EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWHT AND YIELD OF OKRA

NAZMUN NAHAR

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR, DHAKA-1207

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NAZMUN NAHAR

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Approved by:

Prof. Md. Hasanuzzaman Akand
Dept. of Horticulture
Sher-e-Bangla Agricultural University
Dhaka - 1207
Supervisor

Prof.Dr.Md.Ismail Hossain
Dept. of Horticulture
Sher-e-Bangla Agricultural University
Dhaka - 1207
Co-supervisor

Prof. Abul Faiz Md. Jamal Uddin (Ph.D.)
Chairman
Exanimation Committee

DEPARTMENT OF HORTICULTURE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Memo No……… Date…………

CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF OKRA"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* ***NAZMUN NAHAR****, Registration number:* ***08-03021*** *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 duly been acknowledged.

Dated: December, 2014
Dhaka, Bangladesh

Prof. Md. Hasanuzzaman Akand
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

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ABSTRACT

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March - August 2014, to find the effect of nitrogen and phosphorus on growth and yield of okra. BARI Dherosh-1 was used as test crop in the experiment. The experiment was laid out in Randomized Complete Block Design with three replications and was consisted of two factors. Nitrogen fertilizer as N_0: 0, N_1: 115, N_2: 135 and N_3: 155 kg N/ha and Phosphorus fertilizer as P_0: 0; P_1: 70; P_2: 90 and P_3: 110 kg P_2O_5/ha respectively. All the parameters were significantly influenced by different levels of nitrogen and phosphorus. Due to the effect of nitrogen, the highest yield (16.50 t/ha) was observed from N_2 and the lowest yield (12.40 t/ha) from $N_{0.}$ In case of phosphorus, the highest yield (17.05 t/ha) was found from P_2 and the lowest yield (11.30 t/ha) from $P_{0.}$ For combined effect, the highest yield (19.86 t/ha) was found from N_2P_2 and the lowest yield (10.84 t/ha) from N_0P_0. So 135 kg N/ha with 90 kg P_2O_5/ha was the suitable combination for okra production.

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ABBREVITIONS	ELABORATIONS
%	Percent
@	At the rate
AEZ	Agro Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
ANOVA	Analysis of Variance
ATP	Adenosine Tri Phosphate
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CGR	Crop Growth Rate
Cm	Centi-meter
CV%	Percentage of Coefficient of Variation
DAS	Days After Sowing
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
DS	Diameter of the Stem
EC	Emulsifiable Concentration
et al.	and others
etc.	Etcetera
FYM	Farm Yard Manure
g	gram
HI	Harvest Index
J.	Journal
Kg/ha	Kilograms per hectare
kg	kilogram
LA	Leaf Area
LAI	Leaf Area Index
LSD	Least Significant Difference
m^2	Square meter
MP	Murate of Potash
NAR	Net Assimilation Rate
NO.	Number
ppm	parts per million
RCBD	Randomized Complete Block Design
Res.	Research
SAARC	South Asian Association for Regional Co-operation
SAU	Sher - e- Bangla Agricultural University
TSP	Triple Super Phosphate
Sc.	Science
UNDP	United Nation Development Programme

CHAPTER I

INTRODUCTION

Okra(*Abelmoschus esculentus* L.) Moench is a nutritious popular vegetable belongs to the family Malvaceae and locally it is known as “Dherosh” or “Bhindi”. 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 are rich sources of vitamins and minerals. Tender green pods of okra contains approximately 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Purseglove, 1987). In Bangladesh the total production of okra is about 246 thousand tons which was produced from 7287.5 hectare of land in the year 2010 with average yield about 3.38 t/ha which is very low (BBS, 2011) which is very low compared to that of other developed countries where the yield is as high as 7.0-12.0 t/ha (Yamaguchi, 1998).

It is an annual vegetable crop grown from seed in tropical and sub-tropical parts of the world (Tahkur and Arora, 1986). 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, 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. Although, many dietitians prescribed that the daily requirements of vegetables for an adult person is approximately 285g (Rampal and Gill, 1990). Therefore, there is a big gap between the requirement and consumption of per capita vegetable 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.

Nitrogen is the key element to the vegetative growth of plants. It plays an important role to build up the protoplasm and protein which induce cell division and initiate meristematic activities when applied optimum quantity. Uwah *et al*. (2010) reported that 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 of okra. Nitrogen plays a vital role as a constituent of protein, nucleic acid and chlorophyll. 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 (P) 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 Arora, 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 influence in fruiting development (Mohanta, 1998).

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 & 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 now 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 vegetable crops (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.

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

- To find out the optimum level of nitrogen on the growth and yield of okra;
- To determine the optimum level 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 nitrogen and phosphorus for the best growth and yield of okra. However, very 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 re 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-NH_4 +/N-NO_3- ratio, equivalent to 0/100; 25/75; 50/50; 75/25 and 100/0. In I begin it of the flowering the plants were collected and appraised as for the matter accumulation it dries of the aerial part (MDAP), of the system root (MSR) and total (MDT), leaf area (LA), diameter of the stem (DS), height (H) and reason of leaf area (RFA). 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.

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 $plant^{-1}$ (13.7), individual fruit weight (18.5 gm), fruit yield $plant^{-1}$ (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.

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* 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. The 80 kg N/ha rate maximized all the growth and yield attributes.

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.

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 results 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.

A field experiment was conducted by Singh *et al*. (2007) in 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 4 plant populations and 4 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 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 Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *kharif* season of 2002-03 to study the five levels of nitrogen viz., 0, 25, 50, 75 and 100 kg ha^{-1} and four varieties of okra 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).

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.

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.

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.

An experiment was conducted by Jalal-ud-Din *et al.* (2002) to observe the effect of different doses of nitrogen on the growth and yield of okra (*Abelmoschus esculentus* L.) 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.

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) applied in 3 (basal, 30 and 45 days after sowing (DAS)), 5 (basal, 30, 45, 60 and 75 DAS) and 7 (basal, 30, 40, 50, 60, 70 and 80 DAS) split rates. The 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) a field experiment was conducted in Bangalore, Karnataka, India during the 1999 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 (20.40g), stems (35.17g), roots (18.03g), fruits (31.11g) and whole plants (104.71 g) was recorded with 175:125:100 kg NPK/ha treatments. Varsha recorded significantly higher dry matter production in leaves (17.48g), stems (31.44g), roots (17.61g), fruits (29.98g) 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, during 20 March – 8 July 1997 studied the growth and development of 3 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/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 (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, during 20 March – 8 July 1997 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 (LAI) and leaf area duration (LAD) 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.

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.

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.

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.

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.

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.

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 Arora (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

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.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during the period from March - August 2014 to find the growth and yield of okra as influenced by nitrogen and phosphorus. The materials and methods that were used for conducting the experiment have been presented in this chapter. This chapter includes a brief description of the location of experimental site, climate and soil condition of the experimental plot, materials used for the experiment, design of the experiment, data collection procedure and procedure of data analysis.

3.1 Location of the experimental site

The experiment was carried out Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka. It was located in 24.09^0N latitude and 90.26^0E longitudes. The altitude the location will be 8 m from the sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207.

3.2 Climatic condition of the experimental site

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

3.3 Soil characteristics of the experimental site

Selected land was utilized for crop production during the previous season and it was medium high land in nature with adequate irrigation facilities. The soil is belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The soil texture of the experimental plot of soil was sandy loam. The status of nutrient in the experimental plot of soil with in a depth 0-20 cm were collected and analyzed in the Soil Research and Development Institute 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 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Levels of Nitrogen fertilizer

i N_0: 0 kg N/ha (control)

ii. N_1: 115 kg N/ha

iii. N_2: 135 kg N/ha

iv. N_3: 155 kg N/ha

Factor B: Levels of Phosphorus fertilizer

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

ii. P_1: 70 kg P_2O_5/ha

iii. P_2: 90 kg P_2O_5/ha

iv. P_3: 110 kg P_2O_5/ha

All together there were 16 (4 × 4) treatments combination in the experiment 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.The treatments were replicated thrice (3).

3.6 Collection of seeds

The seeds of okra were collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.7 Land preparation

The plot selected for conducting the experiment was opened in the 23 March, 2014 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 until 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 for furnish germination of seeds. The soil was treated with insecticides (cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect against the insects such as cutworm and mole cricket to young plants.

3.8 Application of manure and fertilizers

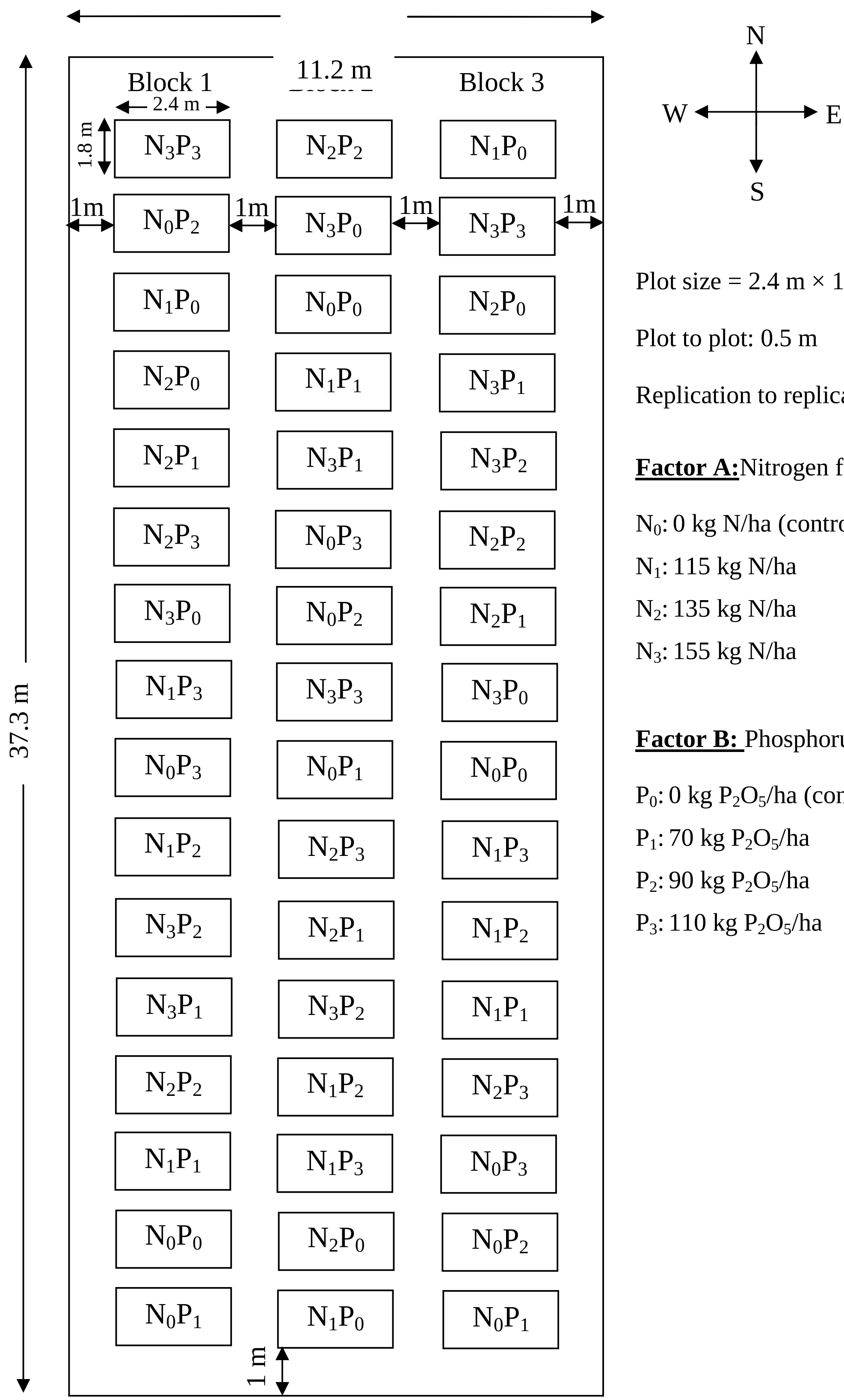
Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, TSP and MP was applied as basal dose at the time of final land preparation dated at 31 March, 2014. Urea were applied at 15, 30 and 45 days after sowing (DAS).

