EFFECT OF NAA AND PHOSPHORUS ON GROWTH AND YIELD OF OKRA

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DHAKA-1207

JUNE, 2016

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Registration No. 10-03960

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

MASTER OF SCIENCE (MS)

IN

HORTICULTURE

SEMESTER: JANUARY- JUNE, 2016

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CERTIFICATE

This is to certify that the thesis entitled "**EFFECT OF NAA AND PHOSPHORUS ON GROWTH AND YIELD OF OKRA**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the results of a piece of *bonafide* research work carried out by **RUKAIYA AFRIN** Registration. No. **10-03960** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2016
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ACKNOWLEDGEMENTS

All praises to Almighty Allah, the Supreme Ruler of the universe who enables the author to complete this present piece of work.

The author would like to express her heartfelt gratitude to her research supervisor, ***Prof. Dr. Md. Nazrul Islam****, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207 for constant supervision and encouragement during her research work and guidance in preparation of manuscript of the thesis.*

The author sincerely express her heartiest respect to her co-supervisor, ***Prof. Md. Hasanuzzaman Akand****, Department of Horticulture, Sher-e-Bangla Agricultural University Dhaka, for constant encouragement, cordial suggestions, constructive criticisms and valuable advice during the research period and preparing the thesis.*

Deepest sense of gratitude and profound appreciation to ***Dr. Tahmina Mostarin,*** *chairman of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207.*

The author would like to express her deepest respect and boundless gratitude to all the respected teachers of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, for the sympathetic co-operation and inspirations throughout the course of this study and suggestions and encouragement to research work. The author would like to express her cordial thanks to the departmental and field staffs for their active help during the experimental period.

Finally, the author is deeply indebted to her respected parents and beloved husband whose inspiration, moral support and continuous blessing paved the way to her higher education.

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The Author

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ABSTRACT

An experiment was conducted to evaluate the response of different levels of naphthalene acetic acid and phosphorus on growth and yield of okra, at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2015. BARI Dherosh-1 was used as test crop in this experiment. The experiment consisted of two factors viz., Naphthalene Acetic Acid (4 levels) as N_0: 0 ppm, N_1: 50 ppm, N_2: 100 ppm and N_3: 150 ppm NAA; and Phosphorus fertilizer (3 levels) as P_0: 0 kg P_2O_5 ha^{-1}, P_1: 50 kg P_2O_5 ha^{-1} and P_2: 70 kg P_2O_5 ha^{-1} respectively. The experiment was laid out in Randomized Complete Block Design with three replications. Due to the effect of naphthalene acetic acid, the highest yield (15.31 t/ha) was recorded from N_2 and the lowest yield (9.51 t/ha) from N_0. In case of phosphorus, the highest yield (14.20 t/ha) was found from P_2 and the lowest yield (12.12 t/ha) from P_0. For combined effect, the highest yield (16.25t/ha) was found from N_2P_2 and the lowest yield from N_0P_0 (8.54 t/ha). So, 100 ppm NAA and 70 kg P_2O_5 ha^{-1} was best for growth and yield of okra.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont')

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF TABLES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a member of Malvaceae and known as Lady's finger. It is a popular vegetable in Bangladesh. It originated in West Africa is an annual vegetable crop grown from seed in tropical and subtropical parts of the world (Thakur and Arora, 1986). It is well distributed throughout the Indian sub-continent and East Asia (Rashid, 1990). It is a nutritious vegetable, which plays an important role to meet the demand of vegetables of the country when vegetables are scanty in the market (Ahmad, 1995). In Bangladesh it is known as 'dherosh' which is also called 'bhindi' in India and Pakistan (Rashid, 1999). Okra is specially valued for its tender and delicious edible pods which is rich source of vitamins and minerals. Tender green pods of okra contains approximately 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Purseglove, 1987). The pods have some medicinal value with mucilaginous preparation which may used as plasma replacement or blood volume expander (Savello *et al.,* 1980).

In Bangladesh, 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 importance in kharif season in our country context. The consumption of vegetables in Bangladesh is 62 g/day/person, which is far below the standard requirement of 220 g/day/person (BBS, 2015). Therefore, there is a big gap between the requirement and per capita vegetable consumption in Bangladesh. Successful okra production may contribute partially in solving vegetable scarcity of summer season in our country. In Bangladesh the total production of okra is about 246 thousand tons which was produced from 7287.5 hectares of land in the year 2010 with average yield about 3.38 t/ha which is very low (BBS, 2011) compared to that of other developed countries.

Naphthalene Acetic Acid (NAA) is a plant growth regulator which can manipulate the growth and yield of crops. It can also play a significant role in increasing physiological processes of Okra. Naphthalene Acetic Acid (NAA) is an important growth regulator of many commercial horticultural products used for rooting and cuttings, inhibition of flower drop, bud shedding and button shedding besides inhibiting sprouting and development of suckers (El-Otmani *et al.,* 2000; Williams and Taji, 1989). Naphthalene Acetic Acid (NAA) belongs to synthetic forms of Auxins that play key role in cell elongation, cell division, vascular tissue, differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting ratio, prevent fruit dropping, promote flower sex ratio and flowering (El-Otmani *et al.,* 2000; Williams and Taji, 1989; Davies, 1987). Foliar application of NAA has also found to increase plant height, number of leaves per plant, fruit size with consequent enhancement in seed yield in different crops (Abro *et al.,* 2004; Lee, 1990). NAA effects on plant growth, pod production, seed yield and seed quality of okra (Patil 2010 ; Muhammad *et al.,*2013). The use of growth regulators is considered as one of the way of increasing yield. NAA, a synthetic growth regulator has proved its potentiality that in appropriate concentration NAA affects the growth and yield of a number of plants viz. tomato (Meena, 2008; Pundir and Yadav, 2001; Bhosle *et al*. 2002; Chhonker and Singh 1959), faba bean (Suty 1984), bitter gourd (Jahan and Fattah, 1991) cotton (Abro, *et al.* 2004), peache (Antonio and Bettio, 2003) and Japanese plum (Ruth *et al*. 2006).

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. Phosphorus supports early phase of crop development, synchronizes the germination process and leading to enhance the final yield, especially in phosphorus deficient soil (Asgedom and Becker, 2001; Arif *et al.,* 2005). 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 while enhanced activities of acid and alkaline phosphatases which increase the availability of P in phosphorus deficient seasons (Supatra and Mukherji, 2004). Akinrinde and Adigun (2005) reported that crop growth is continuously threatened by phosphorus limitation on most tropical and temperate soils. Use of proper doses of fertilizer is one of the most important way of quality green pod yield production of okra and phosphorus fertilizer have a great effect in this respect (Yogesh and Aora, 2001). Okra is a fruit vegetable and phosphorus fertilization can influenced in fruit development (Mohanta, 1998).

Considering the above facts, the experiment has been undertaken with the following objectives:

i. to determine the effect of NAA on growth and yield attributing characters of okra and to find out the optimum concentration of NAA for better growth and yield;

ii. to determine the optimum level of phosphorus for yield contributing characters and higher yield of okra;

iii. to find out the suitable combined effect of NAA and Phosphorus for ensuring better growth and higher yield of okra.

CHAPTER 2

REVIEW OF LITERATURE

Okra is one of the important vegetables grown throughout the tropical world. Different levels of Naphthalene Acetic Acid (NAA) and Phosphorus influence the growth and yield of okra. Many research works have been done in different parts of the world to study the effect of naphthalene acetic acid and phosphorus on growth and yield of okra. However, a little information is available in these regards on okra under Bangladesh condition, which insufficient and sometimes conflicting. However, the available research findings relevant to the present study have been reviewed in this chapter.

2.1 Effect of naphthalene acetic acid

The results of many researchers related to naphthalene acetic acid are reviewed here.

Mehraj *et al.* (2015) stated the impact of GA_3 and NAA on Horticultural Traits of *Abelmoschus esculentus*. The experiment was conducted using BARI Dherosh 1 as genetic materials and some growth regulators viz. G_0: Control (fresh water); G_1: GA_3 (Gibberellic acid) and G_2: NAA (Naphthalene acetic acid) @ 50 ppm. Tallest plant (89.0 cm), longest petiole (29.0 cm), number of leaves (49.0/plant), leaf area (29.7 cm), number of branches (5.5/plant), fresh weight (84.5 g/plant), dry weight (10.9 g/plant), number of pods 2 (33.4/plant), pod length (17.5 cm), pod diameter (1.7 cm) and yield (338.1 g/plant, 2.9 kg/plot and 16.4 t/ha) was found from G_1 which was statistically identical with G_2 while minimum from G_0 . GA_3 and NAA have the potentiality to increase the yield of okra, but GA_3 was found to be most effective in the present study.

Muhammad Rizwan Shahid *et al.* (2013) stated that Plant growth regulators (PGRs) affect various aspects of plant physiology, mainly vegetative and reproductive traits including yield and seed production. Therefore, different concentrations (0, 50, 100 & 200 ppm) of gibberellic acid (GA_3) and naphthalene acetic acid (NAA), alone or in different combinations were sprayed on okra plants at 2-true leaf stage, to ascertain their impact on plant growth, pod production, seed yield and seed quality. All variables regarding vegetative and reproductive growth were significantly influenced by different concentrations of the growth regulators except number of days taken to flowering. Growth regulators were less effective when applied individually as compared to their combined use; however, performance of plants treated with individual PGR was better than the untreated plants. The number of leaves plant^{-1} and plant height was higher in plants when sprayed with GA_3 and NAA @ 200+100 ppm as well as with GA_3 and NAA @ 200+200 ppm. The number of pods plant^{-1}, pod length, pod fresh and dry weight, seed yield and seed quality (in terms of germination percentage and 1000-seed weight) was maximum in plants receiving foliar spray of both GA_3 and NAA @ 200+200 ppm. These results signify the role of GA_3 and NAA in okra pod production for fresh consumption as well as for seed yield.

Patil, D.R. and Patel, M.N.A. (2010) conducted an experiment to find out the response of seed treatment with GA_3 and NAA on growth and yield of okra *abmelmoschus esculentus* (l.) moench] cv. Go-2. The treatments comprised of three concentrations of GA_3 (15 mg/l, 30 mg/l and 45 mg/l), NAA (10 mg/l, 20 mg/l and 40 mg/l), soaking of seeds in distilled water and control (unsoaked seeds), experiment was laid out in Randomized Block Design with three replications. GA_3 at 15 mg/l recorded the highest percentage of seed germination, stem girth, number of branches, number of leaves per plant, early flowering, fruit girth, fruit length, fruit weight, fruit yield per plant and fruit yield per hectare. While GA_3 at 45 mg/l found to be beneficial with respect to plant height, number of internodes and internodal length. However, GA_3 at 30 mg/l produced maximum number of fruits per plant. From the economics point of view, NAA 10 mg/l was found to be profitable as compared to rest of treatments.

Das and Rabhal (1999) conducted an experiment in a greenhouse on cucumber cultivars Chinese green, Pusa Sanyog and poinsett, NAA was applied at 30 ppm or 100 ppm kinetin at 10 ppm or 50 ppm and Ethrel at 250 ppm or 500 ppm at the 4 to 5-leaf stage and at flower bud appearance. NAA application produced the largest fruit With the highest flesh, placenta ratios. TSS and ascorbic acid content were highest when Ethrel was applied.

Singh *et al.* (1999) studied the effect of plant bio-regulator and foliar feeding of urea on growth, yield and yield contributing attributes of okra cv. Pusa Samwani during spring- summer season. They applied various combination of NAA, GA_3 and urea as foliar and seed soaking in a field trial in uttar Pradesh, India in 1995. Seed germination was greatest (71.6%) with the 20 ppm NAA+150 ppm GA_3 treatment and significantly greater than the control (55.5%). They observed that NAA at 20 ppm + 20,000 ppm urea as foliar spray gave significantly earlier flowering. The number of days taken to 50% flowering being approximately 40.8 compared to 42.0 days in the control. They stated that combination of NAA, gibberelic acid and urea applied to okra as foliar application and seed soaking resulted significant number of seeds pod^{-1} .The greatest seed weight per pod (3.2g) and seed yield per hectare (19.4 ha^{-1}) was achieved with 150 ppm GA_3 and was significantly greater than the control (1.8g and 11.8q ha^{-1}) . Treatments of 150 ppm GA_3 and 20 ppm NAA applied by seed soaking and foliar application of 20000 ppm urea increased seed yield by 64.4, 55.9 and 42.8%, respectively.

Bhat and Singh (1998) reported that NAA had significant effect on growth yield and yield contributing characters of okra and different combinations of NAA and GABA significantly gave advanced fruiting by 3.33 days. They found that 100 seed weight of okra was increased significantly with the application of 150 ppm NAA.

Gedam *et al.* (1998) reported that bitter gourd *(Momordica charantia*) plants treated with 15 ppm, 25 ppm or 35 ppm GA_3 50 ppm, 100 ppm or 150 ppm NAA, 50 ppm, 100 ppm or 150 ppm ethephon 100 ppm, 200 ppm or 300 ppm maleic hydrazide, 2 ppm, 4 ppm or 6 ppm boron or with water (control). GA_3 at 35 ppm produced the earliest female flower and NAA at 50 ppm produced the earliest male flower. Fruit maturity was earliest in plants treated with 50 ppm NAA or 4 ppm boron. Fruit and seed yield were also highest in these treatments.

Rai *et al.* (1998) studied with hormones on yield and quality of okra. Seeds were treated and foliar application with 100 ppm GABA, 0.25 ppm potassium dihydrozen orthophosphate and 10 ppm NAA was done at Mohanpur, West Bengal, India in the rainy season of 1994. They observed that the length of fruit was generally improved by foliar application of NAA and fibre quality was generally improved by foliar application of 10 ppm NAA. Path analysis for fibre fineness revealed that cell length/width ratio had a high direct effect. Cell breadth and fibre length showed very high direct effects on tenacity, while fibre fineness and tenacity were negatively correlated.

Asghar *et al.* (1997) studied the growth response of okra (T13) to exogenous growth regulators, i.e. Gibberellic acid (GA_3 Planofix (NAA) and Cultar (Paclobutrazol). Each chemical was applied to foliage @ 50, 100, 150 and 200 ppm. Planofix @ 150 ppm reduced the number of days (75) to first picking whereas Cultar @ 200 ppm delayed it (96.75 days). Cultar @ 150 and 200 ppm restricted plant height to the minimum of 136.22 cm and produced maximum branches (3.65) compared to the tallest plants (253.75 cm) and the least number of branches (2.20) by GA_3@ 200 and 150 ppm respectively. Planofix (200 ppm) enhanced internodal length (11.95 cm) whereas Cultar squeezed it (7.40 cm). Plants treated with Cultar (150 ppm), however, had maximum pods/plants (69.47) and seeds/pod (86.5) whereas these were minimum (44.82 pods) in control plants and those treated with 50 ppm GA_3 (46.60 seeds/pod). GA_3 however, increased pod length (10.10 cm) and diameter (1.82 cm). Cultar spray (100 ppm) gave maximum production/ha (14.32 t) as compared to 11.87 t/ha in with Cultar 200 ppm and 11.97 in control.

Gulshan and Lal (1997) carried out an experiment with flowering, fruiting and seed production of okra as influenced by growth regulators and urea. They applied various combinations of gibberellic acid, NAA and urea treatments to okra cv. Pusa

Sawani in summer 1988 and 1989 at pantnagar, India. The greatest number of pod plant^{-1} was obtained after seed treatment with NAA at 20 ppm + foliar spray of 2% urea at 30 days after sowing followed by seed treatment with 150 ppm GA_3 and 20 ppm NAA + foliar spray of 4% urea at 30 days after sowing. Soaking of seeds in 150 ppm $GA_3$and 20 ppm NAA gave the highest seed yield (20.4 and 19.4 t ha^{-1}, respectively), which were 7.9 and 6.9 ha higher than the control, respectively. All treatment combinations reduced the number of days to 50% flowering and the number of days to first fruit set than control.

Sayed *et al.* (1997) conducted an experiment with three growth regulators such as gibberellic acid (GA_3), Planofix (NAA) and cultar (paclobutrazol) on growth, yield and yield contributing characters of okra. Each growth regulator was applied to the foliage at the rate of 50,100,150 and 200 ppm on okra where NAA was found most effective in increasing the branches plant^{-1}. They found that 150 ppm NAA reduced the number of days to first picking whereas 2000 ppm cultar delayed it. They observed that application of planofix (NAA) to okra at 20 DAS increased the pod length and 150 ppm NAA showed the greatest number of seeds pod^{-1}.

