EFFECT OF TIME OF SOWING AND NITROGEN ON GROWTH AND YIELD OF OKRA

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A Thesis

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This is to certify that the thesis entitled, **"Effect of sowing time and nitrogen on Growth and Yield of Okra"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **Sumon Kumar Saha,** Roll No.110, Registration No. 00890, under my supervision and my guidance. No part of the thesis has been submitted for any other degree in any institutes.

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Dedicated to

My

Beloved Parents

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ABSTRACT

An experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to September 2007, to investigate the effect of different sowing time and levels of nitrogen on growth and yield of okra. The experiment consisted of two factors i, e Sowing time: four dates of sowing were considered 1 April, 2007 (S_1), 16 April, 2007 (S_2), 1 May, 2007 (S_3) and 16 May, 2007 (S_4) and Levels of nitrogen: four different levels of nitrogen were compared 0 (N_0), 50 (N_1), 100 (N_2) and 150 (N_3) kg N/ha respectively. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of sowing time, the highest yield (8.96 t ha^{-1}) was recorded from S_2 and the lowest (6.7 t ha^{-1}) from S_4. Incase of nitrogen, the highest yield (9.44 t ha^{-1}) was obtained from N_3 and the lowest (5.74 t ha^{-1}) from N_0. For combined effect, the maximum yield (9.20 t ha^{-1}) was observed from the treatment combination of S_2N_3 and the minimum (6.22 t ha^{-1}) from S_4N_0. It may be concluded that 16 April with 150 kg nitrogen can be used to obtain higher growth and yield of okra.

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ABBREVIATED TERMS

AEZ	=	Agro- Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BARI	=	Bangladesh Agricultural Research Institute
DAS	=	Days After Sowing
et al.	=	And others
etc	=	Etcetera
FAO	=	Food and Agricultural Organization
LSD	=	Least significant difference
NS	=	Non significant
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e- Bangla Agricultural University

Chapter I

Introduction

CHAPTER 1

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is a member of Malvaceae and known as Lady's finger. It is locally known as "Dherosh'' or "Bhindi". It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world. Okra is probably originated in tropical Africa or possibly tropical Asia, and is now widely grown throughout the tropics. The crop is well distributed throughout the Indian subcontinent and East Asia (Rashid, 1999). Its tender green fruits are popular as vegetables among all classes of people in Bangladesh and elsewhere. Though it is popular, its production is mainly concentrated during the summer. However, now a day's okra is found in the market almost round the year.

Okra is a nutritious and delicious vegetable fairly rich in vitamins and minerals. The edible portion of pod (100g) has moderate levels of vitamin A (0.1 mg) and C (18 mg), calcium (90 mg) and trace amount of phosphorus and potassium. The content of thiamine (0.07 mg), riboflavin (0.08 mg) and niacin (0.08 mg) per 100 g edible portion of pod is higher than that of many vegetable (Rashid, 1999).

In Bangladesh, vegetable production is not uniform round the year. Most of the vegetables are produced in the winter but very low in the summer, around

30% of the total vegetables are produced in the kharif season (Anon, 1993). Among them okra is very important one. In the year 2003-2004, the total production of okra was about 24000 tons in 7288 hectares of land with an average yield 3.38 t/ ha (BBS,2004). The yield is very low compared to that of other developing countries where the yield as high as 7-12 t/ha (Yamaguchi, 1998). In Bangladesh the yield of okra is very low due to lack of management of cultural practices.

Sowing time is an important factor for the yield of a crop. The optimum sowing time depends on the existing cropping pattern and prevailing environment. Growers tend to manipulate sowing time in order to obtain better growth and higher quality pod yield. The time of sowing is also adjusted so as to synchronize the time of harvest with market demand. Okra production is greatly influenced agronomic practices among which, planting time is one of the most important factors that greatly influences the growth and yield of okra (Amjad *et al*., 2001).

Nitrogen plays an important role in build up of protoplasm and protein which induce cell division and initiate meristematic activities when applied in optimum quantity. Nitrogen increases the vegetative growth and produces healthy foliage and promotes carbohydrate synthesis . Patton *et al*. (2002) reported that nitrogen application significantly increased pod yield, diameter, number of fruits per plant and yield of okra per hectare.

Available evidences reveal that in okra production both times of sowing and nitrogen fertilizer play an important role. The yield of okra may be increased through suitable combination of sowing time and nitrogen fertilizer application. The experimental evidences on the effect of sowing time and nitrogen application on the yield and yield components of okra cv. BARI Dherosh-1 are limited under Bangladesh condition. The present study was, therefore, conducted with the following objectives:

1. to find out the optimum sowing times in respect of proper growth and yield of okra.

2. to assesses the optimum levels of nitrogen for maximizing the growth and yield of okra.

3. to find out the suitable combination between time of sowing and level of nitrogen fertilizer on growth and yield of okra.

Chapter II

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Okra is one of the important vegetables grown throughout the tropical world. Different sowing times and levels of nitrogen influence the growth and yield of okra. Many research works have been done in different parts of the world to study the effect of time of sowing and nitrogen on the growth and yield of okra. However, a little information is available in these regards on okra under Bangladesh condition, which is insufficient and sometimes conflicting. However, the available research findings relevant to the present study have been reviewed in this chapter.

2.1 Effect of sowing time on the growth and yield of okra.

Time of sowing is one of the most important and uncontroversial factors for maximizing the yield and quality of the crop. The results of many researchers related to rime of sowing are reviewed here.

Mondal *et al.*(1989) conducted an experiment at Kalyani, West Bengal during Apr.-Aug. 1985 on okra (*Abelmoschus esculentus*) cv. Pusa Sawani. The effects of combinations of 5 sowing dates (20 Apr., 5 May, 20 May, 5 June and 20 June) and 3 inter a row spacings (30, 45 and 60 cm) on growth and yield of okra were investigated. Rows were sown 45 cm apart. The highest plant height (84.5 cm), number of fruits/plant (10.9) and fruit yield (186.9

g/plant, 93.5 q ha^{-1}) were obtained with sowing on the 20 Apr. The 30-cm spacing resulted in the lowest number of fruits/plant (8.1) and fruit yield/plant (107.2 g), but the highest fruit yield ha^{-1} (79.2 q).

Gadakh *et al.* (1990) conducted an experiment of the okra cultivars Pusa Sawani and Sel-2-2 were sown in early June, Oct. and Jan. to produce autumn, winter and summer crops, respectively. The seeds were sown at 30×5, 30×10, 30×15 and 30×30 cm. The fertilizing and harvesting schedules are outlined. The highest yields (up to 185.13 q ha^{-1}) were obtained with the closest spacing and in the summer season. Market acceptance of Pusa Sawani pods was higher than that of Sel-2-2 pods. The treatments had no appreciable effect on pod quality.

Mondal *et al.*(1990) carried out an experiment with okra cv. Pusa Sawani sown at 15-day intervals from 20 Apr. to 20 June 1984 and at 3 intrarow spacings (30, 45 and 60 cm). Interrow spacing was a constant 45 cm. Greatest plant height (85.5 cm) and highest yield (99.0 q ha^{-1}) were obtained from sowing on 20 Apr. at a spacing of 30×45 cm.

Brar *et al.* (1994) studied that the percentage of fruit infestation in okras caused by *Earias spp.* was lowest in cv. EMS 8 in crops sown on 15 May in

Ludhiana, Punjab, India. The greatest fruit yield was obtained in cv. EMS 8 from a crop sown on 15 June, whereas crops sown on 30 July had the lowest yield. The losses in fruit yield were lowest on crops sown on 30 July (22.79%) and greatest on crops sown on 30 May (50.58%).

Raghav (1996) studied that the effects of 4 sowing dates (21 Feb. or 1, 11 or 21 Mar.) and 3 plant spacings (15×30, 30×30 or 45×30 cm) on 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 Mar. and at the closest spacing. Green pod yield was highest with sowing on 1 Mar. (57.32 q ha^{-1}) and at the widest spacing (47.67 q ha^{-1}).

Mazumder, N. *et a*l (1996) conducted field experiment for 2 consecutive years (1992 and 1993) on the incidence of bhendi yellow vein mosaic bigeminivirus and its vector Bemisia tabaci in the okra cultivars Pusa sawani, Parbhani kranti and M-31. Lower disease incidence and whitefly populations were revealed in crops sown between Feb. 25 and Mar. 20 compared with sowing dates of Apr. 15 to Jul. 25. The number of whiteflies was lower on Parbhani kranti and M-31 than on Pusa sawani. The total and marketable yields were max in early sown crops rather than crops sown after 15 April and number of unmarketable okras increased with delayed sowing. Simple correlation studies revealed a positive significant association between disease incidence and whitefly population, temp., RH (evening), rainfall and numbers of rainy days. Marketable fruit yield of okras was negatively correlated with disease incidence and a positive correlation between disease incidence and unmarketable fruit yield was obtained.

Cerri *et al.* (1996) conducted a field trial in Buenos Aires, okra cultivars Clemson Spineless and Colhe Bem were sown in rows 70 cm apart at densities of 2.86 plant^{-1} 2 on 1 December 1991 or 29 January 1992 and supplied with 5 msuperscript 3 worm compost ha^{-1} at sowing plus 100 kg urea ha^{-1} (half at floral initiation and half 4 weeks later). Photoperiod and interception of photosynthetically-active radiation at floral inception and the progress of temperatures throughout development differed between the 2 sowing dates. Leaf area index at floral initiation and dry matter accumulation differed between the sowing dates and although node appearance rate was highest following late sowing, fruit growth rate was highest following early sowing. Following a total growth cycle of 93 days, cv. Clemson Spineless sown in December gave a total economic yield of 1171 g/msuperscript 2 whereas sown in January the growing cycle was only 49 days and the total economic yield only 15 g/msuperscript 2. Colhe Bem sown in December gave a total economic yield of 855.3 g/msuperscript 2 (for a 77-day growing cycle), compared with only 12.7 g/msuperscript 2 when sown in January (a 38 day growing cycle). With the second sowing date, harvesting had to cease around the middle of April 1992 due to frosts. It was concluded that under the conditions of this trial, sowing at the end of January was not practical.

Morales and Franco (1999) evaluated four okra cultivars over 4 planting dates during the winter-spring season of 1994, at Rio Bravo, Tamaulipas, Mexico, to determine their reproductive beha^{-1}vior. The variables measured at the reproductive stage were: plant height, leaf number, fruit number, fruit weight per plant and fruit length. Significant differences were observed for all variables among planting dates and among cultivars.

Dubey and Jha (1999) conducted a field trials in Biha^{-1}r, India, in 1994-95 to assess the effects of planting date (1 Jan.-7 Dec.) and environmental factors (maximum and minimum temperatures, relative humidity and rainfall) on seed germination, pre- and post-germination mortality and development of collar rot disease (*Macrophomina phaseolina*) in okra cv. Prabhani Kranti. Results indicated that later planting was associated with the lowest incidence of collar rot and highest crop yields.

Yadav and Dhankhar (1999) evaluated okra cv. Varsha Uphar in Haryana, India during 1997-98 using 9 sowing dates (from 5 March to 12 August at 20-day intervals) and 2 sowing distances (45×30 and 67.5×20 cm). The highest germination (97.21%) was recorded for seeds sown on 3 July, while highest values for plant height (103.83 cm), number of branches per plant (4.44) and pollen viability (95.85%) were obtained by sowing on 13 June. Days to 50% flowering was significantly affected by sowing date. The number of days required to produce 50% flowering increased with the delay in sowing time, with the lowest number of days (45.33) attained by sowing on 25 March. Sowing on 13 June resulted in the highest values for fruit set (90.86%), number of fruits per plant (24.13), and fruit length (19.11 cm) and girth (1.64 cm).

Incalcaterra and Vetrano (2000) evaluated the effect of 2 sowing dates (1 and 15 April 1996) on okra cultivated with or without a transparent polyethylene film mulch in a field trial in Sicily, Italy. Sowing on 1 April resulted in higher plant height, yields and number of pods per plant than sowing on 15 April.

Islam *et al.* (2000) studied an experiment to evaluate the performance of okra as edible fruit and seed during off-season in Bangladesh, seeds of three okra cultivars (IPSA Okra, BARI Dherosh 1 and Parboni Kanti) were sown on (15 July, August, 15 September and 15 October) in a field experiment conducted in Bangladesh from July 1996 to January 1997. The edible fruit and seed yield decreased significantly with delay in sowing from 15 July to 15 October sowing.

Lal *et al.* (2001) Studied that the performance of three okra cultivars, viz. Parbhani Karanti, Pusa Sawni and Punjab-7, under three sowing dates (16 June, 29 June 29 and 12 July) were conducted in Himachal Pradesh, India during the kharif season of 1996-97. Sowing of okra on 16 June produced the highest pod yield (92.1 q ha^{-1}); the green pod yield decreased by 9.95 and 33.37% for 29 June and 12 July sowing dates, respectively. The first sowing date (16 June) was the most favourable in promoting plant growth and green pod yield.

Bajpai *et al.* (2004) carried out an experiment with okra cv. Parbhani Kranti in Kanpur, Uttar Pradesh, India, consisting of 3 spacings, i.e. 20×15 (S1), 30×15 (S2) and 45×15 cm (S3), and 3 sowing dates, i.e. 5 February (D1), 20 February (D2) and 5 March (D3). Field observations plant population per plot, number of leaves per plant, plant height, plant diameter, flowering date, fruiting date, number of fruits per plant, pod length, pod diameter, number of seeds per pod, 1000-seed weight and seed yield per plot) and laboratory observations (standard germination test, seedling length, seedling dry weight and seed vigor index) were recorded. The plant population and growth were highest in S_2D_2 combination. The sowing dates interacted significantly. However, the D_2S_2 combination was found significantly superior than the other combinations. For quality seed production of okra, the 20 February sowing with 30×15 cm spacing was found the most suitable at Kanpur condition.

