EFFECT OF DIFFERENT ORGANIC SOURCES OF NUTRIENTS AND HARVESTING STAGE ON THE GROWTH YIELD AND QUALITY OF OKRA

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DHAKA - 1207

DECEMBER 2007

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

MASTER OF SCIENCE
IN
HORTICULTURE

SEMESTER: JULY-DECEMBER, 2007

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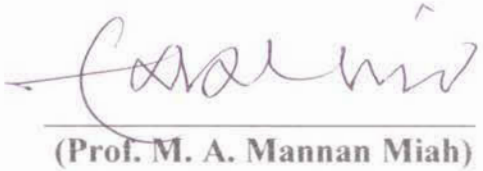

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CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF DIFFERENT ORGANIC SOURCES OF NUTRIENTS AND HARVESTING STAGE ON THE GROWTH YIELD AND QUALITY OF OKRA**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **K.M. Akhter Hossain,** Roll No. 60 Registration No. 26150/00447, under my supervision and my guidance. No part of this thesis has been submitted for any other degree in any institute.

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

Dated: 31.12.2007
Dhaka, Bangladesh

(Md. Hassanuzzaman Akand)
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Dedicated To

My Beloved Parents

Acknowledgement

All praises and boundless gratitude to Almighty "Allah", the Omnipotent, Omnipresent Omniscient who has enabled the author to complete this research and thesis for the fulfillment of the degree of Master of Science in Horticulture.

The author deems it a proud privilege to express his sincere appreciation, gratitude and profound to his reverend teacher Md. Hassanuzzaman Akand, Associate Professor, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, valuable suggestions, sympathetic and valuable co-operation and affectionate feeling at all stages of the study period of research work and preparation of this thesis as a Supervisor.

From the core of his heart, the author expresses his profound gratitude to Prof. M. A. Mannan Miah, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his constructive criticisms and kind cooperation on throughout the progress of this research work as a Co-supervisor.

The author humbly desires to express his deepest and most sincere gratitude to all teachers, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for their inspiration and affectionate encouragement.

The author expresses his heartfelt gratitude and indebtedness to his parents, Khan Anower Hossain and Hasina Anower and well wishers for their encouragement blessings during his whole education life and sacrifices which enabled him to complete the thesis with patience and perseverance.

Finally but not least, the author feels proud to express his heartiest gratitude and gratefulness to his friends, younger and elder brothers and sisters and other well wishers who always inspired him with their good wishes, sacrifice and understanding and provided him with the best of everything in his life.

December 2007 *The Author*

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ABSTRACT

An experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period of April 2006 to August 2006 to investigate the effect of organic sources of nutrients and harvesting stage on the growth, yield and quality of okra. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experiment consists of two factors, factor A: sources of nutrients (4 types) namely no manure, cowdung, poultry litter and farm yard manure (FYM) and factor B: harvesting stage (4 level) viz. harvesting at 5 days, 7, 9 and 11 days after flower anthesis. The organic sources had significant effect on all yield contributing characters and yield of okra like, plant height, plant diameters, number of leaves, number of branches per plant, leaf length, leaf breadth, petiole length, pod length, pod diameter, pod weight, number of pod per plant, yield per plant and yield per hectare except number of days to first flowering. Harvesting stages also had significant influence on the above parameters except plant diameter and petiole length. Poultry litter gave the best yield (9.54t/ha) followed by FYM (8.87t/ha). On the other hand, frequent harvesting viz. 5 day stage enhanced plant height, number of leaves, number of branches per plant, leaf length and leaf breadth. It also produced the tenderest green pod. Eleven day stage gave best result for pod length, pod diameter and pod weight but decreased number of pod per plant which resulted less yield (8.32t/ha) than 7 day stage (8.87 t/ha). Seven day stage pod gave the highest yield (8.87 t/ha) and better marketable quality. Combindly poultry litter with 5 day harvesting stage showed the best growth but the most tender and immature fruit. Poultry litter with 7 day harvesting stage gave the highest yield (10.13 t/ha) and acceptable quality. It also gave the highest benefit cost ratio (1.45).

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ABBREVIATED TERMS

AEZ	=	Agro- Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
CF	=	Chemical fertilizer
cm	=	Centimeter
DAF	=	Days after flowering
DAS	=	Days After Sowing
DM	=	Dry matter
et al.	=	And others
etc	=	Etcetera
FAO	=	Food and Agricultural Organization
FYM	=	Farm Yard Manure
g	=	Gram
ha	=	Hectare
kg	=	Kilogram
LSD	=	Least significant difference
MC	=	Microbial culture
NS	=	Non significant
OCP	=	Oil cake pellets
PCW	=	Processed city waste
PSB	=	Phosphorus solubilizing bacteria
RCBD	=	Randomized Complete Block Design
RDF	=	Recommended dose of fertilizer
Rs	=	Rupee
SAU	=	Sher-e- Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
t	=	Ton
UNDP	=	United Nation Development Program
VAM	=	Vesicular arbuscular mycorrhiza
VC	=	Vermicompost

Chapter 1

Introduction

INTRODUCTION

Okra [*Abelmoschus esculentus* L. Moench] is a member of Malvaceae family and known as Lady's finger. It is locally known as "Dherosh" or "Bhindi". It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Thakur and Arora, 1986). Okra is probably originated in tropical Africa or possibly tropical Asia and is now widely grown throughout the tropics (Tindall, 1988). The crop is well distributed throughout the Indian subcontinent and East Asia (Rashid, 1999). Its tender green fruits are popular as vegetables among all classes of people in Bangladesh and elsewhere. Though it is popular, its production is mainly concentrated during the summer. However, now a-days okra is found in the market almost round the year.

Okra is a nutritious and delicious vegetable fairly rich in vitamins and minerals. The pod has moderate level of vitamin A (0. 1 mg), C (18 mg), Calcium (90 mg), phosphorus and potassium. The content of thiamine (0.07mg), riboflavin (0.08 mg) and niacin (0.08 mg) per 100 g of edible portion is higher than that of many vegetables (Rashid, 1999).

In Bangladesh, vegetable production is not uniform round the year. Most of the vegetables are produced in the winter but very less number in the summer. About 30% of the total vegetables are produced in the kharif season (Anon, 1993). Among them okra is very important one. In the year 2003-2004, the total production of okra was about 24000 tons in 7288 hectares of land with an average yield 3.38 t/ha (BBS, 2004). The yield is very low compared to that of other developing countries where the yield is as high as 7-12 t/ha (Yamaguchi, 1998). In Bangladesh the yield of okra is very low due to improper management of cultural practices.

Growth, yield and quality of okra depend on nutrient availability in soil, which is related to the judicious application of manures and fertilizers. Nutrient may be applied through two sources viz. organic and inorganic. Increased use of inorganic fertilizer in crop production causes health hazards, creates problem to the environment including the pollution of air, water and soil etc. The continuous use of chemical fertilizers badly affects the soil texture, structure, color, aeration, water holding capacity and microbial activity of soil. A good soil has an organic matter content of more than 3%, but in Bangladesh soil of most region have less than 1.5%, some soil have less than 1% organic matter. For continuous cropping, organic manures applied to the crop fields through cowdung, poultry litter, farm yard manure, oil cake, compost, ash, green manuring etc. are insufficient. Now a days, gradual deficiency in soil organic matter and reduced yield of crops are alarming factors and burning issues for the farmers and agriculturists. All effort should be made to develop consciousness of the farmers about the importance of soil organic matter in the long term maintenance of soil productivity. In recent year poultry and livestock farming are increasing. So manure like poultry litter, cow dung, farm yard manure etc. are becoming available.

On the other hand, harvesting at optimum stage is one of the most important cultural practices particularly in okra. According to Nonnecke (1989), okra must be harvested at the most appropriate stage for maximum yield, quality and acceptability. But farmers are not aware of the beneficial effects of appropriate harvesting stage. So, most of the okra green pods are found in the market as over-matured and of very low quality in our country (Rashid, 1999).

Again, tender green pods of okra are generally marketed as fresh vegetables. At early stage, they are free from fiber and are tender. As pods mature, quality deteriorates, fibreness increases, tenderness is reduced and mucilaginous content is also reduced (Peirce, 1987). So, when farmers harvest aged pods, they fail to get market value and face a great loss.

Different manures contain different amount of nutrient in different proportion and there mode of nutrient release is not same. So, different manures may influence the yield and quality in different angles.

Organic sources of nutrients and harvesting stage have close relation with plant growth, yield and quality of okra. Organic sources of nutrients influence the growth and both factors singly and combindly influence yield and quality of okra. But the effects of these factors on the growth yield and quality of okra have not been studied in detail under Bangladesh conditions. Regarding this, information is not adequate. Therefore, to ensure proper crop management and get the highest possible yield, retain the soil productivity, such studies under Bangladesh condition are needed.

Considering the above facts, the present research was under taken with the following objectives:

1. To study the effect of different organic sources of nutrients (cowdung, poultry litter and farm yard manure) which ensure the highest yield and the best quality.
2. To study the effect of harvesting stage on the yield and quality of okra green pod.
3. To identify the optimum harvesting stage for highest yield and best marketable quality of okra green pod.

Chapter 2

Review of Literature

REVIEW OF LITERATURE

Organic sources of nutrients are important factor to retain the soil productivity in long term and better quality yield. Harvesting stage is also the most important factors for maximizing the quality of okra. Research works have been done in various parts 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 in this aspect, have been furnished in this chapter.

2.1 Effect of organic sources of nutrients on growth and yield of okra

The organic matter is called the life of soil. Fertility of particular soil is determined by the presence of organic matter. The organic matter contents of soil vary 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 contain more or less all the essential plant nutrients, but after application of organic manures required time to convert 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 on soil properties, applications of organic manures are encouraged. Some available information about the effects of organic manures are reviewed here.

Wright (1960) studied that horse and cow manure contains approximately 0.5% N, 0.55% K and 0.25 % phosphoric acid. It thus supplies three of main elements needed by fruit plants.

Dumitrescu (1960) 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.

The importance of organic manures and fertilizers in okra production had been reported by Yawalkar *et al.* (1962), who recommended 8 tonnes of farm yard manure, 45 kg N, 22 kg each of P and K per hectare for the production of 2725 kg green fruits.

Palevich (1965) observed that nitrogenous fertilizer and organic manure improved total yield, weight per fruit and height of plants. He also reported that cowdung manure application in addition to N and P fertilizers significantly increased yield by 14-41 % in comparison with plots that received the same amount of N and P but without manure.

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

Under combater conditions, Kamalanathan *et al.* (1970) recommended 40 kg N and 30 kg K per hectare along with 25 tonnes of farillyard manure at the time of soil preparation.

In Rajasthan, at Udaipur, Verma *et al.* (1970) recommended the application of 90 kg N and 80 kg P and 10 tones of farmyard manure per hectare during kharif season for improving the qualitative and quantitative yield of okra.

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

The effect of nitrogenous fertilizer with a basic dressing of FYM was investigated by Tilkynbaev and Umarov (1973). They used 120, 150 and 60 kg/ha N, P_2O_5 and K_2O with a basic dressing of 20 tonnes FYM and reported that the best results were obtained with 120 kg /ha. One half of which was applied after plant establishment and the other at the start of flowering.

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 with 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, 1.8% P and 1.3% K (Ahmad, 1980)

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.

Subbiah (1991) studied on the effect of nitrogen and *Azospirillum* on okra. In 2-season trials (June-July and Nov.-Dec.) with the cultivar CO_2, N as urea was applied at 0, 50, 75 or 100% of the recommended rate and *Azospirillum brasilense* was applied to the soil (2 kg/ha) or to the seeds (100 g/kg seeds), giving a total of 12 treatments combinations. P + K + FYM were applied as basal dressing to all plots. Data are tabulated on fruit yield, fruit N, P and K contents, plant N, P and K contents, total DM yield and nutrient uptake, and N, P and K status of the soil after crop

harvest. The average 2-season yield and N use efficiency were highest on plots receiving N at 50% of the recommended rate plus soil-applied *A. brasilense*.

Isaac *et al.* (1997) conducted an experiment to evaluate the effect of green fruit picking and nutrient sources on the seed production of okra fruit and seed yields were highest with FYM + chemical fertilizers, but there was only a marginal benefit in applying the higher FYM rate. Seed yield declined as more fruits were picked.

Isaac *et al.* (1998) conduct an experiment to evaluate the influence of green fruit picking and nutrient sources on fruit production in okra. The total number of fruits per plant increased with increase in number of pickings to a maximum of 11.58 fruits per plant with 6 pickings (from 6.57 with no fruit picking). Green fruit pickings also significantly affected the weight of mature fruits per plant. Maximum weight of mature fruit was recorded in those plants from which no green fruit was harvested (35.76 g). Total number of fruits per plant, green fruit number per plant and length and girth of fruits were not significantly influenced by the nutrient sources used. Weight of green fruits per plant, weight of mature fruits per plant and total fruit yield per plant were significantly higher in combined applications with 12 or 6 t farmyard manure (FYM). Among the nutrient sources, the integrated use of FYM and chemical fertilizers was best. It was concluded that green fruit picking improved fruit production in okra but when intended for seed; leaving the entire fruits to mature would give the highest yield.

