and germination studies in okra (*Abelmoschus esculentus* L. Moench). *Indian J. Agril. Sci.,* **41** (10): 852-856.

Anonymous. 2007. Annual Weather Report, Bangladesh Meteorological Department, Agargaon, Dhaka.

Arora, S.K., Narinder, K., Sharma, B.R. and Kumar, N. 1991. Effect of nitrogen and phosphorus fertilizer on growth and yield components in okra (*Abelmoschus esculentus* L. Moench). *Haryana J. Hort. Sci.,* **20** (3-4): 261-266.

Bajpai, V.P., Khan, A.A., Kumar, S., Singh, P. and Singh, C.B. 2004. Effect of spacing and sowing dates on growth and seed quality of okra (*Abelmoschus esculentus* L. Moench). *Farm Sci. J.,* **13** (2): 116-117.

BBS. 2005. Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning. Dhaka. pp. 78-86.

Birbal, B.K., Nehra and Malik, Y.S. 1995. Effect of spacing and nitrogen on fruit yield of okra (*Abelmoschus esculentus* L. Moench.). *Indian J. Res.,* **25** (1-2): 47-51.

Chauhan, D.S. and Gupta, M.L. 1973. Effect of nitrogen, phosphorus and potash on the growth and development of okra (*Abelmoschus esculentus* L. Moench). *Indian J. Hort. Sci.,* **30** (1-2): 401-406.

Gadakh, S.R., Lawande, K.E. and Kale, P.N. 1990. Effect of different season and spacing on the yield and quality of bhendi. *Haryana J. Hort. Sci.,* **19** (3-4): 329-332.

Gomez, J.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons Publication, New York. pp. 151-152.

Gowda, M.C.B., Krishnappa, K.S. and Puttaraju, T.B. 2001. Dry matter production and fruit size in okra varieties as influenced by varying fertilizer levels. Current Research University of Agricultural Science, Bangalore. **30** (9-10): 151-153.

Gowda, M.C.B., Krishnappa, K.S., Gowda, M.C. and Puttaraju, T.B. 2002. Effect of NPK levels on dry matter, nutrient accumulation and uptake of nutrients in okra. *South Indian Hort.,* **50** (4-6): 543-549.

Grewal, B.S., Namdpuri, K.S. and Kumar, J.C. 1972. Effect of date of sowing, spacing and picking of green pods on seed production of okra. *Punjab Hort. J.,* **12** (4): 248-254.

Grewal, B.S., Namdpuri, K.S. and Kumar, J.C. 1973. Effect of sowing dates, spacing and picking of green pods on yield and quality of okra seed. *Punjab Hort. J.,* **13** (4): 247-252.

Gupta, A., Srinivas, K. and Shukla, V. 1981. Response of okra (*Abelmoschus esculentus* L. Moench) to plant spacing and nitrogen, phosphorus fertilization. *Indian J. Hort. Sci.,* **38** (3-4): 218-222.

Jalal-ud-Din, A., Ghaffoor, Waseem, K., Farooq, M.A. and Khan, S.N. 2002. Effect of different doses of nitrogen on the growth and yield of okra (*Abelmoschus esculentus* L. Moench). *Pakistan J. S. Sci.,* **21** (4): 9-13.

Khan, A.R. and Jaiswal, R.C. 1988. Effect of nitrogen, spacing and green fruit pickings on the seed production of okra (*Abelmoschus esculentus* L. Moench). *Vege. Sci.,* **15** (1): 8-14.

Kuruf, S.A. and Islam, M.A. 1997. Effect of nitrogen on the yield of okra. *Fertilizer Res.,* **6** (3): 257-267.

Kurup, B.S., Pushpakumani, R. and Isaac, S.R. 1997. Enhancing nitrogen use efficiency in okra with nitrification inhibitors. *Veg. Sci.*, **24** (1): 10-12.

Leghari, M.H., Leghari, N.H., Tunio, S.D. and Kubar, R.A. 2003. Effect of spacing on growth and yield of okra (*Abelmoschus esculentus* L. Moench). *J. Agri.*, **19** (2): 11-13.

Lenka, P.C., Das, D.K. and Mishra, H.N. 1989. Effect of nitrogen and phosphorus on seed yield of bhindi. *J. Agril. Res.*, **2** (1-2): 125-127,218-222.

Majanbu, I.S., Ogunlela, V.B. and Ahmed, M.K. 1986. Response of two okra (*Abelmoschus esculentus* L. Moench) varieties to fertilizer: growth and nutrient concentration as influenced by nitrogen and phosphorus application. *Fertilizer res.*, **8** (3): 297-306.