Olasantan and Bello (2004) conduced an experiments to evaluate the optimum sowing date for okra (*Abelmoschus esculentus*) sown in monoculture was sited on free-draining sandy loam soils in southwestern

Nigeria. Okra was sown at the end of July, in mid-August and early September as a late-season crop in 1999 and at the end of May, in early June and at the end of June as an early-season crop in 2000.The late-season crops had shorter growth duration, received less rainfall, and experienced cooler temperatures during establishment and the early vegetative stage, and warmer temperatures during the reproductive phase than the early-season crops. The phenology and pod yields of the early and late-season okra in both cropping systems were dependent on sowing date, indicating that okra production is only suitable at particular sowing dates in both seasons. July-sown okra in the 1999 late-season and May-sown crop in the 2000 early-season took progressively the longest time (i.e. 3-0 and 2-5 days, respectively) to flower and fruit and gave the highest fresh pod yields and economic returns. It took okra pods longer to reach marketable size in the late season than early season (i.e. 5-9 v. 2-6 days). It is concluded that the optimal sowing date to attain maximum pod yield and economic returns from late-season okra is July or August and from early-season crop is May or early June. Bearing in mind financial constraints and production costs, the optimal season target for maximum edible pods is the early season and for maximum economic returns is the late season.

Mandal *et al.* (2007) conducted an experiments during the summer of 2000 and 2001, in Samastipur, Biha⁻¹r, India, to study leaf hopper (*Amrasca biguttula biguttula*), red spider mite (*Tetranychus neocaledonicus*) and fruit and shoot borer (*Earias vittella*) incidence in relation to different sowing dates (16 and 26 February; 8, 18 and 28 March; and 7 April) and cultivars (Arka Abhay, Arka Anamika, D- 87-5, KS-312 and Pusa Sawani) of okra. Sowing date significantly influenced the magnitude of pests incidence in okra cultivars. Sowing of crops with resistant cultivars during mid-February reduced the incidence of pests attack and increased the yields.

2.2 Effect of nitrogen on the growth and yield of okra.

Arora *et al.* (1991) carried out studies to compare growth and yield of a new okra cultivar, Punjab Padmini, with that of cv. Pusa Sawani grown under variable N (0, 30, 60 and 90 kg ha^{-1}) and P (0, 30 and 60 kg ha^{-1}) fertilizer applications. Data were recorded for plant height, number of fruits per plant, fruit length and weight. Plant height, number of fruits, fruit size and total green fruit yield were significantly improved by application of 90 kg N ha^{-1} and 60 kg P ha^{-1}. Punjab Padmini gave a higher mean fruit yield (124.6 q ha^{-1}) than Pusa Sawani (121.6 q ha^{-1}). A significant increase in mean marketable yield for both cultivars was obtained with an increase in N application from 0 to 90 kg ha^{-1}.

Naik *et al.* (1992) observed that fruit length, number of fruits/plant, number of seeds/fruit of okra are generally highest with the highest rates of fertilizer application.

Birbal *et al.* (1995) conducted an experiment of okra cv. Varsha Uphar were sown on a sandy loam soil at 30×30, 45×30, 45×45, 60×20 or 60×30 cm, with N applied at 0, 50, 100 or 150 kg ha^{-1}. The tallest plants (109.2 cm) were obtained with spacing at 30×30 cm. The number of branches/plant (2.5) was highest at 45×45 cm. Application of N at 100 and 150 kg ha^{-1} resulted in taller plants and more branches/plant than that at 0 and 50 kg ha^{-1}. Spacing did not affect the number of days to 50% flowering, but N at 100 and 150 kg ha^{-1} 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 45×45 and 60×30 cm; these parameters were also increased by N at 100 kg ha^{-1}. Yield ha^{-1} was highest with spacing at 60×20 cm (138.9 q ha^{-1}); 45×30 cm gave a similar yield.

Singh (1995) conducted a field trial during the kharif season in 1992 and 1993, plots of okra received N at 0, 30, 60, 90, 120 or 150 kg ha^{-1}, 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^{-1} gave the highest number of pods/plant (12.7-14.0), pod length (16.7-7.6 cm), seed yield (17.5-9.0 q ha^{-1}) and 1000-seed weight (67.2-68.7 g). Seed germination rate was not affected by fertilizer application In a field trial conducted during the kharif season in 1992 and 1993, plots of okra received N at 0, 30, 60, 90, 120 or 150 kg ha^{-1}, with ha^{-1}lf applied before sowing and the rest applied 30 days after sowing. Plant height increased with increasing rate of N. Application of N at 90-50 kg ha^{-1} gave the highest number of pods/plant (12.7-4.0), pod length (16.7-7.6 cm), seed yield (17.5-9.0 q ha^{-1}) and 1000-seed weight (67.2-68.7 g). Seed germination rate was not affected by fertilizer application.

Singh and Kumar (1998) studied a trial at Meerut in 1992 and 1993, okra cv. Pusa Sawani seeds were treated with 0, 15, 30 and 45 ppm GA3. N fertilizer was applied at 0, 40, 60 and 90 kg ha^{-1}. The application of 90 kg N ha^{-1} increased plant height by 14.03%, advanced flowering by 4.08 days and increased pod yield by 67.20% compared with controls.

Ahmad *et al*. (1999) studied on the effect of different rates of N (0, 100, 120 or 140 kg ha^{-1}) alone and in combination with 90 kg P and 60 kg K ha^{-1} on growth and yield of okra cv. T-3 was studied at Mingora, Swat, Pakistan. Maximum plant height (1.85 m), number of pods per plant (24.59) and the highest pod yield per hectare (16950.79 kg) were recorded from plots given 120 kg N + 90 kg P + 60 kg K ha^{-1}.

Naik and Singh (1999) conducted a Factorial experiments at Ranchi, India, over 2 years, to study the effects of spacing (90×15, 90\multiply\20 and

90×25 cm), N rate (50, 100, 150 or 200 kg ha^{-1}) and P rate (40, 80 or 120 kg P2O5 ha^{-1}) on okra cv. Pusa Sawani growth and yield. Yield (per plant and per ha^{-1}) increased with increasing rates of N up to 150 kg N ha^{-1}.

Paliwal *et al.* (1999) carriead out a trial on the effect of nitrogen and sulfur on the growth and yield of *Abelmoschus esculentus* cv. Pusa Sawani during the kharif season of 1995 in Rajasthan, India. The treatments comprised of 40, 80 and 120 kg nitrogen ha^{-1-1} and 40, 80, 120 and 160 kg sulfur ha^{-1} and a single overall control. Both nitrogen and sulfur application enhanced the growth and fruit yield of okra significantly.

Verma and Batra (2001) conducted a field experiment was conducted in ha^{-1}ryana, India during the spring-summer season of 1997 and 1998 on sandy loam soil to study the response of spring okra to irrigation and nitrogen. Treatments consisted of three levels of irrigation: ID/CPE ratio of I_1 (0.6), I_2 (0.9) and I_3(1.2); and three levels of nitrogen, N_1 (100 kg), N_2 (150 kg) and N_3 (200 kg) applied in 3 (basal, 30 and 45 days after sowing (DAS)), 5 (basal, 30, 45, 60 and 75 DAS) and 7 (basal, 30, 40, 50, 60, 70 and 80 DAS) split rates. The highest fruit yield could be ensured with moderate intensity of irrigation (ID/CPE 0.9) for both years. The maximum number of fruits per plant, fruit weight and plot yield were recorded from the 200 kg N ha^{-1} treatment, which was on a par with the 150 kg N ha^{-1} treatment, 150 kg N ha^{-1} was the optimum treatment.

Patton *et al.* (2002) studied the effects of N (50, 100, and 150 kg ha^{-1}) and P (0, 60, and 90 kg ha^{-1}) fertilizer rates on okra cv. Arka Anamika were studied in Medziphema, Nagaland, India. P as single superphospha^{-1}te was applied along with ha^{-1}lf of the N (urea) rate during sowing. The remaining N was applied at 30 days after sowing. N at 150 kg ha^{-1} and P at 90 kg ha^{-1} gave the greatest 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^{-1} 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^{-1} recorded the greatest 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.

Ogbaji (2002) the effects of nitrogen as ammonium sulfate at 0, 30, 60 and 90 kg N ha^{-1} and potassium, as mureate of potash at 0, 30 and 60 kg K ha^{-1} on okra (*Abelmoschus esculentus*) were investigated for three consecutive years (1996-98) in a sandy loam soil at Makurdi, a Southern Guinea savannah agro-ecological zone of Nigeria. Nitrogen application significantly ($P<0.05$) enhanced okra leaf number per plant and plant height. Application of 90 kg N

ha^{-1} produced fresh pod yield increase of 94% in 1996, 101% in 1997 and 102% in 1998 compared with the control plots. Potassium application did not significantly ($P>0.05$) increase the growth and yield of okra. A combination of 90 kg N ha^{-1} with 60 kg/K ha^{-1} produced the highest yield of fresh okra pods.

Oliveira *et al.* (2003) conducted a study in Paraiba, Brazil during April to October 2002 to determine the effect of different nutrient levels (0, 50, 100, 150, and 200 kg ha^{-1-1} of N) on the yield of okra cv. Santa Cruz. The appraised cha^{-1}racteristics were influenced by the different levels of N. Fruits length increased in linearly in relation of N elevation levels wherein the highest N value (14 cm) was obtained after application of 200 kg ha^{-1} N. Maximum production of commercial fruits per plant was 833 g was obtained with 141 kg ha^{-1} of N, while the level of 140 kg ha^{-1} of N produced maximum commercial fruits (16 701 kg ha^{-1}) in a large scale. The most economic level of N was 133 kg ha^{-1} and the foreseen revenue, due to its application was 8453 kg ha^{-1} of fruits.

Shanke *et al.* (2003) conducted a study during summer 1998 to assess the seed yield potential and other growth cha^{-1}racters of okra cv. Parbhani Kranti under 5 levels of N (0, 50, 75, 100 and 125 kg ha^{-1}) and 4 levels of P (0, 25, 50 and 75 kg ha^{-1}) with agro-climatic 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^{-1} 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^{-1}. Full fruit length and weight were also found highest (15.61 and 19.6 cm, respectively) in this treatment.

Patil and Panchbhai (2003) conducted an experiment in Akola, Maharashtra, India, during the summer of 1997 to study the response of okra cultivars Parbhani Kranti and Arka Anamika to N fertilizer at 0, 25, 50 or 75 kg ha^{-1}.Between the cultivars, Parbhani Kranti had higher number of leaves per plant (24.36), leaf area per plant (545.01 cm^2) and fresh fruit yield per plant (73.22). The number of internodes per plant, length of inter-node, node on which the first flower appeared, number of fruits per plant, fruit length and diameter, number of seeds per fruit, shell seed ratio and yield ha^{-1} did not significantly vary between the cultivars. Among the N rates, 75 kg N ha^{-1} resulted in the greatest plant height (50.17 cm), number of leaves per plant (26.13), leaf area per plant (567.96 cm2), number of branches per plant (3.06), number of internodes per plant (13.60), number of fruits per plant (7.65), shell seed ratio (10.68), fresh fruit yield per plant (85.97) and yield ha^{-1} (57.85 quintal). The interaction effect showed that the greatest plant height (52.20 cm) and fruit yield ha^{-1} (62.29 quintal) were recorded for Parbhani Kranti supplied with 75 kg N ha^{-1}. [1 quintal=100 kg].

Singh *et al.* (2004) conducted a field experiment during the 2000-01 kharif seasons in Jobner, Rajasthan, India, to evaluate the effects of different levels of nitrogen (50, 100 and 150 kg ha^{-1}), phosphorus (30, 60 and 90 kg ha^{-1}), both by soil application, and gibberellic acid (0, 75 and 150 ppm), applied through foliar spray, on the flowering, fruiting, yield attributes and yield of okra cv. Pusa Sawani. Most of the parameters were significantly influenced by the application of nitrogen, phosphorus and gibberellic acid. Increasing levels of nitrogen up to 150 kg ha^{-1}, phosphorus up to 90 kg ha^{-1} and gibberellic acid up to 150 ppm increased the percent fruit set, number of fruits per plant, length of fruit, diameter of fruit, number of pickings, duration of harvesting, mean fruit weight, yield and dry matter yield of fruit. The increasing levels of gibberellic acid also brought substantial reduction in days to 50% flowering of okra.

Ambare *et al.* (2005) conducted a study in 2002 in Maha^{-1}rashtra, India, to assess the growth and fruit yield potential of okra cv. AKOV-97^{-1}6 in combination with other okra cultivars (Parbhani Kranti, Arka Anamika and Pusa A-4) under variable nitrogen rates (0, 25, 50, 75 and 100 kg ha^{-1}). Increasing nitrogen rates up to 100 kg ha^{-1} increased the plant height, leaves per plant, branches per plant, days to first flower, days to 50% flowering, days to first harvest, fruits per plant, weight of fruits per plant and fruit yield. AKOV-976 had the highest leaves per plant, and the shortest number of days to first flower, days to 50% flowering and days to first harvest. Parbhani Kranti had the highest plant height, branches per plant, fruits per plant, weight of fruits per plant and fruit yield.

