RESPONSE OF GROWTH, FLOWERING AND YIELD OF BITTER GOURD INFLUENCED BY NPK FERTILIZERS AND NAA

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DECEMBER, 2018

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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: JULY-DECEMBER, 2018

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CERTIFICATE

This is to certify that the thesis entitled **"RESPONSE OF GROWTH, FLOWERING AND YIELD OF BITTER GOURD INFLUENCED BY NPK FERTILIZERS AND NAA"** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **UMME HABIBA**, Registration No. 17-08232 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2018
Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

ACKNOWLEDGEMENTS

The author seems it a much privilege to express his enormous sense of gratitude to the almighty Allah for there ever ending blessings for the successful completion of the research work.

The author wishes to express her gratitude and best regards to her respected Supervisor, Professor Md. Ruhul Amin , Department of Horticulture , Sher-e-Bangla Agricultural University, Dhaka, for his continuous direction, constructive criticism, encouragement and valuable suggestions in carrying out the research work and preparation of this thesis.

The author wishes to express her earnest respect, sincere appreciation and enormous indebtedness to her reverend Co-supervisor and Chairman Prof. Dr. Mohammad Humayun Kabir, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his scholastic supervision, helpful commentary and unvarying inspiration throughout the research work and preparation of the thesis.

The author feels proud to express her deepest and endless gratitude to all of her course mates and friends to cooperate and help her during taking data from the field and preparation of the thesis. The author wishes to extend his special thanks to her lab mates, class mates and friends for their keen help as well as heartiest co-operation and encouragement.

The author expresses her heartfelt thanks to her beloved parents, Elder Sister and Brother and all other family members for their prayers, encouragement, constant inspiration and moral support for her higher study. May Almighty bless and protect them all.

The Author

RESPONSE OF GROWTH, FLOWERING AND YIELD OF BITTER GOURD INFLUENCED BY NPK FERTILIZERS AND NAA

ABSTRACT

The present study was conducted at the Horticultue farm of Sher-e-Bangla Agricultural University to study the response of growth, flowering and yield of bitter gourd influenced by NPK fertilizers and NAA during the period of March to June, 2018. Four levels of NPK fertilizers *viz*, N_0 ($N_0P_0K_0$ kg ha^{-1}), N_1 ($N_{25}P_{10}K_{15}$ kg ha^{-1}), N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) and N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) and three levels of NAA *viz*, H_0 (0 ppm NAA), H_1 (50 ppm NAA) and H_2 (100 ppm NAA) were laid out in Randomized Complete Block Design (RCBD) with the three replications. Treatment combination of NPK fertilizers and NAA, the highest number of branches $plant^{-1}$ (14.20), number of male flowers (33.20), number of female flowers (28.20), percent fruit set (33.32%), fruit length (12.62 cm), fruit diameter (8.56 cm), fruit weight $plant^{-1}$ (1.47 kg), number of fruits $plant^{-1}$ (20.40), fruit weight $plot^{-1}$ (2.94 kg) and fruit yield (24.52 t ha^{-1}) were achieved from the treatment combination of N_2H_2. The lowest fruit yield (8.60 t ha^{-1}) was recorded from N_0H_0. In terms of economic analysis, the highest BCR (3.01) was obtained from the treatment combination of N_2H_2) whereas the lowest BCR (1.14) was obtained from N_0H_0.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is a tropical and subtropical vegetable crop of the family cucurbitaceae. Bitter gourd is a leading vegetable crop, the higher yield and maximum returns make it the most preferred vegetable crop of the farmers (Behera *et al*., 2011).

Fruits are considered as a rich source of vitamins and minerals and are rich in vitamin C (88 mg/100 g). It possesses antioxidant, antimicrobial, antiviral, antihepatotoxic, anti ulcerogenic properties and also have the ability to lower blood sugar (Behera, 2011). It has great demand in domestic and international market among fresh vegetables due to its hypoglycaemic property.

Vegetables are the main source of vitamins and minerals that are essential for maintaining good health. Though Bangladesh is an agricultural country it has a serious deficiency in vegetables and the scarcity is much more dominate during summer. Bitter gourd can play important role to elevate vegetable consumption in lien summer season. Nutrition council of Bangladesh recommended at least 235 g/day/person of vegetables for Bangladeshi adult but the availability is only 65.5 g/day/person. The annual production of vegetable is only 4.31 million tons including potato but we need around 11.15 million tons (Anon, 2012).

Successful crop production needs proper nutrition. Fertilizers play an important role on growth and productivity of bitter gourd. Nitrogen is essential for synthesis of chlorophyll, enzymes and protein. Phosphorus is essential for root growth, nodulation, energy storage and transfer necessary for metabolic processes. Potassium plays an important role in the promotion of enzyme activity and enhancing the translocation of assimilates and protein synthesis (Zaghlou *et al*., 2015). But the imbalance and improper use of chemical fertilizers has adverse effect on soil health thereby affecting the yield and

sustainability of production, besides causing environmental pollution. Therefore, there is a need for judicious use of fertilizers for sustainable production and better soil health. This will help to sustain crop yield, improve the physical, chemical and biological properties of soil, and increase the efficiency of applied fertilizers (Singh and Biswas, 2000).

In bitter gourd, it is possible to increase the yield by increasing the fruit set by using growth regulators. Use of PGR's like NAA have an ability to modify the plant growth, sex ratios and yield contributing characters, will be a useful alternative to increase crop production (Shantappa *et al*., 2007).

Growth regulators are known to have an effect on the production of earliest flower, yield (Gedam *et al*., 1998), ratio of male/female flower (Bisaria, 1974, Mia *et al*., 2014), number of fruits, weight of fruit (Gopalkrishman and Choudhury, 1978). Exogenous application of growth regulators has shifted the sex expression towards femaleness by increasing the production of female flower and suppressing the male flowers in bitter gourd (Parkash, 1974 and Mishra *et al*., 2015).

Considering the above facts, the present experiment was conducted for the following objectives:

1. To find out the effect of different doses of NPK fertilizers on growth, flowering and yield of bitter gourd.
2. To identify the response of NAA on growth, flowering and yield of bitter gourd.
3. To determine the combined effect of different doses of NPK fertilizers and NAA on growth, flowering and yield of bitter gourd.

CHAPTER II

REVIEW OF LITERATURE

Bitter gourd is one of the important vegetables grown throughout the world. Different levels of Naphthalic Acetic Acid (NAA) and NPK fertilizers influence the growth and yield of bitter gourd. Many research works have been done in different parts of the world to study the effect of naphthalic acetic acid and NPK fertilizers on growth and yield of bitter gourd. However, a little information is available in these regards 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 NPK fertilizers

Bitter gourd (*Momordica charantia* L.) is popular vegetable because of its rich nutritive value, high productivity and easy package of practices which respond favourably to application of different soil organic amendments like vermicompost. In this experiment it was designed to evaluate the effect of different combinations of organic (vermicompost) and inorganic (NPK) source of nutrients on growth, yield and quality of bitter gourd. The application of vermicompost @ 4.68 t ha^{-1} recorded 3.99 kg $fruits^{-1}$ per vine with an average fruit weight of 62.18 g $fruit^{-1}$. Application of NPK @ 100:60:50 kg ha^{-1} recorded maximum branch number (13.26), fruit yield $vine^{-1}$ (3.64 kg) and with average fruit weight 56.75 g $fruit^{-1}$. Interaction effect of vermicompost @ 4.68 t ha^{-1} and inorganic fertilizer, NPK @ 50:30:25 kg ha^{-1} was found to be best treatment combination for yield and yield attributing traits and as well as for benefit cost ratios. The maximum yield i.e. 36.81 t ha^{-1} was found under the combined use of vermicompost@ 4.68 t ha^{-1} and inorganic fertilizer@ 50:30:25 kg ha^{-1}. It was also observed that some of the quality attributes like TSS (o Brix), Zn and Fe content of the fruit were significantly influenced with the application of different levels of vermicompost while vitamin C and Fe were

significantly affected with the application of both organic and inorganic fertilizers in different combinations (Sangeeta, 2018).

Arfan-ul-Haq (2015) conducted a field experiment to evaluate the effect of different organic materials and chemical fertilizers on yield and quality of bitter gourd. Six treatments *viz*. Control (without fertilizer/organic material), Chemical fertilizer (NPK 50:75:60 kg ha^{-1}), Press mud (PM), Farm yard manure (FYM), Poultry manure (PoM) and Composite organic materials (1/3 PM + 1/3 FYM + 1/3 PoM) were applied using randomized complete block design with three replications. Organic materials were added on nitrogen equivalent basis. Fresh bitter gourd samples were analyzed for quality parameters. Results revealed that chemical fertilizers gave maximum yield during all the three years of study (6.69, 7.84 and 8.01 t ha^{-1} during 2010, 2011 and 2012, respectively) while poultry manure was found the best regarding all quality parameters. When effect of organic materials was compared; it was evident that poultry manure produced the highest yield. During the year 2010, poultry manure gave yield (5.77 t ha^{-1}), dry matter (8.56%), crude protein (1.74%), crude fat (2.01%), crude fiber (1.74%) and mineral matter (1.06%) while during 2011, it gave yield (6.92 t ha^{-1}), dry matter (8.84%), crude protein (1.59%), crude fat (2.06%), crude fiber (1.55%) and mineral matter (1.65%). In the third year (2012), poultry manure produced 7.56 t ha^{-1} yield, 8.72% dry matter, 1.88% crude protein, 1.54% crude fiber, 2.26% crude fat and 1.24% mineral matter.

The influences of N, P and K fertilizers on seed yield and seed quality of bitter gourd were studied by Boonmanop (1997). Bitter gourd was grown and treated with the combination of 3 rates of nitrogen (0, 15 and 30 kg N ha^{-1}), 3 rate of phosphorus (0, 10 and 20 kg P_20_5 ha^{-1}) and 2 rates of potassium (0 and 10 kg K_2O ha^{-1}) fertilizers. The results showed that N, P and K fertilizers had no significant effects on the first bloom of male and female flower (earliness), total number of fruits, weight per fruit, number of seeds per 7 square meter (6

plants), number of seeds per fruit, total seed weight and 100 seeds weight. However, the high rates of N, P and K gave the highest germination (92.9%), germination index (23.2) and the best combination was 30, 20 and 10 kg N, P_2O_5 and K_2O ha^{-1}, respectively. The highest vine length (137.6 cm) was also achieved from this treatment combination.

The response of bitter gourd cultivars, Tamab selection and Balsam pear to the application of 0, 60, 80, 100 and 120 kg N ha^{-1} was studied by Ali *et al.* (1995) near Peshawar, Pakistan. They found that the highest number of female flowers (36.13) and fruit set (34.49) was recorded with 120 kg N ha^{-1}. Individual fruit weight was greater (55.26 g) with 80 kg N but the difference was not significant. The highest yield (24.90 t ha^{-1}) was recorded with 80 kg N ha^{-1}. The control plants yielded 17.13 t ha^{-1}. Differences between cultivars were not significant except for the number of female flowers, fruit per plant and yield per hectare. Tamab selection produced 35.5 female flowers per plant, 33.98 fruits per plant and 24.77 ton fruit ha^{-1} compared with 30.05, 28.66 and 18.85 t ha^{-1}, respectively, in Balsam Pear.

Catedral (1974) found that ampalaya (bitter gourd) is very responsive to nitrogen fertilization applied as high as 480 kg ha^{-1}. The most significant effect was on the significant increase in the number of pistillate flowers. In that study, the increase was as high as 6 times when the rate of the level of N was increased from 0 to 480 kg ha^{-1}. It was also shown that fruit number per plant increased with increasing levels of N, where as phosphorus had no effect.

Arora and Satish (1989) observed that N and P increase the number of female flower of sponge gourd *(Luffa aegyptiaca)* cv. Pusa Chikni during the summer and rainy seasons. The plants received N at 0-75 Kg ha^{-1} and P at 40 Kg ha^{-1}. Then highest number of female flower was obtained with N at 50+ P at 20 Kg ha^{-1} in summer season and with N at 25 + P at 40 Kg ha^{-1} in winter season.

Suresh and Pappiah (1991) conducted a trial with bitter gourd cv. MDU 1, where N (0, 40 and 80 kg ha^{-1}) P_20_5 (0, 30 and 60 kg ha^{-1}) were applied and Maleic Hydrazide (Mil) was sprayed at 0, 100 and 200 ppm solution. The highest yield was obtained with 80 kg N ha^{-1}, 30 kg P_20_5 ha^{-1} and 200 ppm MH.

Lingaiah*et al.* (1988) stated that the highest yield of bitter gourd was obtained in coastal region at N: P_2O_5: K_2O at 80:30:20 kg ha^{-1}.