Laskshmamma and Rao (1996) reported that application of 0, 5, 10 or 20 ppm NAA on black gram at 50% flowering stage increased plant height.

Harrington *et al. (*1996) reported leaf area and stem elongation was 20-30% more with the application of growth hormones applied in okra plant.

Chatterjee and Sukul (1995) conducted a trial with plant growth regulators for controlling the root-knot incidence in okra plants. Three plant growth regulators *viz* gibberllic acid, *a*-napthalene acetic acid and boric acid were used as foliar sprays on okra plants against *Meloidogyne incognita* infestations in okra plants, in a pot culture experiment. The growth regulator in general, particularly the NAA was effective in reducing the disease intensity and inducing higher growth rates in the plant.

Gowada *et al* (1992) reported that combinations of NAA, GA_3 and urea were applied to okra cv. Pusa sawani as foliar and seed soaking applications in a field trial. The greatest fruits plant^{-1} and seed yield ha^{-1} was achieved.

Takeno *et al.* (1992) found that female flowers of cucumber cultivars Chojitsu-Ochiai No.2 (parthenocarpic) and Mogami (non-pathenocarpic) were bagged the day before and then artificially pollinated or left unpollinated. BA or NAA at 0.1 mug or 10 mug/fruit was applied to the peduncle of the fruit at anthesis. The growth promoting effects of both BA and NAA were greatest on unpollinated ovaries of Mogami. BA treatment increased cell well thickness in unpollinated fruits. This was due to increased cell number and size which h were 19% and 6% greatest than the control. BA treatment had no effect on endogenous levels of IAA in pollinated or unpollinated fruit.

Arora *et al.* (1990) conducted an experiment on the effect of cycocel (chlormequat) and NAA on growth and yield contributing characters. They found that application of 500 ppm of cycocel and150 ppm of NAA increased the number of leaves per plant in okra.

Islam *et al.* (1990) reported that the bottle gourd plants treated with NAA 200 ppm produced fruits of maximum length and girth in control. Numbers of fruits per plant were also found maximum in plants where NAA 200ppm was applied. Hormone application at the rate of 200ppm NAA produced maximum yield (48.15 t ha^{-1}).

Kapgate *et al.* (1989) found that application of NAA produced 34% more branches production in cotton plant compared to control.

Abdul *et al.* (1985) studied the influence of some growth regulagtors on the growth and yield of okra. IAA, NAA and GA_3 each at 0, 50 and 100 ppm CCC (chlormequat) and B9 (daninozide) each at 250, 500 and 1000 ppm were applied on foliage at the 3-4 leaf stage. GA_3 increased plant height.

Gosh and Basu (1983) reported that with NAA at 17.5 or 35% mg l^{-1} increased the number of female flowers. Ethel at 25 mg l^{-1} increased female flowers but 100 mg/L decreased it. GA application at 60 mg l^{-1} increased the number of female flowers. All GA applications reduced the ratio of male to male flowers.

Choudhury and Phatak (1981) reported the effect of concentration of MH, NAA and 2, 4 -D on the sex expression and sex ratio of cucumber. MH 200 ppm and NAA 100 ppm increased the number of female flower significantly over the control. MH 600 ppm and 800 ppm NAA 100 and IAA 200ppm and IAA 100ppm suppressed the number of male flowers over the control. IAA 100ppm and 200ppm and NAA 200ppm stimulated the growth.

Katiyar (1980) reported that the regulatory effect of different concentration of NAA increased the leaf area. The leaf area of a plant is the best indicator of photosynthetic size, which may be influenced by application of different PGRs. It was found that among the different plant growth regulators, GABA at 0.33ml L^{-1} showed the best effect compared to that of CI-IAA and TNZ-303(Sekh, 2003).

Omran *et al.* (1980) reported that Soaking okra seeds in GA (gibberellic acid), IAA (indole acetic acid) and NAA (naphthalene acetic acid) solutions enhanced their germination, and the best results were obtained from 400, 20 and 20 mg/l for GA, IAA and NAA, respectively. The plant height and yield were surprisingly controlled by soaking the seeds in GA, IAA and NAA. The best three treatments for growth were 200, 5 and 25 mg/l for GA, IAA and NAA respectively, with 200 mg/l GA the greatest.

Singth and singth (1977) studied the effect of seed treatment with plant growth substances on germination, vegetable growth and yield of okra. Seeds of okra, cvs Pusa Sawani and Uaishali Vadhu were soaked in 10-30 ppm GA_3 and 25-100ppm NAA for 24 h before sowing. Germination percentage, plant height, number of branches and spread, number of leaves, leaf area and yield were enhanced by all treatments where, 30ppm GA_3 gave the best results.

Singh *et al.* (1976) analyzed the effect of seed treatment with plant growth regulators on yield and economic of okra. Okra seeds cvs. Pusa Sawani and Uaishali Vadhu were treated with 10-30ppm GA_3 and 50-100 ppm NAA. All treatments improved yield and returns, the best result being obtained with100 ppm NAA.

Bisaria (1974) found that foliar of NAA ppm increased the number of female flowers per plant and the sex ratio is reduced in cucurbits.

Elassar *et al.* (1973) studied on the normal and parthenocarpic fruit development. They found that B-NOA (Napthoxyacetic acid) at rates lower 100 ppm and IAA 10 ppm to 100 ppm were effect normal fruit development and were less effective producing parthenocarpic fruit. GA_3 (100-10000ppm) and GA_4 + 7 (50ppm) slowed down the early rate of fruit development during later stages.

Choudhury *et al.* (1967) reported that NAA 100 ppm and 200 ppm and MH50 ppm and 200 ppm were equally effective in suppressing the male flowers and increasing the number of female flowers in cucumber. These effects subsequently increased the percentage of fruit set and ultimately the yield.

Choudhury and Phatak (1959a) found that cucumber plants treated with MH 200 ppm and NAA 100 ppm increased the number of female flowers. NAA 100 ppm, IAA 200 ppm and IAA 100 ppm suppressed the number of male flowers significantly over control.

Choudhury and Phatak (1959b) reported the effects of growth regulators on sex expression of cucumber. They observed that MH 200 ppm and NAA 100 ppm significantly increased the number of female flowers and MH 600 and 800 ppm, NAA 100 ppm and IAA 200 ppm greatly suppressed the number of male flower over control. All treatments increased the female to male flower ratio when compared with the control.

2.2 Effect of phosphorus

Uddin *et al.* (2014) showed the effect of Phosphorus Levels on Growth and Yield of Okra (*Abelmoschus esculentus*). The experiment was conducted from April to August 2012 to evaluate the different doses of phosphorus on growth and yield of okra (BARI Dherosh-1). Experiment consisted four levels of phosphorus viz. P_0: 0

(control), P_1: 70, P_2: 80 and P_3: 90 kg P_2O_5/ha using Randomized Complete Block Design with three replications. Maximum plant height (87.8 cm), number of leaves (45.4/plant), leaf length (29.5 cm), petiole length (23.2 cm), stem diameter (2.3 cm), internode length (14.8 cm), number of branches (4.0/plant), fruit length (17.0 cm), fruit diameter (1.9 cm), number of flower buds (30.2/plant), number of fruits (22.5/plant) weight of individual fruit (11.4 g), fresh weight of leaves (294.5 g/plant), dry matter content of leaves (11.4%) and yield (7.32 kg/plot and 17.0 t/ha) was found from P_2 whereas minimum from P_0.

Sajid *et al.* (2012) conducted a field experiment at Horticulture Research Farm Malakandher, Khyber Pakhtunkhwa Agricultural University Peshawar, during summer 2010 to evaluate the impact of nitrogen and phosphorus on seed yield and yield components of Okra cultivars. The experiment was laid out in Randomized Complete Block Design with split plot arrangement having three replications. Cultivars were allotted to the main plots, while various levels of nitrogen and phosphorus were kept in the subplots. Urea and single superphosphate (SSP) were used as source of nitrogen and phosphorus, respectively. Germination percentage (%) and seed yield (kg ha^{-1}) were significantly different with respect to cultivars. Maximum germination percentage (89 %) was observed in variety Arka Anamika, and maximum seed yield (1311 kg ha^{-1}) was recorded in variety Green Star. Significant response of various levels of nitrogen and phosphorus were observed in number of pods $plant^{-1}$ and seed yield (kg ha^{-1}). Maximum number of pods $plant^{-1}$ (10.69) and maximum seed yield (1374.9 kg ha^{-1}) were reported in plots having received both 150 kg N/ha and 90 kg P/ha. A non significant difference was observed in parameters i.e. number of seeds pod^{-1} and 1000 seed weight (g). It was found that Okra variety Green Star and application of N and P (at rates of 100 kg N ha^{-1} + 60 kg P ha^{-1}) in combination resulted in higher seed yield of Okra.

Firoz (2009) conducted an experiment at the Hill Agricultural Research Station, Khagrachari from June to November 2004 to find out the effect of nitrogen (60, 80, 100 and 120 kg/ha) and phosphorus (80, 100 and 120 kg/ha) on the growth and yield of okra in hill slope condition during rainy season. The highest yield (16.73 t/ha) was obtained from 100 kg N/ha, which was statistically identical to 120 kg per hectare. In case of phosphorus, the highest yield of 15.77 t/ha was obtained from 120 kg P_2O_5/ha and was closely followed by the dose of 100 kg P/ha (4.73 t/ha). Considering the treatment combinations, the highest yield (19.22 t/ha) was produced by $N_{100}P_{120}$ and there were no significant variations among $N_{100}P_{100}$, $N_{120}P_{100}$ and $N_{120}P_{120}$. The highest gross return (Tk.193200) and net return (Tk.146l40) were obtained from $N_{100}P_{120}$. The BCR was also higher (4.08) under the same treatment combination.

Omotoso and Shittu (2007) conducted a study 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 at150 NPK kg ha^{-1}.

Mishra and Singh (2006) studied 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 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.

Rajpaul *et al.* (2006) conducted an experiment 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 (EC1), 5.00 (EC2) and 8.50 dS/m (EC3) 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%).

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.

El-Shaikh (2005) conducted two field experiments 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 (ElBalady 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.

Nirmal *et al.* (2005) reported that Six okra genotypes (Parbhani Kranti, Pusa Sawani, HRB-55, P-7, VRO-5 and Satdhari Local) were grown 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.

Laxman *et al.* (2004) conducted a field experiment 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.

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

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.

Muhammad *et al*. (2001) investigated the effect of different rates of P and planting densities on seed yield and quality of okra cv. Sabz Pari 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.

Yogesh and Aora (2001) 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 (25 June and 15 July) on okra (cv. Parbhani Kranti) seed yield. One-third of N and 100% of P were applied during sowing , the remaining N was applied as a top dressing at 30 days after sowing and 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, along with sowing on 25 June.

Chattopadhyay and Sahana (2000) studied the seed quality (SQ) and yield (SY) of okra cv. Parbhani Kranti 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.

Rani *et al.* (1999) conducted a field experiment in Bapalta, Andhara Pradesh, India, in response to 4 fertilizer levels (0-0-0,50-25-25,100-50-50 and 150-75-75 kg N,P_2O_5, 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 and number of nodes and yield per plant.

The highest fertilizer level result 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, fertilizers 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 vegetative growth and high NAR, had the highest HI values. Among the fertilizer levels, maximum HI was recorded by 100-50-50 kg NPK/ha.

Rain and Lal (1999) were conducted a field experiment in Bapalta, Andhara 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 , 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.

Bhai and Singh (1998) conducted an experiment at Palampur, India with different levels of phosphorus, GA_3 and pickings on seed production of okra in 1992 and 1993, phosphorus was applied at 50,70 and 90 kg ha^{-1} .They reported that P application significantly increased the plant height, number of pods per plant and seed yield.

Bhat and singh (1997) analyzed the effect of different levels of phosphorus gibberellic acid and picking on seed production of okra. They applied P rate the rate of 50, 70 or 90 kg ha^{-1} and seed treatment with 200 and 300 ppm GA_3 for 12 h which had no significant effect on seed yield. However, two harvests had no detrimental effect on seed yield.

Kalita *el al.* (1995) reported the regulatory effect of different concentrations of NAA on number of pod .

Naik and Srinivas (1992) conducted a field experiments with cv. Pusa Sawani in the rainy seasons of 1985 and 1986 on a sandy loam with low available N and P in soil. 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).

Kumar *et al.* (1988) reported that the effect of nitrogen, phosphorus and potassium fertilizers on the incidence of the noctuid *Earias vitella* on okra was studied in the field in Karnataka, India during the rainy seasons of 1983 and 1984. Nitrogen and Potassium were applied in various proportion with a constant level of 75 kg P/ha. The highest yields were recorded in plots treated with nitrogen and potassium at 250 and 30 or 125 and 120 kg/ha, respectively in 1983 and 250 and 60 kg/ha in 1984. The highest infestation were recorded following the treatment with 250 and 30 kg nitrogen and potassium/ha. There was a positive correlation between nitrogen uptake by the plants and infestation by *Earias vitella,* while potassium uptake was negatively correlated with infestation

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.

Majanbu *et al.* (1985) reported that 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.

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 100 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.

Reddy *et al.* (1984) reported that 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 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.

Gupta *et al*. (1981) studied the 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) 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. 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.

Hooda, *et al.* (1980) Studied on the effect of nitrogen and phosphorus on growth and green pod yield of okra (*Abelmoschus esculentus (L) Moench)*. In 2 year trials with the okra cv. Pusa Sawani the plants received N at 40-120 kg/ha or P_2O_5 at 30-60 kg/ha. The highest average yield (126.45 q/ha) was obtained with 120 kg N/ha. Plant response to P was lower; with 112, 116 an118 q/ha in the control, and in plots receiving P at 30 and 60 kg/ha, respectively.

Chauhan and Gupta (1973) conducted an experiment to find out the effect of NPK on growth and yield of okra (*Abelmoschus esculentus*).They found that plant height and girth, number of leaves and yield of green pod increased by increasing the application of N (22.5, 45.0 or 67.5 kg/ha).P at 22.5 or 45.0 kg/ha and K at 22.5

kg/ha had no effect on growth and yield. NPK applications, however, generally increased yields.

Sharma and Shukla (1973) reported that in a two year trials with okra the effects were assessed of N (as urea) at 40-120 kg/ha, P_2O_5 (as superphosphate) at 17.44-52.32 kg/ha and K (as murate) at 24.9-74.7 kg/ha.The highest yields were obtained with N at 120 P_2O_5 at 34.88 and K at 49.8 kg/ha.

Ahmed and Tullock-Reild (1968) studied the response of okra to nitrogen, phosphorus, potassium and magnesium fertilization at Trindad on loam soil and best yields were obtained with 112 kg N, 168 kg P, 280 kg K and 112 kg Mg per hectare.

2.3 Combined effect of naphthalene acetic acid and phosphorus

Ruchita Gour *et al.* (2009) studied on the effect of phosphorus and plant growth regulators on growth and yield of fenugreek (*Trigonella foenum-graecum L.*) . The results indicated that significantly higher growth and yield (17.62 q ha^{-1}) were observed with application of 60 kg phosphorus ha^{-1}. Foliar spray of naphthalene acetic acid (NAA) 20 ppm at 25 days after sowing (DAS) and 55 DAS resulted in significantly higher growth and seed yield (17.41 q ha^{-1}). The highest benefit : cost ratio (4.20:1) was observed for the treatment, 60 kg phosphorus ha^{-1} + NAA 20 ppm.

CHAPTER 3

METERIELS AND METHOD

This chapter deals with the materials and methods that were used in carrying the experimen**t.**

3.1 Location of the experimental plot

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to July 2015. The site is 23^0 $77^'$ N and $90^0 33^'$ E Latitude and at Altitude of 9.2m from the sea level (BCA, 2004).

3.2 Characteristics of soil

The soil of the experiment was carried out in a medium high land belonging to the Modhupur Tract (UNDP, 1988) under the Agro Ecological Zone (AEZ) 28. The soil texture was silty clay with a pH 5.6 Soil samples of the experimental plot was collected from a depth of a 0 to 30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI) Farmgate, Dhaka and details soil characteristics were presented in Appendix I.