Ambare *et al.* (2005) conducted an experiment at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the kharif season of 2002-03 to study the five levels of nitrogen viz., 0, 25, 50, 75 and 100 kg ha^{-1} and four varieties of okra viz., AKOV-976, Parbhani Kranti, Arka Anamika and Pusa A-4 on growth and fruit yield of okra. The results indicated that the higher levels of nitrogen significantly influenced all the characters under study except the diameter of the fruit. Among the varieties, Parbhani Kranti recorded better performance in respect of yield and quality of okra followed by the Dr. PDKV, Akola's newly evolved okra variety viz., AKOV-976.

Ramphal *et al.* (2005) carried out a field experiment out in the spring-summer season of 2002 and 2003 in Hisar, Haryana, India to investigate the effect of plant spacing (7.5, 10 and 12.5 cm) and N application (80, 100 and 120 kg ha^{-1}) on the growth and flowering behaviour of newly developed okra cultivar, HRB08-2, in comparison to Varsha Uphar. Plant height of both cultivars improved significantly at 10 cm spacing and 120 kg N ha^{-1}, however, the plants of HRB08-2 were shorter than those of Varsha Uphar under similar environment. Various growth parameters, such as number of branches per plant and internode length, did not show any significant variation because of varying levels of N and plant spacing; however, Varsha Uphar kept its superiority over HRB08-2 with respect to these 2 characters. 50% flowering appeared in HRB08-2 significantly earlier compared to Varsha Uphar. Higher levels of N application helped in early flowering compared to lower levels. The yield of the 2 cultivars was highest with 120 kg N ha^{-1} and 10 cm spacing, whereas the lowest yield was obtained at 12.5 cm spacing and 80 kg N ha^{-1}. Varsha Upha recorded fruit yield slightly higher than HRB 108-2 at all the N and plant spacing treatments.

Manga and Mohammed (2006) carried out two field experiments during the rainy season of 2002 and 2004 in Kano, Nigeria, to study the effects of plant population and nitrogen (urea) levels on the growth and yield of okra (cv. LD88). The treatments consisted of 4 plant populations (12 000, 17 000, 30 000 and 50 000 plants ha^{-1}) and 4 nitrogen levels (0, 50, 90 and 120 kg ha^{-1}). The plant population had significant effects on plant height, number of leaves per plant, and number of fruits per plant, but had no effect on number of branches per plant and fruit weight. Increasing the plant population up to 50,000 plants ha^{-1} increased the yield. Nitrogen application increased plant height, number of branches per plant, and number of fruits per plant, but did not significantly affect fruit weight. The high nitrogen content of the experimental fields may be the major reason why the yield response to nitrogen was not significant.

Soni *et al.* (2006) stated that the number of leaves per plant and number of branches increased with increasing rates of N up to 125 kg ha^{-1}, whereas leaf area, number of internodes, and seed yield per plant and per hectare increased with increasing rates of N.

Khan *et al.* (2007) conducted an experiment in 1999 in Medziphema, Nagaland, India to study the response of okra to biofertilizers and N application in terms of growth, yield and leaf nutrient (N, P and K) status. The treatments consisted of five levels of N (0, 30, 60, 90 and 120 kg ha^{-1}) and four levels of bio-fertilizers (no inoculation, Azotobacter, *Azospirillum and Azotobacter+Azospirillum). The application of N and biofertilizers significantly increased the growth and yield. Among the biofertilizers, Azotobacter was found to be the best in enha^{-1}ncing the growth, yield and leaf nutrient content. The optimum N requirement was found to be 60 kg ha^{-1}, along with Azotobacter in foothills of Nagaland.

Singh *et al.* (2007) conducted a field experiment in Meerut, Uttar Pradesh, India, to determine the effect of N (50, 100 and 150 kg ha^{-1}), Cu (500, 1000 and 2000 ppm) and Fe (500, 1000 and 2000 ppm) on the growth and yield of okra cv. Pusa Sawani. The maximum plant height, stem diameter, longest leaf length, longest leaf width, fresh pod weight and green pod yield, including the earliest number of days to emergence was obtained with 100 kg N ha^{-1}, 1000 ppm Cu and 1000 ppm Fe.

2.3 Combined effect of time of sowing and nitrogen on the growth and yield of okra. :

Lee *et al.* (1990) conducted a field trials in 1986-87, okra cv. Dwarf Prolific were sown on 15 Apr., 1 or 15 May, or 1 or 15 June, grown at spacings of 45, 60 or 90×30 cm and given 40, 80 or 100 kg N ha^{-1}. Average green pod yields were 11.36 t ha^{-1} with 40 kg N ha^{-1}, 13.27 t with 80 kg and 12.64 t with 100 kg and were highest at the most dense spacing and lowest at the least dense. Green pod yields, were 7.2 t with the earliest sowing and 12.7 t with sowing on 1 May, then decreased with further delay in sowing to 4.0 t with sowing on 15 June

Amjad *et al.* (2001) observed that sown seeds of okra cv. Pusa Sawani in the field (Pakistan) on various date i.e. 15 April, 25 April and 5 May, using different levels of N and P fertilizers. Maximum germination percentage was observed when crop was sown on either 25 April or 5 May. Plant height, number of days to flower and length of green pod were not affected by the sowing dates. Number of leaves per plant, number of pods per plant and green pod yield were higher when crop was sown on 15 April or 5 May. Germination percentage, green pod length and yield were not influenced by different levels of fertilizers used. Maximum plant height, number of leaves per plant, number of days to flower and number of pods per plant were obtained with the highest fertilizer rate (150 kg N + 80 kg P_2O_5 ha^{-1-1}). Germination percentage, number of days to flower and length of green pods were not influenced by the interaction between sowing time and fertilizer rate. Maximum plant height, number of leaves per plant, number of pods per plant and green pod yield were recorded when the crop was sown on 5 May and given the highest rate of fertilizers (150 kg N + 80 Kg P_2O_5 ha^{-1}).

Sajjan *et al.*(2002) studied an experiment in Bagalkot, Karnataka, India, to elucidate the effect of sowing date (15 June, 15 July (kharif), 15 November and 15 December (rabi)), spacing (60×20, 60×30 and 60×40 cm) and nitrogen rates (100, 125 and 150 kg ha^{-1}) 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 60×30 cm spacing and 150 kg N ha^{-1} recorded the highest yield attributes of branches per plant, fruits per plant length and girth of fruits in the kharif season.

Chapter III

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 location of the experimental plot

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to September 2007. The site is $23^0 46'$ N and $90^0 24'$ E latitude and at altitude of 9m from the sea level.

3.2 Characteristics of soil

The soil of the experiment was carried out in a medium high land belonging to the Modhupur Tract under the Agro Ecological Zone (AEZ) 28. The soil texture was silty loam, non-calcarious, dark grey soil of Tejgoan soil series with a pH 6.7. Soil samples of the experimental plot was collected from a depth of a 0 to 30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI) Farmgate, Dhaka. Details of the mechanical analysis of soil sample are shown in Appendix I.

3.3 Climate

The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to September) and scanty in the Rabi season (October to March). There was no rain fall during the month of December, January and February. The average maximum temperature during the period of investigation was 35.10°C and the average minimum temperature was 30.40°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity the period of the experiment were collected from Bangladesh Metrological Department, Agargoan, Dhaka and have been presented in (Appendix II).

3.4 Planting materials used for experiment

The okra variety "BARI Dherosh-1" was used in this study was resistant to yellow vein mosaic virus, a severe disease of okra. It was an open pollinated high yielding variety developed by the Vegetable Division of Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI). The variety was released for commercial cultivation in 1996.

3.5 Treatments of the Experiment

Experiment consisted of two factors:

Factor-A: Sowing time: Four dates of sowing were considered viz.

I. 1 April, 2007 (S1)
II. 16 April, 2007 (S_2)
III. 1 May, 2007 (S_3)
IV. 16 May, 2007 (S_4)

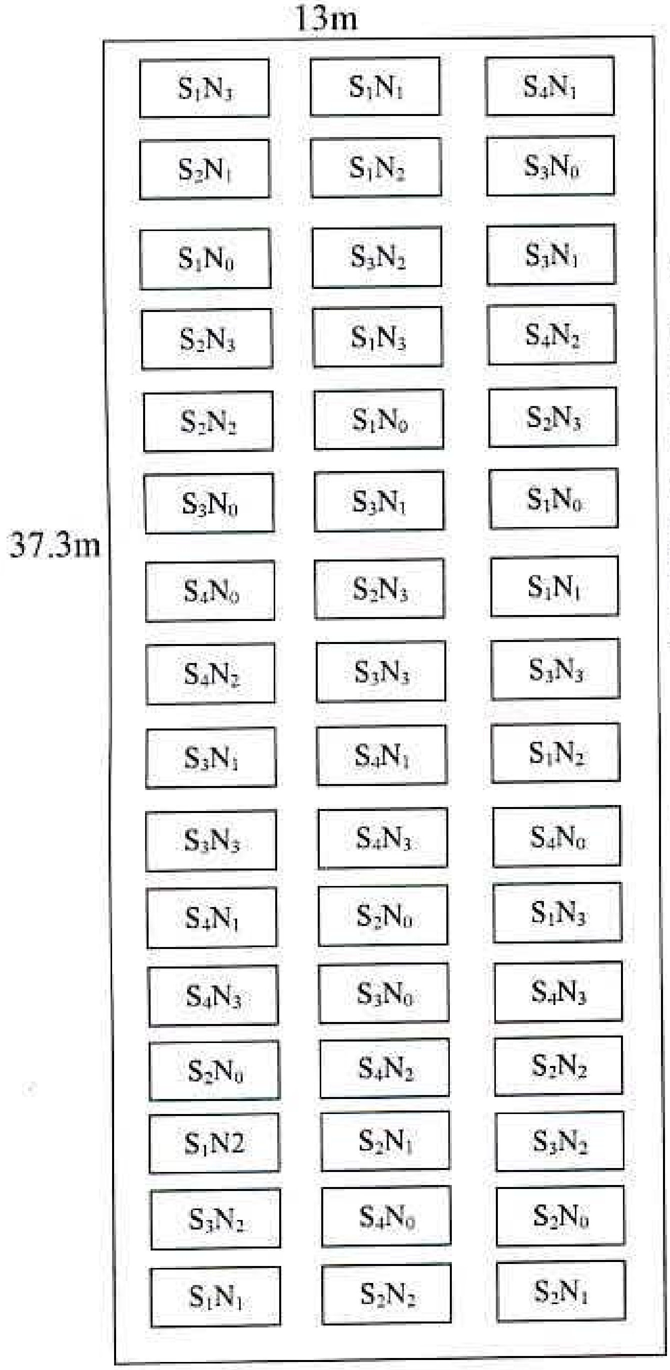
Factor-B: Levels of nitrogen: Four different levels of nitrogen were compared viz.

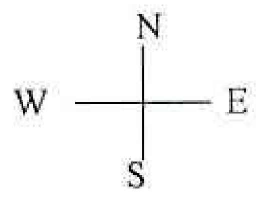
I. 0 kg N/kg (N_0)
II. 50 kg N/ha (N_1)
III. 100 kg N/ha (N_2)
IV. 150 kg N/ha (N_3)

3.6 Layout and design of experiment

The experiment consisting of 16 treatments combination was laid out in RCBD with three replications. The entire field was divided into three blocks and each block consisted of 16 plots. Altogether there were 48 unit plots in the experiment and required 484.9m^2 land. Each unit, bed was 5.4m^2 (3m ×1.8m) in size. The replications were separated from one another by 1m. The distance between plots were 0.50 m, plant to plant distance was 50 cm and row to row distance was 60 cm. The treatment was randomly assigned to each of the block. Each unit plot had 3 rows and each with 6 plants. So there were 18 plants per unit plot.

The layout of the experimental design is shown bellow:





Legend:

Number of treatments	: 16
Replications	: 3
Total plots	: 48
Total area	: 484.9m^2
Unit plot size	: 3m×1.8m
Plot to plot distance	: 0.5m
Block to block distance	: 1m
Row to row distance	: 60 cm
Plant to plant distance	: 50 cm

Factor	A	B
	S_1: 1 April, 2007	N_0 : kg N ha^{-1}
	S_2: 16 April, 2007	N_1 : 50 kg N ha^{-1}
	S_3: 1 May, 2007	N_2 : 100 kg N ha^{-1}
	S_4: 16 May, 2007	N_3 : 150 kg N ha^{-1}

Figure 1 : Layout of two factor experiment in Randomized Complete Block Design (RCBD)

3.7 Cultivation of okra

3.7.1 Land preparation

The selected land for the experiment was first opened on 15 March 2007 by power tiller and expose to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and laddering to obtain good tilth followed each ploughing. Weeds and stubble's were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. After removal of the weeds, stubble's and dead roots, the land was leveled and the experimental plot was partitioned in to the unit plots in accordance with the design, and the edge around each unit plot was raised to check run out of the nutrients.

3.7.2 Manure and fertilizer application

The entire quantity of cowdung (10 t/ha) was applied just after opening the land. Urea was applied as per treatment in each randomized plots of $5.4m^2$. Triple Super Phosphate (TSP) and Muriate of Potash (MP) were applied at the rate of 100kg/ha and 150kg/ha, respectively.

Full dose of TSP and cowdung were applied to the soil at the final land preparation. Urea and MP were applied as side dressing (ring method) in 3 equal installments at 15, 30 and 45 days after germination.

3.7.3 Sowing of seeds

Seed were sown at four different time's viz. 1 April, 16 April, 1 May and 16 May. In each plot, seeds were sown in rows maintaing spacing in each at 30×60 cm. Three seeds were sown in each location. Then the seeds were covered with fine soil by hand. The field was irrigated lightly immediately after sowing.

3.7.4. Intercultural operations

The seedlings were always kept under close observation. Necessary intercultural operations were done through the cropping season for ensuring the proper growth and development of the plants.

