GROWTH AND YIELD OF OKRA AS INFLUENCED BY NITROGEN AND PHOSPHORUS

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CERTIFICATE

This is to certify that the thesis entitled **"Growth and Yield of Okra as Influenced by Nitrogen and Phosphorus"** submitted to the Department of Horticulture, 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 **MOHAMMAD JASIM UDDIN**, Registration No. **06-02136** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2013
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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to August 2012. BARI Dherosh-1 was used as test crop in this experiment. The experiment consisted of two factors viz., Nitrogen fertilizer as N_0: 0, N_1: 110, N_2: 120 and N_3: 130 kg N/ha; and Phosphorus fertilizer as P_0: 0, P_1: 70, P_2: 80 and P_3: 90 kg P_2O_5/ha respectively. The experiment was laid out in Randomized Complete Block Design with three replications. All the parameters were significantly influenced by different levels of nitrogen and phosphorus. Due to the effect of nitrogen, the highest yield (16.40 t/ha) was observed from N_2 and the lowest yield (12.30 t/ha) from N_0. In case of phosphorus, the highest yield (16.95 t/ha) was found from P_2 and the lowest yield (11.20 t/ha) from P_0. For combined effect, the highest yield (19.76 t/ha) was found from N_2P_2 and the lowest yield (10.74 t/ha) from N_0P_0. The highest benefit cost ratio (2.17) was noted from N_2P_2 and the lowest (1.25) from N_0P_0. From growth and yield and also economic point of view, it is apparent that the combination of N_2P_2 was suitable for okra cultivation.

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CHAPTER I

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is a popular vegetable belongs to the family Malvaceae and locally known as “Dherosh” or “Bhindi”. It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Tahkur and Arora, 1986). It is well distributed throughout the Indian sub-continent and East Asia (Rashid, 1990). Okra is specially valued for its tender and delicious edible pods which is rich source of vitamins and minerals. Tender green pods of okra contains approximately 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Purseglove, 1987). The pods have some medicinal value with mucilaginous preparation which may used as plasma replacement or blood volume expander (Savello *et al.,* 1980). In Bangladesh the total production of okra is about 246 thousand tons which was produced from 7287.5 hectares of land in the year 2010 with average yield about 3.38 t/ha which is very low (BBS, 2011) compared to that of other developed countries where the yield is as high as 7.0-12.0 t/ha (Yamaguchi, 1998).

In Bangladesh, vegetable production is not uniform round the year and it is plenty in winter but less in quantity in the summer season. Around 30% of total vegetables are produced during *kharif* season and around 70% in the *rabi* season (Anon., 1993). Therefore, as vegetable okra can get an importance in *kharif* season as well as summer season in our country context. There are variations of the per capita consumption of vegetables in SAARC countries, where it was in Pakistan (69 g), Srilanka (120 g), and India (135 g) and all are higher than that of Bangladesh (35 g). Although, many dietitians prescribed that the daily requirements of vegetables for an adult person is approximately 285 g (Rampal and Gill, 1990). Therefore, there is a big gap between the requirement and per capita vegetable consumption in Bangladesh. As a result, malnutrition is very much evident in our country. Successful okra production may contribute partially in solving vegetable scarcity of summer season for the Bangladeshi people.

The low yield of okra in Bangladesh however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons viz. unavailability of quality seeds of high yielding varieties in appropriate time, fertilizer management, disease and insect infestation, improper or limited irrigation facilities and other appropriate agronomic practices. Among the different reasons fertilizer management is the important factor that greatly affects the growth, development and yield of this crop. The application of fertilizers influences the physical and chemical properties of soil and enhanced the biological activities. Deficiency of soil nutrient is considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). To attain considerable production and quality yield for any crop it is necessary to proper management ensuring the availability of essential nutrient in proper doses. Generally, a large amount of fertilizer is required for the growth and development of okra (Opena *et al.*, 1988). So, the management of fertilizer especially nitrogen and phosphorus is the important factor that greatly affects the growth, development and yield of okra.

Nitrogen is the key element to the vegetative growth of plants. Uwah *et al*. (2010) reported that nitrogen had significant effects on plant height, number of leaves and branches per plant, number of pods per plant, fresh pod weight and total fresh pod yield of okra. It is also the most difficult element to manage in a fertilization system such that an adequate, but not excessive amount of nitrogen is available during the entire growing season (Akanbi *et al.*, 2010). An adequate supply of nitrogen is essential for vegetative growth and desirable yield (Sajjan *et al.*, 2002). On the other hand, excessive application of nitrogen is not only uneconomical, but it can prolong the growing period and delay crop maturity. Excessive nitrogen application causes physiological disorder in crop plant (Obreza and Vavrina, 1993).

Phosphorus (P) is the second most important macronutrient for plant growth. Plants exhibit numerous physiological and metabolic adaptations in response to seasonal variations in phosphorus content.

Activities of both acid and alkaline phosphatases increased manifold in winter to cope up with low phosphorus content. ATP content and ATPase activity were high in summer signifying an active metabolic period. Phosphorus deficiency is characterized by low ATP content and ATPase activity and which are in turn partly responsible for a drastic reduction in growth and yield and enhanced activities of acid and alkaline phosphatases which increase the availability of P in P-deficient seasons (Supatra and Mukherji, 2004). Akinrinde and Adigun (2005) reported that crop growth is continuously threatened by phosphorus limitation on most tropical and temperate soils. Use of proper doses of fertilizer is one of the most important way of quality green pod yield production of okra and phosphorus fertilizer have a great effect in this respect (Yogesh and Aora, 2001). Most of the reports on the effect of phosphorus application on green pod yield in okra have been conflicting. Okra is a fruit vegetable and phosphorus fertilization can influenced in fruiting development (Mohanta, 1998).

Considering the above mentioned facts and based on the prior observation, an investigation was undertaken with the following objectives:

- To determine the optimum levels of nitrogen on the growth and yield of okra;
- To determine the optimum levels of phosphorus on the growth and yield of okra;
- To find out the suitable combination of nitrogen and phosphorus for ensuring the optimum growth and higher yield of okra.

CHAPTER II

REVIEW OF LITERATURE

Okra is specially valued for its tender and delicious edible pods and is an important summer vegetable crop in Bangladesh. Management of fertilizer especially nitrogen and phosphorus is the important factor that greatly affects the growth, development and yield of okra. So it is important to assess the effect of nitrogen and phosphorus for the best growth and yield of okra. However, limited research reports on the performance of okra in response to nitrogen and phosphorus have been done in various part of the world including Bangladesh and the work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works conducted at home and abroad in this aspect reviewed under the following headings:

2.1 Effect of nitrogen on growth and yield of okra

Candido *et al*. (2011) conducted an experiment with the objective of evaluating the influence of the nitrogen fertilizer in different ammonium/nitrate ratio on the vegetative development of the okra. The experimental design was in blocks randomized, arranged in factorial scheme with four repetitions, being the first factor of the scheme constituted by two nitrogen doses (50 and 100 mg kg^{-1}), and the second for different $N\text{-}NH_4^+/N\text{-}NO_3$- ratio, equivalent to 0/100; 25/75; 50/50; 75/25 and 100/0. At the beginning of the flowering the plants were collected and appraised as for the matter accumulation it dries of the aerial part, of the system root and total, leaf area, diameter of the stem, height and reason of leaf area. Significant effect of the interaction was observed between the doses and the appraised forms of nitrogen. The largest development of the plants was found when nitrogen was applied in the largest ratio of ammonium.

Pot and field experiments were conducted by Akanbi *et al*. (2010) at Institute of Agricultural Research and Training, Ibadan, Nigeria between 2002 and 2004 to determine okra response to organic and inorganic sources of nitrogen (N) fertilizer. In the pot experiment okra variety NHAe 47-4 was nourished with four N levels (0, 25, 50 and 75 kg N ha^{-1}) and five compost while in the field experiment the same variety of okra was fertilized with three N levels (0, 25 and 75 kg N ha^{-1}) and four compost rates. Application of 75 kg N ha^{-1} gave the highest okra fruit yield.

Field experiments were conducted by Uwah *et al*. (2010) in 2007 and 2008 at Calabar in the south eastern rainforest zone of Nigeria to evaluate the response of okra [*Abelmoschus esculentus* (L.) Moench] due to the four rates of nitrogen (0, 40, 80 and 120 kg/ha) and three rates of lime. Nitrogen had significant effects on plant height, number of leaves and branches/plant, number of pods/plant, fresh pod weight and total fresh pod yield. 80 kg N/ha rate maximized all the growth and yield attributes.

A field-experiment was conducted by Jana *et al*. (2010) in early winter of 2006 and 2007 under sub-Himalayan terai agroclimatic region of West Bengal to evaluate comparative effect of planting geometry and nitrogen levels on growth, yield and fruit quality in okra variety Arka Anamika. The experiment was laid out in factorial randomized block design with four levels of nitrogen, viz., 50 kg, 100 kg, 150 kg and 200 kg ha^{-1} and four different spacings. Among different nitrogen level 150 kg N ha^{-1} recorded the highest number of fruits/plant (13.7), individual fruit weight (18.5 gm), fruit yield/plant (195.0 g) and fruit yield ha^{-1} (12.2 t). The study amply revealed scope for growing okra crop profitably during early winter season of mild, cool-temperature by adopting nitrogen levels of 150 kg ha^{-1} with plant spacing of 45 cm × 30 cm in the terai agro-climatic region of West Bengal.

The influence of NPK 20-10-10 on the fresh pod yield and root growth of okra variety, V 35 grown in the lowland humid tropics was investigated by Awe *et al*. (2009) during the 2002 and 2003 cropping seasons. Four rates (0, 150, 300 and 450 kg/ha) of the fertilizer were applied to the crop. The findings suggest that the optimum NPK 20-10-10 level for okra variety, V 35 in the study area lies between 300-450 kg NPK 20-10-10/ha. Therefore, application rates above 450 kg NPK 20-10-10/ha for okra production in the study area were not economical.

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

A field experiment was conducted by Khan *et al*. (2007) in 1999 in Medziphema, Nagaland, India, on a sandy loam soil having 5.3 pH, 4.5% organic carbon, 208.0 kg/ha available N, 12.3 kg P_2O_5/ha and 189.6 kg K_2O/ha to study the response of okra to biofertilizers and N application in terms of growth, yield and leaf nutrient (N, P and K) status. The treatments consisted of five levels of N (0, 30, 60, 90 and 120 kg/ha) and four levels of biofertilizers. The application of N and biofertilizers significantly increased the growth and yield. The optimum N requirement was found to be 60 kg/ha, along with Azotobacter in foothills of Nagaland.

Field experiments were conducted by Sunita *et al*. (2006) for two consecutive years (2000 and 2001) at the Feirsa Agricultural University, Ranchi, Jharkhand, India, to determine the effects of intercrop and NPK fertilizer application on the performance of okra (cv. Arka Anamika). Treatments comprised: two intercrops (cowpea and French bean) and five fertilizer rates (0, 25, 50, 75 and 100% recommended dose of NPK). The results revealed that treatment with 100% recommended dose of fertilizers recorded higher okra equivalent yield (153.16 q/ha) and net returns (Rs. 30,709.91/ha) than the rest of the fertilizer rates.

The best performance of okra in terms of yield, number of fruits per plant, fruit weight and plant height were observed with 100% recommended dose of fertilizer.

Two field experiments were carried out by Manga and Mohammed (2006) during the rainy seasons of 2002 and 2004 in Kano, Nigeria, to study the effects of plant population and nitrogen levels on the growth and yield of okra (cv. LD88-1).

The treatments consisted of four plant populations and four nitrogen levels (0, 50, 90 and 120 kg/ha). Nitrogen application increased plant height, number of branches per plant, and number of fruits per plant, but did not significantly affect fruit weight. The high nitrogen content of the experimental fields may be the major reason why the yield response to nitrogen was not significant.

The effects of spacing and N rates (0, 75, 100, 125 and 150 kg/ha) on the growth seed yield of okra cv. Akola Bahar were determined by Soni *et al*. (2006) in a field experiment conducted in Maharashtra, India during the *kharif* season of 2004. The number of leaves per plant and number of branches increased with increasing rates of N up to 125 kg/ha, whereas leaf area, number of internodes, and seed yield per plant and per hectare increased with increasing rates of N.

An experiment was conducted by Ambare *et al*. (2005) at Akola during the *kharif* season of 2002-03 to study the five levels of nitrogen viz., 0, 25, 50, 75 and 100 kg ha^{-1} and four varieties of okra on growth and fruit yield of okra. The results indicated that the higher levels of nitrogen significantly influenced all the characters under study except the diameter of the fruit.

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

The treatment involving 50% N as urea + 50% N as FYM, PM or VC recorded the highest yield (90.61 q/ha).

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

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

Field studies were conducted by Sajjan *et al.* (2002) in Bagalkot, Karnataka, India, to elucidate the effect of sowing date, spacing and nitrogen rates (100, 125 and 150 kg/ha) on the yield attributes and seed yield of okra cv. Arka Anamika. 150 kg N/ha recorded the highest yield attributes of branches per plant, fruits per plant, 100-seed weight, length and girth of fruits, processed seed recovery and processed yield (1139.7 kg/ha) in the *kharif* season.

The effects of nitrogen as ammonium sulfate at 0, 30, 60 and 90 kg N/ha and potassium, as muriate of potash at 0, 30 and 60 kg K/ha on okra (*Abelmoschus esculentus*) were investigated by Ogbaji (2002) for three consecutive years (1996-98) in a sandy loam soil at Makurdi, a Southern Guinea savannah agro-ecological zone of Nigeria. Nitrogen application significantly enhanced okra leaf number per plant and plant height. Application of 90 kg N/ha produced fresh pod yield increase of 94% in 1996, 101% in 1997 and 102% in 1998 compared with the control plots.