Majanbu, I.S., Ogunlela, V.B., Ahmed, M.K. and Olarewaju, J.D. 1985. Response of two okra varieties to fertilizers: yield and yield components as influenced by nitrogen and phosphorus application. *Fert. res.*, **6** (3): 257-267.

Mani, S. and Ramanthan, K.M. 1980. Effect of nitrogen and potassium on the yield of Bhendi fruit. *South Indian Hort.*, **20** (4): 136-138.

Mishra, H.P. and Pandey, R.G. 1987. Effect of N and K on the seed production of okra (*Abelmoschus esculentus* Mill) in calcareous soil. *Indian J. Agron.*, **32** (4): 425-427.

Mondal, G. and Malik, S.C. 1990. Growth and yield of Bhendi (*Abelmoschus esculentus* L. Moench) as influenced by time of sowing and planting density. *Orissa J. Hort.*, **18** (1-2): 26-31.

Mondal, G., Mallik, S.C. and Maity, T.K. 1989. Effect of sowing date and spacing on the growth and yield of okra. *Crop Research Hisar.*, **2** (2): 230-231.

Palaniswamy, V., Vanangamudi, K., Jayarajad, T. and Karivartharaju, T.V. 1986. Influence of date of sowing and spacing on seed quality in Bhendi. *South Indian Hort.*, **34** (1): 23-25.

Pandey, U.C. and Singh, I.J. 1982. Effect of varying moisture regimes, levels of nitrogen and spacing on quality and chemical composition of seeds of okra (*Abelmoschus esculentus* L. Moench). *Haryana Agril. J. Res.*, **12** (3): 450-455.

Pandey, U.C. and Singh, I.J. 1989. Effect of plants spacing, levels of nitrogen and irrigation on the growth and seed yield of okra (*Abelmoschus esculentus* L. Moench). *South Indian Hort.*, **32** (5): 304-306.

Patton, W., Sema, A. and Maiti, C.S. 2002. Effect of different levels of nitrogen and phosphorus on growth, flowering and yield of okra. *Nagaland Uni. J. Hort.*, **15** (1): 81-88.

Raghav, M. 1996. Influence of dates of sowing and plant spacing on growth and yield of okra. *Indian Res. Hort.*, **3** (1): 99-101.

Rain, K.M. and Lal, M.L. 1999. Effect of 4 (four) fertilizer level on the growth and development of okra cultivars (Parbhani Kranti, Arka Anamika and Pusa Sawani). *Haryana J. Hort. Sci.*, **109**: 7-14.

Ramphal and Gill, H.S. 1990. Demands and Supply of Vegetables and Pulses in South Asia.pp.159-165. In: S. Shanmugasundaram(ed.). Vegetables and Research and Development in South Asia. Proe. of a Workshop held at Islamabad, Pakistan, September 24-29, 1990. AVRDC Publication no. 90-331, AVRDC, Tainan, Taiwan.

Rani, K.R., Sankar, C.R. and Prasad, D.M. 1999. Study on growth and yield of okra cultivars in response to fertilizer levels during hot weather period. Advances in Horticulture and Forestry. 7: 101-105.

Rashid, M. 1990. Effect of nitrogen and phosphorus levels on seed production of okra (*Abelmoschus esculentus* L.Moench). *Haryana J. Hort. Sci.*, **9**: 3-4.

Rashid, A. 1976. "Phool Phal-O-Shak Sabjee". 3rd Edition, Al-Haj Zasimuddin Ahmed, Chandpur, Comilla. p.444.

Rashid, M.M. 1999. "Shabjee Biggan" (in Bangla) Bangla Academy, Dhaka, Bangladesh. p.468.

Rastogi, K.B., Sharma, P.P., Singh, N.P. and Parla, B.N. 1987. Effect of different levels of nitrogen and plant spacing on the seed yield of okra. *Veg. Sci.,* **14** (2): 120-123.

Rekhi, S.S. 1997. Vegetable Improvement and Seed Production. Keynote paper presented in the National Seminar on March 3-4, at BARI, Joydebpur, Gazipur, Bangladesh.

Saha, P.K., Aditya, D.K. and Sharfuddin, A.F.M. 1989. Effect of different plant spacing and picking interval on the growth and yield of okra cv. Pusa Sawani. Bangladesh Hort., **17** (2): 10-14.

Saimbhi, M.S., Daljit, S., Sandhu, K.S., Kooner, K.S., Dhillon, N.P.S. and Singh, D. 1997. Effect of plant spacing on fruit yield in okra. *Indian Agril. Sci. Digest.,* **17** (1): 40-42.