3.3 Climate

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

3.4 Planting materials used for experiment

The okra variety “BARI Dherosh-1’’ was used in this study was resistant to yellow vein mosaic virus, a severe disease of okra. It was an open pollinated high yielding variety developed by the Vegetable Division of Horticulture

Research Center, Bangladesh Agricultural Research Institute (BARI). The variety was released for commercial cultivation in 1996.

3.5 Treatments of the Experiment

The experiment consisted of two factors:

Factor A: Naphthalene acetic acid (Four levels) as –

N_0: control (no growth regulators)

N_1: 50 ppm NAA

N_2: 100 ppm NAA and

N_3: 150 ppm NAA

Factor B: Phosphorus (Three levels) as –

P_0: 0 kg P_2O_5 ha^{-1} (control)

P_1: 50 kg P_2O_5 ha^{-1} and

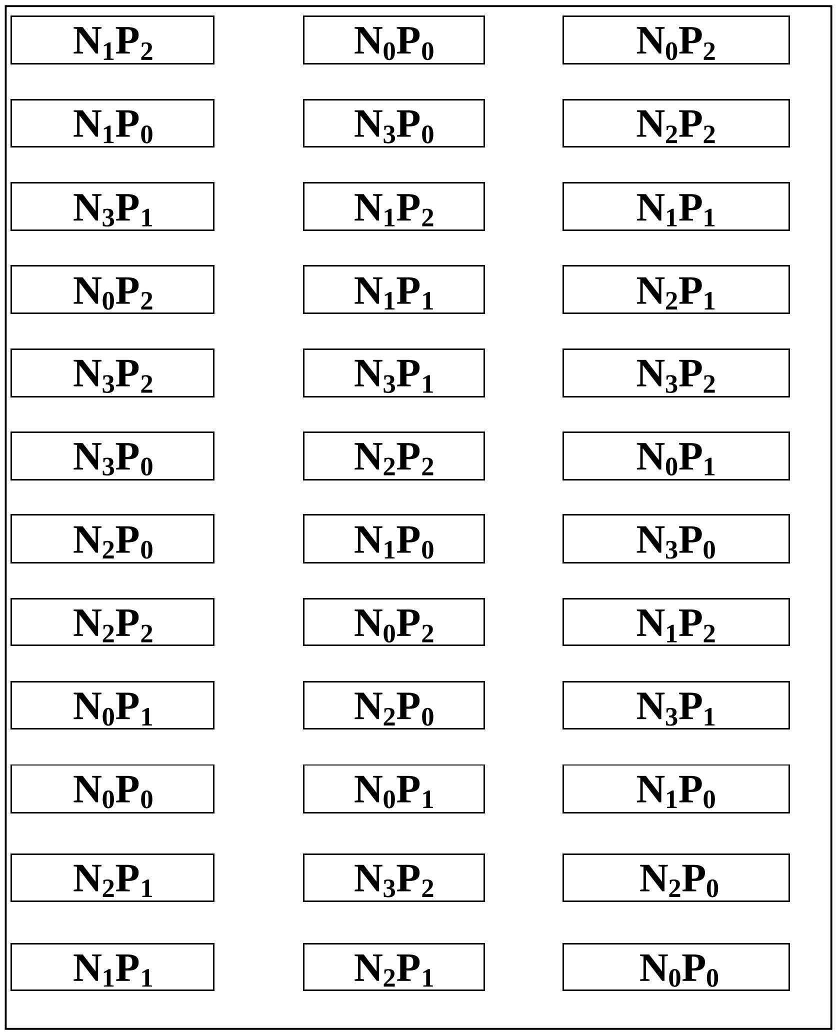
P_2: 70 kg P_2O_5 ha^{-1}

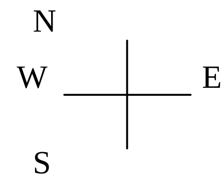
There were 12 (4 × 3) treatments combination such as

$N_0P_0, N_0P_1, N_0P_2, N_1P_0, N_1P_1, N_1P_2, N_2P_O, N_2P_1, N_2P_2, N_3P_0, N_3P_1, N_3P_2,$

3.6 Layout and design of experiment

The experiment consisting of 12 treatments combination was laid out in RCBD with three replications. The whole field was divided into three blocks and each block consisted of 12 plots. Thus the total plot number was 36. The size of each plot was 1.6m×1.5m (2.4 m^2). The distance between two adjacent unit plots was 0.50 m, plant to plant distance was 0.40 m and row to row distance was 0.50 m. The treatment was randomly assigned to each of the block.





Legend:
Number of treatment : 12
Replication : 3
Total plot : 36
Total area : 215.6 m^2
Unit plot size :1.6 m×1.5m
Plot to plot distance: 0.5 m
Block to block distance: 1 m
Row to row distance : 0.50 m
Plant to plant distance: 0.40 m

Factor A
N_0 : 0 ppm NAA
N_1 : 50 ppm NAA
N_2 : 100 ppm NAA
N_3 : 150 ppm NAA

Factor B
P_0: 0 P_2O_5 kg ha-1
P_1: 50 P_2O_5kg ha-1
P_2: 70 P_2O_5kg ha-1

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

3.7 Cultivation of okra

3.7.1 Land preparation

The selected land for the experiment was first opened on 5 March 2015 by power tiller and expose to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and laddering to obtain good tilth followed each ploughing. All Weeds, stubbles and residues were removed from the field. The large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. After removal of the weeds, stubbles and dead roots, the land was leveled and the experimental plot was partitioned in to the unit plots in accordance with the design, and the edge around each unit plot was raised to check run out of the nutrients. All types of manures were applied during final land preparation as basal dose.

3.7.2 Manure and fertilizer application

Manures and fertilizers that were applied to the experimental plot presented in (Table 1). The entire quantity of cowdung (10 ton/ha) was applied just after opening the land. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were applied as the source of Nitrogen, Phosphorus and Potassium respectively. Phosphorus was applied as per treatment in each randomized plots of $2.4m^2$. Urea and Muriate of Potash (MP) were applied at the rate of 150 kg/ha and 120 kg/ha respectively. Full dose of cowdung, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were applied to the soil at the final land preparation. Urea was applied as side dressing in three equal installments at 25, 40 and 55 days after sowing.

Table 1. Dose and method of application of fertilizers in okra field (Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, 2012)

Manures and Fertilizers	Dose/ha	Application (%) at different days after sowing (DAS)		
		25 DAS	40 DAS	55 DAS
Cowdung	10 tons (basal)	-	-	-
Nitrogen (as urea)	150 kg	33.33	33.33	33.33
P_2O_5 (as TSP)	As per treatment			
K_2O (as MP)	120 kg (basal)	-	-	-

3.7.3 Preparation and application of NAA

The stock solution of 1000 ppm of NAA with small amount of ethanol to dilute and then mixed in 1 litre of water turn as per requirement of 50 ppm, 100 ppm, 150 ppm solution of NAA. 50, 100 and 150 ml of stock solution were mixed with 1 litre of water. The NAA solution was applied at 25 DAS.

3.7.4 Sowing of seeds

The okra Seeds (BARI Dheros1) were sown on 20 March, 2015 in rows of the raised beds. Plant to plant distance was 40 cm and row to row distance was 50 cm. Three seeds were sown in each hole. Then the seeds were covered with fine soil by hand. The field was irrigated lightly immediately after sowing.

3.7.5 Intercultural operations

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

3.7.5.1 Thinning

When the seedling got established, one healthy seedling was kept and other seedlings were removed.

3.7.5.2 Gap filling

The seedlings in the experimental plot were kept under careful observation. Dead, injured and weak seedlings were replaced by new healthy seedling from the stock on the border line of the experiment.

3.7.5.3 Weeding

The weeding was done by nirani with roots at 30, 45 and 60 DAS to keep the plots free from weeds.

3.7.5.4 Irrigation

Light watering was given by a watering cane at every morning and afternoon to the plots once immediately after sowing of seed and then it was continued at 3 days interval after seedling emergence for proper growth and development of the seedlings. When the soil moisture level was very low, wherever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wet.

3.7.5.5 Drainage

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

3.7.5.6 Plant protection measure

The crop was sprayed with Ripcord 50 EC, Bavistin, Admire and Malathion 60 EC to prevent infestation of insects and vectors of virus. Some discolored leaves were also collected from the plant and removed from the field.

3.8 Harvesting

Fruits were harvested at 3 days interval based on eating quality at soft and green condition. Harvesting was started from 2 May, 2015 and was continued up to July, 2015.

3.9 Parameters assessed

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

- Plant height
- Number of branches per plant
- Diameter of stem
- Number of leaves per plant
- Leaf length
- Internode length
- Number of days required for first flowering
- Number of flower bud per plant
- Number of green pods per plant
- Pod length
- Pod diameter
- Individual green pod weight
- Pod yield per plant
- Pod yield per plot
- Pod yield per hectare

3.10 Collection of data

For data collection on the yield of green pod of okra, out of 12 plants in each unit plot 5 plants were selected at random. The following yield and yield contributing characters were considered for data collection.

3.10.1 Plant height (cm)

Average plant height of selected plants from each plot was recorded at 20, 40, 60 and 80 days after Sowing (DAS). It was measured with the help of a meter scale from the ground level to the tip of the longest stem in centimeter (cm).

3.10.2 Number of branches per plant

Average number of branches of selected plants from each plot at 20, 40, 60 and 80 days after sowing (DAS) was recorded.

3.10.3 Diameter of Stem (cm)

Average plant stem diameter was measured from random selected plants of each plot at 20, 40, 60 and 80 days after sowing (DAS). The diameter was measured in centimeter (cm) with the help of slide calipers.

3.10.4 Number of leaves per plant

Number of leaves of selected plants from each plot at 20, 40, 60 and 80 days after sowing (DAS) was recorded. Only the smallest young leaves at the growing point of the plant were excluded from counting. Calculating the average number of leaves, the average number was recorded.

3.10.5 Length of leaf (cm)

Leaves of selected plants were measured at 20, 40, 60 and 80 days after sowing (DAS). It is measured in centimeter (cm) with the help of a meter scale.

3.10.6 Length of internode (cm)

Length of internode was measured from 5 sample plants in centimeter and mean value was calculated. Length of internode was also recorded at 20, 40, 60 and 80 days after sowing (DAS) to observe the growth rate of plants.

3.10.7 Number of days required for first flowering

Different dates of first flowering were recorded. Days required for flowering was recorded from the date of sowing to the initiation of 1st flower bud.

3.10.8 Number of flower bud per plant

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

3.10.9 Number of green 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.

3.10.10 Pod length per plant (cm)

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

3.10.11 Pod diameter (cm)

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

3.10.12 Individual green pod weight (g)

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

3.10.13 Pod yield per plant (g)

Mean weight of green pods per plant was estimated from 5 selected plants per plot.

3.10.14 Pod yield per plot (kg)

Mean weight of pods per plot was estimated from 5 selected plants 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.

3.10.15 Pod yield per hectare (t)

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

3.11 Statistical analysis

The collected data were statistically analyzed to find out the level of significance using MSTAT-C software. The significance of the difference among the treatment mean was estimated by Least Significant Difference (LSD) Test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULT AND DISCUSSION

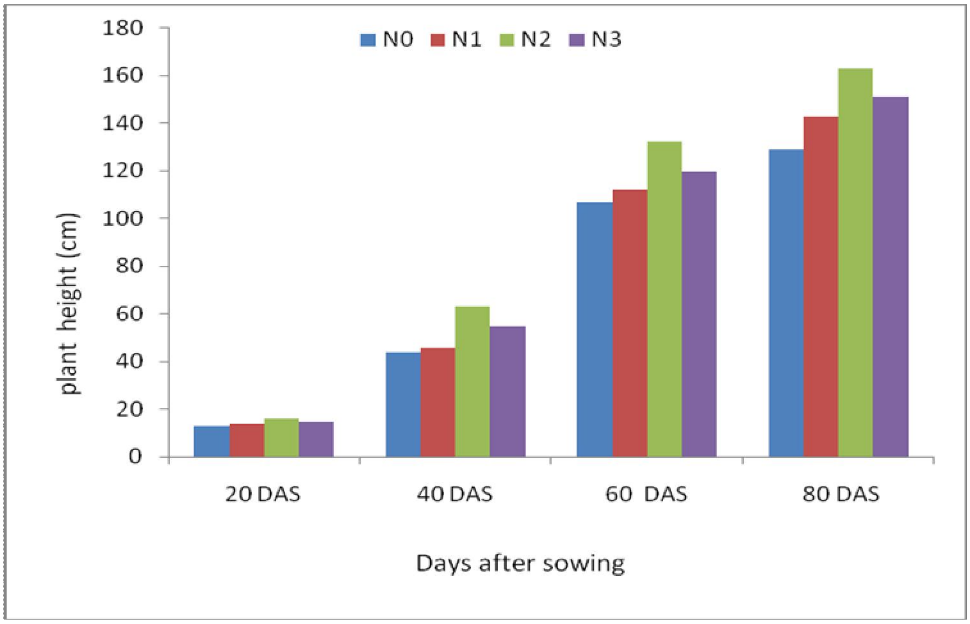
The experiment was conducted to observe the effect of naphthalene acetic acid (NAA) and phosphorus on growth and yield on okra production. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III to Appendix XI. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height (cm)

Plant height of okra varied significantly due to application of different levels of naphthalene acetic acid on plant height of okra at 20, 40, 60 and 80 DAS (Figure 2). At 80 DAS the tallest plant (163 cm) was measured from N_2 (100ppm) treatment and the shortest plant (129.1 cm) was measured from N_0 treatment. Singh and singh (1977) observed that the application of plant growth substances (GA_3 + NAA) as seed soaking and foliar spray and found maximum plant height than control. Singh *et al.* (1999) reported that naphthalene acetic acid increased plant height of okra. Abdul *et al.* (1985), Mehraj *et al.* (2015) and Muhammad Rizwan Shahid *et al.* (2013) also observed the similar result.

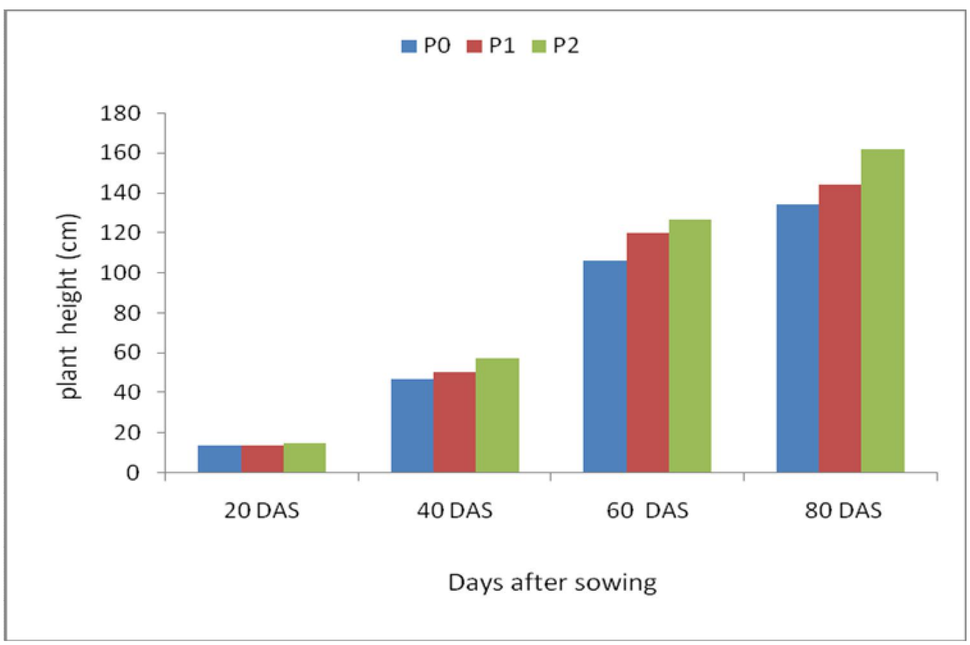
Different levels of phosphorus showed significant variation on plant height of okra at 20, 40, 60 and 80 DAS (Figure 3). At 80 DAS the tallest plant (161.70 cm) was recorded from P_2 (70 kg P_2O_5 ha^1) treatment, whereas the shortest plant (134.1 cm) was obtained from P_0 (control condition) treatment. Bhai and Singh (1998) stated that P application significantly increased the plant height. It was revealed that with the increase of phosphorus plant height increased upto a certain level. phosphorus ensured favorable condition for the growth of okra plant with optimum vegetative growth and the ultimate results was tallest plant. It revealed that with the increase of phosphorus plant height showed increasing trend. Majanbu *et al.* (1986) reported that increase of phosphorus plant height increased with a certain level. Arora *et al.* (1991) stated that plant height was significantly improved by the application of 60 kg P/ha. Bhai and Singh (1998) reported that P application significantly increased the plant height. Sajid *et al.* (2012) also observed the similar result.