Rue (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.

Naidu *et al.* (1999) conducted a study on a medium black soil at the Maharajpur vegetable research farm in Mabalpur, Madhya Pradesh, India during spring-summer seasons of 1996-97, 1997-98 and 1998-99 to evaluate the effect of manures, bio- and chemical fertilizers on the soil microbial population and growth and yield of okra. The treatments used in the experiment were: (T_1) control; (T_2) NPK (80:60:50)+20 tones farmyard manure (FYM)/ha; (T_3) 55 kg N+35 kg P_2O_5+25 tones FYM/ha; (T_4) 25 kg P_2O_5+70 kg K_2O+9 tones poultry manure; (T_5) 10 kg P_2O_5+3 tones vermicompost/ha; (T_6) 12 K_2O+20 tones FYM+4 tones poultry manure/ha; (T_7) 20 tones FYM+14 tones vermicompost/ha; (T_8) 90 kg K_2O+7.5 tones poultry manure+1.0 tonne vermicornpost/ha; (T_9) 35 tones FYM + *Azospirillum* + phosphorus solubilizing bacterium (PSB); (T_{10}) 10 tones poultry manure/ha + *Azospirillum* +PSB; (T_{11}) 3 tones vermicompost + Azospirillum +PSB; and (T_{12}) Azospirillum+PSB. Results showed that plant height, number of leaves per plant, number of nodes per plant, internodal length, number of fruits per plant, weight of fruits per plant and fruit yield were maximum under T_2. On the other hand, crude protein percentage was highest Linder T_8. The maximum net income of Rs. 19089 along with a 0.02 benefit: cost ratio was obtained under T_2.

Patil *et al.* (2000) conduct an experiment to develop a composite technique to produce quality okra pods for export purposes by using organic manures, biofertilizers and biopesticides. The three highest pod yields (128.59, 125.42 and 125.17 q/ha) were recorded from 75 kg N/ha + biofertilizer + FYM, 50 kg N/ha + biofertilizer + FYM and 75 kg N/ha +

FYM, respectively. Although crops sown at the 30 x 15 cm spacing recorded the highest yield (118.23 q/ha), the 30 x 30 cm spacing resulted in comparable yields (117.13 q/ha). The application of biofertilizer (1 litter slurry) + FYM + 50 kg N/ha was beneficial for obtaining higher yields (128.59 q/ha) of export quality pods (5-7 cm in length) when harvested on alternate days, compared to their individual application.

Bandyopadhyay (2001) conduct an experiment to evaluate the effect of polythene and organic mulching under different levels of manuring practices of growth and yield of okra. Okra cv. Parbhani Kranti plants were subjected to different mulching (using green leaves of *Antigonon leptopus* or polyethylene sheets) and fertilizer treatments (oilseed cake and/or NPK at 25:25:25 or 50:25:25) in a field experiment conducted in India during the kharif season. The highest pod yield (171.92 q/ha), cost:benefit ratio (4.86) and growth attributing characters were observed with 10 t FYM/ha + 50:25:25 kg NPK/ha under the green leaves of *A. leptopus*. In general, green leaf mulching was better and cheaper than polythene mulching.

Raj and Kumari (2001) reported that the effect of farmyard manure (FYM: 12 t/ha) and *Azospirillum* Inoculation (1kg/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, 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.

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 farmyard manure (FYM); FYM + microbial culture (FYM + MC); chemical fertilizers (CF); processed city waste (PCW); oil cake pellets (OCP); and vermicompost (VC). Among the different treatments, FYM produced the best rice cooking and milling quality, and the best okra nutritional quality. The protein content and total minerals of okra fruit increased under the FYM treatment.

Ferreira *et al.* (2002) reported that the use of organic and mineral fertilizer for production of okra was evaluated in northern Rio de Janeiro, Brazil, 1998-99. Doses of 0, 10, 20, 30, and 40 t manure/ha were applied with or without NPK fertilizer. A significant increase in yield with mineral fertilizer was observed during both years. A significant increase in yield was also obtained with increase in manure.

Prabu *el al.* (2002) reported that the effects of integrated nutrient management on the economics of okra cv. Parbhani Kranti were determined in a field experiment conducted in Parbhani, Maharashtra, India during the summer of 2001. The treatment comprised application of NPKs fertilizers (0, one-third, two-third and full recommended rate of NPK), farmyard manure (FYM; 0 or 10 t/ha) and biofertilizers (*Azospirillum* + phosphate solubilizing bacteria or *Azospirillum* + Vesicular arbuscular mycorrhiza) to the crop. Application of two-third of the full recommended rate of NPK, FYM at 10 t/ha and *Azospirillum* + VAM resulted in the highest marketable yield (14.17 t/ha), monetary returns (Rs. 141700/ha), net returns over the variable cost only (Rs. 138600.50/ha) and net additional benefit over the control (Rs

4390P.50/ha). Application of one-third of the recommended rate of NPK in combination with *Azospirillum* + phosphate solubilizing bacteria resulted in the highest benefit: cost ratio (1:31.69).

Prabu *et al.* (2002) was conducted an experiment in Parbhani, Maharashtra, India, during the summer season of 2001 to investigate the effects 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 biofertilizers (uninoculated; *Azospirillum* + phosphate solubilizing bacteria; and *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 produced in the highest yield.

Prabu *et al.* (2003) was conducted a study in Parbhani, Maharashtra, India., during summer 2001 to investigate the effect of integrating organic and biofertilizers with reduced levels of inorganic fertilizers on the growth and yield of okra cv. Parbhany Kranti. The treatments included 4 levels of inorganic fertilizers (0, 1/3, 2/3 and full recommended dose of fertilizers (RDF) at 100:50:50 kg NPK/ha), 2 levels of organic manures (without and with farmyard manure (FYM) at 10 t/ha), 3 levels of biofertilizers (uninoculated, inoculated with *Azospirillum*+ phosphorus solubilizing bacteria (PSB) and *Azospirillum* + vesicular arbuscular mycorrhizal. fungi (VAM)), and their combinations. Germination of okra seeds increased when inoculated with biofertilizers, with PSB proving superior. Only FYM application resulted in significant increase in number of branches. Out of the 3 treatment factors, only biofertilizer inoculation resulted in significant increase in number of nodes per plant. Number of

leaves, and fresh and dry weight of the plant increased significantly with increase in fertilizer, FYM and biofertilizer application. Leaf area per plant also increased with an increase in fertilizer, FYM and biofertilizer application. Maximum leaf area was found at 2/3 and full dose of RDF. A significant increase in yield was noticed with increasing level of NPK. The highest yield were obtained in plots with full dose of RDF and 2/3 RDF. Biofertilizer treatment significantly increased the yield, *Azospirillum*+VAM was statistically superior over *Azospirillum*+PSB and both being Superior to the control. The best combination of treatments that resulted in the highest yield was 2/3 RDF+FYM+VAM. The amount of inorganic fertilizer that can be saved is approximately 33.33% of RDF when FYM and biofertilizers are integrated in nutrient management in maximizing production of okra.

Prabu *el al.* (2003) was conducted a correlation study in okra to investigate the extent of relationship between some yield attributes and yield. The treatments consisted of 4 levels of inorganic fertilizer, i.e. 0, 1/3, 2/3 and full of the recommended dose of fertilizer (RDF, 100:50:50 kg NPK/ha), 2 levels of organic manure (with and without farmyard manure (FYM) at 10 tonnes/ha) and 3 levels of biofertilizers (control, *Azospirillum* + phosphorus solubilizing bacteria (PSB) and *Azospirillum*+vesicular arbuscular mycorrhizas (VAM)). The fertilizers and FYM were applied a week prior to sowing of seeds. *Azospirillum* and PSB were given as seed treatment while VAM (multiplied on onion roots) was applied at 1.0 g/hill prior to dibbling of seeds. The seeds were dibbled at a spacing of 30 x 30 cm. The highest yield was recorded with 2/3 RDF + FYM + *Azospirillum* + VAM. Correlation study revealed significantly positive relationship between yield attributes (plant height, leaf area, total chlorophyll content, fruit length, fruit diameter, fruit

weight N, P and K contents in plant) and yield. Amongst the attributes, N content showed the highest correlation (r = 0.954) followed by plant height (r = 0.934) and P content (r = 0.921). The least influence on yield was exhibited by chlorophyll content (r = 0.602). All the attributes exhibited significant positive correlation amongst themselves.

Singh *et al.* (2004) studied that the integrated use of organic and inorganic sources of nutrients and biofertilizers increased the N, P and K concentrations in the plants (including fruits) of okra, pea and tomato. The integrated nutrient management also significantly increased shoot dry matter yield of tomato and fruit yields of okra and tomato.

2.2 Effect of harvesting stage on the yield and quality of okra

Okra production is greatly influenced by cultural management practices. Therefore, there is a scope in improving the yield and quality of okra by manipulates the cultural management practices. Harvesting is one of the most important cultural practices. Optimum stage of harvesting is related to better growth, yield and quality of okra. So it is important to assess the optimum stage of harvesting for better yield and quality of okra green pod. A good number of works has been done on seed production of okra using different picking time, but in case of green pod production, it is not adequate and conclusive in Bangladesh. Nevertheless, some important and informative works done on this aspect at home and abroad have been reviewed here.

In studies over 2 years on 3 varieties and 2 lines of okra, Sistrunk *et al.* (1960) stated that the greatest increase in pod weight, length and diameter occurred during the 4th to 6th day after flowering. They also reported

that the dry matter content of the pods of all 5 varieties declined from about 13%, 3 days after flowering to 8-9%, 8-9 days after flowering, thereafter it rose steeply and all varieties became 30% fibrous as to be inedible by the10th day after flowering.

Kolhe and Chavan (1967) reported that fruit length, thickness, weight, specific gravity and dry matter were the varietal characters in okra. For a maximum yield of edible pods, it was recommended that Pusa Sawani be picked on the 7th and 8th day after fruit set. In India, under Poona condition, the yield of the variety Pusa Sawani was 13.14 t/ha. The number of fruits was reduced to one third when pods were allowed to mature from be beginning, and to one half when they were allowed to mature after the first 3 weeks of picking.

In a field trial at Punjab, India, okra fruits cv. Pusa Swani were picked at 2 day interval when green up to 4 times, after which, the mature dry fruits were harvested. It was observed that green fruit length declined after the first picking (Grewal *et al*., 1974).

Choudhury (1979) in India reported that, the okra fruits were continuously harvested every 2nd or 3rd day from the first pods were formed. The best time of picking being 6-7 days after the opening of flowers depending on the variety and season. The growth and bearing of the plant were adversely affected if the fruits were not harvested when young.

In India the eating quality of okra was rather high at the 4-day stage from blossoming, increased to the 6-day stage, then slowly declined to the 10 to 12 day stage, after which the pods became so fibrous as to be inedible (Thompson and Kelly, 1979).

In a trial conducted by Mani and Ramanathan (1981) at Coimbatore, India, okra fruits (cv. Unspecified) were picked 14 times at 3-4 days interval. It was found that fruit crude fiber content was increased with each picking date and was the lowest on the first picking (11.38%).

Tomar and Chauhan (1982) noticed that picking at every 4 days gave higher yield than other two variants (2 or 3 days intervals) in okra cv. Pusa Sawani at Jabalpur, India.

Peirce (1987) in New York stated that, for the best market quality pods were harvested immature 4 to 6 days after anthesis (approximately 7.5 to 9 cm long). At this stage, they were free of fibre and were tender, as the pods matured, quality deteriorated rapidly.

Tindall (1988) in London stated that young pods might be harvested 60-180 days from sowing, about 5-10 days after flowering depending on the cultivar grown. Successional harvesting of young pods is generally recommended since mature pods became fibrous. For-marketing, pods should be bright green, firm and free of blemish.

In a trial in Maidhya Pradesh, India with the cv. Pusa Sawani, the plants received nitrogen at 25, 50, 75 and 100 kg /ha and the fruits were picked at intervals of 2, 3 or 4 days. Tomar and Rathore (1988) reported that the yield was maximum in plants which received 75 kg N/ha and were picked every 4 days.

Bhuibhar *et al.* (1989) in India reported that early sowing (July 4) produced the highest yield and quality of green fruit. However, the greatest seed yield and the highest quality were obtained from the treatment of no fruit harvest and four harvests resulted in the highest green fruit yield.

MacMillan (1989) in India stated that when pods were young, those were an agreeable mucilaginous vegetables and as the pods approach maturity, they became fibrous and non-edible.

Nonnecke (1989) stated that okra might be harvested at most appropriate stage of maximum quality and acceptability. If okra pods were allowed to remain beyond the 6 to 10 cm length, they quickly became fibrous and flat tasting. Usually each harvest was followed by others at four to six days intervals and should be continued regularly once the harvest began. To be attractive, okra pods should appear bright green, firm, free of blemishes and about 7 to 8 cm in length. If too young and tender the pod lack flavor.