A field experiment was conducted by Verma and Batra (2001) in Haryana, India during the spring-summer season of 1997 and 1998 on sandy loam soil to study the response of spring okra to irrigation and nitrogen. Treatments consisted of three levels of irrigation and three levels of nitrogen, N_1 (100 kg), N_2 (150 kg) and N_3 (200 kg). The maximum number of fruits per plant, fruit weight and plot yield were recorded from the 200 kg N/ha treatment, which was on a par with the 150 kg N/ha treatment. Increased nitrogen fertilization resulted in better leaf nutrient status, although 150 kg N/ha was the optimum treatment.

Gowda *et al*. (2001) was conducted a field experiment in Bangalore, Karnataka, India during summer season to determinate the response of okra cultivars Arka Anamika, Varsha and Vishal to 3 NPK fertilizer rates (125:75:60 kg/ha, 150:100:75 kg/ha and 175:125:100 kg/ha). The highest dry matter production in leaves (20.40 g), stems (35.17 g), roots (18.03 g), fruits (31.11 g) and whole plants (104.71 g) was recorded with 175:125:100 kg NPK/ha treatment. Varsha recorded significantly higher dry matter production in leaves (17.48g), stems (31.44 g), roots (17.61 g), fruits (29.98 g) and whole plants (96.51 g) compared with the other cultivars. In the interaction effect, the highest total dry matter production (1111.48 g/plant) was recorded in Varsha supplemented with 175:125:100 kg NPK/ha, which was at per with Arka Anamika supplemented with 175:125:100 kg NPK/ha. Comparative data on the effect of varying fertilizer rates, cultivars and their interaction on the length, diameter and yield of fruits are tabulated.

Rani *et al*. (1999) was conducted a field experiment in Bapatla, Andra Pradesh, India, in response to 4 fertilizer levels (0-0-0, 50-25-25,100-50-50 and 150-75-75 kg N, P_2O_5 and K_2O/ha respectively). Results showed that leaf area, leaf area index (LAI) and leaf area duration (LAD) were significantly influenced at all stages by cultivars, fertilizer levels and their interaction effects. Among the cultivars, Pusa Sawani showed the maximum leaf area, LAI and LAD. However, Arka Anamika showed significantly superior performance with respect to plant height, number of leaves, number of nodes and yield per plant.

The highest fertilizer level resulted in maximum leaf area, LAI and LAD, which gradually increased up to 60 days after sowing (DAS). Dry matter increased between stages and was influenced significantly by cultivars, fertilizer levels and their combinations. Crop growth regulator(CGR) and relative growth rates were influenced by cultivars and fertilizers. Pusa Sawani supplied with the highest fertilizer level recorded the maximum CGR 60 DAS. Net assimilation rate (NAR) declined 60 DAS. Harvest index (HI) was also influenced by cultivars fertilizer levels and their interactions. Arka Anamika, with a moderate vegetable growth and high NAR, bad the highest HI values. Among the fertilizer levels, maximum HI was recorded by 100-50-50 kg NPK/ha.

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

The effects of soil or seed inoculation of Azospirillum and Azotobacter with or without inorganic N application (0, 20, and 40 kg/ha) on the growth, yield, and quality of okra cv. Parbhani Kranti were studied by Ganeshe *et al*. (1998) in Jabalpur, Madhya Pradesh, India, during the *kharif* season of 1995. Nitrogen was applied through urea in two splits during sowing and 45 days after sowing.

The tallest plants (66.40 cm) and the highest leaf number (15.53 per plant) and fruit yield (56.78 q/ha) were obtained with the recommended N rate (40 kg N/ha). 40 kg N/ha gave the highest net return (Rs 16293/ha) and cost : benefit ratio (2.37).

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

An experiment was conducted by Somkuwar *et al.* (1997) in India to determine the effect of 3 levels of nitrogen (25, 50 and 75 kg/ha) on the growth of okra varieties Punjab 7, Parbhani Kranti and Sel 2-2. The results showed that fruit yield per plant and yield per ha were increased with an increase in nitrogen concentration. Parbhani Kranti produced the highest fruit yield (171.11 kg) per plant and yield per ha (7770 kg) at 75 kg N/ha.

An experiment was conducted by Birbal *et al.* (1995) to study the effect of spacing and nitrogen on fruit yield of okra (*Abelmoschus esculentus* L. Moench.) cv. Varsha Uphar. Seeds of okra cv. Varsha Uphar were sown on a sandy loam soil with N applied at 0, 50, 100 or 150 kg/ha. Application of N at 100 and 150 kg/ha resulted in taller plants and more branches/plant than that at 0 and 50 kg/ha. Number of days to 50% flowering for N at 100 and 150 kg/ha delayed by 4.5 and 6.0 days, respectively, compared with no N. Number of fruits/plant, individual fruit weight and yield/plant were highest with N at 100 kg/ha.

An experiment was conducted by Singh (1995) to study effect of various doses of nitrogen on seed yield and quality of okra (*Abelmoschus esculentus* L. Moench). This trial was conducted during the *kharif* season in 1992 and 1993 and the plots of okra received 6 levels of nitrogen i.e., 0, 30, 60, 90, 120 or 150 kg/ha, with half applied before sowing and the rest applied 30 days after sowing. Plant height increased with increasing rate of N. Application of N at 90-150 kg/ha gave the highest number of pods/plant (12.7-14.0), pod length (16.7-17.6 cm), seed yield (17.5-19.0 q/ha) and 1000-seed weight (67.2-68.7 g). Seed germination rate was not affected by fertilizer application.

In trials conducted by Emebiri *et al*. (1992) during the rainy seasons of 1989 and 1990 on a sandy clay loam, okras (cultivars V89, Tae 38 and Pink Spineless) were given 0 (control), 100, 200 or 300 kg N/ha in split applications 2 and 6 weeks after sowing. N was applied as calcium ammonium nitrate. All vegetative and reproductive characteristics studied increased significantly with N application. At 4 days after anthesis, individual fruit weight was 50, 71 and 48% higher with 100, 200 and 300 kg N/ha, respectively, than in the control plots.

Fruit growth rates between 4 and 10 days after anthesis were 11.97, 14.03 and 13.37 g/day at the 3 N rates, respectively, compared with 8.83 g/day in controls; fruit growth rate was highest in Pink Spineless at all N rates. The number of flowers formed/plant was highest with 100 kg N/ha, but N application also increased the rate of flower abortion. Nevertheless, the average number of fruits set/plant increased from 4.78 without N to 4.91-5.93 with applied N.

Arora *et al.* (1991) compared the growth and yield of a new okra cultivar, Punjab Padmini, with that of cv. Pusa Sawni grown under variable N (0, 30, 60 and 90 kg/ha) fertilizer application. They stated that plant height, numbers of pods pod size and total green pod yield were significantly improved by the application of 90 kg N/ha. A significant increase of marketable yield for both cultivars was obtained with an increase in N application from 0 to 90 kg/ha (100.9 to 156.0 q/ha).

Khan and Jaiswal (1988) found significant effect on seed yield per hectare due to spacing, nitrogenous fertilizer and fruit pickings. They obtained the highest seed yield (833-902 kg/ha) at close spacing with the highest amount of nitrogen (150 kg/ha) and edible pods picked twice.

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

Mishra and Pandey (1987) conducted trails with okra cv. Pusa Sawani, with N and K_2O were each applied at 0, 40, 80 and120 kg/ha. N at 80 kg/ha significantly increased the number of fruits/plant, 1000 seed weight and the seed yield of okra. Application of N above 80 kg/ha adversely affected seed yield. Interaction effect was significant with 80 kg/ha N and 40 kg K_2O/ha giving the highest seed yield and it was 15.47 q/ha.

Abdul and Aarf (1986) carried out subsequently two trails with okra cv. Batrra and it was grown with 5 levels of fertilizers i.e. 100, 250, 300, 350 and 400 kg NPK/ donum (1338 m^2). The maximum okra yield (12.23 t/donum) was obtained with 400 kg NPK. The numbers of pods/plant was increased slightly by increasing fertilizers levels and to a maximum of 59, but there was no significant effect on average pod weight.

Plants of the okra cv. Pusa Sawani, receiving N at 25, 50, 75 or 100 kg/ha were picked at intervals of 2, 3 or 4 day. Plant receiving 75 kg N/ha gave the highest yield of 152.1 q/ha compared with 88.8 q/ha at 25 kg N/ha and 145.3 q/ha at 100 kg/ha (Tomar and Chauhan, 1982). Picking every 4 days higher yield than other 2 (2, 3 days) interval treatments.

Mani and Ramanathan (1980) carried out an experiment to study the effect of nitrogen and potassium on the yield of okra. There were 5 levels of N (0, 20, 40, 60 and 80 kg/ha) and 5 levels of K_2O (0, 15, 30, 45 and 60 kg/ha). Nitrogen fertilization significantly increased yield. The highest N level (80 kg/ha) increased yield by 149.2% over the control and combined application of 80 kg N/ha with either 30 kg or 60 kg K_2O/ha produced maximum yields (17.2 t/ha and 17.5 t/ha respectively).

2.2 Effect of phosphorus on growth and yield of okra

An experiment was conducted by Rajpaul *et al*. (2006) in Haryana, India, to determine the effects of saline water, farmyard manure (FYM) and phosphorus on the performance of four okra cultivars. The cultivars were grown under irrigation with 0.65 (canal), 2.75 (EC_1), 5.00 (EC_2) and 8.50 dS/m (EC_3) saline water. FYM at 15 t/ha, FYM + phosphorus at 50% above the recommended dose, and FYM + phosphorus at 100% above the recommended dose were applied in the highest EC saline water. The addition of a double dose of phosphorus further increased the germination from 78.6 to 79.2% and plant height from 44.8 to 47.2 cm. HRB 108 had the highest germination (87.4%) followed by Versa Uphar (85.3%), Hisar Unnat (83.8%) and HRB 107 (83.4%). Addition of FYM and phosphorus had no significant effect on the number of plants.

Two field experiments were conducted by El-Shaikh (2005) at the Experimental Farm of Sohag, South Valley University, Egypt, during 2003 and 2004 to investigate the effects of phosphorus (22.5, 30.0, 37.5 and 45 kg P_2O_5/fed) and potassium fertilizers on the growth, yield and quality of two okra cultivars (El-Balady and Golden Coast). Applying high levels, i.e. 37.5 and 45 kg P_2O_5/fed, of phosphorus significantly improved the most studied characters.

Six okra genotypes (Parbhani Kranti, Pusa Sawani, HRB-55, P-7, VRO-5 and Satdhari Local) were grown by Nirmal *et al*. (2005) on a Typic Ustochrept soil, in Uttar Pradesh, India, during the rainy seasons, to measure the total phosphorus (P) requirement and removal pattern of the crop at different growth stages. A sudden increase in the rate of P uptake up to 25 to 67% was observed among the genotypes between 40 and 45 days after sowing. The P uptake rate further increased significantly at first picking to peak harvest stage, i.e. between 48 and 60 days after sowing. Maximum P removal (75-80%) was observed between flowering and peak harvesting stage irrespective of the genotypes. Comparison of readily available P measured through resin adsorbed quantity and total P uptake measured through wet digestion technique indicated the superiority of resin disc technique in testing the P requirement of okra under field conditions.

Akinrinde and Adigun (2005) reported that crop growth is continuously threatened by phosphorus (P) limitation on most tropical and temperate soils. Besides P fertilizer management, soil type could significantly determine the efficiency of P use by specific crop species. The influence of 0, 50, 100, 150 and 200 mg P_2O_5 kg^{-1} soil on the growth, P nutrition and production of two fruit vegetables okra (*Abelmoschus esculentus*) were evaluated. The goal was to ascertain and compare P use efficiency by the crop on typical tropical soils (a medium acid, Oxic Paleustalf from Zaria and a slightly acid, Typic Paleudalf from Ibadan) from Nigeria. Growth in height, number of leaves and leaf area as well as biomass production, fruit yield, P content and uptake were determined. Soil available P values obtained after cropping increased significantly with increasing rates of added P.

Okra plants were more efficient in their use of P on the two soil types. It was evident that okra could be produced more successfully on soils with relatively low native or added P.

A field experiment was conducted by Laxman *et al*. (2004) during *kharif* seasons in Jobner, Rajasthan, India, to evaluate the effects of different levels of nitrogen and phosphorus (30, 60 and 90 kg/ha), both by soil application, and gibberellic acid, applied through foliar spray, on the flowering, fruiting, yield attributes and yield of okra cv. Pusa Sawani. Most of the parameters were significantly influenced by the application phosphorus. Increasing levels of phosphorus up to 90 kg/ha increased the percent fruit set, number of fruits per plant, length of fruit, diameter of fruit, number of pickings, duration of harvesting, mean fruit weight, yield and dry matter yield of fruit.

The effect of different rates of P and planting densities on seed yield and quality of okra cv. Sabz Pari was investigated by Muhammad *et al.* (2001) in Faisalabad, Pakistan, during 1999. P as a basal dose was applied at 0, 33 or 66 kg/ha at the time of seedbed preparation. P application had no significant effect on number of mature pods per plant and seed moisture content.

Weight of mature pods per plant, number of seeds per pod, seed yields per plant and per hectare, and 1000-seed weight were significantly affected by the P levels, being maximum at the highest level and minimum at the lowest one. Planting densities did not affect the number of seeds per pod, 1000-seed weight and seed moisture content.

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

Naik and Srinivas (1992) conducted field experiments with cv. Pusa Sawani in the rainy seasons of 1985 and 1986 on a sandy loam with low available P in soil and it was applied at 30, 60 or 90 kg P_2O_5/ha. All the P and 40 kg K_2O/ha were applied before sowing of okra seeds. The highest seed yields were obtained with 90 kg P_2O_5/ha (11.89 and 10.71 q/ha in 1985 and 1986, respectively). Other parameters (fruit length, fruit diameter, number of fruits/plant, number of seeds/fruit and 1000-seed weight) were also generally highest with the highest rate of fertilizer application.