Sajjan, A.S., Shekhargouda, M. and Badanur, V.P. 2002. Influence of date of sowing, spacing and levels of nitrogen on yield attributes and seed yield in okra. Karnataka- *Indian J. Agril. Sci.,* **15** (2): 267-274.

Shanke, B.R., Jadao, B.J., Ghawade, S.M. and Mahorkar, V.K. 2003. Effect of different levels of N and P on growth and seed yield of okra (var. Parbhani Kranti) under Akola condition in Orissa. *Indian J. Hort.,* **31** (1): 123-124.

Sharma, C.B. and Shukla, V. 1973. Nature of response in okra (*Abelmoschus esculentus* L. Moench) to nitrogen, phosphorus and potassium applications and their economic optima. *Indian J. Agril. Sci.,* **43** (10): 930-933.

Singh, B.P. 1990. Effect of spacing on okra. *Indian J. of Agron.,* **35** (4): 439.

Singh and Korla, B.N. 1967. Effect of different levels of nitrogen and plant spacing on seed yield of okra (*Abelmoschus esculentus* L. Moench). *Veg. Sci.,* **14** (2): 120-123.

Singh, I.P. 1995. Effect of various doses of nitrogen on seed yield and quality of okra (*Abelmoschus esculentus* L Moench). *Indian Agril. Res.,* **16** (2): 227-229.

Singh, P.V., Kumar, Jitendra and Kumar, J. 1998. Effect of gibberellic acid as sowing seed treatment and different levels of nitrogen on germination, growth, flowering and yield of okra (*Abelmoschus esculentus* L. Moench). *Indian J. Agril. Res.*, **32** (1): 31-36.

Singh, R. and Kanwar, J.S. 1995. Effect of green fruit picking on plant growth, seed yield and seed quality of okra. The Punjab Vegetable Grower. **30**: 54-57.

Singh, K.P., Malik, Y.S., Lal, S. and Pandita, M.L. 1986. Effect of planting dates and spacing on seed production of okra (*Abelmoschus esculentus* L. Moench). *Harayana J. Hort. Sci.*, **15** (3-4): 267-271.

Singh, R., Saraik, D.A. and Bisen, C.S. 1988. Effect of sowing dates and spacing on the yield and quality of okra seed (*Abelmoschus esculentus* L. Moench). *Res. Dev. Reporter.* **5** (1-2): 83-86.

Somkuwar, R.G., Mahakal, K.G. and Kale, B.P. 1997. Effect of different levels of nitrogen on the growth and yield of okra varieties. *PKV Res. J.*, **21** (2): 202-204.

Thakur, M.K. and Arora, S.K. 1986. In: Vegetable Crops in India, ed. TK Bose and MG Som, Naya Prokash, Calcutta. p.606.

Tomar, S.S. and Chauhan, D.V.S. 1982. Response of summer bhindi (*Abelmoschus esculentus* L. Moench) to levels of nitrogen and picking intervals. *JNKVV Res. J.*, **16** (1): 72-74.

UNDP. 1988. Land Resource Appraisal of Bangladesh for Agricultural Development Report 2. Agro-ecological Regions of Bangladesh, FAO, Rome, Italy. p. 577.

Yadav, P., Singh, P., Yadav, R.L. and Lal, R. 2004. Ameliorative potential of organic manures and nitrogen levels on okra. *Haryana J. Hort. Sci.*, **33** (1/2): 124-126.

Yamaguchi, 1998. Effect of nitrogen, phosphorus and potassium on bhindi (*Abelmoschus esculentus* L. Moench). *Prog. Hort.*, **10** (4): 21-30.

Zanin, A.C.W. and Kimoto, T. 1980. Effect of plant spacing and fertilizers on okra seed production. Revista-de-semente., **2** (3): 105-112.

Appendices

APPENDICES

Appendix I. Characteristics of the entire field soil analyzed by Soil Sources and Development Institute (SRDI), Farmgate, Dhaka

A. Morphological Characteristics of the research field

Morphological Features	Characteristics
Location	Central farm of SAU, Dhaka
AEZ	AEZ no.28 (Madhupur Tract)
Land Type	High Land
General Soil Type	Shallow and Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above Flood level
Drainage	Well Drained
Cropping Pattern	Fellow Tomato

B. Physical and Chemical Properties of the soil

Properties of Soil	Value
Mechanical analysis	
Sand (%)	28
Silt (%)	40
Clay (%)	32
Textural class	Silty clay
Chemical analysis	
P^H	5.6
Organic carbon (%)	0.71
Organic matter (%)	1.29
Total N (%)	18.90
Available P (ppm)	33.25
Exchangeable K (me/100g soil)	0.17
Available S (ppm)	41.40
Available B (ppm)	0.29

