EFFECT OF FARM YARD MANURE AND CHEMICAL FERTILIZERS ON THE GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L.)

BY

MD. HASINUZZAMAN

Reg. No. : 00811

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APPROVED BY:

Prof. Dr. Gopinath Chandra Sutradhar
Department of Soil Science
SAU, Dhaka
Supervisor

Prof. Dr. Alok Kumar Paul
Department of Soil Science
SAU, Dhaka
Co-Supervisor

A. T. M. Shamsuddoha
Chairman
Examination Committee

DEPARTMENT OF SOIL SCIENCE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/Soil Science/(09)/ Date :

CERTIFICATE

This is to certify that the thesis entitled **"Effect of Farm Yard Manure and Chemical Fertilizers on the Yield and Growth of Okra (*Abelmoschus exculentus* L.)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in Soil Science**, embodies the result of a piece of bonafide research work carried out by **Md. Hasinuzzaman**, Registration number: **00811** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
Dhaka, Bangladesh

Prof. Dr. Gopinath Chandra Sutradhar
Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207

DEDICATED
TO
MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to June 2008 to study the effect of farm yard manure and chemical fertilizers on the growth and yield of okra. The red tarrece soil of Tejgaon was silty loam in texture having ph 5.6. The experiment was conducted in a RCBD with 4 replications and 7 treatments. The treatments were T_0: Control, T_1: 100% organic manure [Farm yard manure 25 ton/ha]. T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha], T_3: 80% organic manure + 20% chemical fertilizers, T_4: 60% organic manure + 40% chemical fertilizers, T_5: 40% organic manure + 60% chemical fertilizers, T_6: 20% organic manure + 80% chemical fertilizers. It was observed from the experiment that T_5 combination significantly increased all the parameters studied. Maximum results were found with T_5 treatment and minimum results were found with T_0 treatment in the most of the cases on the growth and yield of okra.

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CHAPTER I

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop in Bangladesh belonging to the family Malvaceae and grown throughout the tropical and subtropical regions of the world. It is also known as Lady's finger and locally known as "Dherosh" or "Bhindi". It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Tahkur and Arora, 1986). It is well distributed throughout the Indian sub continent and East Asia (Rashid, 1990). It is a multipurpose crop and its tender green fruits are popular as vegetable among all classes of people in Bangladesh and elsewhere in the world.

In Bangladesh vegetable production is not uniform round the year. Vegetables are plenty in winter but are in short in summer of the total vegetable production around 30% is produced during Kharif season and around 70% is produced in Rabi season (Anon., 1993). So okra can get an importance for summer season vegetable. The per capita consumption of vegetables in South Asian Association for Regional Co-operation (SAARC) countries, mainly Pakistan (69 g), Srilanka (120 g), and India (135 g) are higher then that of Bangladesh. But many dietitians prescribe daily requirements 285g of vegetable for an adult person (Rampal and Gill, 1990). Therefore, there is a big gap between the requirement and supply of vegetable in Bangladesh. As a result, malnutrition is very much evident in the country. Successful okra production may contribute partially in solving vegetable scarcity of summer season for the increasing population.

Vegetable deficiency is a chronic problem of Bangladesh. At present vegetable are grown 429 thousand hectares of land which is only 3% of the total cropped area, and total annual production of vegetable is estimated to be 2 million metric tons with an average productivity of 5 tons per hectare (Rekhi, 1997). Total production of okra is about 240 thousand tons, produced from 7287.5 ha of land and the average yield was about 3.38 t/ha which is very low (Monthly Bulletin, BBS, February, 2008). Tender green pods of okra generally marketed as fresh condition. The tender fruit of okra contains approximately 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Purseglove, 1987). Tender pods contain high mucilage and are used in soups and graves; seeds are also a good source of protein. The pods also have some medicinal value and a mucilaginous preparation from the pod can be used as a plasma replacement or blood volume expander (Savello *et al.*, 1980).

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. 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 5%. 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 opportunity of increasing okra yield per unit area with proper use of organic and inorganic fertilizer. Application of fertilizers in split at different time reduces the loss of nutrients and gives better response of okra crops.

Nitrogen is the key element to the vegetative growth of plants. It plays an important role to build up the protoplasm and protein which induce cell division and initiate meristematic activities when applied is optimum quantity. Majanbu *et al.* (1985) reported that nitrogen application significantly increased pod weight, diameter, no of fruit/plant and no of seed/pod in okra. Most of the reports on the effect of phosphorus application on green pod yield in okra have been conflicting. Ahmad and Tallock (1964) observed 75 percent yield increase due to phosphorus application at 56 kg/ha. Moreover, okra is a fruit vegetable. So, phosphorus fertilization can influence in fruiting development of fruits which is the nature of phosphorus effect. Potassium also has an important role on balancing physiological activities. Different level of potassium influences the growth and yield of okra.

Under the above circumstances, the present research was undertaken with the following objectives:

1. To study the effect of farm yard manure and chemical fertilizers on the growth and yield of okra.

CHAPTER II

REVIEW OF LITERATURE

Okra is an important vegetable crop in Bangladesh. Different levels of organic manures, nitrogen, phosphorus and potassium application influence the growth and yield of okra. It is important to assess the optimum doses of organic manures, nitrogen, phosphorus and potassium for the best growth, green pod and yield of okra in Bangladesh. Research reports on the effect of organic manures, nitrogen, phosphorus and potassium on the growth and yield of okra has been done in various part of the world including Bangladesh. The work so far done in Bangladesh is not adequate and conclusive. Some of the important and informative works conducted home and abroad is reviewed in this chapter under the following headings:

2.1 Effect of organic manure

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.

Raj and Kumari (2001) reported that the effect of farmyard manure (FYM; 12 t/ha) and *Azosprilillum* 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, All treatments were applied as basal dosi. 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).

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.

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, 1980).

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.

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

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

2.2 Effect of nitrogen, phosphorus and potassium

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

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

Bamel and Sing (2003) was conducted a pot experiment to study the effect of different fertilizer sources on *M. incognita* in okra under greenhouse condition. Better plant growth and reduced nematode damage when a combination of N, P, K and Zn fertilizers was applied at recommended dose. Individually, muriate of potash and potassium sulfate 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 sulfate, showed reduction in nematode damage with a corresponding increase their dose.

Aslam and Bose (2003) reported that excessive use of nitrogen fertilizers is a factor of nitrate accumulation in vegetable, which cause health problems to the consumers. A study was conducted to assess the effect of NPK fertilizers on NO_3 accumulation in okra (*Abelmoschus esculentus*) and carrot (*Daucus carota*) at Ayub Agricultural Research Instute, Faisalabad, Pakistan. For okra five (0, 100, 150, 175 and 200 kg/ha) and two P_2O_5 rates (0, 75 kg/ha) were tested with 60 kg K_2O/ha as basal dose. On carrot, four N (0, 25, 50, 75 kg/ha), three P_2O_5 (0, 50, 75 kg/ha) and two K_2O rates (0, 25 kg/ha) were applied. Increasing fertilizer rates increased NO_3 concentration over the control in okra and carrot. However, the application of N with P reduced NO_3 concentration in okra. Conversely, the NO_3 concentration in carrot increased significantly over the control either with N applied alone or with P.

a balanced use of N and P (2:1) fertilizers reduced the NO_3 accumulation. Additionally, the doses of NPK fertilizers applied in this study did not pose health hazards to the consumers.

Prabu and Pramanik (2002) conducted an experiment in Parbhani, Maharashtra, India, during the summer season of 2001 to investigate the effects of organic 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 (un inoculated; *Azospirillum* + phosphate sollubilizing bacteria, and *Azospirillum* + vesicular arbuscular mycorrhiza) on the performance of okra cultivar Parbhani Kranti. Result showed that the treatment 2/3 recommended NPK dose + FYM + *Azospirillum* vesicular arbuscular mycorrhiza produced in the highest yield.

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

Gowda *et al.* (2001) conducted a field experiment in Bangalore, Karnataka, India, during the 1999 summer season to determine the response of okra cultivers Arka Anamika, Varshal to 3 NPK fertilizer rates (125:75:60 kg/ha, 150:100:75 kg/ha, and 175:125:100 kg/ha). The highest dry matter production in (20.40 g), stems

(35.17g), fruits (31.11 g), and whole plants (104.71 g) was recorded with 175: 125: 100 kg/ha treatments. Varsha recorded significantly higher dry matter production in leaves (17.48 g), stems (31.44 g), roots (17.61 g), fruits (29.98 g), and whole plants (96.51 g) compared with other cultivers. In the interaction effect, the highest total dry matter production (111.48 g/plant) was recorded in Varsha supplemented with 175: 125: 100 kg NPK/ha, which was at par with Arka Anamika supplemented with 175: 125: 100 kg NPK/ha. Yogesh and Arora (2001) conducted a field experiment in Nagina, Uttar Pradesh, India, during the kharif season of 1998 and 1990 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.. The highest number of seed per pod (57.0) and seed yield per plot (2.94kg) was obtained with the application of 120 kg/ha and 80 kg P/ha.