Combined effect of different levels of naphthalene acetic acid and phosphorus showed significant variation on plant height of okra at 20, 40, 60 and 80 DAS (Table 2). At 80 DAS the tallest plant (175.3 cm) was observed in N_2P_2 (100 ppm and 70 kg P_2O_5/ha) treatment. While the shortest (116.3 cm) was obtained from N_0P_0 treatment, which was statistically similar to N_0P_1 (119.3 cm) at 80 DAS.



(N_0: 0ppm NAA, N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA)

Figure 2: Effect of different levels of naphthalene acetic acid on plant height of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5//ha, P_2: 70 kg P_2O_5//ha)

Figure 3: Effect of different levels of phosphorus on plant height of okra

Table 2: Combined effect of different levels of naphthalene acetic acid and phosphorus on plant height of okra at different days after sowing (DAS)

Plant height (cm)				
Treatments	20 DAS	40DAS	60DAS	80DAS
N_0P_0	12.13 g	40.67 g	94.67 f	116.30 g
N_0P_1	12.30 g	42.00 fg	110.80 def	119.30 g
N_0P_2	13.28 f	48.97 de	115.30 cde	151.50 cd
N_1P_0	13.27 f	42.33 fg	102.70 ef	130.70 f
N_1P_1	12.74 fg	45.20 efg	114.00 cde	143.30 e
N_1P_2	15.00 cd	49.00 de	119.30 bcd	155.00 c
N_2P_0	15.24 c	58.00 bc	118.30 cde	150.50 cd
N_2P_1	16.13 b	60.67 b	135.20 ab	163.00 b
N_2P_2	17.27 a	70.23 a	143.30 a	175.30 a
N_3P_0	14.27 e	47.53 ef	109.70 def	138.90 e
N_3P_1	14.50 de	53.80 cd	120.00 bcd	149.70 d
N_3P_2	15.10 cd	62.00 b	129.30 abc	165.00 b
$LSD_{(0.05)}$	0.7	6.22	16.19	5.21
CV (%)	5.91	7.11	8.12	6.1

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: 0ppm NAA, N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.2 Number of branches per plant

A significant variation was recorded on number of branches per plant of okra at 20, 40, 60 and 80 DAS due to different levels of naphthalene acetic acid (Table 3). At 80 DAS the maximum number of branches per plant (2.88) was observed in N_2 treatment and the minimum number of branches per plant (2.11) was recorded from N_0 treatment. Mehraj *et al.* (2015) also observed the similar result. Sayed *et al.* (1997) reported that application of three growth regulators such as gibberellic acid (GA_3), Planofix (NAA) and cultar (paclobutrazol) at 50,100,150 and 200 ppm on okra where NAA was found most effective in increasing the no of branches plant^{-1}.

Number of branches per plant showed significant variation due to application of different levels of phosphorus at 20, 40, 60 and 80 DAS of okra under the present trial (Table 4). At 80 DAS the maximum number of branches per plant (2.76) was recorded from P_2 treatment, whereas the minimum number of branches per plant (2.29) from P_0 treatment. Akinrinde and Adigun (2005) reported that okra plants were more efficient in their use of P.

Significant variations on number of branches per plant of okra were showed due to interaction effect of different levels of naphthalene acetic acid and phosphorus at 20, 40, 60 and 80 DAS (Table 5). At 80 DAS, the maximum number of branches per plant (3.33) was recorded from N_2P_2 treatment combination, while the minimum number of branches per plant (1.96) was recorded from N_0P_0 treatment combination, which was statistically similar to N_0P_1 (2.2 cm) treatment combination.

Table 3. Effect of different levels of naphthalene acetic acid on number of branches per plant of okra at different days after sowing (DAS)

Treatments	Number of branches per plant			
	20DAS	40DAS	60DAS	80DAS
N_0	0.98 d	1.36 c	1.95 c	2.11 d
N_1	1.05 c	1.55 b	2.14 b	2.42 c
N_2	1.47 a	2.22 a	2.44 a	2.88 a
N_3	1.22 b	1.61 b	2.24 b	2.61 b
LSD $_{(0.05)}$	0.08	0.12	0.13	0.11
CV (%)	6.38	7.25	5.99	6.57

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 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA)

Table 4. Effect of different levels of phosphorus on number of branches per plant of okra at different days after sowing (DAS)

Treatments	Number of branches per plant			
	20 DAS	40 DAS	60 DAS	80DAS
P_0	0.96 c	1.46 c	2.03 b	2.29 c
P_1	1.03 b	1.67 b	2.11 b	2.46 b
P_2	1.55 a	1.92 a	2.44 a	2.76 a
LSD $_{(0.05)}$	0.07	0.1	0.11	0.1
CV (%)	6.38	7.25	5.99	6.57

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 (P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Table 5: Combined effect of different levels of naphthalene acetic acid and phosphorus on number of branches per plant of okra at different days after sowing (DAS)

Number of branches per plant				
Treatments	20 DAS	40DAS	60DAS	80DAS
N_0P_0	0.83 f	1.23 g	1.87 g	1.97 g
N_0P_1	0.86 ef	1.33 fg	1.93 fg	2.17 f
N_0P_2	1.23 cd	1.53 ef	2.07 defg	2.20 f
N_1P_0	0.90 ef	1.27 g	2.00 efg	2.23 f
N_1P_1	0.93 ef	1.57 e	2.08 defg	2.30 ef
N_1P_2	1.33 c	1.80 cd	2.33 bc	2.73 c
N_2P_0	1.13 d	2.00 bc	2.17 cde	2.47 de
N_2P_1	1.18 d	2.20 b	2.27 bcd	2.87 bc
N_2P_2	2.10 a	2.47 a	2.90 a	3.33 a
N_3P_0	0.97 e	1.33 fg	2.10 def	2.32 def
N_3P_1	1.15 d	1.60 de	2.14 cdef	2.50 d
N_3P_2	1.54 b	1.90 c	2.47 b	3.01 b
$LSD_{(0.05)}$	0.13	0.21	0.22	0.19
CV (%)	6.38	7.25	5.99	6.57

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 ppm NAA (control), N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.3 Diameter of stem

Significant variation was recorded due to use different levels of naphthalene acetic acid on diameter of stem at 20, 40, 60 and 80 DAS (Table 6). At 80 DAS the highest diameter of stem (2.45 cm) was obtained from N_2 treatment, and the lowest diameter (2.16 cm) was found from N_0 treatment.

Diameter of stem varied significantly for different levels of phosphorus at 20, 40, 60 and 80 DAS of okra under the present trial (Table 7). At 80 DAS the highest diameter of stem (2.47 cm) was found from P_2 treatment, while the lowest diameter of stem (2.15 cm) from P_0 treatment.

Diameter of stem of okra showed significant differences due to the combined effect of naphthalene acetic acid and phosphorus on at 20, 40, 60 and 80 DAS (Table 8). At 80 DAS the highest diameter of stem (2.63 cm) was observed from N_2P_2 treatment combination and the lowest diameter of stem (2.03) was recorded from the treatment combination of N_0P_0, which was statistically similar to N_3P_0 (2.07 cm) treatment combination.

Table 6: Effect of different levels of naphthalene acetic acid on diameter of stem of okra at different days after sowing (DAS)

Treatments	Diameter of stem (cm)			
	20DAS	40DAS	60DAS	80DAS
N_0	0.46 c	1.65 d	2.09 d	2.16 d
N_1	0.48 c	1.75 c	2.36 b	2.40 b
N_2	0.58 a	1.96 a	2.42 a	2.45 a
N_3	0.52 b	1.81 b	2.15 c	2.23 c
LSD $_{(0.05)}$	0.031	0.031	0.031	0.011
CV (%)	3.24	3.75	3.57	2.56

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: 0ppm NAA, N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA).

Table 7: Effect of different levels of phosphorus on diameter of stem of okra at different days after sowing (DAS)

Treatments	Diameter of stem (cm)			
	20 DAS	40 DAS	60 DAS	80DAS
P_0	0.44 c	1.68 c	2.05 c	2.15 c
P_1	0.51 b	1.77 b	2.31 b	2.31 b
P_2	0.59 a	1.92 a	2.40 a	2.47 a
LSD $_{(0.05)}$	0.027	0.027	0.027	0.046
CV (%)	3.24	3.75	3.57	2.56

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 (P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Table 8: Combined effect of different levels of naphthalene acetic acid and phosphorus on diameter of stem okra at different days after sowing (DAS)

	Diameter of stem (cm)			
Treatments	20 DAS	40DAS	60DAS	80DAS
N_0P_0	0.39 f	1.53 h	1.92 h	2.03 g
N_0P_1	0.43 ef	1.60 g	2.20 e	2.13 f
N_0P_2	0.54 bc	1.81 e	2.13 f	2.33 cd
N_1P_0	0.40 f	1.64 g	2.14 f	2.29 de
N_1P_1	0.49 d	1.71 f	2.42 c	2.37 cd
N_1P_2	0.56 bc	1.90 cd	2.53 b	2.53 b
N_2P_0	0.48 de	1.84 de	2.14 f	2.22 e
N_2P_1	0.60 b	1.96 b	2.47 c	2.49 b
N_2P_2	0.68 a	2.08 a	2.64 a	2.63 a
N_3P_0	0.47 de	1.71 f	2.00 g	2.06 fg
N_3P_1	0.52 cd	1.81 e	2.16 ef	2.23 e
N_3P_2	0.58 b	1.90 c	2.31 d	2.40 c
LSD $_{(0.05)}$	0.054	0.054	0.054	0.093
CV (%)	3.24	3.75	3.57	2.56

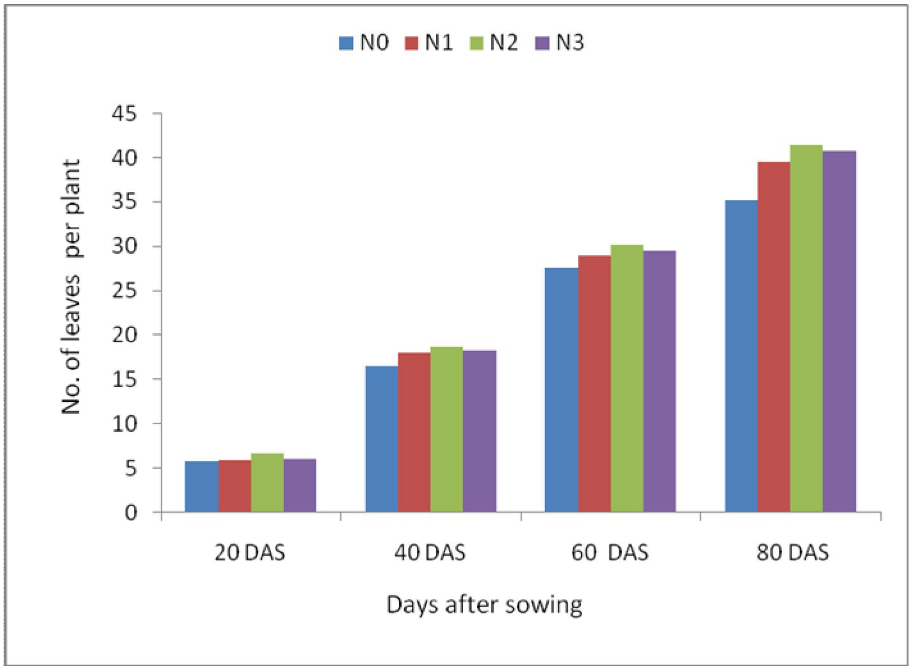
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (N_0: 0ppm NAA (control), N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.4 Number of leaves per plant

Due to application of different levels of naphthalene acetic acid showed significant differences on number of leaves at 20, 40, 60 and 80 DAS (Figure 4). At 80 DAS the maximum number of leaves per plant (41.4) was observed in N_2 treatment, while the minimum number of leaves per plant (35.20) was recorded from N_0 treatment at the same days of observations. Mehraj *et al.* (2015) and Muhammad Rizwan Shahid *et al.* (2013) also observed the similar result. Arora and Sharma (1990) found that application of 500 ppm of cycocel and 150 ppm of NAA increased the number of leaves per plant in okra.

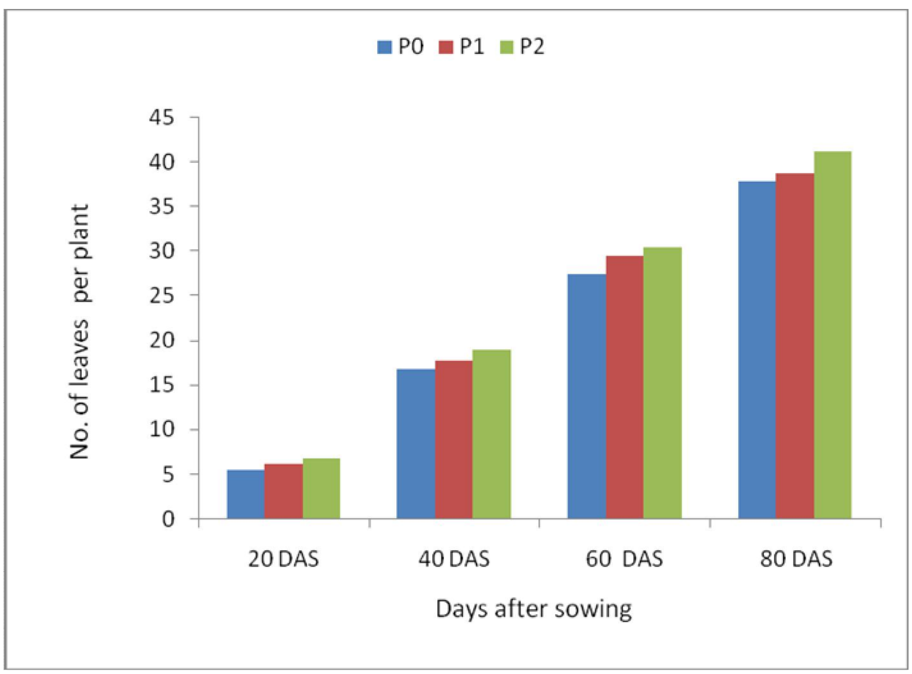
Significant variation was recorded for number of leaves per plant for different levels of phosphorus at 20, 40, 60 and 80 DAS of okra under the present trial (Figure 5). At 80 DAS the maximum number of leaves per plant (41.05) was recorded from P_2 treatment while whereas the minimum number (37.75) from P_0 treatment.

Combined effect of different levels of naphthalene acetic acid and phosphorus showed significant differences on number of leaves per plant of okra at 20, 40, 60 and 80 DAS (Table 9). At 80 DAS, the maximum number of leaves per plant (43.8) was found from N_2P_2 treatment combination and the minimum number (33.47) from the treatment combination of N_0P_0.