3.7.4.1 Thinning

When the seedling got established, one healthy seedling in each location was kept and other seedlings were removed.

3.7.4.2 Gap filling

Dead, injured and weak seedlings were replaced by new vigour seedling from the stock on the border line of the experiment.

3.7.4.3 Weeding

Four weeding were done manually at 15, 30, 45 and 60 DAS to keep the plots free from weeds.

3.7.4.4 Irrigation

Light overhead irrigation was provided with a watering can to the plots once immediately after sowing of seed and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings. When the soil moisture level was very low. Wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.7.4.5 Drainage

Stagnant water effectively drained out at the time of heavy rains.

3.7.4.6 Plant protection measure

To control lady's finger shoot and fruit borer Diazinon 60 EC @ 3.5ml/L was sprayed at an interval of 15 days started soon after the appearance of infestation. After fruit setting, Nogos @ 0.02% was sprayed at an interval of 7 days for controlling Jassid.

3.8 Harvesting

As the seeds were sown in the field at four different times, the crops were harvested at different times. Green pods were harvested at four days interval when they attained edible stage. Green pod harvesting was started from 12, May and was continued up to 15 August, 2007.

3.9 Parameters assessed

Ten plants were selected at random and harvested carefully from each plot and mean data on the following parameters were recorded:

- Plant height
- Plant diameter
- Number of leaves per plant
- Number of branches per plant
- Leaf length
- Leaf breadth
- Petiole length
- Number of days to first flowering
- Green pod length
- Green pod diameter
- Individual green pod weight
- Number of green pods per plant
- Green pod yield per plant
- Green pod yield per plot
- Green pod yield per hectare

3.10 Collection of data

For data collection on the yield of green pod of okra, out of 18 plants in each unit plot 10 plants were selected at random.. The following yield and yield contributing characters were considered for data collection.

3.10.1 Plant height

Average plant height of selected plants from each plot was recorded at 20, 40 and 60 days after sowing (DAS). It was measured with the help of a meter scale from the ground level to the tip of the longest stem in centimeter (cm).

3.10.2 Plant diameter

Average plant diameter was measured from random selected plants of each plot at 20, 40 and 60 days after sowing (DAS). The diameter was measured in centimeter (cm) with the help of slide calipers.

3.10.3 Number of leaves per plant

Number of leaves of selected plants from each plot at 20, 40 and 60 days after sowing (DAS) was recorded. Only the smallest young leaves at the growing point of the plant were excluded from counting. Calculating the average number of leaves, the average number was recorded.

3.10.4 Number of branches per plant

Average number of branches of selected plants from each plot6 at 20, 40 and 60 days after sowing (DAS) was recorded.

3.10.5 Leaf length

Leaves of selected plants were detached and measured at 20, 40 and 60 days after sowing (DAS). It was measured in centimeter (cm) with the help of a meter scale.

3.10.6 Leaf breadth

Leaves of selected plants were detached and leaf breadth was measured at 20, 40 and 60 DAS. It was measured one margin of leaf to another with the help of a meter scale and express in centimeter (cm).

3.10.7 Petiole length

Mean of petiole length was measured at 20, 40 and 60 days after sowing (DAS). It was measured with the help of a meter scale in centimeter (cm) from the point of attachment of the leaf.

3.10.8 Number of days to first flowering

Different dates of first flowering were recorded. Then the observation was made from the date of seed sowing, it was considered with the anthesis of flower.

3.10.9 Green pod length

Green pods were collected from the selected plants of each plot as per treatment and length was measured with the help of a meter scale in centimeter (cm).

3.10.10 Green pod diameter

Mean diameter of collected green pods from each plots as per treatment were measured in centimeter (cm) with the help of a slide calipers.

3.10.11 Weight of individual green pod

Weight of individual green pod collected from the selected plants was measured in gram (g) with the help of an electrical Blanca.

3.10.12 Number of green pods per plant

Mean number of green pods of selected plants from each plot as per treatment was recorded.

3.10.13 Green pod yield per plant

Mean weight of green pod per plant was estimated from 10 selected plants per plot.

3.10.14 Green pod yield per plot

Mean weight of green pods of each plot was measured in kilogram (kg).

3.10.15 Green pod yield per hectare

Green pod yield per hectare was calculated in metric ton by converting the mean green pods yield per plant.

3.11 Statistical analysis

The calculated data on various parameters were statistically analyzed using MSTAT package program. The mean for all the treatments were calculated and analysis of variance for all the characters was performed by F-variance test. The significance of difference between the pairs of treatment mean was calculated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The experiment was conducted to observe the effect of time of sowing and different levels of nitrogen fertilizer on the growth and yield of okra production. Analysis of variance for different characters has been presented in Appendices III to V. Data on different parameters were analyzed statistically and the results have been presented in the Table 1 to 7 and Fig. 1 to 8. The results of each parameter have been discussed and possible interpretations have been given wherever necessary.

4.1 Plant height (cm)

Different time of sowing exhibited significantly influence on the plant height of okra (Appendix III). At 20 DAS, the tallest plant (31.17 cm) was obtained from S_2 (16 April) treatment and the shortest (25.68 cm) from S_4 (16 May) treatment (Fig.1). At 40 DAS, the tallest plant (63.86 cm) was observed from S_2 (16 April) treatment and the shortest (56.51 cm) from S_4 (16 May) treatment. At 60 DAS, the tallest plant height (92.37 cm) was found from 16 April (S_2) treatment

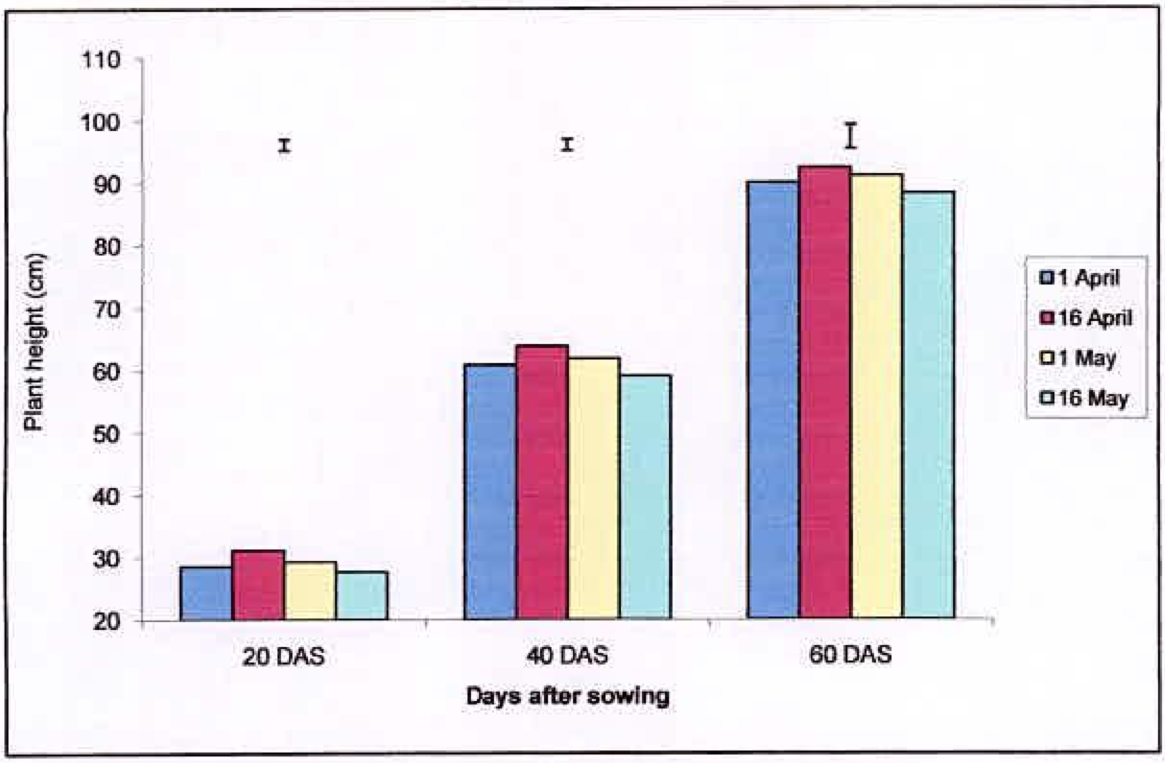


Fig. 1 Effect of sowing time on plant height of Okra. Bars represent LSD at 0.05 level of probability

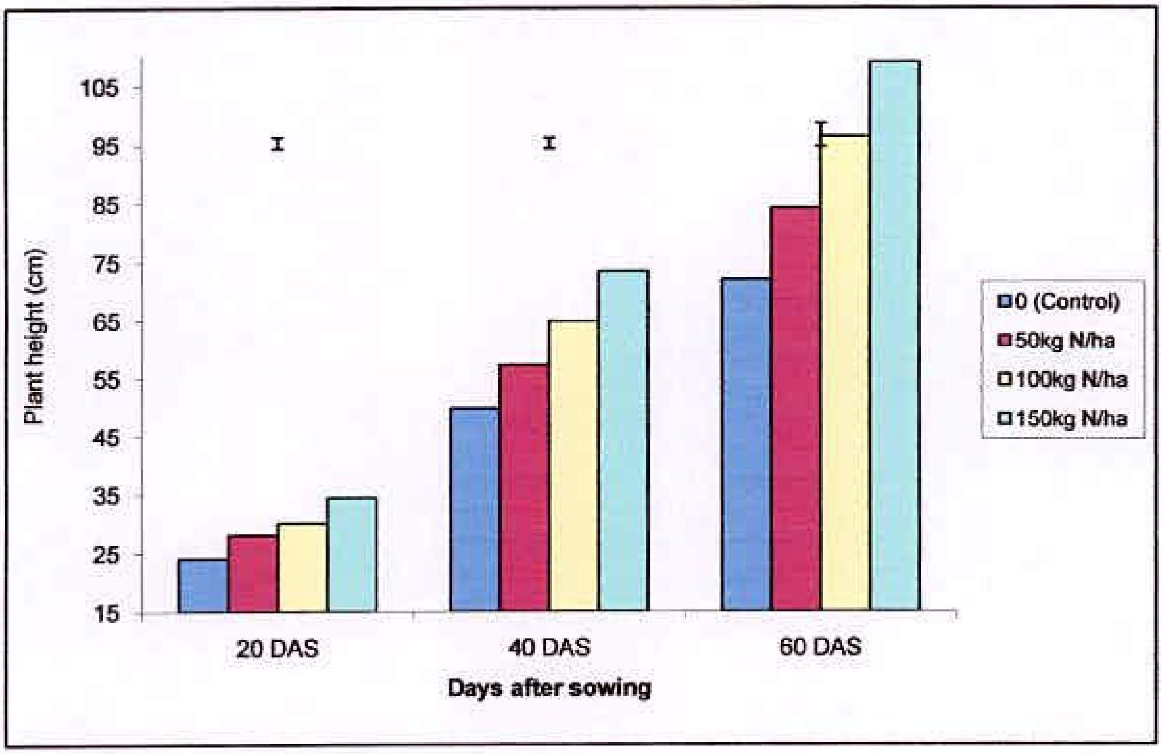


Fig. 2 Effect of levels of nitrogen on plant height of Okra. Bars represent LSD at 0.05 level of probability

and the shortest plant (83.93 cm) from S_4 (16 May) treatment (Fig 1). Mandal (1989) stated that the highest plant (84.5 cm) were obtained from sown plants on the 20 April.

Different levels of nitrogen fertilizer significantly influence plant height up to 60 DAS. The tallest plant height (107.95 cm) was obtained from 150kg N ha^{-1} and the shortest (70.92 cm) from control treatment (Fig 2). Singh (1995) reported that the height of plant increased with increasing levels of nitrogen.

Due to combination effect of time of sowing and different levels of nitrogen fertilizer exhibited non significant influence on plant height at different days after sowing (Appendix iii). However, the tallest plant (111.84 cm) was obtained from S_2N_3 whereas the shortest plant height (65.73 cm) from the treatment combination of S_4N_0 (Table 3).

4.2 Number of branches per plant

Significant variation was found in respect of number of branches per plant due to different sowing time and levels of nitrogen (Appendix III). The present study revealed that there was a highly significant effect on number of branches per plant due to time of sowing. The highest number of branches (1.74) was recorded from S_2 (April 16) and the lowest (1.30) from S_4 (16 May) treatment at 20 DAS. At 40 DAS, the maximum (3.59) and minimum (3.18) number of branches per plant were obtained from S_2 (16 April) and S_4 (16 May) treatment respectively. At 60 DAS the highest number of branches per plant (3.72) and the lowest number of branches per plant (3.35) was found from S_2 (16 April) and S_4 (16 May) treatment respectively (Table 1).

There were a significant influenced on number of branches per plant of 20, 40 and 60 DAS due to application different levels of nitrogen fertilizer. N_3 (150 kg N ha^{-1}) treatment gave the highest number of branches per plant (3.77) and the lowest number of branches per plant (3.22) was obtained from N_0 (0 kg N ha^{-1}) treatment (Table 2). Manga and Mohammed (2006) stated that nitrogen application increased number of branches per plant. Soni *et al.* (2006) also stated that number of branches increased with increasing rates of N up to 125 kg ha^{-1}.

Combined effect of sowing time and levels of nitrogen fertilizer was found significant on number of branches per plant of okra at 20, 40, 60 DAS (Appendix III). However, the treatment combination of S_2N_3 (16 April with 150kg N/ha) gave the highest number of branches (4.10) per plant and the lowest number of branches (3.04) per plant was obtained from S_1N_0 at 60 DAS (Table 3).