An experiment was conducted by Bhai and Shing (1998) at Palampur, India to investigate the effect of P application rate (50, 70, or 90 kg/ha) on okra. They reported that P application significantly increased the plant height, number of pods per plant and seed yield. They also reported that K application significantly increased the plant height, number of nodes per plant and yield of okra.

A field experiment was conducted on okra cv. Pusa Sawani in India. K rate (50, 70 and 90 kg/ha) and GA_3 seed treatment (200 or 300 ppm for 12 h) had no significant effect on yield (Bhat and Singh, 1997).

Arora *et al.* (1991) compared the growth and yield of a new okra cultivar, Punjab Padmini, with that of cv. Pusa Sawni grown under variable N (0, 30, 60 and 90 kg/ha) fertilizer application. They stated that plant height, numbers of pods, pod size and total green pod yield were significantly improved by the application of 90 kg N/ha and 60 kg P/ha. A significant increase in mean marketable yield for both cultivers was obtained with an increase in N application from 0 to 90 kg/ha (100.9 to 156.0 q/ha) and increase in P application from 0 to 60 kg/ha (116.0 to 136.5 q/ha). Optimum treatment was 90 kg N + 60 kg P/ha giving a yield of 192.1 q/ha.
In trails with okra CV. Pusa Sawani, N and K_2O were each applied at 0-120 kg/ha (Misra and Pandey, 1987). N at 80 kg/ha and K at 40 kg/ha significantly increased the number of fruits/plant, 1000 seed weight and the seed yield. Application of N above 80 kg/ha and K above 40 kg/ha adversely affected seed yield. Interaction effect was significant with 80 kg N, 40 kg K/ha giving the highest seed yield of 15.47 q/ha.

Rain and Lal (1990) conducted a field experiment in Bapalta, Andhra Pradesh, India, during 20 March – 8 July 1997 to study the growth and development of okra cultivers(*Parbhani Kranti*, *Arka Anamika* and *Pussa Sawani*) in response to 4 fertilizer levels(0-0-0, 50-25-25, 100-50-50 and 150-75-75 kg N, P_2O_5, K_2O/ha respectively). Results showed that leaf area index (LAI) and leaf area duration (LAD) were significantly influenced at all stages by cultivers, fertilizer levels and their interaction effects. Among the cultivers, Pusa Sawani showed the maximum leaf area, LAI and LAD. However, Arka Anamika showed significantly superior performance with respect to plant height, number of leaves, and number of nodes and yield per plant. The highest fertilizer level resulted in maximum leaf area, LAI and LAD, which gradually increased up to 60 days after sowing (DAS). Dry matter production was influenced significantly by cultivers, fertilizer levels and their combination. Crop growth rate (CGR) and relative growth rates were influenced by cultivars and fertilizers. Net assimilation rate (NAR) declined 60 DAS. Harvest index (HI) was also influenced by cultivars, fertilizer levels and their interaction. Arka Anamicka, with a moderate vegetative growth and high NAR, had the highest HI values. Among the fertilizer levels, maximum HI was recorded by 100-50-50 kg NPK/ha.

Mani and Ramanathan (1990) 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.

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

Manjanbu, *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 up to 100 kg N/ha.

Abdul andArif (1986) stated that in two trails, okra was grown at spacing of 20, 30, 40, 50 and 60 cm with 5 levels of 100, 250, 300, 350 and 400 kg NPK /donum [=1338 m^2]. The maximum yield (12.23 t/donum) was obtained with 400 kg at 20 cm spacing. The number of pods/plant increased slightly by increasing fertilizers levels,but there was no significant effect on average pod weight.

Adelana (1985) reported that significant responses were obtained to 20-40 kg N, 20 kg P and 20-30 kg K/ha at two sites in the derived savanna and at one site in the forest zone. In another study with the cultivars Pusa sawni and Punjab Padmini, the highest pod glycoprotein content was obtained with plants receiving N: P_2O_5 at 90:60 kg/ha (Arora *et al.*, 1985).

In a field trial with the cv. Pusa Sawni the plant received N at 40-120 and or P_2O_5 at 30 or 60 kg/ha (Reddy *et al.*, 1984) and observed that nitrogen alone increased the yields from 58.9 q/ha at 120 kg N/ha, where as P alone increased the yields from 89.16 q/ha at 60 kg P_2O_5. However, the highest yield (101.46 q/ha) was obtained with N+P at the highest rates.

Sing and Pande (1982) reported that the highest N levels (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 . Different K levels had no significant effect on yield in the absence of N.

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 increased by increasing application of N (22.5, 45.0 or 67.5 kg/ha). P at 22.5 or 450 kg/ha .K at 22.5 kg/ha had no response on growth and yield. NPK applications, however, generally increased yields.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to June 2008 to study the effect of farm yard manure and chemical fertilizers on the growth and yield of okra. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

3.1 Experimental site and soil

The experiment was conducted in silt loam soil at the Sher-e-Bangla Agricultural University (SAU) farm, Sher-e-Bangla Nagar, Dhaka. The morphological, physical and chemical characteristics of the soil are shown in the Table 1 and 2.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season March to June 2008 have been presented in Appendix I.

Table 1. Morphological characteristics of the experimental field

Morphology	Characteristics
Location	SAU farm, Dhaka.
Agro-ecological zone	Madhupur Tract (AEZ 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(UNDP, 1988)

Table 2. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (0.2-0.02 mm)	22.53
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
Consistency	Granular and friable when dry.
pH (1: 2.5 soil- water)	6.2
CEC (cmol/kg)	17.9
Organic C (%)	0.686
Organic Matter (%)	1.187
Total N (%)	0.032
Exchangeable K (cmol/kg)	0.12
Available P (mg/kg)	19.85
Available S (mg/kg)	14.40

3.3 Planting material

BARI dherosh-1 was used as the test crop in this experiment. This variety was developed at the Bangladesh Agricultural Research Institute in the year of 1996. Average plant height of the variety is 2.0-2.5 m and the average number of fruits is about 25-30. It can be cultivated year the round and complete its life cycle about 5 months with an average fruit yield of 14-16 t/ha (BARI, 2005).

3.4 Land preparation

The land was first opened on February 02, 2008 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before seed sowing each unit of plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by levelling and distinct border in each plot.

3.5 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD), where the experimental area was divided into four blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into seven unit plots as treatments with raised bunds around. Thus the total number of unit plot was 28 and the size was 2 m × 2 m and ailes of 0.5 m separated plots from each other. The blocks were separated from one another by one-meter drain. Treatments were randomly distributed within the blocks.

3.6 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected from different spots of the experimental field. The composite soil sample were air-dried, crushed and passed through a 2-mm (8 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the soil.

3.7 Treatments

Farm yard manure as organic manure and different combination of chemical fertilizers such as urea, TSP, MOP, gypsum and zinc sulphate were used in the study. The experiment consisted of 7 treatments. The treatments will be as follows:

T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MOP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

T_6: 20% organic manure + 80% chemical fertilizers

3.8 Fertilizer application

The amounts of N, P, K, S and Zn fertilizers required per plot were calculated as per the treatments. Full amounts of TSP, MOP gypsum and Zinc sulphate were applied as basal dose before sowing of seeds. Urea were applied in 3 equal splits: 50% was applied at basal before seeds sowing, rest half was applied in two equal doses at before flowering stage and fruiting stage.

3.9 Organic manure incorporation

Farm yard manure was mixed with soil. For that farm yard manure as per the treatment was distributed the plot and mixed with soil.

3.10 sowing of seeds

The field was divided into 28 plots. In each plot, okra seeds of cv. BARI Dherosh-1 were sown on 27 March, 08. Before that the seeds were soaked in water for 24 hours and then wrapped with a piece of thin cloth. Then the seeds were spread in polythene sheet for 2 hours to dry out the surface water. This encourages the quick germination. Row-row and plant-plant distance were followed according requirements. Three-four seeds were sown in each pit and the seeds were covered with fine soil with hand.

3.10 Intercultural Operation

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

3.10.1 Thinning

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

3.10.2 Gap filling

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

3.10.3 Weeding

Weeding was done 3 times in order to get free from weeds in the plots.

3.10.4 Irrigation

Light irrigation was given just after the sowing seeds. And then it was done as per requirements.

3.10.5 Plant Protection Measures

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

3.11 Harvesting

Green pods were harvested at 1 day interval when they attained edible stage.