Table 1. Dose and method of application of fertilizers in okra field (Fertilizer Recommendation, BARC, 1997)

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 factorial 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 37.3 m length and 11.2 m. width. 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 with 3 replications. The size of the each plot was 2.4 m × 1.8 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experimental plot is shown in Figure 1.



Plot size = 2.4 m × 1.8 m

Plot to plot: 0.5 m

Replication to replication: 1.0 m

Factor A: Nitrogen fertilizer

N_0: 0 kg N/ha (control)

N_1: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

Factor B: Phosphorus fertilizer

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

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 2014. Bavistin was used to treat the seeds to control the soil borne diseases. The seeds were sown in the 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 to achieve better yield.

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 by healthy seedlings having a ball of earth which were also sown on the same date by the side of the unit plot. For proper establishment of the seedlings watering was provided for 5 days starting from germination.

3.11.2 Weeding

Weeding was done by nirani at 15, 30 and 45 days after sowing of seeds to keep the plots free from any weeds.

3.11.3 Irrigation

Watering cane was used to provide light watering 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. If cinocarb 3G was applied during final land preparation but 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 4 days interval based on eating quality. Harvesting was started from 22 May, 2014 and was continued up to September 2014.

3.13 Data collection

Five plants were randomly selected from the middle rows of each unit plot for avoiding border effect and was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth; yield attributes and yield 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 and length of internode were collected at 25, 45, 65 and 85 days after sowing (DAS). Fresh weight of leaves per plant and dry weight per plant was recorded at 85 DAS. All other yield contributing characters and yield parameters such as required days to flowering, number of flower per 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 up to the tip of the longest stem of five plants and mean value was calculated. Plant height was also recorded at 25 days interval starting from 20 days after sowing (DAS) up to 85 days to measure 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 25 DAS to 85 DAS at 20 days interval.

3.13.3 Length of petiole

Length of petiole was measured from sample plants in centimeter from the one side to another side of petiole of the five longest petiole and mean value was calculated. Length of petiole was also recorded at 20 days interval starting from 20 days after sowing (DAS) up to 80 days to observe the growth rate of 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 25 days after sowing (DAS) up to 85 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 25 days after sowing (DAS) up to 85 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 25 DAS to 85 DAS at 20 days interval.

3.13.7 Length of internode

Length of internode was measured from sample plants in centimeter from the one side to another side of internode and mean value was calculated. Length of internode was also recorded at 20 days interval starting from 25 days after sowing (DAS) up to 85 days to observe the growth rate of plants.

3.13.8 Fresh weight of plant

At 80 DAS 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.

3.13.9 Dry weight of plant

After taking fresh weight, the sample was sliced into very thin pieces and put into envelop then placed in oven maintained at 70^0C for 72 hours. It was then transferred into desiccators and allowed to cool down at room temperature. The final dry weight of the sample was taken by using a digital weighing machine.

3.13.10 Days required to flowering

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

3.13.11 Number of flowers per plant

The number of flowers per plant was counted from the sample plants and the average number of flowers produced per plant were counted.

3.13.12 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.

3.13.13 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.

3.13.14 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.

3.13.15 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.

3.13.16 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 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).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find the growth and yield of okra due to the influence of 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 significantly influenced by the effect of different levels of nitrogen at 25, 45, 65 and 85 DAS (Appendix III). At 25, 45, 65 and 85 DAS, the tallest plant (32.33, 58.26, 79.62 and 88.96 cm) was recorded from N_2 (135kg N/ha) which was statistically similar (31.05, 57.74, 77.35 and 86.55 cm) to N_3 (150 kg N/ha) and closely followed (30.75, 55.70, 70.12 and 83.87 cm) by N_1 (115 kg N/ha), whereas the shortest plant (25.32, 46.70, 65.32 and 75.07 cm) from N_0 (0 kg N/ha i.e. control condition) (Figure 2). It was revealed that with the increase of nitrogen fertilizer plant height increased up to a certain level. Nitrogen ensured favorable condition for the growth of okra plant with optimum vegetative growth and the ultimate results was the tallest plant. Singh *et al*. (2007) recorded maximum plant height with 100 kg N/ha .

Different levels of phosphorus showed significant variation on plant height of okra at 25, 45, 65 and 85 DAS (Appendix III). At 25, 45, 65 and 85 DAS the tallest plant (34.81, 60.31, 83.27 and 89.60 cm) was found from P_2 (90 kg P_2O_5/ha), which was statistically similar (32.80, 57.76, 78.05 and 85.23 cm) to P_3 (110 kg P_2O_5/ha) and closely followed (29.20, 52.70, 72.16 and 81.63 cm) by P_1 (70 kg P_2O_5/ha while the shortest plant (26.99, 47.62, 67.04 and 77.07 cm) was observed from P_0 (0 kg $P_2 O_5$/ha i.e. control condition) (Figure 3). It revealed that with the increase of phosphorus plant height showed increasing trend up to a certain level. Bhai and Singh (1998) reported that application of phosphorus significantly increased the plant height.

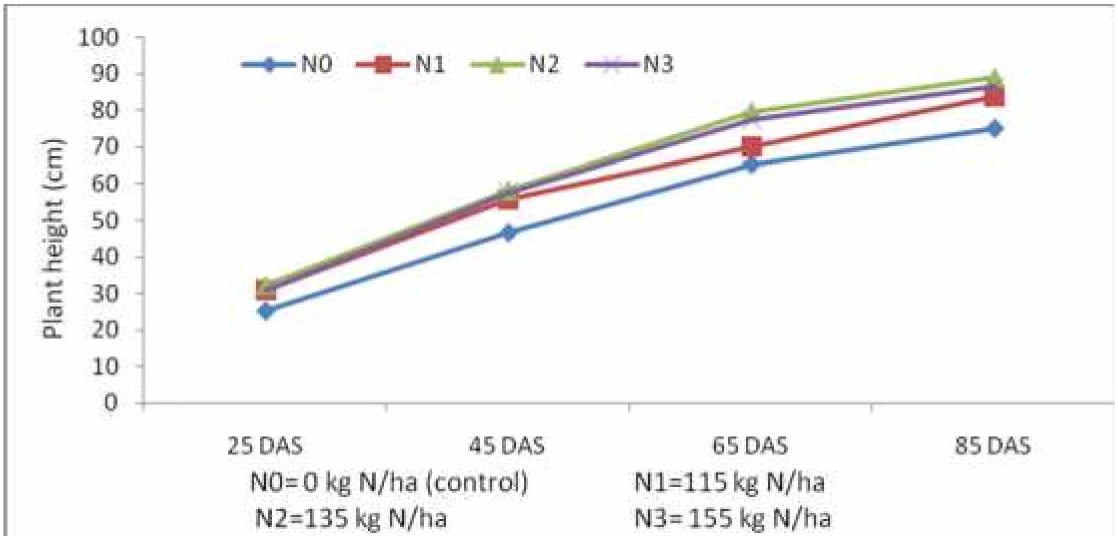


Fig.2. Effect of differnt levels of nitrogen on plant height of okra

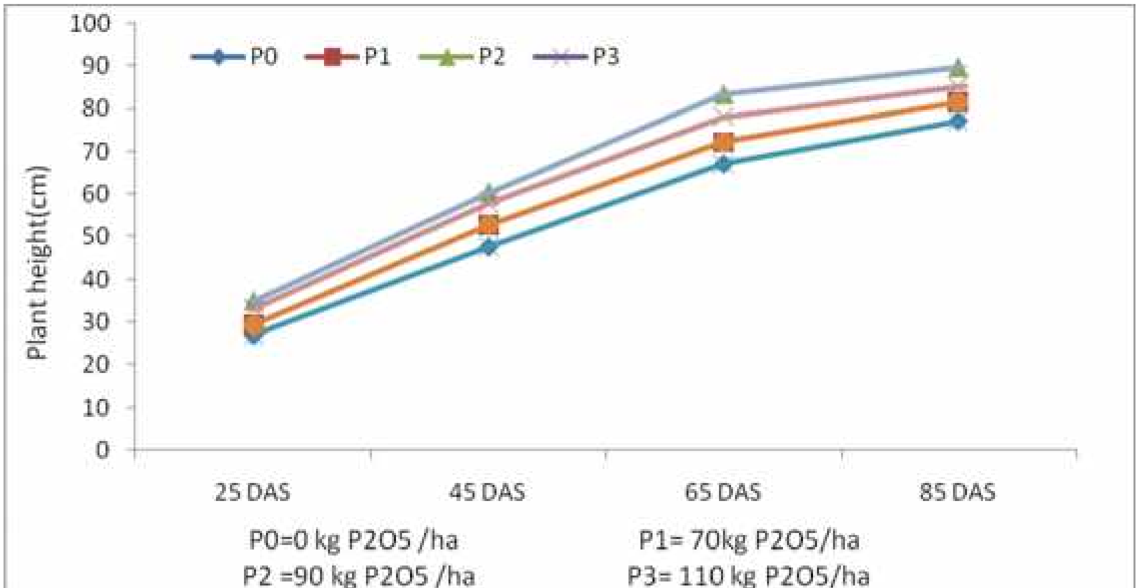


Fig.3 Effect of different levels of phosphorus on plant height of okra

Due to the combined effect of different levels of nitrogen and phosphorus showed significant differences on plant height of okra at 25, 45, 65 and 85 (Appendix III). At 25, 45, 65 and 85 DAS, the longest plant (36.66, 61.34, 87.44 and 99.41 cm) was observed from N_2P_2 (135 kg N/ha and 90 kg P_2O_5/ha), while the shortest (21.36, 40.13, 54.28 and 64.52cm) was recorded from N_0P_0 i.e. control condition (Table 2). Patton *et al.* (2002) reported that nitrogen at 150 kg/ha and P at 90 kg/ha gave the highest plant height (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 observed on number of leaves per plant for different level of nitrogen at 25, 45, 65 and 85 DAS of okra under the present trial (Appendix IV). At 25, 45, 65 and 85 DAS, the maximum number of leaves per plant (9.26, 20.72, 39.66 and 43.89) was recorded from N_2 which was statistically similar (9.20, 20.20, 38.86 and 43.31) to N_3, whereas the minimum number (7.80, 17.60, 33.87 and 35.79) from N_0 (Table 3). Soni *et al*. (2006) reported that number of leaves per plant increased with increasing rates of N up to 125 kg/ha.

Due to the effect of different levels of phosphorus showed significant variation on number of leaves per plant of okra at 25, 45, 65 and 85 (Appendix IV). At 25, 45, 65 and 85 DAS the maximum number of leaves per plant (9.42, 20.54, 40.74 and 46.16) was performed by P_2, which was statistically identical 9.11, 20.29, 39.04 and 46.40) to P_3. On the other hand, the minimum number of leaves per plant (8.01, 18.16, 33.99 and 38.05) was recorded from P_0 (Table 3).