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA)

Figure 4: Effect of different levels of naphthalene acetic acid on number of leave of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Figure 5: Effect of different levels of phosphorous on number of leave of okra

Table 9: Combined effect of different levels of naphthalene acetic acid and phosphorus on number of leaves of okra at different days after sowing (DAS)

	Number of leaves			
Treatments	20 DAS	40DAS	60DAS	80DAS
N_0P_0	5.17 g	15.67 g	26.60 h	33.47 j
N_0P_1	5.88 e	16.53 f	27.53 g	35.40 i
N_0P_2	6.40 c	17.07 de	28.67 e	36.73 h
N_1P_0	5.38 f	17.00 e	27.33 g	38.40 g
N_1P_1	6.06 de	17.40 de	29.07 d	38.87 fg
N_1P_2	6.51 c	19.33 b	30.47 bc	41.00 c
N_2P_0	6.00 de	17.47 d	27.87 f	39.87 de
N_2P_1	6.60 bc	18.60 c	30.73 b	40.53 cd
N_2P_2	7.50 a	20.07 a	31.73 a	43.80 a
N_3P_0	5.51 f	17.13 de	27.60 fg	39.27 ef
N_3P_1	6.10 d	18.20 c	30.20 c	39.93 de
N_3P_2	6.73 b	19.40 b	30.60 b	42.67 b
LSD $_{(0.05)}$	0.2	0.42	0.317	0.686
CV (%)	4.93	5.39	5.64	6.04

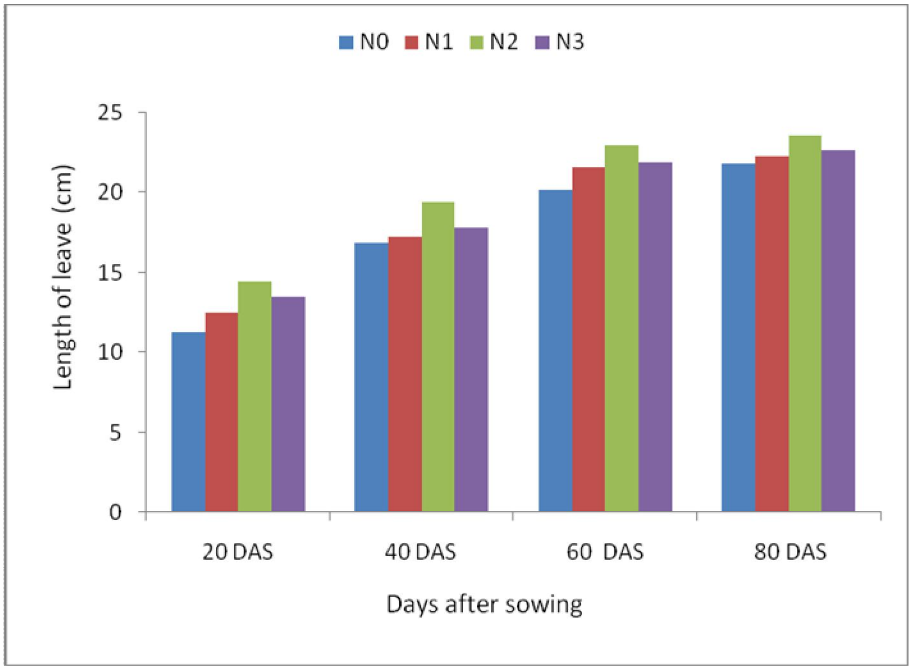
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (N_0: 0ppm NAA (control), N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.5 Leaf length

Leaf length of okra showed significant variation for different levels of naphthalene acetic acid at 20, 40, 60 and 80 DAS (Figure 6). At 80 DAS the longest leaf (23.53 cm) was observed in N_2 treatment and the shortest leaf length (21.80 cm) was found from N_0 treatment. Abd-el-fattah (1997) reported that foliar application of PGRs increased leaf area.

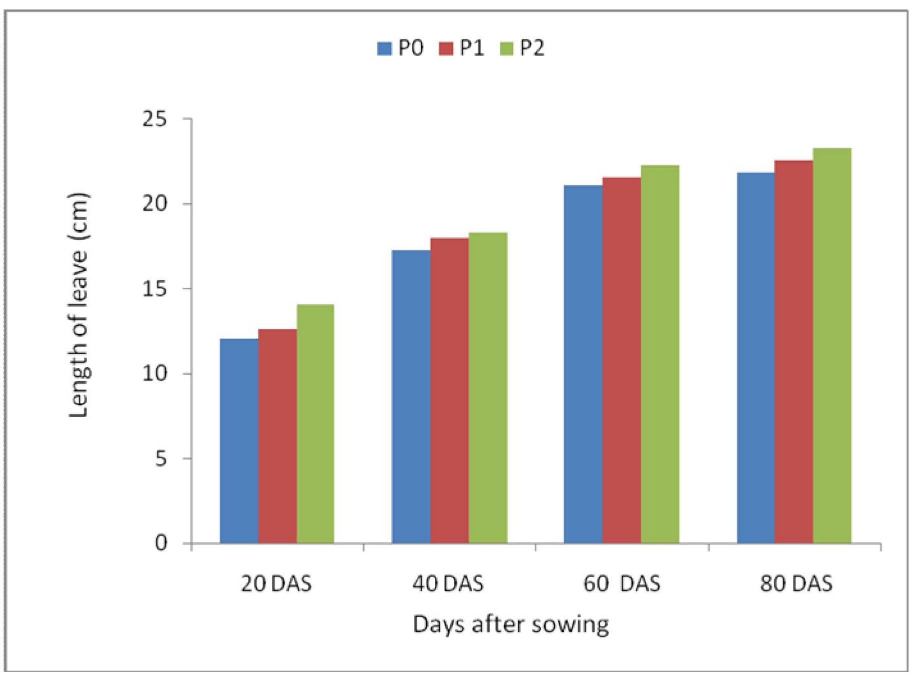
Statistically significant variation was observed in terms of length of leaf of okra due to different levels of phosphorus at 20, 40, 60 and 80 DAS (Figure 7). At 80 DAS the longest leaf (23.25 cm) was found from P_2 treatment and the shortest leaf length (21.82 cm) was recorded from P_0 treatment.

Combined effect of different levels of naphthalene acetic acid and phosphorus showed significant differences on leaf length of okra at 20, 40, 60 and 80 DAS (Table 10). At 80 DAS the longest leaf (24.53 cm) was recorded from N_2P_2 treatment combination, while the shortest leaf (21.33 cm) was found at 80 DAS by N_0P_0 treatment combination, which was similar to N_1P_0 (21.53 cm) treatment combination at 80 DAS.



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA)

Figure 6: Effect of different levels of naphthalene acetic acid on leaf length of okra.



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Figure 7: Effect of different levels of phosphorous on leaf length of okra

Table 10: Combined effect of different levels of naphthalene acetic acid and phosphorus on leaf length of okra at different days after sowing (DAS)

Leaf length (cm)				
Treatments	20 DAS	40DAS	60DAS	80DAS
N_0P_0	10.13 f	16.55 h	19.47 h	21.33 h
N_0P_1	11.07 ef	16.90 fgh	20.20 g	21.73 fg
N_0P_2	12.67 cd	17.00 fg	20.70 f	22.33 e
N_1P_0	11.63 de	16.83 gh	21.07 e	21.53 gh
N_1P_1	11.87 de	17.23 ef	21.33 e	22.37 de
N_1P_2	13.80 bc	17.50 e	22.33 c	22.67 c
N_2P_0	13.83 bc	18.47 c	22.47 bc	22.60 cd
N_2P_1	14.00 b	19.40 b	22.80 b	23.47 b
N_2P_2	15.43 a	20.20 a	23.43 a	24.53 a
N_3P_0	12.63 cd	17.11 fg	21.15 e	21.81 f
N_3P_1	13.43 bc	18.01 d	21.83 d	22.58 cd
N_3P_2	14.23 ab	18.30 cd	22.43 c	23.47 b
LSD $_{(0.05)}$	1.324	0.38	0.34	0.23
CV (%)	6.06	7.27	6.05	5.61

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 ppm NAA (control), N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.6 Internode length

Statistically significant variation was recorded due to effect different levels of naphthalene acetic acid on internode length of okra at 20, 40, 60 and 80 DAS (Table 11). At 80 DAS the longest internode (11.78 cm) was recorded from N_2 treatment, whereas the shortest internode (8.75 cm) was found from N_0 treatment. Harrington *et al.* (1996) reported that stem elongation was 20-30% more with the application of growth hormones.

Different levels of phosphorus varied significantly on internode length at 20, 40, 60 and 80 DAS of okra (Table 12). At 80 DAS the longest internode (11.73 cm) was recorded from P_2 treatment whereas the shortest internode (8.89 cm) was found from P_0 treatment.

Combined effect of different levels of naphthalene acetic acid and phosphorus showed significant differences on internode length of okra at 20, 40, 60 and 80 DAS (Table 13). At 80 DAS the longest internode (14.17 cm) was obtained from N_2P_2 treatment combination, while the shortest internode (8.07 cm) was found at 80 DAS by N_0P_0 treatment, which was statistically identical to N_3P_0 (8.16 cm) treatment combination.

Table 11: Effect of different levels of naphthalene acetic acid on internode length of okra at different days after sowing (DAS)

Treatments	Internode length (cm)			
	20DAS	40DAS	60DAS	80DAS
N_0	4.51 d	5.53 c	8.09 d	8.75 c
N_1	4.91 c	5.82 c	9.51 c	10.29 b
N_2	5.62 a	6.71 a	10.38 a	11.78 a
N_3	5.37 b	6.24 b	9.91 b	10.21 b
LSD $_{(0.05)}$	0.23	0.33	0.36	0.27
CV (%)	5.67	6.57	5.9	5.72

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA).

Table 12: Effect of different levels of phosphorus on internode length of okra at different days after sowing (DAS)

Treatments	Internode length (cm)			
	20 DAS	40 DAS	60 DAS	80DAS
P_0	4.61 c	5.65 c	8.33 c	8.89 c
P_1	5.01 b	6.00 b	9.81 b	10.15 b
P_2	5.68 a	6.58 a	10.27 a	11.73 a
LSD $_{(0.05)}$	0.2	0.29	0.31	0.24
CV (%)	5.67	6.57	5.9	5.72

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Table 13: Combined effect of different levels of naphthalene acetic acid and phosphorus on internode length of okra at different days after sowing (DAS)

Internode length (cm)				
Treatments	20 DAS	40DAS	60DAS	80DAS
N_0P_0	4.33 f	5.46 f	7.33 e	8.06 f
N_0P_1	4.46 ef	5.60 def	8.46 d	8.93 e
N_0P_2	4.73 ef	5.53 ef	8.46 d	9.26 e
N_1P_0	4.60 ef	5.60 def	8.60 d	9.40 e
N_1P_1	4.86 de	5.80 def	9.93 c	10.17 d
N_1P_2	5.26 cd	6.06 cde	10.00 c	11.30 c
N_2P_0	4.73 ef	5.86 def	8.80 d	9.93 d
N_2P_1	5.33 c	6.46 bc	10.80 b	11.23 c
N_2P_2	6.80 a	7.80 a	11.53 a	14.17 a
N_3P_0	4.80 e	5.66 def	8.60 d	8.16 f
N_3P_1	5.40 c	6.13 cd	10.07 c	10.27 d
N_3P_2	5.93 b	6.93 b	11.07 ab	12.20 b
LSD $_{(0.05)}$	0.404	0.57	0.624	0.472
CV (%)	5.67	6.57	5.9	5.72

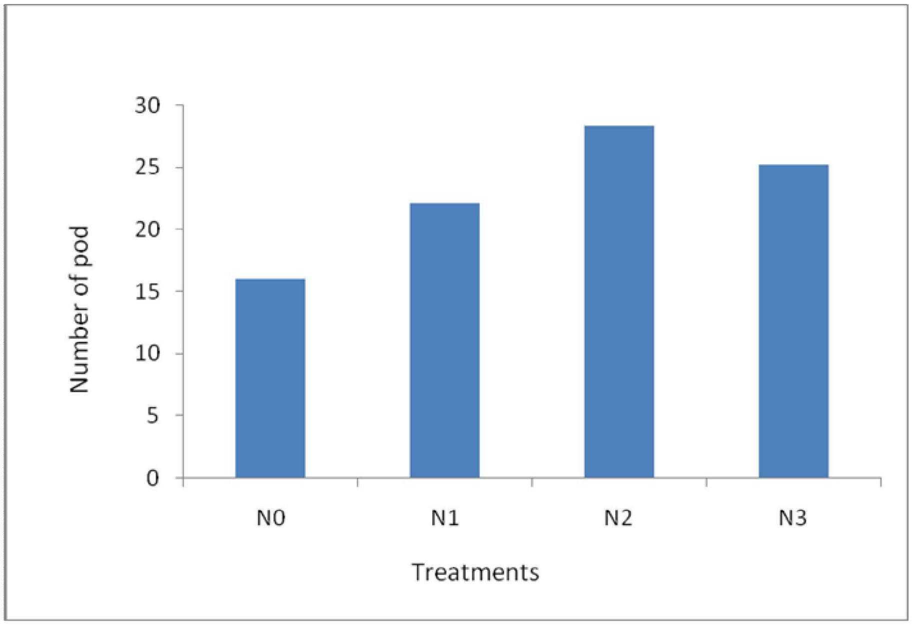
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability (N_0: 0 ppm NAA (control), N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.7 Number of pods per plant

Different levels of naphthalene acetic acid showed significant variation on number of pods per plant of okra (Figure 8). The maximum number of pods per plant (28.22) was observed in N_2 treatment and the minimum (16.04) was counted from N_0 treatment. Mehraj *et al.* (2015) and Muhammad Rizwan Shahid *et al.* (2013) also observed the similar result. The present results were similar with the above present study.

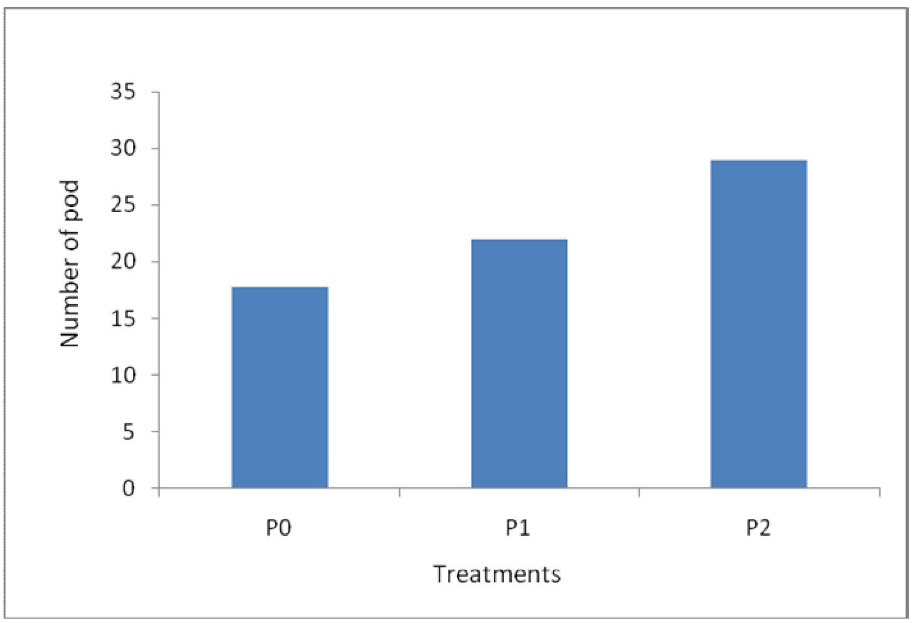
Number of pods per plant of okra varied significantly due to response of different levels of phosphorus (Figure 9). The maximum number of pods per plant (28.95) was observed in P_2 treatment and the minimum (17.79) was counted from P_0 treatment. Laxman *et al.* (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased the number of Pods per plant. Arora *et al.* (1991) stated that number of pods per plant was significantly improved by the application of 60 kg P/ha. Majanbu *et al.* (1985) reported that due to the increase of phosphorus number of pods per plant increased with a certain level. Sajid *et al.* (2012) also observed the similar result.

Due to combined effect of different levels naphthalene acetic acid and phosphorus showed significant differences on number of pods per plant of okra (Table 14). The maximum number of pods per plant (38.67) was found from N_2P_2 treatment combination and the minimum (13.20) was found from N_0P_0 treatment combination, which was similar with (15.33) found from N_0P_1 treatment combination.