Saha *et al.* (1989) from their field trial at Bangladesh Agricultural University, Mymensingh reported that picking interval (1, 3 or 5 days interval) had no appreciable effect on the yield of okra but fruit length was significantly affected i.e. the shortest fruits were produced on plants picked at one day interval and the longest fruits were produced on plants picked at five day interval.

Bose and Som (1990) in India stated that the tender young fruits 7-10 cm long should be harvested every alternate day. Frequent picking promotes fruit development and enhence yield. The time of harvesting for the production of maximum yield of edible fruits is 7-8 days after pollination for the variety Pusa Sawani.

Shukla (1990) stated that yield had a significant positive correlation with number of fruits per plant, number of nodes per plant and fruit length in

okra at Jabalpur, India. It was also reported that days to flowering had the greatest direct affect on yield.

According to Iremiren *et al.* (1991) in Nigeria, harvesting of pods 4, 7, 10 or 13 days after fruit set had no effect on vegetative growth or fruit yield/ha. But fruits harvested more than seven days after fruit set were of poorer quality mainly due to an increase in crude fibre and a reduction in moisture crude protein and ash contents of older fruits.

Ketsa and Chutichudet (1992) studied developmental changes in okra cv.OK#2 between 1 and 12 days stage after full bloom from March to June at Bangkok, Thailand. The result showed that the change in length and fresh weight of pod, pericarp thickness and seed diameter followed simple siomodial carves. Pericarp and seed soluble solids content and pericarp fibre content increased, while pericarp ascorbic acid content and pod calcium peetate content decreased towards pod maturity.

Nataraz *et al.* (1992) carried out an experiment with five level of picking (0, 1, 2, 3 or 4 pods/plant) in okra at Karnataka, India and found that picking levels did not significantly affect seed diameter, 1000-seed weight, germination and field emergence, but significantly affected plant height, number of pods/plant, weight of pod and ultimately the yield of okra green pods.

Swiader *el al.* (1992) in Illinois stated that okra was ready for harvest in about 45-60 days after it had been planted. They suggested that the pods should be picked while they were tender and immature (2-3 inches long). This would usually be 4-6 days after flowering. Removal of all pods

induced the plant to keep producing new fruits, large pod, become tough and woody.

Selva and Montenegro (1993) conducted a pot experiment at Mossoro, Brazil with the okra cultivars Liso Miudo and Santa Cruz-47 where fruiting was totally suppressed by removing the flowers daily, partial suppression was obtained by harvesting immature fruits and normal fruiting was allowed and matured fruits were harvested. They observed that the cultivar and treatment interaction was significant for plant height only. Partial and total fruiting suppression increased total plant yield (roots + stems + leaves + flowers and fruits), compared with normal fruiting.

Damarany and Farag (1994) conducted an experiment at Assiut, Egypt, during the sunirner seasons of 1991 and 1992 to study the performance of 13 cultivars of okra. They found-Blondy as the earliest flowering cultivar, and produced the highest number of pods per plant and the highest total yield of pods.

Farghali *et al.* (1994) investigated fruit development in 12 okra genotypes (6 local accessions and 6 foreign cultivars) over 2 successive seasons. All the traits measured increased markedly up to 8 days after anthesis. After that all parameters (fruit length, fruit diameter, weight of fruit and DM content) continued to increase slightly, except fibre content, which picked 11 days after flowering.

Mandal and Dana (1994) found that fruit yield was significantly and positively associated with number of fruits per plant and fruit length in okra, whereas it was negatively associated with days to 50% flowering.

Gondane *et al.* (1995) investigated interrelationship and path co-efficient of quantitative characters using 50 genotypes of okra at Pantnagar, India.

Shri Dhar (1995) studied with seven varieties at Port Blair, Andaman Islands and observed significant difference among the varieties for most of the traits studies. Pusa Sawani was found to produce the greatest number of fruits per plant (10.5) and had the highest pooled yield (17.8 t/ha).

Singh (1995) studied the effect of various doses of nitrogen on the yield and quality of okra in India. There were 6 levels of nitrogen (0, 30, 60, 90, 120 and 150 kg/ha). He found that application of nitrogen at 90-150 kg/ha gave the highest number of pods/plant (12.7-14.0) and pod length (16.7-17.6 cm).

Sood *el al.* (1995) estimated correlation between all combinations of 12 characters of okra at Palampur, India. They observed that nodes per plant, duration of availability of edible pods, plant height and pod length had positive and strong correlation with yield.

Taya *et al.* (1995) conducted an experiment in Haryana, India and reported that fruit thinning decrease the seed yield per hectare, but increase green pod yield. They recommended that no fruit thinning at a spacing of 15 cm was suitable for okra seed production which produced the maximum yield, and that four thinning resulted in the highest green pod yield.

Chandra *el al.* (1996) estimated variability in okra for ten characters at Coirnbatore, India. The highest coefficient of variation was observed for number of pod, plant height and number of branches per plant. Pod number, plant height and length of pod showed maximum positive direct effect on pod yield.

Katyal and Chadha (1996) in India stated that pods of 6-7 days growth were desirable to be picked as those were still tender and of commercially sizeable growth. When the weather is cooler as in the hills, 8-9 days old fruit might be picked. They also reported that pod growth during day time was relatively slow, and pods were picked best early in the morning.

Patil *et al.* (1996) studied 11 characters in okra grown at Dharawad, India during the rabi season of 1990 and kharif of 1991. They observed considerable seasonal differences for number of pods per plant and weight of green pods per plant. They also reported that plant height, number of pods and weight of pods per plant were the most important yield components in okra for higher yield.

Twenty eight okra genotypes were grown during the rainy season of 1991-92 at Urrisi, India and data were recorded on plant height, days to maturity, fruit length, fruit girth and yield per plant (Mishra *et al.*, 1996). All these characters had positive and strong effect on the yield per plant.

Seed and pod development in okra cv. Pusa Sawani were investigated during 1995 in India (Baruah and Paul, 1997). Consumption maturity of pods occurred at 5 days after flowering (DAF) and physiological maturity of seeds occurred at 35 DAF. It was suggested that harvesting for green pods should be done between 4-7 DAF.

Hazarika *et al.* (1997) observed that pod length, circumference, volume, fresh weight and dry weight increased with pod age, but the growth rate was higher at night than during the day in okra (cv. Pusa Sawani) at Assam, India. Pods were ready for harvest from the 6th day of flowering onwards, but pods harvested on or after the 8th day of flowering became fibrous with prominent seeds and were not suitable for consumption.

Kurup *et al.* (1997) reported that nitrogen rate up to 100 Kg/ha could increase the setting percentage, length and girth of fruit, fruit number and weight per plant, and ultimately the total fruit yield of okra cv. Kiran was increased.

Singh *et al.* (1998) conducted an experiment in Varanasi, India with three genotypes of okra, viz. Parbhani Kranti, Hisar Unnat and Satdhar. They suggested that plant height, number of fruits per plant, fruit length and girth are important characters in okra selection for better yield.

Rashid (1999) stated that harvesting of okra pods starts after 7-8 weeks from seed sowing, but sometime it becomes late due to weather conditions and variety. Generally, pods are ready to harvest at 7-8 days after flowering when they attain 8-10 cm length.

Dhall *et al.* (2000) observed that marketable yield per plant, fruit weight, fruits length, number of fruits per plant and plant height were positively and significantly correlated with the total yield per plant. It was found that the marketable yield per plot, number of fruits per plant, fruit weight, fruit length, fruit diameter and plant height had the highest direct effect on the total yield, indicating that emphasis should be given on such characters to improve the yield.

Yadav and Dhankhar (2001) conducted an experiment at Manipur, India to study the correlation between yield parameters and yield and quality of okra cv. Varsha Uphar. They found that the yield of okra was positively and significantly correlated with plant height, number of branches, number of fruits per plant, fruit length and fruit girth. The yield was negatively correlated with days to 50% flowering and days to fruit maturity.

In New York, Mohammed and Brecht (2003) stated that high quality okra should be firm, fresh and tender with uniform pods that are relatively straight and green without any indication of yellowing. Pods that are dull, flaccid and yellowish are inferior, mainly because of their high fiber content. The size of okra pods seems to be related to maturity and quality.

Wu *et al.* (2003) reported that the yield of marketable fruit per hectare increased as the plant population density increased at Oklahoma, USA. Delayed harvesting until many fruits became over mature did not consistently affect marketable fruit yield, but always decreased the Proportion of marketable fruit (by eight) to total harvested fruit.

Chapter 3

Materials and Methods

MATERIELS AND METHODS

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

3.1 Location of the experimental plot

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to August 2006. The site is 23°46′N and 90°24′E latitude and at an altitude of 9 m. from the sea level.

3.2 Characteristics of soil

The soil of the experimental plots was carried out in a medium high land belonging to the Modhupur Tract under the Agro Ecological Zone (AEZ) 28. The soil texture was silty loam with a pH 6.7. Soil samples of the experimental plot was collected from a depth of 0 to 30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI) Farmgate, Dhaka. Details of the mechanical analysis of soil sample are shown in Appendix I. The morphological characters of soil of the experimental plots as indicated by UNDP(1998) are given below-

AEZ No 28
Soil series- Tejgaon
General soil- Non- calcareous, dark gray.

3.3 Climate

The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season (April to September) and scanty in the Rabi season (October to March). There was no rainfall during the month of December, January and February. The average maximum temperature during the period of experiment was 30.9°C and the average minimum temperature was 28.25°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the period of the experiment were collected from Bangladesh Metrological Department, Agargaon, Dhaka and have been presented in Appendix II.

3.4 Planting materials used for experiment

The okra variety "BARI Dherosh 1" was used in this study which was resistant to yellow vein mosaic virus, a severe disease of okra. It was an open pollinated high yielding variety developed by the vegetable division of Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI). The variety was released for commercial cultivation in 1996 (BARI, 2004).The seeds were collected from the Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Treatments of the Experiment:

Experiment consisted of two factors:

Factor-A: Sources of Nutrients

M_0: No manure (control)
M_1: Cow dung (well decomposed) (18t/ha)
M_2: Poultry Litter (well decomposed) (15t/ha)
M_3: Farm Yard Manure (well decomposed) (16.5t/ha)

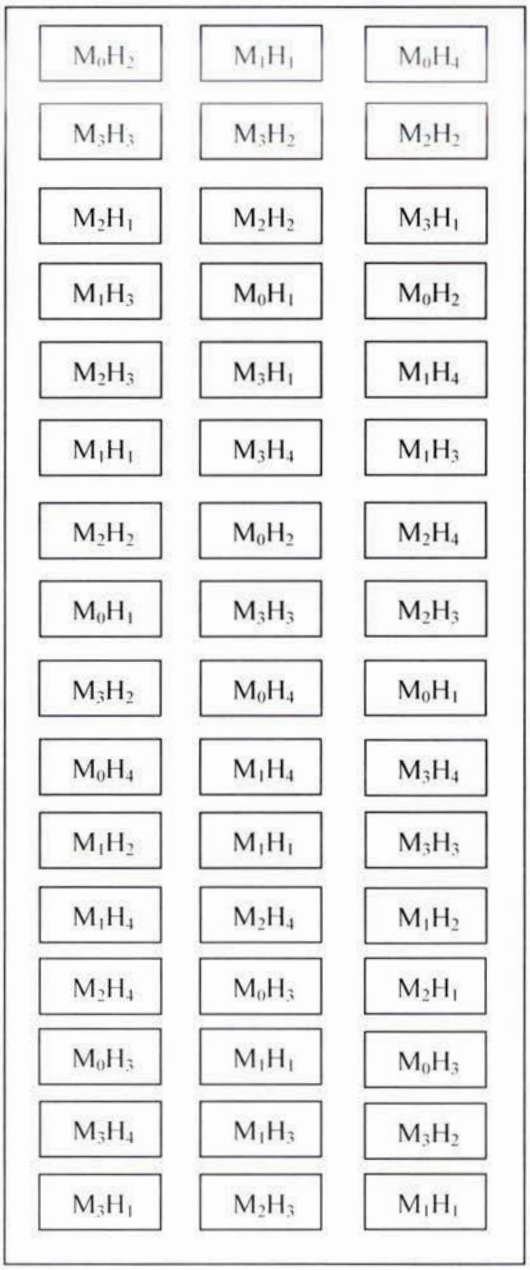
Factor-B: Harvesting stage

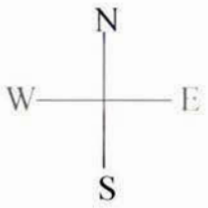
H_1: Harvesting at 5 days after anthesis
H_2: Harvesting at 7 days after anthesis
H_3: Harvesting at 9 days after anthesis
H_4: Harvesting at 11 days after anthesis

3.6 Layout and design of experiment

The experiment consisting of 16 treatments combination was laid out in RCBD with three replication. The whole field was divided into three blocks and each block consisted of 16 plots. Altogether there were 48 unit plots in the experiment and required 373.1m² land. Each unit bed was 3.6 m² (3m×1.2m) in size. The replication were separated form one to another by 1 m. The distance between plots was 0.50 m. Plant to plant distance was 50 cm and row to row distance was 60 cm. The treatments were randomly assigned to each of the block. Each unit plot had 2 rows and each with 6 plants. So there were 12 plants per unit plot.

The layout of the experimental design is shown bellow:





Legand:

Number of treatment	: 16
Replication	: 3
Total plot	: 48
Total area	: 373.1 m^2
Unit plot size	: 3m 1.2m
Plot to plot distance	: 0.5m
Block to block distance	: 1m
Row to row distance	: 60 cm
Plant to plant distance	: 50 cm

Factors:

M_0: No manure

M_1: Cow dung

M_2: Poultry Litter

M_3: Farm Yard Manure

H_1: Harvesting at 5 days after fruit set

H_2: Harvesting at 7 days after fruit set

H_3: Harvesting at 9 days after fruit set

H_4: Harvesting at 11days after fruit set

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

3.7Cultivation of okra

3.7.1 Land preparation

The selected land for the experiment was first opened on first week of April 2006 by power tiller and exposed to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and each ploughing was followed by laddering to obtain good tilth. Weeds and stubbles were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. After removal of the weeds, stubbles and dead roots the land was leveled and the experimental plot was partitioned in to the unit plot in accordance with the design and the edge around each unit plot was raised to check run out of the nutrients. All types of manures were applied during final land preparation as basal dose.

3.7.2 Application of manures

The doses of organic manures were fixed in such a way that the total available NPK remained almost same to recommended dose for each type as suggested by Rashid (1999). According to Rashid (1999) recommended dose was cow dung 10 tons/ ha; urea 150 kg/ha; TSP 100 kg/ha; MP 150 kg/ha. Which supply about 170 kg N, 72 kg P and 182 kg K. For this 18 ton/ha cow dung; 15 ton/ha poultry litter and 16 ton/ha FYM were applied from which we get approximately same amount of N,P and K . The quantity of N, P and K received from the organic manures were almost same to the recommended dose. Slight deviation could not be avoided due to practical reasons.

3.7.3 Sowing of seeds

The okra seeds of cv. BARI Dherosh I were sown on 23, April 2006 in rows of raised beds. Row to row and plant to plant spacing were maintained 60 cm and 50 cm respectively. Three seeds were sown in each location. Then the seeds were covered with fine soil by hand. The field was irrigated lightly immediately after sowing.

3.7.4. Intercultural operations

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

3.7.4.1 Thinning

Only one six days old healthy seedling was kept to grow in each location and other seedling were removed.

3.7.4.2 Gap filing

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

3.7.4.3 Weeding

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

3.7.4.4 Irrigation

Light overhead irrigation was provided with a watering can to the plots once immediately after sowing of seed and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings, when the soil moisture level was very low. Whene ever the plants of a plot had shown the symptoms of wilting the

plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.7.4.5 Drainage

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

3.7.4.6 Plant protection measure

For controlling shoot and pod borer mechanical control was adopted (hand picking). For controlling yellow vain mosaic virus plant was uprooted and destroyed by fire as soon as the symptom found in the field.

3.8 Harvesting

Green pods were harvested with a sharp knife at 5, 7, 9 and 11 days after flower anthesis as per treatments. Green pod harvesting was started from 4 June and was continued up to 20 August.

3.9 Parameters assessed

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

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

3.10 Collection of data

For data collection on the yield of green pod of okra out of 12 plants in each unit plot 10 plants were selected at random. The following yield and yield contributing characters were considered for data collection.

3.10.1 Plant height

In case of organic manures average plant height of selected plants was recorded at 20, 40 and 60 days after sowing (DAS). But for Harvesting stage, the plant height was considered only at 60 DAS, because anthesis occurred after 40 DAS and it was measured with the help of a meter scale from the ground level to the tip of the longest stem in centimeter (cm).

3.10.2 Plant diameter

Average plant diameter was measured from random selected plants of each plot at 20, 40 and 60 days after sowing (DAS) in case of organic sources of nutrients and for harvesting stage at 60 DAS was only considered. Because anthesis occurred after 40 DAS. That is why no effect of harvesting stage at 20 and 40 DAS on plant diameter. The diameter was measured in centimeter (cm) with the help of slide calipers.

3.10.3 Number of leaves per plant

In case of organic sources of nutrients number of leaves of selected plants from each plot at 20, 40 and 60 days after sowing (DAS) was recorded. Only the smallest young leaves at the growing point of the plant were excluded from counting. However, the number of leaves was counted at 60 DAS for harvesting stage. Because anthesis occurred after 40 DAS. Calculating the average number of leaves, the average number was recorded.

3.10.4 Number of branches per plant

Average number of branches per plant of selected plants at 60 days after sowing (DAS) was counted.

3.10.5 Leaf length

Leaves of selected plants were measured at 20, 40 and 60 days after sowing (DAS) for organic sources of nutrients. For harvesting stage it was considered only at 60 DAS. It was measured in centimeter (cm.) with the help of a meter scale.

3.10.6 Leaf breadth

Leaves of selected plants were detached and leaf breadth was measured for organic sources of nutrients at 20, 40 and 60 DAS. But in case of harvesting stage it was only at 60 DAS. It was measured with the help of a meter scale and express in centimeter (cm).

3.10.7 Petiole length

In case of organic sources of nutrients mean of petiole length was measured at 20, 40 and 60 days after sowing (DAS) and for harvesting stage it was recorded at 60 DAS. It was measured with the help of a meter scale in centimeter (cm) from the point of attachment of the leaf.

3.10.8 Number of days to first flowering

Different dates of first flowering of the selected plants of the plots were recorded. Then the calculation was made from the date of seed sowing to flowering, it was considered with the anthesis of flower.

3.10.9 Green pod length

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

3.10.10 Green pod diameter

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

3.10.11 Weight of individual green pod

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

3.10.12 Number of green pods per plant

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

3.10.13 Green pod yield per plant

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

3.10.14 Green pod yield per plot

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

3.10.15 Green pod yield per hectare

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

3.10.16 Attractiveness

A questionnaire wasprepared to asses the attractiveness. Aaccording to the questionnaire 30 people's response was taken on color, size and shape of green pods of each treatment. Then average marks of the three were calculated. The attractiveness was estimated in score using a 1-10 scale (Less attractive to most attractive).

3.10.17 Tenderness

A questionnaire was prepared to asses the tenderness. According to the questionnaire 30 people's response was taken on the basis of tenderness of the pod tip. Tenderness was measured in score by finger felt. The tenderest pods scored highest in a 1-10 scale, and with increase in hard ness the score was decreased.

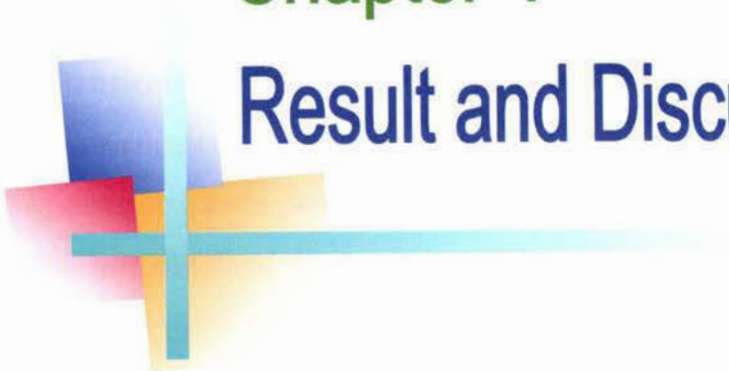
3.10.18 Storage ability

The collected green pods were stored in a room at normal room temperature. Storage ability was measured in days up to which the pods remained in marketable condition.

3.11 Statistical analysis

The calculated data on various parameters were statistically analyzed using MSTAT-C package program. The mean for all the treatments was calculated and analysis of variance for all the characters was performed by F-variance test. The significance of difference between the pair of treatment mean was calculated by the Least Significant Difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

Chapter 4



Result and Discussion

RESULT AND DISCUSSION

The experiment was conducted to observe the effect of organic sources of nutrients and harvesting stage on the growth, yield and quality of okra. A summary of the analysis of variance of all the characteristics studied with their sources of variance and corresponding degrees of freedom have been shown in appendix III and appendix IV. Data on different parameters were analyzed statistically and the result has been presented in tables and figures. The results of the present study have been presented and discussed. Possible interpretations have been made under the following headings.

4.1 Plant height

Plant height was recorded at 20, 40, and 60 DAS. Different organic sources of nutrients exhibited highly significant influence on the plant height of okra (Appendix III). At 20 DAS the tallest (33.08 cm) plant height was obtained from poultry litter (M_2) and the shortest (23.79 cm) plant height was obtained from control (M_0) treatment. At 40 DAS the tallest (72.42 cm) plant height was observed from poultry litter (M_2) and the shortest (49.24 cm) plant height was obtained from control (no manure) (M_0) treatment. At 60 DAS the tallest (108.6 cm.) plant height was found from poultry litter (M_2) and the shortest (71.40 cm.) plant height was obtained from control (no manure) (M_0) treatment (Fig. 2).

Harvesting stage had no significant influence on plant height up to 40 DAS because harvesting start after 40 DAS. But at 60 DAS harvesting stages had highly significant influence on plant height. The maximum (98.25 cm) plant height was obtained from harvesting at 5 days after flower anthesis (H_1)(5 day stage) and the minimum (92.55 cm) plant

height was obtained from harvesting at 11 days after flower anthesis (H_4)(11 day stage) (Fig. 3).

Interaction effect between organic sources of nutrients and harvesting stage showed highly significant influence on plant height at 60 DAS. The tallest (112.30 cm) plant height was obtained from poultry litter with harvesting at 5 days after flower anthesis (M_2H_1) and the shortest (68.69 cm) plant height was obtained from no manure and harvesting at 11 days after flower anthesis (M_0H_4)(Table 3).

Fig. 2. Effect of different organic sources of nutrients on plant height at different days after sowing.

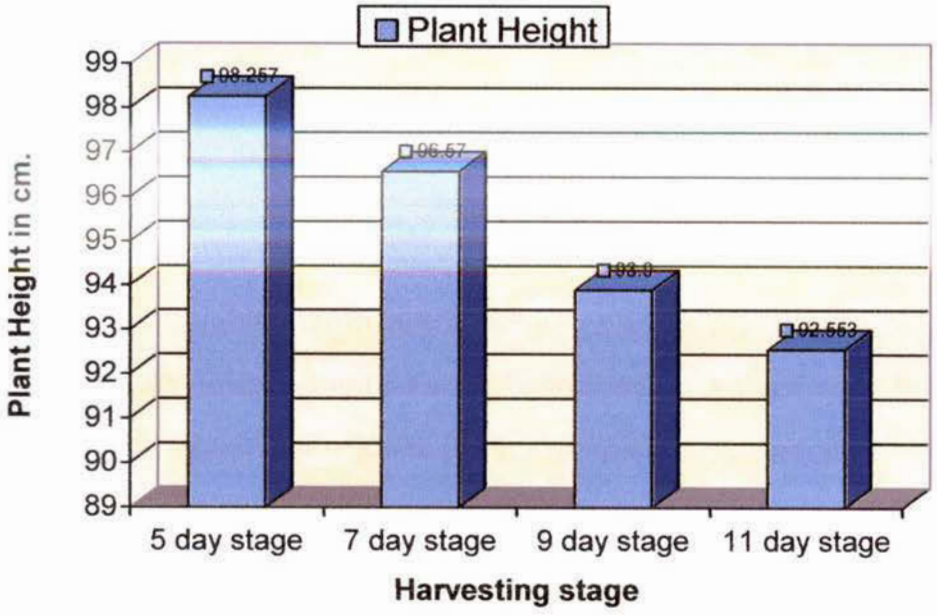


Fig. 3. Effect of different harvesting stages on plant height at 60 DAS.

4.2 Plant Diameter

The present study revealed that there was a highly significant effect of organic sources of nutrients on plant diameter of okra at different days after sowing (Appendix III). The highest (1.45 cm) and the lowest (1.23 cm) plant diameter were recorded from the poultry litter (M_2) and control (M_0) treatment respectively at 20 DAS. At 40 DAS the maximum (2.08 cm) plant diameter was obtained from poultry litter (M_2) and the minimum (1.83 cm) plant diameter was obtained from control (M_0) treatment. At 60 DAS the maximum (2.92 cm) plant diameter was found from poultry litter (M_2) and the minimum (2.65 cm) plant diameter was obtained from control (M_0) treatment (Table 1).

In respect of harvesting stage there was no effect on plant diameter up to 40 DAS, because of no picking of pods. At 60 DAS, harvesting stages had no significant effect on plant diameter. Harvesting at 5 days after

flower anthesis (H_1) gave the highest (2.96 cm) plant diameter and the lowest (2.63 cm) plant diameter was obtained from harvesting at 11 days after flower anthesis (H_4)(Table 2).

Interaction effect between organic sources of nutrients and harvesting stage was found highly significant variation on plant diameter of okra at 60 DAS. Poultry litter combined with harvesting at 5 days after flower anthesis (M_2H_1) gave the highest (3.02 cm) plant diameter and lowest (2.61 cm) plant diameter was obtained from no manure with harvesting at 11 days after flower anthesis (M_0H_4). It was found that late harvesting decrease plant growth (Table 3).

4.3 Number of leaves per plant

A highly significant variation was observed with the application of different organic sources of nutrients on number of leaves per plant at 20, 40 and 60 DAS (Appendix III). However at 20 DAS the maximum (7.23) number of leaves per plant was recorded from poultry litter (M_2) and the minimum (6.07) number of leaves per plant was recorded from control treatment (M_0). The number of leaves increase with the increase of time. At 40 DAS poultry litter (M_2) gave the maximum (16.76) number of leaves and the minimum (14.30) number of leaves was found from control treatment (M_0). At 60 DAS the highest (22.17) number of leaves per plant was recorded from poultry litter (M_2) and the lowest (18.26) number of leaves obtained from control treatment (M_0) (Fig. 4).

Harvesting stages had no effect on number of leaves per plant up to 40 DAS. But at 60 DAS harvesting stages showed highly significant variation on number of leaves per plant. Harvesting at 5 days after flower

anthesis (H_1) showed the maximum (21.48) number of leaves per plant and harvesting at 11 days after flower anthesis (H_4) gave the lowest (19.76) number of leaves (Fig. 5).

Interaction between sources of nutrients and harvesting stage had highly significant influence on number of leaves per plant at 60 DAS. Poultry litter combined with harvesting at 5 days after flower anthesis (M_2H_1) showed the maximum (23.02) number of leaves per plant and the minimum (17.99) number of leaves was observed from no manure with harvesting at 11 days after flower anthesis (M_0H_4) (Table 3).

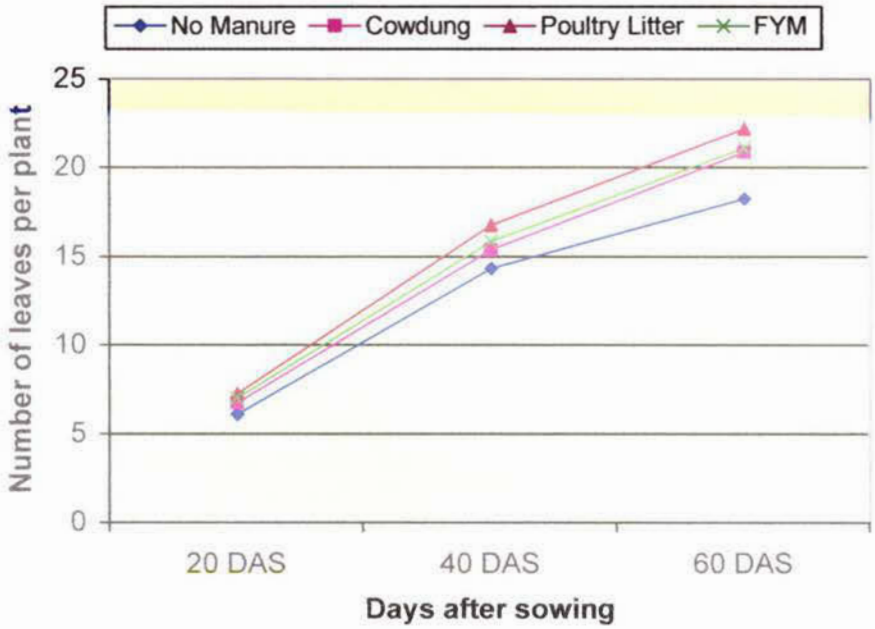


Fig. 4. Effect of different organic sources of nutrients on number of leaves per plant at different days after sowing.

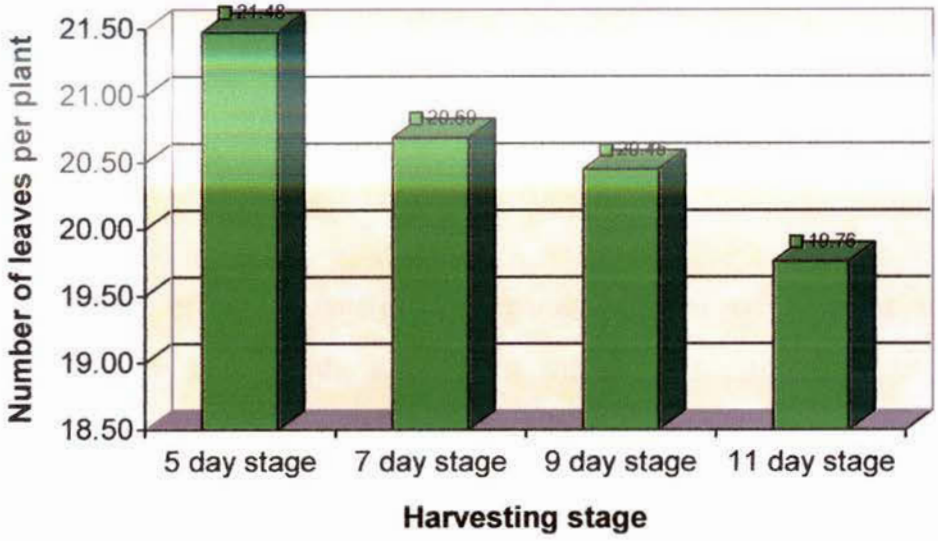


Fig. 5. Effect of different harvesting stages on number of leaves per plant at 60 DAS.

4.4 Number of branches per plant

At 20 DAS highly significant variation was observed in respect of number of branches per plant due to different organic sources of nutrient (Appendix III). The maximum (1.87) number of branches was observed from poultry litter (M_2) and the minimum (1.46) number of branches was recorded from control treatment (M_0). At 40 and 60 DAS significant variation was found. At 40 DAS, the maximum (3.61) number of branches was obtained from poultry litter (M_2) and control treatment (M_0) gave the lowest (3.34) number of branches. The maximum (3.83) number of branches was obtained from poultry litter (M_2) and the minimum (3.67) number of branches was observed from control treatment (M_0) (Table 1).

There was no significant influence on number of branches per plant by the harvesting stages (Appendix III). The maximum (3.90) number of branches was obtained from Harvesting at 5 days after flower anthesis (H_0) and the minimum (3.50) number of branches was obtain from Harvesting at 11 days after flower anthesis(H_4) (Table 2).

The combined effect of different organic sources of nutrient and harvesting stage had highly significant influence on the number of branches per plant. The maximum (4.10) number of branches was obtained from poultry litter with harvesting at 5 days after flower anthesis (M_2H_1) and the lowest (3.40) number of branches was obtained from no manure and harvesting at 11 days after flower anthesis (M_0H_4)(Table 3).

4.5 Leaf length

The effect of different organic sources of nutrients on leaf length was highly significant (Appendix III). Leaf length was observed at 20, 40 and 60 DAS. At 20 DAS the longest (8.89 cm) leaf length was obtained from poultry litter (M_2) and the shortest (7.71cm) leaf length was obtained from no manure (control) (M_0). Poultry litter (M_2) produced the longest (17.32 cm) leaf length and control treatment (M_0) produced the shortest (15.52 cm) leaf length at 40 DAS. At 60 DAS poultry litter (M_2) produced the longest (18.19 cm) leaf length and no manure (M_0) produced the shortest (16.47 cm) leaf length (Table 1).

Harvesting stage had no effect on leaf length up to 40 DAS. But at 60 DAS harvesting stage showed highly significant influence on the leaf length. The longest (17.96 cm) leaf length was found from 5 day harvesting stage (H_1) and the shortest (16.94 cm) leaf length was found from 11 day harvesting stage (H_4) (Table 2).

Combined effect of organic sources of nutrients and harvesting stage had highly significant influence on the leaf length. The highest (18.91cm) leaf length was found from poultry litter with harvesting at 5 days after flower anthesis (M_2H_1) and the shortest (15.84 cm) leaf length was found from no manure with 11 days after flower anthesis (M_0H_4) (Table 3).

4.6 Leaf Breadth

Statistically highly significant result was observed at 20, 40 and 60 DAS on leaf breadth from different organic sources of nutrients (Appendix IV). At 20 DAS the widest (8.71 cm) leaf breadth was observed from poultry litter (M_2) and the narrowest (7.53 cm) leaf breadth obtained from no manure (M_0). At 40 DAS the maximum (22.10 cm) leaf breadth was observed from poultry litter (M_2) and the minimum (20.10 cm) leaf breadth was observed from no manure (M_0). At 60 DAS the maximum (23.43 cm) and the minimum (21.42 cm) leaf breadth was observed from poultry litter (M_2) and no manure (M_0) respectively (Table 1).

Harvesting stages had no influence on leaf breadth up to 40 DAS. But at 60 DAS showed highly significant influence on leaf breadth. The widest (23.32 cm) leaf breadth was found from harvesting at 5 days after flower anthesis (H_1) and the narrowest (21.79 cm) leaf breadth was found from harvesting at 11 days after flower anthesis (H_4) (Table 2).

The combined effect of organic sources of nutrient with harvesting stage exhibited highly significant influence on leaf breadth. The height (24.33 cm.) leaf breadth was observed from poultry litter with 5 day stage (M_2H_1) and the lowest (20.28 cm.) leaf breadth was found from no manure with 11 day stage (Table 3).

Table 1: Effect of organic sources of nutrients on plant diameter, number of branches, leaf length, leaf breadth, petiole length and days to first flowering of okra

Treatment	Plant diameter (cm)			No. of branch per plant			Leaf length(cm)			Leaf breath(cm)			Petiole length(cm)			No.of days to first flowering
	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	
No manure	1.23	1.83	2.65	1.46	3.34	3.54	7.71	15.52	16.47	7.53	20.10	21.42	6.38	16.28	20.58	42.99
Cowdung	1.32	1.90	2.75	1.61	3.48	3.63	8.31	16.65	17.60	8.63	21.38	22.68	6.82	17.32	21.76	42.82
Poultry litter	1.45	2.08	2.92	1.87	3.61	3.83	8.89	17.32	18.19	8.71	22.10	23.43	8.13	18.38	22.48	42.26
FYM	1.43	2.05	2.86	1.63	3.49	3.67	7.91	16.57	17.65	8.42	21.59	22.90	6.43	17.76	22.00	42.59
LSD $_{(0.05)}$	0.095	0.144	0.153	0.134	0.212	0.229	0.271	0.662	0.732	0.459	0.676	0.697	0.286	0.587	0.601	2.193
LSD $_{(0.01)}$	0.128	0.194	0.207	0.181	0.286	0.309	0.365	0.892	0.906	0.619	0.911	0.938	0.385	0.790	0.809	2.953
Level of significance	**	**	**	**	*	*	**	**	**	**	**	**	*	**	**	NS
CV(%)	8.54	8.80	6.58	9.74	7.31	7.54	4.23	4.81	4.62	6.43	3.81	3.70	4.93	4.04	3.32	3.08

* =Significant at 5% level of significance
** =Significant at 1% level of significance
NS = Not Significant

Table 2: Effect of harvesting stage on the plant diameter, number of branches, leaf length, leaf breadth and petiole length of okra

Treatment	Plant diameter (cm)	No. of branch	Leaf length (cm)	Leaf breath (cm)	Petiole length (cm)
5 day stage	2.86	3.70	17.96	23.32	21.87
7 day stage	2.83	3.64	17.67	22.82	21.75
9 day stage	2.77	3.61	17.32	22.51	21.65
11 day stage	2.73	3.50	16.94	21.79	21.55
LSD $_{(0.05)}$	0.154	0.229	0.673	0.697	0.601
LSD $_{(0.01)}$	0.207	0.309	0.906	0.938	0.809
Level of significance	NS	**	**	**	NS
CV(%)	6.58	7.48	4.62	3.7	3.32

** = Significant at 1% level of significance
NS = Not Significant

Table 3 : Combined effect of organic sources of nutrients and harvesting stage on plant height, plant diameter, number of leaves, number of branches, leaf length, leaf breadth and petiole length of okra at 60 DAS

Treatment	Plant height (cm.)	Plant diameter (cm.)	No. of leaves	Total no. of branches	Leaf length (cm.)	Leaf breath (cm.)	Petiole length (cm.)
M_0H_1	74.37	2.71	18.82	3.78	17.07	22.09	20.66
M_0H_2	72.53	2.65	18.16	3.50	16.81	21.72	20.63
M_0H_3	70.01	2.61	18.07	3.47	16.17	21.59	20.58
M_0H_4	68.69	2.61	17.99	3.40	15.84	20.28	20.47
M_1H_1	100.21	2.78	22.00	3.90	17.81	23.45	21.92
M_1H_2	98.91	2.78	21.01	3.60	17.76	22.95	21.86
M_1H_3	96.63	2.73	20.46	3.60	17.70	22.28	21.65
M_1H_4	95.29	2.69	19.96	3.40	17.12	22.05	21.61
M_2H_1	112.30	3.02	23.02	4.10	18.91	24.33	22.69
M_2H_2	100.40	2.98	22.74	3.80	18.37	23.44	22.53
M_2H_3	106.57	2.91	22.56	3.78	17.84	22.99	22.45
M_2H_4	105.25	2.80	20.34	3.63	17.63	22.94	22.23
M_3H_1	106.27	2.93	22.10	3.83	18.06	23.39	22.21
M_3H_2	104.44	2.89	20.86	3.67	17.75	23.16	21.96
M_3H_3	102.39	2.82	20.74	3.58	17.59	23.16	21.93
M_3H_4	100.98	2.81	20.72	3.58	17.19	21.89	21.90
$LSD_{(0.05)}$	2.590	0.154	0.799	0.229	0.673	0.697	0.601
$LSD_{(0.01)}$	3.488	0.207	1.076	0.309	0.906	0.938	0.809
Level of significance	**	**	**	**	**	**	**
CV(%)	3.26	6.58	4.65	7.48	4.62	3.70	3.32

** =Significant at 1% level of significance; M_0= No manure; M_1= Cowdung; M_2= Poultry litter; M_3= FYM;
H_1= 5 day stage; H_2= 7 day stage; H_3= 9 day stage; H_4= 11 day stage

4.7 Petiole length

A significant variation was observed on petiole length with the application of different organic sources of nutrients at 20 DAS and highly significant variation was observed at 40 and 60 DAS (Appendix IV). At 20 DAS the longest (8.14 cm) petiole length was obtained from poultry litter (M_2) and the shortest (6.39 cm) petiole length was recorded from no manure (M_0). At 40 DAS the longest (18.38 cm) petiole length was obtained from poultry litter (M_2) and the shortest (16.28 cm) petiole length was found from no manure (M_0). At 60 DAS the longest petiole length (22.48 cm) was obtained from poultry litter (M_2) and the shortest petiole length (20.58 cm) was found from no manure (M_0) (Table 1).

Up to 40 DAS there was no effect of harvesting stage on petiole length. At 60 DAS harvesting stage had no significant influence on the petiole length. The longest (21.87 cm) petiole length was obtained from harvesting at 5 days after flower anthesis (H_1) and the shortest (21.55 cm) petiole length was obtained from 11 day stage (H_4) (Table 2).

The combined effect of organic sources of nutrient with harvesting stage had highly significant influence on petiole length at 60 DAS. The longest (22.69 cm) petiole length was observed from poultry litter with 5 day stage (M_2H_1) and the shortest (20.47 cm) petiole length was found from no manure with 11 day stage (M_0H_4)(Table 3).

4.8 Number of days to first flowering

Different organic sources of nutrients exhibited no significant influences on the number of days to first flowering (appendix IV).The plant manures with poultry liter (M_2) showed early (42.26 days) flowering and delay (42.99 days) flowering occurred from control (no manure) (Table 1).

4.9 Green pod length

A highly significant variation was found due to the effect of different organic sources of nutrients on green pod length (Appendix IV). Poultry litter produced the maximum (14.26 cm) green pod length followed by FYM (13.48 cm), whereas, control treatment produced the minimum (12.72 cm) green pod length (Table 4).

Okra green pods harvested at different stages demonstrated highly significant variation on pod length (Table 5). The longest (14.72 cm) length of okra green pod was found from harvesting at 11 day stage (H_4) which was statistically similar to harvesting at 9 and 7 day stage (14.40 cm and 13.73 cm respectively). The pod length gradually decreased with decreasing in harvesting duration. The shortest (10.87 cm) pod length was observed at 5 day stage after fruit set (H_1). Production of long pods at 11 day stage was due to continuation of pod growth. Initially the growth rate was very high, which declined with increase in age of okra green pod. Increasing pod length in okra with age was also reported by Hazarika *et al.* (1997). Mohammed and Brecht (2003) stated that the size of okra pods was related to maturity and quality.

The analysis of variance revealed that, green pod length varied highly significant due to the combined effect of sources of nutrients with harvesting stage. The maximum (15.45 cm) green pod length was obtained from poultry litter with 11 day stage after flower anthesis (M_2H_4) followed by (M_2H_3) and (M_2H_2) respectively. The shortest (10.13 cm) green pod length was obtained from no manure with 5 day stages after flower anthesis (M_0H_1) (Table 6).

4.10 Green pod diameter

Significant variation was found due to the effect of different organic sources of nutrients on green pod diameter (Appendix IV). The maximum (1.96 cm) green pod diameter was obtained from poultry litter (M_2)

followed by FYM (1.88 cm), which was statistically similar to M_2 treatment. The minimum (1.78 cm) green pod diameter was obtained from no manure (M_0) (Table 4).

In respect of diameter of green pod, highly significant variation was observed among the harvesting stages. The highest (2.04 cm) diameter of green pod was found from 11 day stage (H_4). The diameter of freshly harvested green pod gradually increased with delay in harvesting. The minimum (1.66 cm) diameter was recorded at 5 day stage (H_1). The increase in diameter of pod with delay in harvesting was due to continuation of pod growth (Table 5).

Highly significant variation was observed in green pod diameter due to the combined effect of organic sources of nutrients and harvesting stage (Appendix IV). The maximum (2.19 cm) green pod diameter was obtained from poultry litter with 11 day harvesting stage (M_2H_4) followed by FYM (2.10 cm). The lowest (1.59 cm) green pod diameter was obtained from no manure with 5 day harvesting stage (M_0H_1) (Table 6).

4.11 Individual green pod weight

Highly significant variation was observed due to the effect of organic sources of nutrients on individual green pod weight (Appendix IV). The maximum (16.60g) pod weight was obtained from poultry litter (M_2) and the minimum (13.54g) pod weight was obtained from no manure (M_0) (Table 4).

A highly significant difference was found on weight of individual green pod among the harvesting stages. The maximum (17.79g) weight of

individual green pod was found at 11 day stage (H_4). On the contrary, the lowest (11.25g) weight of individual green pod was found at 5 day stage (H_1). Gradual increase in weight of individual green pod with age was particularly due to accumulation of more photosynthate (Table 5).

The analysis of variance revealed that highly significant variation was found on individual green pod weight due to the combined effect of organic sources of nutrients and Harvesting stage. The maximum (20.01g) green pod weight was obtained from the treatment combinations of poultry litter with 11 day stages after flower anthesis (M_2H_4) followed by poultry litter with 9 day stage (M_2H_3). The minimum (10.31g) pod weight was obtained from no manure with 5 day stage (M_0H_1) (Table 6).

4.12 Number of green pod per plant

Highly significant variation was found due to the effect of different organic sources of nutrients on number of green pod per plant (Appendix IV). The maximum (17.85) number of green pod was obtained from poultry litter (M_2) and the minimum (15.30) number of green pod was obtained from no manure (M_0) (Table 4).

Different harvesting stages exhibited highly significant variation on number of green pods per plant. The maximum (20.56) number of green pods per plant was recorded from 5 day stage (H_1) and the lowest (13.98) number of green pods per plant was found form 11 day stage (H_4). The number of green pods per plant gradually decreased with delay in harvesting. The number of green pods per plant at 5 day harvesting stage was highest due to frequent harvesting leading to formation of new pod. Kolhe and Chavan (1967) reported that the number of pods was reduced to one third when pods were allowed to mature from be beginning and to

one-half when they were allowed to mature after the first 3 weeks of picking. Again, Anon (1995) reported that plants harvested every three to four days produced three times more pods than when the pods were allowed to ripen (Table 5).

The combined effect of organic sources of nutrients and harvesting stage also showed highly significant variation on number of pod per plant. The maximum (22.51) number of green pod was obtained from poultry litter with 5 day stage after flower anthesis (M_2H_1). The minimum (13.01) number of green pod per plant was obtained from no manure with 11 day stage (M_0H_4) (Table 6).

4.13 Green pod yield per plant

Different sources of nutrients showed highly significant variation on green pod yield per plant (Appendix IV). The maximum (286.09g) green pod yield per plant was recorded from poultry litter (M_2). Whereas, the lowest (202.62g) pods yield was obtained from no manure (M_0)(Table 4).

Weight of green pods per plant varied significant due to harvesting at different stages. The highest weight of green pods per plant (266.21g) was found when the pods were harvested at 7 day stage (H_2), which was statistically similar to 9 day stage (255g). Whereas, 5 day harvesting stage (H_1) was found to gave the lowest (232.09 g) weight of green pods per plant. The weight of individual green pod and number of green pods per plant contributed weight of green pods per plant. Weight of green pods per plant at 5 day harvesting stage was low particularly due to lower weight of individual pod. On the contrary, at 7 day harvesting stage the number of pods per plant was close to the highest and the weight of individual green pod was relatively much higher leading to the highest

total weight of green pods per plant. The weight of green pods per plant gradually declined with delay in harvesting due to decreasing number of green pods per plant. Dhall *et al.* (2000) also stated that the number and weight of green pods had the highest direct effect on the yield of okra (Table 5).

The combined effect of different sources of nutrients and harvesting stage on green pod yield was highly significant. The highest (303.91g) yield of green pod per plant was obtained from poultry litter with 7 day stage (M_2H_2) followed by poultry litter with 11 day stage combination. The lowest (188.70g) green pod yield per plant was recorded from no manure with 5 day stage (M_0H_1) (Table 6).

Table 4: Effect of organic sources of nutrients on pod length, pod diameter, pod weight, yield per plant, yield per plot, attractiveness, tenderness and shelf life of okra pod

Treatment	Green pod length (cm)	Green pod diameter (cm)	Green pod weight (g)	Number of pod/plant	Yield/ plant (g)	Yield/ plot (kg)	Attractive ness	Tenderness	Shelf life
No manure	12.72	1.78	13.54	15.30	202.62	2.42	5.78	5.51	3.25
Cowdung	13.27	1.81	14.78	17.11	247.93	2.98	6.10	5.83	3.34
Poultry litter	14.26	1.96	16.60	17.85	286.09	3.43	6.59	5.88	3.58
FYM	13.48	1.88	15.33	17.80	266.23	3.20	6.35	5.85	3.79
LSD $_{(0.05)}$	1.141	0.139	1.233	0.956	27.65	0.329	0.503	0.316	0.303
LSD $_{(0.01)}$	1.536	0.188	1.661	1.288	37.23	0.443	0.677	0.426	0.408
Level of significance	**	*	**	**	**	**	**	*	**
CV(%)	5.09	4.38	4.91	3.37	6.61	6.59	4.88	3.28	5.35

* = Significant at 5% level of significance
** = Significant at 1% level of significance

Table 5: Effect of harvesting stage on pod length, pod diameter, pod weight, yield per plant, yield per plot, attractiveness, tenderness and shelf life of okra

Treatment	Green pod length (cm)	Green pod diameter (cm)	Green pod weight(g)	Number of pod/plant	Yield/ plant (g)	Yield/ plot (kg)	Attractive ness	Tenderness	Shelf life
5 day stage	10.87	1.66	11.25	20.56	232.09	2.78	7.66	8.39	3.02
7 day stage	13.73	1.83	14.50	18.28	266.21	3.20	8.55	7.47	4.08
9 day stage	14.40	1.90	16.70	15.23	255.00	3.06	5.56	4.95	3.75
11 day stage	14.72	2.04	17.79	13.98	249.57	3.00	3.04	2.26	3.17
LSD $_{(0.05)}$	1.141	0.139	1.233	0.956	27.650	0.329	0.503	0.316	0.303
LSD $_{(0.01)}$	1.536	0.188	1.661	1.288	37.230	0.443	0.677	0.426	0.408
Level of significance	**	**	**	**	*	*	**	**	**
CV(%)	5.09	4.38	4.91	3.37	6.61	6.59	4.88	3.28	5.35

* =Significant at 5% level of significance
** =Significant at 1% level of significance

Table 6: Combined effect of organic sources of nutrient and harvesting stage on pod length, pod diameter, pod weight, yield per plant yield per plot, yield per hectare, attractiveness, tenderness and shelf life of okra

Treatment	Green pod lenth (cm)	Green pod diameter (cm)	Green pod weight (g)	Number of pod/plant	Yield/ plant (g)	Yield/ plot (kg)	Yield/ha (ton)	Attractiveness	Tenderness	Shelf life
M_0H_1	10.13	1.59	10.31	18.32	188.72	2.23	6.29	7.11	7.97	2.95
M_0H_2	12.82	1.77	12.98	16.44	213.51	2.56	7.12	7.63	7.06	3.83
M_0H_3	13.67	1.83	15.32	13.42	205.96	2.47	6.87	5.50	4.92	3.27
M_0H_4	14.25	1.92	15.54	13.01	202.28	2.43	6.74	2.83	2.10	2.97
M_1H_1	10.68	1.64	11.39	19.88	226.64	2.72	7.55	7.63	8.42	2.99
M_1H_2	13.46	1.80	14.19	18.50	262.55	3.15	8.75	8.50	7.49	4.01
M_1H_3	14.31	1.85	15.99	15.74	251.78	3.02	8.39	5.21	4.99	3.57
M_1H_4	14.63	1.93	17.53	14.30	250.76	3.01	8.36	3.07	2.43	3.01
M_2H_1	11.57	1.76	11.78	22.51	265.42	3.19	8.85	8.09	8.55	3.04
M_2H_2	14.70	1.90	15.83	19.20	303.91	3.65	10.13	9.17	7.62	4.10
M_2H_3	15.31	1.99	18.76	15.32	287.25	3.45	9.58	5.92	4.93	4.09
M_2H_4	15.45	2.19	20.01	14.38	287.76	3.45	9.59	3.17	2.30	3.30
M_3H_1	11.09	1.66	11.51	21.51	247.58	2.97	8.25	7.80	8.63	3.11
M_3H_2	13.95	1.86	14.98	18.99	284.85	3.42	9.49	8.89	7.69	4.37
M_3H_3	14.32	1.91	16.72	16.44	275.00	3.30	9.17	5.61	4.97	4.27
M_3H_4	14.55	2.10	18.09	14.24	257.49	3.09	8.58	3.10	2.22	3.41
LSD $_{(0.05)}$	1.141	0.139	1.233	0.956	27.650	0.329	1.106	0.503	0.316	0.302
LSD $_{(0.01)}$	1.536	0.187	1.661	1.288	37.230	0.443	1.489	0.677	0.426	0.407
Level of significance	**	**	**	**	**	**	**	**	**	**
CV(%)	5.09	4.38	4.91	3.37	6.61	6.59	6.61	4.88	3.28	5.35

** =Significant at 1% level of significance; M_0= No manure; M_1= Cowdung; M_2= Poultry litter; M_3= FYM;
H_1= 5 day stage; H_2= 7 day stage; H_3= 9 day stage; H_4= 11 day stage

4.14 Green pod yield per plot

Different organic sources of nutrients showed highly significant variation on the green pod yield per plot (Appendix IV). The maximum (3.43 kg) green pod yield per plot was recorded from poultry litter. Whereas, the lowest (2.42 kg) pods yield was obtained from no manure (Table 4).

Difference in the weight of green pod per plot among the harvesting stages was found significant. The highest (3.20 kg) weight of green pod per plot was found on harvesting at 7 day stage (H_2), which was statistically similar to 9 day and 11 day stages. The lowest (2.78 kg) weight of green pods per plot was found on 5 day harvesting stage (H_1). Production of the highest weight of green pods per plot at 7 day stage was due to the combination of weight of green pod and number of green pod per plant (Table 5).

The combined effect of different organic sources of nutrients and harvesting stage on green pod yield was highly significant (Appendix IV). The highest (3.65 kg) yield of green pod per plot was obtained from poultry litter with 7 day stage (M_2H_2) followed by poultry litter with 11 day stage. The lowest (2.23 kg) green pod yield per plot was recorded from no manure with 5 day stage (M_0H_1) (Table 6).

4.15 Green pod yield per hectare

Different organic sources of nutrients showed a highly significant variation on the green pod yield per hectare (Appendix IV). The maximum (9.54 tons) green pod yield per hectare was recorded from poultry litter (M_2). Whereas, the lowest (6.75 tons) pods yield was obtained from no manure (M_0) (Fig.6).

Harvesting at different stages influenced the yield of green pods per hectare significantly. The maximum (8.87 t/ha) yield of green pods was recorded from harvesting at 7 day stage (H_2), which was statistically similar to 9 day stage (8.50 t/ha). The minimum (7.74 t/ha) yield of green pod was recorded from 5 day stage (H_1) particularly due to lower weight of individual green pod. At 7 day harvesting stage, the yield of green pod was the maximum due to the combination of number of green pods per plant and weight of individual green pod. Green pod yield was gradually decreased after 7 day harvesting stage due to decreasing number of green pods per plant (Fig. 7).

The combined effect of different sources of nutrients and harvesting stage on green pod yield per hectare was highly significant (Table 6). The highest (10.13 tons) yield of green pod per hectare was obtained from poultry litter with 7 day stage (M_2H_2) followed by poultry litter with 11 day stage. The lowest (6.29 kg) green pod yield per hectare was recorded from no manure with 5 day stage (M_0H_1).

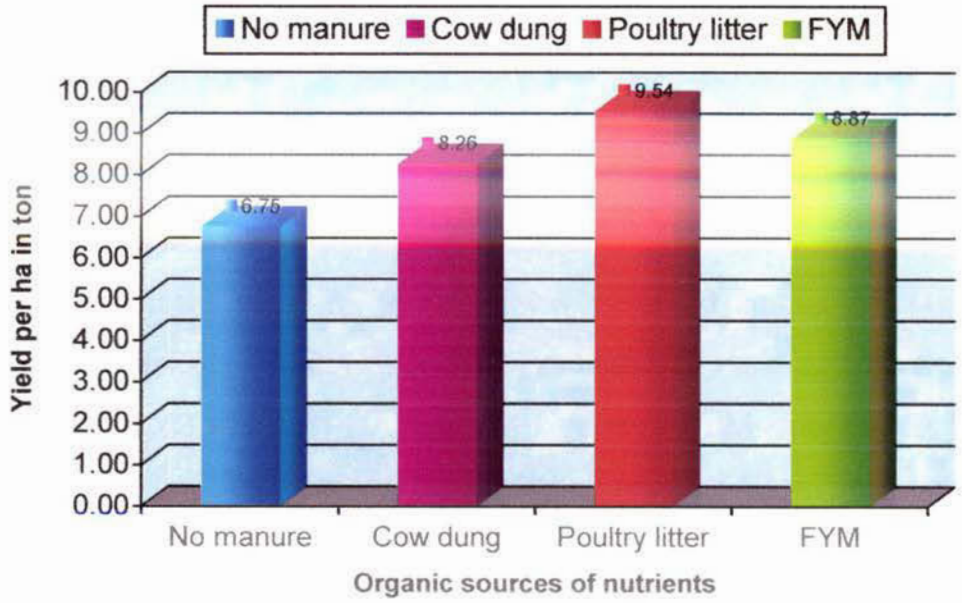


Fig. 6. Effect of different organic sources of nutrients on green pod yield per hectare.

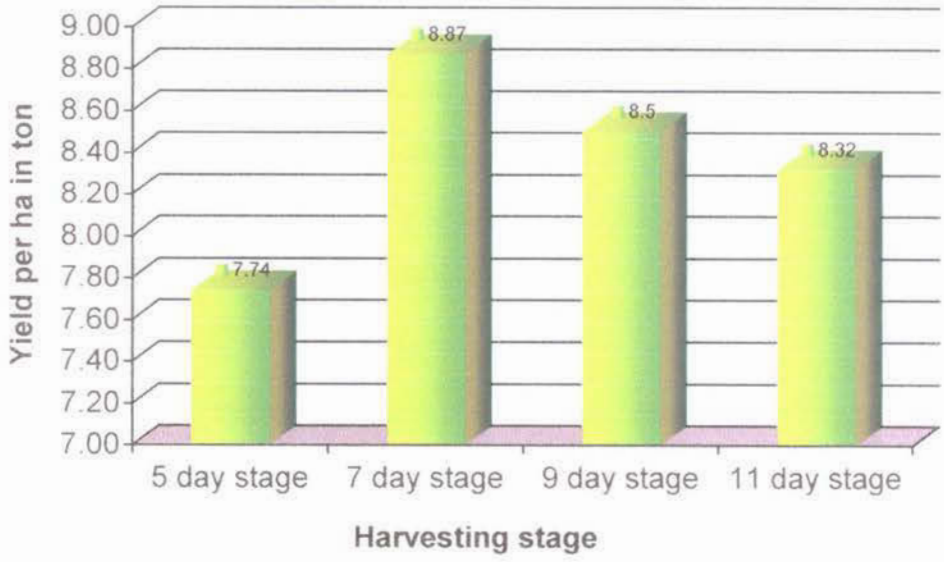


Fig. 7. Effect of different harvesting stages on green pod yield per hectare.

4.16 Attractiveness

Attractiveness of okra green pod was estimated in score by eye estimation with 10 to 1 scale (most attractive to less attractive). Attractiveness of okra green pod was influenced by color, size, and shape and free from blemishes. So in case of numbering color, size and shape was considered. Highly significant variation in score was observed among the organic sources of nutrients. Poultry litter (M_2) produced the most attractive green pods (score 6.59) which was statistically similar to FYM (score 6.35). Less attractive green pods (score 5.77) were produce from no manure treatment(M_0)(Table4).

Highly significant variation in score of attractiveness was observed among the different harvesting stages. Green pod harvested at 7 day stage (H_2) was most attractive (score 8.55) followed by 5 day harvesting stage (score 7.66). The less attractive green pods (score 3.04) were observed at 11 day harvesting stage (H_4) (Table 5). At 7 day stage the green pods became very attractive due to bright green color and attractive size and shape of the pods. At 5 day harvesting stage, though the color of green pods was very bright green but size was very small. After 7 day harvesting stage, attractiveness was dually decreased due to less attractive color, large size and undesirable shape of pods.

Combined effect of organic sources of nutrients with harvesting stage had significant influence on attractiveness (Table 6). Most attractive green pod (score 9.17) was produced from poultry litter combined with 7 day stage (M_2H_2) which was statistically similar to FYM with 7 day stage (score 8.89) and cow dung with 7 day stage (score 8.50) and less attractive green pod (score2.83) was produced from no manure with 11 day stage (M_0H_1).

4.17 Tenderness

Tenderness is one of the most important qualitative characters for green okra in the consumers market. The tenderness of green pod was significantly influenced by the organic sources of nutrients. Tenderness of green pods was estimated in a 10 to 1 scoring scale (tender to hard). The most (score 5.88) tender green pod was produced from FYM (M_3) followed by poultry litter (score 5.85) and cow dung (score 5.83). Less tender green pod (score 5.51) was produced from control (M_0) treatment (Table 4).

The present study demonstrated a highly significant variation among the harvesting stage. The most tender green pods (score 8.39) was found at 5 day harvesting stage (H_1), which was statistically similar to 7 day harvesting stage (score 7.47). The most hard pods (score 2.26) was found at 11 day harvesting stage (H_4). Tenderness was decreased with the increasing age of green pods (Table 5).

Combined effect of organic sources of nutrients with harvesting stage had highly significantly influence on the tenderness of okra green pod (Table 6). FYM combined with 5 day harvesting stage (M_3H_1) produced the most tender green pods (score 8.63) followed by poultry litter with 5 day harvesting stage (score 8.55). The most hard green pods (score 2.10) was obtained from no manure combined with 11 day harvesting stage (M_0H_4).

4.18 Storage ability

Storage ability of okra green pod is an important qualitative character. Storage ability of okra green pods treated with different organic sources of nutrients showed highly significant difference. Storage ability was measured in days up to which the pod remained in marketable condition. The maximum storage ability (score 3.79) of okra green pod was observed from poultry litter (M_2) and the minimum storage ability (score 3.25) was observed from no manure (M_0). Poultry litter and FYM was statistically similar in this respect (Table 4).

Storage ability of okra green pod harvested at different harvesting stages showed highly significant variation. The lowest storage ability (3.02 days) was found in the pods harvested at 5 day stage (H_1). The highest storage ability (4.08 days) was recorded at 7 day harvesting stage (H_2), which was statistically similar to 9 day harvesting stage (3.75 days). When the green

pods were harvested at 5 day stage, they were very soft, tender high moisture content and susceptible to storage loss. As a result, their storage ability was very low. On the other hand, an increase in pod age, fibereness increased and decreased the moisture content of pods. Ultimately, their wilting tendency was gradually decreased. But they gradually turned yellow and showed the sign of dryness starting from the base under storage condition. After 7 day harvesting stage, the rate of yellowing, increased (Table 5).

Interaction effect of organic sources of nutrients with harvesting stage had significant influence on storage ability of okra. The maximum storage ability (score 4.10) of okra green pod was observed from poultry litter combined with 7 day stage (M_2H_2) and the minimum storage ability (score 2.95) was observed from no manure combined with 5 day stage (M_0H_1) (Table 6).

4.19 Economic analysis

Economic analysis in the present experiment was done to find out the gross, net return and the benefit cost ratio and presented in this section.

Gross return:

In the combination of organic sources of nutrients and harvesting stage the highest gross return (TK. 121660) was obtained from M_2H_2 and the second highest gross return (TK. 113980) was obtained from M_3H_2. The lowest gross return (TK. 37170) was obtained from M_0H_4 (Table 7).

Net return:

In case of net return different treatment combination showed different types of net return. In the combination of organic sources of nutrients and harvesting stage the highest net return (TK. 72088) was obtained from M_2H_2 and the second highest net return (TK. 65347) was obtained from M_3H_2. The lowest net return (TK. 1623) was obtained from M_1H_4 (Table 7).

Benefit cost ratio:

In the combination of organic sources of nutrients and harvesting stage the highest benefit cost ratio (1.45) was found from M_2H_2. The second highest benefit cost ratio (1.34) was found from M_3H_2. The lowest benefit cost ratio (0.04) was found from M_1H_4 (Table 7).

Table 7: Cost and return of okra as influenced by organic sources of nutrients and harvesting stage

Treatment combination	Cost of production (TK./ha)	Yield (t/ha)	Gross return (TK./ha)	Net return (TK./ha)	Benefit cost ratio
M_0H_1	41517	6.29	63000	21483	0.52
M_0H_2	39587	7.12	85540	45953	1.16
M_0H_3	37565	6.87	55060	17495	0.47
M_0H_4	35430	6.74	37170	1740	0.05
M_1H_1	50535	7.55	75600	25065	0.50
M_1H_2	48578	8.75	105100	56522	1.16
M_1H_3	46559	8.39	67220	20661	0.44
M_1H_4	44457	8.36	46080	1623	0.04
M_2H_1	51543	8.85	88600	37057	0.72
M_2H_2	49572	10.13	121660	72088	1.45
M_2H_3	47539	9.58	76740	29201	0.61
M_2H_4	45542	9.59	52845	7303	0.16
M_3H_1	50605	8.25	82600	31995	0.63
M_3H_2	48633	9.49	113980	65347	1.34
M_3H_3	46646	9.17	73460	26814	0.57
M_3H_4	44592	8.58	47290	2698	0.06

M_0= No manure
M_1= Cowdung
M_2= Poultry litter
M_3= FYM

H_1= 5 day stage
H_2= 7 day stage
H_3= 9 day stage
H_4= 11 day stage

Chapter 5

Summary and Conclusion

SUMMARY AND CONCLUSION

An experiment was conducted to find out the effect of organic sources of nutrients and harvesting stage on the growth yield and quality of okra. The experiment was carried out at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April 2006 to August 2006. The experiment consisted of two-factors such as factor A: Organic sources of nutrients; factor B: Harvesting stage. There were four sources of nutrients Viz. i) cow dung, ii) Poultry litter iii) Farm Yard manure (FYM) and iv) Control (no manure) and four harvesting stage Viz. i) Harvesting 5 days after flower anthesis (5 day stage), ii) Harvesting 7 days after flower anthesis (7 day stage), iii) Harvesting 9 days after flower anthesis (9 day stage) and iv) Harvesting 11 days after flower anthesis (11 day stage).

The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were although 16 treatments combinations in this experiment. In the experiment, the size of each unit plot was 3m × 1.2 m and 12 plants were accommodated in each plot with a spacing of 60 cm × 50 cm. Each unit plot had 2 rows and each with 6 plants. The okra seeds of cv. BARI Dherosh-l were sown on 23 April, 2006 and the green pods were harvested from 4 June to 30 August, 2006.

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

The result of the experiment showed that all the parameters except number of days to first flowering were observed highly significant or significantly influenced by the sources of nutrients. Poultry litter causes early flowering (42.26 days). The maximum plant height (33.08 cm, 72.42 cm and 108.60 cm at 20, 40 and 60 DAS respectively), plant diameter (1.45 cm, 2.08 cm and 2.92 cm at 20, 40 and 60 DAS respectively), number of leaves per plant (7.23 , 16.76 and 22.17 at 20, 40 and 60 DAS respectively), number of branches per plant (1.87, 3.61 and 3.83 at 20, 40 and 60 DAS respectively), leaf length (8.89 cm, 17.32 cm and 18.19 cm at 20, 40 and 60 DAS respectively), leaf breadth (8.71 cm, 22.10 cm and 23.43 cm at 20, 40 and 60 DAS respectively), petiole length (8.14 cm, 18.38 cm and 22.48 cm at 20, 40 and 60 DAS respectively), green pod length (14.26 cm), green pod diameter (1.96 cm), individual green pod weight (16.60 g), number of green pod per plant (17.85), green pod yield per plant (286.09 g), green pod yield per plot (3.43 kg), green pod yield per hectare (9.54 ton), the most attractive green pod (score 6.59) and the most tender green pod (score 8.39) were produced by the poultry litter treatment. The maximum storage ability (3.79 days) was observed from FYM treatment but it was statistically similar to poultry litter treatment.

The result of the experiment further showed that parameters i.e. plant height, number of leaves per plant, number of branches per plant, leaf length, leaf breadth, were observed significantly influenced by the harvesting stage at 60 DAS. 5 days harvesting stage enhanced to maximize the plant height (98.26 cm), plant diameter (2.86 cm), number of leaves per plant (21.48), number of branches per plant (3.70), leaf length (17.96 cm), leaf breadth (23.32 cm), petiole length (21.87 cm) and total number of green pod per plant (20.56). The minimum result was obtained on the above parameters from 11 day harvesting stages. The maximum green pod length (14.72 cm), green pod diameter (2.04 cm), and green pod weight (17.79 g) were obtained from 11 days harvesting stage and the minimum from 5 day harvesting stage. The maximum yield per plant (266.21 g), yield per plot (3.20 kg) , yield per hectare (8.87 tons), the most attractive

green pod (score 8.55) and the longest storage ability (4.08 days) were obtained from 7 day harvesting stage. The minimum yield, less storage ability and the most tenderness of green pods were found from 5 day harvesting stage. Less tender green pod was produced from 11 day harvesting stage.

Combined effect of organic sources of nutrients and harvesting stage had highly significant influence on plant height, plant diameter, number of leaves per plant, number of branches per plant, leaf length, leaf breadth and petiole length at 60 DAS. Poultry litter combined with 5 day harvesting stage produced the maximum plant height (112.30 cm), plant diameter (3.02 cm), number of leaves per plant (23.02), number of branches per plant (4.10), leaf length (18.91 cm), leaf breadth (24.33 cm), petiole length (22.69 cm) at 60 days after sowing and the highest number of green pod per plant (22.51). The maximum green pod length (15.45 cm), green pod diameter (2.19 cm) and green pod weight (20.01 g) were obtained from poultry litter combined with 11 day harvesting stage. But the maximum yield per plant (303.90 g), yield per plot (3.65 kg) and yield per hectare (10.13 ton) were obtained from poultry litter combined with 7 day harvesting stage. For attractiveness poultry litter combined with 7 day stage gave the best result. In case of tenderness FYM combined with 5 day harvesting stage gave the best result and in case of storage ability FYM combined with 7 day stage gave the longest storage ability. Considering growth of plant poultry litter combined with 5 day stage gave the best result but in case of all the growth parameter the treatment was statistically similar to poultry litter combined with 7 day stage. When the main effect of sources of nutrients and harvesting stage on the yield per hectare were considered, the highest yield 9.54 t/ha and 8.87 t/ha were obtained respectively from poultry litter and 7 day harvesting stage. The above mentioned treatment combinations also gave the highest green pod yield of okra (10.13 t/ha). In case of quality of okra green pod poultry litter combined with 7 day stage gave the most attractive (score 9.17) okra green pod and the highest storage ability (4.10 days) okra green pod found from

FYM combined with 7 day stage. The tenderest green pod produced from FYM combined with 5 day harvesting stage but it tented to short storage ability. Poultry litter combined with 7 day stage gave the height (1.45) benefit cost ratio and the lowest (0.04) benefit cost ratio was observed from cowdung with 11 day stage.

From the above discussion it is suggested to the farmer that using poultry litter as nutrient source 7 days pod harvesting will give the maximum yield and quality green pod of okra.

Conclusion:

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

1. In this study only three organic sources of nutrients (cow dung, poultry litter and FYM) were investigated. Other organic sources of nutrients' performance may be investigated.
2. Combined effect between or among the organic sources of nutrients may be investigated.
3. Time of application of organic sources of nutrient may be investigated for growth, yield and quality.
4. Here four harvesting stage (5, 7, 9 and 11) was considered which was two days interval. One day interval may be considered (i.e. 6, 7 and 8)

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Appendices

APPENDICES

Appendix I. Characteristics of entire farm soil as analyzed by Soil Resources Development Institute (SRDI), Khamarbari , Farmgate , Dhaka.

a . Morphological Characteristics of the experimental field

Morphological Feature	Characteristics
Location	Center farm SAU Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow and Brown Terrace Soil
Land Type	High Land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above Flood Level
Drainage	Well Drained
Cropping Pattern	Fellow Lettuce

b. Physical and chemical properties of the initial soil

Characteristics	Value
Particle size analysis (Mechanical analysis)	
% Sand	27
%Silt	43
%Clay	30
Textural class	Silt clay
Chemical analysis	
Ph	6.7
Organic Carbon (%)	0.45
Organic Matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 gm soil)	0.10
Available S ppm	45.00

Source; SRDI

Appendix II. Monthly records of year rainfall, relative humidity of the experimental site during the period from January to September, 2006

Year	Month	*Air Temperature (^{0}c)`			Relative humidity (%)	Rainfall (mm)
		Maximum	Minimum	Mean		
2006	January	23.5	14.0	19.96	73	01
	February	28.3	17.0	23.73	55	01
	March	32.8	22.4	27.60	58	09
	April	32.6	23.9	28.25	70	167
	May	35.1	26.3	30.90	63	163
	June	32.7	25.0	28.95	79	476
	July	31.5	25.4	28.90	79	498
	August	32.3	26.5	29.40	76	194
	September	30.4	25.5	28.26	83	833

*Monthly average
Source: Bangladesh Meteorological Department (Climate division) Agargaon, Dhaka-1207

Appendix III. Analysis of variance of the data on the growth of okra

Source of Variance	Degrees of freedom (df)	Mean Sum of Square														
		Plant height(cm)			Plant diameter(cm)			No. of leaves per plant			No. of branches			Leaf length(cm)		
		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
Factor A	3	218.386**	1106.189**	3290.064**	0.129**	0.167**	0.188**	2.984**	12.480**	33.019**	0.349**	0.146*	0.179*	19.862**	6.635**	6.231**
Factor B	3	-	-	2.204**	-	-	0.015NS	-	-	1.779**	-	-	0.158**	-	-	0.244**
AB	9	-	-	2.387**	-	-	0.012**	-	-	2.266**	-	-	0.071**	-	-	0.809**
Error	30	2.712	6.088	9.650	0.013	0.030	0.034	0.091	0.550	0.919	0.026	0.065	0.076	0.106	0.632	0.652

Appendix IV : Analysis of variance of the data on the Growth , yield and quality of okra

Source of Variance	Degrees of freedom (df)	Mean Sum of Square															
		Leaf breath(cm.)			Petiole length(cm.)			No. of days to first flowering	Pod length (cm)	Pod diameter	Pod weight (g)	No. of Pods/ Plant	Yield/ Plant (g)	Yield/ Plot (kg)	Yield/ ha(ton)	Attractive ness	Tender ness	Shelf life
		20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS											
Factor A	3	0.181**	8.689**	8.671**	7.998*	9.396**	7.760**	1.207 NS	4.887**	0.081 *	19.313**	17.071**	15250.5**	2.230**	24.403**	1.477 **	0.353 *	0.407**
Factor B	3	-	-	4.892**	-	-	0.218NS	-	37.073**	0.286 **	99.991**	106.082**	2425.67*	0.364*	3.881 *	72.058 **	90.886**	2.652**
AB	9	-	-	0.280**	-	-	0.014**	-	0.099 **	0.004 **	1.054**	1.393 **	61.288**	0.008**	0.098**	0.235 **	0.069 **	0.026**
Error	30	0.304	0.659	0.699	0.118	0.496	0.520	1.730	0.468	0.007	0.547	0.329	274.938	0.039	0.44	0.091	0.036	0.033

* =Significant at 5% level of significance

** =Significant at1% level of significance

NS = Not Significant

Appendix V: Questionnaire

Department of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University
Dhaka-1207

Questionnaire

For Attractiveness and Tenderness of okra green pod

SL No.:

Name:

Father's Name:

Mother's Name:

Address:

Age:

Educational Qualification:

Occupation:

1. Do you like okra green pod as vegetables?

(Put the tick mark in the following box)

a. Very much ☐
b. Medium ☐
c. Not so ☐
d. Not at all ☐

2. What quality a okra green pod should have to be more attractive?

Ans:

3. Which category expresses the shape of this okra green pod?
(First give the tick mark in the category then give marks)

Sl.No.	Category of shape	Distribution of marks	Your given marks
01	Excellent Shape	9-10	
02	Very good	6-8.99	
03	Good	3-5.99	
04	Not so good	1-2.99	
05	Not good at all	0	

Continued.....

4. What's the color of the pod?

(First give the tick mark in the category then give marks)

Sl.No.	Category	Distribution of marks	Your given marks
01	Dark Green	4-5.99	
02	Bright Green	8-10	
03	Light Green	6-7.99	
04	Pale Green	2-3.99	
05	Yellowish Green	0-1.99	

5. What is the size of this okra green pod?

(First give the tick mark in the category then give marks)

Sl.No.	Category	Distribution of marks	Your given marks
01	Very large	0-1.99	
02	Large	3-4.99	
03	Medium	7-10	
04	Small	5-6.99	
05	Too small	1-2.99	

Sl. No.:	Question number	Total Marks	Average
01	3		
02	4		
03	5		

Tenderness

6. How tender this green pod is? (Break the tip of the pod and feel)

(First give the tick mark in the category then give marks)

Sl.No.	Category	Distribution of marks	Your given marks
01	Too much Tender	8-10	
02	Tender	5-8	
03	Medium tender	3-5	
04	Less hard	1-3	
05	Hard	0-1	
06	Very hard	0	

Thank you for co-operation

Signature of the respondent
with date