4.3 Plant Diameter

The study revealed that there was a significant effect of time of sowing on plant diameter of okra (Appendix III). The highest (1.50 cm) and the lowest (1.09 cm) plant diameter were recorded from S_2 (16 April) and S_4 (16 May) treatment respectively at 20 DAS. The maximum (1.90 cm) and minimum

(1.36 cm) plant diameter were obtained from S_2 (16 April) and S_4 (16 May) treatment respectively at 40 DAS. At 60 DAS, the highest plant diameter (2.94 cm) and the lowest (2.28 cm) was found from S_2 (16 April) and S_4 (16 May) treatment respectively (Table 1).

Different levels of nitrogen fertilizer significantly influence on plant diameter at 20, 40 and 60 DAS. However at 60 DAS, N3 (150 kg N ha^{-1}) treatment gave the highest plant diameter (2.95 cm) which was statistically similar to N_2 (2.77 cm) and the lowest (2.30 cm) from control treatment (Table 2).

Combined effect of time of sowing and different levels of nitrogen fertilizer performed significant variation on plant diameter of okra at 20 and 40 except 60 DAS (Appendix III). Treatment combination of S_2N_3 (16 April with 150 kg/ha) gave the highest plant diameter (3.33 cm) and the lowest (2.05 cm) from S_4N_0 (16 May with control) treatment at 60 DAS (Table 3).

4.4 Number of leaves per plant

The main effect of different time of sowing on number of leaves per plant at 20, 40 and 60 DAS were found to be statistically significant (Appendix III). However, at 20 DAS the maximum number of leaves per plant (6.73) was

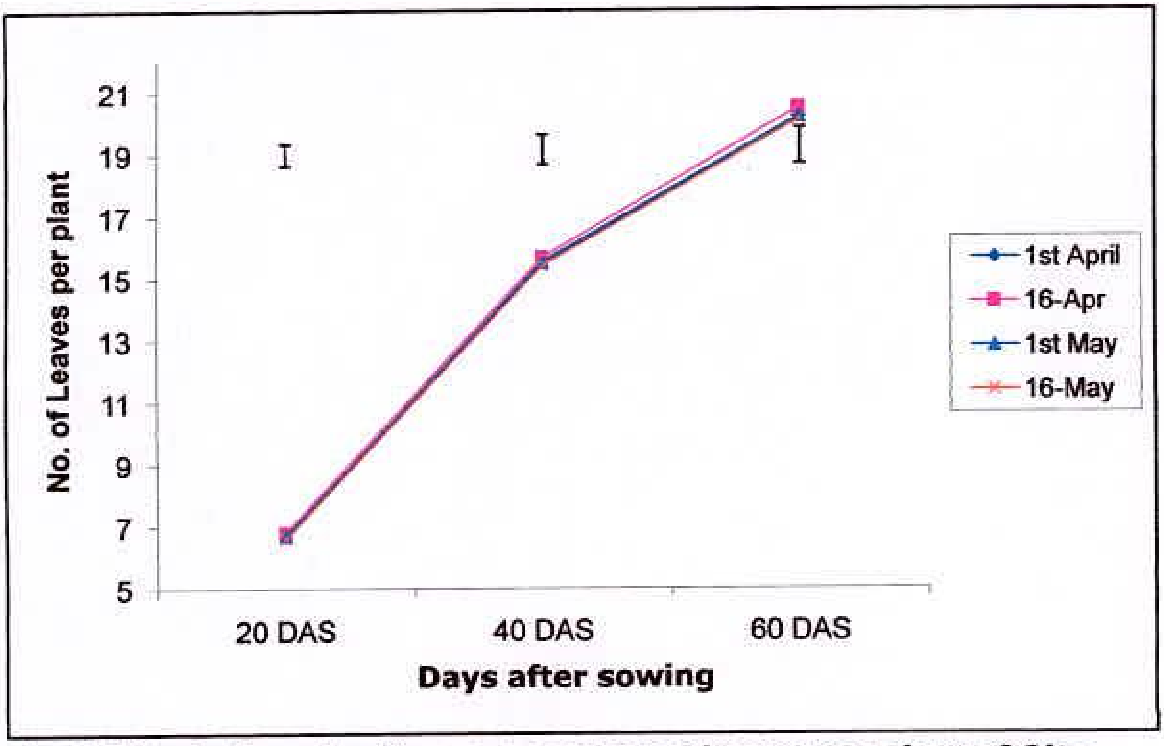


Fig. 3 Effect of sowing time on number of leaves per plant of Okra. Bars represent LSD at 0.05 level of probability

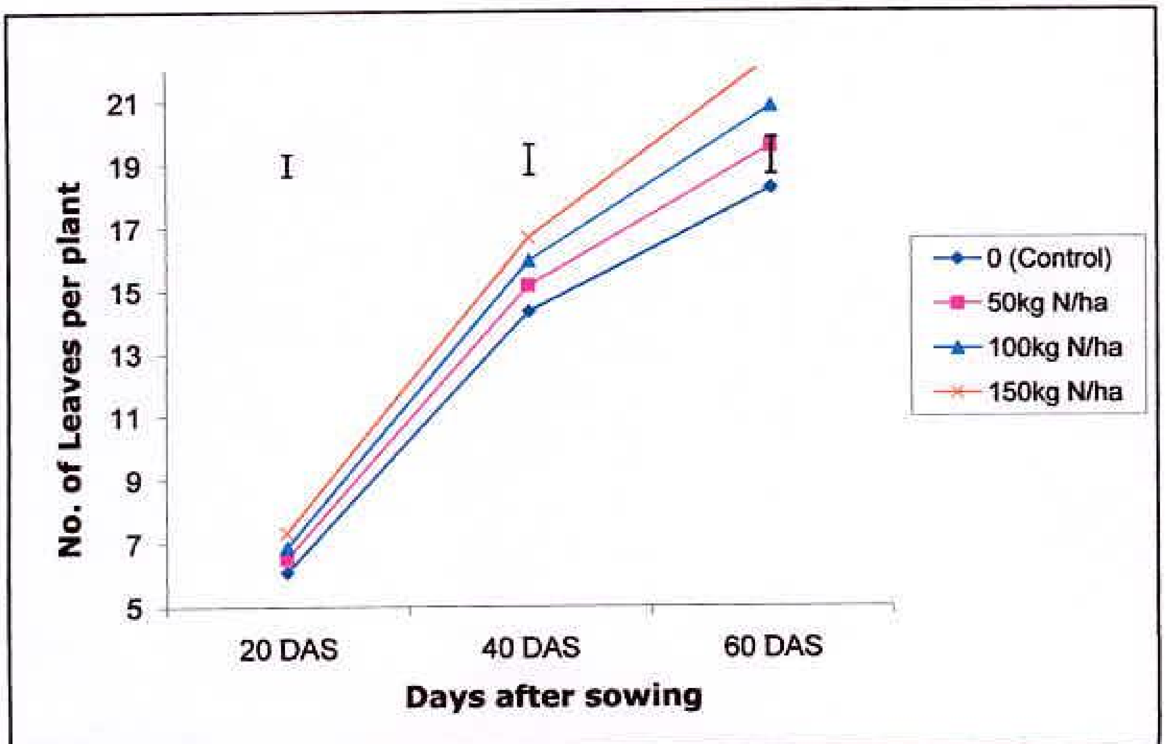


Fig. 4 Effect of Levels of nitrogen on number of leaves per plant of Okra. Bars represent LSD at 0.05 level of probability

recorded from S_2 (16 April) and the minimum (5.12) was recorded from S_4 (16 May) treatment. The number of leaves increase with the increase of time. At 40 DAS, S_2 (16 April) treatment gave the maximum number of leaves (15.99) and the minimum (13.46) from S_4 (16 May) treatment. At 60 DAS, the highest number of leaves per plant (20.64) were recorded from S_2 (16 April) and the lowest (18.14) from (S_4) 16 May treatment (Fig 3). These findings are in agreement with the result of Morales and Franco (1999). He reported that numbers of leaves are statistically significant differences for all planting dates.

A significant effect was found on number of leaves per plant at 20, 40 and 60 DAS. However, at 60 DAS N_3 (150 kg N ha^{-1}) showed the maximum number of leaves per plant (21.89) and the lowest (17.22) from N_0 (0 kg N ha^{-1}) and control treatment, respectively (Fig 4). Patton (2002) found 24.98 number of leaves per plant by using 150 kg nitrogen per hectare .

Combined effect of time of sowing and different levels of nitrogen fertilizer showed non-significant effect on number of leaves per plant at 20, 40 and 60 DAS. At 60 DAS 16 April combined with N_3 (150 kg N ha^{-1}) showed the maximum number of leaves per plant (23.03) and minimum (16.26) from S_4 (16 May) and control treatment (Table 3).

Table 1. Effect of time of sowing on the growth and yield of okra

Sowing date	No. of branches/plant			Plant diameter (cm)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1	1.54c	3.29c	3.40c	1.25c	1.46c	2.69b
S_2	1.74a	3.59a	3.72a	1.50a	1.90a	2.94a
S_3	1.59b	3.42b	3.51b	1.30b	1.60b	2.70b
S_4	1.30d	3.18d	3.35d	1.09d	1.36d	2.28c
$LSD_{(0.05)}$	0.03729	0.05273	0.04567	0.0264	0.013	0.206
Level of significance	**	**	**	**	**	**
CV (%)	3.88	3.94	4.63	4.73	4.03	9.29

S1 = 1 April
S_2 = 16 April
S_3 = 1 May
S_4 = 16 May

* = Significant at 5 level of probability
** = Significant at 1 level of probability
NS = Not significant

Table 2. Effect of Levels of nitrogen on the growth and yield of okra

Doses of Nitrogen	No. of branches/plant			Plant diameter (cm)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
N_0	1.36d	3.09d	3.22d	1.13d	1.32d	2.30c
N_1	1.48c	3.33c	3.43c	1.23c	1.48c	2.59b
N_2	1.59b	3.45b	3.55b	1.31b	1.66b	2.77ab
N_3	1.74a	3.61a	3.77a	1.48a	1.87a	2.95a
$LSD_{(0.05)}$	0.037	0.053	0.0457	0.0263	0.01291	0.2059
Level of significance	**	**	**	**	**	**
CV (%)	3.88	3.94	4.63	4.73	4.03	9.29

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

* = Significant at 5 level of probability
** = Significant at 1 level of probability
NS = Not significant.

Table 3. Combined effects of time of sowing and levels of nitrogen on the growth and yield of okra

Levels of nitrogen × Sowing time	Plant height (cm)			No. of branches/plant			Plant diameter (cm)			No. of leaves per plant		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1N_0	23.79	47.08	71.40	1.33hi	3.03g	3.16j	1.07hi	1.24h	2.22	5.28	14.05	17.13
S_1N_1	27.66	56.96	83.80	1.45fg	3.32e	3.38gh	1.20g	1.34fg	2.70	5.79	15.18	19.54
S_1N_2	29.75	64.69	96.20	1.63cd	3.35de	3.51ef	1.32ef	1.53de	2.86	6.11	15.96	20.85
S_1N_3	33.08	72.42	108.60	1.74b	3.44cd	3.55e	1.41bc	1.71c	2.99	6.81	16.76	22.17
S_2N_0	25.12	51.52	73.68	1.55de	3.32e	3.41g	1.27f	1.60d	2.56	6.13	14.37	18.27
S_2N_1	29.32	59.04	85.87	1.65c	3.44cd	3.65cd	1.38cd	1.77c	2.79	6.38	16.21	20.13
S_2N_2	31.42	66.56	98.07	1.79b	3.61b	3.71bc	1.46b	1.98b	3.07	6.87	16.35	21.13
S_2N_3	38.80	78.32	111.84	1.98a	3.96a	4.10a	1.90a	2.24a	3.33	7.55	17.04	23.03
S_3N_0	24.67	50.71	72.87	1.41gh	3.20f	3.25i	1.17g	1.29gh	2.36	5.38	14.05	17.20
S_3N_1	28.36	58.15	84.99	1.50ef	3.37de	3.42fg	1.28f	1.50e	2.66	5.57	15.17	19.56
S_3N_2	30.26	65.59	97.11	1.62cd	3.51bc	3.58de	1.33de	1.71c	2.81	5.83	16.01	20.87
S_3N_3	33.78	73.05	109.23	1.81b	3.62b	3.78b	1.43bc	1.91b	2.98	6.13	16.42	22.15
S_4N_0	20.64	45.33	65.73	1.15j	2.82h	3.04k	1.00j	1.14i	2.05	4.44	12.30	16.26
S_4N_1	24.87	52.78	77.86	1.29i	3.17f	3.29hi	1.05ij	1.31gh	2.22	5.06	13.12	17.54
S_4N_2	27.01	60.23	89.99	1.32i	3.31e	3.39g	1.12h	1.40f	2.32	5.25	13.86	18.57
S_4N_3	30.21	67.70	102.12	1.45fg	3.42cde	3.66cd	1.18g	1.60d	2.52	5.72	14.57	20.20
$LSD_{(0.05)}$	2.9562	2.8906	6.3156	0.0746	0.1055	0.0913	0.0527	0.0746	0.1179	0.2358	0.3293	0.3981
Level of significance	NS	NS	NS	**	**	**	**	**	NS	NS	NS	NS
CV (%)	6.18	3.96	4.24	3.88	3.94	4.63	4.73	4.03	9.29	4.57	4.12	3.95

4.5 Leaf length

The effect of different time of sowing showed significant variation on leaf length at 40 and 60 except at 20 DAS (Appendix IV). At 20 DAS the longest leaf (8.31 cm) was obtained from S_2 (16 April) and the shortest (6.54 cm) from S_4 (16-May) treatment. 16 April treatment produced longest leaf length (17.08 cm and 17.89 cm) at 40 and 60 DAS respectively and S_4 (16 May) produced the shortest leaf length 14.48 cm and 15.38 cm at 40 and 60 DAS respectively (Table 4).