Source: SRDI, Farmgate, Dhaka

Appendix II. Monthly records of Temperature, Relative humidity and Rainfall of the experimental site during the period from April to July'07

Year	Month	Temperature (0^0c)			Relative Humidity (%)	Rainfall (mm)
		Maximum	Minimum	Mean		
2007	**April**	33.60	23.50	28.55	69.50	163
	May	34.90	25.13	30.01	70.00	185
	June	32.60	25.5	29.05	81.70	628
	July	35.80	26.60	31.20	87.30	710

Source: Bangladesh Meteorological Department (Climate Division), Agargaon, Dhaka-1207

Appendix III. Analysis of variance of the data on the plant height and plant diameter of okra as influenced by plant spacing and different levels of nitrogen

Source of variation	Degree of freedom	Mean square values					
		Plant height (cm)			Plant diameter (cm)		
		Days after sowing (DAS)			Days after sowing (DAS)		
		20	40	60	20	40	60
Replication	2	3.00^{NS}	3.00^{NS}	3.00^{NS}	0.001^{NS}	0.005^{NS}	0.004^{NS}
Spacing (A)	2	33.19*	88.11**	271.00**	0.001^{NS}	0.012*	0.179**
Levels of nitrogen (B)	3	26.63*	52.07*	619.66**	0.003^{NS}	0.007^{NS}	0.121**
Interaction (A × B)	6	1.07*	1.37*	5.66*	0.000^{NS}	0.000^{NS}	0.023^{NS}
Error	22	9.72	15.18	52.27	0.001	0.004	0.022

**= Significant at 1% level of probability

*= Significant at 5% level of probability,

NS= Non-Significant

Appendix IV. Analysis of variance of the data on the number of branches/plant and number of leaves/plant of okra as influenced by plant spacing and different levels of nitrogen

Source of variation	Degree of freedom	Mean square values				
		Number of branches/plant		Number of leaves/plant		
		Days after sowing (DAS)		Days after sowing (DAS)		
		40	60	20	40	60
Replication	2	0.87^{NS}	1.11^{NS}	13.91**	143.52**	102.08**
Spacing (A)	2	6.69**	12.52**	1.75^{NS}	319.10**	995.67**
Levels of nitrogen (B)	3	4.38**	3.30**	2.14*	330.75**	624.54**
Interaction (A × B)	6	0.05*	0.07*	0.19^{NS}	8.07**	30.38**
Error	22	0.40	0.35	0.66	1.06	3.22

**= Significant at 1% level of probability

*= Significant at 5% level of probability,

NS= Non-Significant

Appendix V. Analysis of variance of the data on the petiole length, leaf length and leaf breadth of okra as influenced by plant spacing and different levels of nitrogen

Source of variation	Degree of freedom	Mean square values								
		Petiole length (cm)			Leaf length (cm)			Leaf breadth (cm)		
		Days after sowing (DAS)			Days after sowing (DAS)			Days after sowing (DAS)		
		20	40	60	20	40	60	20	40	60
Replication	2	2.449**	48.00**	0.194^{NS}	4.563**	21.333*	23.250^{NS}	0.011^{NS}	13.052^{NS}	5.333^{NS}
Spacing (A)	2	1.331^{NS}	2.903^{NS}	33.002**	1.508^{NS}	2.568^{NS}	0.092^{NS}	6.692^{NS}	3.260^{NS}	17.310^{NS}
Levels of nitrogen (B)	3	1.026**	15.167*	16.669*	1.156^{NS}	7.722*	10.467*	1.989^{NS}	6.046^{NS}	13.270*
Interaction (A × B)	6	0.155*	1.449*	0.566*	0.021^{NS}	0.027*	0.419*	0.039^{NS}	0.169*	1.250*
Error	22	0.207	4.364	12.104	0.727	5.697	11.159	2.879	8.368	10.606

**= Significant at 1% level of probability

*= Significant at 5% level of probability,

NS= Non-Significant

Appendix VI. Analysis of variance of the data on the number pods/plant, pod length, pod diameter, yield/plot and yield/ha of okra as influenced by plant spacing and different levels of nitrogen