Combined effect of nitrogen and phosphorus showed significant differences on number of leaves per plant of okra at 25, 45, 65 and 85 DAS (Appendix IV). At 25, 45, 65 and 85 DAS the maximum number of leaves per plant (10.47, 23.23, 41.20, and 48.25) found from N_2P_2 and the minimum number (7.37, 16.77, 28.20 and 31.45) from N_0P_0 (Table 4). Patton *et al.* (2002) reported that nitrogen at 150 kg/ha and 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			
	25 DAS	**45 DAS**	**65 DAS**	**85 DAS**
N_0P_0	21.36 h	40.13 g	54.28 g	64.52 f
N_0P_1	23.43 gh	46.61 f	64.02 ef	72.02 d-f
N_0P_2	26.84 fg	49.58 ef	69.26 d-f	79.76 d
N_0P_3	24.65 gh	48.25 ef	65.98 ef	73.81 de
N_1P_0	26.48 fg	49.21 ef	70.94 c-e	79.15 d
N_1P_1	28.62 ef	52.46 de	71.29 c-e	78.14 d
N_1P_2	30.99 c-e	54.56 b-d	77.94 bc	90.29 b
N_1P_3	33.79 a-c	58.16 a-c	78.21 bc	87.73 bc
N_2P_0	23.61 gh	45.68 f	61.45 fg	67.69 ef
N_2P_1	31.83 b-e	56.61 b-d	79.79 ab	90.37 b
N_2P_2	36.66 a	61.34 a	87.44 a	99.41 a
N_2P_3	34.74 ab	59.03 ab	84.01 ab	95.39 ab
N_3P_0	29.42 d-f	54.68 b-d	68.58 ef	80.83 cd
N_3P_1	29.78 d-f	53.86 cd	76.94 b-d	89.12 bc
N_3P_2	32.87 b-d	55.47 b-d	80.89 bc	91.66 ab
N_3P_3	30.56 c-e	54.43 b-d	78.02 bc	89.95 b
$LSD_{(0.05)}$	**3.341**	**4.046**	**7.360**	**8.110**
Significance level	**	**	*	**
CV(%)	**8.26**	**9.52**	**7.77**	**8.08**

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) — P_0: 0 kg P_2O_5/ha (control)

N_1: 115 kg N/ha — P_1: 70 kg P_2O_5/ha

N_2: 135 kg N/ha — P_2: 90 kg P_2O_5/ha

N_3: 155 kg N/ha — P_3: 110 kg P_2O_5/ha

Table3. Effect of different levels of nitrogen and phosphorus on number of leaves per plant of okra

Treatments	Number of leaves per plant at			
	25 DAS	45 DAS	65 DAS	85 DAS
Level of Nitrogen				
N_0	7.80 b	17.60 b	33.87 b	35.79 c
N_1	8.95 a	20.38 a	39.13 a	42.33 b
N_2	9.26 a	20.72 a	39.66 a	43.89 a
N_3	9.20 a	20.20 a	38.86 a	43.31 ab
$LSD_{(0.05)}$	**0.472**	**0.783**	**1.889**	**1.501**
Significance level	**	**	**	**
Level of Phosphorus				
P_0	8.01 c	18.16 b	33.99 b	38.05 c
P_1	8.64 b	19.83 a	39.82 a	43.82 b
P_2	9.42 a	20.54 a	40.74 a	46.16 a
P_3	9.11 a	20.29 a	39.04 a	46.40 a
$LSD_{(0.05)}$	**0.472**	**0.870**	**3.342**	**2.030**
Significance level	**	**	**	**
CV(%)	**6.87**	**8.35**	**9.27**	**8.80**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 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			
	25 DAS	**45 DAS**	**65 DAS**	**85 DAS**
N_0P_0	7.37 f	16.75 h	28.20 f	31.45 h
N_0P_1	7.82 ef	18.82 fg	34.06 de	38.26 fg
N_0P_2	8.43 c- e	19.71 e-g	34.72 de	39.05 e-g
N_0P_3	7.90 ef	19.11 fg	33.73 cd	37.85 fg
N_1P_0	8.30 d -f	20.84 c-e	36.21 bc	40.37 ef
N_1P_1	8.63 c - e	21.12 b-e	38.08 ab	41.88 de
N_1P_2	9.37 bc	21.44 b-e	38.88 ab	46.25 a-c
N_1P_3	9.83 ab	22.17 a-d	38.80 e	44.25 cd
N_2P_0	7.70 ef	18.71 g	32.28 e	37.06 g
N_2P_1	9.38 bc	22.31 a-c	40.34 ab	45.86 a-c
N_2P_2	10.47 a	23.23 a	41.20 a	48.25 a
N_2P_3	9.86 ab	22.71 ab	40.27 ab	47.85 ab
N_3P_0	9.03 b -d	20.44 d-f	34.61 de	38.65 fg
N_3P_1	9.10 b-d	21.17 b-e	38.15 bc	44.84 b-d
N_3P_2	9.77 ab	21.91 a-d	39.46 ab	46.39 a-c
N_3P_3	9.23 b-d	20.32 b-e	38.67 a-c	46.97 a-c
$LSD_{(0.05)}$	**0.878**	**1.582**	**2.336**	**2.957**
Significance level	*	*	*	*
CV(%)	**6.87**	**8.35**	**9.27**	**8.80**

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: 115 kg N/ha
N_2: 135 kg N/ha
N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)
P_1: 70 kg P_2O_5/ha
P_2: 90 kg P_2O_5/ha
P_3: 110 kg P_2O_5/ha

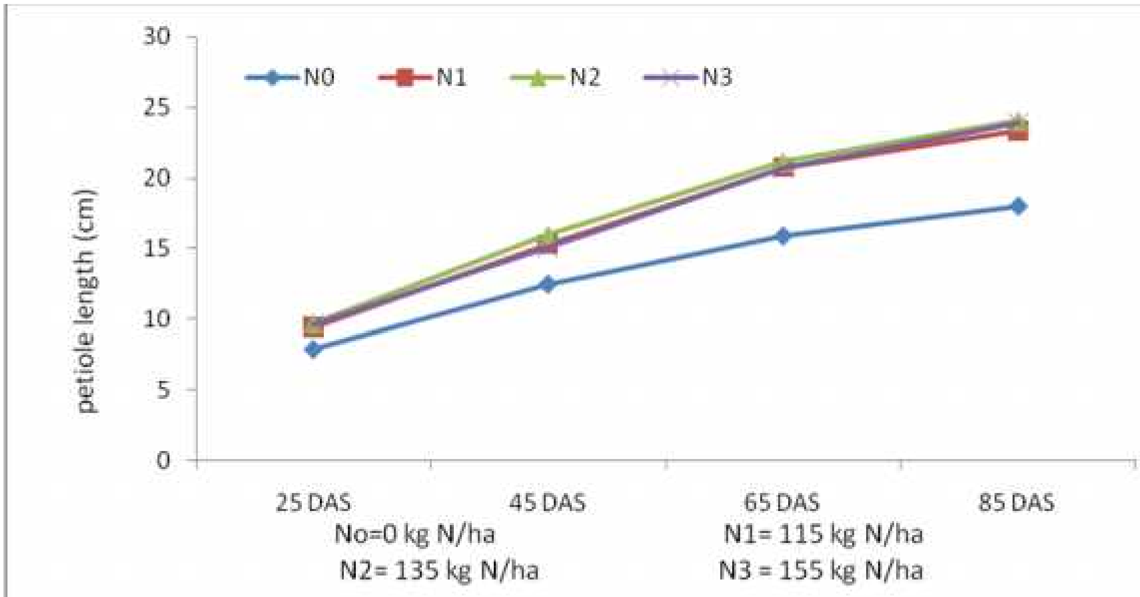


Fig. 4 Effect of different levels of nirogen on petiole length of okra

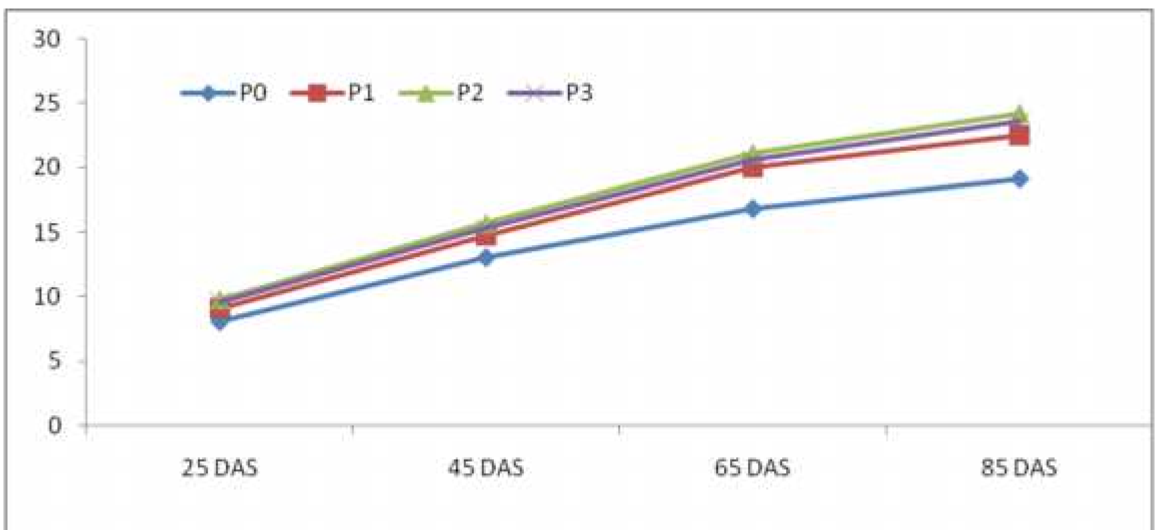


Fig.5 Effect of different levels of phoshorus on petiole length of okra

4.3 Length of petiole

Nitrogen varied significantly on length of petiole at 25, 45, 65 and 85 DAS of okra (Appendix V). At 25, 45, 65 and 85 DAS, the longest petiole (9.70, 15.96, 21.15 and 24.08 cm) was recorded from N_2 which was statistically similar to N_3 (9.60, 15.09, 20.73 and 23.97 cm) and N_1 (9.45, 15.32, 20.35 and 23.36 cm) whereas the shortest petiole (7.87, 12.48, 15.90 and 18.02 cm) from N_0 (Figure 4). 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 25, 45, 65 and 85 DAS (Appendix V). At 25, 45, 65 and 85 the longest petiole (9.78, 15.71, 21.10 and 24.23 cm) was recorded from P_2, which was statistically similar (9.60, 15.35, 20.62 and 23.56 cm) to P_3 and closely followed (9.05, 14.75, 19.99 and 22.52 cm) by P_1, while the shortest petiole (8.19, 13.04, 16.82 and 19.12 cm) was obtained from P_0 (Figure 5).

Significant variation was recorded due to combined effect of different levels of nitrogen and phosphorus on petiole length of okra at 25, 45, 65 and 85(Appendix V). At 25, 45, 65 and 85 DAS the longest petiole (10.18, 18.03, 23.57 and 26.79 cm) was found from N_2P_2, while the shortest petiole (7.10, 11.40, 13.24 and 15.58 cm) was obtained from N_0P_0 (Table 5).

4.4 Diameter of stem

Diameter of stem varied significantly for different level of nitrogen at25, 45, 65 and 85 DAS of okra (Appendix VI). At 25, 45, 65 and 85 DAS the maximum diameter of stem (0.93, 1.39, 1.64 and 2.36 cm) was found from N_2 which was closely followed by (0.86, 1.26, 1.55 and 2.20 cm) by N_3 , while the lowest diameter of stem (0.78, 1.15, 1.37 and 1.65cm) from N_0 (Table 6). Singh *et al*. (2007) recorded the 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			
	25 DAS	**45DAS**	**65 DAS**	**85 DAS**
N_0P_0	7.10 g	11.40 i	13.24 g	15.58 g
N_0P_1	7.77 fg	12.47 hi	16.50 f	18.78 f
N_0P_2	8.53 ef	13.49 gh	17.28 f	19.33 f
N_0P_3	7.93 fg	12.63 hi	16.61 f	18.45 f
N_1P_0	8.51 ef	14.59 e-g	19.83 de	21.84 de
N_1P_1	9.00 de	14.98 d-f	20.06 c-e	22.28 cd
N_1P_2	9.82 a-d	15.41 c-f	21.63 a-d	25.19 ab
N_1P_3	10.32 ab	16.41 b-d	21.51 a-d	24.15 bc
N_2P_0	7.75 fg	12.13 hi	16.11 f	18.98 f
N_2P_1	9.84 a-d	16.64 bc	22.09 a-c	24.58 b
N_2P_2	10.18 a-c	18.03 a	23.57 a	26.79 a
N_2P_3	10.47 a	17.11 ab	22.86 ab	26.01 ab
N_3P_0	9.24 c-e	14.12 fg	18.12 ef	20.13 ef
N_3P_1	9.43 b-e	15.00 d-f	21.33 b-d	24.46 b
N_3P_2	10.43 a	15.02 b-e	21.98 a-d	25.67 ab
N_3P_3	9.52 a-d	15.34 c-f	21.54 a-d	25.66 ab
$LSD_{(0.05)}$	**0.842**	**1.300**	**1.901**	**1.960**
Significance level	**	**	**	**
CV(%)	**7.91**	**8.75**	**8.13**	**6.89**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 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			
	25 DAS	**45 DAS**	**65 DAS**	**85 DAS**
Level of Nitrogen				
N_0	0.78 c	1.15 c	1.37 c	1.65 c
N_1	0.87 b	1.27 b	1.57 b	2.07 b
N_2	0.93 a	1.39 a	1.64 a	2.36 a
N_3	0.86 b	1.26 bc	1.55 b	2.20 ab
$LSD_{(0.05)}$	**0.044**	**0.082**	**0.057**	**0.104**
Significance level	**	**	**	**
Level of Phosphorus				
P_0	0.82 c	1.18 b	1.32 c	1.65 d
P_1	0.90 b	1.38 a	1.54 b	2.07 c
P_2	0.95 a	1.41 a	1.66 a	2.36 a
P_3	0.89 b	1.35 ab	1.58 b	2.20 b
$LSD_{(0.05)}$	**0.019**	**0.072**	**0.065**	**0.102**
Significance level	**	**	**	**
CV(%)	**8.18**	**8.91**	**7.70**	**8.16**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

Significant variation was recorded for different levels of phosphorus on diameter of stem at 25, 45, 65 and 85 DAS (Appendix VI). At 25, 45, 65 and 85 DAS the highest diameter of stem (0.95, 1.41, 1.66 and 2.36 cm) was recorded from P_2, which was closely followed (0.89, 1.35, 1.58 and 2.20 cm) by P_3, while the lowest diameter (0.82, 1.18, 1.32 and 1.65 cm) was performed by P_0 (Table 6).

There were significant differences observed on stem diameter of okra due to the combined effect of nitrogen and phosphorus at 25, 45, 65 and 85 DAS (Appendix VI) . At 25, 45, 65 and 85 DAS, the highest diameter of stem (0.92, 1.59, 1.86 and 2.82 cm) was found from N_2P_2 whereas, the lowest diameter of stem (0.67, 1.20, 1.35 and 1.40 cm) was recorded from N_0P_0 (Table 7).

4.5 Length of leaf

Significant variation was recorded on length of leaf for different levels of nitrogen at 25, 45, 65 and 85 DAS (Appendix VII). At 25, 45, 65 and 85DAS, the longest leaf (11.58, 18.62, 25.23 and 29.80 cm) were found from N_2 which was statistically similar (11.29, 17.50, 24.63 and 28.00 cm) to N_3, while the shortest leaf (9.70, 14.70, 18.34 and 21.50 cm) was recorded from N_0 (Table 8). Singh *et al*. (2007) recorded the longest leaf with 100 kg N/ha (Table 8).

Length of leaf of okra showed significant variation for different levels of phosphorus at 25, 45, 65 and 85 DAS (Appendix VII). At 25, 45, 65 and 85 DAS the longest leaf (11.50, 18.54, 26.01 and 30.52 cm) was obtained from P_2, which was statistically similar (11.26, 18.45, 24.73 and 29.65 cm) to P_3 and closely followed (10.75, 17.20, 23.98 and 26.96 cm) by $P_1$and the shortest leaf (9.60, 15.20, 18.67 and 21.03 cm) was found from P_0 (Table 8).

Due to combined effect of different levels of nitrogen and phosphorus showed significant differences on leaf length of okra at 25, 45, 65 and 85DAS. (Appendix VII). At 25, 45, 65 and 85 DAS the longest leaf (12.38, 21.25, 29.47 and 34.57 cm) was recorded from N_2P_2 and the shortest leaf (8.65, 13.58, 15.77 and 16.18) was recorded from N_0P_0 (Table 9).

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

Treatments	Stem diameter (cm) at			
	25 DAS	**45 DAS**	**65 DAS**	**85 DAS**
N_0P_0	0.67 f	1.20 d	1.35 e	1.40 g
N_0P_1	0.73 ef	1.22 cd	1.41 de	1.75 f
N_0P_2	0.78 de	1.21 cd	1.50 d	1.98 d-f
N_0P_3	0.71 f	1.19 d	1.44 de	1.81 ef
N_1P_0	0.72 f	1.21 cd	1.40de	2.03 de
N_1P_1	0.83 b-d	1.36 b-d	1.54 c	2.18 cd
N_1P_2	0.91 a	1.35 b-d	1.79ab	2.46 b
N_1P_3	0.81 cd	1.30 cd	1.72 bc	2.41 bc
N_2P_0	0.80 cd	1.23 cd	1.45de	1.63 f
N_2P_1	0.88 ab	1.35 b-d	1.74 a-c	2.44 b
N_2P_2	0.92 a	1.59 a	1.86 a	2.82 a
N_2P_3	0.87 ab	1.48 ab	1.76 a-c	2.62 ab
N_3P_0	0.79 de	1.25 cd	1.39 de	1.82 ef
N_3P_1	0.83b-d	1.37 bc	1.67 bc	2.36 bc
N_3P_2	0.84 bc	1.29 cd	1.77 a-c	2.60 ab
N_3P_3	0.80 cd	1.17 d	1.65 c	2.41 bc
$LSD_{(0.05)}$	**0.0555**	**0.144**	**0.119**	**0.236**
Significance level	**	**	**	**
CV(%)	**8.18**	**8.91**	**7.70**	**8.16**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 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			
	25 DAS	**45 DAS**	**65 DAS**	**85 DAS**
Level of Nitrogen				
N_0	9.70 c	14.70 c	18.34 b	21.50 b
N_1	10.97 b	17.69 b	24.31 a	28.42 a
N_2	11.58 a	18.62 a	25.23 a	29.80 a
N_3	11.29 ab	17.50 ab	24.63 a	28.00 a
$LSD_{(0.05)}$	**0.615**	**1.15**	**2.205**	**4.531**
Significance level	**	**	**	**
Level of Phosphorus				
P_0	9.60 c	15.20 c	18.67 c	21.03 c
P_1	10.75 b	17.20 b	23.98 b	26.96 b
P_2	11.50 a	18.54 a	26.01 a	30.52 a
P_3	11.26 a	18.45 a	24.73 ab	29.65 a
$LSD_{(0.05)}$	**0.502**	**0.786**	**1.311**	**1.648**
Significance level	**	**	**	**
CV(%)	**9.05**	**8.19**	**8.69**	**7.38**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 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			
	25 DAS	45 DAS	65 DAS	85 DAS
N_0P_0	8.65 h	13.58 h	15.77 h	16.18 i
N_0P_1	9.22 f-h	14.23 h	19.47 fg	21.37 h
N_0P_2	10.08 d-g	16.02 fg	21.58 d-f	24.96 f
N_0P_3	9.61 e-h	15.79 g	20.91 e-g	24.28 fg
N_1P_0	9.65 e-h	16.69 e-g	23.44 c-e	26.17 ef
N_1P_1	10.28 d-f	17.44 d-g	24.03 cd	27.87 de
N_1P_2	11.17 b-d	18.10 c-e	28.52 a	33.37 ab
N_1P_3	11.55 a-c	19.33 bc	25.50 bc	31.32 bc
N_2P_0	9.12 gh	14.08 h	18.31 gh	22.07 gh
N_2P_1	11.49 a-c	19.63 bc	28.73 a	32.17 a-c
N_2P_2	12.38 a	21.25 a	29.47 a	34.57 a
N_2P_3	12.12 ab	20.28 ab	28.91 a	34.01 ab
N_3P_0	10.61 c-e	16.44 e-g	20.56 fg	23.32 f-h
N_3P_1	10.76 c-e	17.55 d-f	27.04 ab	32.38 cd
N_3P_2	11.64 a-c	18.77 b-d	28.26 ab	33.06 a-c
N_3P_3	10.89cd	17.98 c-e	26.85 ab	32.97 a-c
$LSD_{(0.05)}$	**1.032**	**1.543**	**2.601**	**2.520**
Significance level	*****	*****	******	******
CV(%)	**9.05**	**8.19**	**8.69**	**7.38**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

4.6 Number of branches per plant

Significant variation was found on number of branches per plant due to effect of different levels of nitrogen at 25, 45, 65 and 85 DAS of okra under the present trial (Appendix VIII). At 25, 45, 65 and 85 DAS, the maximum number of branches per plant (1.35, 2.52, 3.07 and 4.05) were recorded from N_2 which was statistically similar to N_3 (1.28 2.43, 3.00 and 4.03) and N_1 (1.25, 2.40 2.98 and 3.90), while the minimum number of branches per plant (1.10, 1.78, 2.35 and 2.83) were recorded from N_0 (Figure 6). Soni *et al.* (2006) reported that number of branches increased with increasing rates of N up to 120 kg/ha.

Number of branches per plant showed significant variation was obtained for different levels of phosphorus on number of branches per plant of okra at 25, 45, 65 and 85 DAS (Appendix VIII). At 25, 45, 65 and 85 DAS the maximum number of branches per plant (1.33, 2.45, 3.10 and 4.07) was counted from P_2, which was statistically identical (1.30, 2.42, 3.02 and 3.95) to P_3 and closely followed (1.20, 2.30 2.90 and 3.73) by P_1 and the minimum number of branches per plant (1.15, 1.92, 2.38 and 3.07) were recorded from P_0 (Figure 7). 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 combined effect of different levels of nitrogen and phosphorus at 25, 45, 65 and 85 DAS (Appendix VIII). At 25, 45, 65 and 85 DAS, the maximum number of branches per plant (1.45, 2.97, 3.50 and 4.57) were recorded from N_2P_2 and the minimum number (1.05, 1.37, 1.97 and 2.37) from N_0P_0 (Table 10).

4.7 Length of internode

Length of internode differed significantly due to the application of different levels of nitrogen at 25, 45, 65 and 85 DAS of okra under the present trial (Appendix IX). At 25, 45, 65 and 85 DAS the longest internode (7.13, 8.85, 11.99 and 14.43 cm) was observed from N_2 which was statistically similar (6.93, 8.40, 11.61 and 14.30 cm) to N_3, whereas the shortest internode (5.50, 6.92, 9.22 cm and 10.18 cm) was found from N_0 (Table 11).

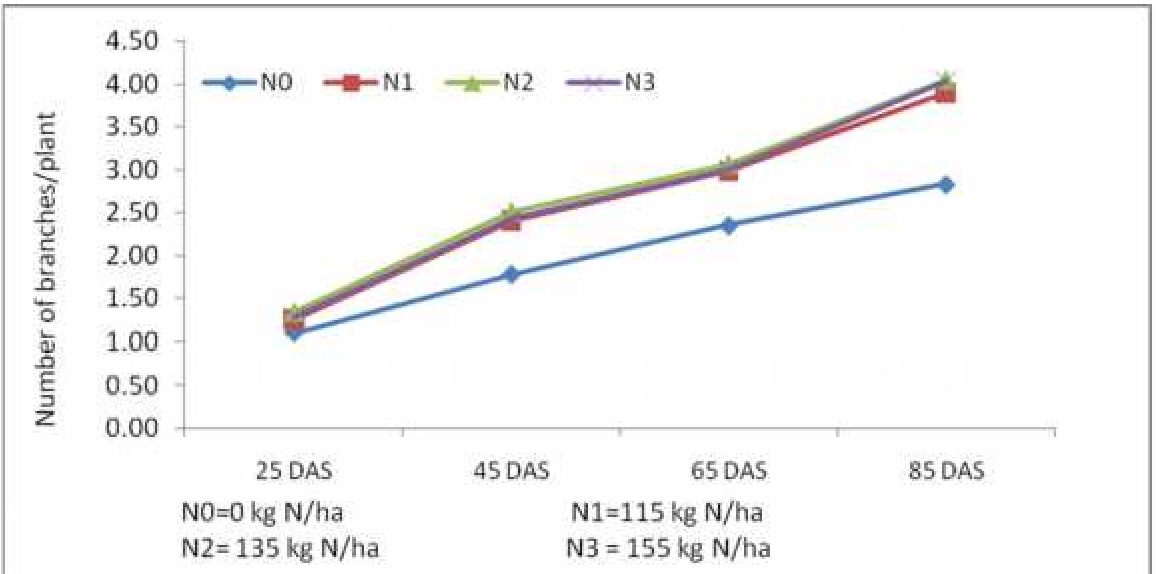


Fig. 6 Effect of different levels of nitrogen on number of branches per plant of okra

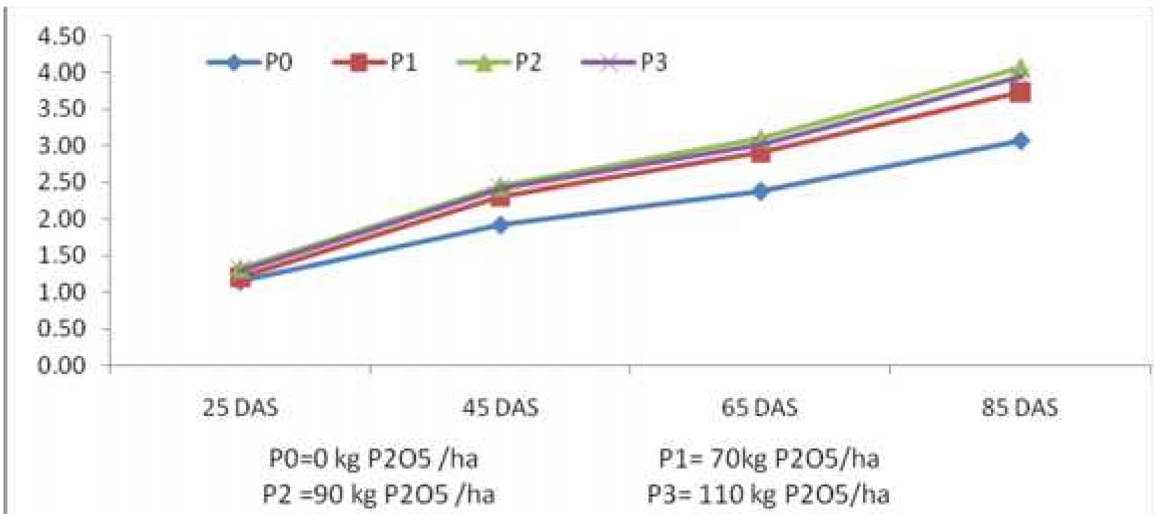


Fig.7 Effect of different levels of phosphorus on number of branches per plant of okra

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			
	25 DAS	**45 DAS**	**65 DAS**	**85 DAS**
N_0P_0	1.05 e	1.37 h	1.97 g	2.37 e
N_0P_1	1.05 e	1.97 g	2.50 ef	3.03 d
N_0P_2	1.18 c-e	2.03 g	2.63 de	3.17 d
N_0P_3	1.12 de	1.97 g	2.50 ef	2.97 d
N_1P_0	1.12 de	2.37 ef	2.90 cd	3.70 bc
N_1P_1	1.18 c-e	2.37 ef	2.90 cd	3.70 bc
N_1P_2	1.32 a-c	2.43 d-f	3.17 bc	4.30 a
N_1P_3	1.38 ab	2.63 b-d	3.17 bc	4.10 ab
N_2P_0	1.18 c-e	1.83 g	2.30 f	3.10 d
N_2P_1	1.32 a-c	2.70 bc	3.23 ab	4.23 a
N_2P_2	1.45 a	2.97 a	3.50 a	4.57 a
N_2P_3	1.44 a	2.77 ab	3.43 ab	4.50 a
N_3P_0	1.25 b-d	2.30 f	2.57 ef	3.30 cd
N_3P_1	1.25 b-d	2.37 ef	3.17 bc	4.17 a
N_3P_2	1.38 ab	2.57 b-e	3.30 ab	4.43 a
N_3P_3	1.25 b-d	2.50 c-f	3.17 bc	4.43 a
$LSD_{(0.05)}$	**0.148**	**0.210**	**0.293**	**0.413**
Significance level	*	**	**	*
CV(%)	**7.30**	**8.42**	**9.03**	**7.14**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 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			
	25 DAS	45 DAS	65 DAS	85 DAS
Level of Nitrogen				
N_0	5.50 c	6.92 b	9.22 b	10.18 b
N_1	6.70 b	8.50 a	11.70 a	13.97 a
N_2	7.13 a	8.85 a	11.99 a	14.43 a
N_3	6.93 a	8.40 a	11.61 a	14.30 a
$LSD_{(0.05)}$	**0.332**	**1.024**	**1.603**	**1.696**
Significance level	**	**	**	**
P_0	5.77 c	7.36 b	10.38 b	11.44 c
P_1	6.56 b	7.67 a	12.45 a	14.56 b
P_2	6.96 a	9.92 a	12.86 a	15.93 a
P_3	6.90 a	9.02 a	12.70 a	15.75 a
$LSD_{(0.05)}$	**0.370**	**0.482**	**0.574**	**1.456**
Significance level	**	**	**	**
CV(%)	**7.65**	**8.82**	**9.12**	**7.73**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

Statistically significant variation was recorded due to effect of different levels of phosphorus on length of internode of okra at 25, 45, 65 and 85 DAS (Appendix IX). At 25, 45, 65 and 85 DAS the longest internode (6.96, 9.92, 12.86 and 15.93 cm) was recorded from P_2, which was statistically similar 6.90, 9.02, 12.70 and 15.75 cm) to P_3 while the shortest internode (5.77, 7.36, 10.38 and 11.44 cm) was found from P_0 (Table 11).

Due to combined effect of different levels of nitrogen and phosphorus showed significant differences on internode length of okra at 25, 45, 65 and 85 DAS (Appendix IX). At 25, 45, 65 and 85 DAS the longest internode (8.91, 10.84, 14.20 and 17.35 cm) was found from N_2P_2, whereas the shortest internode (5.63, 6.67, 8.20 and 8.58 cm) was obtained from N_0P_0 (Table 12).

4.8 Fresh weight of leaves per plant after harvest

Statistically significant variation was found on fresh weight of leaves per plant after harvest of okra due to different levels of nitrogen (Appendix X). The highest fresh weight of leaves per plant (302.50 g) was recorded from N_2 which was statistically similar (297.61 g) to N_3 and the lowest weight (250.43 g) was obtained from N_0 (Table 13).

Fresh weight of plant of okra showed significant variation for different levels of phosphorus (Appendix X). The highest fresh weight of leaves per plant after harvest (298.53 g) was observed from P_2, which was statistically identical (292.78 g) to P_3 and the lowest weight (252.56 g) was recorded from P_0 (Table 13).

Nitrogen and phosphorus showed significant differences due to the combined on fresh weight of leaves per plant after harvest of okra (Appendix X). The highest fresh weight of leaves per plant (334.71g) was found from N_2P_2, whereas, the lowest fresh weight of leaves per plant (229.26 g) was recorded from N_0P_0 (Table 14).

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

Treatments	Internode length (cm) at			
	25 DAS	**45 DAS**	**65 DAS**	**85 DAS**
N_0P_0	5.63 j	6.67 h	8.20 e	8.58 e
N_0P_1	6.42 i	8.37 fg	6.69 d	11.85 cd
N_0P_2	6.35 f-h	8.59 e-g	10.88 d	12.40 b-d
N_0P_3	6.73 hi	8.62 e-g	10.98 d	11.88 cd
N_1P_0	7.42 e-g	9.59 b-e	112.47 bc	13.89 b
N_1P_1	7.60 d-g	8.20 d-f	12.25 c	13.65 bc
N_1P_2	7.94 c-f	9.20 a-d	13.53 ab	16.58 a
N_1P_3	7.93 c-f	9.53 c-e	12.48 bc	15.80 a
N_2P_0	6.76 hi	8.03 g	10.23 d	11.13 d
N_2P_1	8.32 a-c	10.47 a-c	13.69 a	15.93 a
N_2P_2	8.91 a	10.84a	14.20 a	17.35 a
N_2P_3	8.66 ab	9.62 ab	13.76 a	16.27 a
N_3P_0	7.27 gh	8.36 fg	10.58 d	11.36 d
N_3P_1	7.93 c-f	8.81 a-d	13.16 a-c	16.01 a
N_3P_2	7.96 b-e	8.82 a-d	13.12 a-c	16.62 a
N_3P_3	7.21 b-d	10.16 a-c	13.47 ab	16.17 a
$LSD_{(0.05)}$	**0.578**	**0.948**	**0.995**	**1.832**
Significance level	**	**	**	**
CV(%)	**7.65**	**8.82**	**9.12**	**7.79**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

4.9 Dry matter content of leaves after harvest

Significant variation was found on dry matter content of leaves after harvest due to the effect of different levels of nitrogen (Appendix X). The highest dry matter content of leaves after harvest (12.19 %) was found from N_2 while the lowest dry matter content of leaves (8.32 %) was found from N_0 (Table 13).

Statistically significant variation was recorded on dry matter content of leaves after harvest of okra due to different levels of phosphorus (Appendix X). The highest dry matter content of leaves after harvest (11.49 %) was performed by P_2, which was statistically identical (10.89 %) to P_3 and closely followed by P_1 while the lowest dry matter content of leaves after harvest (8.71 %) was obtained from P_0 (Table 13).

Combined effect of nitrogen and phosphorus showed significant differences on dry matter content of leaves after harvest of okra The highest dry matter content of leaves (13.20 %) was observed from N_2P_2, while the lowest dry matter content of leaves after harvest (7.0 %) from N_0P_0 (Table 14).

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

Treatments	Fresh weight of leaves/plant after harvest (g)	Dry matter content of leaves (%)	Number of flowers/plant	Number of pods/plant
Levels of Nitrogen				
N_0	250.43 c	8.32 c	25.60 b	19.53 b
N_1	284.15 b	10.93 b	29.58 a	21.17 a
N_2	302.50 a	12.19 a	30.37 a	23.25 a
N_3	297.61 a	10.81 ab	29.96 a	22.67 a
$LSD_{(0.05)}$	**8.461**	**0.451**	**2.751**	**1.921**
Significance level	**	**	**	**
Levels of Phosphorus				
P_0	252.56 c	8.71 c	24.82 c	17.63 c
P_1	284.13 b	10.28 b	29.47 b	21.33 b
P_2	298.53 a	11.49 a	31.28 a	23.61 a
P_3	292.78 ab	10.89 a	30.19 ab	22.58 a
$LSD_{(0.05)}$	**13.40**	**0.701**	**1.683**	**1.842**
Significance level	**	**	**	**
CV(%)	**6.83**	**7.15**	**7.93**	**8.28**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

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

Treatments	Fresh weight of leaves/plant after harvest (g)	Dry matter content of leaves after harvest (%)	Number of flowers/plant	Number of pods/plant
N_0P_0	229.26 h	7.0 g	23.40 g	17.33 gh
N_0P_1	262.60 fg	8.25 f	28.27 ef	19.86 d-f
N_0P_2	277.48 e-g	9.18 ef	28.26 de	21.33 c-e
N_0P_3	267.11 fg	8.46 f	28.00 e	20.00 e-g
N_1P_0	284.82 d-f	9.66 e	29.27 c-e	18.47 fg
N_1P_1	286.01 c-f	10.27 de	29.80 c-e	19.80 d-f
N_1P_2	305.80 b-d	11.50 bc	33.06 ab	23.60 ab
N_1P_3	308.20 a-d	11.87 bc	31.40 b-d	22.82 a-c
N_2P_0	353.05 gh	8.32 f	24.60 fg	15.86 h
N_2P_1	314.90 a-c	11.56 bc	33.46 ab	23.13 a-c
N_2P_2	334.71 a	13.20 a	34.73 a	24.92 a
N_2P_3	332.18 ab	12.56 ab	33.80 ab	24.67 a
N_3P_0	275.95 e-g	9.88 e	28.79 ef	18.07 fg
N_3P_1	301.50 b-e	11.07 cd	32.19 a-c	21.66 b-d
N_3P_2	310.05 a-d	12.06 ac	33.27 ab	23.93 ab
N_3P_3	305.40 b-d	12.41 ac	32.33 a-c	23.00 a-c
$LSD_{(0.05)}$	**22.70**	**1.123**	**2.981**	**2.111**
Significance level	*	**	*	**
CV(%)	**6.83**	**7.15**	**7.93**	**8.28**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

4.10 Days required to flowering

Days required to flowering varied significantly due to application of different levels of nitrogen under the present trial (Appendix X) The minimum days required to flowering (39.0) was recorded from N_2, whereas the maximum days to flowering (44.25) was found from N_0 (Figure 8).

Due to application of different levels of phosphorus showed significant differences on days required to flowering of okra (Appendix X). The minimum days required to flowering (40.0) was found from P_2, which was statistically identical (40.60) to P_3. On the other hand, the maximum days (44.93) was found from $P_{0,}$ (Figure 9).

Due to combined effect of different levels of nitrogen and phosphorus showed significant variation on days required to flowering of okra (Appendix X). The minimum days required to flowering (36.43) was obtained from N_2P_2, and the maximum days (48.77) from the treatment combination of N_0P_0(Figure 10). 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) .

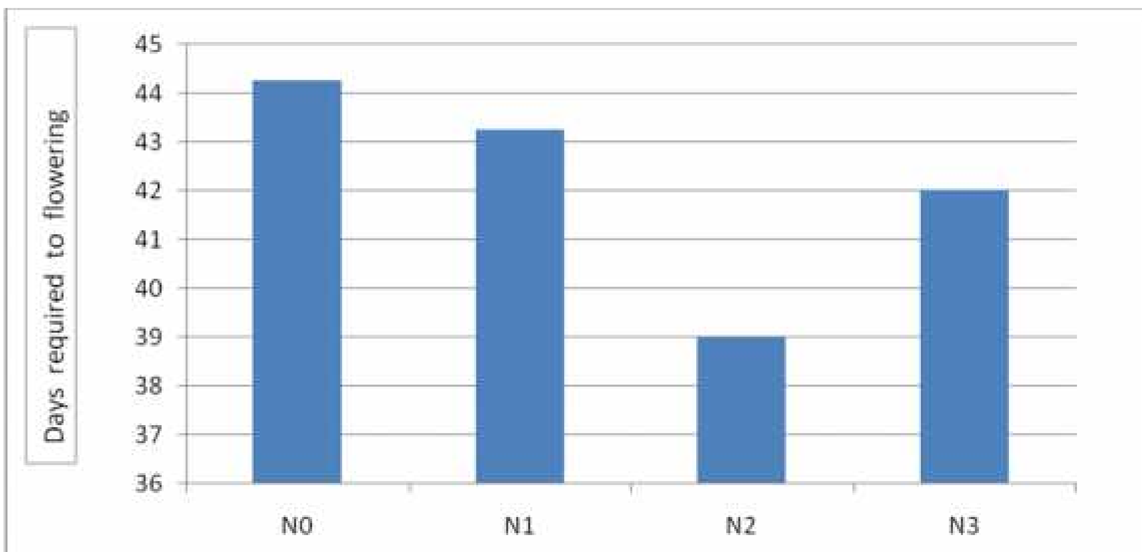


Fig. 8 Effect of different levels of nitrogen on days required to flowering

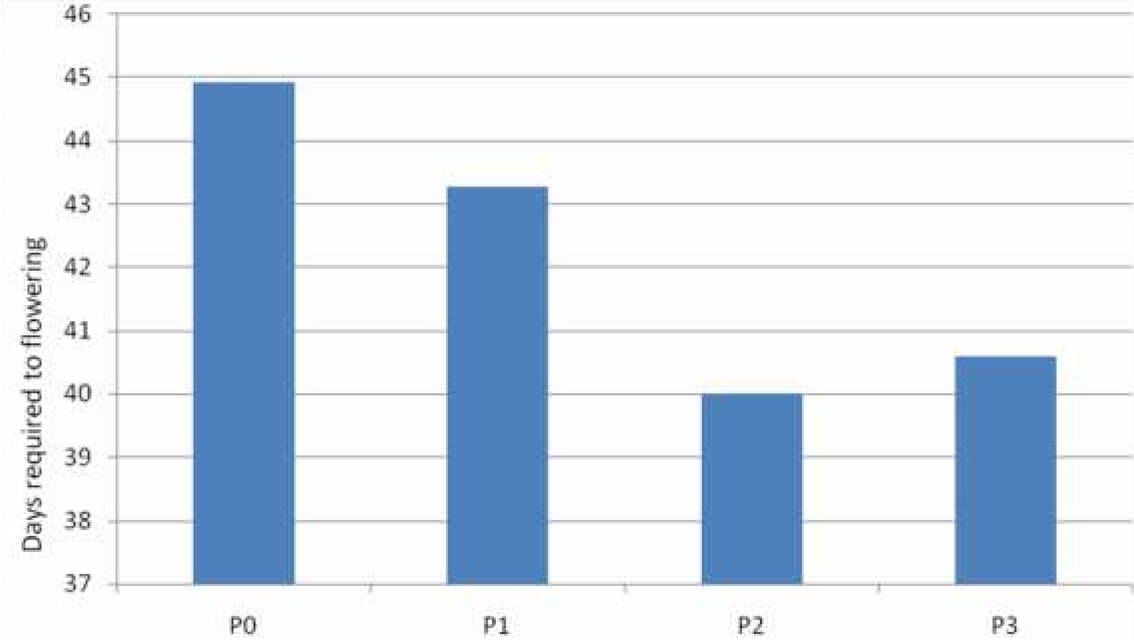


Fig.9 Effect of different levels of phosphorus days to required flowering

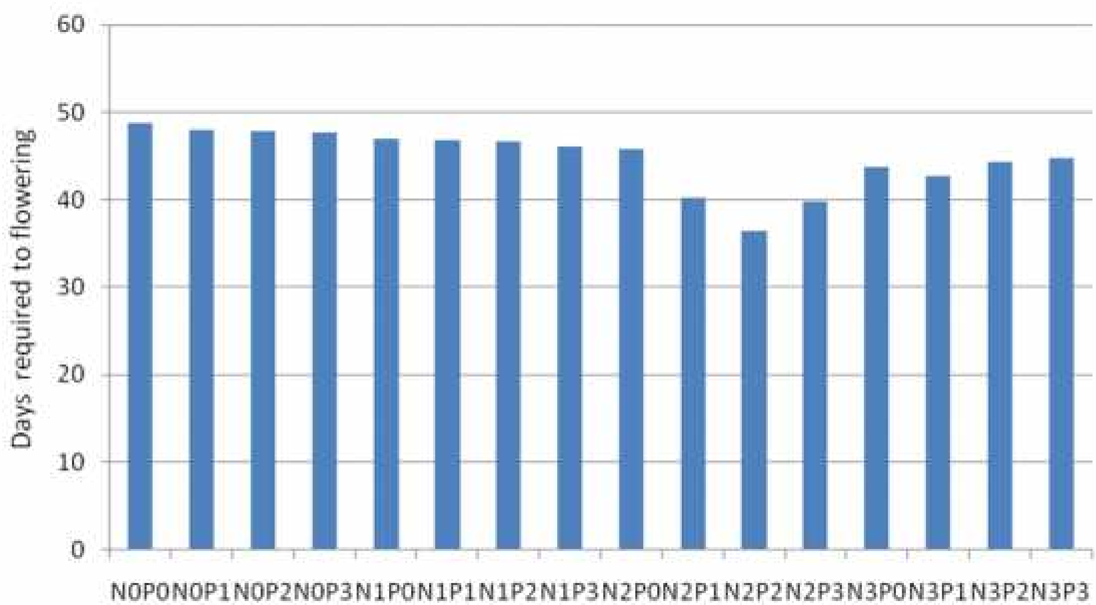


Fig. 10 Combined effect of different levels of nitrogen and phosphorus on days required to flowering

4.11 Number of flower per plant

Significant variation was found on number of flowers per plant of okra due to the effect of different levels of nitrogen (Appendix X). The maximum number of flower per plant (30.37) was found from N_2 which was statistically similar (29.96 and 29.58) to N_3 and N_1, whereas the minimum (25.60) was recorded from N_0 (Table 13)

Due to the application of different levels of phosphorus significant variation was recorded on number of flowers per plant (Appendix X). The maximum number of flowers per plant (31.28) was observed from P_2, which was statistically similar (30.19) with P_3 and closely followed (29.47) by P_1, whereas the minimum (24.82) was recorded from P_0 (Table 13).

Number of flowers per plant of okra showed significant variation due to the combined effect of different levels of nitrogen and phosphorus (Appendix X). The maximum number of flowers per plant (34.73) was recorded from N_2P_2, while the minimum (23.40) was obtained from N_0P_0 (Table 14).

4.12 Number of pods per plant

Number of pods per plant of okra varied significantly due to application of different levels of nitrogen under the present trial (Appendix X). The maximum number of pods per plant (23.25) was obtained from N_2 which was statistically similar (22.67) to N_3 and the minimum (19.53) from N_0 (Table 13). Jana *et al*. (2010) reported that 150 kg N ha^{-1} produced the highest number of fruits $plant^{-1}$ (13.7).

Different levels of phosphorus showed significant variation on number of pods per plant of okra The maximum number of pods per plant (23.61) was recorded from P_2, which was statistically similar (22.58) to P_3, whereas the minimum (17.63) was found from P_0 (Table 13). Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased the number of pods per plant.

Combined effect of different levels of nitrogen and phosphorus showed significant variation on number of pods per plant of okra (Appendix X). The maximum number of pods per plant (24.92) was found from N_2P_2 and the minimum (17.33) from N_0P_0

(Table 14). 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.

4.13 Pod length

Statistically significant differences was recorded on pod length of okra due to the application different levels of nitrogen (Appendix XI). The longest pod (17.88cm) was found from N_2 which was statistically similar to N_3 (17.77 cm), while the shortest pod (14.92 cm) from N_0 (Table 15). 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 application different levels of phosphorus (Appendix XI). The longest pod (18.11 cm) was obtained from P_2, which was statistically identical to P_3 (17.37 cm), while the shortest pod (14.38 cm) was recorded from P_0 (Table 15). Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased length of pod.

Due to the combined effect of different levels of nitrogen and phosphorus showed significant variation on pod length of okra (Appendix XI). The longest pod (20.25 cm) was observed from N_2P_2 and the shortest pod (12.60 cm) was found from N_0P_0 (Table 16).

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

Treatments	Pod length (cm)	Pod diameter (cm)	Individual pod weight (g)	Yield/hectare (t)
Level of Nitrogen				
N_0	14.92 c	1.62 c	10.97 c	12.40 c
N_1	16.42 b	1.94 b	11.90 b	14.76 b
N_2	17.88 a	2.14 a	12.65 a	16.50 a
N_3	17.77 a	1.97 b	12.00 b	15.32 b
$LSD_{(0.05)}$	**1.041**	**0.132**	**0.446**	**0.587**
Significance level	**	**	**	**
Level of Phosphorus				
P_0	14.38 c	1.60 c	10.65 c	11.30 d
P_1	16.43 b	1.84 b	11.67 b	14.48 c
P_2	18.11 a	1.99 a	12.15 a	17.05 a
P_3	17.37 a	1.92 a	11.95 a	16.14 b
$LSD_{(0.05)}$	**0.880**	**0.135**	**0.461**	**0.710**
Significance level	**	**	**	**
CV(%)	**7.13**	**9.62**	**6.89**	**6.60**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

4.14 Pod diameter

Application of different levels of nitrogen varied significantly on pod diameter (Appendix XI). The highest diameter of pod (2.14 cm) was recorded from N_2 , whereas the lowest diameter of pod (1.62 cm) from N_0 (Table 15). Ambare *et al*. (2005) reported that the higher levels of nitrogen significantly influenced all the characters under study except the diameter of the pod.

Due to the application of different levels of phosphorus showed significant variation on pod diameter of okra (Appendix XI). The highest diameter of pod (1.99 cm) was recorded from P_2, which was statistically similar (1.92 cm) to P_3 and the lowest diameter of pod (1.60 cm) was recorded from P_0 (Table 15) .Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased diameter of pod.

Significant variation was recorded due to the combined effect of different levels of nitrogen and phosphorus on diameter of pod of okra (Appendix XI). The highest diameter of pod (2.28) was found from the treatment combination of N_2P_2 and the lowest diameter of pod (1.47 cm) was recorded from N_0P_0 (Table 16). 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 .

4.15 Weight of individual pod

Weight of individual pod of okra varied significantly by different levels of nitrogen under the present trial (Appendix XI). The highest weight of individual pod (12.65 g) was recorded from N_2, whereas the lowest weight of individual pod (10.97 g) from N_0 (Table 15). Jana *et al*. (2010) reported that 150 kg N ha^{-1} produced the highest individual fruit weight (18.5 gm).

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

Treatments	Pod length (cm)	Pod diameter (cm)	Weight of individual pod (g)	Yield/hectare (t)
N_0P_0	12.60 f	1.47 e	11.50 e	10.84 gh
N_0P_1	14.23 d-f	1.50 de	11.97 e	12.74 ef
N_0P_2	15.50 d	1.63 de	12.24 de	13.92 de
N_0P_3	14.63 de	1.45 e	11.77 e	12.07 fg
N_1P_0	15.80 d	1.68 c-e	11.97 e	11.97 fg
N_1P_1	15.63 d	1.74cd	12.29 de	13.15 ef
N_1P_2	18.25 b	1.95 b	13.25 c	16.86 b
N_1P_3	17.71 bc	1.92 b	13.78 bc	17.05 b
N_2P_0	13.36 ef	1.49 de	11.90 e	10.29 h
N_2P_1	18.26 b	2.08 ab	13.50 bc	16.86 b
N_2P_2	20.25 a	2.28 a	14.73 a	19.86 a
N_2P_3	19.40 ab	2.25 a	14.25 ab	18.99 a
N_3P_0	16.12 cd	1.62 de	12.33 de	12.11 fg
N_3P_1	17.97 b	1.87 bc	12.97 cd	15.16 cd
N_3P_2	18.57 ab	1.99 b	13.60 bc	17.55 b
N_3P_3	19.15 b	1.96 b	13.27 c	16.46 bc
$LSD_{(0.05)}$	**1.812**	**0.317**	**0.817**	**1.531**
Significance level	**	**	**	**
CV(%)	**7.13**	**9.62**	**6.89**	**6.60**

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: 115 kg N/ha

N_2: 135 kg N/ha

N_3: 155 kg N/ha

P_0: 0 kg P_2O_5/ha (control)

P_1: 70 kg P_2O_5/ha

P_2: 90 kg P_2O_5/ha

P_3: 110 kg P_2O_5/ha

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 differences on weight of individual pod of okra (Appendix XI). The highest weight of individual pod (12.15 g) was observed from P_2, which was statistically similar (11.95 g) to P_3 , whereas the lowest weight of individual pod (10.65 g) was recorded from P_0 (Table 15). Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased mean fruit weight.

Due to the combined effect of nitrogen and phosphorus showed significant differences on weight of individual pod of okra (Appendix XI). The maximum weight of individual pod (14.73 g) was recorded from N_2P_2 and the minimum weight of individual pod (11.50 g) was found from the treatment combination of N_0P_0 (Table 16).

4.16 Yield per plot

Yield per plot of okra varied significantly due to the effect of different levels of nitrogen (Appendix XI) . The highest yield per plot (7.19 kg) was found from N_2 and the lowest yield per plot (5.41 kg) from N_0 (Figure 11).

Due to the application of different levels of phosphorus showed significant differences on yield per plot of okra (Appendix XI). The highest yield per plot (7.42 kg) was recorded from P_2 and the lowest yield per plot (4.94 kg) was obtained from P_0 (Figure 12).

Combined effect of different levels of nitrogen and phosphorus showed significant variation on yield per plot of okra (Appendix XI). The highest yield per plot (8.64 kg) was observed from N_2P_2, while the lowest yield per plot (4.74 kg) was found from N_0P_0 (Figure 13).

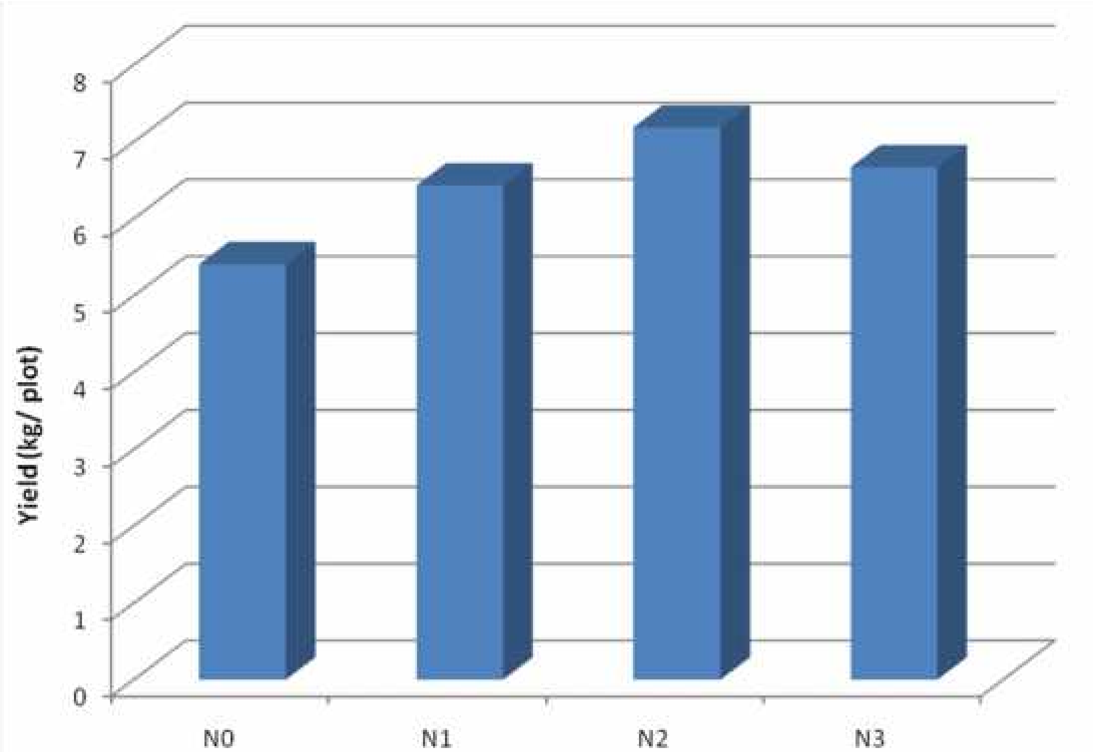


Fig. 11 Effect of different levels of nitrogen on yield per plot of okra

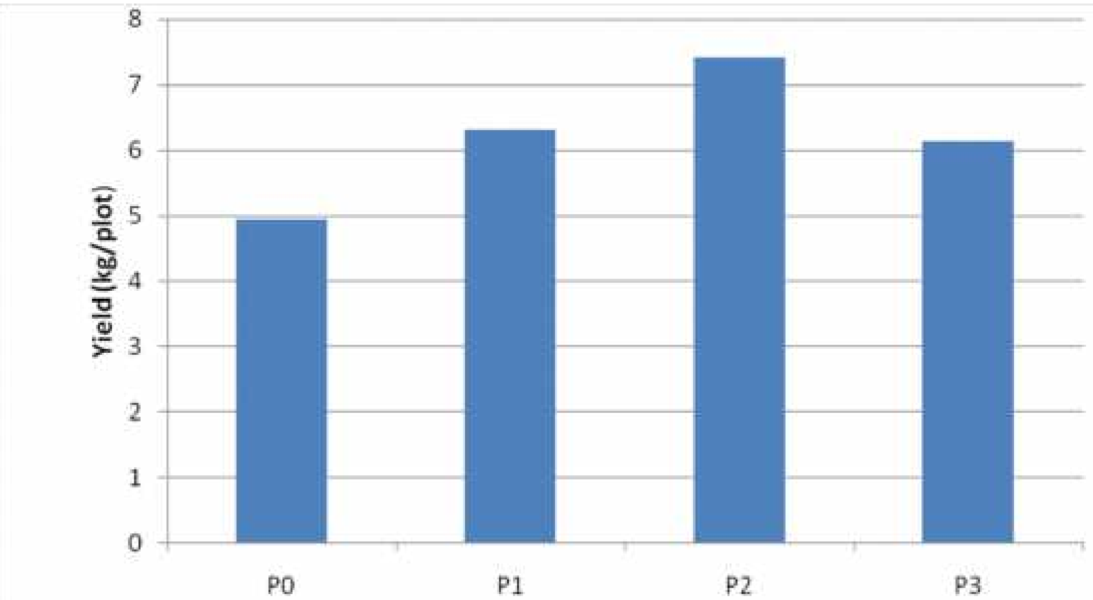


Fig. 12 Effect of different levels of phosphorus on yield per plot of okra

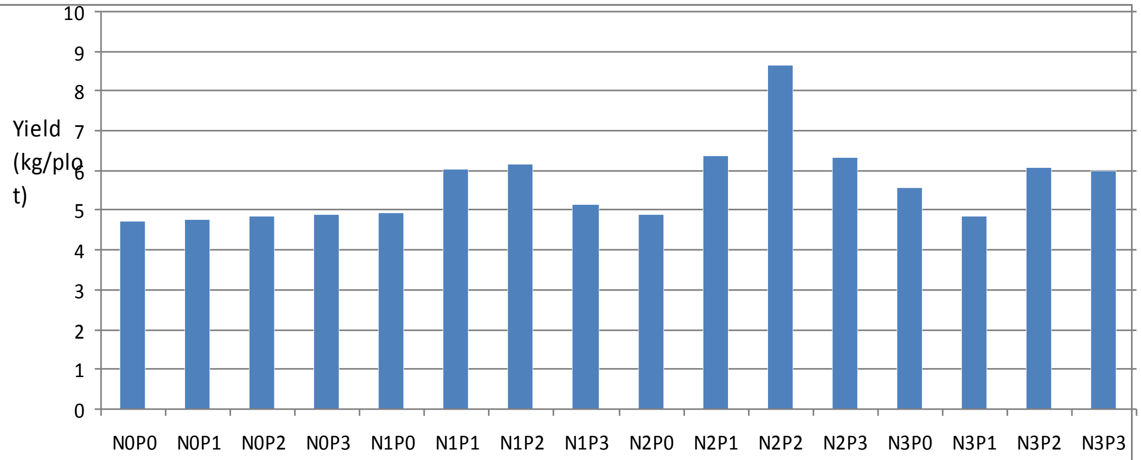


Fig. 13 Combined effect of different levels of nitrogen and phosphorus on yield per plot of okra

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 (Appendix XI). The highest yield per hectare (16.50 t) was performed by N_2, while the lowest yield per hectare (12.40 t) was found from N_0 (Table 15). 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 t/ha).

Different levels of phosphorus showed significant variation on yield per hectare of okra (Appendix XI).The highest yield per hectare (17.05 t) was found from P_2, wheres the lowest yield per hectare (11.30 t) was found from P_0 (Table 15). 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.

Significant differences were recorded on yield per hectare of okra due to the combined effect of different levels of nitrogen and phosphorus (Appendix XI). The highest yield per hectare (19.86 t) was recorded from the treatment combination of N_2P_2, whereas the lowest yield per hectare (10.84 t) was found from N_0P_0 (Table 16). 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.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from March - August 2014. 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: 115 kg N/ha, N_2: 135 kg N/ha and N_3: 155 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: 90 kg P_2O_5/ha and P_3: 110 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 25, 45, 65 and 85 DAS the tallest plant (32.33, 58.26, 79.62 and 88.96 cm) was recorded from N_2, whereas the shorter plant (25.32, 46.70, 65.32 and 75.07 cm) from N_0. At 25, 45, 65 and 85 DAS the highest number of leaves per plant (9.26, 20.72, 39.66 and 43.89) was recorded from N_2, while while the minimum number of leaves per plant (7.80, 17.60, 33.87 and 35.79) from N_0. At 25, 45, 65 and 85 DAS the longest petiole (9.70, 15.96, 21.15 and 24.08 cm) was obtained from N_2, whereas the shortest petiole (7.87,12.48, 15.90 and 18.02 cm)was found from N_0. At 25, 45, 65 and 85 DAS the highest diameter of stem (0.93, 1.39, 1.64 and 2.30 cm) was found from N_2, while the lowest diameter of stem (0.78, 1.15, 1.37 and 1.65 cm) was recorded from N_0. At 25, 45, 65 and 85 DAS the longest leaf (11.58, 18.62, 25.23 and 29.80 cm) was obtained from N_2, again the shortest leaf 9.70, 14.70, 18.34 and 21.50 cm) was recorded from N_0. At 25, 45, 65 and 85 DAS the maximum number of branches per plant (1.35, 2.52, 3.07 and 4.05) was recorded from N_2, while the minimum number of branches per plant (1.10, 1.78, 2.35 and 2.83) was counted from N_0. At 25, 45, 65 and

85 DAS the longest internode (7.13, 8.85, 11.99 and 14.43 cm) was observed from N_2, whereas the shortest (5.50, 6.92, 9.22 and 10.18 cm) from N_0.

At 25, 45, 65 and 85 DAS the longest plant (34.81, 60.31, 83.27 and 89.60 cm) was observed from P_2, whereas the shortest plant (26.99, 47.62, 67.04 and 77.07 cm) was observed from P_0. At 25, 45, 65 and 85 DAS the maximum number of leaves per plant (9.42, 20.54, 40.74 and 46.16) was counted from P_2 and the minimum number of leaves per plant (8.01, 18.16, 33.99 and 38.05) was recorded from P_0. At 25, 45, 65 and 85 DAS the longest petiole (9.78, 15.71, 21.10 and 24.23 cm) was found from P_2, whereas the shortest petiole (8.19, 13.04, 16.82 and 19.12 cm) was recorded from P_0. At 25, 45, 65 and 85 DAS the maximum diameter of stem (0.95, 1.41, 1.66 and 2.36 cm) was recorded from P_2, whereas the minimum diameter of stem (0.82, 1.18, 1.32 and 1.65 cm) was obtained from P_0. At 25, 45, 65 and 85 DAS the longest leaf (11.50, 18.54, 26.01 and 30.52 cm) was observed from P_2, whereas the shortest leaf (9.60, 15.20, 18.67 and 21.03 cm) from P_0. At 25, 45, 65 and 85 DAS the maximum number of branches per plant (1.33, 2.45, 3.10 and 4.07) was observed from P_2 and the minimum number of branches per plant (1.15, 1.92, 2.38 and 3.07) was obtained from P_0. At 25, 45, 65 and 85 DAS the longest internode (6.96, 9.02, 12.86 and 15.93 cm) was recorded from P_2, again the shortest internode (5.77, 7.36, 10.38 and 11.44 cm) was found from P_0.

At 25, 45, 65 and 85 DAS the tallest plant (36.66, 61.34, 87.44 and 99.41 cm) was observed from N_2P_2, while the shortest (21.36, 40.13, 54.28 and 64.52 cm) was recorded from N_0P_0. At 25, 45, 65 and 85 DAS, the maximum number of leaves per plant (10.47, 23.23, 41.20 and 48.25) was counted from N_2P_2 and the minimum number (7.37, 16.77, 28.20 and 31.45) from N_0P_0. At 25, 45, 65 and 85 DAS the longest petiole (10.18, 18.03, 23.57 and 26.79 cm) was obtained from N_2P_2, whereas the shortest petiole (7.10, 11.40, 13.24 and 15.58 cm) found from N_0P_0. At 25, 45, 65 and 85 DAS the highest diameter of stem (0.92, 1.59, 1.86 and 2.82 cm) was observed from N_2P_2 and the lowest diameter of stem (0.67, 1.20, 1.35 and 1.40 cm) from N_0P_0. At 25, 45, 65 and 85 DAS the longest leaf (12.38, 21.25, 29.47 and 34.57 cm) was observed from N_2P_2, while the shortest leaf (8.65, 13.58, 15.77 and 16.18 cm) from

N_0P_0. At 25, 45, 65 and 85 DAS, the maximum number of branches per plant (1.45 2.97, 3.50 and 4.57) was recorded from N_2P_2 and the minimum number (1.05, 1.37, 1.97 and 2.37) from N_0P_0. At 25, 45, 65 and 85 DAS the longest internode (8.91, 10.84, 14.20 and 17.35 cm) was obtained from N_2P_2, while the shortest internode (5.63, 6.67, 8.20 and 8.58 cm)was found from N_0P_0.

The highest fresh weight of leaves after harvest (302.50 g) was recorded from N_2, whereas the lowest weight (250.43 g) was found from N_0. The highest dry matter content of leaves (12.19%) was found from N_2, while the lowest (8.32%) from N_0. The minimum days required to flowering (39.00) was recorded from N_2, whereas the maximum days (44.25) from N_0. The maximum number of flowers per plant (30.37) was recorded from N_2, whereas the minimum (25.60) was from N_0. The maximum number of pods per plant (23.25) was observed from N_2, whereas the minimum (19.53) from N_0. The longest pod (17.88 cm) was observed from N_2, while the shortest pod (14.92 cm) from N_0. The highest diameter of pod (2.14 cm) was recorded from N_2, whereas the lowest (1.62 cm) from N_0. The highest weight of individual pod (12.65 g) was recorded from N_2, while the lowest (10.97 g) from $N_{0.}$ The highest yield per plot (7.19 kg) was found from N_2, whereas the lowest yield per plot (5.41 kg) from N_0. The highest yield per hectare (16.50 t) was recorded from N_2, while the lowest yield per hectare (12.40 t) from N_0

The highest fresh weight of leaves per plant (298.53 g) was observed from P_2 and the lowest weight (252.56 g) was recorded from P_0. The highest dry matter content of leaves (11.49 %) was obtained from P_2 and the lowest (8.71 %) was recorded from P_0. The minimum days required to flowering (40.10) were found from P_2 and the maximum days (44.93) were obtained from P_0. The maximum number of flowers per plant (31.28) was observed from P, and the minimum (24.82) was found from P_0. The maximum number of pods per plant (23.61) was found from P_2 whereas the minimum (17.63) was obtained from P_0. The longest pod (18.11 cm) was found from $P_2$and the shortest pod (14.38 cm) was recorded from P_0. The highest diameter of pod (1.99 cm) was observed from P_2, again the lowest diameter of pod (1.60 cm) was recorded from P_0. The highest weight of individual pod (12.65 g) was observed from P_2, whereas the lowest weight of individual pod (10.97 g) was recorded from P_0. The highest yield per plot (7.42 kg) was recorded from P_2 and the lowest yield per plot (4.94 kg) was obtained from P_0. The highest yield per hectare (19.86 ton) was observed from P_2 and the lowest yield per hectare (10.84 ton) was found from P_0.

The highest fresh weight of leaves per plant (334.71 g) was recorded from N_2P_2, while the lowest weight (229.26 g) was recorded from N_0P_0. The highest dry matter content of leaves (13. 20%) was observed from N_2P_2 and the lowest (7.00 %) was from N_0P_0. The minimum days required to flowering (36.43) was found from N_2P_1, and the maximum days (48.77) from N_0P_0. The maximum number of flowers per plant (34.73) was recorded from N_2P_2, whereas the minimum (23.40) from N_0P_0. The maximum number of pods per plant (24.92) was found from N_2P_2 and the minimum (17.33) from N_0P_0. The longest pod (20.25 cm) was observed from N_2P_2 and the shortest pod (12.60 cm) was found from N_0P_0. The highest diameter of pod (2.28) was found from N_2P_2 and the lowest diameter of pod (1.47 cm) was recorded from N_0P_0. The highest weight of individual pod (14.73 g) was recorded from N_2P_2 and the lowest weight of individual pod (11.50 g) was found from N_0P_0. The highest yield per plot (8.64 kg) was observed from N_2P_2, while the lowest yield per plot (4.74 kg) was found from N_0P_0. The highest yield per hectare (19.86 t) was recorded from N_2P_2, while the lowest yield per hectare (10.84 t) was found from N_0P_0.

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

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh to observe regional performance.

2. Another experiment may be carried out with different levels of various fertilizers in order to achieve the more yield.

Conclusion

From above study it may be said that both nitrogen and phosphorus is very important to achieve the higher yield of okra. Among various levels of nitrogen and phosphorus, 135 kg N with 90 kg P_2O_5/ha performed the best results in all observations. So, it may be concluded that, 135 kg N with 90 kg P_2O_5/ha is the suitable combination for okra production.

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APPENDICES

Appendix I. Monthly record of air temperature, rainfall, relative humidity, and sunshine of the experimental site

Month (2014)	Air temperature (ºC)		*Relative humidity (%)	*Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
April	32.6	23.5	68	164	6.5
May	33.7	25.5	70	186	7.7
June	32.8	25.8	82	226	5.7
July	35.9	22.3	65	299	5.8
August	31.6	19.3	63	104	6.3

* Monthly average; Source: Bangladesh Meteorological Department, Agargoan, Dhaka-1214

Appendix II. Soil characteristics of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Horticulture Garden , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Soil series	Tejgaon
Topography	High land and fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
Sand, silt and clay (%)	27, 43 and 30
Textural class	Silty-clay
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10

Appendix III. Analysis of variance of the data on plant height at days after sowing (DAS) as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		25 DAS	45 DAS	65 DAS	85DAS
Replication	2	2.213	0,432	12.763	5.987
Nitrogen (A)	3	143.721**	212.564**	534,567**	454.093**
Phosphorus (B)	3	106.098**	153.438**	478.981**	436.012**
Interaction (A×B)	9	15.812**	26.902**	47.903*	77.743**
Error	30	6.654	5,325	20,097	7.056

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix IV. Analysis of variance of the data on number of leaves per plant at days after sowing (DAS) as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square			
		Number of leaves per plant at			
		25 DAS	45 DAS	65 DAS	85 DAS
Replication	2	0.024	0.017	0.158	1.158
Nitrogen (A)	3	5.60**	26.705**	56.373**	188.506**
Phosphorus (B)	3	4.578**	16.8043**	83.341**	161.884**
Interaction (A×B)	9	0.603*	1.856*	5.003*	7.844*
Error	30	0.275	0.861	1.444	3.192

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix V. Analysis of variance of the data on petiole length at days after sowing (DAS) as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square			
		Petiole length (cm) at			
		25 DAS	45 DAS	65 DAS	85 DAS
Replication	2	0.170	0.346	0.087	0.056
Nitrogen (A)	3	8.620**	26.267**	77.772**	161.402**
Phosphorus (B)	3	6.103**	16.842**	47.770**	69.833**
Interaction (A×B)	9	0.784**	3.233**	4.043**	5.042**
Error	30	1.254	4.602	6.314	2.383

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix VI. Analysis of variance of the data on stem diameter at days after sowing (DAS) as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square			
		Stem diameter (cm) at			
		25 DAS	45 DAS	65 DAS	85 DAS
Replication	2	0.065	0.544	0.523	0.662
Nitrogen (A)	3	0.354**	0.564**	0.198**	1.979**
Phosphorus (B)	3	0.987**	0.544**	0.290-**	3.538**
Interaction (A×B)	9	0.072*	0.521*	0.859*	0.951*
Error	30	0.001	0.008	0.005	0.020

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix VII. Analysis of variance of the data on leaf length at days after sowing (DAS) as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square			
		Leaf length (cm) at			
		25 DAS	45 DAS	65 DAS	85 DAS
Replication	2	0.032	0.506	0.199	0.360
Nitrogen (A)	3	8.897**	35.990**	127.983**	265.690**
Phosphorus (B)	3	8.7128**	30.168**	181.294**	250.793**
Interaction (A×B)	9	1.357*	6.583*	12.491**	4.619**
Error	30	0.384	0.892	4.423	3.068

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix VIII. Analysis of variance of the data on number of branches per plant at days after sowing (DAS) as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square			
		Number of branches per plant at			
		25 DAS	45 DAS	65 DAS	85 DAS
Replication	2	0.789	0.893	0.834	0.879
Nitrogen (A)	3	0.546**	4.308**	4.389**	7.009**
Phosphorus (B)	3	0.657**	0.898**	3.708**	3.656**
Interaction (A×B)	9	0.887*	0.761**	0.194**	1.192*
Error	30	0.879	1.964	1.458	3.008

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix IX. Analysis of variance of the data on internode length at days after sowing (DAS) as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square			
		Internode length (cm) at			
		25 DAS	45 DAS	65 DAS	85 DAS
Replication	2	0.453	0.452	0.609	0.478
Nitrogen (A)	3	8.751**	7.432**	13.705**	32.434**
Phosphorus (B)	3	7.854**	8.349**	14.048**	42.476**
Interaction (A×B)	9	0.768**	1.898**	1.972**	6.190**
Error	30	0.120	0.313	0.353	1.143

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix X. Analysis of variance of the data on some yield contributing characters as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square				
		Fresh weight /plant (g)	Dry matter content /plant (g)	Days to starting of flowering	Number of flowers/ plant	Number of pods/ plant
Replication	2	1.890	0.677	5.920	0.626	0.870
Nitrogen (A)	3	53.78**	23.098**	12.240**	43.823**	16.481**
Phosphorus (B)	3	503.76**	14.978**	58.303**	65.363**	45.090**
Interaction (A×B)	9	21.787*	2.230**	21.384**	8.446*	7.111**
Error	30	1.754	0.423	3.182	2.902	1.022

**: Significant at 0.01 level *: Significant at 0.05 level

Appendix XI. Analysis of variance of the data on some yield contributing characters and yield of okra as influenced by different level of nitrogen and phosphorus fertilizer

Source of variation	Degrees of freedom	Mean square				
		Pod length (cm)	Pod diameter (cm)	Individual fruit weight (g)	Yield/ plot (kg)	Yield/ hectare (ton)
Replication	2	0.644	0.586	0.695	0.574	0.399
Nitrogen (A)	3	31.343**	0.691**	8.770**	5.041**	23.723**
Phosphorus (B)	3	22.674**	0.554**	7.622**	12.280**	42.662**
Interaction (A×B)	9	2.751**	0.667**	0.970**	2.620**	5.750**
Error	30	1.048	0.016	0.207	0.128	0.688

**: Significant at 0.01 level *: Significant at 0.05 level