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA)

Figure 8: Effect of different levels of naphthalene acetic acid on number of pod per plant of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

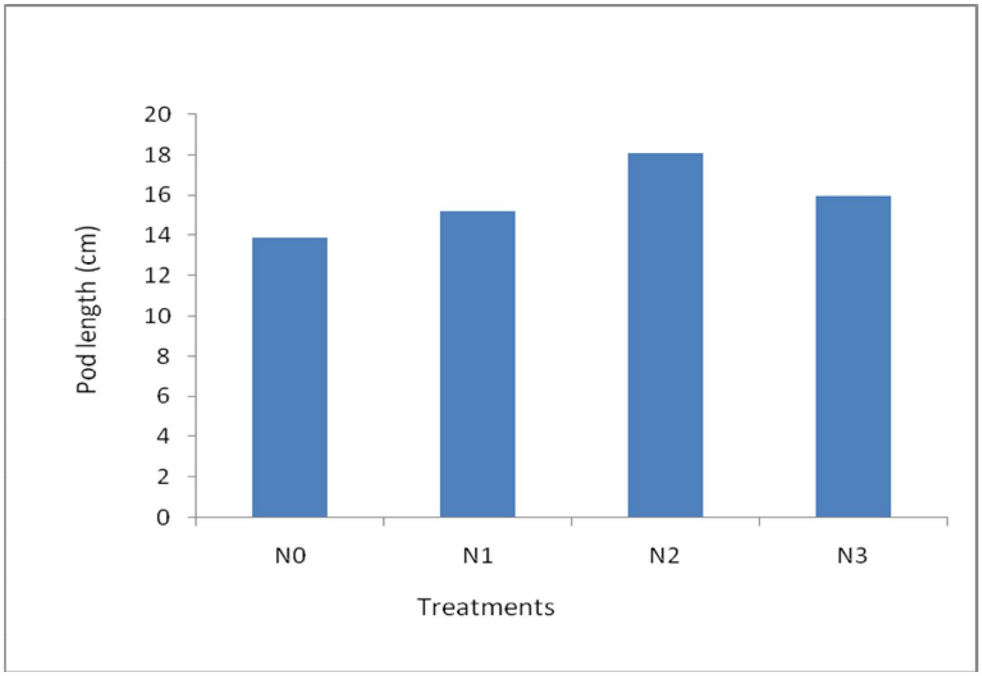
Figure 9: Effect of different levels of phosphorus on number of pod per plant of okra

4.8 Pod length

Pod length of okra varied significantly due to response of different levels of naphthalene acetic acid (Fig. 10). The longest pod (18.13 cm) was found from N_2 treatment, whereas the shortest pod (13.89 cm) was recorded from N_0 treatment. Mehraj *et al.* (2015) and Muhammad Rizwan Shahid *et al.* (2013) also observed the similar result. Sayed *et al.* (1997) observed similar results and reported that the application of phanofix (NAA) to Okra at 20 DAS increased the pod length.

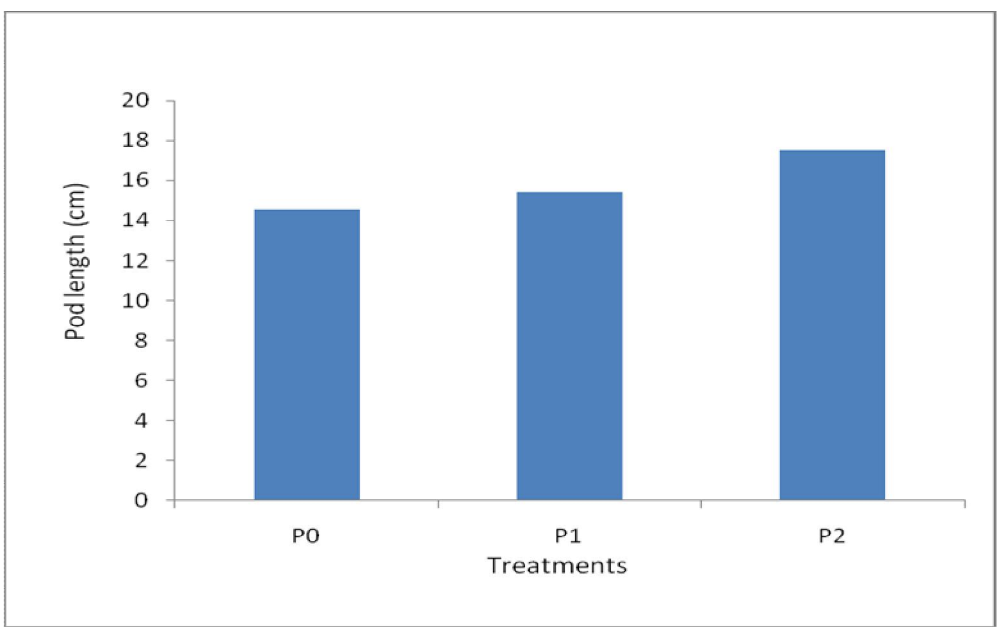
Statistically significant variation was observed on pod length of okra due to the application different levels of phosphorus (Fig. 11). The longest pod (17.52 cm) was observed from P_2 treatment, while the shortest pod (14.52 cm) from P_0 treatment. Laxman *et al*. (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased Pod length. Mohanta (1998) reported that increasing level of phosphorus increased pod length but after a certain level then the length decreased. Gupta *et al*. (1981) stated that phosphorus fertilization increased pod size which finally contributed towards increasing the pod yield.

Combined effect of different levels of naphthalene acetic acid and phosphorus showed significant differences on pod length of okra (Table 14). The longest pod (21.57cm) was observed from N_2P_2 treatment combination while the shortest pod (13.73 cm) from N_0P_0 treatment combination, which was statistically similar (13.87) to $N_0P_{1,}$ (13.93) to $N_1P_{0,}$ (14.07) to N_0P_2 and (14.27) to $N_3P_{0.}$



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA)

Figure 10: Effect of different levels of naphthalene acetic acid on pod length per plant of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Figure 11: Effect of different levels of phosphorus on pod length per plant of okra

4.9 Pod diameter

Different levels of naphthalene acetic acid showed significant variation on pod diameter of okra (Table 15). The highest diameter of pod (1.76 cm) was observed from N_2 treatment which was statistically identical (1.71 cm) to N_3 treatment whereas the lowest diameter of pod (1.44 cm) was recorded from N_0 treatment.

Application of different levels of phosphorus varied significantly on pod diameter under the present trial (Table 16). The highest diameter of pod (1.76 cm) was recorded from P_2 treatment whereas the lowest diameter of pod (1.50cm) from P_0 treatment. Laxman *et al.* (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased Pod diameter. Mohanta (1998) reported that increasing level of phosphorus increased Pod diameter but after a certain level then decreased.

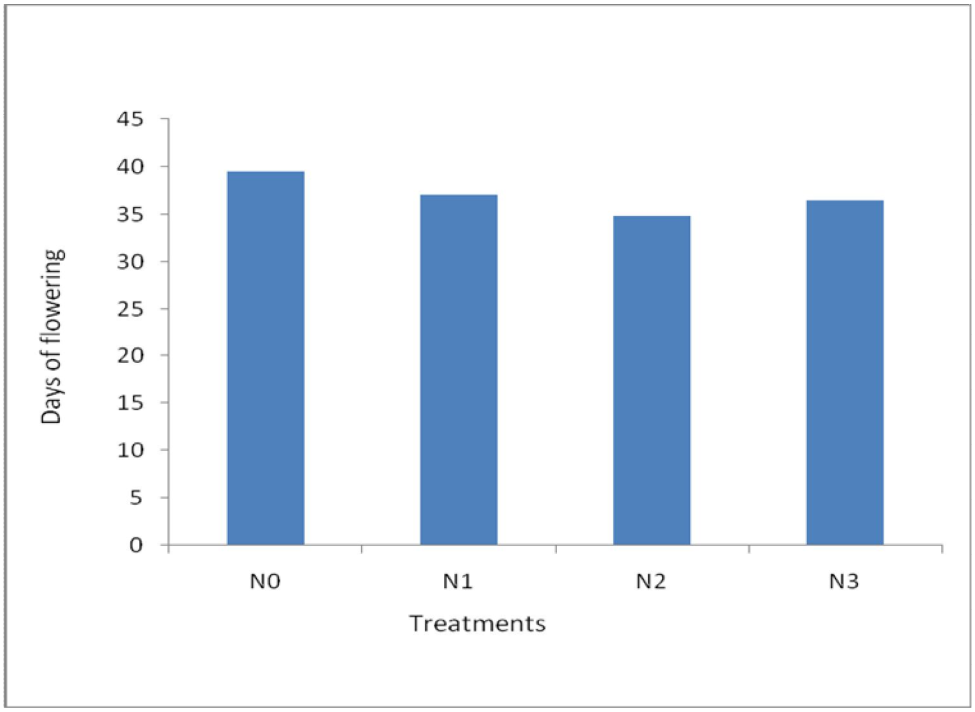
Significant variation was recorded due to the combined effect of different levels of naphthalene acetic acid and phosphorus on diameter of pod of okra (Table 17).The highest diameter of pod (2.03) was found from N_2P_2 treatment combination and the lowest diameter of pod (1.40 cm) was recorded from N_0P_0 treatment combination, which was statistically identical (1.433 cm) to N_0P_1, (1.46 cm) to N_1P_0, (1.50 cm) to N_0P_2, (1.53 cm) to N_3P_0, (1.56 cm) to N_2P_0 and (1.63 cm) to N_1P_2 treatment combination.

4.10 Days required for first flowering

Application of different levels of naphthalene acetic acid showed significant variation on days required for flowering of okra (Figure 12). Singh *et al* (1999), Gulshan and Lal (1997), Sayed *et al.* (1997) stated that NAA increased advanced flowering. The minimum (34.89) days for flowering was found from N_2 treatment. On the other hand, the maximum (39.56) days was from N_0 treatment.

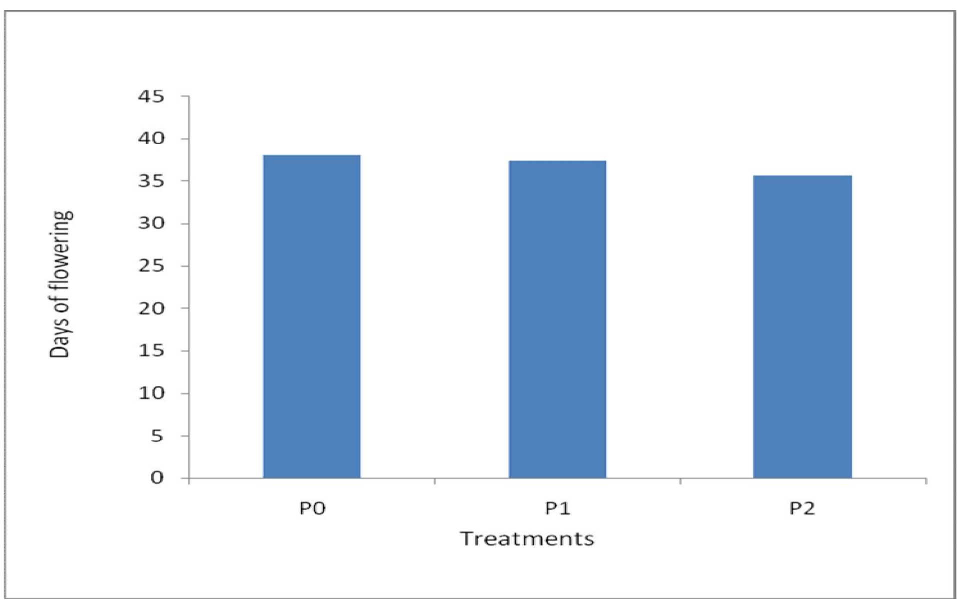
Days required for flowering varied significantly due to response of different levels of phosphorus (Figure 13). The minimum (35.67) days required for flowering was recorded from P_2 treatment, whereas the maximum (38.0) days was from P_0 treatment, which was statistically similar (37.33) to P_1 treatment.

Due to combined effect of different levels of naphthalene acetic acid and phosphorus showed significant differences on days required for flowering of okra (Table 14). The minimum (33.67) days required for flowering was found from N_2P_2 treatment combination, which was statistically similar (34.67) to $N_3P_{2,}$ (35.33) to N_2P_0 and (35.67) to N_2P_1 treatment combination. Whereas the maximum (41.33) days required for flowering was found from N_0P_0 treatment combination, which was statistically similar (39.67) to N_0P_1 treatment combination.



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA)

Figure 12: Effect of different levels of naphthalene acetic acid on days of flowering of okra.



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ ha)

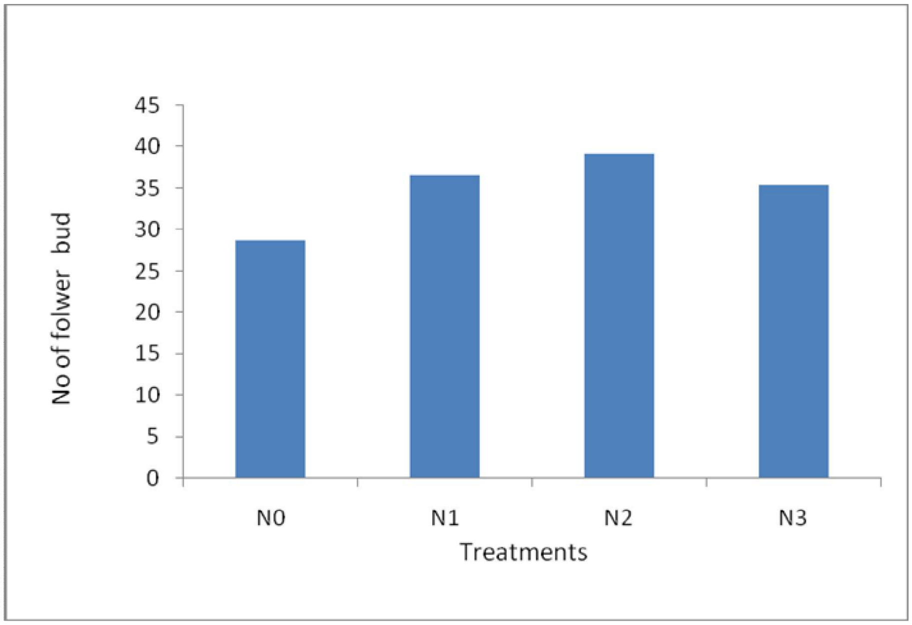
Figure 13: Effect of different levels of phosphorus on days of flowering of okra

4.11 Number of flower buds per plant

Due to application of different levels of naphthalene acetic acid on number of flower buds per plant varied significantly (Figure 14). The maximum number of flower buds per plant (39.06) was observed in N_2 treatment and the minimum (28.63) was recorded from N_0 treatment. Gulshan and Lal (1997) and Sayed *et al* (1997) also found the similar result.

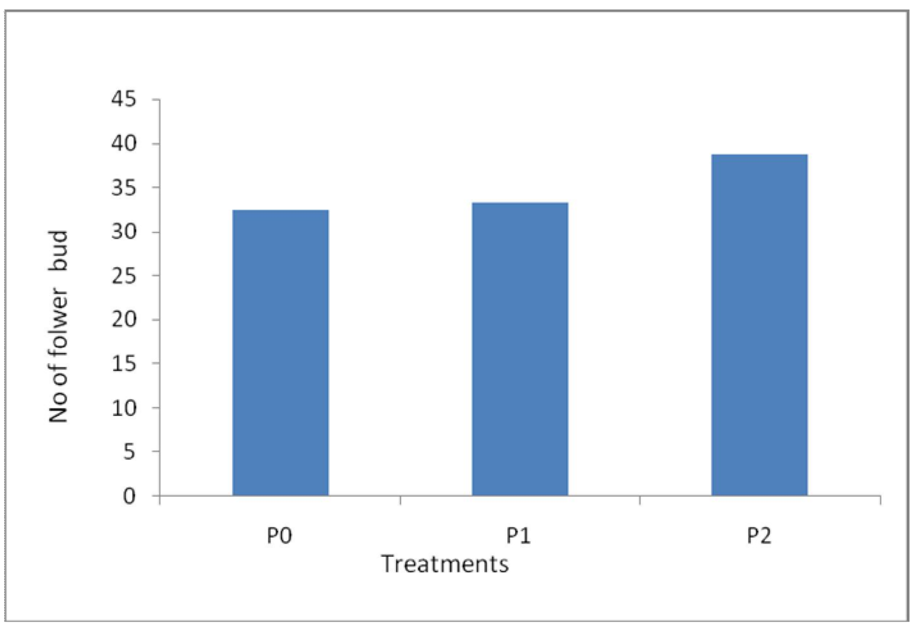
Significant variation was found due to application of different leaves of phosphorus on number of flower buds per plant (Figure 15). The maximum number of flower buds per plant (38.77) was counted from P_2 treatment, whereas the minimum (32.43) was obtained from P_0 treatment, which was statistically similar and with P_1 (33.33) treatment.