3.12 Data Collection

Ten (10) plants were randomly selected from each unit plot for the collection of data. The border plants in each plot were selected for the collection of growth data of okra and the other plants were selected for the collection of yield data of okra. Data were collected at 30, 50 and 70 DAS on the following parameters from the selected plants during the experiments:

i) Plant height

Plant height was measured in centimeter (cm) by a meter scale at 30, 50 and 70 DAS from the soil surface of stem up to the tip of the longest leaf. Average height was taken very carefully from the randomly selected plants.

ii) Plant diameter

Plant diameter was measured by a slide calipers. It was measured in centimeter (cm) at 30, 50 and 70 DAS at the thickened portion of the plant.

iii) Number of leaves per plant

Excluding young leaves from counting number of leaves per plant was counted at 30, 50 and 70 DAS. All the leaves of each plant were counted separately. Average number of leaf per plant was recorded very carefully.

iv) Length of leaves

Length of ten (10) leaves were measured in centimeter (cm) with the help of a meter scale from the base of the leaf which attached with petiole up to the point of leaves and average leaf length were also recorded from the randomly selected plants.

v) Breadth of leaves (cm)

Ten (10) leaves of randomly selected plants were made detached and measured in centimeter (cm) by a meter scale at 30, 50 and 70 DAS from the middle of the leaves. Average leaf breath of 10 plants was recorded from randomly selected sample plants.

vi) Petiole length

Petiole length was measured in centimeter (cm) by a meter scale at 30, 50 and 70 DAS from the point of attachment of the leaf.

vii) Days to flowering

Days to flowering were recorded from seed sowing to first flowering of okra and express in days.

viii) Days to edible maturity

Days to edible were recorded from flowering to attaining for edible of okra and express in days.

ix) Green pod diameter

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

x) Green pod length

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

xi) Number of green pods per plant

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

xii) Green pod yield per hectare

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

3.13 Chemical analysis of plant samples

3.13.1 Collection of plant samples

Plant and fruit samples were collected after cleaning. The samples were finely ground by using a Wiley-Mill with stainless contact points to pass through a 60-mesh sieve. The samples were stored in plastic vial for analyses of N, P, K and S.

3.13.2 Preparation of plant samples

The plant samples were dried in an oven at 70 ^{0}C for 72 hours and then ground by a grinding machine to pass through a 20-mesh sieve. The plant and fruit samples were analyzed for determination of N, P, K and S concentrations. The methods were as follows:

3.13.3 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 5 ml conc. H_2SO_4 were added. The flasks were heating at 120^{0}C and added 2.5 ml 30% H_2O_2 then heated was continued at 180 ^{0}C until the digests became clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

3.13.4 Digestion of plant samples with nitric-perchloric acid for P, K and S

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest.

3.13.5 Determination of P, K and S from plant samples

3.13.5.1 Phosphorus

Phosphorus was digested from the sample (plant and fruit) with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 ml for plant and fruit sample from 100 ml extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

3.13.5.2 Potassium

Five milli-liter of digest sample for plant and fruit were taken and diluted 50 ml volume to make desired concentration so that the absorbance of sample were measured within the range of standard solutions. The absorbances were measured by atomic absorption flame photometer.

3.13.5.3 Sulphur

Sulphur content was determined from the digest of the samples (plant and fruit) with $CaCl_2$ (0.15%) solution as described by (Page *et al.* 1982). The digested S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

3.14 Nutrient Uptake

After chemical analysis of plant and fruit samples the nutrient contents were calculated and from the value of nutrient contents, nutrient uptakes were also calculated by following formula:

Nutrient uptake(kg/ha) = Nutrient content (%) × Yield (kg/ha)/100

3.15 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil sample of each plot were air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.16 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, K, and S contents. These results have been shown in the Table 4.6. The soil samples were analyzed by the following standard methods as follows:

3.16.1 Textural class

Mechanical analysis of soil were done by hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values of % sand, % silt and % clay to the Marshall's triangular co-ordinate following the USDA system.

3.16.2 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1962).

3.16.3 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.16.4 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200 ^0C and added 3 ml H_2O_2 and then heating at 360 ^0C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.16.5 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated the standard P curve (Page *et al.*, 1982).

3.16.6 Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.*, 1982).

3.16.7 Available sulphur

Available S content was determined by extracting the soil with $CaCl_2$ (0.15%) solution as described by (Page *et al.*, 1982). The extractable S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

3.17 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield and yield contributing characters of okra. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of farm yard manure and chemical fertilizers on the yield and growth of okra. Data on different growth parameters, yield and nutrients concentration and uptake by plants and fruits was recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix II-VII. The results have been presented and possible interpretations given under the following headings:

4.1 Yield contributing characters and yield of okra

4.1.1 Plant height

Plant height of okra showed statistically significant variation due to the application of farm yard manure and inorganic fertilizer at 30, 50 and 70 DAS (Appendix II). At the different days after sowing (DAS) the highest plant (23.008 cm, 77.89 cm and 120.97 cm) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically similar (21.13 cm, 75.04 cm and 113.07 cm) with T_2 (100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]) at 30, 50 and 70 DAS, respectively. Again, at the same DAS the lowest plant (14.00 cm, 49.89 cm and 74.56 cm) was observed from T_0 as control condition (Table 4). From the data it was revealed that all the treatments produced significantly taller plants compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the plant height compared to single application of recommended dose of farm yard manure or chemical fertilizers. Plant height was significantly influenced by the application of farm yard manure and chemical fertilizers. Shanke *et al.* (2003) reported that tallest plant (68.88 cm) was recorded under 125 kg N/ha and the shortest (54.90 cm) under no nitrogen application.

4.1.2 Plant diameter

Statistically significant variation was recorded for plant diameter of okra due to the application of farm yard manure and inorganic fertilizer at 30, 50 and 70 DAS (Appendix II). At the different days after sowing (DAS) the maximum plant diameter (2.29 cm, 3.35 cm and 5.22 cm) was obtained from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (2.14 cm, 3.54 cm and 5.22 cm) with T_2 (100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]) at 30, 50 and 70 DAS, respectively. Whereas, at the same DAS the minimum plant diameter (1.57 cm, 1.74 cm and 2.91 cm) was found from T_0 as control condition (Table 4). From the data it was revealed that all the treatments produced significantly thickest plants compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the plant diameter compared to single application of recommended dose of farm yard manure or chemical fertilizers. Bamel and Sing (2003), Aslam and Bose (2003), Gowda and Bharme (2002) and Prabu and Pramanik (2002) reported similar findings from their earlier experiment.

Table 3. Effect of farm yard manure and chemical fertilizers on plant height and plant diameter of okra

Treatment	Plant height (cm) at			Plant diameter (cm) at		
	30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS
T_0	14.00 e	49.89 c	74.56 d	1.57 e	1.74 b	2.91 c
T_1	19.14 bc	66.14 b	105.42 bc	2.14 ab	2.99 a	4.70 ab
T_2	21.13 ab	75.04 a	113.07 ab	2.14 ab	3.54 a	5.22 a
T_3	16.07 de	60.46 b	96.16 c	1.86 cd	1.94 b	3.38 c
T_4	18.11 cd	63.94 b	102.07 bc	1.96 bc	3.41 a	4.91 ab
T_5	23.00 a	77.89 a	120.97 a	2.29 a	3.35 a	5.22 a
T_6	17.62 cd	61.25 b	83.31 d	1.73 de	2.94 a	4.17 b
$LSD_{(0.05)}$	2.401	7.065	12.73	0.210	0.700	0.732
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	8.77	7.32	8.62	7.25	6.55	11.30

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

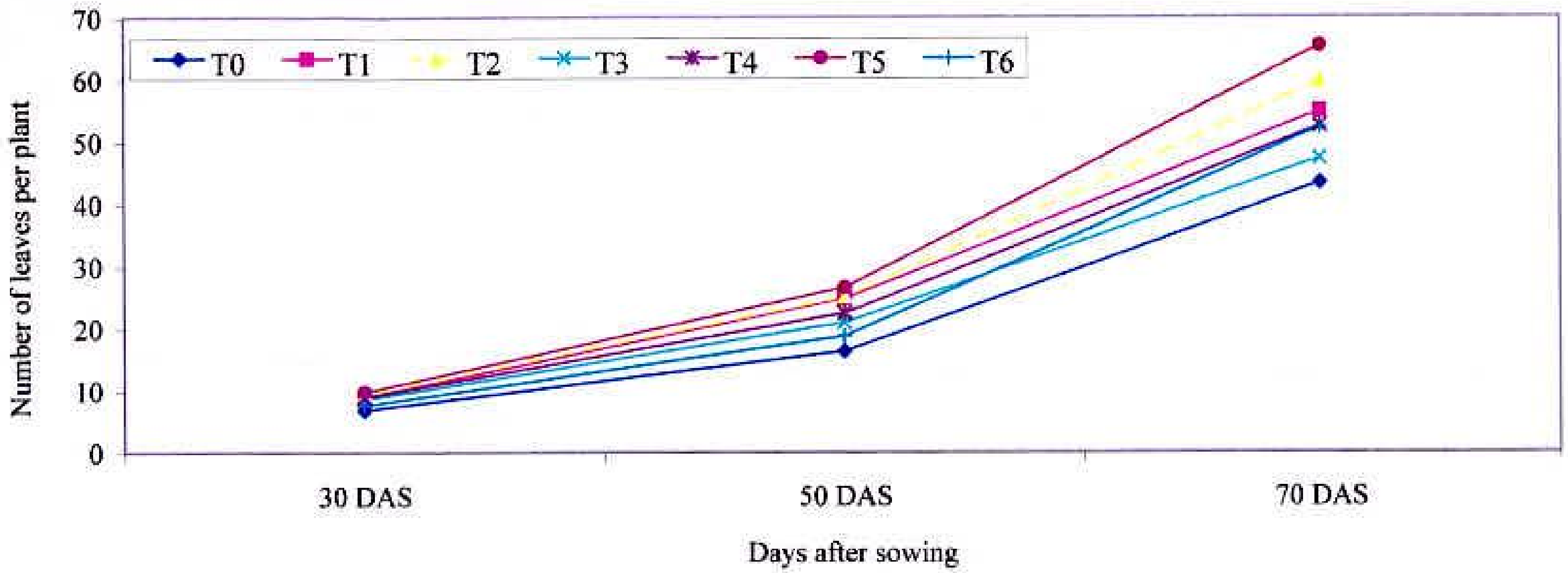
T_6: 20% organic manure + 80% chemical fertilizers