Different levels of nitrogen fertilizer performed significantly influenced on leaf length at 20 and 60 DAS. The longest leaf length (17.90 cm) was found from N_3 (150 kg N ha^{-1}) treatment and the shortest (15.42 cm) from control treatment at 60 DAS (Table 5).

Combined effect of sowing time and doses of nitrogen fertilizer significantly influenced on leaf length. The longest leaf length (19.03 cm) was found from S_2N_3 (16 April with 150 kg N ha^{-1}) and the shortest (14.39 cm) from S_4N_0 (16 May with control) treatment at 60 DAS (Table 6).

4.6 Leaf Breadth

A significant variation was found on leaf breadth at different time of sowing (Appendix IV). At 20 DAS, the widest leaf breadth (8.67 cm) was observed from S_2 (16-April) treatment and narrowest (6.68 cm.) from S_4 (16 May). At 40 DAS the maximum leaf breadth (22.08 cm) was observed from S_2 (16 April) and the lowest (19.07 cm) from S_4 (16 May). At 60 DAS the highest (23.06 cm.) and the lowest (20.74 cm) leaf breadth was observed from S_2 (16 April) and S_4 (16 May) respectively (Table 4).

Application of different doses of nitrogen fertilizer showed significant influence on leaf breadth at different days after sowing (DAS). The widest leaf breadth (23.48 cm) was found from 150 kg N ha^{-1} and the lowest (20.27) from control treatment (Table 5).

The combined effect of sowing time with different levels of nitrogen fertilizer influence on leaf breadth at 40 DAS but non-significant at 20 and 60 DAS. The highest leaf breadth (24.63 cm) was observed from the treatment combination of 16 April with 150 kg N ha^{-1} (S_2N_3) and the lowest (19.35 cm) from 16 May with control treatment of nitrogen fertilizer (S_4N_0) at 60 DAS (Table 6).

4.7 Petiole length (cm)

Petiole length was to be observed significant at 20, 40 and 60 DAS (Appendix IV). At 20 DAS, the longest petiole (7.05 cm) was obtained from S_2 (16 April) treatment which statistically identical with (7.00 and 6.95 cm) from S_3 (1 May) and S_1 (1 April) respectively and the shortest petiole length (5.32 cm) was obtained from S_4 (16 May) treatment. 16 April treatment (S_2) produced longest petiole length (17.68 cm and 21.97 cm) at 40 and 60 DAS respectively and S_4 (16 May) produced the shortest petiole length 15.37 cm and 19.56 cm at 40 and 60 DAS respectively (Table 4).

Different levels of nitrogen fertilizer showed significant influence on petiole length at 20, 40 and 60 DAS. The longest petiole length (22.18 cm) was found from N_3 (150 kg N ha^{-1}) while the shortest (19.44 cm) from control condition (Table 5).

Combined effect of sowing time and doses of nitrogen fertilizer significantly influenced on the petiole length at 40 and 60 DAS but non-significant was found at 20 DAS. The highest petiole length (23.10 cm) was found from 16 April with 150 kg N ha^{-1} (S_2N_3) and the shortest (18.46 cm) from (S_4N_0)16 May with control treatment in this respect at 60 DAS (Table 6).

Table 4. Effect of time of sowing on the growth and yield of okra.

Sowing date	Leaf Length (cm)			Leaf Breath (cm)			Petiole Length(cm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
S_1	8.13	16.15b	17.22b	8.22b	21.17c	22.05b	6.95a	17.25b	21.36b
S_2	8.31	17.08a	17.89a	8.67a	22.08a	23.06a	7.05a	17.68a	21.97a
S_3	8.04	16.30b	17.25b	8.25b	21.44b	21.92b	7.00a	17.34b	21.50b
S_4	6.54	14.48c	15.38c	6.68c	19.07d	20.74c	5.32b	15.37c	19.56c
Level of significance	NS	**	**	**	**	**	**	**	**
CV (%)	4.95	4.65	4.70	4.38	4.39	4.21	4.45	4.16	1.22

Table 5. Effect of doses of nitrogen on the growth and yield of okra.

Levels of Nitrogen	Leaf Length (cm)			Leaf Breath (cm)			Petiole Length(cm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
N_0	7.11	14.51d	15.42c	7.01c	19.44d	20.27d	6.01c	15.42d	19.44d
N_1	7.54	16.10c	17.14b	8.10b	20.97c	21.58c	6.07c	16.98c	21.27c
N_2	7.94	16.38b	17.27b	8.29ab	21.39b	22.43b	6.46b	17.29b	21.49b
N_3	8.42	17.02a	17.90a	8.41a	21.96a	23.48a	7.77a	17.96a	22.18a
Level of significance	NS	**	**	**	**	**	**	**	**
CV (%)	4.95	4.65	4.70	4.38	4.39	4.21	4.45	4.16	1.22

Table 6. Combined effect of time of sowing and Levels of nitrogen on the growth and yield of okra

Levels of Nitrogen × Sowing time	Leaf length (cm)			Leaf breath (cm)			Petiole Length (cm)		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1N_0	7.41	14.51g	15.43f	7.10	19.61g	20.18	6.39	15.55f	19.18g
S_1N_1	7.91	16.13e	17.60d	8.42	21.38e	21.77	6.44	17.32d	21.76d
S_1N_2	8.31	16.65d	17.65d	8.63	21.59de	22.80	6.82	17.76c	22.00d
S_1N_3	8.89	17.32b	18.19bc	8.71	22.10cd	23.43	8.14	18.38b	22.48bc
S_2N_0	7.71	15.67f	16.56e	8.09	20.82f	21.42	6.47	16.37e	20.71e
S_2N_1	8.10	17.16bc	17.85bcd	8.64	21.97cd	22.66	6.52	17.71c	21.86d
S_2N_2	8.42	17.40b	18.11bcd	8.86	22.43bc	23.52	6.96	17.92c	22.19cd
S_2N_3	9.01	18.07a	19.03a	9.10	23.12a	24.63	8.22	18.73a	23.10a
S_3N_0	7.20	14.33g	15.30f	7.01	19.72g	20.11	6.42	15.57f	19.42fg
S_3N_1	7.86	16.65d	17.65d	8.58	21.19ef	21.70	6.49	17.56cd	21.79d
S_3N_2	8.24	16.82cd	17.74cd	8.67	22.08cd	22.34	6.87	17.83c	22.08cd
S_3N_3	8.85	17.39b	18.31b	8.72	22.76ab	23.51	8.20	18.40b	22.71ab
S_4N_0	6.11	13.53h	14.39g	5.86	17.59h	19.35	4.76	14.19g	18.46h
S_4N_1	6.30	14.46g	15.46f	6.76	19.36g	20.20	4.84	15.32f	19.67f
S_4N_2	6.81	14.64g	15.57f	7.01	19.47g	21.05	5.18	15.66f	19.70f
S_4N_3	6.93	15.29f	16.08e	7.11	19.87g	22.35	6.51	16.32e	20.42e
Level of significance	NS	**	**	NS	**	NS	NS	**	**
CV (%)	4.95	4.65	4.70	4.38	4.39	4.21	4.45	4.16	1.22

4.8 Number of pods yield per plant

Different time of sowing showed significant variation on pod yield per plant (Appendix V). The maximum pods yield per plant (22.80) was recorded from S_2 (16 April) whereas, the lowest (20.48) from S_4 (16 May) treatment (Fig. 4.5). Similar result was also observed by Mondal (1989) found that highest number of pods/plant (10.9) was obtained with sowing on the 20 Apr. Yadav and Dhankhar (1999) find out in the number of pods per plant (24.13) at Sowing on 13 June.

Number of pods per plant was varied due to application of different doses of nitrogen. The highest number of pods per plant (23.46) was found from 150kg N ha^{-1} and control treatment gave the lowest number of pods per (20.25). The number of leaf, length and breath of leaf contributed the number of pods per plant. It may be more sunlight absorbed and more produced food of the plants. The number of pods per plant gradually increased with the increasing of nitrogen rate (Fig. 4.6). Ahmad (1999) was found highest number of pods per plant (24.59) by using 120 kg nitrogen.

A significant variation was observed due to the combined effect of different time of sowing and levels of nitrogen fertilizer on number of pods per plant. The highest number of pods per plant (24.58) was obtained from 16 April

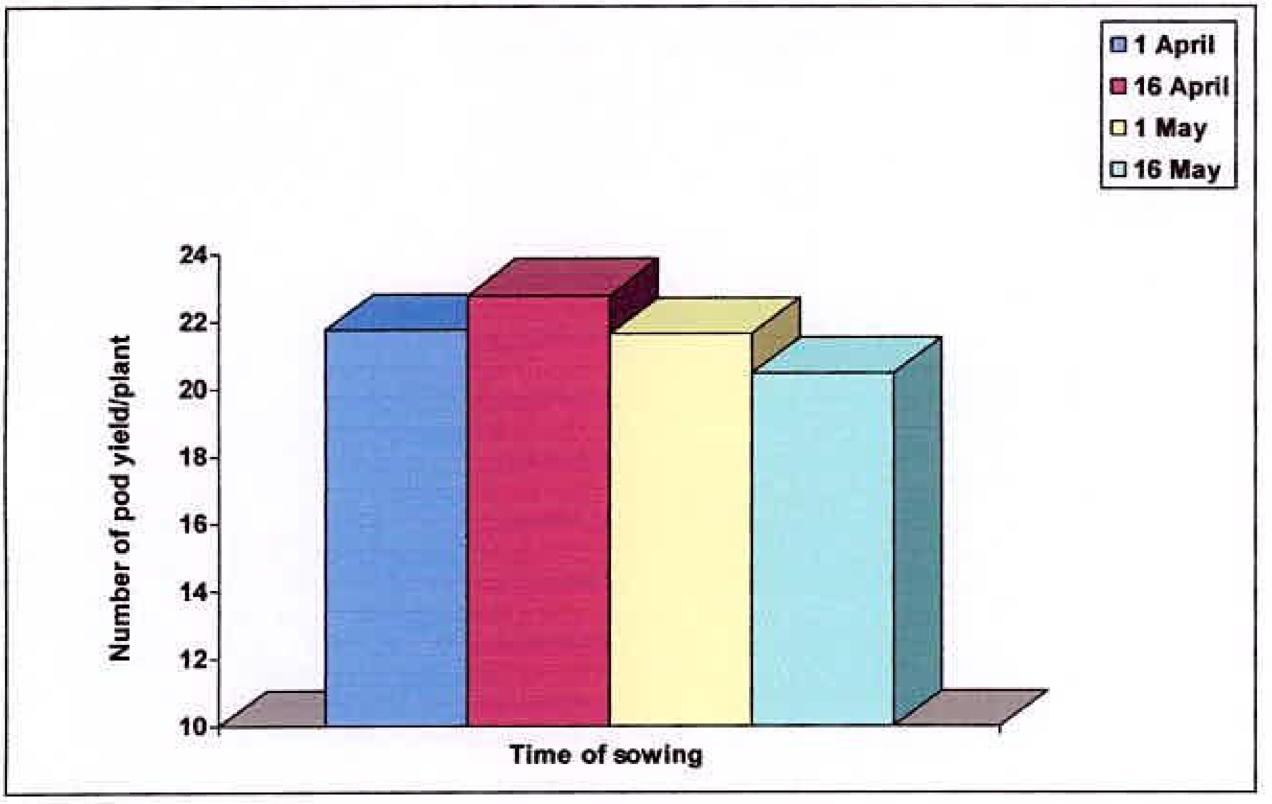


Fig. 4.5 Effect of time of sowing on number of pods yield/plant of Okra. Bars represent LSD at 0.05 level of probability.

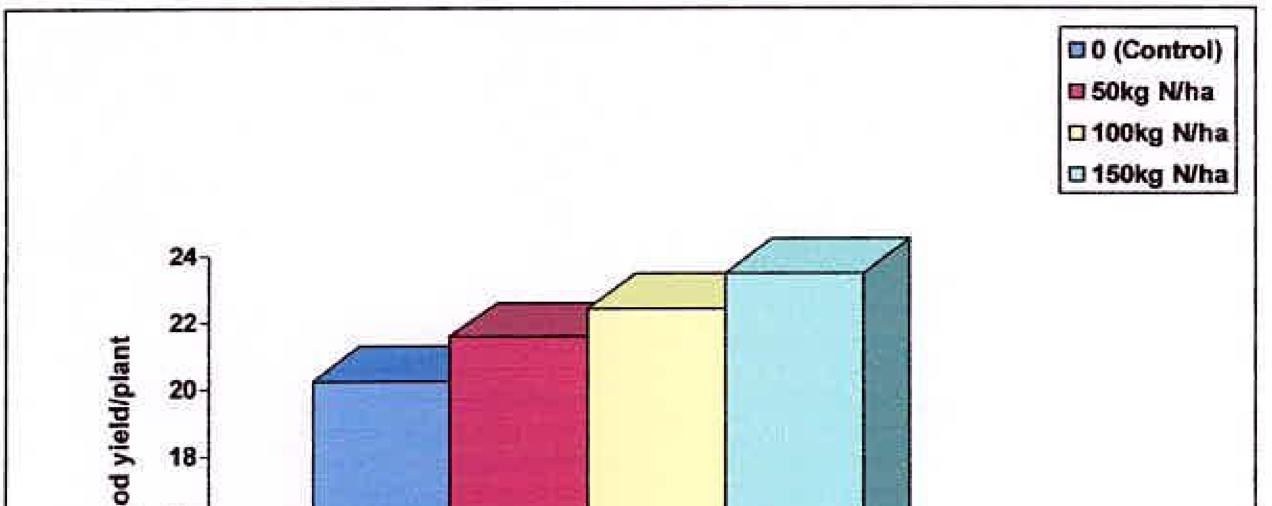


Fig.4.6 Effects of levels of nitrogen on number of pods yield/plant of Okra. Bars represent LSD at 0.05 level of probability.

with 150 kg N ha^{-1} and the lowest (20.02) from S4 (16 May) with control treatment (Table 9).

4.9 Pod length (cm)

Different time of sowing showed significant variation on the pod length (Appendix V). The maximum pod length (13.98 cm) was recorded from 16 April. Whereas, the lowest pod length (10.76 cm) was obtained from S_4 (16 May) (Table 7). Yadav and Dhankhar (1999) find out pod length (19.11 cm) at Sowing on 13 June. These findings are also in aggrement with the result of Morales and Franco (1999). They reported that pod length differed significantly for all planting dates.

Different levels of nitrogen showed significant effect on the length of pod. The highest length of pod (13.50 cm) was observed from 150 kg N ha^{-1} and the lowest (11.24 cm) from control treatment (Table 8).

The combined effect of different time of sowing and doses of nitrogen fertilizer on pod length was significant (Appendix V). The highest pod length (15.17 cm) was obtained from 16 April with 150kg N ha^{-1} and the lowest (9.92 cm) from S_4 (16 May) with control treatment (Table 9).

4.10 Pod diameter (cm)

The effect of different time of sowing on pod diameter was found to be statistically significant (Appendix V). However the maximum pod diameter (1.96 cm) was recorded from S_2 (16 April) treatment and the minimum (1.50 cm) from S_4 (16 May) treatment (Table 7).

A significant effect was found on pod diameter (Appendix V). The maximum pod diameter (1.93 cm) was found from N_3 and the minimum (1.66 cm) from control treatment (Table 8). The findings of Patton et al. (2002) were in agreement with the present result. They stated that 150 kg N produced the highest pod diameter.

Combined effect of different time of sowing and levels of nitrogen showed significant on pod diameter. S_2 (16 April) combined with N_3 (150 kg N ha^{-1}) showed maximum pod diameter (2.23 cm) and the minimum (1.47 cm) from S_4 (16 May) with control treatment (Table 9).

4.11 Individual pod weight (g)

A significant variation was found due to the effect of time of sowing on individual pod weight (Appendix V). The maximum pod weight (19.40 g) was obtained from 16 April treatment (S_2) and the minimum (16.44 g) from S_4 (16 May) treatment (Table 7).

Weight of individual pod was found significant variation among doses of nitrogen. The highest weight of individual pod (18.75 g) was found at 150 kg

N ha^{-1}. On the contrary, the lowest weight of individual pod (15.25g) was found control treatment. Gradual increase in weight of individual pod with the increasing of nitrogen (Table 8). The finding of Patton *et al.* (2002) were in agreement with the present result. They stated that 150 kg N produced the highest pod weight.

The analysis of variance revealed that individual pod weight varied significant due to the combined effect of time of sowing and doses of nitrogen fertilizer (Appendix V). The maximum pod weight (21.00 g) was obtained from the treatment combinations of 16 April with 150 kg N ha^{-1} (S_2N_3) and the minimum (14.80 g) from S_4(16 May) with control treatment (Table 9).

4.12 Number of days to first flowering

Different sowing time exhibited no significantly influence on the number of days to first flowering (Appendix V). The time of sowing with S_2 (16 April) produce early flowering (37.50 days) and delay flowering (40.89 days) occurred in S_4 (16 May) treatment (Table 7).

A significant effect was to be found on the number of days to first flowering (Appendix V). The early number of days to first flowering showed (37.06 days) from 150 kg Nha^{-1} and delay (41.98 days) from control treatment (Table 8). Nitrogen enhances the flowering in this study. Patton (2002) stated that the lowest number of days to flowering was found by using 150 kg nitrogen per hectare

Combined effect between time of sowing and doses of nitrogen fertilizer showed significant on number of days to first flowering. S_2 (16 April) combined with N_3 (150 kg N ha^{-1}) showed early number of days to first flowering (35.62 days) and the delay (44.04 days) from S_4(16 May) with control treatment (Table 9).

4.13 Pod yield per plant

Different time of sowing showed significant variation on pod yield per plant (Appendix V). The maximum pod yield per plant (273.10 g) was recorded from S_2 (16 April) whereas, the lowest (244.63 g) from S_4 (16 May) treatment (Table 7). These finding are in agreement with the results of Mondal (1989). He reported that the pod yield per plant was maximum in early sown crops rather than crops sown after 20 April.

Weight of pods per plant varied significantly due to application of different doses of fertilizer. The highest weight of pods per plant (277.39 g) was found from 150kg N ha^{-1} while the control treatment gave the lowest (240.00 g) yield. Weight of pods per plant at control treatment was low particularly due to lower weight of individual pod. On the contrary, at 150 kg N ha^{-1} the number of pods per plant was close to the highest and the weight of individual pod was relatively much higher leading to the highest total weight of pods per plant. (Table 8). Naik and Singh (1999) found that pods yield per plant increased with increasing rates of N up to 150 kg N ha^{-1}.

The combined effect of different time of sowing and doses of nitrogen on pod yield was significant. The highest yield of pod per plant (291.20 g) was obtained from 16 April with 150kg N ha^{-1} (S_2N_3). The lowest pod yield per plant (228.60 g) was recorded from S_4 (16 May) with control treatment (Table 9).

4.14 Pod yield per plot

A significant variation in different time of sowing showed on the pod yield per plot (Appendix V). The maximum pod yield per plot (4.84 kg) was recorded from 16 April. Whereas, the lowest pods yield (3.65 kg) was obtained from S_4 (16 May) (Table 7). These finding are in agreement with the results of Mobdal (1989). He reported that the total yields per plot were maximum in early sown crops rather than crops sown after 15 April.

The weight of pod per plot among doses of nitrogen fertilizer was found significant. The highest weight of pod per plot (5.10 kg) was found on 150 kg N ha^{-1} and the lowest (3.10 kg) from control treatment. Production of the highest weight of pods per plot at 150 kg N ha^{-1} was due to the combination of weight of pod and number of pod per plant (Table 8).

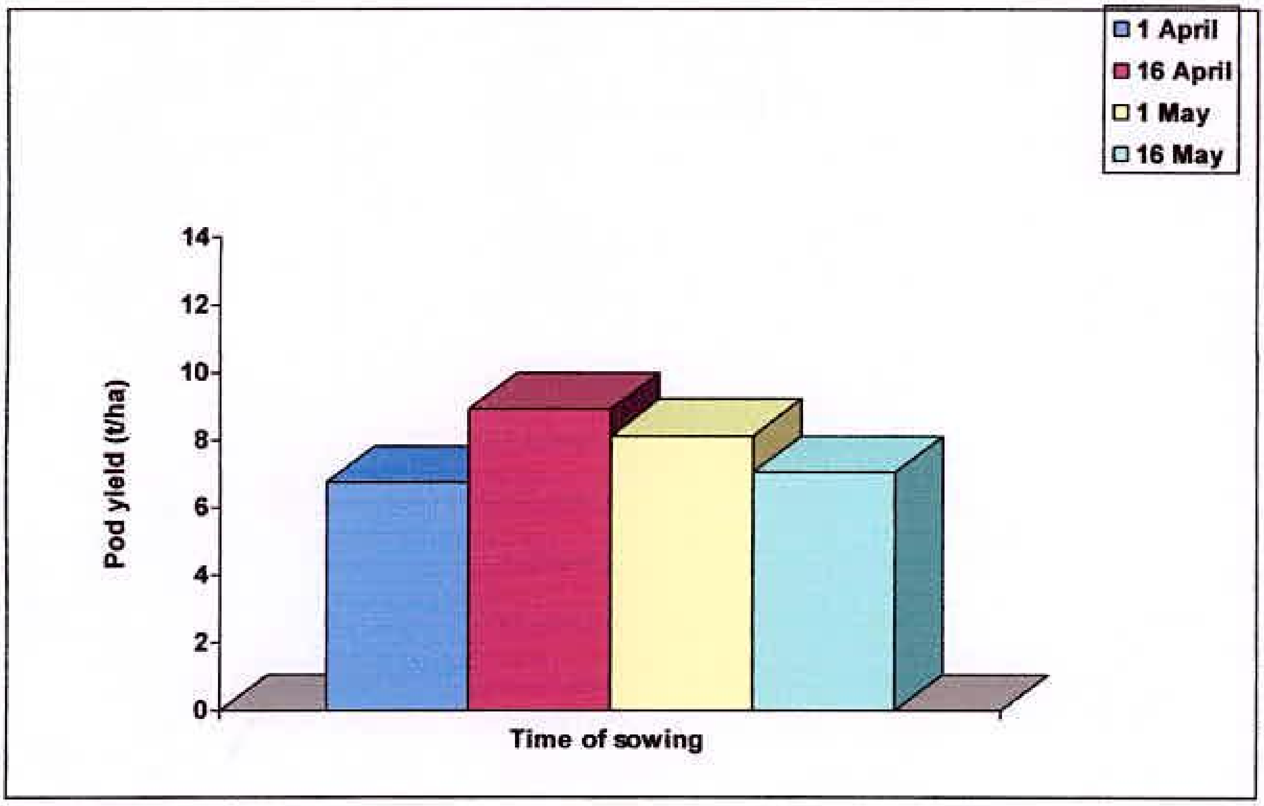


Fig. 4.7 Effect of time of sowing on pod yield (t/ha) Okra. Bars represent LSD at 0.05 level of probability.

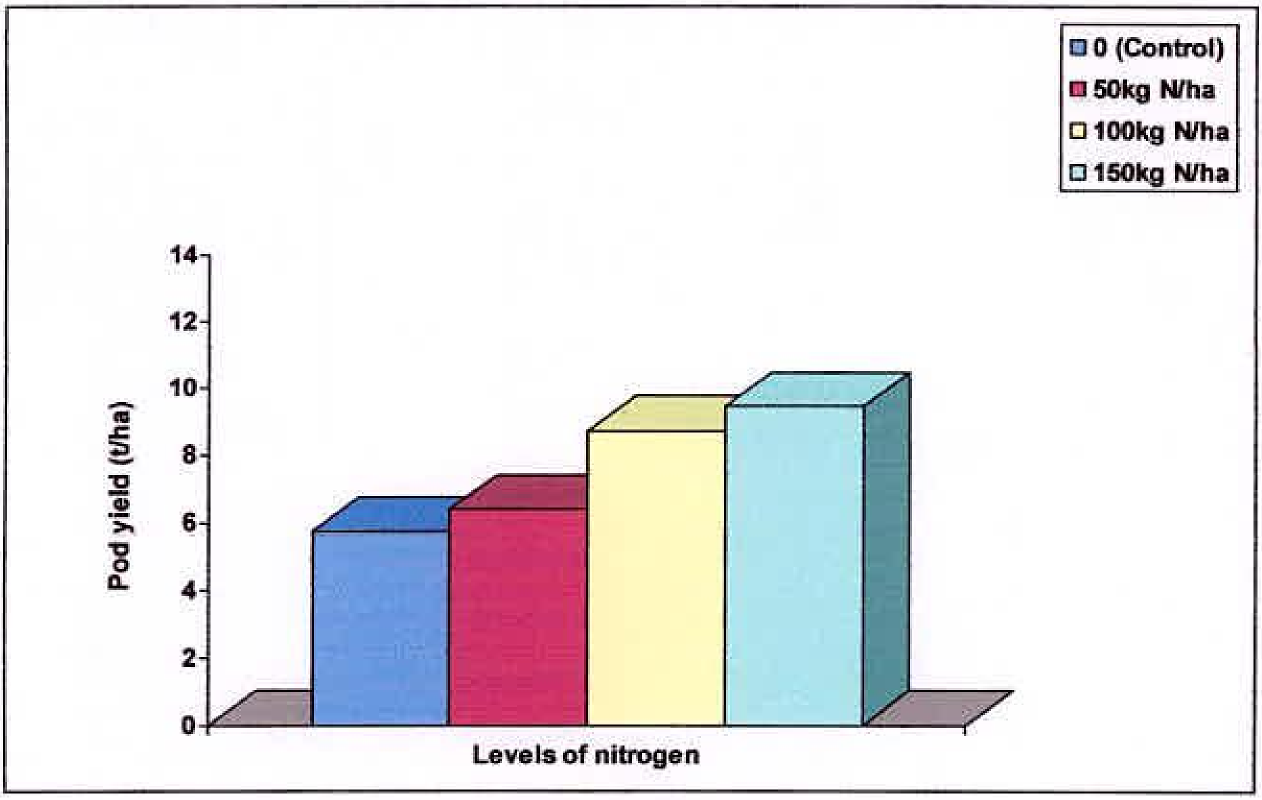


Fig. 4.8 Effects of levels of nitrogen on pod yield (t/ha) of Okra. Bars represent LSD at 0.05 level of probability.

A significant variation was found due to the combined effect of different time of sowing and levels of nitrogen on pod yield (Appendix V). The highest yield of pod per plot (4.85 kg) was obtained from the treatment combination of 16 April with 150kg N ha^{-1} (S_2N_3) and the lowest (2.66 kg) from S_4 (16 May) with control treatment (Table 9).

4.15 Pod yield per hectare

Different time of sowing showed a highly significant variation on the pod yield per hectare (Appendix V). The maximum pod yield per hectare (8.96 tons) was recorded from 16 April whereas, the lowest (6.75 tons) from S_4 (16 May) treatment (Fig. 7). These finding are in agreement with the results of Mondal (1990) stated that the highest yield (9 t ha^{-1}) were obtained from sowing on 20 April.

Different levels of nitrogen fertilizer influenced the yield of pods per hectare was significant. It was ranging from 5.74 t/ha to 9.44 t/ha. The maximum yield of pods (9.44 t/ha) was recorded from 150 kg N $ha^{-1}$and the minimum (5.74 t/ha) from control treatment particularly due to lower weight of individual pod. At 150 kg N ha^{-1}, the yield of pod was maximum due to the combination of number of pods per plant and weight of individual pod. Pod yield was gradually decreased due to decreasing number of pods per plant (Fig. 8). Naik and Singh (1999) found that pods yield per ha^{-1} increased with increasing rates of N up to 150 kg N ha^{-1}.

Combined effect of different time of sowing and doses of nitrogen fertilizer on pod yield per hectare was highly significant. The highest yield of pod yield (9.20 t/ha) was obtained from the treatment combination of S_2N_3 (16 April with 150 kg N ha^{-1})and the lowest (6.22 kg) from S_4N_0 (16 May with control treatment) (Table 9).

Table 7. Effect of time of sowing on the growth and yield of okra

Sowing time	No. of days to 1st flowering	Pod length (cm)	Pod diameter (cm)	Individual Pod weight (g)/Pod	Pod yield/plant (g)	Pod yield (kg/plot)
S_1	39.92b	12.70b	1.73b	18.02c	260.03b	3.82c
S_2	37.50c	13.98a	1.96a	19.40a	273.10a	4.84a
S_3	39.94b	12.74b	1.79b	18.44b	258.00c	4.40b
S_4	40.89a	10.76c	1.50c	16.44d	244.63d	3.65b
Level of significance	**	**	**	**	**	**
CV (%)	2.88	6.43	4.45	4.92	7.23	4.13

Table 8. Effect of levels of nitrogen on the growth and yield of okra

Levels of Nitrogen	No. of days to 1st flowering	Pod length (cm)	Pod diameter (cm)	Individual Pod weight (g)/Pod	Pod yield/plant (g)	Pod yield (kg/plot)
N_0	41.98a	11.24d	1.66d	15.25d	240.00d	3.10d
N_1	39.03c	12.47c	1.70c	16.60c	254.03c	3.45c
N_2	40.19b	12.97b	1.82b	17.88b	263.32b	4.70b
N_3	37.06d	13.50a	1.93a	18.75a	277.39a	5.10a
Level of significance	**	**	**	**	**	**
CV (%)	2.88	6.43	4.45	4.92	7.23	4.13

Table 9. Combined effect of time of sowing and Levels of nitrogen on the growth and yield of okra

Sowing time ×Levels of Nitrogen	No. of days to 1st flowering	Number of pod yield/plant	Pod length (cm)	Pod diameter (cm)	Individual Pod weight (g)/Pod	Pod yield/plant (g)	Pod yield (kg/plot)	Pod yield (t/ha)
S_1N_0	42.17b	20.44h	11.12g	1.57e	15.97j	238.05h	3.01h	6.40m
S_1N_1	39.54d	21.73e	12.89e	1.71d	17.41fg	257.06e	3.53f	6.56i
S_1N_2	40.85c	22.76c	13.21d	1.90c	18.95d	270.10c	4.02d	7.72g
S_1N_3	37.13f	23.40b	13.56c	1.95c	19.81c	277.02b	4.34c	8.09d
S_2N_0	39.56d	21.39f	12.82e	1.91c	17.80e	253.44f	3.55f	7.35h
S_2N_1	36.90f	22.61c	13.85b	1.93c	19.01d	268.30c	4.03d	7.67g
S_2N_2	37.93e	23.47b	14.09b	2.01b	19.80c	278.66b	4.36c	8.83c
S_2N_3	35.62g	24.58a	15.17a	2.23a	21.00a	291.20a	4.85a	9.20a
S_3N_0	42.15b	20.06h	11.10g	1.63e	16.05ij	237.78h	3.02h	6.94j
S_3N_1	39.56d	21.66e	12.43f	1.71d	17.19g	255.99e	3.48f	7.26i
S_3N_2	40.87c	22.33d	13.46cd	1.94c	19.57c	264.47d	4.08d	8.42e
S_3N_3	37.20f	23.55b	13.96b	1.98c	20.25b	277.98b	4.45b	8.79b
S_4N_0	44.04a	20.02i	9.92i	1.47g	14.80k	228.60i	2.66i	6.22h
S_4N_1	40.13d	20.17h	10.69h	1.50g	16.33i	238.83h	3.07h	6.72k
S_4N_2	41.13c	21.01g	11.11g	1.55ef	16.92h	248.99g	3.30g	7.88f
S_4N_3	38.27e	22.32d	11.32g	1.62e	17.63f	265.00d	3.68e	8.25c
Level of significance	**	**	**	**	**	**	**	**
CV (%)	2.88	7.87	6.43	4.45	4.92	7.23	4.13	6.19

Chapter V

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted to find out different sowing time and levels of nitrogen influence the growth and yield of okra. The experiment was carried out at the Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to September 2007. The experiment consisted of two factors such as (A) Sowing time: Four dates of sowing were considered viz. i) 1 April, 2007 (S_1), ii) 16 April, 2007 (S_2), iii) 1 May, 2007 (S_3) and iv) May, 2007 (S_4) (B) Levels of nitrogen: Four different levels of nitrogen were compared viz. i) 0 kg N/ha (N_0), ii) 50 kg N/ha (N_1), iii) 100 kg N/ha (N_2) and iv) 150 kg N/ha (N_3).

The experiment consisting of 16 treatments combination was laid out in RCBD with three replications. The whole field was divided into three blocks and each block consisted of 16 plots. Altogether there were 48 unit plots in the experiment and required 484.9m^2 lands. Each unit, bed was 5.4m^2 (3m $\times$1.8m) in size. The replications were separated from one another by 1m. The distance between plots was 0.50m, plant to plant distance was 50cm and row to row distance was 60cm. The treatment was randomly assigned to each of

Form each plot 10 plants were randomly selected and identified with tag for collection of data. Data were recorded on growth and yield contributing characters such as plant height, plant diameter, number of leaves per plant, number of branches per plant, leaf length, leaf breadth, petiole length, number of days to first flowering, green pod length, green pod diameter, individual green pod weight, number of green pods per plant, green pod yield per plant, green pod yield per plot, green pod yield per hectare. The data were statistically analyzed by using MSTAT package program to evaluate the treatment effects.

Different time of sowing and different levels of nitrogen exhibited significantly influence on the plant height of okra. The tallest plant height was found (92.37 cm) from S_2 (16 April) and the shortest (83.93cm) from S4 (16 May), at 60 DAS. The tallest plant height (107.95 cm) was obtained from 150kg N ha^{-1} and the lowest (70.92 cm) was obtained from control at, 60 DAS. Time of sowing and doses of nitrogen fertilizer combined 16 April with 150 kg N ha^{-1} showed the tallest plant height (111.84 cm) and the lowest (65.73 cm) from 16 May and control, at 60 DAS.

A significant effect of time of sowing on number of leaves per plant and the highest number of leaves per plant (20.60) and the lowest number of leaves per plant (18.14) was from S_2 (16 April) and S_4 (16 May) treatment respectively, at 60 DAS. Different levels of nitrogen have significantly influence on number of leaves per plant. At 60 DAS, the highest number of leaves per plant (21.89) and the lowest number of branches per plant (17.22) was obtained from N_3 and N_0 (control) respectively. Combined effect between time of sowing and different levels of nitrogen fertilizer was found non-significant on number of leaves per plant of okra at.

The effect of time of sowing, nitrogen fertilizer and combined with time of sowing and nitrogen fertilizer have highly significant influence on pod length, pod diameter, pod yield per plant, pod yield per hectare The highest results of pod length (13.98 cm), pod diameter (1.96 cm), pod yield per plant (273.10 g), pod yield per hectare (8.96 ton) were produced by the S_2 (16 April) and the lowest results of pod length (10.76 cm), pod diameter (1.50 cm), pod yield per plant (244.63 g), pod yield per hectare (6.75 ton) were produced by the S_4 (16 May)

The maximum pod length (13.50 cm), pod diameter (1.93 cm), pod yield per plant (277.39 g), pod yield per hectare (9.44 tons) were obtained from 150kg N ha^{-1}. The minimum result was obtained on the control or no fertilizer.

The highest result of pod length (15.17 cm), pod diameter (2.23 cm), pod yield per plant (291.20 g), pod yield per hectare (9.20 ton) were produced by combined with S_2 (16 April) and N3 (150 kg N ha^{-1}) treatment and lowest result was found from combined with S_4 (16 May) and control treatment.

Conclusion

Finally it may be concluded that for better growth and yield of okra 16 April may be considered as suitable time for sowing with 150 kg nitrogen per hectare.

Considering the situation of the present study, further studies in the following areas may be put forwarded:

1. In this study only four different time of sowing at 15 days intervals were investigated. More days' intervals performance may be investigated.
2. Here only time of sowing and nitrogen fertilizer was investigated. Time of sowing between or among other inorganic fertilizers performance may be investigated.
3. Time of sowing with time of application of nitrogen fertilizer interaction may be investigated.

Chapter VI

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Appendices

APPENDICES

Appendix I. Soil analysis data of the experiment plot

Constituents	Present
Sand	34.2
Silt	63.3
Clay	5.6
Textural class	Silty loam

Chemical analysis

Soil parameters	Analytical data
Soil pH	6.7
Organic carbon (%)	0.89
Total nitrogen (%)	0.077
Available phosphorus (ppm)	20.00
Exchangeable potassium (% me/100 g soil)	0.28
Available sulphur (ppm)	10.70

Source: SRDI, 2008.

Appendix II. Mean monthly temperature, relative humidity and rainfall of the experimental site during the period from April to September 2007.

Months	** Air temperature (^{0}C)			** Relative humidity (%)	* Rainfall (mm)
	Maximum	Minimum	Average		
April	32.03	23.33	27.68	70	167
May	35.10	26.30	30.90	63	163
June	32.70	25.68	28.13	79	476
July	31.50	25.40	28.90	76	498
August	32.30	26.50	29.40	76	194
September	30.40	25.50	28.26	83	833

** Monthly average

* Monthly total

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

Appendix III Analysis of variance of the data of plant height, no. of branches/plant, plant diameter (cm) and no. of leaves per plant of okra as influenced by different days after sowing and different levels of nitrogen.

Sources of variation	df	Means Square											
		Plant height			**No. of branches/plant**			**Plant diameter (cm)**			**No. of leaves per plant**		
		20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
Replication	2	0.775	2.378	10.462	0.001	0.004	0.002	0.003	0.009	0.104	0.101	0.046	0.116
Factor A (S)	3	62.085**	116.318**	167.35**	0.401**	0.367**	0.325**	0.352**	0.654**	0.911**	5.372**	14.908**	13.653**
Factor B (N)	3	225.507**	1286.328**	3040.642**	0.322**	0.569**	0.647**	0.264**	0.67**	0.93**	3.338**	13.669**	46.516**
AB (SxN)	9	3.314 NS	4.278 NS	0.527 NS	0.004**	0.021**	0.014**	0.028**	0.007**	0.021 NS	0.081 NS	0.129 NS	0.28 NS
Error	30	3.143	3.229	14.345	0.002	0.004	0.003	0.001	0.002	0.061	0.073	0.102	0.337

Appendix IV. Analysis of variance of the data of Leaf length (cm), Leaf breath (cm) and Petiole length(cm) of okra as influenced by different days after sowing and different levels of nitrogen.

Sources of variation	df	Means Square								
		Leaf length (cm)			**Leaf breath (cm)**			**Petiole length(cm)**		
		20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
Replication	2	0.102	0.187	0.107	0.141	0.106	0.043	0.002	0.036	0.248
Factor A (S)	3	8.041 NS	14.31**	14.086**	9.115**	20.396**	10.825**	8.422**	13.054**	13.357**
Factor B (N)	3	3.764 NS	13.642**	13.562**	4.902**	14.056**	22.151**	8.012**	13.89**	16.361**
AB (SxN)	9	0.071 NS	0.268**	0.299**	0.123 NS	0.168**	0.112 NS	0.001 NS	0.121**	0.442**
Error	30	0.094	0.07	0.083	0.072	0.085	0.071	0.086	0.039	0.067

Appendix V. Analysis of variance of the data of no. of days to 1st flowering, number of pod yield/plant, pod length(cm), individual pod weight (g)/pod, pod yield/plant, pod yield kg/plot and green pod yield t/ha of okra as influenced by different days after sowing and different levels of nitrogen

Sources of variation	df	Means Square							
		No. of days to 1st flowering	Number of pod yield/plant	Pod length(cm)	Pod diameter (cm2)	Individual Pod Weight (g)/Pod	Pod yield/plant	Pod yield kg/plot	Green pod yield t/ha
Replication	2	0.180	0.27	0.011	0.663	0.178	7.29	0.009	0.179
Factor A (S)	3	24.54**	13.314**	21.258**	1.773**	25.333**	2340.181**	3.815**	18.309**
Factor B (N)	3	14.423**	27.253**	11.225**	0.427**	35.111**	4280.634**	2.672**	28.056**
AB (SxN)	9	0.895**	0.195**	0.349**	0.185**	0.973**	17.795**	7.005 **	0.242**
Eror	30	0.12	0.123	0.025	0.314	0.427	6.003	1.200	0.417