Source of variation	Degree of freedom	Mean Square				
		Pods/plant	Pod length (cm)	Pod diameter (cm)	Yield/plot (kg)	Yield (t/ha)
Replication	2	6.32^{NS}	12.81^{NS}	0.055^{NS}	0.054^{NS}	0.01^{NS}
Spacing (A)	2	938.25**	10.77^{NS}	0.167^{NS}	12.84*	10.96**
Level of nitrogen (B)	3	191.58**	5.68^{NS}	0.084^{NS}	16.27**	13.96**
Interaction (A × B)	6	47.58**	0.73*	0.025^{NS}	1.55 *	1.32*
Error	22	7.35	4.44	0.064	3.30	0.87

**= Significant at 1% level of probability

*= Significant at 5% level of probability,

NS= Non-Significant

Appendix VII. Production cost of okra per hectare

A. Input cost

Treatment Combination	Labor Cost (Tk.)	Ploughing Cost (Tk.)	Seed Cost (Tk.)	Irrigation Cost (Tk.)	Manure and Fertilizer Cost (Tk.)				Insecticide/ Pesticide (Tk.)	Sub-Total (A) (Tk.)
					Cowdung	Urea	TSP	MP		
S_1N_0	10000.00	1600.00	1600.00	1000.00	4200.00	00.00	2000.00	2700.00	1000.00	24100.00
S_1N_1	10000.00	1600.00	1600.00	1000.00	4200.00	870.00	2000.00	2700.00	1000.00	24970.00
S_1N_2	10000.00	1600.00	1600.00	1000.00	4200.00	1740.00	2000.00	2700.00	1000.00	25840.00
S_1N_3	10000.00	1600.00	1600.00	1000.00	4200.00	2610.00	2000.00	2700.00	1000.00	26710.00
S_2N_0	10000.00	1600.00	1400.00	1000.00	4200.00	00.00	2000.00	2700.00	1000.00	23900.00
S_2N_1	10000.00	1600.00	1400.00	1000.00	4200.00	870.00	2000.00	2700.00	1000.00	24770.00
S_2N_2	10000.00	1600.00	1400.00	1000.00	4200.00	1740.00	2000.00	2700.00	1000.00	25640.00
S_2N_3	10000.00	1600.00	1400.00	1000.00	4200.00	2610.00	2000.00	2700.00	1000.00	26510.00
S_3N_0	10000.00	1600.00	1200.00	1000.00	4200.00	00.00	2000.00	2700.00	1000.00	23700.00
S_3N_1	10000.00	1600.00	1200.00	1000.00	4200.00	870.00	2000.00	2700.00	1000.00	24570.00
S_3N_2	10000.00	1600.00	1200.00	1000.00	4200.00	1740.00	2000.00	2700.00	1000.00	25440.00
S_3N_3	10000.00	1600.00	1200.00	1000.00	4200.00	2610.00	2000.00	2700.00	1000.00	26310.00

S_1= 75 cm x 20 cm, S_2= 75 cm x 40 cm, S_3= 75 cm x 60 cm
N_0= 0 kg N/ha, N_1= 50 kg N/ha, N_2= 100 kg N/ha, N_3= 150 kg N/ha
Urea @ Tk.8/kg, TSP @ Tk.20/kg, MP @ Tk.18/kg, Labor cost @ Tk.80/day
Seed cost @ Tk.400/kg, Cowdung @ Tk. 420/ton

Appendix (Cont'd)

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (13% of value of the land Tk. 6,00000/year)	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 months (Tk.13% of cost/year)	Sub- Total (Tk.) (B)	Total cost of production (Tk./ha) [Input cost + Overhead cost] (A+B)
S_1N_0	.39000.00	1205.00	4180.00	44385.00	68485.00
S_1N_1	39000.00	1248.00	4239.00	44487.00	69457.00
S_1N_2	39000.00	1292.00	4298.00	44590.00	70430.00
S_1N_3	39000.00	1335.00	4358.00	44693.00	71403.00
S_2N_0	39000.00	1195.00	4166.00	44361.00	68261.00
S_2N_1	39000.00	1238.00	4225.00	44463.00	69233.00
S_2N_2	39000.00	1282.00	4285.00	44567.00	70207.00
S_2N_3	39000.00	1325.00	4344.00	44669.00	71179.00
S_3N_0	39000.00	1185.00	4152.00	44337.00	68037.00
S_3N_1	39000.00	1228.00	4212.00	44440.00	69010.00
S_3N_2	39000.00	1272.00	4271.00	44543.00	69983.00
S_3N_3	39000.00	1315.00	4330.00	44645.00	70955.00

S_1= 75 cm x 20 cm, S_2= 75 cm x 40 cm, S_3= 75 cm x 60 cm
N_0= 0 kg N/ha, N_1= 50 kg N/ha, N_2= 100 kg N/ha, N_3= 150 kg N/ha