4.1.3 Number of leaves per plant

Farm yard manure and inorganic fertilizer showed statistically significant variation for number of leaves per plant of okra at 30, 50 and 70 DAS (Appendix II). At 30, 50 and 70 DAS the maximum number of leaves per plant (9.70, 26.52 and 65.36) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (9.34, 24.99 and 54.79) with T_2 (100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]), respectively. On the other hand, at the same DAS the minimum number of leaves per plant (6.77, 16.25 and 43.35) was obtained from T_0 as control condition (Table 4). From the data it was revealed that all the treatments produced significantly higher number of leaves per plants compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the number of leaves per plant compared to sole application of recommended dose of farm yard manure or chemical fertilizers. Aslam and Bose (2003) reported similar findings from their earlier experiment.

4.1.4 Length of leaf

A statistically significant variation was recorded due to the application of farm yard manure and inorganic fertilizer for length of leaf of okra at 30, 50 and 70 DAS (Appendix III). At the different days after sowing (DAS) the longest leaf (11.51 cm, 23.73 cm and 27.44 cm) was found from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (10.75 cm, 22.58 cm and 25.89 cm) with T_2 (100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha])



T0: Control
T1: 100% organic manure [Farm yard manure 25 ton/ha]
T2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]
T3: 80% organic manure + 20% chemical fertilizers
T4: 60% organic manure + 40% chemical fertilizers
T5: 40% organic manure + 60% chemical fertilizers
T6: 20% organic manure + 80% chemical fertilizers

Figure 1. Effect of farm yard manure and chemical fertilizer on number of leaves per plant of okra

at 30, 50 and 70 DAS, respectively. Whereas, at the same DAS the shortest leaf (8.11 cm, 16.61 cm and 18.52 cm) was observed from T_0 as control condition (Table 5). From the data it was revealed that all the treatments produced significantly longest length of leaf compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the length of leaf compared to single application of recommended dose of farm yard manure or chemical fertilizers.

4.1.5 Breadth of leaf

Breadth of leaf of okra differs significantly due to the application of farm yard manure and inorganic fertilizer at 30, 50 and 70 DAS (Appendix III). At the different days after sowing (DAS) the maximum breadth of leaf (19.61 cm, 27.61 cm and 31.10 cm) was obtained from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (17.78 cm, 25.68 cm and 29.79 cm) with T_2 (100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]) at 30, 50 and 70 DAS, respectively. Whereas, at the same DAS the minimum breadth of leaf (12.00 cm, 18.62 cm and 21.12 cm) was recorded from T_0 as control condition (Table 5). From the data it was revealed that all the treatments produced significantly higher breadth of leaf compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the breadth of leaf compared to single application of recommended dose of farm yard manure or chemical fertilizers. Prabu and Pramanik (2002) reported similar findings from their earlier experiment.

Table 4. Effect of farm yard manure and chemical fertilizers on length and breadth of leaf of okra

	Length of leaf (cm) at			Breadth of leaf (cm) at		
	30 DAS	50 DAS	70 DAS	30 DAS	50 DAS	70 DAS
T_0	8.11 d	16.61 c	18.52 e	12.00 c	18.62 c	21.12 d
T_1	9.70 bc	21.24 ab	25.29 ab	15.72 b	23.48 b	29.52 a
T_2	10.75 ab	22.58 ab	25.89 ab	17.78 a	25.68 a	29.79 a
T_3	9.79 bc	20.02 b	21.91 cd	12.93 c	21.48 b	25.72 bc
T_4	10.28 b	21.46 ab	23.44 bc	15.16 b	22.55 b	27.34 ab
T_5	11.51 a	23.73 a	27.44 a	19.61 a	27.61 a	31.10 a
T_6	8.80 cd	17.27 c	19.64 de	15.48 b	22.11 b	22.23 cd
$LSD_{(0.05)}$	0.973	2.504	3.078	1.839	2.172	3.544
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.65	8.25	8.95	7.97	6.33	8.94

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

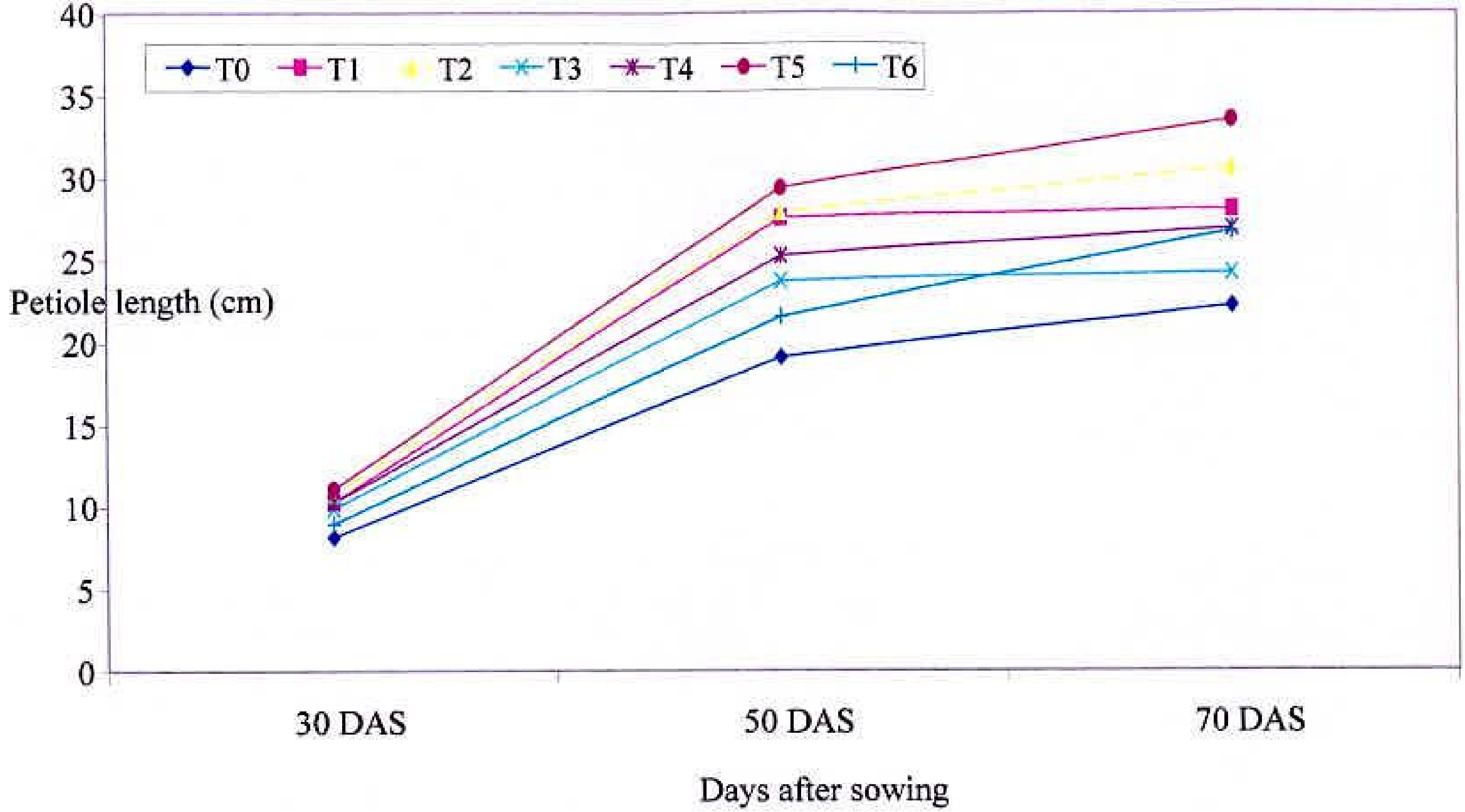
T_6: 20% organic manure + 80% chemical fertilizers

4.1.6 Petiole length

Farm yard manure and inorganic fertilizer showed statistically significant variation for petiole length of okra at 30, 50 and 70 DAS (Appendix III). At the different days after sowing (DAS) the maximum petiole length (11.08 cm, 29.40 cm and 33.52 cm) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (10.72 cm, 27.88 cm and 30.63 cm) with T_2 (100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]) at 30, 50 and 70 DAS, respectively. Whereas, at the same DAS the minimum petiole length (8.15 cm, 19.13 cm and 22.23 cm) was observed from T_0 as control condition (Table 5). From the data it was revealed that all the treatments produced significantly thickest petiole compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the petiole length compared to single application of recommended dose of farm yard manure or chemical fertilizers.