Combined effect of naphthalene acetic acid and phosphorus showed significant variation on number of flower buds per plant (Table 14). The maximum number of flower buds per plant (43.83) was counted from the treatment combination of N_2P_2, while the minimum (24.0) was obtained from N_0P_0.



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA)

Figure14: Effect of different levels of naphthalene acetic acid on number of flower bud per plant of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Figure 15: Effect of different levels of phosphorus on number of flower bud per plant of okra

Table 14: Combined effect of different levels of naphthalene acetic acid and phosphorus on days of flowering, no. of flower bud, no. of pod per plant, length of pod of okra

Treatments	Days of flowering	No. of flower bud /plant	No. of pod/ plant	Length of pod (cm)
N_0P_0	41.33 a	24.00 h	13.20 g	13.73 f
N_0P_1	39.67 ab	27.87 g	15.33 fg	13.87 ef
N_0P_2	37.67 bcd	34.03 ef	19.60 de	14.07 def
N_1P_0	37.00 cde	34.97 def	21.00 d	13.93 ef
N_1P_1	37.67 bcd	35.00 def	20.33 d	15.43 cde
N_1P_2	36.67 cdef	39.30 b	25.03 c	16.30 c
N_2P_0	35.33 efg	35.90 cde	19.67 d	16.13 c
N_2P_1	35.67 defg	37.43 bcd	26.33 c	16.70 bc
N_2P_2	33.67 g	43.83 a	38.67 a	21.57 a
N_3P_0	38.33 bc	34.87 ef	17.30 ef	14.27 def
N_3P_1	36.33 cdef	33.00 f	25.67 c	15.60 cd
N_3P_2	34.67 fg	37.90 bc	32.50 b	18.13 b
$LSD_{(0.05)}$	2.25	2.556	2.302	1.603
CV (%)	3.59	4.33	5.94	5.99

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 ppm NAA (control), N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.12 Individual pod weight

Statistically significant variation was recorded on individual pod weight of okra due to different levels of naphthalene acetic acid (Table 15). The highest individual pod weight (19.12 g) was found from N_2 treatment, and the lowest individual pod weight (15.28 g) was recorded from N_0 treatment.

Individual pod weight of okra significantly differed due to different levels of phosphorus under the present trial (Table 16). The highest individual pod weight (19.3 g) was found from P_2 treatment. While the lowest individual pod weight (15.78 g) was obtained from P_0 treatment, which was statistically identical (16.91 g) to P_1 treatment. Mohanta (1998) reported that increasing level of phosphorus increased Individual Pod weight but after a certain level then decreased**.**

Due to combined effect of naphthalene acetic acid and phosphorus showed significant differences on individual pod weight of okra (Table 17). The highest individual pod weight (22.13 g) was observed from N_2P_2 treatment combination, which was statistically identical (20.93 g) to N_3P_2 treatment combination. The lowest individual pod weight (15.07 g) was observed from N_0P_0 treatment combination, which was statistically identical (15.23 g) to N_0P_1, (15.53 g) to $N_0P_{2,}$ (15.63 g) to $N_1P_{0,}$ (15.8 g) to $N_2P_{0,}$ (16.33 g) to N_3P_1 and (16.63 g) to N_3P_0 treatment combination.

Table 15: Effect of different levels of naphthalene acetic acid on individual pod weight and pod diameter of okra

Treatments	Individual pod weight (g)	Pod diameter (cm)
N_0	15.28 d	1.44 c
N_1	16.96 c	1.59 b
N_2	19.12 a	1.77 a
N_3	17.97 b	1.71 ab
LSD $_{(0.05)}$	0.65	0.1417
CV (%)	9.71	9.01

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: 0ppm NAA, N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA).

Table 16: Effect of different levels of phosphorus on individual pod weight and pod diameter of okra

Treatments	Individual pod weight (g)	Pod diameter (cm)
P_0	15.78 b	1.49 c
P_1	16.91 b	1.63 b
P_2	19.30 a	1.75 a
LSD $_{(0.05)}$	1.43	0.123
CV (%)	9.71	9.01

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 (P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

.

Table 17: Combined effect of different levels of naphthalene acetic acid and phosphorus on individual pod weight and pod diameter of okra

Treatments	Individual pod weight (g)	Pod diameter (cm)
N_0P_0	15.07 e	1.40 f
N_0P_1	15.23 e	1.43 ef
N_0P_2	15.53 e	1.50 cdef
N_1P_0	15.63 e	1.46 def
N_1P_1	16.63 cde	1.66 bcde
N_1P_2	18.60 bcd	1.63 bcdef
N_2P_0	15.80 de	1.57 cdef
N_2P_1	19.43 abc	1.70 bcd
N_2P_2	22.13 a	2.03 a
N_3P_0	16.63 cde	1.53 cdef
N_3P_1	16.33 de	1.73 bc
N_3P_2	20.93 ab	1.86 ab
LSD $_{(0.05)}$	2.851	0.245
CV (%)	9.71	9.01

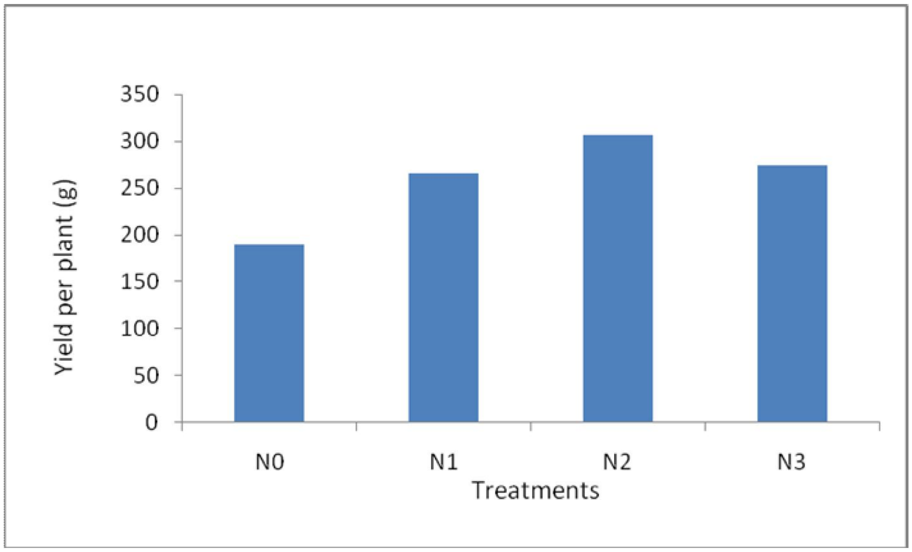
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. (N_0: 0 ppm NAA (control), N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

4.13 Yield per plant

Different levels of naphthalene acetic acid showed significant variation on yield per plant of okra (Fig.16). The highest yield per plant (306.11 g) was recorded from N_2 treatment, On the contrary, the lowest yield per plant (190.36 g) was observed from N_0 treatment. Mehraj *et al.* (2015) and Muhammad Rizwan Shahid *et al.* (2013) also observed the similar result.

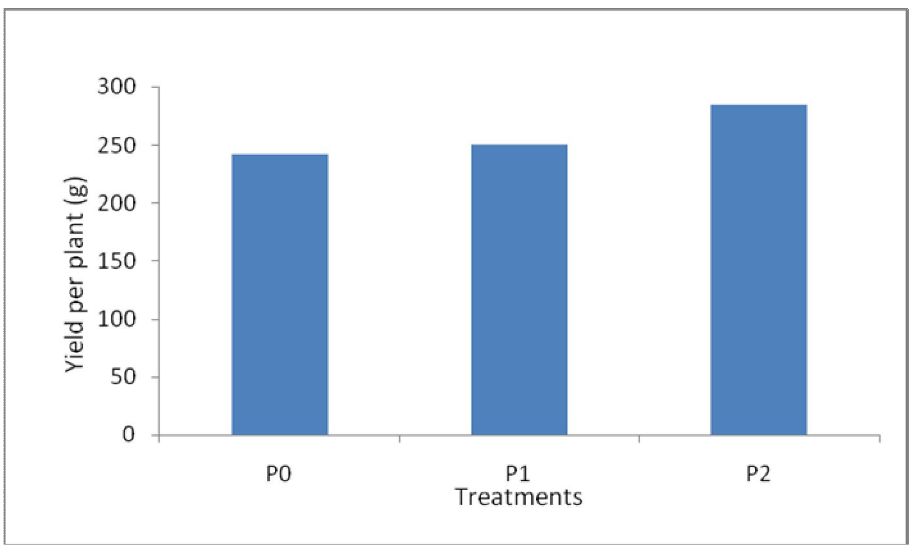
Yield per plant of okra varied significantly for different levels of phosphorus (Fig. 17). The highest yield per plant (284.08 g) was found from the P_2 and lowest yield per plant (242.35 g) from P_0 treatment. Arora *et al.* (1991) stated that Yield was significantly improved by the application of 60 kg P/ha. Gupta *et al*. (1981) stated that phosphorus fertilization increased pod size which finally contributed towards increasing the pod yield.

Combined effect of different levels of naphthalene acetic acid and phosphorus showed significant differences on yield per plant of okra under the present trial (Table 18). The highest yield per plant (325.0 g) was observed from N_2P_2. While the lowest yield per plant (170.84 g) was found from N_0P_0, which was statistically identical (177.75 g) to N_0P_1. Maurya *et al.* (1987) stated that combination of naphthalene acetic acid and fertilizer gave the highest yield.



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3:150 ppm NAA)

Figure16: Effect of different levels of naphthalene acetic acid on yield per plant of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

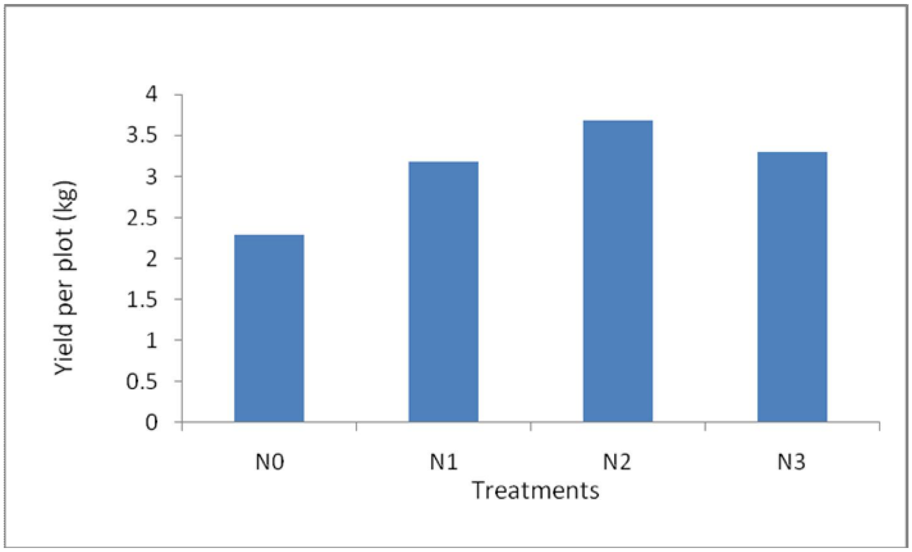
Figure17: Effect of different levels of phosphorus on yield per plant of okra

4.14 Yield per plot

Application of different levels of naphthalene acetic acid showed significant variation on yield per plot of okra (Fig. 18). The highest yield per plot (3.67 kg) was recorded from N_2 treatment, On the contrary, the lowest yield per plot (2.28 kg) was observed from N_0 treatment. Mehraj *et al.* (2015) and Muhammad Rizwan Shahid *et al.* (2013) also observed the similar result.

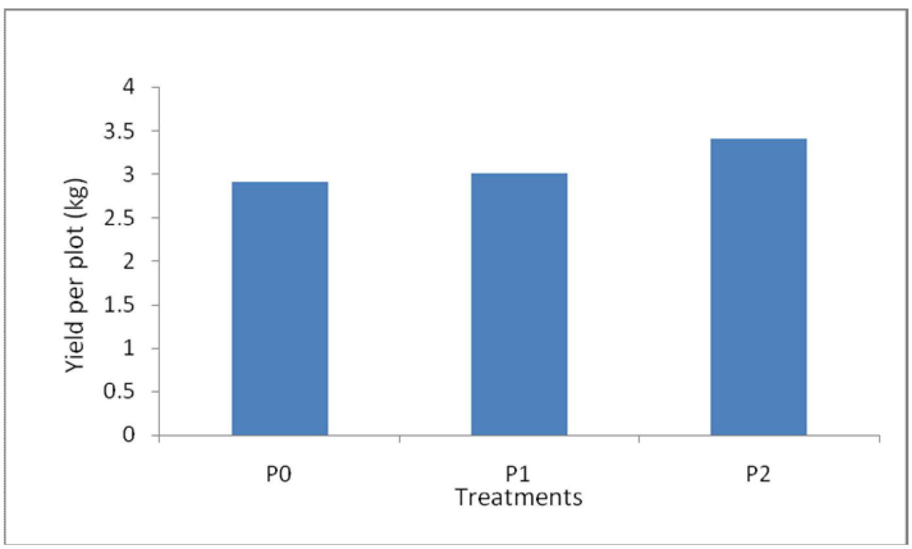
Yield per plot of okra varied significantly for different levels of phosphorus (Fig. 19). The highest yield per plot (3.41 kg) was found from the P_2 and lowest yield per plot (2.91 kg) from P_0 treatment. Arora *et al.* (1991) stated that Yield per plot was significantly improved by the application of 60 kg P/ha. Gupta *et al.* (1981) stated that phosphorus fertilization increased pod size which finally contributed towards increasing the pod yield.

Combined effect of different levels of naphthalene acetic acid and phosphorus showed significant differences on yield per plot of okra under the present trial (Table 18). The highest yield per plot (3.90 kg) was observed from N_2P_2 treatment combination. While the lowest yield per plot (2.05 kg) was found from N_0P_0 treatment combination, which was statistically identical (2.13 kg) to N_0P_1 treatment combination. Maurya *et al.* (1987) stated that combination of naphthalene acetic acid and fertilizer gave the highest yield.