Rekha and Gopalakrishnan (2001) conducted a field experiment with bitter gourd *(Momordicacharantia* L.) cv. Preethi in Thrissur. Kerala.India during kharif 1999. Considering the total yield, marketable yield and size of fruits, the treatment T7 which received a basal application of 20 tones of dry Cowdung, 2.5 tones of poultry manure, fortnightly drenching of 2.5 tones of cowdung and a fertilizer dose of 70:25:25 kg NPK ha^{-1} was found superior to all other treatments. More or less equal fruit yield and fruit size were also recorded in T_5, which received same manures but lacked inorganic fertilizers. This was clearly revealed the possibility of achieving a reasonably good yield by basal application of dry cowdung, top dressing with poultry manure and by drenching cowdung slurry at fortnightly interval.

Islam (1995) conducted an experiment with live levels of NPK such as 0- 0-0, 1200-0, 120-120-60, 240-0-0 and 240-120-60 kg ha^{-1} on bitter gourd seed production. He observed that plots treated with N alone at the rate of 240 kg ha^{-1} improved the vegetative growth of bitter gourd as manifested by an increase number and length of vines, diameter of stem, number, length and diameter of leaves. The inclusion of P and K to N significantly reduced the above parameters, except the number of lateral vines and diameter of stem, which remains unaffected. However, application of NPK significantly increased the number of fruits per plant, size and weight of fruits and the fruit yield compared to plots treated with N alone. The increase in fruit yield due to the

application of P and K was 11.35 t ha^{-1} at 240 kg N ha^{-1}. The same trend of result was noted for seed yield and quality where plants fertilized with 240-120-60 kg ha^{-1} produced the highest yield due to greater number of filled seeds per fruit which were bigger and heavier than the seeds produced from other treatments. Moreover, the above treatment produced seeds with the highest percentage of germination (99.00) and seed vigor index (20.03%).

All gourds respond well to manures and fertilizer application. The doses of fertilizers depend upon the soil type, climate and system of cultivation. In cucurbits, excessive nitrogen and consequently enormous vine growth require to be avoided. In general, high N under high temperature conditions promote maleness in flowering and number of female/perfect flowers per vine gets reduced resulting in low fruit set and low yield (Seshadri, 1986).

Ogunrcmi (1978) reported that the fruit size and numbers were the highest when applied with N at 48 kg ha^{-1} in melon.

Satish *et al* (1988) stated that in 2 season trials, N at 0, 25, 50 and 75 kg ha^{-1} and P at 0, 20, and 40 kg ha^{-1} were applied to the cv. PusaChikni. Half of the N dose and all P were applied before sowing on 9 March and 9 July and the remaining N was used for top dressing in 2 equal doses at 25 and 50 days after sowing. In both seasons, 50 kg N+20 kg P ha^{-1} gave the maximum number of fruits and the greatest weight $plant^{-1}$ in the early and total yields. Maximum fruit dry matter content was obtained by applying 25 kg N + 40 kg P ha^{-1} in the summer season crop and 40 kg P ha^{-1} in the rainy season (July).

Makal*et al.* (1977) studied the effect of NPK on yield of tinda. It was reported that N, P_2O_5 and K_2O at the rate of 75, 50 and 100 kg ha^{-1} enhanced the yield from 3207.7 kg ha^{-1} to 3697.7 kg ha^{-1}.

Pelaez*et al.* (1984) studied the effect of NPK and organic matter on yield and marketable fruits of squash *(Cucurbitapepo* L.). According to their investigations plots receiving 10 t ha^{-1} poultry manure gave the highest

followed by plots receiving 100 kg N, 300 kg P_2O_5 and 75 kg K_20 per hectare, which yielded 21.24 t ha^{-1} and 3.2 fruits $plant^{-1}$.

Vishnu *et al.* (1987) studied the effect of plant spacing and fertilizers on yield of bottle gourd. It was reported that the average yield was 38537 kg ha^{-1} with the full dose of NPK (180:100:100 kg ha^{-1}) and 30074 kg ha^{-1} with the reduced dose (one third of the full dose).

In a field experiment during 1981-83, application of 3 levels of N, P and K, each at O, 40 and 80 kg ha^{-1}, was evaluated by Mishra (1987). It was observed that N did not show a significant effect in increasing the height and number of the main branches and of 100 seed weight, however. P increased plant height significantly. Increased K doses reduced the height and number of main branches. The seed yield increased with increasing doses by N and P but K beyond 40 kg ha^{-1} did not show any significant effect.

Naik and Srinivas (1992) in trials conducted at the Division of Vegetable Crops, Indian Institute of Horticultural Research, Bangalore, Karnataka. India with cv. PusaSawani to observe the influence of nitrogen and phosphorus fertilization on seed crop of okra in the rainy seasons of 1985 and 1986 on a sandy loam soil with low available N and P. N was applied at 50, 100, 150 and 200 kg ha^{-1} and P at 30, 60 and 90 kg P_2O5 ha^{-1}. Half of the N, all the P and 40 kg IC_2O ha^{-1} 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^{-1} (13.00 and 11.25 q ha^{-1} in 1985 and 1986 respectively) and 90 kg P_20_5 ha^{-1} (11.89 and 10.71 q ha^{-1} during 1985 and 1986 respectively). Other parameters (fruit length, number of fruits $plant^{-1}$, number of seeds fruit and 1000 seed weight) were also highest with the highest rates of fertilizer application.

Isaac and Pushpakumari (1997) conducted a Held trial at Department of Agronomy, College of Agriculture, Vellayani, India in 1994-95, where okras were grown with 6 t ha^{-1} FYM + chemical fertilizers and 12 t ha^{-1} FYM + chemical fertilizers or vermicompost or poultry manure. The effect of picking no, 2, 4 or 6green fruits $plant^{-1}$ was also examined. Fruit and seed yields were highest with FYM + chemical fertilizers, but there was only a marginal benefit in applying the higher rate of FYM. Seed yield declined as more fruits were picked.

2.2 Effect of NAA

Khatoon and Moniruzzaman (2019) conducted a field experiment to assess the effect of GA3 and NAA on sex expression, yield and yield components of bitter gourd (*Momordicacharantia L.*) var. BARI Karola-1. Eeleven treatments comprising five concentrations each of gibberellic acid (50, 100, 150, 200 and 300 ppm) and naphthalene acidic acid (50, 100, 150, 200 and 300 ppm) along with distilled water considered as control were evaluated in randomized complete block design with three replications. Gibberellic acid (GA_3) and Naphthalene acidic acid (NAA) were sprayed at 4 leaf stage; second spray was done at 35-38 DAS and third spray done at flowering stage. All the treatments improved the flowering and yield characters over control. Foliar spray of NAA @ 150 ppm and 200 ppm was found better in terms of sex expression, yield and yield attributes of bitter gourd as compared to control and other treatments. Spray of NAA @ 150 ppm gave the lowest number of male flowers and the highest number of female flowers thereby produced the lowest sex ratio (male:female). Number of fruits $plant^{-1}$, individual fruit weight and fruit yield $plant^{-1}$ were also found maximum from NAA 150 ppm. Maximum fruit yield was recorded with the application of NAA @ 150 ppm. Spraying of NAA @ 150 ppm gave the maximum gross return and net return with the highest BCR of 3.17.

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^{-1}), leaf area (29.7 cm), number of branches (5.5 plant^{-1}), fresh weight (84.5 g plant^{-1}), dry weight (10.9 g plant^{-1}), number of pods (33.4 plant^{-1}), pod length (17.5 cm), pod diameter (1.7 cm) and yield (338.1 g plant^{-1}, 2.9 kg plot^{-1} and 16.4 t ha^{-1}) 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.

Al-Masouma and Al-Masri (1999) reported that Cucumber cv. Beit Alpha was grown in a greenhouse in 1996-1997 and ethephon applied at 250 ppm, 350 ppm and 450 ppm at the seedling stage (2-4 true leaves). Data were collected on the total yield. Early yield, late yield, number of female flowers, number of male flowers, days to the first male flowers, days to first female flowers and plant height. All the cases positive results were found from rthephonteated plants. Ethephon introduce femaleness (pistilate flowers) on the main stem that led to greater fruit production.

Das and Rabhal (1999) conducted an experiment in a greenhouse on cucumber cultivars Chinese green, PusaSanyog 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.

Susmita *et al.* (1998) reported that foliar application of silver nitrate (50 mg litre^{-1}); an ihibitor of ethylene- induced plant responses reduced the vegetative

phase and silver extended the flowering phase of Momordica charantia L. silver nitrate promoted female flowering, fruit setting, and fruit development. It also increased the length, girth, weight and quality of fruits.

Baruah and Das (1997) reported that during robi season in India the effects of NAA(25 and 100 ppm) and Mleichydrazide(50 and 100 ppm) applied at the 2-true leaf stage and sowing date 15 days interval on the growth of Lagenariasiceraria(cv.kiyari Lao).They observed that plants sprayed with NAA at 25 ppm and MH at 50 ppm produced the best yields (5.48 and 4.86 kg plant^{-1}), respectively. Yield decreased with later sowing dates from 5.49 to 2.62 kg plant^{-1}.

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 ppmproduced 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.

Tomar and Rmgiry (1997) conducted an experiment and found that plants treated with GA_3 showed significantly greater plant height, number of branches plant^{-1}, number of fruit plant^{-1} and yield than untreated controls. GA_3 treatment at the seedling stage offered valuable scope for obtaining higher commercial tomato yields.

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^{-1} 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 bitter gourd.

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 200 ppm was applied. Hormone application at the rate of 200 ppm 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.

Gosh and Basu (1983) reported that with NAA at 17.5 or 35% mg l^{-1} increased the number of female flowers. Ethrel at 25 mg l^{-1} increased female flowers but 100 mg L^{-1} 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.

Seeramulu (1987) found that ethrel 100g l^{-1} increased the number of pistillate flowers and also hastened the appearance of the female flower compared to the control in sponge gourd. It also delayed the appearance of the first staminatew flower and also decrease the total number of male flowers.

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 and 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.

Gopalkrishman and choudhury (1978) reported that in contrast with IT BA, Ci A in general produced the largest number of male flowers ; GA at the lowest concentration of 10 ppm produced more number of female flowers in first year. In the first year MH 100 ppm to 600 ppm as well as NAA and IAA at 50 ppm to 150 ppm induced reduction in the meanrnumber of female flowers. Treatment with TIBA at 50 ppm, 100 ppm and 200 ppm excelled all the other

treatments in producing a favorable female to male flower ratio. TIBA from 50 to 200 ppm gave a significant increased in the number of fruits weight of fruits of water melon.

Irshad Ahmad and Gupta(1981) found that the minimum ratio of male to female flower was reached at 1000 ppm of cycocel in case of smooth gourd and at 1500 ppm in bottle gourd and snake gourd. Nodes per female flower as well as days to flower were minimum at 1000 ppm in snake gourd and 1500 ppm in smooth gourd and bottle gourd. Earliest node for first female flower was observed at 1000 ppm in smoth gourd and snake gourd but at 1500 ppm in bottle gourd.

Mangel*et al.*(1981) conducted an investigation to study the influence of various chemicals(Ethrel, NAA,Cycocel,MH,PCPA,Ascorbic acid and Boron) on the growth, flowering and yield of bitter gourd. PCPA at 100 ppm improved plant growth significantly. The treatment of CCC at 250 and 500 ppm produced female flowers about 12 days earlier in comparison to control plant 250 ppm Maximum fruit yield per plant (3124 gm) was produced Cycocel 500 ppm.

Suresh and Pappiah (1991) conducted a trial with bitter gourd cv. MDU. The effects of NAA (25 and 100 ppm) and Maleic hydrazide (50 and 100 ppm), applied at the 2-true leaf stage. The highest yield was obtained with NAA 100 ppm and fruit quality also.

Irving et al.(1968) found that TIBA at 25 ppm was particularly effective in promoting the gfemaleness in cucumber. The increased TIBA stimulation of female flowers ranged from 100 to 200 percent. TIBA also increased the number of female flowers but lowered the male and female ratio.

Ravindran (1971) reported that bitter gourd seedlings were sprayed with ethereal at concentrations ranging from 200 ppm to 600 ppm. Stunting. Growth

retardation and pollen sterility were induced in proportion to the dose applied and production of male flowrs significantly reduced.

McMurray and Miller(1969) found that cucumber seedling treated with etephon at con centrations of 120 ppm, 180 ppm and 240 ppm increased the number of pistilate flowers. The staminate to pistilate flower ratio was approximately 10:1. But in case of etephon treated plants, the staminate to pistillate flower rand from 1:6 to1:14, depending on the concentration of ethephon used.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to June, 2018 to study the response of growth, flowering and yield of bitter gourd influenced by NPK fertilizers and NAA. The details of the materials and methods have been presented below:

3.1 Experimental location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix I.

3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of

the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix II.

3.4 Planting material

Seeds of TIA better gourd F_1 variety was used for the present study. .

3.5 Experimental details

3.5.1 Treatments

The experiment comprised of two factors.

Factor A: NPK fertilizers

1. N_0 = Control ($N_0P_0K_0$ kg ha^{-1})
2. N_1 = $N_{25}P_{10}K_{15}$ kg ha^{-1}
3. N_2 = $N_{35}P_{20}K_{25}$ kg ha^{-1}
4. N_3 = $N_{45}P_{30}K_{35}$ kg ha^{-1}

Factor B: Concentration of NAA

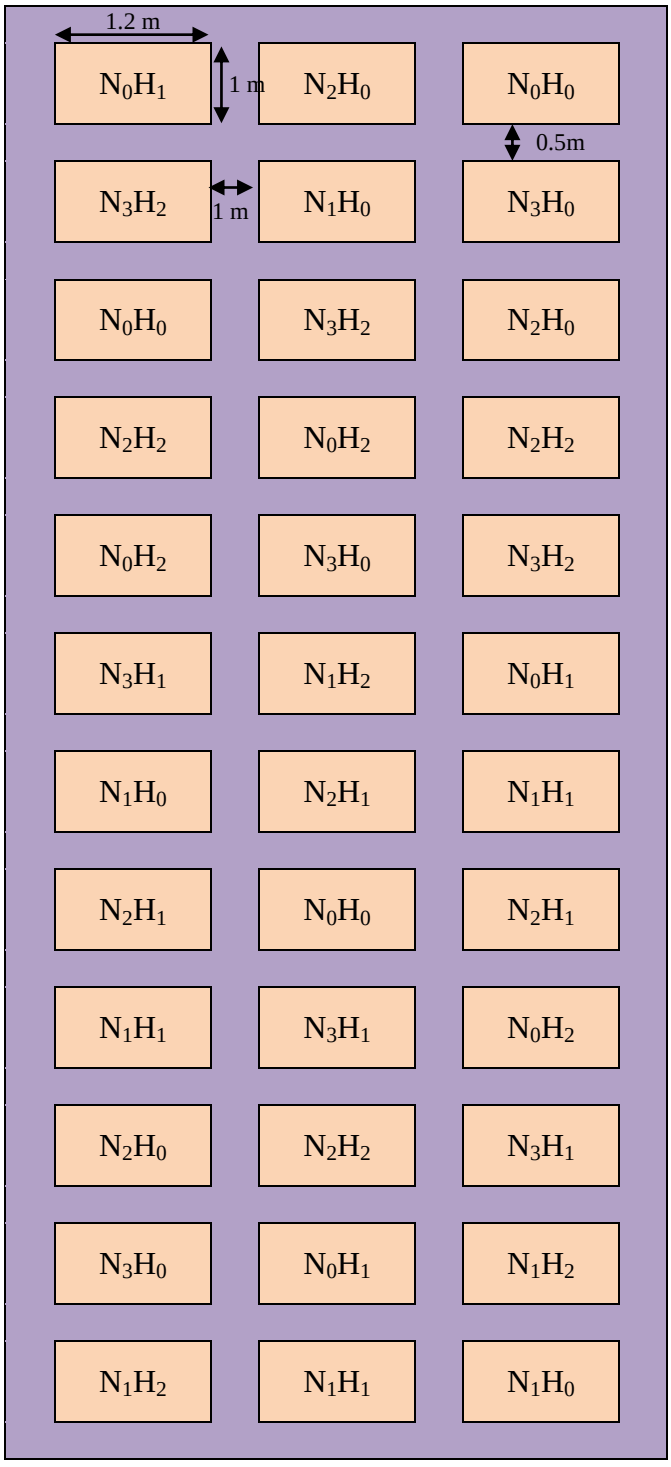
1. H_0 = Control (0 ppm NAA)
2. H_1 = 50 ppm NAA
3. H_2 = 100 ppm NAA

Treatment combinations –Twelve (12) treatment combinations were as follows:

N_0H_0, N_0H_1, N_0H_2, N_1H_0, N_1H_1, N_1H_2, N_2H_0, N_2H_1, N_2H_2, N_3H_0, N_3H_1 and N_3H_2.

3.5.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of different nutrient management and NAA levels. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot 1.2 m × 1 m (1.2 m^2). The distance between blocks and plots were 1.0 m and 0.5 m, respectively.



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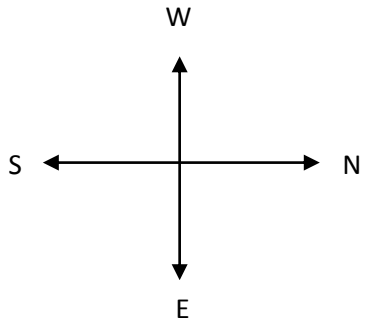

Plot Size: 1.2m×1m = 1.2 m^2
Block to block distance = 1 m
Plot to plot distance = 0.5 m

Treatments:

Factor A: NPK fertilizers

1. N_0 = Control ($N_0P_0K_0$)
2. $N_1 = N_{25}P_{10}K_{15}$ kg ha^{-1}
3. $N_2 = N_{35}P_{20}K_{25}$ kg ha^{-1}
4. $N_3 = N_{45}P_{30}K_{35}$ kg ha^{-1}

Factor B: Concentration of NAA

1. H_0 = Control (0 ppm NAA)
2. H_1 = 50 ppm NAA
3. H_2 = 100 ppm NAA

Fig. 1. Layout of the experiment field

3.6 Raising of seedlings

3.6.1 Preparation of poly bags

Seeds were sown in poly bags which were filled with loose friable, dead roots free, sandy loam soil previously mixed with well rotten cowdung. The soil was treated by Sevin 50WP @ 5kg/ha to protect the seed and young plants from the attack of ants. Size of the poly bags was (8×8) inches.

3.6.2 Seed treatment

Seed treatment was done by vitavax @ 3 g/kg seeds to prevent some seed borne diseases.

3.6.3 Seed sowing

The poly bags were kept in the bed for raising the seedlings. Seeds were sown in the poly bags on 11 March, 2018. Each poly bags contained two seeds of bitter gourd. After sowing, the seeds were covered with light soil. Watering was done by water cane regularly. Complete germination of the seeds took place with 5 days after seed sowing. Necessary shading was made by white polythene to protect the seedlings from scorching sunshine or rain. No chemical fertilizer was used in the seed bed.

3.7 Preparation of the main field

The plot selected for the experiment was opened in the first week of March,2018 with a power tiller and was exposed to the sun for a few days, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting. The land operation was completed on 11March, 2018. The individual plots were made by raising soil (20 cm high) from the ground level.

3.8 Fertilizers and manure application

The N, P, K fertilizer were applied according to the treatment through urea, Triple super phosphate (TSP) and MoP respectively. Cowdung also used as organic manure. Nutrient doses used through fertilizers under the present study are presented as follows:

Nutrients	Manures/fertilizers	Doses ha^{-1}	BARI recommended dose ha^{-1}
-	Cowdung	5 ton	5 ton
N	Urea	As per treatment	250 kg
P	TSP	As per treatment	350 kg
K	MoP	As per treatment	250 kg

Source: BARI Fertilizer recommendation guide, 2012

Full amount of TSP, MoP, and well rotten cowdung were applied at the time of final land preparation. Urea was applied in two equal installments 25and 35 days after transplanting (DAT) respectively.

3.9 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 liter of water turn as per requirement of 50 ppm and 100 ppm solution of NAA. 50 and 100 ml of stock solution were mixed with 1 liter of water. The NAA solution was applied at 25 DAT.

3.10 Sowing of seeds and transplanting of seedlings

Seeds were sown in poly bags having compost mixed soil on 11 March, 2018 for germination and seedling raising. Two seeds were sown in each poly bag. The poly bags were kept in shady place. They were watered regularly during the seedling raising period. When the seedlings (16 days old) attained 4 leaves and hard enough, they were transplanted in the main field on 27 March, 2018.

3.11 Intercultural Operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of bitter gourd.

3.11.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling were done by healthy plants from the border whenever it was required. Weeds of different types were controlled manually as and when necessary.

3.11.2 Irrigation

Light irrigation was given immediately after transplanting around each seedling for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was given by observing the soil moisture condition.

3.11.3 Plant protection

The insects were controlled successfully by spraying Malathion 57 EC @ 2ml /L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting.

3.12 Harvesting and cleaning

Fruits were harvested during maturity stage. Harvesting was started from 10 May 2018 and completed by 26June, 2018.

3.13 Data collection

The data pertaining to following characters were recorded from four plants from each plot except yield of fruits which was recorded plot wise.

3.14 Procedure of recording data

3.14.1 Vine length

The vine length was recorded in centimeter (cm) at different days after transplanting of crop duration with a meter scale. Data were recorded from each plot. The length was measured from the ground level to the top of the vine using meter scale. Data were taken at 30, 45 and 60 days after transplanting (DAT).

3.14.2 Number of leaves plant^{-1}

Number of leaves per plant was counted at different days after transplanting of crop. Leaves number per plant was recorded from each selected plants of each plot and mean was calculated. Data was taken at 30, 45 and 60 days after transplanting (DAT).

3.14.3 Number of branches plant^{-1}

Number of branch per plant was counted at different days after transplanting of crop. Branch number per plant was recorded from each selected plants of each plot and mean was calculated. Data was taken at 30, 45 and 60 days after transplanting (DAT).

3.14.4 Days to 1st flowering

Days to first (1st) flowering were recorded from the date of transplanting to when first flower is appeared in each plant and the average value was calculated.

3.14.5 Number of female flower

Number of female flowers was counted from each plant of each plot and mean was calculated. Female flowers were selected based on the presence of initial oval shape fruit like structure at the base of flower.

3.14.6Number of male flower

Number of male flowers was counted from each plant of each plot and mean was calculated. Male flower selected based on the absence of initial oval shape fruit like structure at the base of flower.

3.15.7 Percent fruit set (%)

To obtain percent fruit set, total number of flowers and fruits per plant was counted and percent fruit set was measured using the following formula-

$$\text{Percent fruit set (\%)} = \frac{\text{Total number of fruits}}{\text{Total number of flowers}} \times 100$$

3.14.8 Fruit length

The length of the fruit was measured with a meter scale in centimeter from the neck of the fruit to the bottom of the fruit. It was measured from each plot and their average was calculated in centimeter.

3.14.9 Fruit diameter

The diameter of individual fruit was measured in several directions from five selected fruits with slide calipers and the average of all directions was finally recorded and expressed in centimeter (cm).

3.14.13 Number of fruits plant^{-1}

Total number of fruit was counted from each plant of each plot from first harvest to last harvest and average number of fruit was calculated and termed as number of fruits per plant.

3.14.14 Single fruit weight

From first harvest to last harvest total fruit number was counted and total fruit weight was measured from each plant of each plot to determine single fruit weight. Single fruit weight was calculated from total fruit weight dividing by total number of fruits.

3.14.15 Fruit weight plot^{-1}

Total fruit was collected from 1st harvest to last harvest from each plot and weighed. The total weight was considered as fresh fruit yield per plot and expressed in kilogram (kg).

3.14.16Fruit weight ha^{-1}

After collection of fruit per plot, it was converted to ton per hectare by the following formula:

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000\ m^2}{\text{Plot size } (m^2) \times 1\,000\ kg}$$

3.15 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

3.16 Economic analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of fertilizer doses and NAA in cost and return were done in details according to the procedure of Alam *et al*. (1989).

3.16.1 Analysis of total cost of production

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. Total cost of production (input cost, overhead cost), gross return, net return and BCR are presented in Appendix IX.

3.16.2 Gross income

Gross income was calculated on the basis of mature fruit sale. The price of bitter gourd was assumed to be Tk. 18/kg basis of current market value of farmer level, at the time of harvesting.

3.16.3 Net return

Net return was calculated by deducting the total production cost from gross income for each treatment combination.

3.16.4 Benefit cost ratio (BCR)

The economic indicator BCR was calculated by the following formula for each treatment combination.

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to find out the response of growth, flowering and yield of bitter gourd influenced by NPK fertilizers and NAA. Data recorded on different parameters were analyzed statistically and the results have been presented in tables, graphs and figures. The results of the present study have been presented and discussed and possible interpretations have been given under the following headings.

4.1 Growth parameters

4.1.1 Vine length (cm)

Significant variation was recorded on vine length of bitter gourd at different growth stages due to different NPK fertilizers (Fig. 2 and Appendix III). The maximum vine length (44.46, 92.73 and 130.70 cm at 30, 45 and 60 DAT, respectively) was recorded from N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) which was significantly different from all other treatments. The minimum vine length (34.17, 69.20 and 101.40 cm at 30, 45 and 60 DAT, respectively) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Under the present study, it was observed that maximum doses of NPK showed maximum vine length which was supported by Boonmanop (1997) who recorded maximum vine length with high rates of N, P and K. Similar result was also observed by Islam (1995).

Different rate of NAA application showed significant difference among the treatments regarding vine length of bitter gourd at different growth stages (Fig. 3 and Appendix III). The maximum vine length (41.35, 85.67 and 121.50 cm at 30, 45 and 60 DAT, respectively) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA).

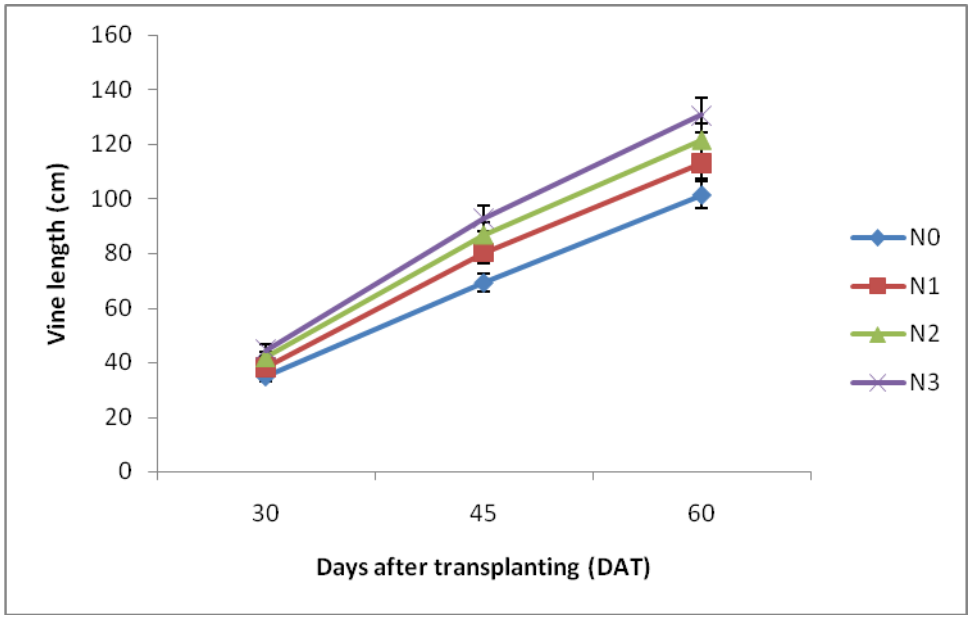

Fig. 2. Vine length of bitter gourd as affected by NPK fertilizers (Vertical bar represented error bar with percentage)

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

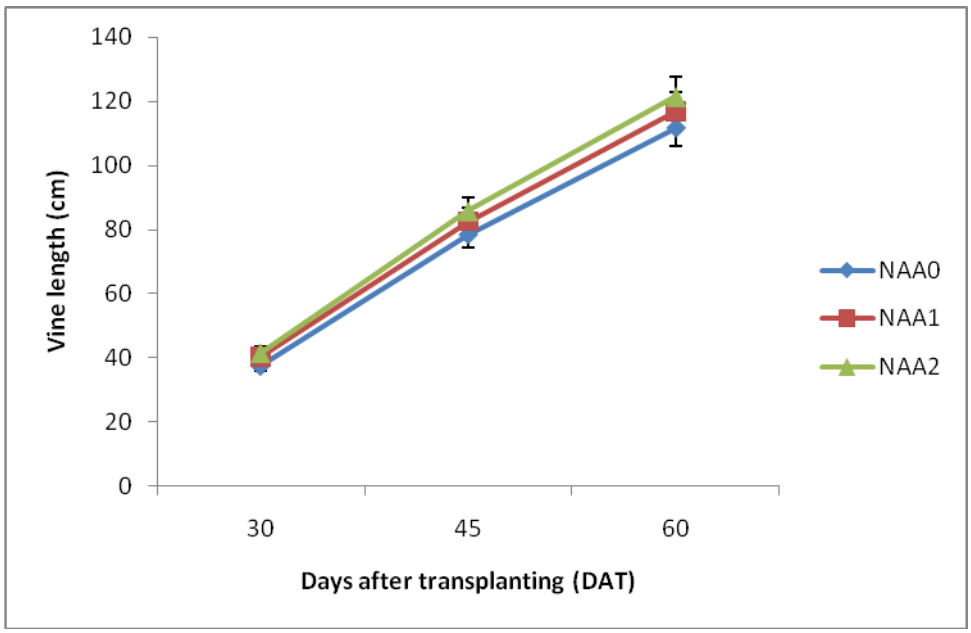

Fig. 3. Vine length of bitter gourd as affected by NAA (Vertical bar represented error bar with percentage)

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

The minimum vine length (37.57, 78.46 and 111.70 cm at 30, 45 and 60 DAT, respectively) was recorded from the control treatment H_0 (0 ppm NAA). Similar result was also observed by Muhammad-Rizwan-Shahid *et al.* (2013) stated that plant growth regulators (PGRs) affect various aspects of plant physiology like vine length which supported the present study. The result obtained from the present study was also similar with the findings of Al-Masouma and Al-Masri (1999).

Table 1. Vine length of bitter gourd as affected by NPK fertilizers and NAA

Treatments	Vine length (cm)		
	30 DAT	45 DAT	60 DAT
N_0H_0	31.63 f	64.93 h	96.29 h
N_0H_1	36.10 e	70.27 g	103.20 g
N_0H_2	36.40 e	72.40 g	104.70 g
N_1H_0	36.67 e	77.56 f	109.50 f
N_1H_1	37.50 de	78.28 f	111.20 f
N_1H_2	39.82 cd	84.54 de	118.20 de
N_2H_0	39.80 cd	83.33 e	116.50 e
N_2H_1	42.10 bc	86.87 cd	120.00 d
N_2H_2	43.37 ab	90.17 b	128.40 b
N_3H_0	42.17 bc	88.02 bc	124.60 c
N_3H_1	45.43 a	94.58 a	132.90 a
N_3H_2	45.79 a	95.59 a	134.60 a
$LSD_{0.05}$	2.79	2.84	3.15
CV(%)	6.31	8.64	9.81

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

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

Combined effect of NPK fertilizers and NAA showed significant variation on vine length of bitter gourd at different growth stages among the treatment combinations (Table 1 and Appendix III).The maximum vine length (45.79, 95,and 134.60 cm at 30, 45 and 60 DAT, respectively) was recorded from the treatment combination of N_3H_2 which was statistically identical with N_3H_1

whereas the minimum vine length (31.63, 64.93 and 96.29 cm at 30, 45 and 60 DAT, respectively) was recorded from the treatment combination of N_0H_0.

4.1.2 Number of leaves plant^{-1}

Significant variation was recorded on number of leaves plant^{-1} of bitter gourd at different growth stages due to different NPK fertilizers (Fig. 4 and Appendix IV). The maximum number of leaves plant^{-1} (78.18, 122.00 and 135.50 at 30, 45 and 60 DAT, respectively) was recorded from N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) followed by N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) whereas the minimum number of leaves plant^{-1} (47.83, 85.97 and 91.67 at 30, 45 and 60 DAT, respectively) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Excess doses of chemical fertilizer showed higher vegetative plant growth but yield is lower than optimum dose (Rekha and Gopalakrishnan, 2001). Under the present study, the result obtained on leaf number was similar with the findings of Islam (1995).

Different rate of NAA application showed significant difference among the treatments regarding number of leaves plant^{-1} of bitter gourd at different growth stages (Fig. 5 and Appendix IV). The maximum number of leaves plant^{-1} (68.73, 111.20 and 121.10 at 30, 45 and 60 DAT, respectively) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA). The minimum number of leaves plant^{-1} (56.70, 98.42 and 107.40 at 30, 45 and 60 DAT, respectively) was recorded from the control treatment H_0 (0 ppm NAA). This result indicated that NAA showed significant variation on leaf number which might be due to cause of chemical properties of NAA that influence to increase leaf number with higher doses. Similar result was also observed by Mehraj*et al.* (2015) which supported the present study.

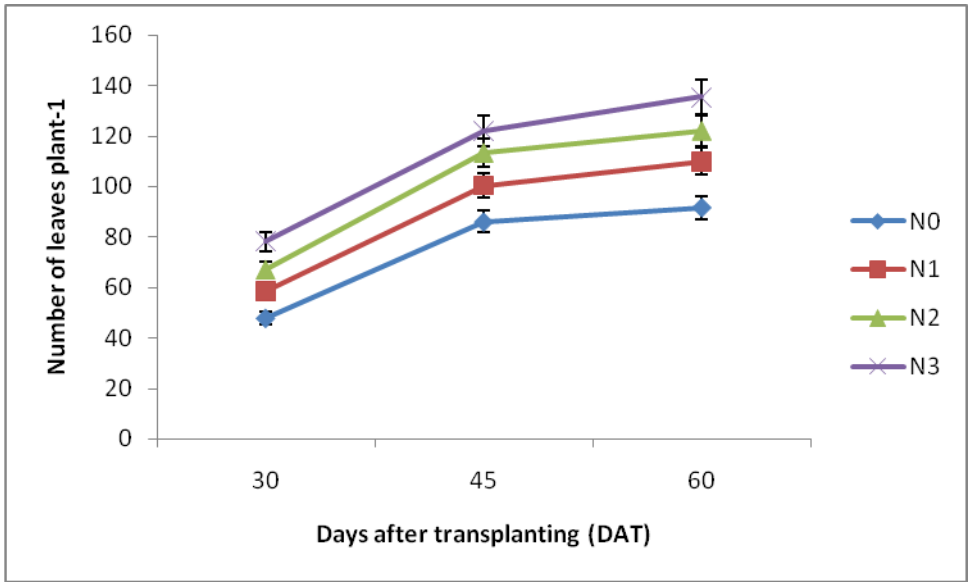

Fig. 4. Number of leaves plant^{-1} of bitter gourd as affected by NPK fertilizers (Vertical bar represented error bar with percentage)

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

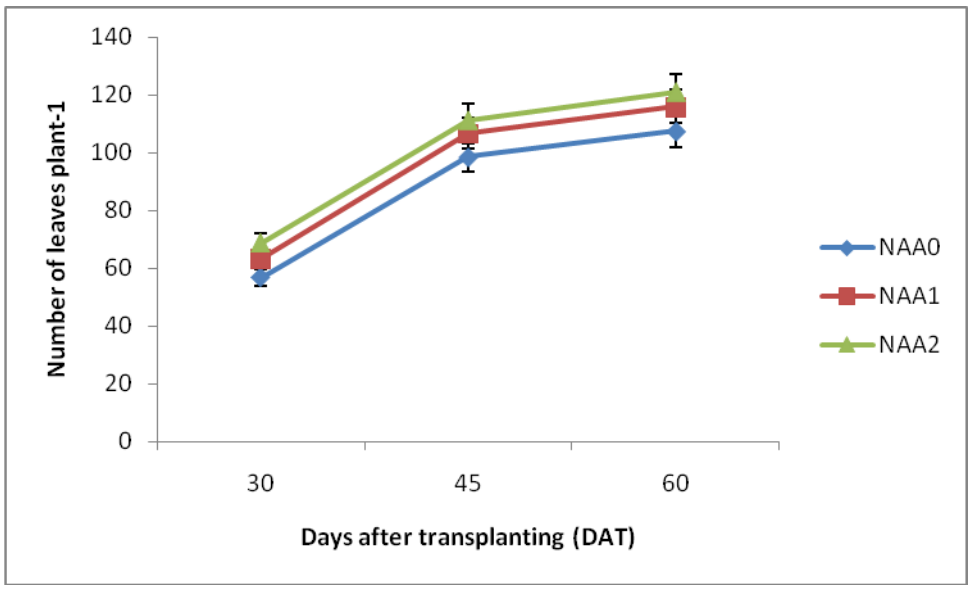

Fig. 5. Number of leaves plant^{-1} of bitter gourd as affected by (Vertical bar represented error bar with percentage)

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

Combined effect of NPK fertilizers and NAA showed significant variation on number of leaves plant^{-1} of bitter gourd at different growth stages among the treatment combinations (Table 2 and Appendix IV). The maximum number of leaves plant^{-1} (82.47, 125.90 and 140.70 at 30, 45 and 60 DAT, respectively) was recorded from the treatment combination of N_3H_2 which was statistically identical with N_3H_1 at all growth stages. The minimum number of leaves plant^{-1} (41.99, 78.32 and 86.51 at 30, 45 and 60 DAT, respectively) was recorded from the treatment combination of N_0H_0.

Table 2. Number of leaves plant^{-1} of bitter gourd as affected by NPK fertilizers and NAA

Treatments	Number of leaves plant^{-1}		
	30 DAT	45 DAT	60 DAT
N_0H_0	41.99 i	78.32 g	86.51 i
N_0H_1	49.85 h	88.42 f	93.09 h
N_0H_2	51.65 gh	91.18 ef	95.41 h
N_1H_0	54.44 fg	93.78 e	104.30 g
N_1H_1	55.29 f	98.41 d	110.10 f
N_1H_2	65.29 d	109.0 c	115.70 e
N_2H_0	58.71 e	106.0 c	111.40 ef
N_2H_1	66.68 d	115.0 b	121.80 d
N_2H_2	75.49 b	118.7 b	132.60 b
N_3H_0	71.65 c	115.6 b	127.30 c
N_3H_1	80.42 a	124.6 a	138.50 a
N_3H_2	82.47 a	125.9 a	140.70 a
$LSD_{0.05}$	3.06	3.87	4.64
CV(%)	6.88	10.17	8.63

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

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

4.1.3 Number of branches plant^{-1}

Significant variation was recorded on number of branches plant^{-1} of bitter gourd at different growth stages due to different NPK fertilizers (Table 3 and Appendix V). The maximum number of branches plant^{-1} (3.85, 8.98 and 12.61 at 30, 45 and 60 DAT, respectively) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) whereas the minimum number of branches plant^{-1} (2.51, 5.84 and 9.09 at 30, 45 and 60 DAT, respectively) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). This result indicated that branch number increased with increasing NPK to a certain level and excess NPK doses showed reduced number of branches plant^{-1}. The result obtained from the present study was conformity with the findings of Sangeeta (2018).

Table 3. Number of branches plant^{-1} of bitter gourd as affected by NPK fertilizers

Treatments	Number of branches plant^{-1}		
	30 DAT	45 DAT	60 DAT
N_0	2.51 b	5.84 c	9.09 c
N_1	3.50 a	8.14 b	11.97 b
N_2	3.85 a	8.98 a	12.61 a
N_3	3.78 a	8.96 a	12.56 a
$LSD_{0.05}$	0.54	0.61	0.54
CV(%)	5.24	7.83	8.00

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

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

Different rate of NAA application showed significant difference among the treatments regarding number of branches plant^{-1} of bitter gourd at different growth stages (Table 4 and Appendix V). The maximum number of branches plant^{-1} (3.79, 8.76 and 12.51 at 30, 45 and 60 DAT, respectively) was recorded from the treatment H_2 (100 ppm NAA) which was statistically identical with H_1 (50 ppm NAA) whereas the minimum number of branches plant^{-1} (2.89, 7.00

and 10.22 at 30, 45 and 60 DAT, respectively) was recorded from the control treatment H_0 (0 ppm NAA). Similar result was also observed by Mehraj*et al.* (2015) , Kapgate *et al.* (1989) and Islam *et al.* (1990) which supported the present study and they found that NAA application with optimum doses showed higher branch number in plants.

Table 4. Number of branches plant^{-1} of bitter gourd as affected by NAA

Treatments	Number of branches plant^{-1}		
	30 DAT	45 DAT	60 DAT
H_0	2.89 b	7.00 c	10.22 b
H_1	3.54 a	8.17 b	11.95 a
H_2	3.79 a	8.76 a	12.51 a
$LSD_{0.05}$	0.31	0.53	0.63
CV(%)	5.24	7.83	8.00

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

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

Combined effect of NPK fertilizers and NAA showed significant variation on number of branches plant^{-1} of bitter gourd at different growth stages among the treatment combinations (Table 5 and Appendix V). The maximum number of branches plant^{-1} (4.40, 10.24 and 14.20 at 30, 45 and 60 DAT, respectively) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1. The minimum number of branches plant^{-1} (2.34, 5.20 and 8.60 at 30, 45 and 60 DAT, respectively) was recorded from the treatment combination of N_0H_0.

Table 5. Number of branches plant^{-1} of bitter gourd as affected by NPK fertilizers and NAA

Treatments	Number of branches plant^{-1}		
	30 DAT	45 DAT	60 DAT
N_0H_0	2.34 f	5.20 f	8.60 e
N_0H_1	2.39 f	5.44 f	8.78 de
N_0H_2	2.80 e	6.89 e	9.90 cd
N_1H_0	2.90 e	7.12 e	10.48 c
N_1H_1	3.50 c	8.45 cd	12.27 b
N_1H_2	4.10 ab	8.84 cd	13.16 ab
N_2H_0	3.27 cd	7.89 de	10.94 c
N_2H_1	3.87 b	8.81 cd	12.70 b
N_2H_2	4.40 a	10.24 a	14.20 a
N_3H_0	3.05 de	7.81 de	10.85 c
N_3H_1	4.38 a	9.99 ab	14.05 a
N_3H_2	3.90 b	9.08 bc	12.78 b
$LSD_{0.05}$	0.32	1.06	1.14
CV(%)	5.24	7.83	8.00

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

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

4.2 Yield contributing parameters

Table 6. Yield contributing parameters of bitter gourd as affected by NPK fertilizers and NAA

Treatments	Yield contributing parameters					
	Days to 1st flowering (days)	Number of male flowers plant^{-1}	Number of female flowers plant^{-1}	Percent fruit set (%)	Fruit length (cm)	Fruit diameter (cm)
Effect of NPK fertilizers						
N_0	34.70 a	22.83 c	17.43 c	26.99 c	8.93 c	6.21 c
N_1	29.93 b	28.40 b	23.68 b	29.69 b	10.78 b	7.27 b
N_2	28.11 c	30.00 a	25.59 a	31.47 a	11.39 a	7.69 a
N_3	28.70 c	29.93 a	25.37 a	29.78 b	11.17 a	7.63 a
$LSD_{0.05}$	0.64	1.22	1.16	1.67	0.34	0.18
CV(%)	10.54	4.48	8.15	6.71	5.39	6.66
Effect of NAA concentration						
H_0	32.89 a	25.35 c	20.36 c	26.95 c	9.57 c	6.61 c
H_1	29.67 b	28.37 b	23.63 b	29.69 b	10.81 b	7.29 b
H_2	28.53 c	29.65 a	25.07 a	31.81 a	11.32 a	7.70 a
$LSD_{0.05}$	0.39	1.05	1.00	1.17	0.48	0.16
CV(%)	10.54	4.48	8.15	6.71	5.39	6.66
Combined effect of NPK fertilizers and NAA						
N_0H_0	35.44 a	20.70 h	15.60 g	24.15 e	8.36 h	5.92 h
N_0H_1	34.67 ab	23.48 g	18.30 f	27.55 cd	9.04 gh	6.30 g
N_0H_2	34.00 b	24.30 fg	18.40 f	29.28 b	9.40 fg	6.41 fg
N_1H_0	33.44 bc	25.60 ef	20.75 e	28.64 bc	9.67 efg	6.63 ef
N_1H_1	29.33 de	28.00 cd	23.00 cd	28.44 bc	10.78 cd	7.10 cd
N_1H_2	27.00 g	31.60 ab	27.30 a	31.99 a	11.88 ab	8.07 b
N_2H_0	30.33 d	27.80 cd	23.60 c	26.51 d	10.33 de	7.02 cd
N_2H_1	28.33 ef	29.00 cd	25.00 bc	29.52 b	11.22 bc	7.32 c
N_2H_2	25.67 h	33.20 a	28.20 a	33.32 a	12.62 a	8.56 a
N_3H_0	32.33 c	27.30 de	21.50 de	28.50 bc	9.920 ef	6.88 de
N_3H_1	26.33 gh	33.00 a	28.17 a	33.27 a	12.18 a	8.44 a
N_3H_2	27.44 fg	29.50 bc	26.40 ab	32.65 a	11.40 bc	7.76 b
$LSD_{0.05}$	1.33	2.11	2.01	1.44	0.772	0.33
CV(%)	10.54	4.48	8.15	6.71	5.39	6.66

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

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

4.2.1 Days to 1st flowering

Significant variation was recorded on days to 1st flowering of bitter gourd due to different NPK fertilizers (Table 6 and Appendix VI). The maximum days to 1st flowering (34.70 days) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}) whereas the minimum days to 1st flowering (28.11 days) was recorded from treatment N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}). From the result it can be observed that early flowering was found with NPK application compared to control and minimum days to flowering was found with increasing of NPK doses but it is upto a certain level.

Different rate of NAA application showed significant difference among the treatments regarding days to 1st flowering of bitter gourd (Table 6 and Appendix VI).The maximum days to 1st flowering (32.89 days) was recorded from the control treatment H_0 (0 ppm NAA) and the minimum days to 1st flowering (28.53 days) was recorded from the treatment H_2 (100 ppm NAA). Generally it was known that growth regulators promote flowering habit and under the present study early flowering was occurred with NAA application compared control.

Combined effect of NPK fertilizers and NAA showed significant variation on days to 1st flowering of bitter among the treatment combinations (Table 6 and Appendix VI). The maximum days to 1st flowering (35.44 days) was recorded from the treatment combination of N_0H_0which was statistically similar with N_0H_1 whereas the minimum days to 1st flowering (25.67 days) was recorded from the treatment combination of N_2H_2.

4.2.2 Number of male flowers

Significant variation was recorded on number of male flowers of bitter gourd due to different NPK fertilizers (Table 6 and Appendix VI). The maximum number of male flowers (30.00) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1})

which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) whereas the minimum number of male flowers (22.83) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Similar result was also observed by Boonmanop (1997) and Ali *et al.* (1995) which supported the present study.

Different rate of NAA application showed significant difference among the treatments regarding number of male flowers of bitter gourd (Table 6 and Appendix VI).The maximum number of male flowers (29.65) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA). The minimum number of male flowers (25.35) was recorded from the control treatment H_0 (0 ppm NAA). Khatoon and Moniruzzaman (2019) and Al-Masouma and Al-Masri (1999) also found similar result which supported the present study.

Combined effect of NPK fertilizers and NAA showed significant variation on number of male flowers of bitter gourd among the treatment combinations (Table 6 and Appendix VI).The maximum number of male flowers (33.20) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1. The minimum number of male flowers (20.70) was recorded from the treatment combination of N_0H_0.

4.2.3 Number of female flowers

Significant variation was recorded on number of female flowers of bitter gourd due to different NPK fertilizers (Table 6 and Appendix VI).The maximum number of female flowers (25.59) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}). The minimum number of female flowers (17.43) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Similar result was also observed by Boonmanop (1997) and Ali *et al.* (1995) which supported the present study.

Different rate of NAA application showed significant difference among the treatments regarding number of female flowers of bitter gourd (Table 6 and Appendix VI). The maximum number of female flowers (25.07) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA) whereas the minimum number of female flowers (20.36) was recorded from the control treatment H_0 (0 ppm NAA). supported result was also observed by Khatoon and Moniruzzaman (2019) and Al-Masouma and Al-Masri (1999).

Combined effect of NPK fertilizers and NAA showed significant variation on number of female flowers of bitter gourd among the treatment combinations (Table 6 and Appendix VI). The maximum number of female flowers (28.20) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1 whereas the minimum number of female flowers (15.60) was recorded from the treatment combination of N_0H_0.

4.2.4 Percent fruit set (%)

Significant variation was recorded on percent (%) fruit set of bitter gourd due to different NPK fertilizers (Table 6 and Appendix VI). The maximum percent fruit set (31.47%) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) whereas the minimum percent fruit set (26.99%) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). The result obtained from the present study was similar with the findings of Ali *et al.* (1995).

Different rate of NAA application showed significant difference among the treatments regarding percent (%) fruit set of bitter gourd (Table 6 and Appendix VI). The maximum percent fruit set (31.81%) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA) whereas the minimum percent fruit set (26.95%) was recorded from the control treatment H_0 (0 ppm NAA). Susmita *et al.* (1998) also found similar result with supported the present study.

Combined effect of NPK fertilizers and NAA showed significant variation on percent (%) fruit set of bitter gourd among the treatment combinations (Table 6 and Appendix VI). The maximum percent fruit set (33.32%) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1 and N_3H_2. The minimum percent fruit set (24.15%) was recorded from the treatment combination of N_0H_0.

4.2.5 Fruit length (cm)

Significant variation was recorded on fruit length of bitter gourd due to different NPK fertilizers (Table 6 and Appendix VI). The maximum fruit length (11.39 cm) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}). The minimum fruit length (8.93 cm) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Fruit length is an important character for higher yield of bitter gourd. Result indicated that fruit length is increased with increasing of NPK doses to a certain level. Similar result was also observed by Sangeeta (2018) and Arfan-ul-Haq (2015).

Different rate of NAA application showed significant difference among the treatments regarding fruit length of bitter gourd (Table 6 and Appendix VI). The maximum fruit length (11.32 cm) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA) whereas the minimum fruit length (9.57 cm) was recorded from the control treatment H_0 (0 ppm NAA). Results indicated that different NAA doses gave variations on fruit length of bitter gourd and this result was supported by the findings of Mehraj*et al.* (2015).

Combined effect of NPK fertilizers and NAA showed significant variation on fruit length of bitter gourd among the treatment combinations (Table 6 and Appendix VI). The maximum fruit length (12.62 cm) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1. The minimum fruit length (8.36 cm) was recorded from the treatment combination of N_0H_0.

4.2.6 Fruit diameter (cm)

Significant variation was recorded on fruit diameter of bitter gourd due to different NPK fertilizers (Table 6 and Appendix VI).The maximum fruit diameter (7.69 cm) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}). The minimum fruit diameter (6.21 cm) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Similar result was also observed by Sangeeta (2018) and Arfan-ul-Haq (2015).

Different rate of NAA application showed significant difference among the treatments regarding fruit diameter of bitter gourd (Table 6 and Appendix VI). The maximum fruit diameter (7.70 cm) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA). The minimum fruit diameter (6.61 cm) was recorded from the control treatment H_0 (0 ppm NAA). This result was also supported by the findings of Mehraj*et al.* (2015).

Combined effect of NPK fertilizers and NAA showed significant variation on fruit diameter of bitter gourd among the treatment combinations (Table 6 and Appendix VI). The maximum fruit diameter (8.56 cm) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1. The minimum fruit diameter (5.92 cm) was recorded from the treatment combination of N_0H_0.

4.3 Yield parameters

Table 7. Yield parameters of bitter gourd as affected by NPK fertilizers and NAA

Treatments	Yield parameters				
	Single fruit weight (g)	Number of fruits plant^{-1}	Fruit weight plant^{-1} (kg)	Fruit weight plot^{-1} (kg)	Fruit yield (t ha^{-1})
Effect of NPK fertilizers					
N_0	62.07 b	10.93 c	0.69 c	1.36 c	11.37 c
N_1	67.24 a	15.54 b	1.05 b	2.09 b	17.47 b
N_2	69.03 a	17.49 a	1.20 a	2.39 a	19.93 a
N_3	68.09 a	16.66 a	1.16 a	2.31 a	19.25 a
$LSD_{0.05}$	1.81	1.01	0.05	0.11	0.79
CV(%)	7.81	6.81	5.71	5.71	5.72
Effect of NAA concentration					
H_0	64.16 b	12.39 c	0.80 c	1.60 c	13.35 c
H_1	67.06 a	15.58 b	1.05 b	2.10 b	17.52 b
H_2	68.61 a	17.50 a	1.21 a	2.42 a	20.13 a
$LSD_{0.05}$	1.59	0.87	0.05	0.09	1.45
CV(%)	7.81	6.81	5.71	5.71	5.72
Combined effect of NPK fertilizers and NAA					
N_0H_0	58.80 h	8.77 g	0.52 h	1.03 h	8.60 h
N_0H_1	62.70 g	11.52 f	0.72 g	1.44 g	12.00 g
N_0H_2	64.72 f	12.50 ef	0.81 fg	1.62 fg	13.50 fg
N_1H_0	65.11 f	13.28 de	0.87 ef	1.73 ef	14.40 ef
N_1H_1	67.52 de	14.49 cd	0.98 d	1.96 d	16.30 d
N_1H_2	69.10 bc	18.85 ab	1.30 b	2.60 b	21.70 b
N_2H_0	67.13 e	13.62 de	0.92 de	1.83 de	15.22 de
N_2H_1	67.80 de	15.96 c	1.08 c	2.16 c	18.00 c
N_2H_2	72.17 a	20.40 a	1.47 a	2.94 a	24.52 a
N_3H_0	65.60 f	13.91 de	0.91 de	1.82 def	15.20 de
N_3H_1	70.22 b	20.33 a	1.43 a	2.85 a	23.78 a
N_3H_2	68.44 cd	18.23 b	1.25 b	2.50 b	20.80 b
$LSD_{0.05}$	1.21	1.75	0.09	0.20	1.65
CV(%)	7.81	6.81	5.71	5.71	5.72

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

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

4.3.1 Single fruit weight (g)

Significant variation was recorded on single fruit weight of bitter gourd due to different NPK fertilizers (Table 7 and Appendix VII). The maximum single fruit weight (69.03 g) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) and N_1 ($N_{25}P_{10}K_{15}$ kg ha^{-1}). The minimum single fruit weight (62.07 g) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). This result indicated that N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) doses gave maximum single fruit weight which might be due to cause of optimum nutrition that was obtained from this treatment. Arfan-ul-Haq (2015) also found similar result which supported the present study.

Different rate of NAA application showed significant difference among the treatments regarding single fruit weight of bitter gourd (Table 7 and Appendix VII). The maximum single fruit weight (68.61 g) was recorded from the treatment H_2 (100 ppm NAA) which was statistically identical with H_1 (50 ppm NAA). The minimum single fruit weight (64.16 g) was recorded from the control treatment H_0 (0 ppm NAA). Similar result was also observed by Khatoon and Moniruzzaman (2019) and Mehraj*et al.* (2015).

Combined effect of NPK fertilizers and NAA showed significant variation on single fruit weight of bitter gourd among the treatment combinations (Table 7 and Appendix VII). The maximum single fruit weight (72.17 g) was recorded from the treatment combination of N_2H_2 which was significantly different from all other treatment combinations. The minimum single fruit weight (58.80 g) was recorded from the treatment combination of N_0H_0.

4.3.2 Number of fruits $plant^{-1}$

Significant variation was recorded on number of fruits $plant^{-1}$ of bitter gourd due to different NPK fertilizers (Table 7 and Appendix VII). The maximum number of fruits $plant^{-1}$ (17.49) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}). The minimum number of

fruits plant^{-1} (10.93) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Similar result was also observed by Sangeeta (2018) and Arfan-ul-Haq (2015).

Different rate of NAA application showed significant difference among the treatments regarding number of fruits plant^{-1} of bitter gourd (Table 7 and Appendix VII). The maximum number of fruits plot^{-1} (17.50) was recorded from the treatment H_2 (100 ppm NAA) whereas the minimum number of fruits plant^{-1} (12.39) was recorded from the control treatment H_0 (0 ppm NAA). This result was supported by the findings of Khatoon and Moniruzzaman (2019) and Mehraj*et al.* (2015).

Combined effect of NPK fertilizers and NAA showed significant variation on number of fruits plant^{-1} of bitter gourd among the treatment combinations (Table 7 and Appendix VII). The maximum number of fruits plant^{-1} (20.40) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1. The minimum number of fruits plant^{-1} (8.77) was recorded from the treatment combination of N_0H_0.

4.3.3 Fruit weight plant^{-1}

Significant variation was recorded on fruit weight plant^{-1} of bitter gourd due to different NPK fertilizers (Table 7 and Appendix VII). The maximum fruit weight plant^{-1} (1.20 kg) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}). The minimum fruit weight plant^{-1} (0.69 kg) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). The result obtained from the present study was similar with the findings of Sangeeta (2018) and Arfan-ul-Haq (2015).

Different rate of NAA application showed significant difference among the treatments regarding fruit weight plant^{-1}of bitter gourd (Table 7 and Appendix VII). The maximum fruit weight plant^{-1} (1.21kg) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA). The minimum fruit weight plant^{-1} (0.80kg) was recorded from the control treatment H_0 (0 ppm

NAA). Mehraj*et al.* (2015) also found similar result which supported the present study.

Combined effect of NPK fertilizers and NAA showed significant variation on fruit weight plant^{-1}of bitter gourd among the treatment combinations (Table 7 and Appendix VII). The maximum fruit weight plant^{-1} (1.47 kg) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) which was statistically identical with N_3H_1. The minimum fruit weight plant^{-1} (0.52kg) was recorded from the treatment combination of N_0H_0.

4.3.3 Fruit weight plot^{-1} (g)

Significant variation was recorded on fruit weight plot^{-1}of bitter gourd due to different NPK fertilizers (Table 7 and Appendix VII). The maximum fruit weight plot^{-1} (2.39 kg) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}). The minimum fruit weight plot^{-1} (1.36 kg) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}).

Different rate of NAA application showed significant difference among the treatments regarding fruit weight plot^{-1}of bitter gourd (Table 7 and Appendix VII). The maximum fruit weight plot^{-1} (2.42 kg) was recorded from the treatment H_2 (100 ppm NAA) whereas the minimum fruit weight plot^{-1}(1.60 kg) was recorded from the control treatment H_0 (0 ppm NAA).

Combined effect of NPK fertilizers and NAA showed significant variation on fruit weight plot^{-1}of bitter gourd among the treatment combinations (Table 7 and Appendix VII). The maximum fruit weight plot^{-1} (2.94 kg) was recorded from the treatment combination of N_2H_2which was statistically identical with N_3H_1. The minimum fruit weight plot^{-1}(1.03 kg) was recorded from the treatment combination of N_0H_0.

4.3.4 Fruit yield (t ha^{-1})

Significant variation was recorded on fruit yield of bitter gourd due to different NPK fertilizers (Table 7 and Appendix VII). The maximum fruit yield (19.93 t ha^{-1}) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) which was statistically identical with N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}). The minimum fruit yield (11.37 t ha^{-1}) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Results indicated that N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) showed maximum fruit yield ha^{-1} which might be due to cause of maximum number of fruits $plant^{-1}$, fruit weight $plant^{-1}$ and single fruit weight were from the same treatment. Moreover, NPK doses from this treatment might be optimum for plant growth and development. Similar result was also observed by Sangeeta (2018) and Arfan-ul-Haq (2015).

Different rate of NAA application showed significant difference among the treatments regarding fruit yield of bitter gourd (Table 7 and Appendix VII). The maximum fruit yield (20.13 t ha^{-1}) was recorded from the treatment H_2 (100 ppm NAA) followed by H_1 (50 ppm NAA). The minimum fruit yield (13.35 t ha^{-1}) was recorded from the control treatment H_0 (0 ppm NAA). Yield contributing parameters like number of fruits $plant^{-1}$, fruit weight $plant^{-1}$ and single fruit weight were also recorded from the treatment H_2 (100 ppm NAA) which might be resulted maximum fruit yield ha^{-1}. Again, 100 ppm NAA application to bitter gourd might be considered as optimum rate of plant growth regulators compared to other doses including control. Khatoon and Moniruzzaman (2019) and Mehraj*et al.* (2015) also found similar result which supported the present study.

Combined effect of NPK fertilizers and NAA showed significant variation on fruit yield of bitter gourd among the treatment combinations (Table 7 and Appendix VII). The maximum fruit yield (24.52 t ha^{-1}) was recorded from the treatment combination of N_2H_2 which was statistically identical with N_3H_1 whereas the minimum fruit yield (8.60 t ha^{-1}) was recorded from the treatment combination of N_0H_0.

4.4 Economic analysis

Different variable cost (material and non-material input cost) and miscellaneous cost were considered for calculating the total cost of production in per hectare basis (Table 8 and Appendix VIII). Price of bitter gourd was considered at market rate. The economic analysis is presented under the following headlines:

Table 8. Economic performance of bitter gourd affected by the combination of NPK fertilizers and NAA

Treatment	Bitter gourd yield ha^{-1} (t)	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
N_0H_0	8.60	136320	154800	18480	1.14
N_0H_1	12.00	139116	216000	76884	1.55
N_0H_2	13.50	141911	243000	101089	1.71
N_1H_0	14.40	139127	259200	120073	1.86
N_1H_1	16.30	141922	293400	151478	2.07
N_1H_2	21.70	144718	390600	245882	2.70
N_2H_0	15.22	141184	273960	132776	1.94
N_2H_1	18.00	143980	324000	180020	2.25
N_2H_2	24.52	146776	441360	294584	3.01
N_3H_0	15.20	143572	273600	130028	1.91
N_3H_1	23.78	146367	428040	281673	2.92
N_3H_2	20.80	149163	374400	225237	2.51

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

4.4.1 Gross return

The combination of different NPK fertilizers and NAA levels showed different gross return (Table 8). Gross return was calculated on the basis of sale of bitter gourd. The maximum gross return (Tk. 441360) obtained from N_2H_2 treatment combination and minimum gross return (Tk. 154800) was obtained from the treatment combination of N_0H_0.

4.4.2 Net return

Treatment combinations of different NPK fertilizers and NAA levels showed net returns variation (Table 8). The maximum net return (Tk. 294584) was obtained from the treatment combination of P N_2H_2 and minimum net return (Tk. 18480) was obtained from the treatment combination of N_0H_0.

4.4.3 Benefit cost ratio (BCR)

Among different treatment combinations of different NPK fertilizers and NAA levels, difference on benefit cost ration (BCR) was observed among the treatment combinations (Table 8). The maximum BCR (3.01) was obtained from the treatment combination of N_2H_2 whereas the minimum BCR (1.14) was obtained from N_0H_0 treatment combination. From economic point of view, it was noticeable from the above results, the treatment combination of N_2H_2 was more cost-effective than rest of the treatment combinations. The result obtained from the present study was conformity with the findings of Sangeeta (2018) and Khatoon and Moniruzzaman (2019).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at the Horticultue farm of Sher-e- Bangla Agricultural University during the period of March to June, 2018 to study the response of growth, flowering and yield of bitter gourd influenced by NPK fertilizers and NAA. The experiment consists of two factors such as four levels of NPK fertilizers *viz*, N_0 ($N_0P_0K_0$ kg ha^{-1}), N_1 ($N_{25}P_{10}K_{15}$ kg ha^{-1}), N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) and N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) and three levels of NAA *viz*, H_0 (0 ppm NAA), H_1 (50 ppm NAA) and H_2 (100 ppm NAA). Two factors experiment was laid out in Randomized Complete Block Design (RCBD) with the three replications.

Data were recorded on different growth, yield contributing parameters and yield of bitter gourd. Considering growth parameters influenced by NPK fertilizers, the highest vine length (130.70 cm) and number of leaves $plant^{-1}$ (135.50) were recorded from N_3 ($N_{45}P_{30}K_{35}$ kg ha^{-1}) but the highest number of branches $plant^{-1}$ (12.61) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) whereas the lowest vine length (101.40 cm), number of leaves $plant^{-1}$ (91.67) and number of branches $plant^{-1}$ (9.09) were recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). In terms of yield and yield contributing parameters, the lowest days to 1st flowering (28.11 days) was recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) whereas the highest days to 1st flowering (34.70 days) was recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}). Similarly, the highest number of male flowers (30.00), number of female flowers (25.59), percent fruit set (%) (31.47), fruit length (11.39 cm), fruit diameter (7.69 cm), fruit weight $plant^{-1}$ (1.20 kg), number of fruits $plant^{-1}$ (17.49), single fruit weight (69.03 g), fruit weight $plot^{-1}$ (2.39 kg) and fruit yield (19.93 t ha^{-1}) were recorded from N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) whereas the lowest number of male flowers (22.83), number of female flowers (17.43), percent fruit set (%) (26.99), fruit length (8.93 cm), fruit diameter (6.21 cm), fruit weight $plant^{-1}$ (0.69 kg), number of fruits $plant^{-1}$ (10.93), single fruit

weight (62.07 g), fruit weight plot^{-1} (1.36 kg) and fruit yield (11.37 t ha^{-1}) were recorded from control treatment N_0 ($N_0P_0K_0$ kg ha^{-1})

Considering, NAA application, in terms of growth parameters, the highest vine length (41 121.50 cm), number of leaves plant^{-1} (121.10) and number of branches plant^{-1} (12.51) and recorded from H_2 (100 ppm NAA) whereas the lowest vine length (111.70 cm), lowest number of leaves plant^{-1} (107.40) and lowest number of branches plant^{-1} (10.22) were recorded from the control treatment H_0 (0 ppm NAA). In terms of yield and yield contributing parameters, the lowest days to 1st flowering (28.53 days) was recorded from H_2 (100 ppm NAA) whereas the highest days to 1st flowering (32.89 days) was recorded from control treatment H_0 (0 ppm NAA). Similarly, the highest number of male flowers (29.65), number of female flowers (25.07), percent fruit set (%) (31.81), fruit length (11.32 cm), fruit diameter (7.70 cm), fruit weight plant^{-1} (1.21 kg), number of fruits plot^{-1} (17.50), single fruit weight (68.61 g), fruit weight plot^{-1} (2.42 kg) and fruit yield (20.13 t ha^{-1}) was recorded from the treatment H_2 (100 ppm NAA) whereas lowest number of male flowers (25.35), number of female flowers (20.36), percent fruit set (%) (26.95), fruit length (9.57 cm), fruit diameter (6.61 cm), fruit weight plant^{-1} (0.80 kg), number of fruits plant^{-1} (12.39), single fruit weight (64.16 g), fruit weight plot^{-1} (1.60 kg) and fruit yield (13.35 t ha^{-1}) were recorded from the control treatment H_0 (0 ppm NAA)

Regarding combined effect of NPK fertilizers and NAA, in terms of growth parameters, the highest vine length (134.60 cm) and number of leaves plant^{-1} (140.70) were achieved from N_3H_2 whereas the highest number of branches plant^{-1} (14.20) was achieved from N_2H_2. But the lowest vine length (96.29 cm), number of leaves plant^{-1} (86.51) and number of branches plant^{-1} (8.60) was recorded from the treatment combination of N_0H_0. In terms of yield and yield contributing parameters, the lowest days to 1st flowering (25.67 days) was recorded from N_2H_2 whereas the highest days to 1st flowering (35.44 days) was

recorded from N_0H_0. Similarly, the highest number of male flowers (33.20), number of female flowers (28.20), percent fruit set (%) (33.32), fruit length (12.62 cm), fruit diameter (8.56 cm), fruit weight plant^{-1} (1.47 kg), number of fruits plant^{-1} (20.40), single fruit weight (72.17 g), fruit weight plot^{-1} (2.94 kg) and fruit yield (24.52 t ha^{-1}) were achieved from the treatment combination of N_2H_2 whereas lowest number of male flowers (20.70), number of female flowers (15.60), percent fruit set (%) (24.15), fruit length (8.36 cm), fruit diameter (5.92 cm), fruit weight plant^{-1} (0.52 kg), number of fruits plant^{-1} (8.77), single fruit weight (58.80 g), fruit weight plot^{-1} (1.03 kg) and fruit yield (8.60 t ha^{-1}) was recorded from the treatment combination of N_0H_0.

In terms of economic analysis, the highest gross return (Tk. 441360), with the highest BCR (3.01) were obtained from the treatment combination of N_2H_2 ($N_{35}P_{20}K_{25}$ with 100 ppm NAA ppm) whereas the lowest gross return (Tk. 154800) and BCR (1.14) were obtained from $N_0P_0K_0$.

From the above discussion it can be concluded that among the four NPK fertilizers, N_2 ($N_{35}P_{20}K_{25}$ kg ha^{-1}) showed the best performance in respect of yield and economic performance. In terms of NAA application, H_2 (100 ppm NAA) gave the best result. Again, Interaction effect of NPK fertilizers and NAA, the combination of N_2H_2 showed best performance regarding yield and economic performance.

REFERENCES

Abdul, K.S., Arif, L.H.A. and Yadgar, M.F. (1985). Effect of some growth regulators on the growth and yield of okra. Iraqi *J. Agril. Sci.* **3**(3): 95-104.

Ali, N., Rehman, M. and Hussain, S. A. (1995). Response of *Momordicacharantia* L. (Bitter gourd) cultivars to nitrogen levels. *Sarhad J. Agric.* **11**(5): 585-589

Anonymous. (2012). Statistical Pocket Book of Bangladesh 2002.Bangladesh Bureau of Statistics. Government of the Peoples' Republic of Bangladesh, Dhaka, Bangladesh, p. 184.

Arfan-ul-Haq, M. (2015). Effect of different organic materials and chemical fertilizer on yield and quality of bitter gourd (*Momordica charantia L*.). Soil Environ. **34**(2): 142-147.

Arora, S. K. and Satish, S. (1989). Effect of N and P on growth, flowering and sex expression of sponge gourd. *Horyana J. Hort. Sci.* **18**(1-2): 106-112.

Arora, S.K., Dhankar, B.S. and Sharma, N.K. (1990).Research and development reporter Dept. Vegetables Crops, Haryana Agril. University.

Asghar,S., Hussain, S.A. and Ali, N. (1997). Effect of exogenous growth regulators on growth, flowering and yield of okra *(AbelmoschusesculentusL.). Sarhad J. Agric.* pp. 216-223.

Baruah, G.K.S and Das, R.K. (1997). Effect of growth regulators on growth, floweringand yield of bottle gourd at different sowing dates. *Annals Agril. Res*. **18**(3): 31-374

Behera T.K., Sureja, A. K., Sabina, I., Munshi, A.D. and Sidhu, A.S. (2011). Minor cucurbits. Genetics, genomics and breeding of cucurbits. pp17-60.

Bisaria, A.K. (1974). Sex expression and fruit development in cucumber as effect by Gibberellins. *Indian J. Hort*., **16**: 233-235.

Boonmanop, S. (1997). Influences of nitrogen, phosphorus and potassium fertilizers on seed yield, yield and seed quality of bitter gourd. Bull, Kasetsart Univ. Bangkok, Thailand, pp. 711-729.

Catedral, I. G. (1974). Seed production studies in Ampalaya. MS Thesis, UPLB College, Laguna, The Philippines.

Choudhury, B. and Phatak, S.C. (1981).Further studies on Sex expression and Sex ratio in cucumber *(Cucumis stavus* L.)as affected by plant regulator sprays. *Indian J. Hort.* **39**: 210-216.

Das, R. and Rabhal, B.K. (1999). Effect of growth regulators on size and quality of cucumber *(Cucumis sativa* L.) in plastic green house during Rabi season.*Crop Res. Hisar*.**18:** 390-396.

Edris, K.M., Islam, A.T.M.T., Chowdhury, M.S. and Haque, A.K.M.M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

FAO. (1988). Production Year Book. Food and Agricultural Organizations of the United Nations Rome, Italy. **42**: 190-193.

Gedam, V.M., Patil, R.B., Suryawanswhi, Y.B. and. Mate, S.N. (1998). Effect of plant growth regulators and boron of flowering, fruiting and seed yield in bitter gourd. *Seed Res*., **26**(1): 97-100.

Gopalkrishnan, and Choudhury, B. (1978). Effect of plant regulator sprays on modification of sex, fruit set and development in water melon(*Citruluslanatus*). *Indian J. Hort*. **35**: 235-241.

Gosh, H.S. and Basu, P.S. (1983). Effect of plant growth regulators and boron on flowering, fruiting and seed yield of bitter gourd. *Hort*. *Abst.* **54:** 149.

Irving, R.M., Rogers, B. and Lanphear, F.O.(1968). Studies in growth promoting substances of cucumber. *American J. Hort. Sci*. **94**: 419-422.

Islam, M.S. (1995). Seed production studies on bitter gourd *(Momordica charantia* L.) Ph. D Thesis, CLSU, Munoz, Nueva Ecija, the Philippines.

Islam, M.S., Begum, R.A., Saha, S.R., Hossain, S.M. and Hoque, M.M. (1990). Effect of artificial pollination and hormone application on the yield of bottle *gourd. Bangladesh Hort.* **11:** 47-49.

Issac, S.R. and Pusphakumari, R. (1997). Effect of green fruit picking and nutrient sources on the seed production of okra *(.Abelmoschus esculentus* (L.) Monech.). *Seed Res.* **25**(1): 83-85.

Katiyar, R.P. (1980). Developmental changes in leaf area index and other growth parameters in chickpea. *Indian J.Agric. Sci.* **50:** 648-691.

Khatoon, R. and Moniruzzaman M. (2019). Effect of foliar spray of ga_3 and naa on sex expression and yield of bitter gourd. *Bangladesh J. Agril. Res*. **44**(2): 281-290.

Lingaiah, H. B., Uthaiah, B. C., Herle, P. S. and Rao, K. B. (1988). Influence of nitrogen and phosphorus on the yield of bitter gourd in the coastal region of Karnataka. *Current Res. Univ. Agri. Sci. Bagalore, India*. **17**(9): 116-117.

Makal, K.G., Joshi, A.T., Deshmukh, P.O. and Pawar, P.R. (1977). Effect of N, P and K on tinda*(Citrullus vulgaris* var. *fistulosus). Orissa J. Hort.* **5**(1/2): 62-63.

Mangal, J.L., Pandita, M.L. and Singh G.R. (1981). Effect of various chemicals on growth,flowering and yield of bitter gourd. *Indian J, Agric. Res.* **15**(3): 185-188.

Mehraj, H., Taufique, T., Ali, M.R., Sikder, R.K. and Jamal Uddin A.F.M. (2015).Impact of GA and NAA on Horticultural Traits of *Abelmoschus esculentus. World Appl. Sci. J.* **33**(11): 1712-1717.

Mia, B.M., Islam, M.S., Miah, M.Y., Das, M.R. and Khan, H.I. (2014). Flower synchrony, growth and yield enhancement of small type bitter gourd (*Momordica charantia* L.) through plant growth regulators and NPK fertilization. *Pak. J. Biol. Sci*. **17**(3): 408-413.

Mishra, H.P. (1987.) Effect of NPK on growth seed yield and quality of radish cv. Puna radish grow in the calcareous oils of North Bihar. *Indian J. Hort.* **44**(1/2): 69-73.

Mishra, S., Behera, T.K. and Munshi, A.D. (2015). Induction and morphological characterization of hermaphrodite flowers in a gynoecious line of bitter gourd by silver nitrate, gibberellic acid, and silver thiosulfate. *Int. J. Vegetable Sci*. **21**(2): 204-211.

Muhammad, R.S., Muhammad, A., Khurram, Z., Muhammad, M.J., Saeed, A., Qumer, I. and Aamir, N. (2013). Growth, yield and seed production of okra as influenced by different growth regulators. *Pakistan. J. Agri. Sci.* **50**(3): 387-392.

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

Ogunremi, E. A. (1978). Effect of nitrogen on melon *(Citrulluslanatus)* at Ibadan, Nigeri. *Hort*. **32**(1): 11-14.

Patil, D.R., Patel, M.N. (2010). Effect of seed treatment with GA_3 and NAA on growth and yield of okra *[Abmelmoschus esculentus* (L.) Moench] cv. *GO-2. Asian J. Hort.* **5**(2): 269-272.

Pelaez, R.J., Calero De La Pava and Jaramillo, V. (1984). Response of squash *(Cucurbita pepo* L.) and organic matter. *Acta Agronomica.* **34**(3): 86-95.

Prakash, G.F. (1974). Effect of photoperiod, alpha-NAA and MH on sex expression and ratio in bitter gourd (*Momordica charantia* L.). *Plant. Sci*., **6**: 553.

Ravindran, D.N. (1971). Effect of photoperiod and growth substances on sex expression in snake gourd (*Trichosanthes anguina L.*) *South Indian Hort.* **15**: 1-21.

Rekha, C. R. and Gopalakrishnan, T. R. (2001). Effect of levels and frequencies of organic manures and inorganic fertilizers on growth and productivity of bitter gourd *(Momordica charantia L.*).*South Indian Hort.* **49**(Special): 137-139.

Sangeeta, S. (2018). Effect of Organic and Inorganic Fertilizers on Growth, Yield and Quality Attributes of Hybrid bitter gourd (*Momordica charantia L.*). *Int. J. Curr. Microbiol. App. Sci*. **7**(4): 2256-2266.

Satish, S.S., Arora, K and Siyag, S. (1988). Effect of nitrogen and phosphorus on fruit yield and quality of sponge gourd *(Lagenaria aegytiaca). Indian J. Agril. Sci.* **58**(11): 860-861.

Seshardi, V.S. (1986). Cucurbits. In: Vegetable Crops in India, edited by T.K. Bose and M. G. Som. 1986. Naya Prokash, Calcutta, India, pp. 91-166.

Singh, G.B., Biswas, P.P. (2000). Balanced and integrated nutrient management for sustainable crop production. *Indian J. Fert*. **45**: 55-60.

Singh. R.K., Singh, K.P. and Mandal, G. (1976). Effect of seed treatment with PGR on yield and economics of okra. Proceedings of the Bihar *Acta. Agric. Sci.* **24**(2): 108- 109.

Sreeamulu, N. **(**1987). Effect of ethrel on sex expression and endogeneousauxin content in sponge gourd(*Luffa cylindrica*) . *Indian J. Hort*. **44:** 85-87.

Suresh, J. and Pappiah, C.M. (1991). Growth and yield of bitter gourd as influenced by nitrogen, phosphorus and maleic hydrazide. *South Indian Hort.* **38**(3): 158.

Susmita, D. Basu, P.S. and Das, S. **(**1998). Effect of silver nitrateon flowering, fruit setting and development of *Momordica charantia* L. Department of Botany, Burdwan University, Gopalbag, Burdwan, India. **25**(2): 140-143.

Takeno, K., Ise, H., Minowa, H. and Dounowaki, T. (1992). Fruit growth induced by benzyladenine on cell division, cell enlargement and indole-3-acetic acid content of okra. *J. Japanese Soc. Hort. Sci.* **60**: 915-920.

Tomar, I.S. and Ramgiry, S.R. **(**1997). Effect of growth regulators on yield and yield attributes in tomato (*Lycoprsicon esculentum*). *Advance plant Sci*. **10(2):** 29-31.

UNDP. (1988). Land Resource Apprisal of Bangladesh for Agricultural Development Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome, Italy. p. 577.

Vishnu, S.H., Prabhakar, B.S. and Sukla, V. (1987). Effect of plant spacing and fertilizer on yield of bottle gourd. *South Indian hort.* **35**(6): 453-454.

Zaghlou, R.A., Abou, H.E., Rasha, M.E. and Mohamed, T.E. (2015). Improvement of growth and yield of pea plants using integrated fertilization management. *Universal J. Agric. Res*. **3**(4): 135-143.

APPENDICES

Appendix I. Monthly records of air temperature, relative humidity and rainfall during the period from March to June 2018.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2018	March	35.20	21.00	28.10	52.44	20.4
2018	April	34.70	24.60	29.65	65.40	165.0
2018	May	32.64	23.85	28.25	68.30	182.2
2018	June	27.40	23.44	25.42	71.28	190

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	HorticutureFarm, SAU, Dhaka
AEZ	Modhupur 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
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III. Vine length of bitter gourd as affected NPK fertilizers and NAA

Sources	df	Mean square of vine length (cm)		
		30 DAT	45 DAT	60 DAT
Replication	2	0.841	0.524	2.263
Factor A	3	164.10*	915.78*	1404.29*
Factor B	2	45.555*	156.74*	286.442*
AB	6	1.866**	5.832**	12.142*
Error	22	1.728	1.814	4.470

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IV. Number of leaves plant^{-1} of bitter gourd as affected by NPK fertilizers and NAA

Sources	df	Mean square of number of leaves plant^{-1}		
		30 DAT	45 DAT	60 DAT
Replication	2	29.843	19.546	12.255
Factor A	3	1493.76*	2221.02*	3109.78*
Factor B	2	434.525*	502.875*	573.409*
AB	6	21.412**	13.357*	25.578**
Error	22	3.267	5.229	3.518

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Number of branches plant^{-1} of bitter gourd as affected by NPK fertilizers and NAA

Sources	df	Mean square of number of branches plant^{-1}		
		30 DAT	45 DAT	60 DAT
Replication	2	1.322	0.348	4.032
Factor A	3	3.438**	19.62*	25.086*
Factor B	2	2.636**	9.639**	17.141*
AB	6	0.324**	1.057*	1.904**
Error	22	0.235	0.390	0.855

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Yield contributing parameters of bitter gourd as affected by NPK fertilizers and NAA

Sources	df	Mean square of yield contributing parameters					
		Days to 1st flowering (days)	Number of male flowers plant^{-1}	Number of female flowers plant^{-1}	Percent fruit set (%)	Fruit length (cm)	Fruit diameter (cm)
Replication	2	0.587	2.632	0.138	1.439	0.213	0.030
Factor A	3	80.56*	103.45*	131.27*	30.89*	11.24*	4.247*
Factor B	2	61.38*	58.498*	69.703*	71.27*	9.751*	3.620*
AB	6	6.374**	9.484*	7.862**	5.401*	0.900*	0.677*
Error	22	0.219	1.551	1.406	3.919	0.324	0.037

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Yield parameters of bitter gourd as affected by NPK fertilizers and NAA

Sources	df	Mean square of yield parameters				
		Fruit weight plant^{-1} (kg)	Number of fruits plant^{-1}	Single fruit weight (g)	Fruit weight plot^{-1} (kg)	Fruit yield (t ha^{-1})
Replication	2	0.084	0.509	0.000	0.039	0.000
Factor A	3	77.13*	87.09*	1.962*	136.69*	0.489*
Factor B	2	79.67*	61.15*	2.019*	140.12*	0.501*
AB	6	8.340*	5.621*	0.225*	15.704*	0.057*
Error	22	1.064	3.507	0.014	0.946	0.003

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII: Cost of production of bitter gourd per hectare

A. Input cost (Tk. ha-1)

Treatments	Labor cost	Ploughing cost	Seed and seedling cost	Transplanting cost	Irrigation	Fertilizer				Cost of NAA	Subtotal (A)
						Cowdung	Urea	TSP	MOP		
N_0NAA_0	15000	8000	7000	15000	5000	10000	0	0	0	0	60000
N_0NAA_1	15000	8000	7000	15000	5000	10000	0	0	0	2500	62500
N_0NAA_2	15000	8000	7000	15000	5000	10000	0	0	0	5000	65000
N_1NAA_0	15000	8000	7000	15000	5000	10000	870	1190	450	0	62510
N_1NAA_1	15000	8000	7000	15000	5000	10000	870	1190	450	2500	65010
N_1NAA_2	15000	8000	7000	15000	5000	10000	870	1190	450	5000	67510
N_2NAA_0	15000	8000	7000	15000	5000	10000	1220	2380	750	0	64350
N_2NAA_1	15000	8000	7000	15000	5000	10000	1220	2380	750	2500	66850
N_2NAA_2	15000	8000	7000	15000	5000	10000	1220	2380	750	5000	69350
N_3NAA_0	15000	8000	7000	15000	5000	10000	1565	3570	1350	0	66485
N_3NAA_1	15000	8000	7000	15000	5000	10000	1565	3570	1350	2500	68985
N_3NAA_2	15000	8000	7000	15000	5000	10000	1565	3570	1350	5000	71485

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA

B. Overhead cost (Tk. ha-1), Cost of production (Tk. ha-1), Gross return (Tk. ha-1), Net return (Tk. ha-1) and BCR

Treatments	Overhead cost (Tk. ha^{-1})				Subtotal (A)	Total cost of production (A+B)	Bitter gourd yield ha^{-1} (t)	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
	Cost of leased land for 6 months (13% of value of land Tk. 10,00,000/-	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (13% of cost $year^{-1}$)	Subtotal (B)						
N_0NAA_0	65000	3000	8320	76320.00	60000	136320	8.60	154800	18480	1.14
N_0NAA_1	65000	3125	8491	76615.63	62500	139116	12.00	216000	76884	1.55
N_0NAA_2	65000	3250	8661	76911.25	65000	141911	13.50	243000	101089	1.71
N_1NAA_0	65000	3125.5	8491	76616.81	62510	139127	14.40	259200	120073	1.86
N_1NAA_1	65000	3250.5	8662	76912.43	65010	141922	16.30	293400	151478	2.07
N_1NAA_2	65000	3375.5	8833	77208.06	67510	144718	21.70	390600	245882	2.70
N_2NAA_0	65000	3217.5	8617	76834.39	64350	141184	15.22	273960	132776	1.94
N_2NAA_1	65000	3342.5	8788	77130.01	66850	143980	18.00	324000	180020	2.25
N_2NAA_2	65000	3467.5	8958	77425.64	69350	146776	24.52	441360	294584	3.01
N_3NAA_0	65000	3324.25	8763	77086.85	66485	143572	15.20	273600	130028	1.91
N_3NAA_1	65000	3449.25	8933	77382.48	68985	146367	23.78	428040	281673	2.92
N_3NAA_2	65000	3574.25	9104	77678.10	71485	149163	20.80	374400	225237	2.51

Selling cost of bitter gourd = Tk. 18/kg

N_0=Control ($N_0P_0K_0$ kg ha^{-1}), N_1=$N_{25}P_{10}K_{15}$ kg ha^{-1}, N_2=$N_{35}P_{20}K_{25}$ kg ha^{-1}, N_3=$N_{45}P_{30}K_{35}$ kg ha^{-1}

H_0 = Control (0 ppm NAA), H_1 = 50 ppm NAA, H_2 = 100 ppm NAA