4.1.7 Days to flowering

Days to flowering of okra varied non significantly due to the application of farm yard manure and inorganic fertilizer (Appendix IV). Days to flowering varied from 39.75 days to 42 days. The highest days to flowering (42 days) was recorded from T_4 (60% organic manure + 40% chemical fertilizers) whereas, the lowest days to flowering (39.75 days) was found from T_1 (Table 5). From the data it was revealed that all the treatments required more or less days to flowering. Mainly it is a genetical character and treatment did not significantly influence it.



T0: Control
T1: 100% organic manure [Farm yard manure 25 ton/ha]
T2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha
+ 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]
T3: 80% organic manure + 20% chemical fertilizers
T4: 60% organic manure + 40% chemical fertilizers
T5: 40% organic manure + 60% chemical fertilizers

Figure 2. Effect of farm yard manure and chemical fertilizer on petiole length of okra

4.1.8 Days to edible maturity

Statistically non significant variation was recorded for days to edible maturity of okra due to the application of farm yard manure and inorganic fertilizer (Appendix IV). Days to edible maturity varied from 6.25 days to 6.50 days. The highest days to edible maturity (6.50 days) was obtained from most of the treatment except T_0, T_2 and T_3 (Table 5). From the data it was revealed that all the treatments required more or less same days to edible maturity. Mainly it is a genetical character and treatment did not significantly govern it.

4.1.9 Pod length

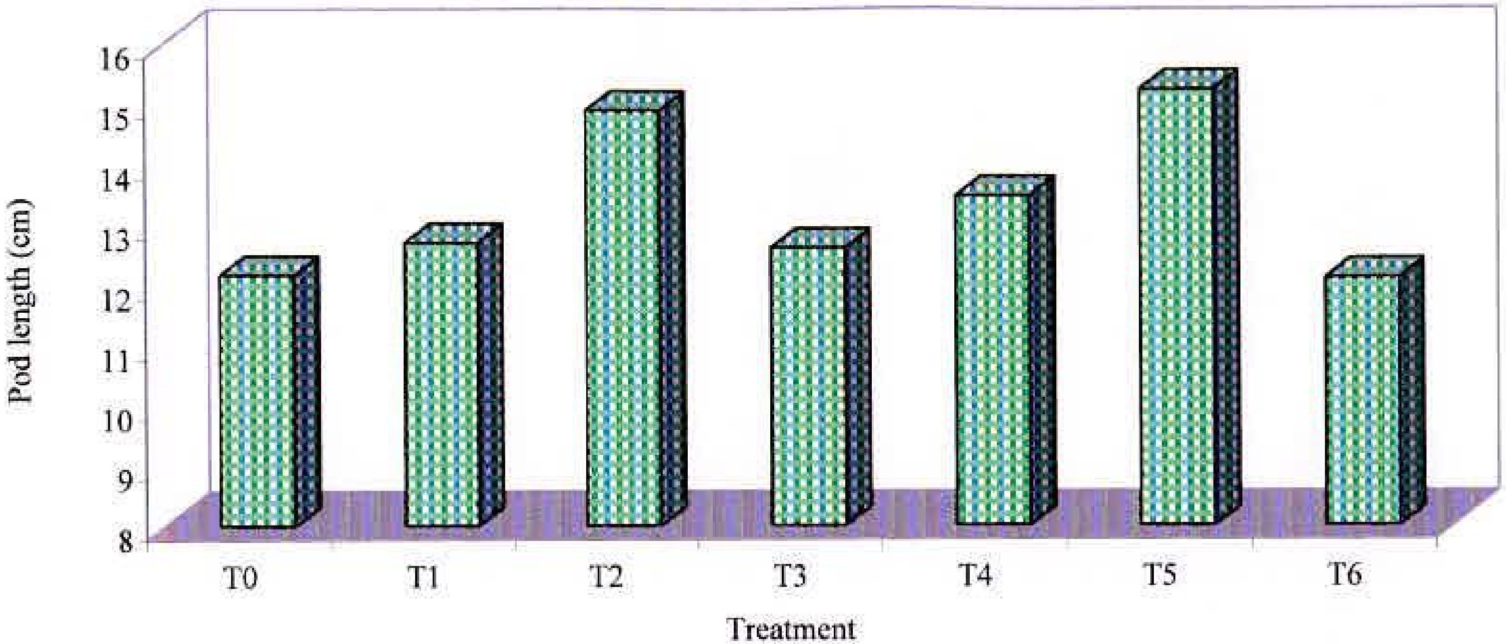
Pod length of okra showed statistically significant variation due to the application of farm yard manure and inorganic fertilizer (Appendix IV). The highest pod length (15.24 cm) was found from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (14.89 cm) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha] and closely followed (13.46 cm) by T_4 (60% organic manure + 40% chemical fertilizers) whereas, the lowest pod length (12.17 cm) was observed from T_0 as control condition (Table 5). From the data it was revealed that all the treatments produced significantly longest pod compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the pod length compared to single application of recommended dose of farm yard manure or chemical fertilizers. Bamel and Sing (2003), Aslam and Bose (2003) and Prabu and Pramanik (2002) reported similar findings from their earlier experiment.

Table 5. Effect of farm yard manure and chemical fertilizers on yield contributing characters and yield of okra

	Days to flowering	Days to edible maturity	Diameter of pod (cm)	Number of pods per plant	Yield (t/ha)
T_0	41.25	6.25	1.25 e	19.96 c	6.57 b
T_1	39.75	6.50	1.45 cd	23.30 b	9.51 a
T_2	40.50	6.25	1.73 b	27.82 a	9.92 a
T_3	40.50	6.25	1.45 cd	23.03 b	9.17 a
T_4	42.00	6.50	1.56 c	24.67 b	9.50 a
T_5	40.75	6.50	1.90 a	29.63 a	10.26 a
T_6	40.75	6.50	1.37 de	22.54 b	7.54 b
$LSD_{(0.05)}$	--	--	0.141	2.159	1.223
Level of significance	NS	NS			
CV(%)	3.56	8.92	6.09	5.95	9.23

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control
T_1: 100% organic manure [Farm yard manure 25 ton/ha]
T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]
T_3: 80% organic manure + 20% chemical fertilizers
T_4: 60% organic manure + 40% chemical fertilizers
T_5: 40% organic manure + 60% chemical fertilizers
T_6: 20% organic manure + 80% chemical fertilizers



T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha

+ 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

Figure 3. Effect of farm yard manure and chemical fertilizer on the pod length of okra

4.1.10 Diameter of pod

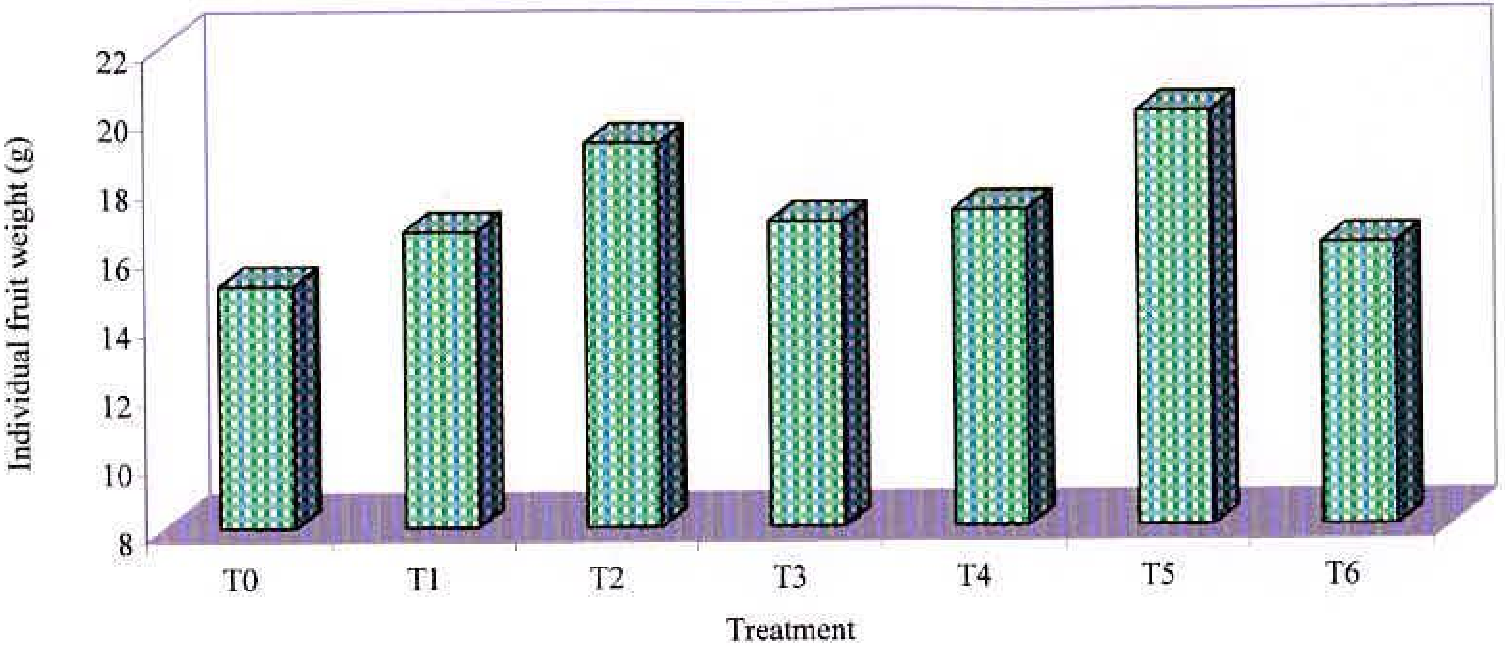
Statistically significant variation was recorded for diameter of pod of okra due to the application of farm yard manure and inorganic fertilizer (Appendix IV). The maximum diameter of pod (1.90 cm) was observed from T_5 (40% organic manure + 60% chemical fertilizers) which was closely followed (1.73 cm) by T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha] and the lowest diameter of pod (1.25 cm) was recorded from T_0 as control condition (Table 5). From the data it was revealed that all the treatments produced significantly thickest pod compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the diameter of pod compared to single application of recommended dose of farm yard manure or chemical fertilizers. Bamel and Sing (2003) reported similar findings from their earlier experiment.

4.1.11 Number of pods per plant

Due to the application of farm yard manure and inorganic fertilizer statistically significant variation was recorded for number of pods per plant of okra (Appendix IV). The highest number of pods per plant (29.63) was found from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (27.82) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha] and closely followed (24.67) by T_4 (60% organic manure + 40% chemical fertilizers) whereas, the lowest number of pods per plant (19.96) was observed from T_0 as control condition (Table 5). From the data it was revealed that all the treatments produced significantly highest number of pod compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the number of pods per plant compared to single application of recommended dose of farm yard manure or chemical fertilizers. Bamel and Sing (2003), Aslam and Bose (2003) and Prabu and Pramanik (2002) reported similar findings from their earlier experiment.

4.1.12 Individual fruit weight

Individual fruit weight of okra differs significantly due to the application of farm yard manure and inorganic fertilizer (Appendix IV). The highest individual fruit weight (20.05 g) was obtained from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (19.17 g) with T_2 (100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha] and closely followed (17.17 g) by T_4 (60% organic manure + 40% chemical fertilizers) whereas, the lowest individual fruit weight (15.05 g) was observed from T_0 as control condition (Table 5). It was revealed that all the treatments produced significantly highest weight of individual pod compared to the control treatment. The combined application of farm yard manure with chemical fertilizers increased the individual fruit weight compared to single application of recommended dose of farm yard manure or chemical fertilizers.



T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha
+ 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

Figure 4. Effect of farm yard manure and chemical fertilizer on individual fruit weight of okra

4.1.13 Yield per hectare

Yield per hectare of okra showed statistically significant differences due to the application of farm yard manure and inorganic fertilizer (Appendix IV). The highest yield (10.26 t/ha) was observed from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical with all of the treatments except T_0 and T_6 (20% organic manure + 80% chemical fertilizers), but the lowest yield (6.57 t/ha) was recorded from T_0 as control condition (Table 5). From the data it was revealed that all the treatments produced significantly higher yield compared to the control treatment. The combined application of farm yard manure with chemical fertilizers ensured maximum vegetative and reproductive growth that leads to highest yield per hectare compared to single application of recommended dose of farm yard manure or chemical fertilizers. Bhadoria *et al.* (2002) FYM produced the best okra with nutritional quality.

4.2 NPKS concentration in plant and fruit

4.2.1 N concentration in plant

Statistically significant variation was recorded for N concentration in plant of okra due to the application of farm yard manure and chemical fertilizer (Appendix V). The highest N concentration in plant (0.740%) was found from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.706%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]) and T_1 (100% organic matter) On the other hand, the lowest N concentration in plant (0.624%) was obtained from T_0 as

Table 6. Effect of farm yard manure and chemical fertilizers on NPKS nutrient concentration in plant and fruits of okra

	Concentration (%) in plant				Concentration (%) in fruit			
	N	P	K	S	N	P	K	S
T_0	0.624 c	0.204 d	0.282 e	0.090 c	0.373 e	0.058 c	0.890 d	0.066 c
T_1	0.696 ab	0.264 b	0.327 bc	0.109 b	0.461 b	0.076 ab	1.131 ab	0.087 ab
T_2	0.706 ab	0.282 a	0.336 ab	0.120 ab	0.490 a	0.080 ab	1.137 ab	0.090 ab
T_3	0.629 c	0.235 c	0.303 d	0.105 bc	0.407 d	0.065 bc	1.015 c	0.074 bc
T_4	0.678 b	0.254 b	0.316 cd	0.113 ab	0.446 b	0.073 abc	1.094 abc	0.083 ab
T_5	0.740 a	0.292 a	0.348 a	0.127 a	0.501 a	0.082 a	1.159 a	0.094 a
T_6	0.678 b	0.235 c	0.308 d	0.106 bc	0.423 c	0.065 bc	1.062 bc	0.077 bc
$LSD_{(0.05)}$	0.047	0.015	0.015	0.015	0.015	0.015	0.081	0.015
Level of significance								
CV(%)	4.04	5.34	3.22	4.78	2.89	5.36	4.74	3.53

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

T_6: 20% organic manure + 80% chemical fertilizers

control condition which was statistically identical (0.629%) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the N content in plant markedly.

4.2.2 P concentration in plant

P concentration in plant of okra showed a statistically significant variation due to the application of farm yard manure and chemical fertilizer (Appendix V). The highest P concentration in plant (0.292%) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.282%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest P concentration in plant (0.204%) was recorded from T_0 as control condition which was closely followed (0.235%) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the P content in plant markedly.

4.2.3 K concentration in plant

Significant difference was recorded for K concentration in plant of okra due to the application of farm yard manure and chemical fertilizer (Appendix V). The highest K concentration in plant (0.7348%) was found from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.336%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest K concentration in plant (0.282%) was obtained from T_0 as control condition which was closely followed (0.303%) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the K content in plant markedly.

4.2.4 S concentration in plant

Application of farm yard manure and chemical fertilizer showed a statistically significant variation for S concentration in plant of okra due to the (Appendix V). The highest S concentration in plant (0.127%) was observed from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.120%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest S concentration in plant (0.090%) was recorded from T_0 as control condition which was closely followed (0.113%) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the S content in plant markedly.

4.2.5 N concentration in fruit

A statistically significant differences was recorded for N concentration in fruit of okra due to the application of farm yard manure and chemical fertilizer (Appendix V). The highest N concentration in fruit (0.501%) was obtained from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.490%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest N concentration in fruit (0.373%) was recorded from T_0 as control condition which was closely followed (0.407%) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the N content in fruit markedly.

4.2.6 P concentration in fruit

P concentration in fruit of okra showed a statistically significant variation due to the application of farm yard manure and chemical fertilizer (Appendix V). The highest P concentration in fruit (0.082%) was found from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.080%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha which was closely followed by T_1 & T_4]). On the other hand, the lowest P concentration in fruit (0.058%) was recorded from T_0 as control condition which was closely followed (0.065%) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the P content in fruit markedly.

4.2.7 K concentration in fruit

A statistically significant difference was observed for K concentration in fruit of okra due to the application of farm yard manure and chemical fertilizer (Appendix V). The highest K concentration in fruit (1.159%) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (1.137%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha which was closely followed by T_1& T_4)]. On the other hand, the lowest K concentration in fruit (0.890%) was found from T_0 as control condition which was closely followed (1.015%) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the K content in fruit markedly.

4.2.8 S concentration in fruit

Due to the application of farm yard manure and chemical fertilizer a statistically significant variation was recorded for S concentration in fruit of okra (Appendix V). The highest S concentration in fruit (0.094%) was obtained from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.090%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha which was closely followed by T_1& T_4]). On the other hand, the lowest S concentration in fruit (0.066%) was found from T_0 as control condition which was closely followed (0.074%) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 6). Application of farm yard manure and chemical fertilizers increased the S content in fruit markedly.

4.3 NPKS uptake by plant and fruit

4.3.1 N uptake by plant

Significant difference was recorded for N uptake by plant of okra due to the application of farm yard manure and chemical fertilizer (Appendix VI). The highest N uptake by plant (52.53 kg/ha) was found from T_5 (40% organic manure + 60%

chemical fertilizers) which was statistically identical (45.52 kg/ha) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest N uptake by plant (18.53 kg/ha) was recorded from T_0 as control condition which was closely followed (26.35 kg/ha) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the N content in plant markedly.

4.3.2 P uptake by plant

P uptake by plant of okra showed a statistically significant variation due to the application of farm yard manure and chemical fertilizer (Appendix VI). The highest P uptake by plant (20.71 kg/ha) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (18.19 kg/ha) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest P uptake by plant (7.19 kg/ha) was recorded from T_0 as control condition which was closely followed (9.75 kg/ha) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the P content in plant markedly.

4.3.3 K uptake by plant

Statistically significant difference was recorded for K uptake by plant of okra due to the application of farm yard manure and chemical fertilizer (Appendix VI). The highest K uptake by plant (24.73 kg/ha) was obtained from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (21.74 kg/ha) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest K uptake by plant (8.90 kg/ha) was found from T_0 as control condition which was statistically similar (12.61 kg/ha) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the K content in plant markedly.

Table 7. Effect of farm yard manure and chemical fertilizers on NPKS nutrient uptake by plant and fruits of okra

Treatment	Uptake by plant (kg/ha)				Uptake by fruit (kg/ha)			
	N	P	K	S	N	P	K	S
T_0	18.53 d	7.19 d	8.90 c	2.70 d	19.61 d	3.13 d	47.48 c	3.55 c
T_1	44.26 b	16.75 b	20.76 ab	6.93 b	32.20 bc	5.30 bc	79.29 b	6.09 b
T_2	45.52 ab	18.19 ab	21.74 ab	7.73 ab	35.06 b	5.75 ab	80.73 b	6.42 b
T_3	26.35 c	9.75 d	12.61 c	4.38 c	21.30 d	3.44 d	53.20 c	3.89 c
T_4	41.76 b	15.63 bc	19.47 b	6.96 b	32.99 bc	5.34 bc	80.72 b	6.13 b
T_5	52.53 a	20.71 a	24.73 a	9.03 a	39.76 a	6.52 a	91.87 a	7.49 a
T_6	38.82 b	13.65 c	17.70 b	6.09 b	29.77 c	4.59 c	74.70 b	5.40 b
$LSD_{(0.05)}$	7.354	2.679	4.207	1.601	4.002	0.788	8.945	0.982
Level of significance								
CV(%)	12.94	12.39	15.75	7.22	8.95	10.89	8.30	11.87

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

T_6: 20% organic manure + 80% chemical fertilizers

4.3.4 S uptake by plant

Farm yard manure and chemical fertilizer showed a statistically significant variation was recorded for S uptake by plant of okra (Appendix VI). The highest S uptake by plant (9.03 kg/ha) was observed from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (7.73 kg/ha) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest S uptake by plant (2.70 kg/ha) was recorded from T_0 as control condition which was closely followed (4.38 kg/ha) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the S content in plant markedly.

4.3.5 N uptake by fruit

Statistically significant variation was recorded for N uptake by fruit of okra due to the application of farm yard manure and chemical fertilizer (Appendix VI). The highest N uptake by fruit (39.76 kg/ha) was recorded from T_5 (40% organic manure + 60% chemical fertilizers). On the other hand, the lowest N uptake by fruit (19.61 kg/ha) was obtained from T_0 as control condition which was statistically identical (21.30 kg/ha) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the N content in fruit markedly.

4.3.6 P uptake by fruit

P uptake by fruit of okra varied significantly due to the application of farm yard manure and chemical fertilizer (Appendix VI). The highest P uptake by fruit (6.52 kg/ha) was observed from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (5.75 kg/ha) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest P uptake by fruit (3.13 kg/ha) was recorded from T_0 as control condition which was statistically similar (3.44 kg/ha) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the P content in fruit markedly.

4.3.7 K uptake by fruit

Statistically significant variation was recorded for K uptake by fruit of okra due to the application of farm yard manure and chemical fertilizer (Appendix VI). The highest K uptake by fruit (91.87 kg/ha) was obtained from T_5 (40% organic manure + 60% chemical fertilizers). On the other hand, the lowest K uptake by fruit (47.48 kg/ha) was found from T_0 as control condition which was statistically similar (53.20 kg/ha) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the K content in fruit markedly.

4.3.8 S uptake by fruit

A statistically significant difference was recorded for S uptake by fruit of okra due to the application of farm yard manure and chemical fertilizer (Appendix VI). The highest S uptake by fruit (7.49 kg/ha) was observed from T_5 (40% organic manure + 60% chemical fertilizers). On the other hand, the lowest S uptake by fruit (3.55 kg/ha) was obtained from T_0 as control condition which was statistically identical (3.89 kg/ha) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 7). Application of farm yard manure and chemical fertilizers increased the S content in fruit markedly.

4.4 pH, organic matter and NPKS in post harvest soil

4.4.1 pH

Due to the application of farm yard manure and chemical fertilizer showed a statistically significant differnces for pH of post harvest soil (Appendix VII). The highest pH (6.30) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (6.10 and 5.95) with T_1 (100% organic manure [Farm yard manure 25 ton/ha] and T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest pH (5.57) was recorded from T_0 as control condition which was statistically identical (5.65) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 8).

4.4.2 Organic matter

A statistically significant variation was observed for organic matter of post harvest soil due to the application of farm yard manure and chemical fertilizer (Appendix

VII). The maximum organic matter (1.293%) was obtained from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (1.280% and 1.268%) with T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]) and T_1 (100% organic manure [Farm yard manure 25 ton/ha]. On the other hand, the minimum organic matter (1.130%) was found from T_0 as control condition which was statistically identical (1.132%) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 8). 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. Gaur *et al.* (1971) found that FYM and organic residues were effective in increasing the level of organic matter even under tropical conditions.

4.4.3 Total Nitrogen

Statistically significant variation was recorded for total N of post harvest soil due to the application of farm yard manure and chemical fertilizer (Appendix VII). The highest total N (0.053%) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.050% and 0.049%) with T_1 (100% organic manure [Farm yard manure 25 ton/ha] and T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest total N (0.029%) was recorded from T_0 as control condition which was statistically identical (0.036%) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 8).

Table 8. Effect of farm yard manure and chemical fertilizers on ph, organic matter and NPKS nutrient in post harvest soil of okra field

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
T_0	5.57 c	1.130 b	0.029 c	20.03 c	0.115 d	14.42 e
T_1	6.10 ab	1.268 a	0.050 ab	24.49 ab	0.155 a	19.20 ab
T_2	5.96 abc	1.280 a	0.049 ab	24.14 ab	0.152 a	19.10 ab
T_3	5.65 c	1.132 b	0.036 bc	22.36 b	0.132 c	15.98 de
T_4	5.91 abc	1.217 a	0.043 abc	23.29 ab	0.148 ab	16.61 cd
T_5	6.30 a	1.293 a	0.053 a	25.24 a	0.162 a	20.46 a
T_6	5.86 bc	1.220 a	0.041 abc	24.18 ab	0.136 bc	18.05 bc
$LSD_{(0.05)}$	0.387	0.081	0.015	2.021	0.015	1.696
Level of significance						
CV (%)	4.14	4.74	6.90	5.82	3.48	6.45

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% organic manure [Farm yard manure 25 ton/ha]

T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]

T_3: 80% organic manure + 20% chemical fertilizers

T_4: 60% organic manure + 40% chemical fertilizers

T_5: 40% organic manure + 60% chemical fertilizers

T_6: 20% organic manure + 80% chemical fertilizers

4.4.4 Available phosphorus

Available P of post harvest soil showed a statistically significant variation due to the application of farm yard manure and chemical fertilizer (Appendix VII). The highest available P (25.24 ppm) was recorded from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (24.49 ppm and 24.14 ppm) with T_1 (100% organic manure [Farm yard manure 25 ton/ha] and T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest available P (20.03 ppm) was found from T_0 as control condition which was closely followed (22.36) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 8). Edmond *et al.* (1977) reported that organic matter increased the physio-chemical and biological condition of the soil providing plant nutrients.

4.4.5 Exchangeable potassium

A statistically significant variation was obtained for exchangeable K of post harvest soil due to the application of farm yard manure and chemical fertilizer (Appendix VII). The highest exchangeable K (0.162 me%) was observed from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (0.155 me% and 0.152 me%) with T_1 (100% organic manure [Farm yard manure 25 ton/ha] and T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulexchangeable Kate/ha]). On the other hand, the lowest exchangeable K (0.115

me%) was recorded from T_0 as control condition which was closely followed (0.132me%) by T_3 as 80% organic manure + 20% chemical fertilizers (Table 8).

4.4.6 Available sulphur

Statistically significant differences was recorded for available S of post harvest soil due to the application of farm yard manure and chemical fertilizer (Appendix VII). The highest available S (20.46 ppm) was found from T_5 (40% organic manure + 60% chemical fertilizers) which was statistically identical (19.20 ppm and 19.10 ppm) with T_1 (100% organic manure [Farm yard manure 25 ton/ha] and T_2 (100% chemical fertilizers [Urea 200 kg/ha [(100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MOP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha]). On the other hand, the lowest available S (14.42 ppm) was obtained from T_0 as control condition which was statistically identical (15.98 ppm) with T_3 as 80% organic manure + 20% chemical fertilizers (Table 8).

Chapter V

SUMMARY

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to June 2008 to study the effect of farm yard manure and chemical fertilizers on the growth and yield of okra. The experiment consisted of 7 treatments. The treatments were T_0: Control, T_1: 100% organic manure [Farm yard manure 25 ton/ha]. T_2: 100% chemical fertilizers [Urea 200 kg/ha (100 kg +50 kg + 50 kg) + 150 kg TSP/ha + 125 kg MOP/ha + 75 kg Gypsum/ha + 5 kg Zinc sulphate/ha], T_3: 80% organic manure + 20% chemical fertilizers, T_4: 60% organic manure + 40% chemical fertilizers, T_5: 40% organic manure + 60% chemical fertilizers, T_6: 20% organic manure + 80% chemical fertilizers. The experiment was laid out in a randomized complete block design (RCBD) with three replications.

At 30, 50 and 70 DAS the longest plant (23.008 cm, 77.89 cm and 120.97 cm), the maximum plant diameter (2.29 cm, 3.35 cm and 5.22 cm), the maximum number of leaves per plant (9.70, 26.52 and 65.36), the longest leaf (11.51 cm, 23.73 cm and 27.44 cm), the maximum breadth of leaf (19.61 cm, 27.61 cm and 31.10 cm), the maximum petiole length (11.08 cm, 29.40 cm and 33.52 cm), the highest days to flowering (42 days), the highest days to edible maturity (6.50 days), the highest pod length (15.24 cm), the maximum diameter of pod (1.90 cm), the highest number of pods per plant (29.63), the highest individual fruit weight (20.05 g) and the highest yield (10.26 t/ha) were obtained from the treatment T_5 (40% organic manure + 60% chemical fertilizers). At the same DAS, the shortest plant (14.00 cm, 49.89 cm and

74.56 cm), the minimum plant diameter (1.57 cm, 1.74 cm and 2.91 cm), the minimum number of leaves per plant (6.77, 16.25 and 43.35), the shortest leaf (8.11 cm, 16.61 cm and 18.52 cm), the minimum breadth of leaf (12.00 cm, 18.62 cm and 21.12 cm), the minimum petiole length (8.15 cm, 19.13 cm and 22.23 cm), the lowest days to flowering (39.75 days), the lowest pod length (12.17 cm), the lowest diameter of pod (1.25 cm), the lowest number of pods per plant (19.96), the lowest individual fruit weight (15.05 g) and the lowest yield (6.57 t/ha) was observed from the as control where no organic or inorganic fertilizers were added.

The highest N concentration in plant (0.740%), the highest P concentration in plant (0.292%), the highest K concentration in plant (0.7348%), the highest S concentration in plant (0.127%), the highest N concentration in fruit (0.501%), the highest P concentration in fruit (0.082%), the highest K concentration in fruit (1.159%), the highest S concentration in fruit (0.094%) were obtained from the treatment T_5 (40% organic manure + 60% chemical fertilizers) and the lowest N concentration in plant (0.624%), the lowest P concentration in plant (0.204%), the lowest K concentration in plant (0.282%), the lowest S concentration in plant (0.090%), the lowest N concentration in fruit (0.373%), the lowest P concentration in fruit (0.058%), the lowest K concentration in fruit (0.890%) and the lowest S concentration in fruit (0.066%) were found in the control. Moreover, the highest N uptake by plant (52.53 kg/ha), the highest P uptake by plant (20.71 kg/ha), the highest K uptake by plant (24.73 kg/ha), the highest S uptake by plant (9.03 kg/ha), the highest N uptake by fruit (39.76 kg/ha), the highest P uptake by fruit (6.52 kg/ha), the highest K uptake by fruit (91.87 kg/ha), the highest S uptake by fruit

(7.49 kg/ha) were observed in the treatment T_5 again, the lowest N uptake by plant (18.53 kg/ha), the lowest P uptake by plant (7.19 kg/ha), the lowest K uptake by plant (8.90 kg/ha), the lowest S uptake by plant (2.70 kg/ha), the lowest N uptake by fruit (19.61 kg/ha), the lowest P uptake by fruit (3.13 kg/ha), the lowest K uptake by fruit (47.48 kg/ha), and the lowest S uptake by fruit (3.55 kg/ha) were found in case of the control (T_0).

The highest pH (6.30) was observed from T_5 and the lowest pH (5.57) was recorded from T_0. The maximum organic matter (1.293%) was observed from T_5 and the minimum organic matter (1.130%) was recorded from T_0. The highest total N (0.053%) was observed from T_5 and the lowest total N (0.029%) was recorded from T_0. The highest available P (25.24 ppm) was observed from T_5 and the lowest available P (20.03 ppm) was recorded from T_0. The highest exchangeable K (0.162 me%) was observed from T_5 while, the lowest exchangeable K (0.115 me%) was recorded from T_0. The highest available S (20.46 ppm) was observed from T_5 and the lowest available S (14.42 ppm) was recorded from T_0.

From the above discussion it can be concluded that integrated use of organic manure and chemical fertilizer in the rate of 40% organic (10 t/ha) and 60% chemical fertilizer (120 kg urea + 90 kg TSP + 75 kg MP + 45 kg Gypsum + 3 kg Zinc sulphate ha^{-1}) was found suitable for better growth and yield of lady's finger.

Considering the situation of the present experiment, the following recommendations and suggestions may be made:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and Sunshine of the experimental site during the period from March to June 2007

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
March, 2008	31.4	19.6	54	11	8.2
April, 2008	33.6	23.6	69	163	6.4
May, 2008	34.7	25.9	70	185	7.8
June, 2008	34.5	26.8	76	213	7.1

* Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka - 1212

Appendix II. Analysis of variance of the data on plant height, diameter and number of leaves per plant of okra as influenced by farm yard manure and chemical fertilizer

Source of variation	Degrees of freedom	Mean square								
		Plant height (cm) at			Plant diameter (cm) at			Number of leaves per plant		
		30 DAS	40 DAS	60 DAS	30 DAS	40 DAS	60 DAS	30 DAS	40 DAS	60 DAS
Replication	3	1.161	41.061	130.053	0.023	0.253	0.591	0.530	4.634	19.253
Treatment	6	36.448**	354.943**	1054.615**	0.260**	2.075**	3.329**	4.192**	54.609**	216.873**
Error	18	2.613	22.617	73.396	0.020	0.222	0.243	0.413	4.899	14.653

** : Significant at 0.01 level of probability

Appendix III. Analysis of variance of the data on length of leaf, breadth of leaf and petiole length per plant of okra as influenced by farm yard manure and chemical fertilizer

Source of variation	Degrees of freedom	Mean square								
		Length of leaf (cm) at			Breadth of leaf (cm) at			Petiole length (cm) at		
		30 DAS	40 DAS	60 DAS	30 DAS	40 DAS	60 DAS	30 DAS	40 DAS	60 DAS
Replication	3	0.136	3.042	1.208	4.550	3.547	5.020	0.874	4.634	5.046
Treatment	6	5.255**	28.014**	43.945**	27.423**	34.041**	59.503**	4.191**	54.609**	57.034**
Error	18	0.429	2.840	4.293	1.533	2.137	5.691	0.316	4.899	3.779

** : Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on yield contributing characters and yield plant of okra as influenced by farm yard manure and chemical fertilizer

Source of variation	Degrees of freedom	Mean square						
		Days from sowing to flowering	Days to edible maturity	Length of pod (cm)	Diameter of pod (cm)	Number of pods per plant	Individual fruit weight (g)	Yield (t/ha)
Replication	3	1.000	0.131	0.487	0.005	4.379	1.919	1.688
Treatment	6	1.952	0.071	6.532**	0.197**	43.616**	11.962**	7.295**
Error	18	2.111	0.325	0.323	0.009	2.112	0.755	0.678

** : Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on N, P, K, S in plant and fruit as influenced by farm yard manure and chemical fertilizer

Source of variation	Degrees of freedom	Mean square							
		Concentration in plant (%)				Concentration in fruit (%)			
		N	P	K	S				
Replication	3	0.001	0.0001	0.0001	0.0001	0.001	0.0001	0.004	0.0001
Treatment	6	0.007**	0.004**	0.002**	0.001**	0.008**	0.001**	0.035**	0.001**
Error	18	0.001	0.0001	0.0001	0.0001	0.0001	0.0001	0.003	0.0001

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on N, P, K, S uptake by plant and fruit as influenced by farm yard manure and chemical fertilizer

Source of variation	Degrees of freedom	Mean square							
		Uptake by plant (kg/ha)				Uptake by fruit (kg/ha)			
		N	P	K	S				
Replication	3	73.144	12.679	11.533	0.866	26.883	0.848	119.383	0.247
Treatment	6	557.437**	90.147**	120.566**	17.993**	212.205**	6.022**	1039.915**	7.939**
Error	18	24.507	3.253	8.021	1.162	7.256	0.281	36.253	0.437

**: Significant at 0.01 level of probability

Appendix VII. Analysis of variance of the data on pH, organic matter and N, P, K, S in post harvest soil as influenced by farm yard manure and chemical fertilizer

Source of variation	Degrees of freedom	Mean square					
		Post harvest soil					
		pH	Organic matter (%)	K (meq/100 g soil)	N (ppm)	P (ppm)	S (ppm)
Replication	3	0.020	0.0001	0.0001	3.039	0.0001	4.974
Treatment	6	0.249*	0.018**	0.001**	12.141**	0.001**	17.926**
Error	18	0.068	0.003	0.0001	1.850	0.0001	1.303

**: Significant at 0.01 level of probability; *: Significant at 0.01 level of probability