(N_0: 0 ppm NAA, N_1: 50 ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA)

Figure 18: Effect of different levels of naphthalene acetic acid on yield/plot of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

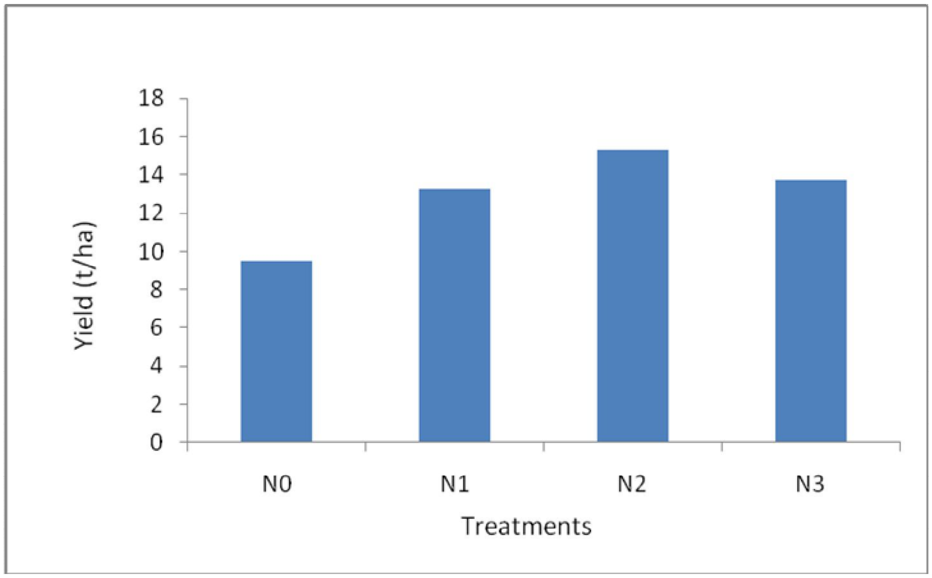
Figure 19: Effect of different levels of phosphorus on yield/plot of okra

4.15 Yield per hectare

Different levels of naphthalene acetic acid showed significant variation on yield per hectare of okra (Fig. 20). The highest yield per hectare (15.31 t) was observed in N_2 treatment. On the other hand, the lowest yield per hectare (9.51 t) was found from N_0 treatment. Singh *et al.* (1976), Mehraj *et al.* (2015) and Muhammad Rizwan Shahid *et al.* (2013) also observed the similar result. The findings of the present study were in agreement with above result**.**

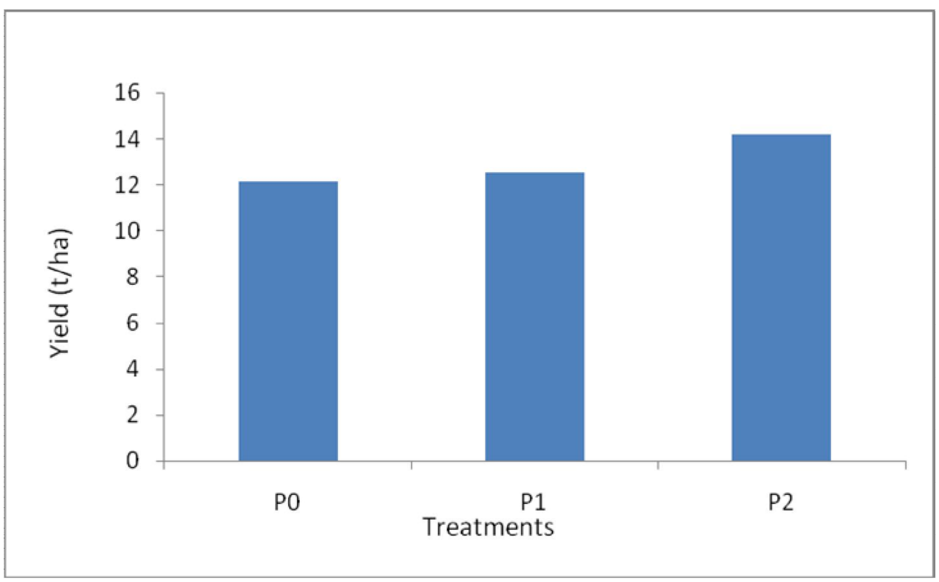
Statistically significant variation was recorded on yield per hectare (ton) of okra due to the application of different levels of phosphorus under the present trial (Fig. 21). The highest yield per hectare (14.20 t) was recorded from P_2 treatment, while the lowest yield per hectare (12.12 t) from P_0 treatment. Majanbu *et al.* (1985) reported that the increase of phosphorus, yield per hectare increased with a certain level. Laxman *et al.* (2004) reported that increasing levels of phosphorus up to 90 kg/ha increased yield per hectare.

Yield per hectare of okra showed significant differences due to the combined effect of different levels of naphthalene acetic acid (Table 18). The highest yield per hectare (16.25 t) was recorded from N_2P_2 treatment combination. While the lowest yield per hectare (8.54 t) was found from N_0P_0 treatment combination, which was statistically identical (8.89 ton) to N_0P_1 treatment combination.



(N_0: 0 ppm NAA, N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA)

Figure 20: Effect of different levels of naphthalene acetic acid on yield of okra



(P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

Figure 21: Effect of different levels of phosphorus on yield of okra

Table 18: Combined effect of different level of naphthalene acetic acid and phosphorus on yield of okra

Treatments	Yield/plant (g)	Yield /plot (kg)	Yield (t/ha)
N_0P_0	170.84 f	2.05 f	8.54 f
N_0P_1	177.75 f	2.13 f	8.89 f
N_0P_2	222.5 e	2.67 e	11.12 e
N_1P_0	252.75 d	3.03 d	12.64 d
N_1P_1	255.58 d	3.06 d	12.78 d
N_1P_2	286.08 c	3.43 c	14.31 c
N_2P_0	290.58 bc	3.48 bc	14.53 bc
N_2P_1	302.75 b	3.63 b	15.14 b
N_2P_2	325.0 a	3.90 a	16.25 a
N_3P_0	255.25 d	3.06 d	12.76 d
N_3P_1	265.58 d	3.18 d	13.28 d
N_3P_2	302.75 b	3.63 b	15.14 b
$LSD_{(0.05)}$	0.014	0.169	0.698
CV (%)	6.24	6.18	6.19

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 ppm NAA (control), N_1: 50ppm NAA, N_2: 100 ppm NAA, N_3: 150 ppm NAA, P_0: 0 kg P_2O_5/ha (control), P_1: 50 kg P_2O_5/ha, P_2: 70 kg P_2O_5/ha)

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was carried out at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from March to July, 2015. The experiment was conducted to find out the growth and yield of okra as influenced by naphthalene acetic acid and phosphorus. BARI Dherosh-1 was used as test crop in this experiment. The experiment consisted of two factors, Factor A: Naphthalene Acetic Acid (4 levels) as i. N_0: 0 ppm NAA (control) ii. N_1: 50 ppm NAA iii. N_2: 100 ppm NAA. iv. N_3: 150 ppm NAA. Factor B: Phosphorus fertilizer (3 levels) as i. P_0: 0 kg P_2O_5 ha^{-1}, ii. P_1: 50 kg P_2O_5 ha^{-1} iii. P_2: 70 kg P_2O_5 ha^{-1}. There were 12 (4 × 3) treatments combination such as the experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Size of each plot was 1.6m×1.5m (2.4 m^2). Data were collected in respect of yield contributing characters and yield of okra and statistically significant variation was recorded.

At 20, 40, 60 and 80 DAS the tallest plant (16.21, 62.97, 132.3 and 163 cm), the maximum number of branches per plant (1.47, 2.22, 2.44 and 2.88), the highest diameter of stem (0.58, 1.96, 2.42 and 2.45 cm), maximum number of leaves per plant (6.70, 18.71, 30.11 and 41.40), the longest leaf (14.42, 19.36, 22.9 and 23.53 cm), the longest internode (5.62, 6.71, 10.38 and 11.78 cm), the maximum number of pods per plant (28.22), the longest pod (18.13 cm), the highest diameter of pod (1.76 cm), the minimum days required for flowering (34.89), the maximum number of flower buds per plant (39.06), the highest individual pod weight (19.12 g), the highest yield per plant (306.11 g), the highest yield per plot (3.67 kg), the highest yield per hectare (15.31 t) was recorded from $N_{2.}$ whereas the shortest plant (12.57, 43.88, 106.9 and 129.1 cm), minimum number of branches per plant (0.98, 1.36, 1.95 and 2.11), the lowest diameter (0.45, 1.65, 2.08 and 2.16 cm), the minimum number of leaves per plant (5.81, 16.42, 27.6 and 35.2), the shortest leaf length (11.29, 16.82, 20.12 and 21.8 cm), the shortest internode (4.51, 5.53, 8.09 and 8.75 cm), the minimum number of pods per plant (16.04), the shortest pod (13.89 cm), the lowest diameter of pod (1.44 cm), the maximum days required for flowering (39.56), the minimum number of flower buds per plant (28.63), the lowest individual pod weight (15.28 g), the lowest yield per plant (190.36g), the lowest yield per plot (2.28 kg), the lowest yield per hectare (9.52 ton) was recorded from N_0 treatment.

At 20, 40, 60 and 80 DAS the tallest plant (15.16, 57.55, 126.8 and 161.7 cm), the maximum number of branches per plant (1.55, 1.92, 2.44 and 2.76), the highest diameter of stem (0.59, 1.92, 2.40 and 2.47 cm), the maximum number of leaves per plant (6.78, 18.97, 30.37 and 41.05), the longest leaf (14.03, 18.25, 22.33 and 23.25 cm), the longest internode (5.68, 6.58, 10.27 and 11.73 cm), the maximum number of pods per plant (28.95), the longest pod (17.52 cm), the highest diameter of pod (1.75 cm), the minimum days required for flowering (35.67), the maximum number of flower buds per plant (38.77), the highest individual pod weight (19.3 g), the highest yield per plant (284.08 g), the highest yield per plot (3.40 kg), the highest yield per hectare (14.2 t) was observed from $P_{2,}$ and the shortest plant (13.73, 47.13, 106.3 and 134.1 cm), the minimum number of branches per plant (0.96, 1.46, 2.03 and 2.29), the lowest diameter of stem (0.43, 1.68, 2.05 and 2.15 cm), the minimum number of leaves per plant (5.51, 16.82, 27.35 and 37.75), the shortest leaf length (12.06, 17.24, 21.04 and 21.82 cm), the shortest internode (4.62, 5.65, 8.33 and 8.89 cm), the minimum number of pods per plant (17.79), the shortest pod (14.52 cm), the lowest diameter of pod (1.49 cm), the maximum days required for flowering (38.0), the minimum number of flower buds per plant (32.43), the lowest individual pod weight (15.78 g), the lowest yield per plant (242.35 g), the lowest yield per plot (2.90 kg), the lowest yield per hectare (12.12 t) was observed from P_0 treatment.

At 20, 40, 60 and 80 DAS the tallest plant (17.27, 70.23, 143.3 and 175.3 cm), the maximum number of branches per plant (2.1, 2.46, 2.9 and 3.33), the highest diameter of stem (0.68, 2.08, 2.64 and 2.63 cm), the maximum number of leaves per plant (7.5, 20.07, 31.73 and 43.8), the longest leaf (15.43, 20.2, 23.43, and 24.53 cm), the longest internode (6.8, 7.8, 11.53 and 14.17 cm), the maximum number of pods per plant (38.67), the longest pod (21.57 cm), the highest diameter of pod (2.03), the minimum days required for flowering (33.67), the maximum number of flower buds per plant (43.83), the highest individual pod weight (22.13 g), the highest yield per plant (325.0 g), the highest yield per plot (3.9 kg), the highest yield per hectare (16.25 t) was observed from N_2P_2, while the shortest plant (12.13, 40.67, 94.67 and 116.3 cm), the minimum number of branches per plant (0.83, 1.23, 1.86 and 1.96), the shortest leaf (10.13, 16.55, 19.47 and 21.33 cm), the shortest internode (4.33, 5.46, 7.33 and 8.06 cm) was observed from N_0P_0, The lowest diameter of stem (0.39, 1.53, 1.92 and 2.03), the minimum number of leaves per plant (5.17, 15.67, 26.6 and 33.47), the minimum number of pods per plant (13.2), the shortest pod (13.73 cm), the lowest diameter of pod (1.40 cm), the maximum days required for flowering (41.33), the minimum number of flower buds per plant (24.0), the lowest individual pod weight (15.07g), the lowest yield per plant (170.84g), the lowest yield per plot (2.05 kg), the lowest yield per hectare (8.54 t) was also recorded from N_0P_0 treatment combination.

Considering the yield and yield contributing attributes, it is concluded that the combination of N_2P_2 (N_2: 100 ppm NAA, P_2: 70 P_2O_5 kg ha^{-1}) was better than rest of the combination. However, to reach a specific conclusion and recommendation, more research work on the application of naphthalene acetic acid and phosphorus in okra cultivation should be done over different Agro-ecological zones.

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APPENDICES

Appendix I. Characteristics of experimental plot soils

A . Morphological Characteristics of the experimental field

Morphological Feature	**Characteristics**
Location	Horticulture Field of SAU,Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	High Land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above Flood Level
Drainage	Well Drained

B.Physical and Chemical Properties of Initial Soil

Characteristics	Value
Particle size analysis(Mechanical analysis)	
%Sand %Silt %Clay	27 43 30
Textural Class	Silty Clay
Chemical analysis	
PH Organic Carbon(%) Organic Matter(%) Total N(%) Avalable P (ppm) Exchangeable K(me/100gm soil) Available S ppm	5.6 0.45 0.78 0.03 13.00 0.10 45

Source;SRDI, Dhaka

Appendix II. Monthly records of rainfall , relative humidity , total rainfall from March to July 2015

Month	Air temperature (^{0}C)		R.H(%)	Total rainfall(mm)
	Maximum	Minimum		
March	34.40	17.60	60	61
April	37.30	21.40	64	137
May	36.20	23.25	78	245
June	36.42	25.50	81	315
July	34.25	27.20	80	329

Source; Bangladesh Meteorological Department (Climate division) Agargaon, Dhaka-1207

Appendix III. Analysis of variance of the data on plant height of okra as influenced by different levels of naphthalene acetic acid and

Sources of Variation	Degrees of freedom	Error Means Square			
		Plant height			
		20 Days	40 Days	60 Days	80 Days
Replication	2	0.296	13.403	194.921	0.481
Factor A (N)	3	21.473**	701.878**	1094.57**	1827.102**
Factor B (P)	2	7.273**	340.343**	1306.081**	2351.974**
AB (NxP)	6	0.572*	11.617**	14.189**	70.326**
Error	22	0.172	13.505	91.399	9.454

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of branch of okra as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square			
		Number of branch			
		20 Days	40 Days	60 Days	80 Days
Replication	2	0.002	0.016	0.021	0.117
Factor A (N)	3	0.426**	1.243**	0.374**	0.961**
Factor B (P)	2	1.248**	0.648**	0.57**	0.659**
AB (NxP)	6	0.073**	0.011**	0.049*	0.185**
Error	22	0.006	0.015	0.017	0.013

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on diameter of stem as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square			
		Diameter of stem			
		20 Days	40 Days	60 Days	80 Days
Replication	2	0	0	0.001	0
Factor A (N)	3	0.028**	0.157**	0.234**	0.163**
Factor B (P)	2	0.074**	0.179**	0.41**	0.304**
AB (NxP)	6	0.002**	0.003**	0.016**	0.006*
Error	22	0	0	0.001	0.003

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on number of leave of okra as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square			
		Number of Leave			
		20 Days	40 Days	60 Days	80 Days
Replication	2	0.019	0.534	0.163	1.618
Factor A (N)	3	1.32**	8.809**	10.23**	68.718**
Factor B (P)	2	4.845**	14.041**	28.403**	34.724**
AB (NxP)	6	0.034*	0.361**	0.749**	0.721**
Error	22	0.014	0.062	0.035	0.164

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on leave length of okra as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square			
		Length of leave			
		20 Days	40 Days	60 Days	80 Days
Replication	2	0.155	0.015	0.086	0.006
Factor A (N)	3	16.245**	11.286**	11.75**	4.991**
Factor B (P)	2	12.527**	3.15**	4.263**	6.135**
AB (NxP)	6	0.294**	0.259**	0.063*	0.176**
Error	22	0.611	0.051	0.041	0.019

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on length of internode of okra as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square			
		Length of internode			
		20 Days	40 Days	60 Days	80 Days
Replication	2	0.361	0.008	0.034	0.056
Factor A (N)	3	2.197**	2.372**	8.783**	13.711**
Factor B (P)	2	3.484**	2.668**	12.281**	24.331**
AB (NxP)	6	0.444**	0.56**	0.499**	1.959**
Error	22	0.057	0.114	0.136	0.078

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on days of flowering, no of flower bud /plant, no. of pod/ plant & length of pod of okra as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square			
		Days of flowering	No of flower bud /plant	no. of pod/ plant	Length of pod
Replication	2	3.25	1.616	1.258	3.974
Factor A (N)	3	33.926**	176.909**	243.049**	28.41**
Factor B (P)	2	17.333**	141.036**	381.984**	28.521**
AB (NxP)	6	2.37*	8.631**	40.64**	4.734**
Error	22	1.765	2.279	1.848	0.896

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data on individual pod weight and pod diameter per plant of okra as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square	
		Individual pod weight	Pod diameter per plant
Replication	2	0.341	0.014
Factor A (N)	3	23.908**	0.184**
Factor B (P)	2	38.705**	0.214**
AB (NxP)	6	6.156*	0.029*
Error	22	2.834	0.021

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix XI. Analysis of variance of the data on yield per plant, yield per plot and yield per hectare of okra as influenced by different levels of naphthalene acetic acid and phosphorus

Sources of Variation	Degrees of freedom	Error Means Square		
		Yield per plant	Yield per plot	Yield per hectare
Replication	2	0.0001	0.007	0.129
Factor A (N)	3	0.0213**	3.112**	54.052**
Factor B (P)	2	0.0056**	0.847**	14.709**
AB (NxP)	6	0.0001*	0.014*	0.243*
Error	22	0.0001	0.01	0.17

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability