EFFECT OF SOURCE OF NUTRIENTS AND SPACING ON THE GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L.)

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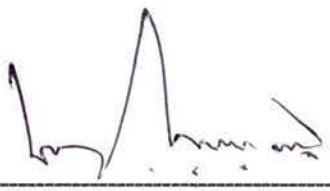

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This is to certify that the thesis entitled, EFFECT OF SOURCE OF NUTRIENTS AND SPACING ON THE GROWTH AND YIELD OF OKRA *(Abelmoschus esculentus* L.*) submitted to the Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN HORTICULTURE*** *embodies the result of a piece of bona-fide research work carried out byMD. JAHIRUL ISLAM,* ***Registration No. 00796*** *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.

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Dedicated To My
Beloved Parents

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By

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ABSTRACT

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during April 2007 to July 2007 to study the effects of spacing and source of nutrients on the growth and yield of okra. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was (3.0 m x 2.4m). There were 12 treatments combination in the experiment comprising 3 different spacing viz.,S_1 (60 X 20cm); S_2 (60 X 30cm) & S_3 (60 X 40cm) and 4 levels of sources of nutrients, F_0: no fertilizer (control); F_2 : cow dung(14 t/ha) ; F_3: compost (14 t/ha) and F_4 : inorganic fertilizer (urea 150 kg/ha+ TSP 100 kg/ha +MP 150 kg/ha). The individual and combined effect of spacing and sources of nutrients on the growth and yield of okra were significant. The results showed that plant height, plant diameter, number of leaves per plant, leaf length, leaf width and number of branches per plant were significantly affected by different spacing and source of nutrients at 40 days after sowing (DAS) and 60 DAS except 20 DAS. Pod length, pod diameter, number of pod per plant, pod weight per plot and pod yield per hectare was also influenced significantly by different spacing and sources of nutrients. The wider spacing (60 X 40cm) produced higher yield (7.38 t/ha) and lowest yield (5.51 t/ha) was produced by higher spacing (60 X 20cm). Again inorganic fertilizer (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) gave the highest yield (7.36 t/ha), while control treatment gave the lowest yield (5.69 t/ha). The combined effect of spacing and inorganic fertilizer was highly significant on all parameters at 40 DAS and 60 DAS. The combination of spacing (60 X 40cm) and inorganic fertilizer (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) produced maximum pod yield (7.70 t/ha) and minimum pod yield of okra (4.5 t/ha) was found from the treatment combination of 60 X 20 cm spacing and where the plots were not received any fertilizer.

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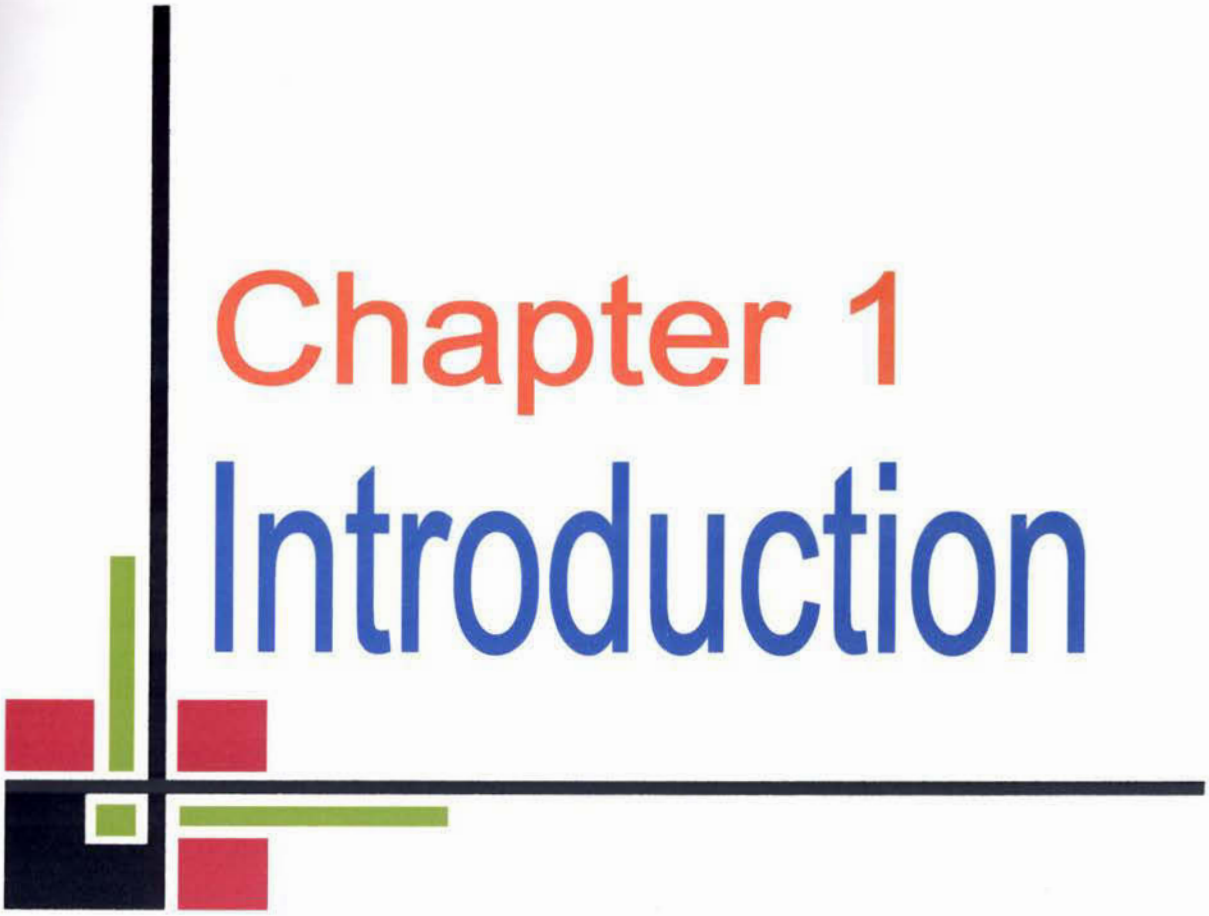


Chapter 1
Introduction

Chapter 1

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop belonging to the family Malvaceae and grown throughout the tropical and sub-tropical regions of the world. It is known by local names in different parts of the world, such as Lady's finger in England, Gumbu in USA, Gombu in France, Bhindi in India and Dherosh in Bangladesh. It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Thakur and Arora, 1986). Okra probably has originated in Tropical Africa or Tropical Asia (Tindal, 1988). It is well distributed throughout the Indian sub-continent and East Asia (Rashid, 1990).

Okra is a multipurpose crop. Its tender pods are cooked as vegetables, stewed with meat, cooked to make soup and also canned and dried. Okra seeds are roasted, ground and used as substitute of coffee in Turkey. Mature pods and stems containing crude fibre are used in the paper industry. Okra is a nutritious and delicious vegetable, fairly rich in vitamins and minerals. The edible portion of pod (100 g) has moderate levels of vitamin A (0.01 mg) and C (18 g), calcium (90 mg), 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 vegetables (Rashid, 1990). Tender pods have high mucilage content and are used in soup and gravies. It has medicinal value too and used in genitor-urinary disorder, to control goiter and against constipation.

Vegetable production is not equally distributed throughout the year in Bangladesh. Vegetables are plenty in winter, but are low in summer. Of 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 has importance in summer. Total production of okra is about 19210 metric tons produced from 6210.53 hectare of land in the year 2001-2002 and the average yield is about 3.093 t/ha (BBS, 2004), 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). Less production and unequal supply of vegetable in the market during various parts of the year resulted in the lowest per capita vegetable consumption (25 g/head/day) in Bangladesh (Hossain *et al.*, 1990). As a year-round vegetable okra can contribute much in vegetable supply in the market throughout the year. Okra is less sensitive to adverse environmental condition. It can be grown in 21-42^0 C temperature and can withstand drought to heavy monsoon during growing season. So, it is better suited to our unstable climatic condition as prevailed in Bangladesh.

Growth and yield of okra depends on nutrient availability in soil, which is related to the judicious application of manures and fertilizers. Nutrients may be applied through two sources viz. organic and inorganic. Increased use of inorganic fertilizers in crop production causes health hazards, creates problem to the environment including the pollution of air, water, soil etc. The continuous use of chemical fertilizers badly affects the soil texture and structure, reduces organic matter content and decrease microbial activities of soil. On the other hand, the use of organic manure improves soil texture, structure, humus, color, aeration, water holding capacity and microbial activity of soil. A good soil has an organic matter

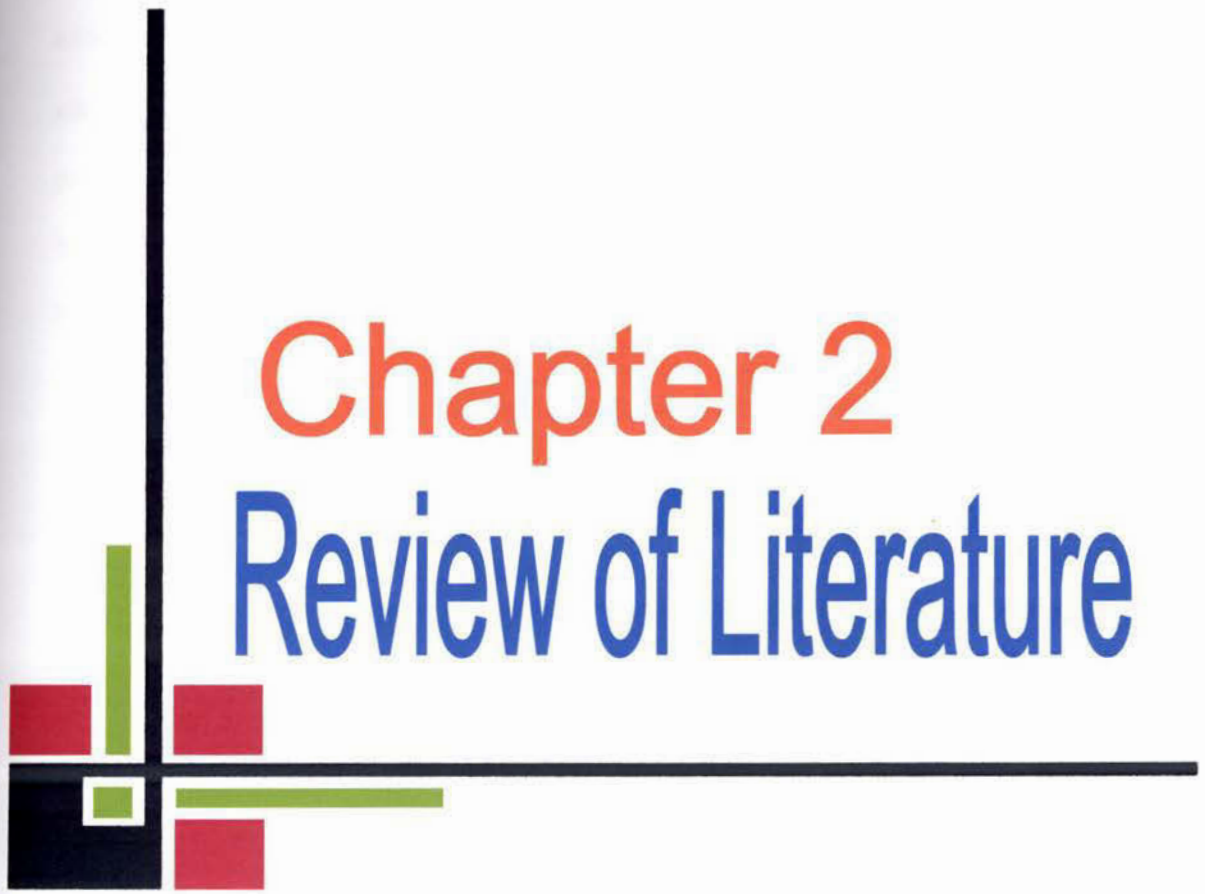
content of more than 3%. In Bangladesh soils of most regions have less than 1.5%, and some other soils have ever less than 1% organic matter. For continuous cropping, organic manures applied to the crop fields through cowdung, oilcake, compost, ash, green manuring etc. are insufficient. Now a days, gradual deficiency in soil organic matter and reduced yield of crops are alarming and burning issues for the farmers and agriculturists. All efforts should be made to develop knowledgw of the farmers about the importance of soil organic matter for the long-term maintenance of soil productivity. Balanced use of fertilizers in crops will act as an insurance against possible nutrient deficiencies that may be created by the judicious application of nutrient. Balanced fertilizers can play a vital role in sustaining higher yield of crops as well as maintaining fertility status of soils on a long-term basis. In Bangladesh there is a great possibility of increasing okra yield per unit area with proper use of organic and inorganic fertilizer. The efficient use of fertilizers by plant depends largely on the soil type, environmental conditions and method of application. Application of fertilizers in split at different time reduces loss of the nutrients and gives better response to okra crops.

Farmers in Bangladesh generally do not use any special technique for quality okra production. To get higher yield with good quality, proper growth of the plant and its pods are desired. Plant spacing directly affects the yield and quality of okra. Closer spacing for increasing yield has been advocated by Rastogi *et al.*, (1987) and Singh *et al.*, (1988). Again the amount of vegetative growth made by individual plant is markedly influenced by plant population (Palaniswamy and Karivarataraju, 1984). Different spacing also plays an important role on the overall yield of okra. In compact spacing, number of plants/ha increased but yield is not

overall increased. In large spacing number of plants/ha is reduced and production is also reduced. So, standard spacing should be maintained for better yield.

Hence, considering the above circumstances the present investigation was undertaken with the following objectives:

- to determine the appropriate spacing for maximizing the growth and yield of okra.
- to determine the different effect of nutrients (inorganic and organic fertilizers) on the growth and yield of okra.
- to determine the combined effect of nutrients (inorganic and organic fertilizers) and spacing for maximizing the growth and yield of okra.



Chapter 2
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Sources of nutrients and plant spacing are the most important factors for maximizing the yield of a crop. Organic manure and inorganic fertilizers like NPK are responsible for the yield of okra. An appropriate spacing or plant population per unit area is another important factor that influences the yield. The fertilizer requirement however, vary with the soil and cultural conditions. Research works have been done in various parts of the world including Bangladesh is not adequate and conclusive. Some of the important and informative work conducted at home and abroad in this aspect have been furnished in this chapter.

2.1 Effect of organic manures on the growth and yield of okra

Organic matter is called the life of the soil. Fertility of particular soil is determined by the presence of organic matter. The organic matter content of soil varies from 0-5% and it depends on several factors like origin of soil, climatic conditions, vegetation, microbial activities etc. The physical, chemical and biological properties of soil are greatly influenced by organic matter. Although, organic matter contains all the essential plant nutrients, after application organic manures take time to get converted in available its available form to the plant. That is why the response of crops to organic manure is low. Due to the residual and beneficial effects applications of organic manures are encouraged. Some available information about the effects of organic manures on growth and yield of okra are reviewed here.

Wright (1960) stated that horse and cow dung contains approximately 0.5% nitrogen, 0.55% potash and 0.25% phosphoric acid. It thus supplies three of main elements needed by fruit plants.

Dumitrescu (1965) from his experiment on "composts as organic manures of high fertilizing value" reported that application of FYM at the rate of 20 t/ha gave higher total yield.

Kamaluddin (1968) reported that organic manure increases soil organic matter and essential nutrient elements for plants.

Gaur *et al.*, (1971) found that FYM and organic residues were effective in increasing the level of organic matter even under tropical conditions.

Edmond *et al.*, (1977) reported that organic matter increased the pore space of the soil and thus improved the rate of gas exchange. Application of compost to the soil increased water-holding capacity, reduced soil erosion and improved the physio-chemical and biological condition of the soil besides providing plant nutrients.

Mustard oil cake (MOC) is a good source of N and S. Among different oil cakes, mustard oil cake is the most common in Bangladesh which contains 4.7% N, 108% P and 1.3% K (Ahmed, 1880).

Organic manures like cow dung, composts, farmyard manure, green manure and oil cake supply more or less complete food for plants. (Ahmed, 1982).

Prezotti *et al.*, (1988) suggested that organic manure applications increased total productivity by 48% and improved the proportion of large fruits in the total yield.

Roe (1998) carried out an experiment by using compost obtained from dairy manure and municipal solid waste to find out the beneficial effects on broccoli. He found beneficial effects on growth, yield and nutrient component with compost application in the broccoli production.

Raj and Kumari (2001) reported that the effect of farmyard manure (FYM; 12 t/ha) and *Azosprililum* inoculation (1 kg/ha), singly or in combination (1: 1) with other organic amendments (neem cake, green leaf and enriched compost) on the yield and quality of okra cv. Arka Anamika which was studied in Vellayani, Kerala, India, from January to May 1998. All treatments were applied as basal dressing. All organic manures except FYM alone were superior to the control (recommended fertilizer of 12 t FYM/ha + 50: 8:25 N: P: K kg/ha) with respect to yield, with FYM + neem cake giving the highest yield (158.48 q/ha). Total fruit yield was significantly higher with *Azospirillum* inoculation (141.94 q/ha) than that obtained with control (129.74 q/ha).

Bhadoria *et al.*, (2002) conducted field experiments in 1997-98 and 1998-99, in Kharagpur, West Bengal, India to investigate the effect of organic manure in improving the quality of rice (autumn crop) and okra (spring crop). Treatments consisted of farm yard manure (FYM), FYM + micro culture (MC), chemical fertilizers (CF), processed city waste (PCW), oil cake pellets (OCP) and vermicompost (VC). Among the treatments, FYM produced the best okra with nutritional quality.

2.2 Effect of inorganic fertilizers on the growth and yield of okra

Fertilizers are indispensable for the production system of modern agriculture and play a vital role to increase the yield, provided other factors are not limiting. Chemical

fertilizers today hold the key to success of the production system of Bangladesh. The chemical fertilizer supplies sufficient nutrients readily for proper growth and yield of plant. Among the micronutrients, NPK are used largely by the plants. Physio-morphological development of plants depends on the judicious application of NPK. An excess or deficiency of NPK causes adverse effect on growth and yield of plant. Some available information about the effects of inorganic fertilizers on growth and yield of okra are reviewed here.

In an investigation at the Punjab Agricultural University, Ludhiana, India, Singh *et al.* (1967) 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 crops (Anon., 1983). In Himachal Pradesh, NPK at the rate of 60, 50 and 30 kg per hectare, respectively, were recommended for getting the best yield (Anon., 1978).

Ahmed and Reid (1998) studied the response of okra to nitrogen, phosphorus, potassium and magnesium fertilization in India on loam soil and best yields were obtained with 112 kg N, 168 kg P, 280 kg K and 112 kg Mg per hectare.

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 nitrogen (22.5, 45.0 or 67.5 kg/ha). Phosphorous at 22.5 or 45.0 kg/ha and potassium at 22.5 kg/ha had no effect on growth and yield. NPK applications, however, generally increased yields.

In a 2 year trials with okra, the effects were assessed for N (as urea) at 40-120 kg/ha, P_2O_5 (as superphosphate) at 17.44- 52.32 kg/ha and potassium (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.

In a trial with okra, cv. Pusa Sawani, the effects were compared applying N @ 0.75 or 150 kg/ha and P_2O_5 and K_2O, each at 0, 60 or 120 kg/ha, in all possible combinations by Singh (1979). He found that the highest yield was given by a combination of $N_{75}P_{60}K_0$.

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) 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.

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, 13.0 and 26.0 kg P/ha (Majanbu *et al.*, 1985). Nitrogen application significantly increased green pod yield, pod diameter, number of fruits/plant, number of seeds/pod. For optimum green pod yield of White Velvet 35 kg N/ha was suggested while for NHAE 47-4, N fertilization could be increased up to 70 kg/ha.

Majanbu *et al.* (1986) observed that nitrogen application generally increased fruit and shoot dry weights markedly, whereas phosphorus increased them only moderately. Leaf and primary branch production and plant height were also enhanced by nitrogen fertilization upto 100 kg N/ha, but were influenced by P application.

In trials with okra cv. Pussa Sawani, N and K were applied each @ 0-120 kg/ha (Mishra and Pandey, 1987). N @ 80 kg/ha and K @ 40 kg/ha significantly increased the number of fruits per plant. Application of N above 80 kg/ha and K above 40 kg /ha adversely affected seed yield. Interaction effect was significant with 80 kg N and 40 kg K/ha giving the highest seed yield of 15.47 q/ha.

Lenka *et al.* (1989) conducted a field trial with three replicates with N (as urea) applied at 4 levels (0, 50, 75 and100 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 its other attributes. Application of 100kg N/ha and 30 kg P_2O_5/ha gave satisfactory seed yield (7.60 q/ha.).

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

An experiment was conducted by Somkuwar et al. (1997) in India to determine the effect of 3 levels of N (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 g) per plant and yield per ha (7770 kg) at 75 kg N/ha.

An experiment was conducted by Bhai and Singh (1998) at Palamur, India to investigate the effect of P application rate (50, 70 or 90 kg/ha). They reported that P

application significantly increased the plant height, number of pods per plant and seed yield.

Yogesh *et al.*, (2001) conducted a field experiment in Nagina, Uttar Pradesh, India during the kharif seasons of 1998 and 1999 to study the effect of N (80, 100, and 120 kg/ha), P (60 and 80 kg/ha), and sowing date (25 June and 15 July) on okra (cv. Parbhani Kranti) seed yield. One-third of N and 100% of P were applied during sowing; the remaining N was applied as a top dressing at 30 days after sowing and at the flowering stage. Seed yield, which increased with the increase in N rate, was not significantly affected by P rate. The highest number of seeds per pod (57.0) and seed yield per plot (2.94 kg) were obtained with the application of 120 kg N/ha and 80 kg P/ha, along with sowing on 25 June.

Gowda *et al.*, (2002) conducted a study in the summer season of 1999 in Bangalore, Karnataka, India to investigate the effect of different fertilizer levels (N: P: K at 125:75:60, 150:100:75 and 175:125:100 kg/ha respectively) 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.

Prabu *et al.*, (2002) conducted an experiment in Parbhani, Maharashtra, India, during the summer season of 2001 to investigate the effect of inorganic fertilizers at 0, 1/3, 2/3 and full rate (N: P: K at 100: 50: 50 kg/ha), in the presence or absence of farmyard manure (FYM at 10 t/ha) and bio-fertilizers (uninoculated; *Azospirillum* + phosphate solubilizing bacteria; *Azospirillum* + vesicular arbuscular mycorrhiza) on the

performance of okra cultivar Parbhani Kranti. Results showed that the treatment 2/3 recommended NPK dose + FYM + *Azospirillum* + vesicular arbuscular mycorrhiza product gave the highest yield.

Bamel *et al.* (2003) conducted a pot experiment to study the effect of different fertilizer sources on *M. incognita* in okra under greenhouse conditions. Better plant growth was observed when a combination of N, P, K and Zn fertilizers was applied at recommended dose. Individually, muriate of potash and potassium sulphate at higher doses recorded maximum plant growth. Ammonium sulphate and gypsum reduced nematode reproduction significantly compared to other treatments. All the fertilizers except calcium nitrate, muriate of potash and potassium sulphate, showed reduction in nematode damage with a corresponding increase in their dose.

2.3 Effect of spacing on the growth and yield of okra

Plant growth and yield performance of okra with respect to spacing has been studied in various parts of the world. A brief review of the relevant information available in the literature pertaining to the study is discussed below.

Rastogi *et al.* (1987) conducted a trial for 3 years with the cultivar Sel. 6-2, planted at 45 x 40 cm, 60 x 40 cm and 75 x 40 cm spacing treated with N at 45, 60 and 75 kg/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 for different spacing.

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 pod picked twice.

Mondal *et al.* (1989) conducted an experiment to investigate the effect of sowing dates and inter row spacing on the growth and yield of okra cv. Pussa Sawani. They obtained 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 fruits and quality of fruit per plant but the highest fruit yield per hectare was obtained from higher spacing.

The highest level of NPK and closer spacing gave maximum yield of okra and number of fruit per plant increased with the increase of fertilizer levels and spacing (Abdul and Araf, 1986).

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 highest fruit yield with the closest (40 x 20 cm) spacing (6037 kg/ha) but the maximum fruit weight (35.58 g) and fruit length (19.06 cm) were recorded with the widest spacing (50 x 40 cm).

Gadakh *et al.*, (1990) conducted an experiment and observed that 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 x30 cm apart. The highest pod yield was obtained with the closest spacing and in the summer season (1851 kg/ha). The treatment had no appreciable effect on pod quality.

In an experiment Saha *et al.*, (1989) studied the effect of plant spacings 60 x 40 cm, 80 x 10 cm, 80 x 20 cm and picking intervals (1, 3 and 5 days) on the growth and yield of okra cv. Pusa Sawani at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh. The fresh weight of plant, 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 was recorded from wide spacing of 80 x 40 cm (3.23 t/ha).

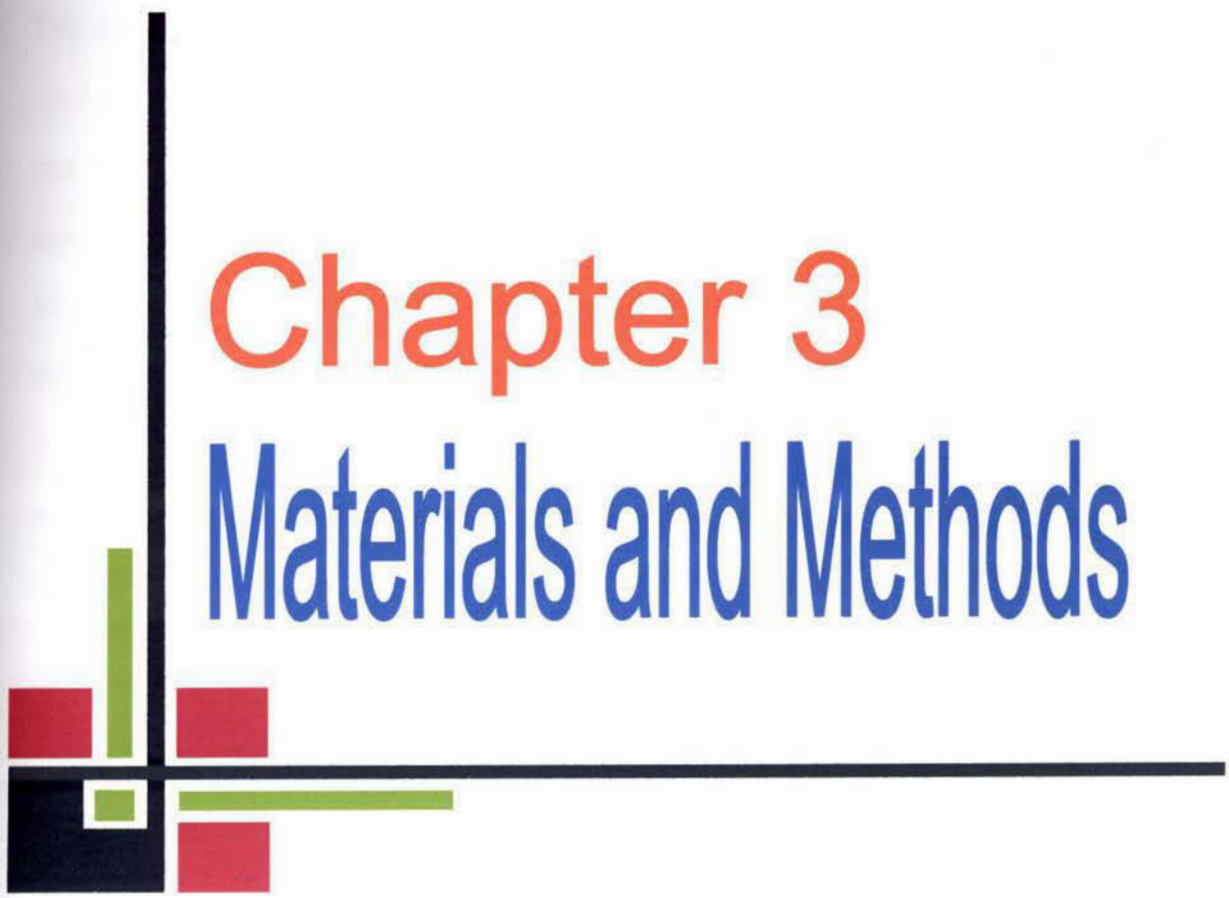
Palaniswamy and Karivaratharaju (1984) reported that plant populations affected seed yield of okra significantly. They got maximum seed yield (1820 kg/ha) with closer spacing (45 x 15 cm) and minimum yield (1168 kg/ha) with wider spacing (60 x 30 cm). The effect of different spacing on seed germination was not significant.

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, 60 x 20 cm spacings. They obtained the best quality seed in March, April and May sowing.

Singh *et al.* (1986) conducted a two-year trial to study the effect of planting dates and spacing on seed production of okra. The seeds were sown on 15 and 30th day of June and July at 60 x30 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.

Singh *et al.* (1988) investigated the effect of sowing dates and spacing on the yield and quality of okra seed. 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).

An experiment was conducted by Grewal *et al.* (1972 and 1973) to observe the effect of sowing dates and spacing on the yield and quality of okra cv. Pusa Sawani. Seeds were sown on June 20, July 10 and 30 in rows at 30, 45 or 60 cm apart. The earliest sowing date and closest spacing gave the highest yield of okra. A gradual decline in this character was recorded with delayed sowing and increased spacing.



Chapter 3
Materials and Methods

Chapter III

MATERIALS AND METHODS

The experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during April, 2007 to July, 2007 to examine the effect of source of nutrients and spacing on the growth and yield of okra.

3.1 Experimental site and soil

The experimental site was carried out at Sher-e- Bangla Agricultural University, Dhaka . The location of the experimental site which was located at $23^0 77'$ N latitude and $90^0 3'$ E longitude with an elevation of 8.2 meter from sea level. The soil of the experimental site belongs to Tejgaon series under the Agro-ecological zone, Madhupur Tract (AEZ -28), which falls into Deep Red Brown Terrace Soils. Soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are shown in Appendix1 .

3.2 Climate

The experimental area has sub tropical climate characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site is 2152 mm and potential evapotranspiration is 1297 mm, the average maximum temperature is 30.34^0C and average minimum temperature is 21.21^0C. The average mean temperature is 25.17^0C. The experiment was carried out during kharif season, 2007. The monthly average temperature, humidity and rainfall of the site during the experimental work are enclosed in appendix I.

3.3 Seeds and variety

BARI Dherosh-1, a high yielding variety of okra (*Abelmoschus esculentus* L. Moench) has been developed by Bangladesh Agricultural Research Institute (BARI), Gazipur. The seeds were collected from Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.4 Design and layout of experiment

The experiment was laid out in a two factor Randomized Complete Block Design (RCBD) with three replications. Factor A consisted of 3 levels of spacing (60 x 20cm, 60 x 30cm and 60 x 40cm designated as S_1, S_2 and S_3 respectively) and Factor B consisted of 4 levels of source of nutrients (no fertilizer,cow dung, compost and inorganic fertilizers designated as F_0, F_1, F_2 and F_3, respectively). There were 12 treatments combination in all together.

The treatments combination were as follows:

S_1F_0= 60 x 20cm spacing + no fertilizer

S_1F_1= 60 x 20cm spacing + cow dung (14 t/ha)

S_1F_2= 60 x 20cm spacing + compost (14 t/ha)

S_1F_3= 60 x 20cm spacing + inorganic fertilizer(Urea 150 kg/ha+ TSP 100 kg/ ha + MP 15o kg/ ha)

S_2F_0= 60 x 30cm spacing + no fertilizer

S_2F_1= 60 x 30cm spacing + cow dung (14 t/ha)

S_2F_2= 60 x 30cm spacing + compost (14 t/ha)

S_2F_3= 60 x 30cm spacing + inorganic fertilizer(urea 150 kg/ha+ TSP 100 kg/ ha + MP 15o kg/ ha)

S_3F_0= 60 x 20cm spacing + no fertilizer

S_3F_1= 60 x 20cm spacing + cow dung (14 t/ha)

S_3F_2= 60 x 20cm spacing + compost (14 t/ha)

S_3F_3= 60 x 20cm spacing + inorganic fertilizer(urea 150 kg/ha+ TSP 100 kg/ ha + MP 15o kg/ ha)

Fertilizer treatments were randomly distributed in each block. Each block consisted of 12 plots and unit plot was 3m × 2.4m i.e 7.2 sq. m in size. The adjacent block and neighboring plots were separated by 0.75 m and 0.5 m, respectively and the total land was 35.8m x 12.0 m. The layout of the experiment is shown in Fig. 1.

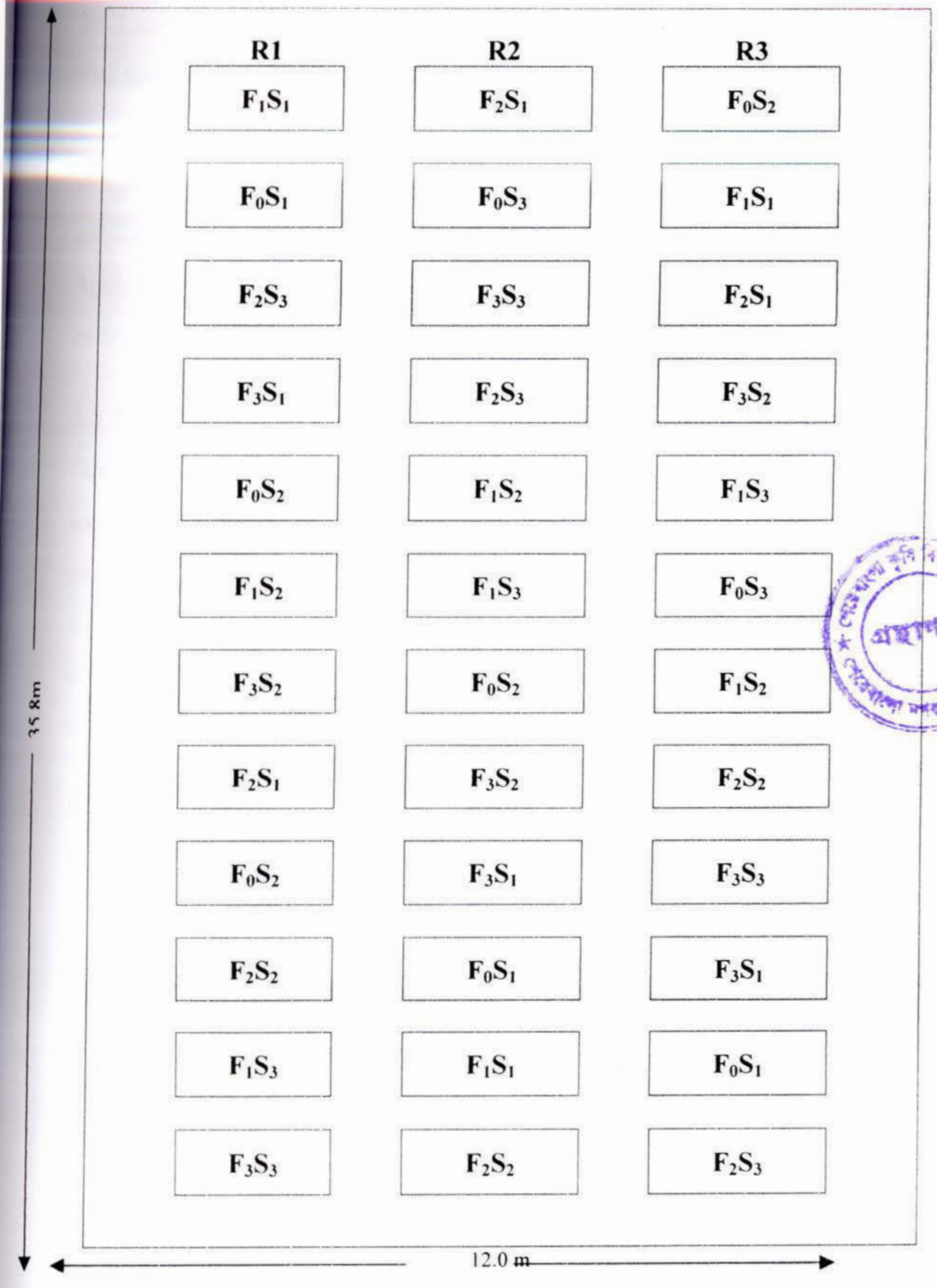


Fig. 1.Layout of the experiment

3.5 Land preparation

The land was first ploughed with a tractor drawn disc plough on 3 April, 2007. Ploughed soil was brought into desirable tilth condition by four operations of ploughing and harrowing with country plough and ladder. The stubbles of the previous crops and weeds were removed. The land operation was completed on 6 April, 2007. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.6 Application of fertilizers

Cow dung, compost and inorganic fertilizers (Urea, TSP and MP) were applied as the source of nutrient as per treatment in each experiment. The whole amount of cow dung (14 t/ha), compost (14 t/ha) and TSP (100 kg/ha) were applied at the time of final land preparation. Urea (150 kg/ha) and MP (150 kg/ha) were applied in two equal installment as top dressing around the plant and incorporated with soil at 3rd and 5th week after seedling emergence.

3.7 Seed sowing

Seeds were sown on 8 April, 2007 by hand in rows maintaining treatmentwise spacing. A strip of the same crop was established around the experimental field as border crop. After sowing the seeds were covered with fine soil and slightly pressed by laddering.

3.8 Weeding and thinning

Weeds of different types were controlled manually for the first time and removed from the field on 20 April 2007. At the same time first thinning was done. The final weeding and thinning were done after 15 days of first weeding, on 5 May 2007. Care was taken to maintain constant plant population per plot.

3.9 Irrigation

Irrigation was done three times. The first irrigation was given in the field on 23 April 2007 at 15 days after sowing (DAS) through irrigation channel. The second irrigation was given at 30 DAS, on 8 May 2007. The final irrigation was given at 50 DAS, on 28 May 2007.

3.10 Pest management

Diazinon 60 EC @ 3.5 ml/L in water was sprayed for controlling shoot and pod borer at an interval of 10 days after shoot emergence. After fruit setting Nogos @ 0.02% was sprayed for controlling Jassid at an interval of 7 days. The crop was kept under constant observations from sowing to harvesting.

3.11 Harvesting of pod

Green pods were harvested plot wise at 1 day interval when they attained edible stage. Green pods harvesting was started on 02 June 2007 and harvesting was continued upto 26 July 2007.

3.12 Collection of experimental data

Ten (10) plants from each plot were selected as random and were tagged for the data collection. The plants in the outer rows were selected for data collection on growth of okra and the other rows were selected for data collection on yield of okra. Data were collected on the following parameters:

1) Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale 20, 40 and 60 DAS from the point of attachment of the leaf to the ground level up to the tip of the longest leaf.

2) Plant diameter (cm)

Average plant diameter of selected plant from each plot 20, 40 and 60 DAS with the slide calipers.

3) Number of leaves per plant

Number of leaves per plant of 10 randomly selected plants was counted 20, 40 and 60 DAS. All the leaves of selected plants were counted separately. 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.

4) Leaf length (cm)

Leaves of ten (10) randomly selected plants were made detached and leaf length was measured in centimeter (cm) by a meter scale 20, 40 and 60 DAS.

5) Leaf breadth (cm)

Leaves of ten (10) randomly selected plants were made detached and leaf breadth was measured in centimeter (cm) by a meter scale at 20, 40 and 60 DAS.

6) Number of branches per plant

At 20, 40 and 60 DAS, number of branches per plant from ten (10) randomly selected plants was counted. All the branches of selected plants were counted separately and then it was calculated for getting average.

7) Number of pods per plant

Mean number of green pods of randomly selected plants from each plot was recorded.

8) Pod length (cm)

Ten (10) randomly selected pods from each plot were taken and length was recorded by a meter scale in cm and finally mean was calculated.

9) Pod diameter (cm)

Mean diameter of 10 randomly selected pods from each plot were measured in cm with the help of slide calipers.

10) Weight of pod per plot

Mean weight of edible green pods of 10 plants from each plot was measured in kilogram (kg).

11) Pod yield (t/ha)

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

3.13 Statistical Analysis

The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Duncan's Multiple Range Test (DMRT) with Least Significant Difference value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

Chapter 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

This Chapter includes the experimental results along with discussion. Effects of sources of nutrients and spacing on plant height, plant diameter, number of leaves per plant, leaf length, leaf width, number of branches per plant, number of pods per plant, pod length, pod diameter, weight of pods per plot and pod yield are shown in the Tables1-7 and Fig. 1- 5.A summary of the analysis of variances of all the characters studied with their sources of variation and corresponding degrees of freedom have been shown in appendix III & IV. The results presented in tables are discussed character wise under the following heads.

4.1 Plant height

Plant height was recorded 20 DAS, 40 DAS and 60 DAS. The different spacing had significant effect on plant height of okra (Fig. 2 and Appendix IV). The highest plant (63.79 cm and 115.2 cm) was found from 60 x 40cm spacing and lowest plant (54.46 cm and 98.81 cm) was found from 60 x 20cm spacing at 40 & 60 DAS respectively. The results also showed that there was no significant effect of spacing on plant height at 20 DAS but the tallest (39.02cm) was obtained from S_3 (60 x 40 cm) and the shortest (37.43 cm) was found from S_1 (spacing 60 x20 cm).

The highest plant (61.31 cm and 113.5 cm) was found from inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) and lowest plant (44.44 cm and 83.92 cm) was found from control condition at 40 and 60 DAS respectively. The experiment also showed that there was no significant effect of sources of nutrients on plant height at 20 DAS (Fig 3). Chauhan and Gupta (1973) reported that chemical fertilizer (NPK fertilizer) increased plant height.

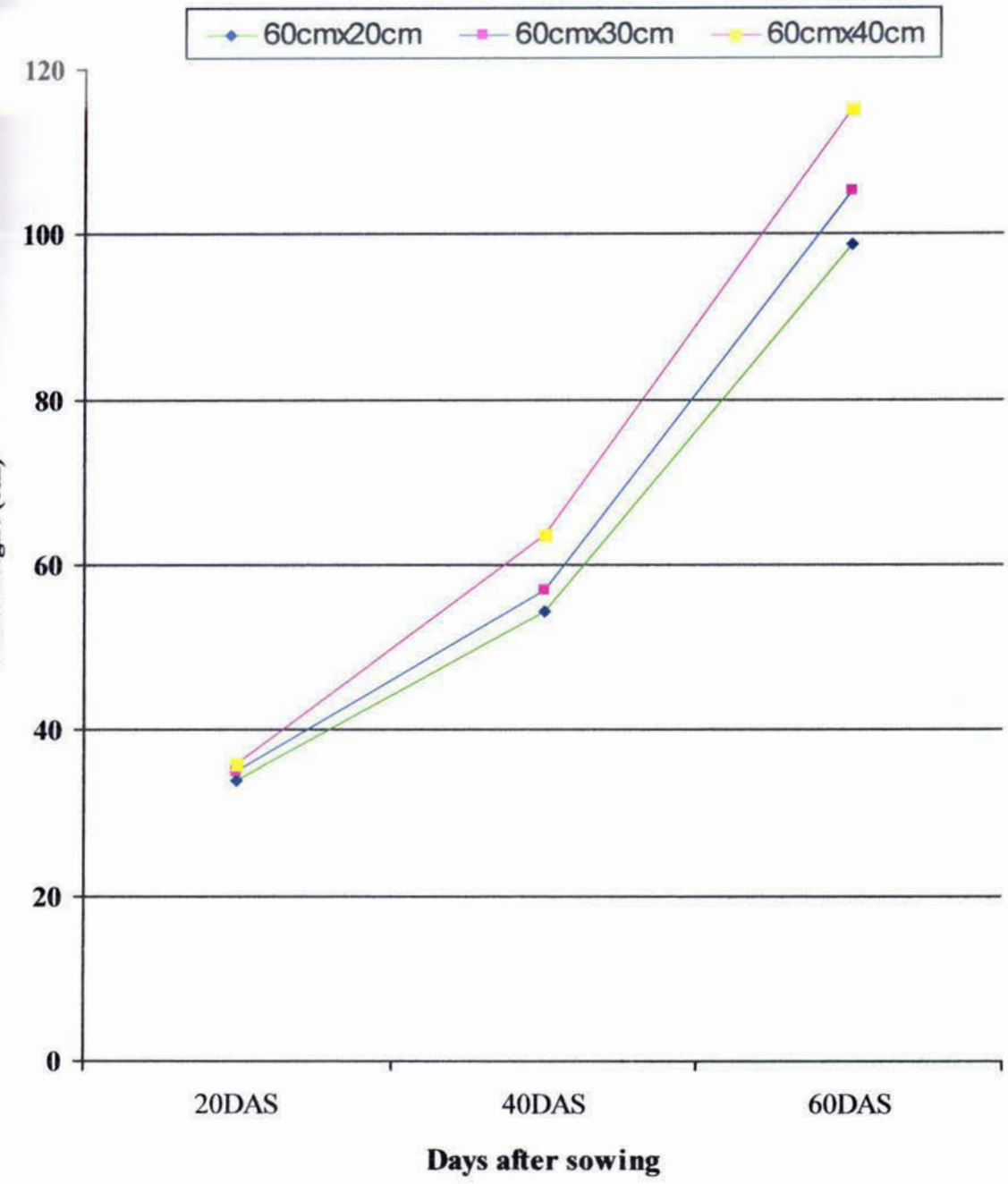


Fig 2. Effect of spacing on plant height of okra

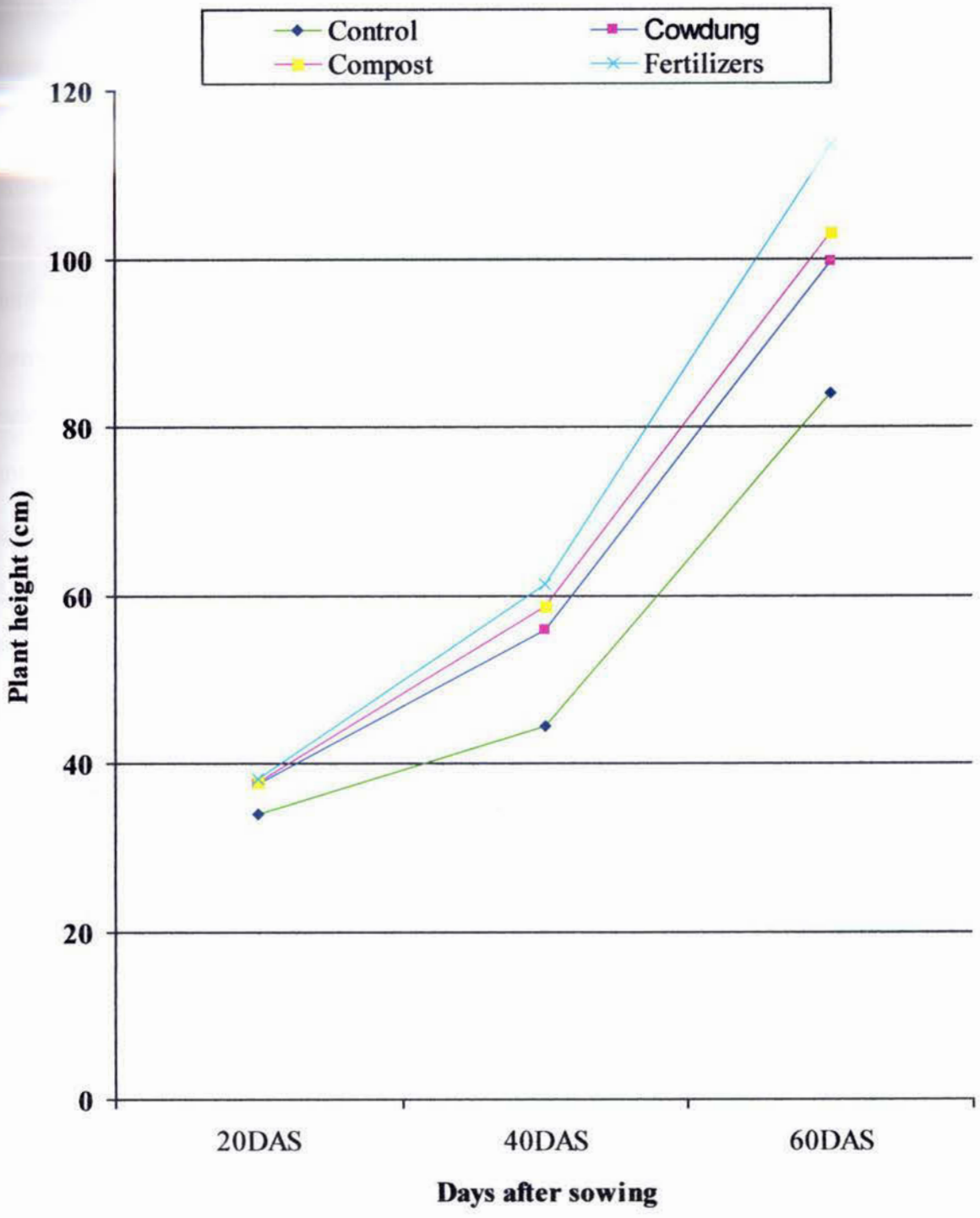


Fig 3. Effect of source of nutrients on plant height of okra

It was observed that the combined effect of spacing and source of nutrients on plant height of okra highly significant at 20, 40 and 60DAS (Table 2). The tallest plant height(36.67 cm, 66.57 cm and 119.8 cm) was found at 40DAS and 60DAS, respectively with 50 x 40cm spacing and inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The shortest plant (32.97cm, 50.57cm and 85.80cm) were found at 20DAS, 40DAS and 60DAS, respectively with 80 x 60cm spacing andcontrol treatmenmt. Further, it was observed that plant height was increasing with decreasing spacing and with inorganic fertilizers followed by organic fertilizer. At lower spacing, plants got insufficient space and sunlight. So, they grow upwardly to get more sunlight and free space.

4.2 Plant diameter

Plant diameter was also recorded at 20DAS, 40DAS and 60DAS. There was no significant effect of different spacing on plant diameter of okra (Table 1 and Appendiox IV). The highest plant diameters 1.80cm, 2.778cm and 3.20cm were found from S_3 (60 x 40cm spacing)at 20, 40 and 60 DAS respectively.The lowest 1.73 cm, 2.61 cm and 3.02 cm were found from S_1 (spacing at 60 x20 cm)

There was positive and significant effect of different source of nutrients on plant diameter (Table 1). The highest plant diameters 1.90cm, 2.73cm and 3.16cm were found from inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) and lowest plant diameters 1.20 cm, 2.02cm and 2.35cm were found from control condition at 20, 40 and 60DAS respectively. The results also showed that plant diameter increased with the application of cow dung, compost and inorganic fertilizers. Chauhan and Gupta (1973) observed that inorganic fertilizer gave heist plant diameter, which was consonance with the present findings.

The combined effect of spacing and source of nutrients on plant diameter of okra were significant at 20, 40 and 60DAS (Table 2). The highest plant diameter(2.10cm, 3.10cm

and 3.50cm were found at 20, 40 and 60DAS, respectively with 60 x 40cm spacing and inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The lowest plant diameter 1.80 cm, 2.0cm and 2.733cm were recorded at 20 , 40and 60DAS respectively from 60 x 20cm spacing and no fertilizers.

4.3 Number of leaves per plant

The number of leavers per plant varied significantly among different spacing at 40 and 60DAS but not 20DAS (Table 1). The number of leaves per plant ranged from 12.56 to 23.33 at 40DAS and 30.11 to 36.44 at 60DAS. The highest number of leaves per plant 23.33 and 36.44 at 40DAS and 60DAS, respectively were recorded from S_3 (spacing at 80 x 60cm). The lowest number of leaf per plant in both cases was obtained from the treatment of 60cmx20cm spacing.

The number of leaves per plant was influenced significantly due to different source of nutrients at 40DAS and 60DAS (Table 1). The number of leaves per plant ranged from 16.78 to 20.44 and 31.22 to 37.44 at 40 and 60DAS, respectively. The highest number of leaves per plant (20.44 and 37.44) were recorded at 40 and 60 DAS, respectively from the treatment of inorganic fertilizers F_3 (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The lowest number of leaf per plant (16.78 and 31.22)were obtained from the control treatment . There was no significant effect of source of nutrients on number of leaf in the trail was observed at 20DAS. Chauhan and Gupta (1973) stated that highest number of leaf per plant was produced by inorganic fertilizer, which supported to the present study.

The combined effects of spacing and source of nutrients on number of leaf per plant were highly significant at 40 and 60DAS (Table 2). The highest numbers of leaves per plant 9.09, 27.33 and 44.00 were obtained from the treatment combination of 60 x 40cm spacing + inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) at 20, 40 and 60DAS,

respectively. The lowest number of leafves per plant 7.67, 11.67 and 27.33 at 20, 40 and 60DAS, respectively were obtained from the treatment combination of S_1F_0.

Table1. Main effect of spacing and sources of nutrients on plant diameter and number of leaves per plant at different days after sowing of okra

Treatment(s)	Plant diameter(cm)			Number of leaves per plant		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
Speacing						
S_1 (60cmX20cm)	1.73a	2.61a	3.02c	8.22a	12.56c	30.11c
S_2 (60cmX30cm)	1.75a	2.68a	3.10a	8.33a	19.56b	32.56b
S_3 (60cmX40cm)	1.80a	2.78a	3.20a	8.78a	23.33a	36.44a
LSD(0.05)	0.420	0.024	0.048	0.051	2.92	4.74
CV(%)	9.21	10.89	8.68	8.94	6.85	6.33
Source of nutrients						
F_0 (Control)	1.20d	2.02d	2.35d	8.22a	16.78b	31.22b
F_1 (Cowdung)	1.37c	2.39c	2.67c	8.44a	18.52ab	31.44b
F_2 (Compost)	1.67b	2.58b	2.85b	8.50a	19.22ab	31.89b
F_3 (Inorganic fertilizers)	1.90a	2.73a	3.17a	8.67a	20.44a	37.44a
LSD(0.05)	0.420	0.024	0.048	0.051	2.92	4.74
CV(%)	9.21	10.89	8.68	8.94	6.85	6.33

Table 2. Combined effect of spacing and sources of nutrient on plant height, plant diameter and number of leaves per plant at different days after

sowing of okra

Treatment(s)	Plant height (cm)			Plant diameter (cm)			Number of leaves per plant		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1F_0	32.97c	50.87f	85.80f	1.80a	2.00c	2.73b	7.67	11.67f	27.33f
S_1F_1	33.05c	53.07e	98.42e	2.00a	2.51ab	2.80b	8.33	12.67f	29.33ef
S_1F_2	34.17bc	56.03c	100.03e	2.06a	2.57ab	2.90b	8.66	13.33ef	32.00cde
S_1F_3	34.87abc	59.73bc	112.20b	2.04a	2.67ab	3.10ab	8.68	13.97ef	33.33bcd
S_2F_0	33.09c	51.41f	101.92e	1.92bc	2.48ab	2.83b	8.67	12.67f	30.37def
S_2F_1	35.57ab	56.46d	102.64ef	1.81ab	2.03c	2.80b	9.00	21.33cd	32.99bcd
S_2F_2	34.40bc	56.67d	104.36cde	1.96ab	2.50bc	3.05ab	9.01	23.33bc	33.91bcd
S_2F_3	35.13ab	57.63cd	108.60bcd	1.84d	2.60ab	3.07ab	8.33	24.17bc	35.00bc
S_3F_0	33.48c	52.51ef	100.13e	1.90a	2.50bc	2.96b	8.66	13.33ef	33.47b
S_3F_1	35.20ab	60.57b	110.52bc	2.08a	2.56ab	3.00b	8.00	25.00b	34.59b
S_3F_2	36.07ab	64.23a	115.22ab	2.04a	2.60ab	3.10ab	8.33	25.33b	36.33b
S_3F_3	36.67a	66.57a	119.80a	2.10a	3.10a	3.50a	9.09	27.33a	44.00a
LSD (0.05)	1.770	2.480	6.590	0.319	0.483	0.451	0.013	2.230	3.612
Level of significance	*	**	**	**	*	*	NS	*	*
CV (%)	4.93	4.46	5.85	9.21	10.83	8.68	8.94	6.85	6.33

In a column having same letter(s) do not differ singnificantly at 1% level of singnificance.

* = Significant at 5% level of probablity; ** = Significant at 1% level of probablity; NS = Not significant

S_1= 60cm X 20cm; S_2= 60cm X 30cm; S_3= 60cm X 40cm

F_0 = Control; F_1= cowdung (14 t/ha); F_2 = Compost (14 t/ha); F_3 = Inorganic fertilizer (Urea 150 kg/ha + TSP 100 kg/ha + MP 150 kg/ha)

4.4 Leaf length

Leaf length was statistically significant at 40 and 60DAS (Table 3 and Appendix IV) due to spacing.. At 40DAS, the maximum leaf length (38.41cm) was obtained from the plant spacing 60 x 40cm, which was statistically similar(37.64 cm) with 60 x 30cm spacing and at 60 DAS the maximum leaf length (47.33 cm) was found in the same treatment. The lowest leaf length (29.07 cm and 41.83 cm) were observed from the spacing of 60 x 20cm at 40 and 60DAS, respectively. There was no significant difference among the plant spacing in respect of leaf length at 20DAS. The results also showed that leaf length was increased with increasing plant spacing. This might be due to higher availability of nutrients and lower competition among the plants for light, water, air and all nutrients that progressively enhanced the vegetative growth of the plant.

There was positive and significant effect of different sources of nutrients on leaf length of okra (Table 3). The highest leaf length (25.39cm, 36.43cm and 46.57cm) were obtained from the treatment F_3 (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) at 20. 40 and 60 DAS respectively, which was identical to the treatment F_2 (compost). The lowest leaf length (21.96cm, 33.32cm and 42.13cm) at 20, 40 and 60DAS were found from F_0 (conrol the treatment).

Combined effect of spacing and source of nutrients on leaf length was and significant (Table 4). Treatment S_3F_3 gave the maximum leaf length (27.00 cm) closely follwed by S_2F_3(25.40 cm),S_1F_2 (24.17 cm), S_2F_2(23.77 cm), S_2F_1(23.70 cm), S_3F_1(23.60 cm), S_3F_2 (25.87 cm) and S_1F_3 (24.81 cm). The lowest leaf length (18.10cm) was found from S_1F_0 treatment combination at 20DAS. At 40DAS and 60DAS, the highest leaf length 43.50cm and 49.60cm, respectively were obtained from the treatment combination of S_3F_3 (60 x 40cm spacing + Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The lowest leaf length (26.30cm) at 40DAS and (39.70cm) at 60DAS were recorded from the treatment combination of S_1F_0 .

4.5 Leaf breadth

The present study revealed that there was a significant effect of plant spacing on leaf width of okra except at 20 DAS (Table 3 and Appendix IV). At 40 and 60 DAS the highest leaf breadths were 28.66cm and 37.17cm, respectively in case of with the treatment S_3 (60 x 40cm). The lowest leaf breadth (22.60 cm and 31.70 cm) were found from the spacing of 60 x 20cm, at 40DAS and 60DAS, respectively. It was observed that leaf width increased with increasing plant spacing. There was no significant effect of plant spacing on leaf breadth in case of 20DAS.

Highly significant results were observed in the leaf breadth due to different sources of nutrients (Table 3). Leaf breadth progressively increased with the application of cow dung (14 t/ha), compost (14 t/ha) and inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The highest leaf breadth (0.63cm, 27.47cm and 35.80cm were obtained from F_3 (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) at 20, 40 and 60DAS, respectively. The lowest leaf breadth 17.10cm, 22.97cm and 32.26cm were recorded at 20DAS, 40DAS and 60DAS, respectively from F_0 (contro).

Combined effect of spacing and source of nutrients on leaf breadth was highly significant (Table 4). The maximum leaf breadth (21.28 cm, 30.30 cm and 41.40 cm) were found from S_3F_3 treatment at 20, 40 and 60DAS, respectively. The treatment combination S_1F_0 gave the minimum leaf breadth (14.60 cm, 18.73 cm and 29.20 cm) at 20, 40and 60DAS, respectively. These results revealed that higher spacing with inorganic fertilizers (60 x 40cm spacing + Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) was instrumental in producing maximum leaf breadth because plants got sufficient space for spreading leaf and got available nutrients within a short time as compared to organic fertilizers.

Table 3. Main effect of spacing and sources of nutrients on leaf length, leaf breadth and number of branches per plant at different days after sowing of okra

Treatment(s)	Leaf length (cm) at			Leaf breadth (cm) at			Number of branches per plant		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
Speacing									
S_1 (60cmX20cm)	21.23	29.07b	41.83b	17.83	22.60b	31.70b	2.1	2.83b	3.10b
S_2 (60cmX30cm)	23.69	37.64a	45.27ab	18.9	24.97b	33.36b	2.12	2.85b	3.43b
S_3 (60cmX40cm)	25.58	38.41a	47.33a	19.26	28.66a	37.17a	2.26	4.10a	4.23a
LSD(0.05)	1.281	4.963	3.830	0.927	2.068	3.439	0.024	1.140	0.481
Level of significance	NS	**	**	NS	**	**	NS	**	**
CV(%)	9.28	6.45	5.37	4.64	4.98	4.47	9.85	7.34	5.98
Source of nutrients									
F_0 (Control)	21.96b	33.32c	42.13b	17.10b	22.97b	32.26b	1.62	2.50b	2.23b
F_1 (Cowdung)	23.16ab	35.37ab	45.73ab	18.26b	25.79ab	34.47ab	1.67	2.75b	3.79b
F_2 (Compost)	23.63ab	35.81ab	45.91ab	19.02b	25.94ab	34.51ab	2.36	3.25b	3.66ab
F_3 (Inorganic fertilizers)	25.39a	36.43a	46.57a	20.63a	27.47a	35.80a	2.43	3.75a	3.76a
LSD(0.05)	3.940	2.763	3.830	1.965	2.802	3.417	0.024	1.140	0.481
Level of significance	*	*	**	**	**	**	NS	**	**
CV(%)	9.28	6.45	5.37	4.64	4.98	4.47	9.85	7.34	5.98

Table 4. Combined effect of spacing and sources of nutrient on leaf length, leaf breadth and number of branches per plant at different days after sowing of okra

Treatment(s)	Leaf length (cm) at			Leaf breadth (cm) at			Number of branches per plant at		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
S_1F_0	18.10 c	26.30 c	39.70 c	14.60 d	18.73 d	29.20 d	1.50c	2.30 c	3.00c
S_1F_1	24.17ab	32.82 b	41.55 c	17.10 c	19.05 d	31.23 d	1.57c	2.50bc	3.10c
S_1F_2	24.57ab	27.50 c	44.37 cd	18.40 bc	20.27 d	32.01 c	1.72c	3.00bc	3.20c
S_1F_3	24.81ab	39.63 b	48.03 ab	19.60 b	26.30 bc	33.70 bc	2.00bc	3.30 b	3.30c
S_2F_0	20.20 bc	32.40 b	40.53 c	18.07 bc	19.51 d	30.46 d	1.53c	3.00 bc	3.02c
S_2F_1	23.70 ab	32.93 b	43.20 cd	18.30 bc	22.37 cd	30.62 d	2.41ab	3.01 bc	3.87c
S_2F_2	23.77ab	33.40 b	4485 cd	19.73 b	24.60 c	32.30 c	2.50ab	3.36 bc	3.93c
S_2F_3	25.40 a	42.20 a	49.47 ab	19.97 b	28.30 ab	34.80 bc	2.56ab	4.20 a	4.00b
S_3F_0	22.01ab	33.03 b	41.66 c	18.80 b	20.93 d	32.20 c	2.03bc	3.27 bc	3.30c
S_3F_1	23.60 ab	34.21ab	44.30 cd	21.03 a	24.00 c	32.47 c	2.27ab	4.43 a	3.37c
S_3F_2	25.87ab	36.40 b	45.80 bc	21.06 a	29.50 a	33.87 bc	2.30ab	4.60 a	3.70b
S_3F_3	27.00 a	43.50 a	49.60 a	21.28 a	30.30 a	41.40 a	2.73 a	4.70 a	5.00a
LSD (0.05)	3.771	3.897	2.924	1.500	2.181	2.644	0.592	0.872	0.367
Level of significance	**	**	**	**	**	**	*	*	**
CV (%)	9.28	6.25	5.77	4.64	4.98	4.77	9.85	7.34	5.98

In a column having same letter(s) do not differ singnificantly at 1% level of singnificance.

* = Significant at 5% level of probablity; ** = Significant at 1% level of probablity; NS = Not significantS_1= 60cm X 20cm; S_2= 60cm X 30cm; S_3= 60cm X 40cm

F_0 = Control; F_1= cowdung (14 t/ha); F_2 = Compost (14 t/ha); F_3 = Inorganic fertilizer (Urea 150 kg/ha + TSP 100 kg/ha + MP 150 kg/ha)

4.6 Number of branches per plant

The effect of plant spacing on number of branches per plant was significant at 20 , 40 and 60DAS (Table 3).The highest numbers of branches per plant 2.26, 4.17 and 4.23 were recorded from spacing at 60cmx40cm at 20, 40 and 60 DAS, respectively. Plants in the plot of lower spacing (60 x 20cm) produced the lowest numbers of branches per plant 2.10, 2.83 and 3.10 at 20, 40 and 60 DAS respectively. Gaffer and Razzaque (1983) also observed similar results in okra. At 20DAS, effect of spacing on number of branches per plant was not significant.

The effect of source of nutrients on number of branches per plant of okra was influenced significantly at 40 and 60 DAS (Table 3). The highest numbers of branches per plant (3.76 and 3.77) were recorded from the treatment of inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) and the minimum numbers of branches per plant (2.50 and 3.23) were produced by the treatment control (F_0) at 40 and 60 DAS, respectively. At 20DAS there was no much effect of spacing on number of branches per plant. Majanbu *et al.* (1986) found that maximum numbers of branches per plant was produced by inorganic fertilizer.

Combined effects of spacing and different source of nutrients on number of branches per plant of okra was significant (Table 4). Treatment S_3F_3 produced the maximum number of primary branches per plant (2.73), which was not statistically different from S_2F_1, S_2F_2, and S_1F_1 at 20 DAS. At 40 DAS the maximum number of primary branches per plant (4.70) was found in S_3F_3 treatment, which was statistically similar to S_3F_1, S_3F_2 and S_2F_3 treatment. The highest number of branches per plant (5.0) was produced by the treatment S_3F_3 at 60 DAS, which was significantly different with all other treatments. The lowest number of branches per plant 1.50, 2.30 and 3.00 were obtained from S_3F_1 at 20,40 and 60 DAS respectively.

4.7 Pod length

There was significant effect on the pod length due to different plant spacing of okra (Table 5 and Appendix III). The highest pod length (14.76 cm) was found from treatment S_3 (at spacing, 60 x 40cm), which was not statistically different from second highest pod length (14.46 cm), found in the treatment 60 x 30cm spacing. The lowest pod length (11.14 cm) was recorded in S_1 treatment (60 x 20cm). The result showed that pod length increased with increasing plant spacing. Singh (1990) found the highest pod length (19.06 cm) with widest spacing (50 x 40 cm) which is in accord with the present finding.

The pod length of okra was significantly influenced by different sources of nutrients (Table 5). The maximum pod length (14.94 cm) was obtained from the treatment F_3 (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha), which was significantly different from the other treatments. The minimum pod length(12.12 cm) was observed in treatment F_0 (control treatment). Similar results were found by Kuruf *et al.* (1997).

Significant variation of pod length was found due to the combined effect of plant spacing and sources of nutrients of okra plant (Table 6). Pod length varied from 10.77 cm to 15.27 cm due to plant spacing and source of nutrients of okra. The highest pod length (15.27 cm) was obtained from the treatment combination of S_3F_3 (60 x 40cm spacing + Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha), which was statistically identical to the treatment combination of S_2F_3, S_3F_1 and S_3F_2. The lowest pod length (10.77 cm) was recorded from S_1F_0 (60 x 20cm +control treatment), which was identical to S_1F_1(11.13 cm), S_1F_2 (11.53 cm), S_2F_0(11.10 cm) and S_3F_0 (10.92 cm) treatments.

4.8 Pod diameter

The diameter of pod was significantly influenced by plant spacing of okra (Table 5).

The highest pod diameter (1.53 cm) was produced by S_3 (60 x 40cm) treatment, which was statistically similar to that of 60cm x 30cm plant spacing (S_2). The lowest pod diameter (1.23 cm) was found in the plot of lower spacing (60 x 20cm).

Significant variation was found due to the different source of nutrients (Table 5). The maximum pod diameter (1.53 cm) was obtained from treatment F_3 (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha), which was significantly different from all other treatments. The minimum pod diameter(1.30 cm) was observed in treatment F_0 (control). The results are in confirmity with the finding of Majanbu *et al.* (1985) who are recorded maximum pod diameter with inorganic fertilizers.

The combined effect of plant spacing and source of nutrients on pod diameter was stastistically significant (Table 6 and Appendix III). Due to spacing and source of nutrients, pod diameter varied from 1.17 cm to 1.70 cm. The maximum pod diameter (1.70 cm) was obtained from treatment S_3F_3 (60 x 40cm spacing + Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha), which was statistically differed from all other treatments. The lowest pod diameter (1.17 cm) was recorded from S_1F_0 (60 x 20cm + control treatment).

4.9 Number of pod per plant

Number of pods per plant under the present experiment showed statistically significant variation among different plant spacing (Table 5). The highest number of pods per plant (41.06) was recorded in plant spacing S_3 (60cm X 40cm) and the lowest number of pods per plant (28.48) was recorded from the nearest spacing

S_1(60cm X 20cm). Saha et al., (1989) found that number of pods per plant increased with increasing plant spacing.

A significant variation was recorded in case of number of pod per plant in different source of nutrients (Table 5). The highest number of pod per plant (36.50) was recorded from S_3 (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) which was statistically similar to F_1 (cowdung,14 t/ha)and F_2 (compost, 14 t/ha).The lowest number of pods per plant (30.92) was recorded from plot. Majanbu *et al.* (1985) found highest number of pod per plant with the application of chemical fertilizers. Similar results were found by Mishra and Pandey (1987).

The combined effect of spacing and source of nutrients was statistically significant in respect of number of pod per plant of okra under the present experiment (Table 6 and Appendix III). The highest number of pods per plant (43.97) was recorded in spacing of 60 x 40 cm with inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The lowest number of pod per plant (26.60) was recorded from spacing of 60cm x 20 cm withno fertilizer. Abdul and Araf (1986) found that number of fruit per plant increased with increasing inorganic fertilizer levels and plant spacing, which is in agreement with the present findings.

Table 5. Main effect of spacing and sources of nutrients on pod length, pod diameter, a

Treatment	pod length (cm)	pod diameter (cm)	number of pods per plant	pod yield per plant (kg)
Spacing				
S_1 (60cmX20cm)	11.14b	1.23b	28.48c	3.97b
S_2 (60cmX30cm)	14.46a	1.42ab	32.11b	5.10a
S_3 (60cmX40cm)	14.76a	1.53a	41.06a	5.32a
LSD(0.05)	1.104	0.203	3.83	1.24
CV(%)	5.62	6.41	7.90	5.39
Sources of nutrient				
F_0 (Control)	12.12c	1.30b	30.92b	4.10b
F_1 (Cowdung)	13.29b	1.35b	34.73ab	4.51a
F_2 (Compost)	13.43b	1.37b	35.05ab	5.22a
F_3 (Inorganic fertilizers)	14.94a	1.53a	36.50a	5.43a
LSD(0.05)	1.10	0.203	3.83	1.24
Level of significance	**	**	**	**
Cv(%)	5.62	6.41	7.90	5.39

number of pods per plant and pod yield per plant of okra

In a column having same letter(s) do not differ singnificantly at 1% level of singnificance.

*= Significant at 5% level of probablity; ** = Significant at 1% level of probablity; NS = Not significant

S_1= 60cm X 20cm; S_2= 60cm X 30cm; S_3= 60cm X 40cm

F_0 = Control; F_1= cowdung (14 t/ha); F_2 = Compost (14 t/ha); F_3 = Inorganic fertilizer (Urea 150 kg/ha + TSP 100 kg/ha + MP 150 kg/ha)

4.10 Pod yield per plot

The effect of plant spacing on yield of pods per plant was significant (Table 5).The highest weight of pod per plant (5.32 kg) was recorded from the treatment S_3 (60 x 40 cm spacing), which was not significantly different(5.10 kg) from the treatment S_2 (60x30 cm). Plants in the plot of the nearest spacing (60 x 20cm) produced the lowest weight of pod per plant (3.97 kg). Singh (1990) reported that maximum pod weight was obtained from widest spacing .

The effect of different source of nutrients on pod yield per plot of okra was found significant (Table 5).The highest pod yield per plot (5.43 kg) was recorded from the treatment of inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) and the minimum pod yield per plot (4.10 kg) was produced by the control treatment (F_0). Kuruf *et a.* (1997) found the highest pod weight per plot with application of NPK fertilizer (inorganic fertilizer).

The combined effect of spacing and different source of nutrients showed statistically significant effects in respect of pod yield per plot of okra under the present experiment (Table 6 and Appendix III). The highest pod yield per plot (5.55 kg) was recorded from the spacing of 60 X 40cm with inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha), which was statistically similar to S_2F_1, S_3F_2 and S_2F_3. The lowest pod yield per plot (3.25 kg) was recorded from the spacing of 60X20cm with control treatment, which was statistically identical to all the treatments except S_3F_2, and S_3F_3.

4.11 Pod yield per hectare

There was wide variation among the plant spacing in respect of pod yield (t/ha) of okra (Fig.4).The highest pod yield (7.38t/ha) was recorded from the spacing 60x40cm, Plants in the plot of the nearest spacing (60x20cm) produced the lower pod yield (5.51 t/ha). This might be due to lower plant population per unit area. Saha *et al.*, (1989) found that yield per hectare increased with the increasing plant spacing, which is in well support of the present result.

Different source of nutrients showed significant variation on pod yield (t/ha) of okra (Fig. 5). Pod yield (t/ha) increased according to the application of cow dung (14 t/ha), compost (14 t/ha) and inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The maximum pod yield (7.361 t/ha) was recorded from the treatment of inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha), which was identical with the application of compost (14 t/ha) and the minimum pod yield (5.69 t/ha) was produced by the control treatment (F_0). Anonymous, (1978) found a similar result. Similar results were found by Ahmed and Reid (1998); Mani and Ramanathan (1980).

The combined effect of spacing and different source of nutrients was found statistically significant in case of pod yield (t/ha) of okra under the present experiment (Table 6 and Appendix III). Due to the combination of spacing and different source of nutrients pod yield (t/ha) ranged from 4.50 t/ha to 7.70 t/ha. The highest pod yield (7.70 t/ha) was recorded from spacing of 60 X 40cm with inorganic fertilizers (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha). The lowest pod yield (4.50 t/ha) was recorded from the treatment combination of S_1F_0 (spacing of 60 X 20cm with no fertilizer). Rastogi *et al.* (1987) found seed yield as well as pod yield with 60 x 40 cm spacing + 60 kg N/ha. Abdul and Araf (1986) reported that highest level of NPK and closer spacing gave the maximum yield.