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

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

2.3 Interaction effect of nitrogen and phosphorus on growth and yield of okra

A study was conducted by Omotoso and Shittu (2007) to determine the effect of NPK fertilizer application rates and method of application on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) at the Teaching and Research Farm, University of Ado-Ekiti. Okra seed variety LD88 were treated to three levels of NPK fertilizer rates (0, 150 and 300 kg NPK ha^{-1}) and two methods of fertilizer application. Treatments were arranged in a split-plot design with fertilizer application method as main plot factor and NPK rates as sub-plot factor. The treatments were replicated three times to give a total of eighteen experimental field plots.

The result indicated that the fertilizer NPK significantly increase growth parameters (plant height, leaf area, root length, number of leaves), yield and yield components with optimum yield of okra obtained at 150 NPK kg ha^{-1}.

The influence of nitrogen (40, 80, 120, 160 and 200 kg/ha) and phosphorus (30, 60 and 90 kg/ha) on the performance and production economics of rainfed okra intercropped with tomato was studied by Mishra and Singh (2006) during *kharif* 1998 and 1999 in Uttaranchal, India. Application of increased doses of nitrogen recorded significantly higher plant height, yield and fruit size of the base crop (okra). The highest nitrogen rate showed 15.26, 7.29 and 1.33% higher mean okra equivalent yield over 40, 80 and 120 kg/ha, respectively. The higher mean net return (Rs. 48,853) and net profit (428%) were also recorded with 160 kg nitrogen/ha. Phosphorus application did not show any significant effect on individual plant performance, fruit size and unmarketable yield in okra. The maximum mean net return and net profit were also recorded with 60 kg phosphorus/ha.

A field experiment was conducted by Laxman *et al*. (2004) during the 2000-01 *kharif* seasons in Jobner, Rajasthan, India, to evaluate the effects of different levels of nitrogen (50, 100 and 150 kg/ha), phosphorus (30, 60 and 90 kg/ha), both by soil application, and gibberellic acid, applied through foliar spray, on the flowering, fruiting, yield attributes and yield of okra cv. Pusa Sawani.

Most of the parameters were significantly influenced by the application of nitrogen, phosphorus. Increasing levels of nitrogen up to 150 kg/ha, phosphorus up to 90 kg/ha increased the percent fruit set, number of fruits per plant, length of fruit, diameter of fruit, number of pickings, duration of harvesting, mean fruit weight, yield and dry matter yield of fruit.

A study was undertaken by Shanke *et al.* (2003) during summer 1998 to assess the seed yield potential and other growth characters of okra cv. Parbhani Kranti under 5 levels of N (0, 50, 75, 100 and 125 kg/ha) and 4 levels of P (0, 25, 50 and 75 kg/ha) with agro-climatic conditions of Akola, Maharashtra, India.

There was a linear increase in plant height with the application of N and P. The tallest plant (68.88 cm) was recorded under 125 kg N/ha and the shortest (54.90 cm) under no N. A similar trend was observed in respect of P application. The interaction effect between N and P was found to be significant, indicating maximum plant height with higher N and P levels. The number of fruits per plant increased significantly with an increase in N level. The highest number of fruits (5.78) was observed with 125 kg N/ha. Full fruit length and weight were also found highest (15.61 and 19.6 cm, respectively) in this treatment. The effect of application of P was also observed significant for fruit length, fruit number per plant and fruit weight, the highest values for these parameters being recorded at 75 kg P/ha. The maximum seed yield per plot (0.330 kg) was observed with the highest levels of N and P.

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

Yogesh and Aora (2001) was conducted a field experiment in Nagina, Uttar Pradesh, India during the *kharif* season to study the effect of N (80, 100 and 120 kg/ha), P (60 and 80 kg/ha) and sowing date on okra (cv. Parbhani Kranti) seed yield. One-third of N and 100% of P were applied during sowing, the remaining N was applied as a top dressing at 30 days after sowing and the flowering stage. They reported that seed yield increased with the increasing of N rate but was not significantly affected by P rate. The highest number of seed per pod (57.0) and seed yield per plot (2.94 kg) was obtained with the application of 120 kg N/ha and 80 kg P/ha.

The seed quality (SQ) and yield (SY) of okra cv. Parbhani Kranti were studied by Chattopadhyay and Sahana (2000) during *kharif* seasons of 1998-99 in West Bengal, India. Five N rates (0, 60, 80, 100 and 120 kg/ha) were tested against 4 P rates (0, 40, 60 and 80 kg/ha). Urea (50% of the total N dose), single superphosphate and muriate of potash (50 kg K_2O) were applied basally. The remaining urea was applied 30 days after sowing. Most of the SQ and SY parameters improved significantly with increasing rates of N and P, the optimum N and P rates, being 100 and 60 kg/ha, respectively. Germination percentage and 100-seed weight were not significantly affected by N or P, while P had no significant effect on fruit length.

In trials conducted by Naik and Srinivas (1992) with cv. Pusa Sawani in the rainy seasons of 1985 and 1986 on a sandy loam with low available N and P, N was applied at 50, 100, 150 or 200 kg/ha and P at 30, 60 or 90 kg P_2O_5/ha.

Half of the N, all the P and 40 kg K_2O/ha were applied before sowing; the rest of the N was applied as a top dressing 30 days after sowing. The highest seed yields were obtained with 200 kg N/ha (13.00 and 11.25 q/ha in 1985 and 1986, respectively) and 90 kg P_2O_5/ha (11.89 and 10.71 q/ha in 1985 and 1986, respectively). Other parameters (fruit length, number of fruits/plant, number of seeds/fruit and 1000-seed weight) were also generally highest with the highest rates of fertilizer application.

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

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

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

The response of okra (*Abelmoschus esculentus)*, cultivars white velvet and NHAE 47-4 to fertilization in Northern Nigeria was examined using 0, 25, 50 and 100 kg N/ha and 0, 13 and 26 kg P/ha (Majanbu *et al*., 1985).

Nitrogen application significantly increased green pod yield, pod diameter, number of fruits/plant, number of seed/pod and pod weight. Application of P also significantly increased green pod yield, pod number and number of seeds/pod. For optimum green pod yield of white velvet 35 kg N/ha was suggested while NHAE 47-4, N fertilization could be increased to 70 kg/ha. There was no differential response of cultivars to P fertilization for green pod yield; however, the application of 13 kg/ha enhanced the performance of both cultivars.

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

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

From above reviewed results it was found that nitrogen and phosphorus fertilizers and their interaction effect are indispensable for the production system of okra and play a vital role to increase the yield and yield attributes, providing other factors are not limiting. Among the macronutrients, N and P are used largely by the okra plants. Physio-morphological and biological development of okra plants depends on the judicious application of N and P. An excess or deficiency of N and P cause remarkable effect on growth and yield of okra plant.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during the period from April to August 2012. The materials and methods that were used for conducting the experiment have been presented in this chapter.

3.1 Location of the experimental site

The experiment was carried out at the Horticulture Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. It was located in $24^{0}09^{/}$N latitude and $90^{0}26^{/}$E longitudes. The altitude of the location was 8 m from the sea level**.**

3.2 Climatic condition of the experimental site

Experimental location is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of the meteorological data during the period of the experiment were collected from the Bangladesh Meteorological Department, Agargoan, Dhaka (Appendix I).

3.3 Soil characteristics of the experimental site

Selected land of the experimental field was medium high land in nature with adequate irrigation facilities and remained utilized for crop production during the previous season. The soil is belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The soil texture of the experimental soil was sandy loam. The nutrient status of the farm soil under the experimental plot with in a depth 0-20 cm were collected and analyzed in the Soil Resources Development Institute (SRDI) Dhaka, and result have been presented in Appendix II.

3.4 Planting materials

The test crop used in the experiment was BARI Dherosh-1.

3.5 Collection of seeds

The seeds of okra variety were collected from Siddique Bazar, Dhaka.

3.6 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Nitrogen fertilizer (4 levels) as

i N_0: 0 kg N/ha (control)

ii. N_1: 110 kg N/ha

iii. N_2: 120 kg N/ha

iv. N_3: 130 kg N/ha

Factor B: Phosphorus fertilizer (4 levels) as

i. P_0: 0 kg P_2O_5/ha (control)

ii. P_1: 70 kg P_2O_5/ha

iii. P_2: 80 kg P_2O_5/ha

iv. P_3: 90 kg P_2O_5/ha

There were 16 (4 × 4) treatments combination such as N_0P_0, N_0P_1, N_0P_2, N_0P_3, N_1P_0, N_1P_1, N_1P_2, N_1P_3, N_2P_0, N_2P_1, N_2P_2, N_2P_3 N_3P_0, N_3P_1, N_3P_2 and N_3P_3.

3.7 Land preparation

The plot selected for conducting the experiment was opened in the third week of March, 2012 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for sowing okra seeds.

All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. The soil was treated with insecticides (cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.8 Application of manure and fertilizers

Urea, Triple super phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, TSP and MP was applied as basal dose at the time of final land preparation dated at 31 March, 2012. Urea was applied at 15, 30 and 45 days after sowing (DAS).

Table 1. Dose and method of application of fertilizers in okra field (Fertilizer Recommendation Guide, BARC, 2005)

Fertilizers	Dose/ha	Application (%)			
		Basal	15 DAS	30 DAS	45 DAS
Cowdung	10 tons	100	--	--	--
Nitrogen (as urea)	As per treatment	--	33.33	33.33	33.33
P_2O_5 (as TSP)	As per treatment	100	--	--	--
K_2O (as MP)	150 kg	100	--	--	--

3.9 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 417.76 m^2 with length 37.3 m and width 11.2 m. The total area was divided into three equal blocks. Each block was divided into 16 plots where 16 treatments combination were allotted at random. There were 48 unit plots altogether in the experiment. The size of the each plot was 2.4 × 1.8 m. The distance maintained between two blocks and two plots were 1.0 and 0.5 m, respectively. The spacing was at 60 × 30 cm. The layout of the experimental plot is shown in Figure 1.

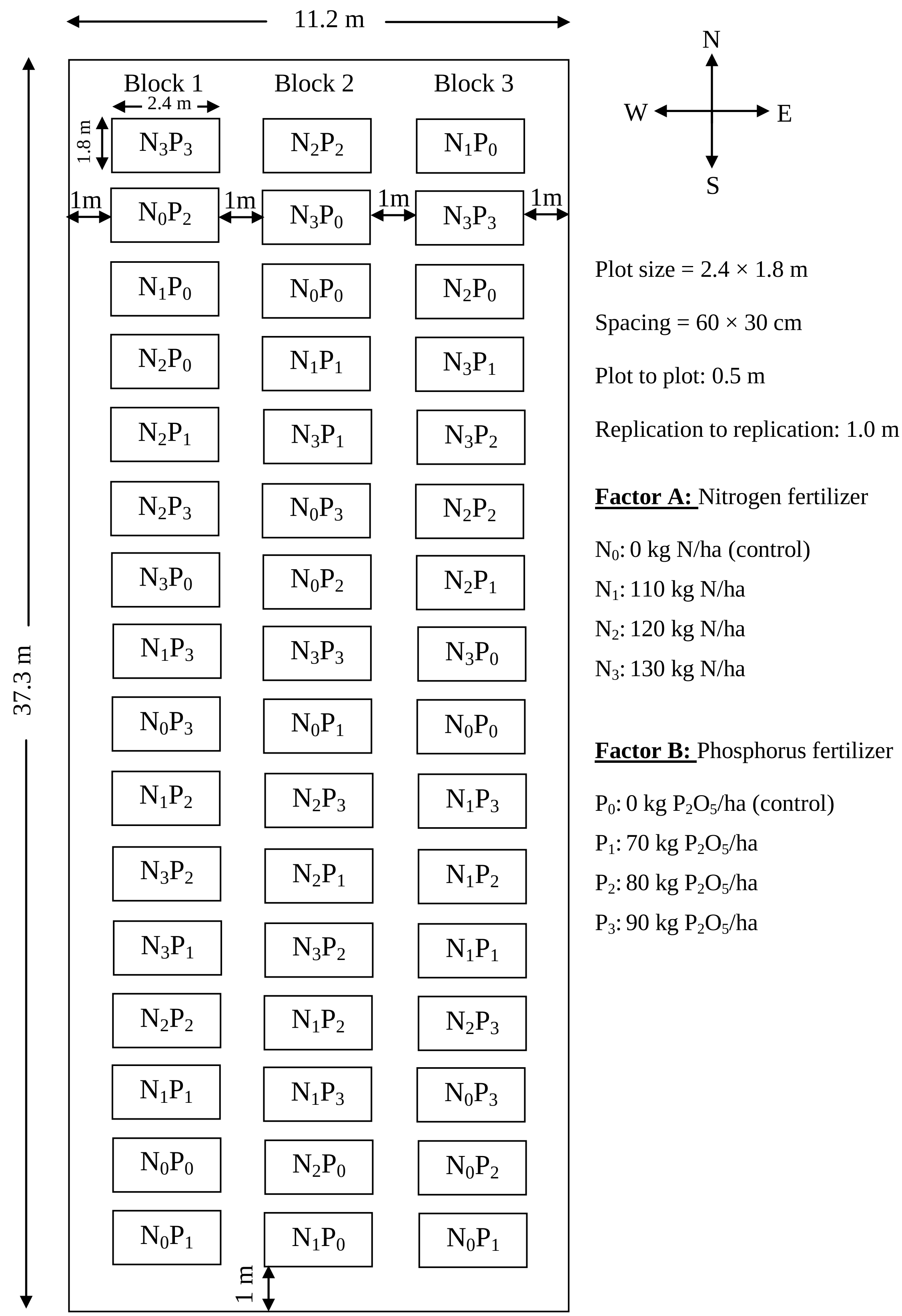

Figure 1. Field layout of the experimental plot

3.10 Seeds sowing

The okra seeds were sown in the main field at 06 April in 2012. Seeds were treated with Bavistin @ 2ml/L of water before sowing the seeds to control the seed borne diseases. The seeds were sown in rows having a depth of 2-3 cm with maintaining distance from 30 cm and 60 cm from plant to plant and row to row, respectively. So there were 24 seeds were sown in a plot.

3.11 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the okra seedlings.

3.11.1 Gap filling

The seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after germination and such seedling were replaced by new seedlings Replacement was done with healthy seedling in the afternoon having a boll of earth which was also planted on the same date by the side of the unit plot. The seedlings were given watering for 7 days starting from germination for their proper establishment.

3.11.2 Weeding

The weeding was done by nirani with roots at 15, 30 and 45 days after sowing to keep the plots free from weeds.

3.11.3 Irrigation

Light watering was given by a watering cane at every morning and afternoon and it was continued for a week for rapid and well establishment of the germinated seedlings.

3.11.4 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedings in the field. In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some discolored and yellowish diseased leaves were also collected from the plant and removed from the field.

3.12 Harvesting

Fruits were harvested at 5 days interval based on eating quality at soft and green condition. Harvesting was started from 22 May, 2012 and was continued up to September 2012.

3.13 Data collection

Five plants were randomly selected from the middle rows of each unit plot for avoiding border effect, except yields of plots, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yields as affected by different treatments of the experiment. Data on plant height, number of leaves, length of petiole, diameter of stem, length of leaf, number of branches per plant, length of internode and leaf area were collected at 20, 40, 60 and 80 days after sowing (DAS). Fresh weight per plant and dry weight per plant was recorded at 80 DAS at maximum growth stages. All other yield contributing characters and yield parameters such as days to flowering, number of flower buds/plant, number of pods per plant, weight of individual pods, length of pod, diameter of pod, yield per plot was also recorded as per the suitable time of optimum performance of okra plants.

3.13.1 Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest stem of five plants and mean value was calculated. Plant height was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of plants.

3.13.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS to 80 DAS at 20 days interval.

3.13.3 Length of petiole

Length of petiole was measured from the longest petiole of 5 sample plants in centimeter and mean value was calculated. Length of petiole was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of the plants.

3.13.4 Diameter of stem

Stem diameter was measured from sample plants with a digital calipers-515 (DC-515) from the three different parts of five plants and mean value was calculated. Stem diameter was recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of plants.

3.13.5 Length of leaf

Length of leaf was measured from sample plants in centimeter from the one side to another side of leaf of the longest five leaves and mean value was calculated. Length of petiole was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of plants.

3.13.6 Number of branches per plant

The total number of branches per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAS to 80 DAS at 20 days interval.

3.13.7 Length of internode

Length of internode was measured from 5 sample plants in centimeter and mean value was calculated. Length of internode was also recorded at 20 days interval starting from 20 days after sowing (DAS) upto 80 days to observe the growth rate of plants.

3.13.8 Days required for flowering

Days required for flowering was recorded from the date of sowing to the initiation of 1^{st} flower bud.

3.13.9 Number of flower buds per plant

The number of flower buds per plant was counted from the sample plants and the average numbers of flower buds produced per plant were recorded.

3.13.10 Number of pods per plant

The number of pods per plant was counted from the sample plants for the whole growing period and the average number of pods produced per plant was recorded and expressed in pods per plant.

3.13.11 Pod length

The length of pod was measured with a meter scale from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and there average was taken and expressed in cm.

3.13.12 Pod diameter

Diameter of pod was measured at the middle portion of 10 selected marketable fruit from each plot with a digital calipers-515 (DC-515) and average was taken and expressed in cm.

3.13.13 Weight of individual pods

The weight of individual pod was measured with a digital weighing machine from 10 selected marketable fruits from each selected plots and there average was taken and expressed in gram.

3.13.14 Fresh weight of leaves/plant

At 80 DAS leaves of three okra plants from inner rows selected and pulled out then the plant was taken, clean and weighted by a digital weighing machine and average was calculated for measuring fresh weight of plant.

3.13.15 Dry matter content of leaves (%)

After taking fresh weight the sample it was sliced into very thin pieces and put into envelop then placed in oven maintained at 70^{0}C for 72 hours. It was then transferred into desiccators and allowed to cool down at room temperature. The final dry content was taken by following formula:

$$\text{Dry matter content of leaves} = \frac{\text{Dry weight of leaves (g)}}{\text{Fresh weight of leaves (g)}} \times 100$$

3.13.16 Yield per plot

Yield of okra per plot was recorded as the whole fruit per plot by a digital weighing machine for the whole growing period and was expressed in kilogram.

3.13.17 Yield per hectare

Yield per hectare of okra fruits was estimated by converting the weight of plot yield into hectare and was expressed in ton.

3.14 Statistical analysis

The data obtained for different characters were statistically analyzed by using MSTAT-C software to find out the significance of the difference for nitrogen and phosphorus fertilizer on growth and yield of okra. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the means of treatment combinations was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.15 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of nitrogen and phosphorus fertilizer. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of okra was considered for estimating the cost and return.

Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find the growth and yield of okra as influenced by nitrogen and phosphorus. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III-XII. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height of okra varied significantly due to application of different levels of nitrogen at 20, 40, 60 and 80 DAS (Figure 2). At 20, 40, 60 and 80 DAS the tallest plant (29.69, 53.65, 76.16 and 86.19 cm) was recorded from N_2 (120 kg N/ha) which was statistically similar (28.64, 52.59, 73.58 and 85.87 cm) to N_3 (130 kg N/ha) and closely followed (27.92, 51.58, 72.46 and 81.81 cm) by N_1 (110 kg N/ha), whereas the shortest plant (22.05, 44.12, 61.37 and 70.00 cm) was obtained from N_0 (0 kg N/ha i.e. control condition). It was revealed that with the increase of nitrogen plant height increased upto a certain level. Nitrogen ensured favorable condition for the growth of okra plant with optimum vegetative growth and the ultimate results was tallest plant. Singh *et al*. (2007) found maximum plant height with 100 kg N/ha.

Different levels of phosphorus showed significant variation on plant height of okra at 20, 40, 60 and 80 DAS (Figure 3). At 20, 40, 60 and 80 DAS the tallest plant (29.82, 53.22, 76.36 and 87.75 cm) was observed from P_2 (80 kg P_2O_5/ha), which was statistically identical (28.89, 52.95, 74.54 and 84.70 cm) to P_3 (90 kg P_2O_5/ha) and closely followed (26.40, 50.37, 70.99 and 80.39 cm) by P_1 (70 kg P_2O_5/ha), and the shortest plant (23.20, 45.41, 61.79 and 71.03 cm) was observed from P_0 (0 kg P_2O_5/ha i.e. control condition). It revealed that with the increase of phosphorus plant height showed increasing trend. Bhai and Singh (1998) reported that P application significantly increased the plant height.

Combined effect of different levels of nitrogen and phosphorus showed significant variation on plant height of okra at 20, 40, 60 and 80 DAS (Table 2). At 20, 40, 60 and 80 DAS the tallest plant (34.64, 59.32, 85.42 and 97.39 cm) was observed in N_2P_2 (120 kg N/ha and 80 kg P_2O_5/ha), while the shortest (19.34, 38.11, 52.26 and 62.50 cm) was obtained from N_0P_0 i.e. control treatment. Patton *et al.* (2002) reported that nitrogen at 150 kg/ha and P at 90 kg/ha gave the tallest plant (159.15 and 137.37 cm). Arora *et al.* (1991) stated that plant height were significantly improved by the application of 90 kg N/ha and 60 kg P_2O_5/ha.

4.2 Number of leaves per plant

Significant variation was recorded for number of leaves per plant for different levels of nitrogen at 20, 40, 60 and 80 DAS of okra under the present trial (Table 3). At 20, 40, 60 and 80 DAS the maximum number of leaves per plant (9.28, 21.28, 37.63 and 43.84) was recorded from N_2 which was statistically similar (9.22, 21.12, 36.83 and 43.24) with N_3, while whereas the minimum number (7.82, 18.50, 31.90 and 35.74) from N_0. Soni *et al*. (2006) reported that number of leaves per plant increased with increasing rates of N up to 125 kg/ha.

Due to application of different levels of phosphorus showed significant differences on number of leaves at 20, 40, 60 and 80 DAS (Table 3). At 20, 40, 60 and 80 DAS the maximum number of leaves per plant (9.45, 21.67, 38.45 and 45.41) was observed in P_2, which was statistically identical (9.35, 21.41, 37.75 and 44.09) to P_3, while the minimum number of leaves per plant (8.04, 18.19, 33.50 and 37.97) was recorded from P_0 at the same days of observations.

Combined effect of nitrogen and phosphorus showed significant differences on number of leaves per plant of okra at 20, 40, 60 and 80 DAS (Table 4).

At 20, 40, 60 and 80 DAS, the maximum number of leaves per plant (10.45, 23.21, 40.30 and 47.35) was found from N_2P_2 and the minimum number (7.35, 16.45, 27.30 and 30.55) from the treatment combination of N_0P_0. Patton *et al.* (2002) reported that nitrogen at 150 kg/ha and P at 90 kg/ha gave the highest number of leaves per plant (24.98 and 23.57).

Table 2. Combined effect of different levels of nitrogen and phosphorus on plant height of okra

Treatments	Plant height (cm) at			
	20 DAS	40 DAS	60 DAS	80 DAS
N_0P_0	19.34 h	38.11 g	52.26 g	62.50 f
N_0P_1	21.41 gh	44.59 f	62.00 ef	70.00 def
N_0P_2	24.82 fg	47.56 ef	67.24 def	75.72 d
N_0P_3	22.63 gh	46.23 ef	63.96 ef	71.79 de
N_1P_0	24.46 fg	47.19 ef	68.92 cde	77.13 d
N_1P_1	26.60 ef	50.44 de	69.27 cde	76.12 d
N_1P_2	28.97 cde	52.54 bcd	75.92 bc	88.27 b
N_1P_3	31.67 abc	56.14 abc	76.19 bc	85.71 bc
N_2P_0	21.59 gh	43.66 f	59.43 fg	65.67 ef
N_2P_1	29.81 bcde	54.59 bcd	77.77 ab	88.35 b
N_2P_2	34.64 a	59.32 a	85.42 a	97.39 a
N_2P_3	32.72 ab	57.01 ab	82.00 ab	93.37 ab
N_3P_0	27.40 def	52.66 bcd	66.56 ef	78.81 cd
N_3P_1	27.76 def	51.84 cd	74.92 bcd	87.10 bc
N_3P_2	30.85 bcd	53.45 bcd	76.85 bc	89.64 ab
N_3P_3	28.54 cde	52.41 bcd	76.00 bc	87.93 b
$LSD_{(0.05)}$	**3.350**	**4.049**	**7.356**	**8.106**
CV(%)	**7.42**	**4.81**	**6.22**	**6.00**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Table 3. Effect of different levels of nitrogen and phosphorus on number of leaves per plant of okra

Treatments	Number of leaves per plant at			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
Levels of Nitrogen				
N_0	7.82 b	18.50 b	31.90 b	35.74 c
N_1	8.97 a	21.28 a	37.10 a	42.28 b
N_2	9.28 a	21.63 a	37.63 a	43.84 a
N_3	9.22 a	21.12 a	36.83 a	43.24 ab
$LSD_{(0.05)}$	**0.520**	**0.815**	**1.712**	**1.534**
Levels of Phosphorus				
P_0	8.04 c	18.13 b	33.50 b	37.97 c
P_1	8.67 b	20.06 a	37.82 a	43.07 b
P_2	9.45 a	21.67 a	38.45 a	45.41 a
P_3	9.35 a	21.41 a	37.75 a	44.09 a
$LSD_{(0.05)}$	**0.560**	**0.896**	**1.052**	**1.821**
CV(%)	**7.81**	**6.16**	**5.96**	**4.86**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Table 4. Combined effect of different levels of nitrogen and phosphorus on number of leaves per plant of okra

Treatments	Number of leaves per plant at			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
N_0P_0	7.35 f	16.75 h	27.30 f	30.55 h
N_0P_1	7.80 ef	18.82 fg	33.16 de	37.36 fg
N_0P_2	8.41 cde	19.69 efg	33.82 de	38.15 efg
N_0P_3	7.88 ef	19.09 fg	32.83 cd	36.95 fg
N_1P_0	8.28 def	20.82 cde	35.31 bc	39.47 ef
N_1P_1	8.61 cde	21.10 bcde	37.18 ab	40.98 de
N_1P_2	9.35 bc	21.42 bcde	37.98 ab	45.35 abc
N_1P_3	9.81 ab	22.15 abcd	37.90 e	43.35 cd
N_2P_0	7.68 ef	18.69 g	31.38 e	36.16 g
N_2P_1	9.36 bc	22.29 abc	39.44 ab	44.96 abc
N_2P_2	10.45 a	23.21 a	40.30 a	47.35 a
N_2P_3	9.84 ab	22.69 ab	39.37 ab	46.95 ab
N_3P_0	9.01 bcd	20.42 def	33.71 de	37.75 fg
N_3P_1	9.08 bcd	21.15 bcde	37.25 bc	43.74 bcd
N_3P_2	9.75 ab	21.89 abcd	38.56 ab	45.49 abc
N_3P_3	9.21 bcd	20.30 bcde	37.77 abc	46.07 abc
$LSD_{(0.05)}$	**0.881**	**1.565**	**2.325**	**2.942**
CV(%)	**7.81**	**6.16**	**5.96**	**4.86**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

4.3 Length of petiole

Different levels of nitrogen varied significantly on length of petiole at 20, 40, 60 and 80 DAS of okra (Figure 4). At 20, 40, 60 and 80 DAS the longest petiole (8.69, 14.95, 20.14 and 23.07 cm) was obtained from N_2 which was statistically similar to N_3 (8.59, 14.08, 19.72 and 22.96 cm) and N_1 (8.44, 14.31, 19.74 and 22.35 cm), whereas the shortest petiole (6.86, 11.47, 14.89 and 17.01 cm) was found from N_0. Uwah *et al*. (2010) reported longest petiole with the application of 120 kg N/ha.

Different levels of phosphorus showed significant variation on length of petiole of okra at 20, 40, 60 and 80 DAS (Figure 5). At 20, 40, 60 and 80 DAS the longest petiole (8.77, 14.70, 20.09 and 23.22 cm) was found from P_2, which was statistically identical (8.59, 14.34, 19.61 and 22.55 cm) with P_3 and closely followed (8.04, 13.74, 18.98 and 21.51 cm) by P_1, whereas the shortest petiole (7.18, 12.03, 15.81 and 18.11 cm) was recorded from P_0.

Significant variation was recorded due to combined effect of different levels of nitrogen and phosphorus on petiole length of okra at 20, 40, 60 and 80 DAS (Table 5). At 20, 40, 60 and 80 DAS the longest petiole (9.50, 17.00, 22.55 and 25.77 cm) was obtained from N_2P_2, while the shortest petiole (6.13, 10.37, 12.22 and 14.56 cm) was from N_0P_0.

4.4 Diameter of stem

Diameter of stem varied significantly for different levels of nitrogen at 20, 40, 60 and 80 DAS of okra under the present trial (Table 6). At 20, 40, 60 and 80 DAS the highest diameter of stem (0.90, 1.36, 1.60 and 2.27 cm) was found from $N_{2,}$ while the lowest diameter of stem (0.75, 1.12, 1.32 and 1.60 cm) from N_0. Singh *et al*. (2007) recorded maximum stem diameter with the application of 100 kg N/ha.

Table 5. Combined effect of different levels of nitrogen and phosphorus on petiole length of okra

Treatments	Petiole length (cm) at			
	20 DAS	40 DAS	60 DAS	80 DAS
N_0P_0	6.13 g	10.37 i	12.22 g	14.56 g
N_0P_1	6.80 fg	11.44 hi	15.48 f	17.76 f
N_0P_2	7.56 ef	12.46 gh	16.26 f	18.31 f
N_0P_3	6.96 fg	11.60 hi	15.59 f	17.43 f
N_1P_0	7.54 ef	13.56 efg	18.81 de	20.82 de
N_1P_1	8.02 de	13.95 def	19.04 cde	21.26 cd
N_1P_2	8.85 abcd	14.38 cdef	20.61 abcd	24.17 ab
N_1P_3	9.35 ab	15.38 bcd	20.49 abcd	23.13 bc
N_2P_0	6.78 fg	11.10 hi	15.09 f	17.96 f
N_2P_1	8.87 abcd	15.61 bc	21.07 abc	23.56 b
N_2P_2	9.50 a	17.00 a	22.55 a	25.77 a
N_2P_3	9.21 abc	16.08 ab	21.84 ab	24.99 ab
N_3P_0	8.27 cde	13.08 fg	17.10 ef	19.11 ef
N_3P_1	8.46 bcde	13.97 def	20.31 bcd	23.44 b
N_3P_2	9.46 a	14.98 bcde	20.95 abcd	24.65 ab
N_3P_3	8.55 abcd	14.31 cdef	20.52 abcd	24.64 ab
$LSD_{(0.05)}$	**0.840**	**1.294**	**1.912**	**1.957**
CV(%)	**6.19**	**5.66**	**6.16**	**5.50**

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

N_0: 0 kg N/ha (control)
N_1: 110 kg N/ha
N_2: 120 kg N/ha
N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)
P_1: 70 kg P_2O_5/ha
P_2: 80 kg P_2O_5/ha
P_3: 90 kg P_2O_5/ha

Table 6. Effect of different levels of nitrogen and phosphorus on stem diameter of okra

Treatments	Stem diameter (cm) at			
	20 DAS	40 DAS	60 DAS	80 DAS
Levels of Nitrogen				
N_0	0.75 c	1.12 c	1.32 c	1.60 d
N_1	0.84 b	1.24 b	1.54 b	2.14 c
N_2	0.90 a	1.36 a	1.60 a	2.27 a
N_3	0.81 b	1.23 bc	1.52 b	2.18 b
$LSD_{(0.05)}$	**0.042**	**0.081**	**0.058**	**0.103**
Levels of Phosphorus				
P_0	0.78 d	1.14 b	1.28 c	1.61 d
P_1	0.86 b	1.34 a	1.50 b	2.03 c
P_2	0.91 a	1.39 a	1.62 a	2.32 a
P_3	0.84 c	1.31 ab	1.54 b	2.16 b
$LSD_{(0.05)}$	**0.017**	**0.073**	**0.066**	**0.109**
CV(%)	**5.58**	**6.97**	**4.71**	**7.35**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Significant variation was recorded due to use different levels of phosphorus on diameter of stem at 20, 40, 60 and 80 DAS (Table 6). At 20, 40, 60 and 80 DAS the highest diameter of stem (0.91, 1.39, 1.62 and 2.32 cm) was obtained from P_2, which was closely followed (0.84, 1.31, 1.54 and 2.16) by P_3, and the lowest diameter (0.78, 1.14, 1.28 and 1.61 cm) was found from P_0.

Diameter of stem of okra showed significant differences due to the combined effect of nitrogen and phosphorus on at 20, 40, 60 and 80 DAS (Table 7). At 20, 40, 60 and 80 DAS the highest diameter of stem (0.87, 1.55, 1.82 and 2.75 cm) was observed from N_2P_2 and the lowest diameter of stem (0.62, 1.16, 1.31 and 1.33) was recorded from the treatment combination of N_0P_0.

4.5 Length of leaf

Statistically significant variation was observed in terms of length of leaf of okra due to different levels of nitrogen at 20, 40, 60 and 80 DAS (Table 8). At 20, 40, 60 and 80 DAS the longest leaf (10.55, 17.60, 24.25 and 28.78 cm) was found from N_2 and the shortest leaf (8.67, 13.68, 17.36 and 20.48 cm) was recorded from N_0. Singh *et al*. (2007) recorded the longest leaf with 100 kg N/ha.

Length of leaf of okra showed significant variation for different levels of phosphorus at 20, 40, 60 and 80 DAS (Table 8). At 20, 40, 60 and 80 DAS the longest leaf (10.60, 17.52, 24.99 and 29.50 cm) was observed in P_2, whereas the shortest leaf (8.77, 14.18, 17.65 and 20.01 cm) was performed by P_0.

Combined effect of different levels of nitrogen and phosphorus showed significant differences on leaf length of okra at 20, 40, 60 and 80 DAS (Table 9). At 20, 40, 60 and 80 DAS the longest leaf (11.36, 20.23, 27.45 and 32.55 cm) was recorded from N_2P_2, while the shortest leaf (7.63, 12.56, 13.75 and 14.17 cm) was from N_0P_0.

Table 7. Combined effect of different levels of nitrogen and phosphorus on stem diameter of okra

Treatments	Stem diameter (cm) at			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
N_0P_0	0.62 f	1.16 d	1.31 e	1.33 g
N_0P_1	0.68 ef	1.18 cd	1.37 de	1.68 f
N_0P_2	0.73 de	1.17 cd	1.46 d	1.91 def
N_0P_3	0.66 f	1.15 d	1.40 de	1.74 ef
N_1P_0	0.67 f	1.17 cd	1.36 de	1.96 de
N_1P_1	0.78 bcd	1.32 bcd	1.50 c	2.11 cd
N_1P_2	0.86 a	1.31 bcd	1.75 ab	2.39 b
N_1P_3	0.76 cd	1.26 cd	1.68 bc	2.34 bc
N_2P_0	0.75 cd	1.19 cd	1.41 de	1.56 f
N_2P_1	0.83 ab	1.31 bcd	1.70 abc	2.37 b
N_2P_2	0.87 a	1.55 a	1.82 a	2.75 a
N_2P_3	0.82 ab	1.44 ab	1.72 abc	2.55 ab
N_3P_0	0.74 de	1.21 cd	1.35 de	1.75 ef
N_3P_1	0.78 bcd	1.33 bc	1.63 bc	2.29 bc
N_3P_2	0.79 bc	1.25 cd	1.73 abc	2.53 ab
N_3P_3	0.75 cd	1.13 d	1.61 c	2.34 bc
$LSD_{(0.05)}$	**0.056**	**0.143**	**0.116**	**0.234**
CV(%)	**5.58**	**6.97**	**4.71**	**7.35**

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

N_0: 0 kg N/ha (control)
N_1: 110 kg N/ha
N_2: 120 kg N/ha
N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)
P_1: 70 kg P_2O_5/ha
P_2: 80 kg P_2O_5/ha
P_3: 90 kg P_2O_5/ha

Table 8. Effect of different levels of nitrogen and phosphorus on leaf length of okra

Treatments	Leaf length (cm) at			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
Levels of Nitrogen				
N_0	8.67 c	13.68 c	17.36 b	20.48 b
N_1	9.94 b	16.67 b	23.33 a	27.40 a
N_2	10.55 a	17.60 a	24.25 a	28.78 a
N_3	10.26 ab	16.48 b	23.65 a	27.98 a
$LSD_{(0.05)}$	**0.610**	**0.843**	**2.195**	**3.169**
Levels of Phosphorus				
P_0	8.77 c	14.18 c	17.65 c	20.01 c
P_1	9.72 b	16.19 b	22.96 b	25.94 b
P_2	10.60 a	17.52 a	24.99 a	29.50 a
P_3	10.23 a	17.43 a	23.71 b	28.63 a
$LSD_{(0.05)}$	**0.716**	**0.665**	**1.126**	**1.647**
CV(%)	**9.51**	**8.83**	**8.17**	**7.72**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Table 9. Combined effect of different levels of nitrogen and phosphorus on leaf length of okra

Treatments	Leaf length (cm) at			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
N_0P_0	7.63 h	12.56 h	13.75 h	14.17 i
N_0P_1	8.20 fgh	13.21 h	17.45 fg	19.35 h
N_0P_2	9.06 defg	15.00 fg	19.56 def	22.94 f
N_0P_3	8.59 efgh	14.77 g	18.89 efg	22.26 fg
N_1P_0	8.63 efgh	15.67 efg	21.42 cde	24.15 ef
N_1P_1	9.26 def	16.42 defg	22.01 cd	25.85 de
N_1P_2	10.15 bcd	17.08 cde	26.50 a	31.35 ab
N_1P_3	10.53 abc	18.31 bc	23.57 bc	29.30 bc
N_2P_0	8.10 gh	13.06 h	16.29 gh	20.05 gh
N_2P_1	10.47 abc	18.61 bc	26.71 a	30.15 abc
N_2P_2	11.36 a	20.23 a	27.45 a	32.55 a
N_2P_3	11.10 ab	19.26 ab	26.89 a	31.99 ab
N_3P_0	9.59 cde	15.42 efg	18.54 fg	21.60 fgh
N_3P_1	9.74 cde	16.53 def	25.02 ab	28.36 cd
N_3P_2	10.62 abc	17.75 bcd	26.26 ab	31.04 abc
N_3P_3	9.87 cd	16.96 cde	24.93 ab	30.95 abc
$LSD_{(0.05)}$	**1.024**	**1.522**	**2.597**	**2.511**
CV(%)	**9.51**	**8.83**	**8.17**	**7.72**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

4.6 Number of branches per plant

Number of branches per plant showed significant variation due to application of different levels of nitrogen at 20, 40, 60 and 80 DAS of okra under the present trial (Figure 6). At 20, 40, 60 and 80 DAS the maximum number of branches per plant (1.30, 2.47, 3.02 and 4.00) was recorded from N_2 which was statistically similar (1.23, 2.38, 2.95 and 3.98) to N_3 and closely followed (1.20, 2.35, 2.93 and 3.85) by N_1, whereas the minimum number of branches per plant (1.05, 1.73, 2.30 and 2.78) from N_0. Soni *et al*. (2006) reported that number of branches increased with increasing rates of N up to 125 kg/ha.

A significant variation was recorded on number of branches per plant of okra at 20, 40, 60 and 80 DAS due to effect of different levels of phosphorus (Figure 7). At 20, 40, 60 and 80 DAS the maximum number of branches per plant (1.28, 2.40, 3.05 and 4.02) was observed in P_2, which was statistically identical (1.25, 2.37, 2.97 and 3.90) with P_3 and closely followed (1.15, 2.25, 2.85 and 3.68) by P_1 and the minimum number of branches per plant (1.10, 1.87, 2.33 and 3.02) was recorded from P_0. Akinrinde and Adigun (2005) reported that okra plants were more efficient in their use of P.

Number of branches per plant of okra showed significant variations due to interaction effect of different levels of nitrogen and phosphorus at 20, 40, 60 and 80 DAS (Table 10). At 20, 40, 60 and 80 DAS, the maximum number of branches per plant (1.40, 2.87, 3.40 and 4.47) was recorded from N_2P_2 and the minimum number (1.00, 1.27, 1.87 and 2.27) was recorded from N_0P_0.

4.7 Length of internode

Length of internode differed significantly due to the application of different levels of nitrogen at 20, 40, 60 and 80 DAS of okra under the present trial (Table 11). At 20, 40, 60 and 80 DAS the longest internode (7.03, 8.75, 11.89 and 14.33 cm) was observed in N_2, while the shortest internode (5.40, 6.82, 9.12 and 10.08 cm) was measured from N_0.

Table 10. Combined effect of different levels of nitrogen and phosphorus on number of branches per plant of okra

Treatments	Number of branches per plant at			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
N_0P_0	1.00 e	1.27 h	1.87 g	2.27 e
N_0P_1	1.00 e	1.87 g	2.40 ef	2.93 d
N_0P_2	1.13 cde	1.93 g	2.53 de	3.07 d
N_0P_3	1.07 de	1.87 g	2.40 ef	2.87 d
N_1P_0	1.07 de	2.27 ef	2.80 cd	3.60 bc
N_1P_1	1.13 cde	2.27 ef	2.80 cd	3.60 bc
N_1P_2	1.27 abc	2.33 def	3.07 bc	4.20 a
N_1P_3	1.33 ab	2.53 bcd	3.07 bc	4.00 ab
N_2P_0	1.13 cde	1.73 g	2.20 f	3.00 d
N_2P_1	1.27 abc	2.60 bc	3.13 ab	4.13 a
N_2P_2	1.40 a	2.87 a	3.40 a	4.47 a
N_2P_3	1.40 a	2.67 ab	3.33 ab	4.40 a
N_3P_0	1.20 bcd	2.20 f	2.47 ef	3.20 cd
N_3P_1	1.20 bcd	2.27 ef	3.07 bc	4.07 a
N_3P_2	1.33 ab	2.47 bcde	3.20 ab	4.33 a
N_3P_3	1.20 bcd	2.40 cdef	3.07 bc	4.33 a
$LSD_{(0.05)}$	**0.149**	**0.211**	**0.294**	**0.412**
CV(%)	**7.37**	**5.73**	**6.24**	**6.74**

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

N_0: 0 kg N/ha (control)
N_1: 110 kg N/ha
N_2: 120 kg N/ha
N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)
P_1: 70 kg P_2O_5/ha
P_2: 80 kg P_2O_5/ha
P_3: 90 kg P_2O_5/ha

Table 11. Effect of different levels of nitrogen and phosphorus on internode length of okra

Treatments	Internode length (cm) at			
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
Levels of Nitrogen				
N_0	5.40 c	6.82 b	9.12 b	10.08 b
N_1	6.60 b	8.40 a	11.60 a	13.87 a
N_2	7.03 a	8.75 a	11.89 a	14.33 a
N_3	6.73 b	8.30 a	11.51 a	14.20 a
$LSD_{(0.05)}$	**0.319**	**0.631**	**0.529**	**0.426**
Levels of Phosphorus				
P_0	5.67 c	6.26 b	9.28 b	10.34 c
P_1	6.46 b	7.57 a	11.35 a	13.46 b
P_2	6.86 a	7.92 a	11.76 a	14.83 a
P_3	6.80 a	7.82 a	11.70 a	14.65 a
$LSD_{(0.05)}$	**0.314**	**0.467**	**0.495**	**0.309**
CV(%)	**6.45**	**8.32**	**7.50**	**8.97**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Statistically significant variation was recorded due to effect different levels of phosphorus on length of internode of okra at 20, 40, 60 and 80 DAS (Table 11). At 20, 40, 60 and 80 DAS the longest internode (6.86, 7.92, 11.76 and 14.83 cm) was recorded from P_2, which was statistically identical (6.80, 7.82, 11.70 and 14.65 cm) with P_3, whereas the shortest internode (5.67, 6.62, 9.28 and 10.34 cm) was found from P_0.

Combined effect of different levels of nitrogen and phosphorus showed significant differences on internode length of okra at 20, 40, 60 and 80 DAS (Table 12). At 20, 40, 60 and 80 DAS the longest internode (7.81, 9.74, 13.10 and 16.25 cm) was recorded from N_2P_2, while the shortest internode (4.53, 5.57, 7.10 and 7.48 cm) was obtained from the treatment combination of N_0P_0.

4.8 Days required for flowering

Days required for flowering varied significantly due to response of different levels of nitrogen (Figure 8). The minimum (38.00) days required for flowering was recorded from N_2, whereas the maximum (43.25) days was from N_0, which was statistically similar (42.25 and 41.00) to N_1 and N_3.

Application of different levels of phosphorus showed significant variation on days required for flowering of okra (Figure 9). The minimum (39.00) days for flowering was found from P_2 which was statistically identical (39.50) to P_3. On the other hand, the maximum (43.83) days was obtained from $P_{0,}$ which was closely followed (42.17 days) by P_1.

Due to combined effect of different levels of nitrogen and phosphorus showed significant differences on days required for flowering of okra (Figure 10). The minimum (34.33) days required for flowering was found from N_2P_1, and the maximum (46.67) days from N_0P_1. Patton *et al.* (2002) reported that nitrogen at 150 kg/ha and P at 90 kg/ha gave the lowest number of days to flowering (40.93 and 41.48 days after sowing).

Table 12. Combined effect of different levels of nitrogen and phosphorus on internode length of okra

Treatments	Internode length (cm) at			
	20 DAS	40 DAS	60 DAS	80 DAS
N_0P_0	4.53 j	5.57 h	7.10 e	7.48 e
N_0P_1	5.32 i	7.27 fg	5.59 d	10.75 cd
N_0P_2	5.25 fgh	7.49 efg	9.78 d	11.30 bcd
N_0P_3	5.63 hi	7.52 efg	9.88 d	10.78 cd
N_1P_0	6.32 efg	8.49 bcde	11.37 bc	12.79 b
N_1P_1	6.50 defg	7.10 def	11.15 c	12.55 bc
N_1P_2	6.84 cdef	8.10 abcd	12.43 ab	15.48 a
N_1P_3	6.83 cdef	8.43 cde	11.38 bc	14.70 a
N_2P_0	5.66 hi	6.93 g	9.13 d	10.03 d
N_2P_1	7.22 abc	9.37 abc	12.59 a	14.83 a
N_2P_2	7.81 ab	9.74 ab	13.10 a	16.25 a
N_2P_3	7.56 a	9.52 a	12.66 a	15.17 a
N_3P_0	6.17 gh	7.26 fg	9.48 d	10.26 d
N_3P_1	6.83 cdef	7.71 abcd	12.06 abc	14.91 a
N_3P_2	6.96 bcde	7.71 abcd	12.02 abc	15.52 a
N_3P_3	6.11 bcd	9.06 abc	12.37 ab	16.07 a
$LSD_{(0.05)}$	**0.569**	**0.939**	**0.996**	**1.823**
CV(%)	**7.62**	**8.32**	**7.50**	**8.97**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

4.9 Number of flower buds per plant

Significant variation was found due to application of different leaves of nitrogen on number of flower buds per plant (Table 13). The maximum number of flower buds per plant (29.35) was counted from N_2 which was statistically similar and with N_3 (28.86) and N_1 (28.56), whereas the minimum (26.68) was obtained from N_0.

Due to application of different levels of phosphorus number of flower buds per plant varied significantly (Table 13). The maximum number of flower buds per plant (30.18) was observed in P_2, which was statistically similar (29.09) to P_3 and the minimum (23.72) was recorded from P_0.

Combined effect of nitrogen and phosphorus showed significant variation on number of flower buds per plant (Table 14). The maximum number of flower buds per plant (33.63) was counted from the treatment combination of N_2P_2, while the minimum (20.30) was obtained from N_0P_0.

4.10 Number of pods per plant

Number of pods per plant of okra varied significantly due to response of different levels of nitrogen (Table 13). The maximum number of pods per plant (22.15) was observed in N_2 which was statistically similar (21.57) to N_3 and the minimum (18.43) was counted from N_0. Jana *et al*. (2010) reported that 150 kg N ha^{-1} produced the highest number of fruits per plant (13.7).

Different levels of phosphorus showed significant variation on number of pods per plant of okra (Table 13). The maximum number of pods per plant (22.51) was found from P_2, which was statistically identical (21.48) with P_3, whereas the minimum (16.53) was observed from P_0. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased the number of fruits per plant.

Table 13. Effect of different levels of nitrogen and phosphorus on yield contributing characters of okra

Treatments	Number of flower buds/plant	Number of pods/plant	Pod length (cm)	Pod diameter (cm)
Levels of Nitrogen				
N_0	24.58 b	18.43 c	13.82 c	1.42 c
N_1	28.56 a	20.07 b	15.32 b	1.74 b
N_2	29.35 a	22.15 a	16.78 a	1.94 a
N_3	28.86 a	21.57 ab	16.67 a	1.77 b
$LSD_{(0.05)}$	**2.081**	**1.835**	**1.032**	**0.124**
Levels of Phosphorus				
P_0	23.72 c	16.53 c	13.28 c	1.50 c
P_1	28.37 b	20.23 b	15.33 b	1.74 b
P_2	30.18 a	22.51 a	17.01 a	1.89 a
P_3	29.09 ab	21.48 a	16.27 a	1.82 a
$LSD_{(0.05)}$	**1.673**	**1.821**	**0.765**	**0.132**
CV(%)	**6.39**	**6.18**	**7.19**	**8.26**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Table 14. Combined effect of different levels of nitrogen and phosphorus on yield contributing characters of okra

Treatments	Number of flowers buds/plant	Number of pods/plant	Pod length (cm)	Pod diameter (cm)
N_0P_0	22.30 g	16.23 gh	11.50 f	1.37 e
N_0P_1	27.17 ef	18.76 def	13.13 def	1.40 de
N_0P_2	27.16 de	20.23 cde	14.40 d	1.53 de
N_0P_3	26.90 e	18.90 efg	13.53 de	1.35 e
N_1P_0	28.17 cde	17.37 fg	14.70 d	1.58 cde
N_1P_1	28.70 cde	18.70 def	14.53 d	1.64 cd
N_1P_2	31.96 ab	22.50 ab	17.15 b	1.85 b
N_1P_3	30.30 bcd	21.77 abc	16.61 bc	1.82 b
N_2P_0	23.50 fg	14.76 h	12.26 ef	1.39 de
N_2P_1	32.36 ab	22.03 abc	17.16 b	1.98 ab
N_2P_2	33.63 a	23.82 a	19.15 a	2.18 a
N_2P_3	32.70 ab	23.57 a	18.30 ab	2.15 a
N_3P_0	27.69 ef	16.97 fg	15.02 cd	1.52 de
N_3P_1	31.09 abc	20.56 bcd	16.87 b	1.77 bc
N_3P_2	32.17 ab	22.83 ab	17.47 ab	1.89 b
N_3P_3	31.23 abc	21.90 abc	18.05 b	1.86 b
$LSD_{(0.05)}$	**2.99**	**2.102**	**1.803**	**0.316**
CV(%)	**6.39**	**6.18**	**7.19**	**8.26**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Due to combined effect of different levels of nitrogen and phosphorus showed significant differences on number of pods per plant of okra (Table 14). The maximum number of pods per plant (23.82) was found from N_2P_2 and the minimum (16.23) was found from N_0P_0. Arora *et al.* (1991) stated that number of pods were significantly improved by the application of 90 kg N/ha and 60 kg P_2O_5/ha.

4.11 Pod length

Statistically significant variation was observed on pod length of okra due to the application different levels of nitrogen (Table 13). The longest pod (16.78 cm) was observed from N_2 which was statistically similar N_3 (16.67 cm) to, while the shortest pod (13.82 cm) from N_0. Jalal-ud-Din *et al.* (2002) observed that pod length showed a favorable behavior under 150 kg N/ha, but above this particular dose it declined.

Pod length of okra varied significantly due to response of different levels of phosphorus (Table 13). The longest pod (17.01 cm) was found from P_2, which was statistically identical (16.27 cm) with P_3 and closely followed (15.33 cm) by P_1, whereas the shortest pod (13.28 cm) was recorded from P_0. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased length of fruit.

Combined effect of different levels of nitrogen and phosphorus showed significant differences on pod length of okra (Table 14). The longest pod (19.15 cm) was observed from N_2P_2, again the shortest pod (11.50 cm) was found from N_0P_0.

4.12 Pod diameter

Application of different levels of nitrogen varied significantly on pod diameter under the present trial (Table 13). The highest diameter of pod (1.94 cm) was recorded from N_2 which was closely followed (1.77 cm and 1.74 cm) by N_3 and N_1, whereas the lowest diameter of pod (1.42 cm) from N_0. Ambare *et al*. (2005) reported that the higher levels of nitrogen significantly influenced all the characters under study except the diameter of the fruit.

Different levels of phosphorus showed significant variation on pod diameter of okra (Table 13). The highest diameter of pod (1.89 cm) was observed from P_2, which was statistically identical (1.82 cm) to P_3 and closely followed (1.47 cm) by P_1, whereas the lowest diameter of pod (1.50 cm) was recorded from P_0. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased diameter of fruit.

Significant variation was recorded due to the combined effect of different levels of nitrogen and phosphorus on diameter of pod of okra (Table 14). The highest diameter of pod (2.18) was found from N_2P_2 and the lowest diameter of pod (1.37 cm) was recorded from N_0P_0. Arora *et al.* (1991) stated from their earlier experiment that diameter of pod were significantly improved by the application of 90 kg N/ha and 60 kg P_2O_5/ha.

4.13 Weight of individual pod

Weight of individual pod of okra varied significantly due to application of different levels of nitrogen under the present trial (Table 15). The highest weight of individual pod (11.55 g) was recorded from N_2, while the lowest weight of individual pod (9.87 g) was from N_0. Jana *et al*. (2010) reported that 150 kg N ha^{-1} produced the highest individual fruit weight (18.5 gm). Jalal-ud-Din *et al.* (2002) observed that weight of pods showed a favorable behavior under 150 kg N/ha, but above this particular dose it declined.

Different levels of phosphorus showed significant variation on weight of individual pod of okra (Table 15). The highest weight of individual pod (11.35 g) was observed in P_2, whereas the lowest weight of individual pod (9.85 g) was recorded from P_0. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased mean fruit weight.

Table 15. Effect of different levels of nitrogen and phosphorus on yield contributing characters and yield of okra

Treatments	Weight of individual pod (g)	Fresh weight of leaves/plant at harvest (g)	Dry matter content of leaves (%)	Yield/hectare (ton)
Levels of Nitrogen				
N_0	9.87 c	246.33 c	8.12 c	12.30 c
N_1	10.80 b	280.05 b	10.73 b	14.66 b
N_2	11.55 a	298.40 a	11.99 a	16.40 a
N_3	11.00 b	293.51 a	10.81 ab	15.22 b
$LSD_{(0.05)}$	**0.437**	**8.44**	**0.444**	**0.588**
Levels of Phosphorus				
P_0	9.85 c	248.46 c	8.61 c	11.20 d
P_1	10.57 b	280.03 b	10.18 b	14.38 c
P_2	11.35 a	294.45 a	11.39 a	16.95 a
P_3	11.15 a	288.68 ab	10.79 a	16.04 b
$LSD_{(0.05)}$	**0.452**	**13.32**	**0.695**	**0.701**
CV(%)	**6.66**	**8.36**	**7.51**	**6.06**

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

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

Combined effect of nitrogen and phosphorus showed significant differences on weight of individual pod (Table 16). The highest weight of individual pod (14.63 g) was recorded from N_2P_2, and the lowest weight of individual pod (11.40 g) was found from N_0P_0.

4.14 Fresh weight of leaves per plant

Statistically significant variation was recorded on fresh weight of leaves per plant of okra due to different levels of nitrogen under the present trial (Table 15). The highest fresh weight of plant (298.40 g) was recorded from N_2 which was statistically similar (293.51 g) to N_3, whereas the lowest weight (246.33 g) was obtained from N_0.

Fresh weight of leaves per plant of okra showed significant variation due to application different levels of phosphorus (Table 15). The highest fresh weight of leaves per plant (294.45 g) was observed in P_2, which was statistically identical (288.68 g) to P_3 whereas the lowest weight (248.46 g) was recorded from P_0.

Combined effect of nitrogen and phosphorus showed significant differences on fresh weight of leaves per plant of okra (Table 16). The highest fresh weight of plant (330.61 g) was recorded from the treatment combination of N_2P_2, while the lowest weight (225.16 g) was found from N_0P_0.

4.15 Dry matter content of leaves

Percent dry matter content of leaves of okra significantly differed due to different levels of nitrogen under the present trial (Table 15). The highest dry matter of plant (11.99%) was found from N_2, while the lowest dry matter (8.12%) was obtained from N_0.

Statistically significant variation was recorded on dry matter percent 0f leaves of okra due to different levels of phosphorus (Table 15). The highest dry matter (11.39%) was found from P_2, which was statistically identical (10.79%) to P_3 and closely followed (10.18%) by P_1 and the lowest dry matter (8.61%) was recorded from P_0.

Table 16. Combined effect of different levels of nitrogen and phosphorus on yield contributing characters and yield of okra

Treatments	Weight of Individual pod (g)	Fresh weight of leaves/plant at harvest (g)	Dry matter content/plant (%)	Yield/hectare (ton)
N_0P_0	11.40 e	225.16 h	6.90 g	10.74 gh
N_0P_1	11.87 e	258.50 fg	8.15 f	12.64 ef
N_0P_2	12.14 de	273.38 efg	9.08 ef	13.82 de
N_0P_3	11.67 e	263.01 fg	8.36 f	11.97 fg
N_1P_0	11.87 e	280.72 def	9.56 e	11.87 fg
N_1P_1	12.19 de	285.91 cdef	10.17 de	13.05 ef
N_1P_2	13.15 c	301.70 bcd	11.40 bc	16.76 b
N_1P_3	13.68 bc	304.10 abcd	11.77 bc	16.95 b
N_2P_0	11.80 e	248.95 gh	8.22 f	10.19 h
N_2P_1	13.40 bc	310.80 abc	11.46 bc	16.76 b
N_2P_2	14.63 a	330.61 a	13.10 a	19.76 a
N_2P_3	14.15 ab	328.08 ab	12.46 ab	18.89 a
N_3P_0	12.23 de	271.85 efg	9.78 e	12.01 fg
N_3P_1	12.87 cd	297.40 bcde	10.97 cd	15.06 cd
N_3P_2	13.50 bc	305.95 abcd	11.96 ac	17.45 b
N_3P_3	13.17 c	301.30 bcd	11.31 ac	16.36 bc
$LSD_{(0.05)}$	**0.815**	**22.69**	**1.113**	**1.526**
CV(%)	**6.66**	**8.36**	**7.51**	**6.06**

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

N_0: 0 kg N/ha (control)
N_1: 110 kg N/ha
N_2: 120 kg N/ha
N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)
P_1: 70 kg P_2O_5/ha
P_2: 80 kg P_2O_5/ha
P_3: 90 kg P_2O_5/ha

Due to combined effect of nitrogen and phosphorus showed significant differences on dry matter percent of leaves of okra (Table 16). The highest dry matter of leaves (13.10%) was observed from N_2P_2, and the lowest dry matter (6.90%) was obtained from the treatment combined of N_0P_0.

4.16 Yield per plot

Yield per plot of okra varied significantly for different levels of nitrogen (Figure 11). The highest yield per plot (7.09 kg) was found from N_2 which was closely followed (6.57 kg and 6.33 kg) with N_3 and N_1 and they were statistically identical, whereas the lowest yield per plot (5.31 kg) from N_0.

Application of different levels of phosphorus showed significant variation on yield per plot of okra (Figure 12). The highest yield per plot (7.32 kg) was recorded from P_2, which was closely followed (16.04 kg) by P_3. On the contrary, the lowest yield per plot (4.84 kg) was observed from P_0 which was followed (6.21 kg) by P_1.

Combined effect of different levels of nitrogen and phosphorus showed significant differences on yield per plot of okra under the present trial (Figure 13). The highest yield per plot (8.54 kg) was observed from N_2P_2, while the lowest yield per plot (4.64 kg) was found from N_0P_0.

4.17 Yield per hectare

Statistically significant variation was recorded on yield per hectare of okra due to the application of different levels of nitrogen under the present trial (Table 15). The highest yield per hectare (16.40 ton) was recorded from N_2, while the lowest yield per hectare (12.30 ton) from N_0. It was revealed that nitrogen ensured favorable condition for the growth of okra plant with optimum vegetative growth and the ultimate results was the highest yield. Jana *et al*. (2010) reported that 150 kg N ha^{-1} produced the highest fruit yield (12.2 ton/ha).

Different levels of phosphorus showed significant variation on yield per hectare of okra (Table 15). The highest yield per hectare (16.95 ton) was observed in P_2. On the other hand, the lowest yield per hectare (11.20 ton) was found from P_0. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased yield per hectare. Akinrinde and Adigun (2005) reported that okra plants were more efficient in their use of P in terms of yield per hectare.

Yield per hectare of okra showed significant differences due to the combined effect of different levels of nitrogen and phosphorus (Table 16). The highest yield per hectare (19.76 ton) was recorded from N_2P_2, while the lowest yield per hectare (10.74 ton) was found from N_0P_0. Arora *et al.* (1991) stated that total green fruit yield were significantly improved by the application of 90 kg N/ha and 60 kg P_2O_5/ha. Gupta *et al.* (1981) reported that application of 100 kg nitrogen and 60 kg phosphorus per hectare gave the highest yield.

4.18 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of okra were recorded as per experimental plot and converted into cost per hectare. Price of okra was considered as per market rate. The economic analysis presented under the following headings-

4.18.1 Gross return

The combination of different levels of nitrogen and phosphorus showed different value in terms of gross return under the trial (Table 17). The highest gross return (Tk. 395,200) was obtained from the treatment combination of N_2P_2 and the second highest gross return (Tk. 377,800) was found in N_2P_3. The lowest gross return (Tk. 214,800) was obtained from N_0P_0.

Table 17. Cost and return of okra cultivation as influenced by nitrogen and phosphorus fertilizer

Treatments	Cost of production (Tk./ha)	Yield of okra (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
N_0P_0	172,364	10.74	214,800	42,436	1.25
N_0P_1	175,972	12.64	252,800	76,828	1.44
N_0P_2	176,491	13.82	276,400	99,909	1.57
N_0P_3	177,010	11.97	239,400	62,390	1.35
N_1P_0	177,756	11.87	237,400	59,644	1.34
N_1P_1	181,365	13.05	261,000	79,635	1.44
N_1P_2	181,884	16.76	335,200	153,316	1.84
N_1P_3	182,403	16.95	339,000	156,597	1.86
N_2P_0	178,228	10.19	203,800	25,572	1.14
N_2P_1	181,837	16.76	335,200	153,363	1.84
N_2P_2	182,356	19.76	395,200	212,844	2.17
N_2P_3	182,875	18.89	377,800	194,925	2.07
N_3P_0	178,723	12.01	240,200	61,477	1.34
N_3P_1	182,331	15.06	301,200	118,869	1.65
N_3P_2	182,850	17.45	349,000	166,150	1.91
N_3P_3	183,369	16.36	327,200	143,831	1.78

Price of okra @ Tk. 20/kg

N_0: 0 kg N/ha (control)

N_1: 110 kg N/ha

N_2: 120 kg N/ha

N_3: 130 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 80 kg P_2O_5/ha

P_3: 90 kg P_2O_5/ha

4.18.2 Net return

In case of net return, different levels of nitrogen and phosphorus showed different amount of net return under the present trial (Table 17). The highest net return (Tk. 212,844) was found from the treatment combination of N_2P_2 and the second highest net return (Tk. 194,925) was obtained from the combination of N_2P_3. The lowest (Tk. 42,436) net return was obtained from N_0P_0.

4.18.3 Benefit cost ratio

In the different levels of nitrogen and phosphorus the highest benefit cost ratio (2.17) was noted from the treatment combination of N_2P_2 and the second highest benefit cost ratio (2.07) was estimated from the combination of N_2P_3. The lowest benefit cost ratio (1.25) was obtained from N_0P_0 (Table 17). From economic point of view, it is apparent from the above results that the combination of N_2P_2 was better than those of other combinations.

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to August 2012. The objective of the study was to find the growth and yield of okra as influenced by nitrogen and phosphorus. BARI Dherosh-1 was used as test crop in this experiment. The experiment consisted of two factors. Nitrogen fertilizer (4 levels) as N_0: 0 kg N/ha (control), N_1: 110 kg N/ha, N_2: 120 kg N/ha and N_3: 130 kg N/ha; Phosphorus fertilizer (4 levels) as P_0: 0 kg P_2O_5/ha (control); P_1: 70 kg P_2O_5/ha; P_2: 80 kg P_2O_5/ha and P_3: 90 kg P_2O_5/ha. There were a total of 16 (4 × 4) treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Size of each plot was 2.4 × 1.8 m. Data were collected in respect of yield contributing characters and yield of okra and statistically significant variation was recorded.

At 20, 40, 60 and 80 DAS the tallest plant (29.69, 53.65, 76.16 and 86.19 cm), the maximum number of leaves per plant (9.28, 21.28, 37.63 and 43.84), the longest petiole (8.69, 14.95, 20.14 and 23.07 cm), the highest diameter of stem (0.90, 1.36, 1.60 and 2.27 cm), the longest leaf (10.55, 17.60, 22.25 and 28.78 cm), the maximum number of branches per plant (1.30, 2.47, 3.02 and 4.00) and the longest internode (7.03, 8.75, 11.89 and 14.33 cm), the minimum days required for flowering (38.00), the maximum number of flower buds per plant (29.35), the maximum number of pods per plant (22.15), the longest pod (16.78 cm), the highest diameter of pod (1.94 cm), the highest weight of individual pod (11.55 g), the highest fresh weight of leaves per plant (298.40 g), the highest dry matter content of leaves (11.99%) and the highest yield (16.40 t/ha) was recorded from N_2, whereas the shortest plant (22.05, 44.12, 61.37 and 70.00 cm), the minimum number of leaves per plant (7.82, 18.50, 31.90 and 35.74), the shortest petiole (6.86, 11.47, 14.89 and 17.01 cm), the lowest diameter of stem (0.75, 1.12, 1.32

and 1.60 cm), the shortest leaf (8.67, 13.68, 17.36 and 20.48 cm), the minimum number of branches per plant (1.05, 1.73, 2.30 and 2.78) and the shortest internode (5.40, 6.82, 9.12 and 10.08 cm), the maximum days required for flowering (43.25), the minimum number of flower buds per plant (28.86), minimum number of pods per plant (18.43), the shortest pod (13.82 cm) the lowest diameter of pod (1.42 cm), the lowest diameter of pod (9.87 g), the lowest fresh weight of leaves per plant (246.33 g), the lowest dry matter content of leaves (8.12%) and the lowest yield (12.30 t/ha) was recorded from N_0.

At 20, 40, 60 and 80 DAS the tallest plant (29.82, 53.22, 76.36 and 87.75 cm), the maximum number of leaves per plant (9.45, 21.67, 38.45 and 45.41), the longest petiole (8.77, 14.70, 20.09 and 23.22 cm), the highest diameter of stem (0.91, 1.39, 1.62 and 2.32 cm), the longest leaf (10.60, 17.52, 24.99 and 29.50 cm), the maximum number of branches per plant (1.28, 2.40, 3.05 and 4.02), the longest internode (6.86, 7.92, 11.76 and 14.83 cm), the minimum days required for flowering (39.00), the maximum number of flower buds per plant (30.18), the maximum number of pods per plant (22.51), the longest pod (17.01 cm), the highest diameter of pod (1.89 cm), the highest weight of individual pod (11.35 g), the highest fresh weight of leaves per plant (294.45 g), the highest dry matter content of leaves (11.39%) and the highest yield (16.95 t/ha) was observed from P_2 and the shortest plant (23.20, 45.41, 61.79 and 71.03 cm), the minimum number of leaves per plant (8.04, 18.19, 33.50 and 37.97), the shortest petiole (7.18, 12.03, 15.81 and 18.11 cm), the lowest diameter of stem (0.78, 1.14, 1.28 and 1.61 cm), the shortest leaf (8.77, 14.18, 17.65 and 20.01 cm), the minimum number of branches per plant (1.10, 1.87, 2.33 and 3.02), the shortest internode (5.67, 6.26, 9.28 and 10.34 cm), the maximum days required for flowering (43.83), the minimum number of flower buds per plant (23.72), the minimum number of pods per plant (17.01), the shortest pod (13.28 cm), the lowest diameter of pod (1.50 cm), the lowest weight of individual pod (9.85 g), the lowest fresh weight of leaves per plant (248.46 g), the lowest dry matter content of leaves (8.61%) and the lowest yield (11.20 t/ha) was observed from P_0.

At 20, 40, 60 and 80 DAS the tallest plant (34.64, 59.32, 85.42 and 97.39 cm), the maximum number of leaves per plant (10.45, 23.21, 40.30 and 47.35), the longest petiole (9.50, 17.00, 22.55 and 25.77 cm), the highest diameter of stem (0.87, 1.55, 1.82 and 2.75 cm), the longest leaf (11.36, 20.23, 27.45 and 32.55 cm), the maximum number of branches per plant (1.40, 2.87, 3.40 and 4.47), the longest internode (7.81, 9.74, 12.66 and 15.17 cm), the highest fresh weight of leaves per plant (330.61 g), the highest dry matter content of leaves (13.10%), the minimum days required for flowering (34.33), the maximum number of flower buds per plant (33.63), the maximum number of pods per plant (23.82), the longest pod (19.15 cm), the highest diameter of pod (2.18 cm), the highest weight of individual pod (14.63 g) and the highest yield (19.76 t/ha) was observed from N_2P_2, while the shortest (19.34, 38.11, 52.26 and 62.50 cm), the minimum number of leaves per plant (7.35, 16.75, 27.30 and 30.55), the shortest petiole (6.13, 10.37, 12.22 and 14.56 cm), the lowest diameter of stem (0.62, 1.16, 1.31 and 1.33 cm), the shortest leaf (7.63, 12.56, 13.75 and 14.17 cm), the minimum number of branches per plant (1.00, 1.27, 1.87 and 2.27), the shortest internode (4.53 cm, 5.57 cm, 7.10 cm and 7.48 cm), the lowest weight (225.16 g), the lowest dry matter content of leaves (6.90%), the maximum days required for flowering (46.67), the minimum number of flower buds per plant (22.30), the minimum number of pods per plant (16.23), the shortest pod (11.50 cm), the lowest diameter of pod (1.37 cm), the lowest weight of individual pod (11.40 g) and the lowest yield (10.74 t/ha) was recorded from N_0P_0.

The highest gross return (Tk. 395,200), the highest net return (Tk. 212,844) and The highest benefit cost ratio (2.17) was obtained from the treatment combination N_2P_2 and the lowest gross return (Tk. 214,800), the lowest net return (Tk. 42,436) and the lowest benefit cost ratio (1.25) was obtained from N_0P_0. From economic point of view, it is apparent from the above results that the combination of N_2P_2 was more better than rest of the combination.

Conclusion:

Considering the growth parameters, yield and economic point of view, it is apparent that the combination of N_2P_2 was more better than rest of the combination.

Recommendation:

Considering the situation of the present experiment, further studies in the following areas may be suggested:

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

2. Another experiment may be carried out with different fertilizers and manure with different levels.

3. The experiment was conducted only for one growing season, so such type of research works maybe needed in another season for more confirmation of the results.

REFERENCES

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

Akanbi, W.B., Togun, A.O., Adediran, J.A. and Ilupeju, E.A.O. 2010. Growth, dry matter and fruit yields components of okra under organic and inorganic sources of nutrients. *American Eurasian J. Sust. Agric*., **4**(1): 1-13.

Akinrinde, E.A. and Adigun, I.O. 2005. Phosphorus-use efficiency by pepper (*Capsicum frutescens*) and okra (*Abelmoschus esculentus*) at different phosphorus fertilizer application levels on two tropical soils. *J. Appl. Sci*., **5**(10): 1785-1791.

Alam, M.S., Iqbal, T.M.T., Amin, M. and Gaffar, M.A. 1989. Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T.M. Jubair Bin Iqbal, Sirajgonj. pp. 231-239.

Ambare, T.P., Gonge, V.S., Rewatkar, S.S., Anjali, M., Shelke, T.S. 2005. Influence of nitrogen levels and varieties on yield and quality of okra. *Crop Res. Hisar*., **30**(1): 80-82.

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

Arora, S.K., Narinder, K., Sharma, B.R. and Kumar, N. 1991. Effect of nitrogen and phosphorus and fertilizer on growth and yield components in okra *(Abelmoschus esculentus* L. Moench). *Haryana J. Hort. Sci.*, **13**(2): 8-11.

Awe, O.A., Abdulsalam, R.A. and Ogunsola, O.A. 2009. Influence of NPK 20-10-10 fertilizer on the pod yield and root growth of okra in the humid tropics. *Nigerian J. Soil Sci*., **19**(2): 140-144.

BBS. 2011. Monthly Statistical Bulletin of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning. Government of the People's Republic of Bangladesh, Dhaka. p. 42.

Bhai, K.L. and Singh, A.K. 1998. Effect of different levels of phosphorus, GA_3 and picking on seed production of okra *(Abelmoschus esculentus* L. Moench*). Indian J. Sci.*, **38**(3-4): 119-122.

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

Candido, W.S., Oliveira, F.A., Silva, R.C.P., Medeiros, J.F. and Silva, O.M.P. 2011. Initial development of okra nitrogen fertilization in different ammonium/nitrate. *Agro Eco. Dev. Sust*., **6**(1): 28-35.

Chattopadhyay, A. and Sahana, B.C. 2000. Response of okra seed crop to nitrogen and phosphorus fertilization in acidic soil of Old Alluvial Zone, West Bengal. *Res. Crops*. **1**(2): 176-180.

El-Shaikh, K.A.A. 2005. Effect of phosphorus and potassium fertilization on green yield, seed production and quality of two okra cultivars in reclaimed soils. *Assiut J. Agril. Sci*., **36**(1): 51-68.

Emebiri, L.C., Obiefuna, J.C., Abanij, M.S.C. and Ikpor, M.N. 1992. Growth, yield and yield component responses of three okra cultivars [*Abelmoschus esculentus* (L.) Moench] to nitrogen fertilization in the humid tropics. *Beitra. Trop. Land. Veteri*., **30**(1): 47-58.

Fertilizer Recommendation Guide. (2005). Bangladesh Agriculture Research Council (BARC), Farmgate, Dhaka. 219p.

Ganeshe, R.K., Pandey, R.P. and Rawat, A.K. 1998. Influence of biofertilizers and nitrogen on growth, yield, shelf life and economics of okra (*Abelmoschus esculentus* L. Moench). *JNKVV Res. J*., **32**(1-2): 33-37.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research (2nd edn.). *Int. Rice Res. Inst., A Willey Int. Sci*., 3: 28-192.

Gowda, K.P., Mohanta, B.K. and Bharma, R.J. 2001. Effect of nitrogen, spacing and green fruit pickings on the seed production of okra *(Abelmoschus esculentus* L. Moench*). Veg. Sci*., **15**(1): 8-14.

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

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

Islam, J.K. and Noor, S.P. 1982. Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh. *Pakistan J. Sci. Res*., **34** (3-4): 113-119.

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

Jana, J.C., Guha, S. and Chatterjee, R. 2010. Effect of planting geometry and nitrogen levels on crop growth, fruit yield and quality in okra grown during early winter in terai zone of West Bengal. *J. Hort. Sci*., **5**(1): 30-33.

Khan, A.H., Singh, A.K. and Singh, V.B. 2007. Response of okra to biofertilizers and nitrogen fertilization in relation to growth, yield and leaf nutrient status in foothill condition of Nagaland. *Environ. Ecol*., **25**(1): 109-112.

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

Kurup, P. and Gupta, A., Srinivas, K. and Shukla, V. 1997. Response of okra *(Abelmoschus esculentus* L. Moench*)* to plant spacing and nitrogen, phosphorus fertilization. *Indian J. Hort., Sci.,* **38**(3-4):218-222.

Laxman, S., Dhaka, R.S. and Mukherjee, S. 2004. Flowering and fruiting of okra [*Abelmoschus esculentus* (L.) Moench] as influenced by application of nitrogen, phosphorus and gibberellic acid. *J. Eco Physiol.*, **7**(3/4): 181-185.

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

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

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

Manga, A.A. and Mohammed, S.G. 2006. Effect of plant population and nitrogen levels on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench]. *Adv. Hort. Sci*., **20**(2): 137-139.

Mani, S. and Ramanthan, K.M. 1980. Effect of nitrogen and potassium on the yield of behind fruit. *South Indian Hort*., **28**(4): 136-138.

Mishra, D.N. and Singh, L.R. 2006. Effect of N, P fertilization on the performance and production economics of rainfed okra intercropped with tomato under mid-hill condition of Uttranchal. *Environ. Ecol*., **24**(Special 3): 546-550.

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

Mohanta, H.C. 1998. Effect of phosphorus and genotype on the yield and yield contributing characters of okra (*Abelmoschus esculentus* L. Moench). *Fert. Res.*, **6**(3): 257-267.

Muhammad, A., Anjum, M.A. and Ahmed, A. 2001. Effect of phosphorus and planting density on seed production in okra (*Abelmoschus esculentus* L. Moench). *Internl. J. Agric. Biol.*, **3**(4): 380-383.

Naik, L.B. and Srinivas, K. 1992. Influence of nitrogen and phosphorus fertilization on seed crop of okra (*Hibiscus esculentus*). *Indian J. Agron.*, **37**(4): 769-771.

Nirmal, D., Singh, B., Mathura, R. and Kalloo, G. 2005. Phosphate dynamics in okra (*Abelmoschus esculentus* L. Moench). *Veg. Sci.*, **32**(2): 154-157.

Obreza, T.A. and Vavrina, C.S. 1993. Production of vegetable in relation to nitrogen Source, Rate and Leaf nutrient concentration in Soil Science and Plant Analysis. **24**: 13-14.

Ogbaji, M.I. 2002. Response of okra to nitrogen and potassium fertilizers in a Southern Guinea savannah agro-ecological location. *J. Sus. Agric. Envir.*, **4**(1): 17-22.

Omotoso, S.O. and Shittu, O.S. 2007. Effect of NPK fertilizer rates and method of application on growth and yield of okra (*Abelmoschus esculentus*) at Ado-Ekiti southwestern, Nigeria. *Internl. J. Agric. Res.*, **2**(7): 614-619.

Opena, R.T., Kuo, C.C. and Yoon, J.Y. 1988. Breeding and Seed Production of okra in the Tropics and Subtropics. *Tech. Bul.* 17, AVRDC. p. 97.

Patton, W., Sema, A. and Maiti, C.S. 2002. Effect of different levels of nitrogen and phosphorus on growth, flowering and yield of okra cv. Arka Anamika grown under the foothills of Nagaland. Dept. Hort. SASRD, *Nagaland Univ. J. Hort*., **15**(1): 81-88.

Purseglove, J.W. 1987. Tropical crops dicotyledons. Longman Singapore publishers (Ptv.) Ltd. pp. 369.

Rain, K.M. and Lal, M.L. 1999. Effect of 4 (four) fertilizer level on the growth and development of okra cultivars (Parbani Kranti, Arka Anamika and Pusa Sawani). *Haryana J. Hort. Sci.,* **9**: 3-14.

Rajpaul, C., Kapoor, A.K. and Sharma, S.K. 2006. Effect of saline water, FYM and phosphorus on the performance of different varieties of okra. *Haryana J. Agron*., **22**(1): 98-100.

Ramphall, C. and Gill, H.S. 1990. Demand and supply of vegetables and pulses in South Asia. In: Vegetable research and development in South Asia: Proceeding of a workshop held at Islamabad, Pakistan, 24-29 September, 1990. Shanmugasundaram (ed). AVRDC publication no. 90-331. AVRDC, Tainan, Taiwan.

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

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

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

Reddy, P.S., Veeraraghavaiah, R. and Subrahmanyam, K. 1984. Effect of nitrogen and phosphorus on fruit yield of okra. *South Indian Hort.,* **32**(5): 304-305.

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

Savello, P.A., Mortin, F.W. and Hill, J.M. 1980. Nutritional composition of okra seed meal. *Agril food Chem*., **28**: 1163-1166.

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

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

Singh, K.V., Singh, M.K. and Singh, B. 2007. Response of macro and micro-nutrients on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] cv. Pusa Sawani. *Prog. Agric*., **7**(1/2): 63-65.

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

Soni, N., Bharad, S.G., Gonge, V.S., Nandre, D.R. and Ghawade, S.M. 2006. Effect of spacing and nitrogen levels on growth and seed yield of okra. *Internl. J. Agril. Sci*., **2**(2): 444-446.

Sunita, K., Prasad, K.K., Chowdhary, B.M. and Singh, S.K. 2006. Effect of intercrop and NPK fertilization of performance of okra (*Abelmoschus esculentus* L. Moench). *J. Res. Birsa Agric. Univ*., **18**(2): 251-255.

Supatra, S. and Mukherji, S. 2004. Alterations in activities of acid phosphatase, alkaline phosphatase, ATPase and ATP content in response to seasonally varying Pi status in okra (*Abelmoschus esculentus*). *J. Envir. Biol*., **25**(2): 181-185.

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

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

UNDP. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome. pp. 212, 577.

Uwah, D.F., Nwagwu, F.A. and Iwo, G.A. 2010. Response of okra (*Abelmoschus esculentus* (L.) Moench) to different rates of nitrogen and lime on an acid soil. *Internl. J. Agric. Sci*., **2**(2): 14-20.

Verma, I.M. and Batra, B.R. 2001. Effect of irrigation and nitrogen on growth and yield in okra. Changing scenario in the production systems of horticultural crops. Proceedings of a National Seminar, Coimbatore, Tamil Nadu, India, 28-30 August 2001. *South Indian Hort*., **49**(Special): 386-388.

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

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

Yogesh, M.D. and Arora, S.K. 2001. Effect of N, P and sowing date on okra (cv. Parbani Kranti) yield. *Indian J. Agron*., **36**(9): 81-86.