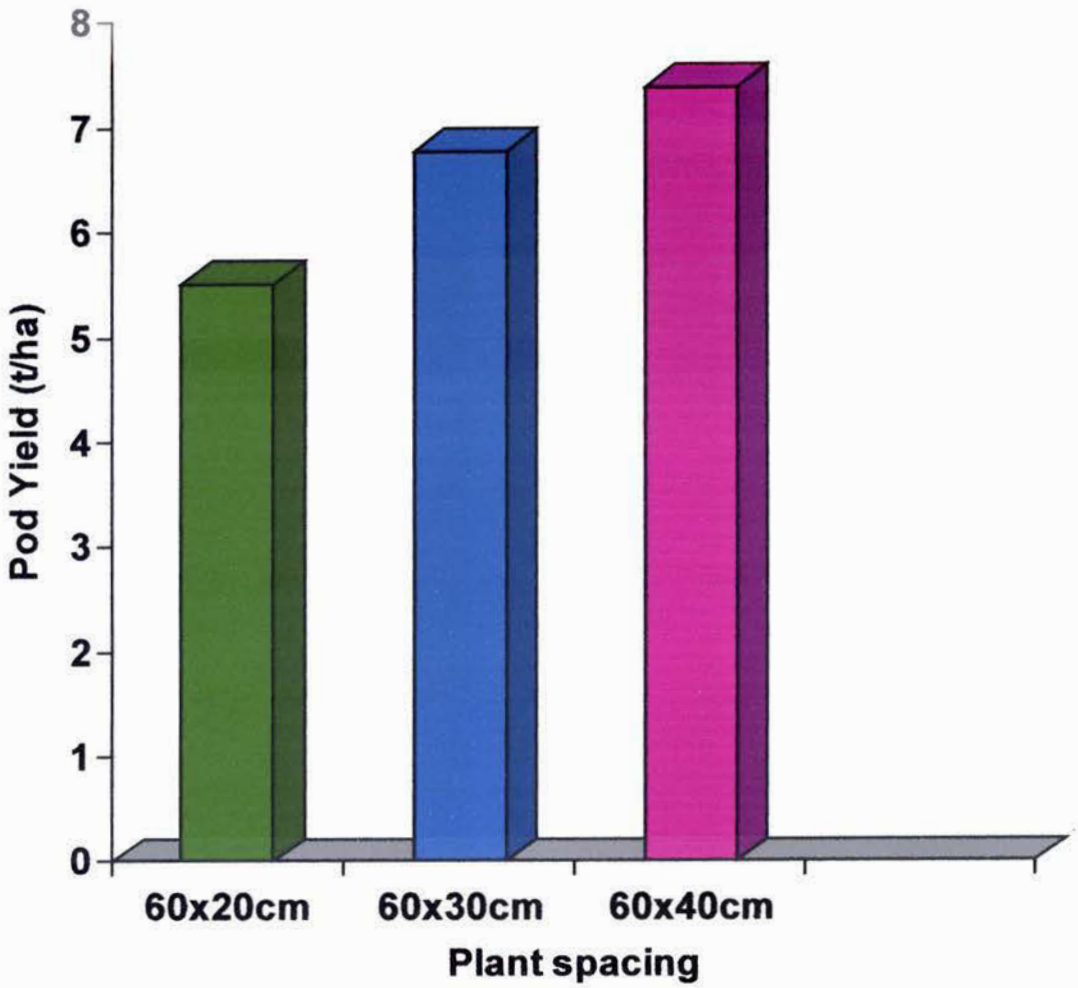


Fig 4. Effect of spacing on pod yield (t/ha) of okra.

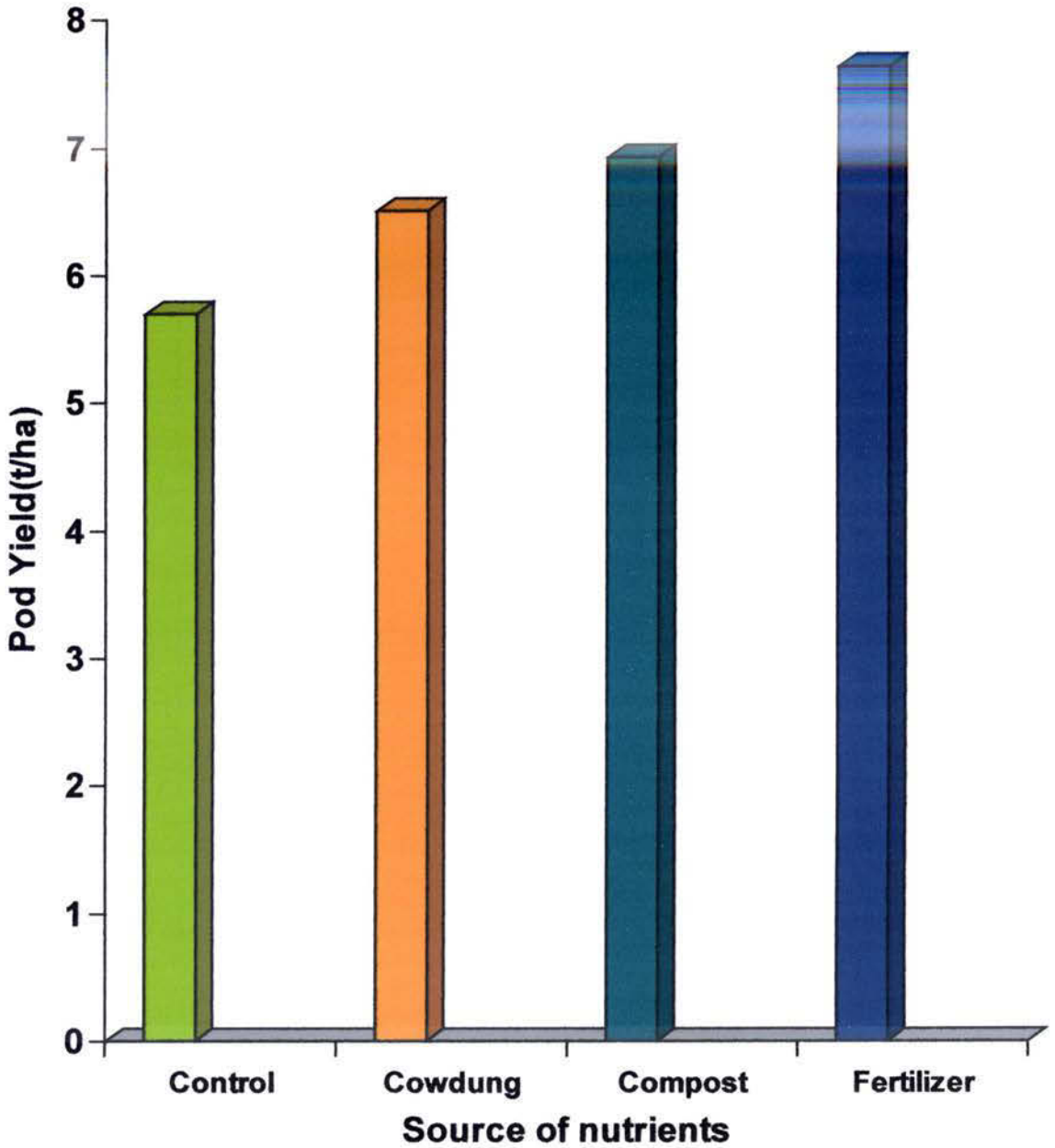


Fig 5. Effect of source of nutrients on pod yield (t/ha) of okra.

Table 6 Combined effect of spacing and sources of nutrient on pod length, pod diameter, number of pods per plant, pod yield per plot and pod yield per hectare of okra

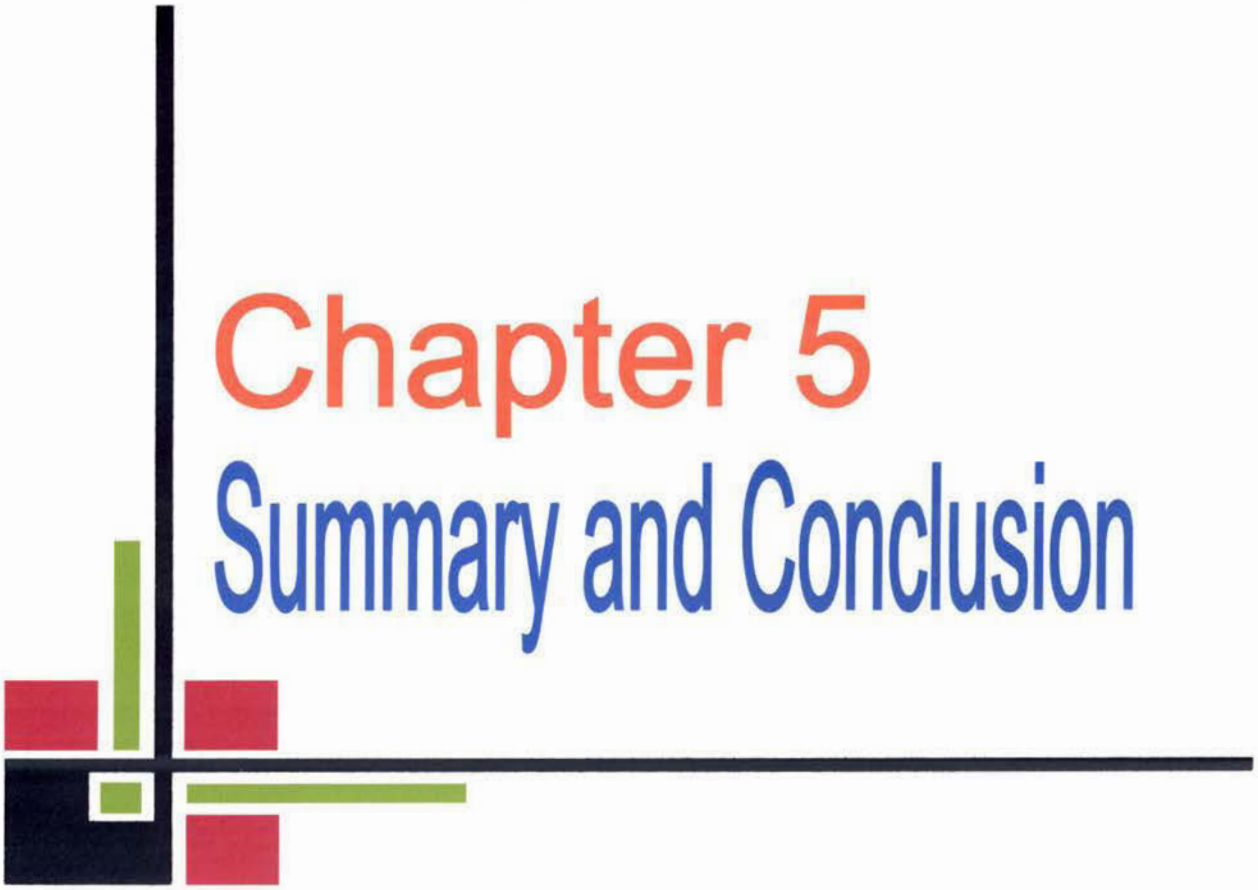
Treatments combination	Pod length(cm)	Pod diameter(cm)	Number of pods per plant	Pod yield per plot (kg)	Pod yield per hectare (ton)
S_1F_0	10.77c	1.17d	26.60j	3.25b	4.50d
S_1F_1	11.13c	1.19d	27.97i	3.30b	5.47c
S_1F_2	11.53c	1.42bc	31.94f	3.39b	6.39ab
S_1F_3	14.20b	1.46bc	34.17e	4.00b	6.81ab
S_2F_0	11.10c	1.23d	27.83h	3.60b	5.21c
S_2F_1	14.03b	1.33b	28.01h	3.91b	5.97c
S_2F_2	14.13b	1.35b	35.00d	4.62ab	6.53ab
S_2F_3	15.03ab	1.47bc	37.00c	4.96ab	7.01a
S_3F_0	10.92c	1.30cd	29.17g	3.96b	5.63c
S_3F_1	14.40ab	1.43bc	31.00f	4.57ab	6.94ab
S_3F_2	14.60ab	1.50b	42.20b	5.16a	7.36a
S_3F_3	15.27a	1.70a	43.97a	5.55a	7.71a
LSD(0.05)	0.843	0.155	1.510	1.420	0.931
Level of significance	**	*	**	**	**
CV(%)	5.62	6.41	7.90	5.39	6.92

In a column having same letter(s) do not differ singnificantly at 1% level of singnificance.

* = Significant at 5% level of probablity; ** = Significant at 1% level of probablity; NS = Not significant

S_1= 60cm X 20cm; S_2= 60cm X 30cm; S_3= 60cm X 40cm

F_0 = Control; F_1= cowdung (14 t/ha); F_2 = Compost (14 t/ha); F_3 = Inorganic fertilizer (Urea 150 kg/ha + TSP 100 kg/ha + MP 150 kg/ha)



Chapter 5
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, during April 2007 to July 2007 to study the effects of spacing and sources of nutrients on growth and yield of okra. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 7.2 m^2 (3.0 m x 2.4m). There were 9 treatments combinations in the experiment comprising three (3) different spacing (60 X 20cm, 60 X 30cm and 60 X 40cm designated as S_1, S_2 and S_3, respectively) and 4 levels of source of nutrients (no fertilizer, cow dung, compost & inorganic fertilizer designated as F_0, F_1, F_2 and F_3, respectively).

Data on plant characters were recorded at 20 DAS, 40 DAS and 60DAS. Spacing and different source of nutrients individually influenced plant characters. The individual and interaction effect of spacing and source of nutrients on growth and yield was found positive.

Plant height, plant diameter, number of leaf per plant, leaf length, leaf width, number of branches per plant, pod length, pod diameter, number of pod per plant, pod weight per plot and pod yield per hectare were significantly affected by different spacing.

At 20 DAS the spacing 60 X 40cm gave the highest plant height (35.02 cm), plant diameter (1.80 cm), number of leaves per plant (8.778) and maximum leaf length (25.58 cm) and leaf breadth (19.26 cm). The spacing of 60 X 20 cm produced the minimum leaf length (21.23cm), leaf breadth (17.83 cm) and lowest plant height (37.43 cm), plant diameter (1.80 cm), number of leaves per plant (8.22), number of branches per plant (2.10). At 40 DAS, the highest plant height (61.31 cm), plant

diameter (2.78 cm) and the lowest number of leaves per plant (12.56), leaf length (29.07 cm), leaf breadth (22.60 cm), number of branches per plant (2.83) were recorded from 60 X 40cm plant spacing. Spacing 60 X 40cm gave the highest number of branches per plant (4.10) and the highest number of leaves per plant (20.44), leaf length (38.41 cm), leaf breadth (28.66 cm). Spacing 60x 20 cm showed the lowest plant height (54.46 cm), plant diameter (2.61cm). At 60 DAS the highest plant height (115.2 cm), plant diameter (3.20 cm), number of leaf per plant (37.44), leaf length (47.33 cm), leaf breadth (37.17 cm), number of branches per plant (4.23) were recorded with 60 X 40cm plant spacing.and spacing 60 X 20cm gave the lowest number of branches per plant (3.18), the lowest plant diameter (3.02 cm), leaf breadth (31.70 cm), and lowest plant height (98.81 cm) and the number of leaf per plant (30.11).

The highest pod length (14.76 cm) was found in 80 X 60cm spacing and maximum pod diameter (1.53 cm), number of pods per plant (41.06), pod weight per plot (5.32 kg) and pod yield (7.38 t/ha) was recorded in 60cm X 40cm spacing. The lowest pod diameter (1.23 cm), number of pod per plant (28.48), pod yield per plot (3.97 kg) was obtained from the spacing 60X 20 cm.

Data on plant height, plant diameter, number of leaf per plant, leaf length, leaf width, number of branches per plant, pod length, pod diameter, number of pods per plant, pod weight per plot and pod yield per hectare were significantly affected by different source of nutrients. The highest plant height (113.5 cm), plant diameter (3.20 cm), number of leaf per plant (37.44), leaf length (46.57 cm), leaf breadth (35.80 cm), number of branches per plant (3.76) were observed from the inorganic fertilizer treated plot at 60 DAS. The lowest plant height (83.92 plant diameter (2.68 cm), number of leaf per plant (31.22), leaf length (42.13 cm), leaf breadth (32.26 cm) and number of branches per plant (3.23) were found control plot at 60 DAS. Further

inorganic fertilizer gave the maximum pod length (14.94 cm), pod diameter (1.53 cm), number of pod per plant (36.50), pod weight per plot (5.43 kg) and pod yield (7.361 t/ha) and cow dung gave the minimum pod length (12.12 cm), pod diameter (1.30 cm), number of pod per plant (30.92), pod weight per plot (4.10 kg) and pod yield (5.69 t/ha).

The combination of spacing and inorganic fertilizer was highly significant in respect of plant height, plant diameter, number of leaf per plant, leaf length, leaf breadth, number of branches per plant, pod length, pod diameter, number of pod per plant, pod weight per plot and pod yield per hectare. The spacing 60 X 40cm with inorganic fertilizer produced highest number of branches per plant (5.00), plant diameter (3.50 cm), number of leaf per plant (44.0), leaf length (49.60 cm) and leaf width (41.40 cm) at 60 DAS. The shortest plant height (85.80 cm), the minimum number of leaf per plant (27.33) and number of branches per plant (3.0), leaf length (39.70 cm) was recorded from the treatmentcombination of S_1F_0 (60 X 20 cm spacing with no fertilizer) at 60 DAS.

The treatment combination of 60 X 40cm with inorganic fertilizer gave the maximum pod length (15.27 cm), pod diameter (1.70 cm), number of pod per plant (43.97), pod weight per plot (5.55 kg) and pod yield (7.71 t/ha) and the lowest pod weight per plot (3.250 kg) and pod yield (4.50 t/ha) were obtained from 60 X 20 cm spacing with no fertilizer. The minimum pod length (10.77 cm), pod diameter (1.17 cm) and number of pods per plant (26.60) were also observed with 60 X 20cm spacing and no fertilizer.

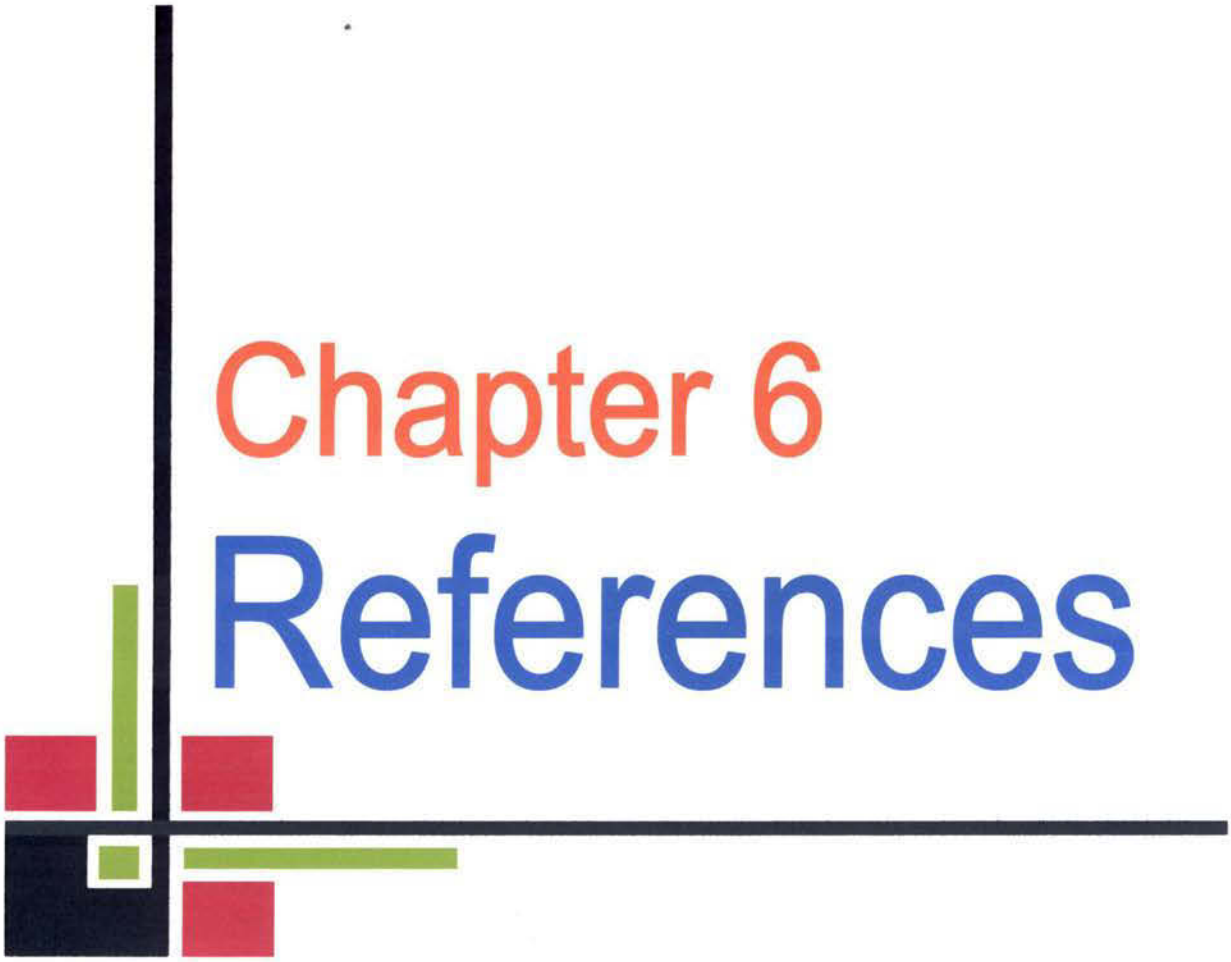
Considering the present study, the following conclusion may be drawn –

- Individual effect of spacing and source of nutrients on growth and yield of okra was found positive and significant.

- The combined effect of spacing and source of nutrients enhanced growth, yield and yield attributes of okra.

- Application of inorganic fertilizer (Urea 150 kg/ha, TSP 100 kg/ha and MP 150 kg/ha) and 60 X 40 cm spacing was the most suitable combination to ensure the highest yield of okra production.

Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings.



Chapter 6
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CHAPTER VI

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APPENDICES

Appendix1.A. Morphological Characteristics of experimental field

Morphological Features	Characteristics
Location	Sher-e Bangla Agril. University Farm, Dhaka
AEZ No. and name	AEZ-28, Modhupur Tract
General soil type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of inundation	Above flood level
Drainage condition	Well drained
Land type	High land

B. Physical and chemical properties of the experimental soil

Soil properties	Value
A. Physical properties	
1. Particle size analysis of soil.	
% Sand	29.04
% Silt	41.80
% Clay	29.16
2. Soil texture	Clay loam
B. Chemical properties	
1. Soil pH	5.8
2. Organic carbon (%)	0.78
3. Organic matter (%)	1.35
4. Total N (%)	0.08
5. C : N ratio	9.75 : 1
6. Available P (ppm)	35
7. Exchangeable K (me/100g soil)	0.18
8. Available S (ppm)	40
9. Available B (ppm)	0.34

Appendix II. Monthly records of meteorological observation at the period of experiment (April, 2007 to July, 2007)

Month	Temperature		Humidity (%)	Precipitation (mm)
	(Maximum. ^{O}C)	(Minimum. ^{O}C)		
April	30.60	19.5	76.50	45
May	31.90	20.13	78.00	52
June	33.60	22.5	82.7	65
July	35.80	22.9	88.3	72

Source : Weather Yard, Bangladesh Meteorological department, Dhaka.

Appendix III . Analysis of variance of the data on the yield characters of okra

Source of variation	Degrees of Freedom	Mean Sum of Square				
		Number of pods per plant	Pod length	Pod diameter	Weight of pod per plot	Pod yield
Replication	2	0.074	0.351	0.073	0.080	0.056
Factor (A) Spacing (S)	2	377.11**	36.14**	0.207**	4.252**	8.836**
Factor (B) Source of nutrients (F)	2	62.658**	1.70**	0.074**	1.833**	4.135**
Interaction S x F	4	6.336**	0.056**	0.019**	0.411**	0.724**
Error	16	9.085	0.237	0.008	0.253	0.287

Appendix IV. Analysis of variance of the data on the plant characters of okra

Source of variation	DF	Mean of Sum Square																	
		Plant height (cm)			Plant diameter (cm)			Number of leaves per plant			Leaf length (cm)			Leaf breadth (cm)			Number of branches 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	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
Replication	2	6.92	2.19	7.89	0.05	0.03	0.03	0.44	14.37	10.04	1.66 NS	2.30	4.78 **	0.66 NS	5.91	3.56	1.07	0.78	1.87
Factor (A) Spacing (S)	2	8.81NS	210.8 **	612.2 **	0.16 **	0.35*	0.25*	0.78*	281.8 *	26.82 *	42.71 *	242.2 **	69.46 **	4.93 *	83.82 **	69.06 **	0.06 NS	5.24 **	2.50 **
Factor (B) Source of nutrients (F)	2	2.26NS	68.28 **	435.8 **	0.65 **	0.27*	0.19*	0.44*	31.37 *	78.48 **	27.32 *	22.50 *	49.96 **	29.21 *	46.55 **	28.85 **	1.58 NS	1.82 **	0.72 **
Interaction S x F	4	1.59*	13.89 **	90.39 **	0.13 **	0.16*	0.08*	0.56*	45.09 *	98.59 *	10.54	94.81 *	24.15	10.83	24.17 **	18.74 **	0.31 NS	0.83 **	0.47 **
Error	16	1.05	2.07	14.52	0.03	0.08	0.07	0.57	1.66	4.37	4.75	4.79	2.85	0.75	1.60	2.33	0.12	0.25	0.05

NS = Not significant
* = 5% level of significant
** = 1% level of significant