EFFECT OF NITROBENZENE CONCENTRATIONS WITH APPLICATION METHODS ON PLANT GROWTH AND YIELD OF CUCUMBER

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EFFECT OF NITROBENZENE CONCENTRATIONS WITH APPLICATION METHODS ON PLANT GROWTH AND YIELD OF CUCUMBER

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CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF NITROBENZENE CONCENTRATIONS WITH APPLICATION METHODS ON PLANT GROWTH AND YIELD OF CUCUMBER"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* ***MST. MARIUM TANIA****, Registration number:* ***18-09288*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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TO

MY

BELOVED PARENTS

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The Authoress

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ABSTRACT

A field experiment was conducted in the Horticulture Farm of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during October 2019 to March 2020 to study the effects of nitrobenzene on plant growth, flowering, fruit setting and yield of cucumber. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. It was consisted with two factors viz. i. Concentrations of Nitrobenzene (F_0 = control, F_1 = Nitrobenzene @ 500ppm, F_2 = Nitrobenzene @ 600ppm, F_3 = Nitrobenzene @ 700ppm), ii. Application Methods (T_1= Foliar Application, T_2= Soil Application, T_3 = Combined i.e. Foliar + Soil Application). A statistically significant variation was recorded in terms of all the characters related to growth and yield of cucumber. Maximum vine length (175.65 cm) at harvest was found in F_2 treatment and minimum (124.44 cm) was found in F_0 treatment. Nitrobenzene concentration of 600ppm showed better vine growth than concentration of 500ppm and 700ppm. However, the maximum number of leaves (71.36), branches (12.02), female flower (25.61), fruit per plant (18.22), fruit weight (169.09 g) and yield (34.43 t/ha) were recorded from F_2 and F_3 treatment. The minimum values of the same parameters were observed in F_0 treatment or control. The minimum yield (14.71 Kg/plot) was found in T_2 and maximum yield (16.16 Kg/plot) was found in T_3 treatment. In the combination of nitrobenzene concentration and application method, the maximum yield (36.90 t/ha) was found in F_2T_3 treatment and lowest yield (19.90 t/ha) was recorded in F_0T_3 treatment. The second highest (35.49 t/ha) yield was obtained from F_3T_3 treatment. The highest benefit cost ratio (2.632) was attained from the treatment combination of F_2T_3 (nitrobenzene @ 600ppm with combined application) treated plants.

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LIST OF ABBREVIATED TERMS

ABBREVIATIONS	FULL WORD
Agric.	Agriculture
Agril.	Agricultural
AEZ	Agro Ecological Zone
ANOVA	Analysis of Variance
et al.	And others
AVRDC	Asian Vegetable Research and Development center
@	At the rate
BARI	Bangladesh Agricultural Research Institute
cv.	Cultivar (s)
°C	Degree Celsius
df	Degrees of Freedom
DMRT	Duncan's Multiple Range Test
etc.	Etcetera
LSD	Least significant difference
Max.	Maximum
ml/L	Milliliter per liter
viz.	Namely
ppm	Parts Per Million
%	Percent
CV%	Percentage of Coefficient of Variation
R.H	Relative Humidity
BBS	Bangladesh Bureau of Statistics
FAO	Food and Agricultural Organization
MP	Murat of Potash
DAS	Days After Sowing
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate
RCBD	Randomized Complete Block Design

CHAPTER I

INTRODUCTION

Cucumber (*Cucumis sativus* L.) belongs to the family of Cucurbitaceae, is a major vegetable crop worldwide and develops rapidly, with a shorter time from planting to harvest (Wehner and Gurner, 2004). It is a sub-tropical vegetable crop that grows successfully under conditions of high light, high humidity and soil moisture, temperature with fertilizers in green-houses (El-Aidy *et.al.*, 2007). The crop is the second most important vegetable crop after tomato in Western Europe and is the fourth most cultivated vegetable in the world after tomatoes, brassicas and onions (Wehner, 2007). In tropical Africa, the crop has not been ranked because of limited use. Cucumber is grown widely in different parts of the world. It is a year-round outdoor vegetable in the tropics and an important greenhouse vegetable especially in Northern Europe and North America (Mingbao, 1991).

In Bangladesh, vegetable production is far below actual requirements. In 2019-20, total vegetable (summer and winter season) production area was 10.72 lac hectares of land with total production of 43.36 million tons (BBS, 2020). Our daily requirement of vegetables is 235 g/day/person for adults which are recommended by Bangladesh Council of Nutrition. Cucumbers can meet up the shortage of vegetable consumption in our country. It is considered as a good source of nutrients for the human body as it is mostly taken as fresh. It is a primary source of vitamins and minerals of man (AVRDC, 1999). It contains 0.6g protein, 2.6g carbohydrate (CHO), 12 calorie energy, 18 mg calcium (Ca), 0.2 mg Fe, 0.02 mg thiamin, 0.02g riboflavin, 0.01 mg niacin and vitamin per 100g of edible portion (Rashid, 1999).

Cucumber is cultivated during summer but it can be grown round the year except the acute cold months of winter in Bangladesh. For its growth and development optimum temperature is required within 20-30^{0}C. Cucumber can be grown in well-drained soil. The total production of cucumber in Bangladesh was about 78,845 metric ton in 25,303 acres of land with an average yield of 7.69971 ton/ha (BBS, 2020). This indicates the low yield of this crop and the low yield in Bangladesh however, is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz. unavailability of quality seeds 2 of high yielding varieties in appropriate time, fertilizer management, disease and insect infestation, improper or limited irrigation facilities and other appropriate agronomic practices including sowing of seeds. Among the factors sowing time and appropriate dose of phosphorus fertilizer with high yield potentiality is an important factor (Liang and Shang, 2013).

Cucumber is a kharif season vegetable but needs cool temperature for flowering. Its growth and development are greatly influenced by the growing environment. Cucumber demands high temperatures and soil moisture for satisfactory yield. An unfavorable climatic condition causes problem, such as the reduction of female flowers (Cantliffe, 1981) and in fruit growth (Medany, 1999) and mineral disorders (Bakker and Sonneveld, 1988) reduced the quality and quantity of the yield. Premature fruit yellowing or light-colored fruit is associated with low nitrogen (low EC), high temperatures, over-maturity, low light levels and high humidity (low vapor pressure deficit). Increasing the amount of light reaching the fruit, reducing the number of fruits per plant and increasing the concentration of fertilizer in the nutrient solution, may help to reduce the incidence of fruit yellowing (Janice, 2006).

The role of plant growth regulators in various physiological and biochemical process in plant is well known from its identification. The exogenous application of plant growth regulators has proved to be quite useful in the regulation of flowering and fruiting. Growth regulators are known to have an effect on the production of earliest flower (Gedam et. al., 1998), minimizing ratio of male/female flower (Bisaria, 1974), increasing number, weight and yield of fruits (Gopalakrishnan and Choudhury, 1978). Initiation of flower bud, development of flowers and fruits are controlled by physiological process. Exogenous application of growth regulators has shifted the sex expression towards femaleness by increasing the production of female flower and suppressing that of male flower in bitter gourds (Parkash, 1974).

Sex expression and sex ratio in cucurbits are important factors for governing the yield. All the cultivars of cucurbits differ in production of pistillate flowers. It is a tendency of all the cucurbits to produce more numbers of male flowers and less numbers of pistillate and hermaphrodite flowers. Plant growth regulators play a key role in controlling internal mechanisms of plant growth by interacting with key metabolic processes such as nucleic acid metabolism and protein synthesis (Samad *et al*., 2019). Different plant growth regulators are auxins, gibberellins, nitrobenzene, cytokinin, abscisic acid (ABA) and ethylene, etc. Among them, nitrobenzene (20% w/w) plays an important role for higher growth and yield of vegetables (Pathan, 2014).

Nitrobenzene is a combination of nitrogen and plant growth regulators, extracted from seaweeds that act as plant energizer, flowering stimulant and yield booster. 'Flora' is a commercially available plant growth substance containing 20% (w/w) nitrobenzene. Nitrobenzene 20% used to repair the hormonal function of a plant thus promotes the flowering activity and growth of roots (Aziz and Miah, 2009). Nitrobenzene produces best results in combination with plant growth regulators, which have capacity to increase flowering in plants and also prevent flower shedding. It is especially recommended for vegetable crops and flowering plants (Khalil and Mandurah, 1989). Nitrobenzene is a new generation plant energizer and yield booster of low cost PGRs compared to others. The application of nitrobenzene produces the highest number of fruits and flowers per plant. It is quickly absorbed into the plants and influences the biochemical pathway of the plants to uptake more nutrients from the soil (Kohombange *et. al*., 2019). It also increases the nutrient use efficiency thus improves the vegetative growth. Induces profuse flowering and helps in the retention of the flowers and fruits (Mithila *et al*., 2012).

Nitrobenzene spray resulted in a high number of inflorescences in Jatropha (Babu *et. al*., 2009). Besides the concentration of nitrobenzene, a number of the spray of growth regulators have an effect on the production. Four sprays of nitrobenzene during 40, 55, 80 and 105 days after sowing (DAS) improve the yield up to 40%. Number of sprays of plant growth regulators play an important role for producing maximum yield (Jeyakumar, 2005). Unfortunately, very limited researches have been carried out regarding the use of nitrobenzene on year-round cucumber varieties in Bangladesh.

Therefore, this research was designed with the following objectives:

i) to identify the suitable connection of nitrobenzene for maximum growth and yield of cucumber;

ii) to select the appropriate nitrobenzene application method for maximum growth and yield of cucumber; and

iii) to find out the suitable combination of nitrobenzene concentration and application method for maximum growth, yield and economic benefit of cucumber.

CHAPTER II

REVIEW OF LITERATURE

Cucumber is one of the most popular nutritious salad vegetables throughout the world including Bangladesh and has drawn attention from the researchers for its diversified way of consumption. It is adapted to a wide range of climates ranging from tropics to within a few degrees of the Arctic Circle. However, in spite of its broad adaptation, production is concentrated facing diverse type biotic and abiotic factors. Plant growth regulator nitrobenzene plays an effective role for the growth and yield of cucumber in low temperature. But very few research works are available related to growth, sex expression and yield of cucumber due to nitrobenzene application. The research work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works and research findings related to nitrobenzene in cucumber, so far been done at home and abroad, have been reviewed here:

Review results of growth regulators along with nitrobenzene:

Choudhury and Pahatak (1959) stated that cucumber plants treated with MH 200 ppm and NAA 100 ppm and IAA 100 increased the number of female flowers and MH 600 and 800 ppm, NAA 100 ppm and IAA 200 ppm greatly suppressed the number of male flowers over control. All treatments increased the female to male flower ratio when compared with the control.

Bukovac and Wittwer (1961) reported that cucumber plants treated with gibberellins at a concentration of 100 ppm to young pickling type cucumber seedling hastened pistillate flowers formation earlier when cucumber plants were grown under short rather than long photoperiod.

Choudhury *et. al*. (1967) carried out an experiment with NAA 100 ppm, IAA 100 ppm and 200 ppm and MH 50 ppm and 200 ppm. They found that the treatments were equally effective in suppressing the male flowers and increasing the number of female flowers in cucumber over control. These effects subsequently increase the percentage of fruit set and ultimately the yield.

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

McMurray and Miller (1969) stated that cucumber seedlings treated with ethephon at concentrations of 120 ppm, 180 ppm or 240 ppm increased the number of pistillate flowers. 15 The staminate to pistillate flower ratio was approximately 10:1. But in the case of ethephon treated plants, the staminate to pistillate flower ratio ranged from 1:6 to 1:14, depending on the concentration of ethephon used.

Lower *et. al*. (1970) reported that cultivar of cucumber Galaxy treated with ethephon at a concentration of 120 ppm at the one-leaf stage or at subsequent leaf stages increased pistillate flower formation.Freytag *et. al*. (1970) carried out an experiment on cucumber sex-expression modified by growth regulators. They found that TIBA l0ppm and l00ppm treated plants produced a smaller number of female flowers which treated with ethrel at 100ppm increased femaleness.

Randhawa and Singh (1970) stated that MH 200-300 ppm induced maximum number of hermaphrodite flowers thereby decreasing the sex ratio of cucumber. They suggested that maximum production of fruits can be obtained from the use of MH 200-300 ppm in cucumber.

Augustine *et. al*. (1973) found that MCEB (5-methyl-7 chloro-4- ethoxycarbonylmethyl-2, 1, 3-benzothiadiazole) had no effect on the androecious phenotype of cucumber while ethephon 500 ppm induced pistillate flowers. The effect of MCEB and ethephon treatment was a marked reduction in the number of staminate flowers. Ethylene induced pistillate flowers except when there was a 48-hour period between application of ethephon and MCEB in gynoecious phenotype, MCEB 75 ppm induced staminate flowers, ethephon had no effect, and the effect of MCEB and ethephon treatment was to induce staminate flowers at relatively high concentrations of MCEB 150 ppm.

Elassar *et. al*. (1973) conducted an experiment on the normal and parthenocarpy fruit development. They reported that B-NOA (naphthoxyacetic acid), at rates lower than 100 ppm and IAA 10 ppm to 100 ppm were effective in normal fruit development and were less effective in producing parthenocarpy fruit, GA_3 (100- 1000 ppm) and GA_{4+7} (50 ppm) slowed down the early rate of fruit development as compared with pollinated fruit, but were very effective in accelerating fruit development during later stages.

Beyer and Quebedeaux (1974) observed that a single application of NAA at concentration ranging from 500 to 5000 ppm increased the number of pistillate flowers of cucumber to develop into fruits, while numbers of fruits were minimum on the controls. Fruit's shape was normal but the growth was slightly retarded at 5000 ppm. They reported that application of N-l-naphthyl-phthalamic acid had a positive effect on fruit set and development in cucumber.

Das and Swain (1977) reported that Alar 200 ppm produced the maximum number of fruits followed by its lower concentration and ethrel as compared to the control. Alar 200 ppm with 40 kg/ha nitrogen significantly produced a greater number of fruits followed by Alar 100 ppm with 40 kg/ha nitrogen and also produced heaviest fruit followed by ethrel 100 ppm with 40 kg/ha of nitrogen, ethrel 200 ppm with 20 kg/ha of nitrogen.

Gopalakrishnan and Choudhury (1978) reported that in contrast with TIBA, GA_3 in general produced the largest number of male flowers; GA_3 at the lowest concentration of 10 ppm produced a greater number of female flowers in the first year. 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 ppm to 200 ppm gave a significant increase in the number of fruits and weight of fruits of cucumber.

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

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 Maximum fruit yield per plant (3123gm) was produced under Cycocel 250 ppm followed by Ascorbic acid 25 ppm and Cycocel 500 ppm.

Sidhu *et. al*. (1982) conducted an experiment to study the effect of pruning and growth regulators on musk melon. They recommended that the foliar spray of ethephon 500 ppm for obtaining maximum fruit yield in both pruned and unpruned muskmelon cv Hara Madhu.

Gosh and Basu (1983) found that spraying with IAA at 17.5 or 35 mg/1 increased the number of female flowers. Ethrel at 25 mg/1 increased female flowers but 100 flowers. All GA applications reduced the ratio of male to female flowers.

Hume and Lovell (1983) reported that application of ethephon to field-grown plants of both bush and trailing forms of Cucurbita maxima and C. pepo caused leaf epinasty, suppression of male flowers and earlier production and increase in numbers of female flowers. This gave rise to an increase in the ratio of female to male flowers per plant and a decrease in the total number of flowers. The sex of the main bud at the first five to six nodes is usually determined at this stage but the secondary buds still have bisexual potential. The change in sex expression was brought about by all male flower buds that had formed by the spraying time aborting, and all buds that developed (both main and secondary) for at least 7 days after spraying became female flowers. Thus, nodes five and six had male flowers in the controls, whereas in ethephon-sprayed plants the presumptive male flowers aborted at the bud stage at these nodes and secondary primordial developed into functional female flowers.

Verma *et. al*. (1984) reported that ethrel 100 ppm delayed the appearance of first male flowers of cucumber MH 200 ppm and Bom 3 ppm and 4 ppm produced the earliest female flowers but at a higher node, while ethrel 100 ppm induced the first staminate and pistillate flower at the lowest nodes at 6.5 and 9.5 respectively. Boron 4 ppm also proved superior to all the other chemicals in producing the maximum fruits and yield.

Sriramulu (1987) reported that ethrel 100 g/L 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 staminate flower and also decreased the total number of male flowers.

Vadigeri and Madalageri (1989) found that Seedlings of Poinsette and Belgaum Local at the 4-6 leaf stage were sprayed with Ethrel [ethephon] at 200 ppm or 400 ppm and GA_3 [gibberellic acid] 5 ppm or 10 ppm and subsequently evaluated for sex ratio (male: female flower) and yield. Ethrel at 400 ppm had the greatest effect on both genotypes, significantly increasing the number of female flowers and fruits/plants compared with the untreated controls.

Islam *et al*. (1990) reported that the bottle gourd plants treated with NAA 200 ppm produced fruits of maximum length and girth, whereas fruits to minimum 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).

Samdyan *et. al*. (1994) carried out an experiment on bitter gourd with different plant growth regulators. They reported that thickness or weight of rind and fruit rind: flesh ratio were recorded maximum with MH 50 mg/1, while maximum thickness or weight of flesh, dry matter vitamin 'C' and T.S.S. contents were observed with cycocel 250 mg/1 GA_3 25 mg/1 resulted in maximum seeds in fruits, while MH 25 mg/1 and ethrel 100 mg/1 caused maximum weight loss of fruits 2 DAS or 4 DAS, respectively. N 50 kg/ha + ethrel 100 mg/1 or GA_3 25 mg/1 improved the shape index and speed control of fruits, respectively.

Arora *et. al*. (1994) reported that flower application of plant growth regulator had significant effect on growth, flowering and yield of long melon. The experiment was conducted during the summer seasons of 1991 and 1992 to study the effect of ethephon, GA_3 maleic hydrazide (MH), and NAA on melon. Growth regulators were applied at the 2-and 4-leaf stages. GA_3 at 25 mg/liter resulted in the longest vine length (3.97m), whereas vine length in controls (water sprayed) was 2.82 m. Ethephon at 250 mg/liter resulted in the highest number of branches/plant (10.8), shortest internode length (8 cm), lowest male: female flower ratio (3.1), fewest days to first female flower (68 days), highest number of female flower/plant (27) and fruits /plant (17.7) and highest plant yield (1.36 kg/plant). Ethephon at 250 mg/liter also gave the highest fruit yield/ha (29.76 t), while GA_3 at 25 mg/liter gave the lowest (11.08 t).

Ying *et al.* (1994) conducted an experiment on hormonal control of sexual differentiation in bottle gourd. They reported that the sex expression of cucurbit flowers can be modified by plant growth regulators, especially ethylene. The treatment of leaves or shoot tips of bottle gourd with ethephon (3.5 mm) resulted in the production of female flowers. Female flower production and ethylene evolution increased with the earliness of the cultivar. They also reported that ethylene response was inversely correlated with the amount of 1- (molonylamino) cyclopropane-1- carboxylic acid (ACC) in the tissue. Treatment with ACC changed the direction of sexual differentiation in potentially male buds to female buds. At last, the scientists concluded that ethylene induces female flowers in bottle gourd by suppressing 20 the differentiation of stamen primordial and thereby promoting that of pistil primordial.

Kim *et at*. (1994) reported that application of auxin transport inhibitors, Naptalam (N-Naphthylphthalamic Acid) and T1BA to the ovary or peduncle of cucumber flowers (cultivars Khira and Pandex and their F_1 hybrid) significantly increased the IAA content of the ovary. The ratio of IAA: IBA in pollinated or Naptalam or TIBA treated ovaries was also higher than that in unpollinated controls. The unpollinated ovaries of genetically parthenocarpy cv. Pandex showed 92% fruit set, whereas the non-parthenocarpy cv. Khira ovaries failed to set fruit and the Fi hybrid had only 8% fruit set. Application of auxins, NAA and 4-CPA, GA_3 cytokinin, BA and CPPU [4-forchlorfenuron] to the ovary at anthesis, however, induced over 60% parthenocarpy-fruit set in Khira and the F_1 hybrid.

Baruah and Das (1997) stated that NAA (25 and 100 ppm) and Maleic hydrazide (50 and 100 ppm), applied at the 2-true leaf stage and sowing dates (15 days intervals from 10 September to 25 October) had significant influence on the growth of *Lagenaria siceraria* (cv. Kiyari Lao) during rabi 1994 to 1995 in India. They observed that treated plants with

NAA at 25 ppm and MH at 50 ppm produced the best yields (5.48 and 4.86 kg/plant respectively). Yield decreased with later sowing dates from 5.49 to 2.62 kg/plant.

Gedam *et. al.* (1998) conducted an experiment on bitter gourd plants treated with 15 ppm, 25 ppm or 35 ppm GA3 50 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). GA3 at 35 ppm produced the earliest male flower and NAA at 50 ppm produced the earliest female flower. Fruit maturity was earliest in plants treated with 50 ppm NAA or 4 ppm boron.

Das and Rabhal (1999) reported that in a greenhouse experiment on cucumber cultivars Chinese green, Pusa Sanyog and Poinsette, 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 fruits with the highest flesh: placenta ratio. TSS and ascorbic acid content were highest when Ethrel was applied.

Al-Masoum (1999) reported that Cucumber cv. Beit Alpha was grown in a greenhouse in 1996-97 and ethephon applied at 250 ppm, 350 ppm or 450 ppm at the seedling stage (2-4 true leaves). Data were collected on the total yield, early, late yield, number of female flowers; number of male flowers; days to the first female flowers; days to the first male flowers; number of nodes to first female flower, number of nodes to the first male flower and plant height. Positive result was found from ethephon treated pants in case of all parameters. Greater fruit yield was given from the ethephon treated plants because ethephon induced femaleness (pistillate flowers) on the main stem. Ethephon induced femaleness (pistillate flowers) on the main stem that led to greater fruit production.

Hossain (2004) conducted an experiment to study the effect of “Crop's care” (Naphthalene Acetic Acid, NAA 4.5%) and “Ripon-15” (15% Ethephon) on the flower initiation, fruit set and yield of cucumber (Barisal HYV) and bitter gourd (Tia HYV) during April to August, 2003 at the experimental farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. Four concentrations of “Crop's care” 0.2 ml (9 ppm), 0.3 ml (13.5 ppm), 0.4 ml (18 ppm) and 0.5 ml (22.5 ppm) and five concentrations of “Ripon-15” 1.0 ml (150 ppm), 1.5 ml (225 ppm), (300 ppm), 2.5 ml (375 ppm) and 3.0

ml (450 ppm) were applied in the experiment. “Crops care” and “Ripen-15” showed positive effects on different yields attributing characters of cucumber and bitter gourd treated plants compared to the control. Early female flowers (6 to 7 days) and early fruit maturation (5 days) were found in both cucumber and bitter gourd plants treated with “Crop's care” (0.5 ml) and “Ripen-15” (3 ml) compared to control. “Crops care” (0.4 ml) gave about (30%) more female flowers in cucumber and (32%) more in bitter gourds.

Mir (2007) studied the effect of three different types of growth regulators viz. Maleic hydrazide 200 ppm, Ripen-15 (ethephon 300 ppm), Crop's care (NAA 18 ppm) with control (No growth regulator) on growth, flowering, sex ratio and fruit setting and yield of cucumber (year-round). A statistically significant variation was recorded in terms of all the characters related to growth and yield of cucumber and the maximum yield was recorded in Ripen-15 (ethephon 300 ppm) treatment.

Sultana (2018) conducted an experiment to find out the effect of nitrobenzene (four different doses- 0ml, 1.5ml, 2ml and 2.5ml per L water) on plant growth, yield and minerals content of two varieties of tomato named BARI Tomato-1 and BARI Tomato-2. Application of nitrobenzene significantly influenced the height, yield and minerals content of tomatoes. In case of combined effect of variety and nitrobenzene doses, maximum yield per hectare, maximum content of nutrients like K, Na, Ca and P was observed in 2ml dose of nitrobenzene along with BARI Tomato-2.

Samad *et. al*. (2019) conducted an experiment with aim to assess the influence of two concentrations and three applications of nitrobenzene in relation to control i.e., without nitrobenzene on the growth and yield of bottle gourd. Two concentrations of nitrobenzene applied were: @ 2 ml/L water and 3 ml/L water. Further, the above treatments were applied number of times, e.g., one spray, two sprays and three sprays. Due to combined effect, the maximum number of flowers, the maximum number of fruits harvested per plant and the highest yield with net income and BCR was observed from nitrobenzene dose 2ml/L water along with three sprays.

Kohombange *et. al*. (2019) performed a study to examine the effect of nitrobenzene on sweet cucumber yield to evaluate the optimum dose of nitrobenzene for economically better yield. The study was conducted at a farmer poly tunnel located in Athgala (WU1) along with four treatments: Control (without Nitrobenzene), Nitrobenzene 10%, Nitrobenzene 15%, and Nitrobenzene 20%. Plants were established in drip-fustigated bags in the Polytunnel and standard crop management practices were done throughout the study. Nitrobenzene was sprayed to the seedlings 20 and 35 days after sowing. Albert solution, 6: 30: 30 fertilizer mixture 20: 20 fertilizer mixture and $Ca(NO_3)_2$ were used as recommended fertilizers. Specially, advanced flowering and fruit setting, number of flowers per plant and total yield per plant were recorded from 20% Nitrobenzene applied treatments. So, 20% nitrobenzene applied plants showed superior results in contrast to other nitrobenzene levels with enhancing flowering, fruit setting, yield qualities as well as postharvest performances.

CHAPTER III

MATERIALS & METHOD

This chapter deals with the major information that was considered to conduct the experiment.

3.1 Experimental site

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experiment was carried out during the month October, 2019 to March, 2020. The experimental site is situated between 23°74" N latitude and 90°35" E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Climate

The experimental site is located in a subtropical region where climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during October to March (Rabi season). The maximum and minimum temperature, humidity rainfall and soil temperature during the study period are collected from the Bangladesh Meteorological Department (Climate division) and have been presented (Appendix-1).

3.3 Soil

The soil of the experimental area belongs to the Madhupur Tract (UNDP, 1988). Soil analysis report of the experimental area was collected from Khamar Bari, Dhaka which was determined by SRDI, Soil testing Laboratory. The analytical data have been presented in appendix-II.

The experimental site was a medium high land and p of the soil was 5.4 to 5.6. The morphological characters of the soil as indicated by FAO (1988) are given below:

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

3.4 Planting Materials

Seed of "Baromashi" local variety of cucumber were obtained from BADC, Dhaka. Flora was used as the source of nitrobenzene (20% w/w), Flora is a product of ACI Formulations Ltd. which contain nitrobenzene (Nitrobenzene 20% w/w). About 2.5ml/L flora contains 500ppm nitrobenzene, 3.0ml/L flora contains 600ppm nitrobenzene and 3.5ml/L flora contains 700ppm nitrobenzene.

3.5 Treatments of the experiment

The experiment was designed to study the effects of nitrobenzene on growth, flowering, fruit setting and yield of cucumber in winter. The experiment consisted of two factors as follows:

Factor A: Nitrobenzene concentrations (4 types)

i) F_0 (control)

ii) F_1 (Nitrobenzene @ 500 ppm)

iii) F_2 (Nitrobenzene @ 600 ppm)

iv) F_3 (Nitrobenzene @ 700 ppm)

Factor B: Nitrobenzene application method (3 types)

i) T_1 (Foliar application)

ii) T_2 (Soil application)

iii) T_3 (Combined i.e. foliar + soil application)

There were in total 12 (4×3) treatment combinations such as: F_0T_1, F_0T_2, F_0T_3, F_1T_1, F_1T_2, F_1T_3, F_2T_1, F_2T_2, F_2T_3, F_3T_1, F_3T_2, and F_3T_3.

3.6 Experimental design

It was a factorial experiment. The experiment was laid out in a two factorial Randomized Complete Block Design (RCBD) with three replications. Total land was divided into three equal blocks. Each block was divided into twelve plots. Every replication had twelve plots where 12 treatments were allotted at random. The size of each plot was 1.8m x 1.8m. The distance between two blocks and two of the plots both were 1m.

3.7 Land preparation

The selected land for the experiment was opened 03 October, 2019 with the help of a power tiller and then it was kept open to sun for 4 days prior to further ploughing. Then the land was prepared well by ploughing and cross ploughing followed by laddering. Weeds and stubble were removed and the basal dose of fertilizers were applied and mixed thoroughly with the soil before final land preparation. The unit plots were prepared by keeping 1m spacing in between two plots and the space between two blocks and two plots were made as a drain having a depth of about 30 cm.

3.8 Pit preparation

There were six pits in every plot. The length and breadth of each pit was 30cm and 30cm respectively. There was 20cm depth in pits and 30cm distance from the border of the plots. The pits were prepared with necessary manures and fertilizers.

3.9 Fertilizer application

Following doses of manures and fertilizers were recommended for cucumber production by Rashid (1994).Urea, triple super phosphate (TSP), muriate of potash (MP), gypsum, zinc sulphate, boric acid and molybdenum were used as a source of nitrogen, phosphorous, potassium, gypsum, Sulphur, zinc, boron and molybdenum, respectively. Urea@150kg, TSP @125kg, muriate of potash (MP) @100kg, gypsum @40kg, zinc sulphate @10kg, boric acid @2kg and molybdenum@1kg were applied following the BARI recommendation. All of the fertilizers except urea and ½ MP (50 kg/ha) were applied during final land preparation. Urea and ½ MP (50 kg/ha) was applied in two equal installments at 25 and 45 days after seed sowing.

3.10 Nitrobenzene application

Flora was applied in 4 different concentrations: control, 500ppm, 600ppm and 700ppm. Total four sprays were done, first nitrobenzene dose was applied at 25 days after sowing, and rest three doses were applied at 15 days interval.

3.11 Intercultural operations

Thinning

Seed's germination was seen at 4 DAS (Days after Sowing). Thinning was done two times; first thinning was done at 15 DAS and second was done at 30 DAS to maintain optimum plant population in each plot.

Irrigation and weeding

Irrigation was provided at 10, 20, 30 and 40 DAS for optimizing the vegetative growth of cucumber for the all-experimental plots equally. Weeding was done in the crop field as per necessary. Earthling up was done at 25 and 45 days after sowing followed by the application of fertilizers on both sides of rows by taking the soil from the space between the rows by a small spade.

Stacking

When the plants were well established, staking was given to each plant to keep them straight.

Protection against insect and pest

At an early stage of growth few worms (*Agrotisipsilon)* infested the young plants and at later stages of growth pod borer (*Marucates tulalis*) attacked the plant. Ripcord 10 EC was sprayed with 1 liter water for two times at 15 days interval after seedlings germination to control the insects.

3.12 Harvesting

The plant bears flowers within 27-33 days after sowing of seeds and the fruit goes to the edible stage 10-15 days after fruit setting. The fruit should be harvested before hardening of seeds in the fruit. The tender fruits are harvested, which is helpful for increasing the number of flowers. Picking of fruit at the right edible maturity stage but it depends upon individual kinds and varieties. In salad, slicing cucumber, dark green color not turning into brownish-yellow or rosetting and white spine color will also be useful indications for edible maturity. Optimum length of the fruit will be around 12-15 cm at edible maturity stage, depending upon the cultivar in case of slicing cucumber.

3.13 Crop sampling and data collection

Three plants from each treatment were randomly selected and marked with a sample card. Plant height, number of leaves per plant and number of branches per plant were recorded from selected plants at an interval of 10 days starting from 30 DAS to harvest.

3.14 Procedure of data collection

Plant height (cm)

The plant height was measured at 30 DAS, 45 DAS and harvest and with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 3 plants selected at random of each plot at 15 days interval starting from 30 days after sowing (DAS) and continued up to harvest.

Number of branches per plant

The total number of branches per plant was counted from each selected plant. Data were recorded as the average of 3 plants selected at random of each plot at 15 days interval starting from 30 days after sowing (DAS) and continued up to harvest. Only side branches that arose from the main vine were counted.

Number of male flowers per plant

The number of male flowers per plant was counted from each plot after flowering and recorded per plant basis. Male flowers selected based on the absence of initial oval shaped fruit like structure at the base of the flower.

Number of female flowers per plant

The number of female flowers per plant was counted from each plot after flowering and recorded per plant basis. Female flower selected based on the presence of initial oval shaped fruit like structure at the base of the flower.

Ratio of male and female flower

The ratio of male and female flowers was calculated by dividing male flowers to female flowers recorded from at least 3 selected plants.

Number of fruits per plant

The number of fruits per plant was counted after harvesting of fruits and recorded per plant basis.

Length of fruit (cm)

The length of individual fruit was measured in one side to another side of fruit from five selected fruits with a meter scale and average of individual fruit length recorded and expressed in centimeter (cm).

Diameter of fruit (cm)

The diameter of individual fruit was measured in several directions with meter scale and the average of all directions was finally recorded and expressed in centimeter (cm).

Fruit weight (g)

The weight of individual fruit was recorded in gram (g) by a digital weighing machine from all fruits of selected three plants and converted individually.

Fruit yield/plant (kg)

Fruit yield per plant was recorded in kilogram (kg) by multiplying individual fruit weight and number of fruits/plants.

Fruit yield/plot (kg)

Fruit yield of cucumber per plot was recorded as the whole fruit per plot and was expressed in kilogram.

Fruit yield/hectare (ton)

Fruit yield per hectare of cucumber was calculated by converting the weight of plot yield into hectare and was expressed in ton.

3.15 Statistical analysis

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

3.16 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of sowing time and level of phosphorus. All input costs were considered in computing the cost of production. The market price of cucumber was considered for estimating the return. Analyses were done according to the procedure of Alam *et. al*. (1989).

Gross Return

Gross return was calculated on the sale price of marketable fruit of cucumber. The price of cucumber fruits in the market was considered at Tk. 25/kg.

Net Return

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

Benefit Cost Ratio

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

$$\text{Benefit cost ratio (BCR)} = \frac{\text{gross return}}{\text{Total cost of production}}$$

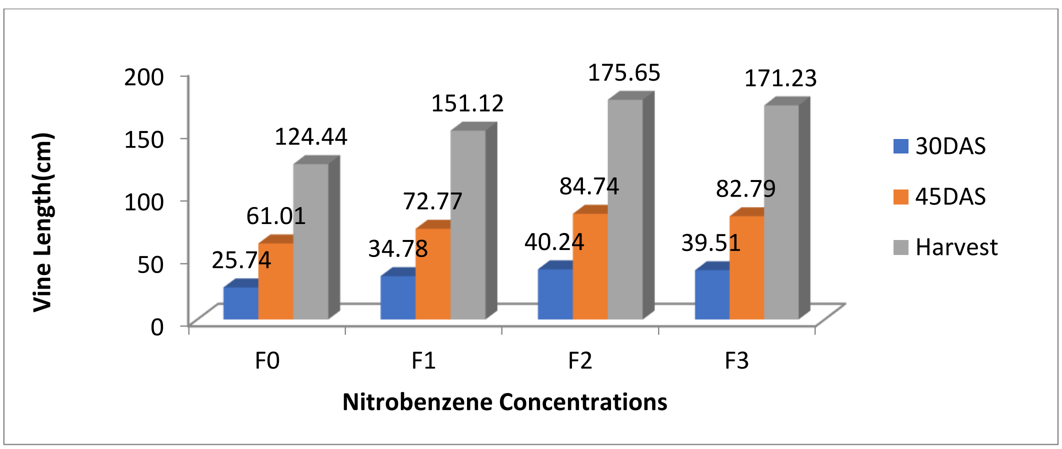
CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of nitrobenzene doses and application method on growth and yield contributing characters and yield of cucumber. The analysis of variance (ANOVA) of the data on different yield components and yield of cucumber are given in Appendix III-VIII. The results have been presented and discussed, and possible interpretations have been given under the following headings:

4.1 Vine length (cm)

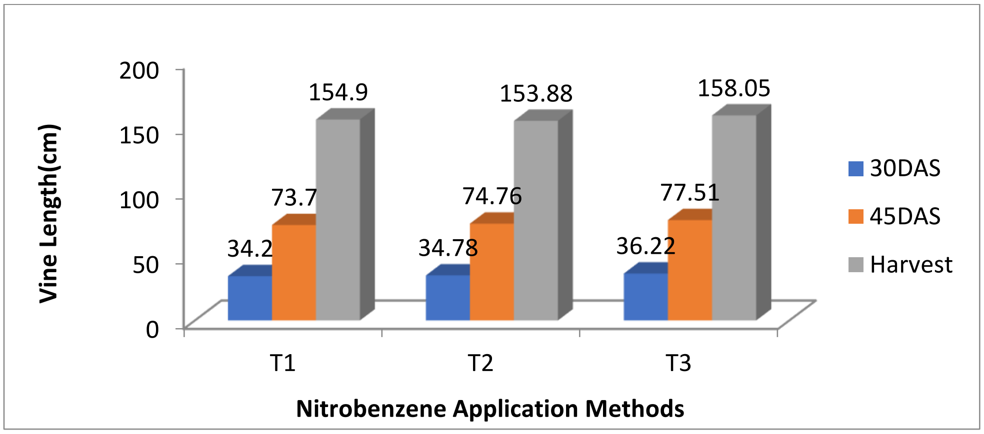
A statistically significant variation was found in vine length due to different levels of nitrobenzene concentration at 30 DAS, 45 DAS and harvesting stage. At harvest the maximum vine length (175.65 cm) was recorded from F_2 (nitrobenzene @ 600ppm) treatment and the minimum vine length (124.44cm) was recorded from F_0 (control) treatment (Fig.01). The result indicated that nitrobenzene application increased plant height comparing with the control, which might be due to increases the nutrient use efficiency thus improves the vegetative growth. Mithila *et al*. (2012) observed similar trend of results.



Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm

Fig.01. Performance of Nitrobenzene Concentrations on Vine Length (cm) at 30DAS, 45 DAS and Harvest

In terms of vine length in relation with nitrobenzene application method at 30 DAS, 45 DAS and harvest a statistically significant difference were recorded under the trial. At harvest, the maximum vine length (158.05 cm) was recorded from T_3 (foliar + soil application) treatment and the minimum vine length (153.88 cm) was recorded from T_2 (soil application) treatment (Fig.02).



Here, T_1: Foliar application, T_2: Soil application, T_3: Combined application

Fig.02. Performance of Nitrobenzene Application Methods on Vine Length (cm) at 30DAS, 45 DAS and Harvest

Table 01: Combined effect of nitrobenzene concentrations and application methods on vine length (cm) of cucumber

Combinations	30 DAS	45 DAS	Harvest
F_0T_1	25.09k	59.96l	122.98l
F_0T_2	26.20i	60.34k	125.78j
F_0T_3	25.94j	62.73j	124.57k
F_1T_1	33.83h	71.61i	150.26h
F_1T_2	34.53g	72.26h	148.75i
F_1T_3	35.98f	74.44g	154.35g
F_2T_1	38.34e	82.61d	176.15b
F_2T_2	40.15c	84.27c	172.39d
F_2T_3	42.23a	87.33a	178.41a
F_3T_1	39.55d	80.63f	170.22e
F_3T_2	38.24e	82.18e	168.62f
F_3T_3	40.75b	85.56b	174.86c
CV%	6.41	7.67	8.25
$LSD_{(0.05)}$	0.50	0.73	0.58

Means in a column followed by same letter do not differ significantly at 5% level. Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

Combined effects of different nitrobenzene doses and application methods showed statistically significant variation in terms of vine length of cucumber 30 DAS, 45 DAS and harvest. At harvest, the highest vine length (178.41cm) was recorded from the treatment combination F_2T_3 and the minimum vine length (122.98 cm) was recorded from the treatment combination of F_0T_1 treatment (Table 01). The results indicated that plant growth regulator application ensures the maximum growth and development of cucumber plant and ultimate result is the maximum vine length.

4.2 Number of leaves

Leaves are an important vegetative organ, as it assists plants in photosynthesis, transpiration and respiration process. Statistically significant variation was recorded due to different levels of nitrobenzene concentration in terms of number of leaves per plant of cucumber at 30 DAS, 45 DAS and harvest. At harvest, the maximum number of leaves per plant (71.36) was found from F_3 (nitrobenzene @ 700ppm) treatment followed by (71.08) F_2 (nitrobenzene @ 600ppm) treatment, whereas the minimum number of leaves per plant (56.69) was recorded from F_0 (control) treatment (Table 02). Samad *et. al.* (2019) also found similar result in bottle gourd. They reported that, application of different concentration of nitrobenzene were significantly influences on number of leaves in bottle gourd plant.

Table 02: Effect of nitrobenzene concentration on leaf number of cucumber

Treatment A	30 DAS	45 DAS	Harvest
F_0	14.30d	38.70d	56.69d
F_1	18.91c	42.63c	65.69c
F_2	25.08a	48.94a	71.08b
F_3	23.06b	45.63b	71.36a
CV%	10.98	8.16	12.97
$LSD_{(0.05)}$	0.36	0.40	0.42

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm.

Number of leaves per plant of cucumber varied significantly in terms of nitrobenzene application method at 30 DAS, 45 DAS and harvest. At harvest, the maximum number of leaves per plant (67.56) was found from T_3 (foliar + soil application) treatment while the minimum number of leaves per plant (65.18) was found from T_2 (soil application) treatment (Table 03).

Table 03: Effect of nitrobenzene application method on leaf number of cucumber

Treatment B	30 DAS	45DAS	Harvest
T_1	20.18b	43.66b	65.87b
T_2	18.89c	43.06c	65.18c
T_3	21.93a	45.21a	67.56a
CV%	10.98	8.16	12.97
$LSD_{(0.05)}$	0.31	0.35	0.36

Here, T_1: Foliar application, T_2: Soil application, T_3: Combined application

Combined effects of different nitrobenzene doses and application method showed statistically significant variation in terms of number of leaves per plant of cucumber 30 DAS, 45 DAS and harvest. At harvest, the maximum number of leaves per plant (74.41) was observed from F_2T_3 treatment combination followed by (72.58) F_3T_3 treatment combination and the minimum number of leaves per plant (56.16) were recorded from F_0T_1 treatment combination (Table 04).

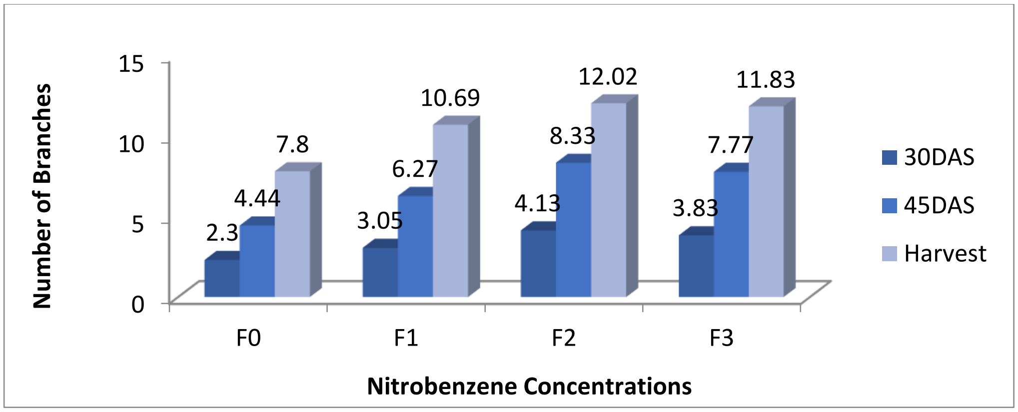
Table 04: Combined effect of nitrobenzene concentration and application method on leaf number of cucumber

Combinations	30 DAS	45 DAS	Harvest
F_0T_1	14.33jk	38.08k	56.16k
F_0T_2	14.41j	39.58i	57.33i
F_0T_3	14.16k	38.43j	56.58j
F_1T_1	18.83h	42.58g	65.58g
F_1T_2	18.33i	41.91h	64.83h
F_1T_3	19.58g	43.41f	66.66f
F_2T_1	24.66c	48.08b	70.41d
F_2T_2	22.42e	46.58c	68.41e
F_2T_3	28.16a	52.16a	74.41a
F_3T_1	22.91d	45.91d	71.33c
F_3T_2	20.41f	44.16e	70.16d
F_3T_3	25.83b	46.83c	72.58b
CV%	10.98	8.16	12.97
$LSD_{(0.05)}$	0.62	0.70	0.73

Means in a column followed by same letter do not differ significantly at 5% level. Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

4.3 Number of branches

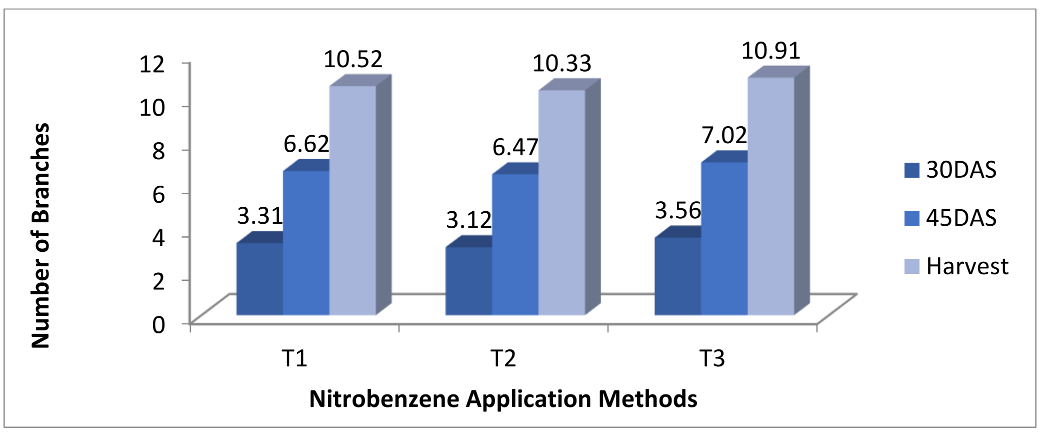
Number of branches per plant of cucumber showed statistically significant differences due to different levels of nitrobenzene concentration at 45 DAS and harvesting. At harvesting, the maximum number of branches per plant (12.02) was found from F_2 (nitrobenzene @ 3.0ml/L water) treatment, whereas the minimum number of branches per plant (7.80) was recorded from F_0 (nitrobenzene @ 0ml/L water) treatment (Fig.03). The result also indicated that the increasing concentration of nitrobenzene significantly increased the number of branches of cucumber. This result is in agreement with the finding of Pathan, 2014.



Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm

Fig.03. Effect of Nitrobenzene Concentrations on Branch Number at 30DAS, 45 DAS and Harvest

In terms of the number of branches in relation to the nitrobenzene application method, a statistically significant difference was recorded. The maximum number of branches (10.91) were recorded from T_3 (foliar + soil application) and the minimum number of branches (10.33) were produced by the T_2 (soil application) treatment (Fig.04).



Here, T_1: Foliar application, T_2: soil application, T_3: Foliar + soil application.

Fig.04. Performance of Nitrobenzene Application Method on Branch Number at 30DAS, 45 DAS and Harvest

Combined effect of different nitrobenzene doses and application methods showed statistically significant variation in terms of number of branches per plant of cucumber at 30DAS, 45 DAS and harvest. At harvest, the maximum number of branches per plant (12.50) was observed from F_2T_3 treatment combination and the minimum number of branches per plant (7.66) was recorded from F_0T_3 treatment combination (Table 05). This might be due to the fact that application of nitrobenzene maintained balanced absorption of nutrients improve physiological activities resulted the maximum number of branches per plant of cucumber.

Table 05: Combined effect of nitrobenzene concentration and application method on branch number of cucumber

Combinations	30 DAS	45 DAS	Harvest
F_0T_1	2.33gh	4.41gh	7.91g
F_0T_2	2.41g	4.33h	7.83gh
F_0T_3	2.16h	4.58g	7.66h
F_1T_1	2.91f	6.16f	10.50e
F_1T_2	2.83f	6.08f	10.25f
F_1T_3	3.41e	6.58e	11.33d
F_2T_1	4.16b	8.33b	11.83c
F_2T_2	3.66cd	8.08c	11.75c
F_2T_3	4.58a	8.58a	12.50a
F_3T_1	3.83c	7.58d	11.83c
F_3T_2	3.58de	7.41d	11.50d
F_3T_3	4.08b	8.33b	12.16b
CV%	10.68	11.58	10.45
$LSD_{(0.05)}$	0.66	0.42	0.37

Means in a column followed by same letter do not differ significantly at 5% level. Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

4.4 Number of male flowers per plant

Number of male flowers per plant showed statistically significant variation due to different nitrobenzene concentration. The maximum number of male flowers per plant (26.63) was recorded from F_2 treatment, whereas the minimum number of male flowers per plant (23.41) was found from F_1 treatment (Table 06). The result indicates that minimum male flower was produced from low concentration of nitrobenzene applied plant comparing with others. Chowdhury *et al* (1967) found almost same result in his earlier experiment.

Number of male flowers per plant of cucumber varied significantly in terms of nitrobenzene application method. The maximum number of male flowers per plant (26.00) was found from T_3 treatment while the minimum number of male flowers per plant (25.37) was found from T_1 treatment which was statistically identical (25.27) with T_2 treatment (Table 07).

Combined effects of different nitrobenzene doses and application method showed statistically significant variation in terms of number of male flowers per plant of cucumber. The maximum number of male flowers per plant (27.08) was observed from F_2T_3 treatment combination and the minimum number of male flowers per plant (22.66) was recorded from F_1T_1 treatment combination, which was statistically identical (22.91) to F_1T_2 treatment combination (Table 08).

4.7 Number of female flowers per plant

Different nitrobenzene concentrations varied significantly in terms of number of female flowers per plant of cucumber. The maximum number of female flowers per plant (25.61) was recorded from F_2 treatment whereas the minimum number of female flowers per plant (18.38) was found from F_0 treatment (Table 06). The results indicated that maximum female flower was produced by the application of plant growth regulator compared to control. Al Masoum and Al Masori (1999) reported similar trends from their experiment.

In terms of the number of female lowers per plant, the nitrobenzene application method varied significantly in cucumber. The maximum number of female flowers per plant (23.27) was found from T_3, while the minimum number of female flowers (22.56) was found from T_2 treatment (Table 07).

Table 06: Effect of nitrobenzene concentrations on floral character of cucumber

Treatment A	Male Flower	Female Flower	Ratio
F_0	26.33b	18.38d	1.43a
F_1	23.41d	22.44c	1.04b
F_2	26.63a	25.61a	1.04b
F_3	25.80c	24.90b	1.03b
CV%	8.62	9.35	13.65
LSD	0.48	0.12	0.04

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm

Table 07: Effect of nitrobenzene application method on floral character of cucumber

Treatment B	Male Flower	Female Flower	Ratio
T_1	25.37b	22.67b	1.13a
T_2	25.27b	22.56c	1.13a
T_3	26.00a	23.27a	1.13a
CV %	8.62	9.35	13.65
LSD $_{(0.05)}$	0.43	0.14	0.03

Here, T_1: Foliar application, T_2: Soil application, T_3: Combined application

Table 08: Combined effect of nitrobenzene concentration and application method on floral character of cucumber

Combinations	Male Flower	Female Flower	Ratio
F_0T_1	26.08d	18.33j	1.42b
F_0T_2	26.33cd	18.16j	1.45a
F_0T_3	26.58bc	18.66i	1.42b
F_1T_1	22.66h	22.41g	1.01e
F_1T_2	22.91h	22.08h	1.03d
F_1T_3	24.66g	22.83f	1.07c
F_2T_1	26.16d	25.41b	1.03d
F_2T_2	26.66b	25.08cd	1.06c
F_2T_3	27.08a	26.33a	1.02de
F_3T_1	26.58bc	24.55e	1.08c
F_3T_2	25.16f	24.91d	1.01e
F_3T_3	25.66e	25.25bc	1.02de
CV%	8.62	9.35	13.65
$LSD_{(0.05)}$	0.84	0.46	0.07

Means in a column followed by same letter do not differ significantly at 5% level. Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

Combined effects of different nitrobenzene doses and application method showed statistically significant variation in terms of number of female flowers per plant of cucumber. The maximum number of female flowers per plant (26.33) was observed from F_2T_3 treatment combination and the minimum number of female flowers per plant (18.16) was recorded from F_0T_2 treatment combination (Table 08). The result indicated that combination of nitrobenzene with their application method produces the maximum number of female flower per plant. Kohombange *et al* (2019) reported that application of nitrobenzene results quickly absorbed into the plants and influences the biochemical pathway of the plants to uptake more nutrient use efficiency thus improve vegetative and reproductive growth of plants.

4.8 Ratio of male and female flowers

Statistically significant variation was recorded in terms of ratio of male and female flowers of cucumber due to different nitrobenzene concentration. The highest ratio of male and female flowers (1.43) was recorded from F_0 treatment, whereas the lowest ratio of male and female flowers (1.03) was found from F_3 treatment which was statistically identical (1.04) to F_1 and F_2 treatment (Table 06). The result indicated that minimum ratio of male and female flower were produced by application of nitrobenzene compared to control.

Ratio of male and female flowers of cucumber varied insignificantly in terms of nitrobenzene application method. The ratio of male and female flowers (1.13) was found from all the T_1, T_2 and T_3 treatments (Table 07).

Combined effect of different nitrobenzene doses and application methods showed statistically significant variation in terms of ratio of male and female flowers of cucumber. The highest ratio of male and female flowers (1.45) was observed from F_0T_2 treatment combination and the lowest ratio of male and female flowers (1.01) was recorded from F_1T_1 treatment combination which was statistically identical with F_3T_2 treatment combination (Table 08).

4.9 Number of fruits per plant

Significant variation was recorded due to different nitrobenzene concentration in terms of number of fruits per plant of cucumber. The maximum number of fruits per plant (18.22) was recorded from F_2 treatment which was statistically identical (18.16) to F_3 treatment, whereas the minimum number of fruits per plant (13.30) was found from F_0 treatment (Table 09).

Table 09: Effect of nitrobenzene concentration on fruit characters of cucumber

Treatment A	No. of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
F_0	13.30c	14.84d	3.37d	135.35d
F_1	15.36b	16.57c	4.17c	155.50c
F_2	18.22a	17.92a	4.66a	169.09a
F_3	18.16a	17.46b	4.33b	166.01b
CV%	11.66	10.43	9.27	8.56
$LSD_{(0.05)}$	0.34	0.33	0.17	1.06

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm.

Number of fruits per plant of cucumber varied significantly in terms of the nitrobenzene application method. The maximum number of fruits per plant (16.70) was found from T_3 treatment while the minimum number of fruits per plant (15.66) was found from T_2 treatment (Table 10).

Table 10: Effect of nitrobenzene application method on fruit characters of cucumber

Treatment B	No. of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
T_1	16.41b	16.54b	4.18a	156.21b
T_2	15.66c	16.60b	4.07b	154.78c
T_3	16.70a	16.95a	4.15a	158.47a
CV%	11.66	10.43	9.27	8.56
$LSD_{(0.05)}$	0.29	0.28	0.15	0.87

Here, T_1: Foliar application, T_2: Soil application, T_3: Combined application

Table 11: Combined effect of nitrobenzene concentration and application method on fruit characters of cucumber

Combinations	No. of fruit per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
F_0T_1	13.41j	14.81j	3.49f	135.33k
F_0T_2	13.33jk	15.06i	3.36fg	134.75 l
F_0T_3	13.16k	14.65k	3.27g	135.97j
F_1T_1	15.33h	16.65g	4.20d	155.52h
F_1T_2	15.08i	16.23h	4.05e	154.29i
F_1T_3	15.66g	16.83f	4.26cd	156.69g
F_2T_1	18.58c	17.25e	4.67a	168.60c
F_2T_2	16.91f	17.96b	4.51b	166.41d
F_2T_3	19.16a	18.55a	4.80a	172.27a
F_3T_1	18.33d	17.45d	4.35c	165.41e
F_3T_2	17.33e	17.14e	4.38bc	163.66f
F_3T_3	18.83b	17.79c	4.27cd	168.96b
CV%	11.66	10.43	9.27	8.56
$LSD_{(0.05)}$	0.59	0.57	0.31	1.07

Means in a column followed by same letter do not differ significantly at 5% level. Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

Combined effect of different nitrobenzene doses and application methods showed statistically influence in terms of number of fruits per plant of cucumber. The maximum number of fruits per plant (19.16) was observed from F_2T_3 treatment combination and the minimum number of fruits per plant (13.16) was recorded from F_0T_3 treatment combination which was statistically identical to F_0T_2 treatment combination (Table 11).

4.10 Length of fruits

Different nitrobenzene concentration showed statistically significant variation in terms of length of fruits of cucumber. The longest fruit (17.92 cm) was recorded from F_2 treatment, whereas shortest fruit (14.86 cm) was found from F_0 treatment (Table 09).

In terms of length of fruits of cucumber, the nitrobenzene application method varied significantly. The longest fruit (16.95 cm) was found from T_3 treatment, while the shortest fruit (16.54 cm) was found from T_1 treatment which was statistically identical (16.60) to T_2 treatment (Table 10).

Combined effect of different nitrobenzene doses and application methods showed significant variation in terms of length of fruits. The maximum length of fruits (18.55 cm) was observed from F_2T_3 treatment combination and the minimum length of fruits (14.65 cm) from F_0T_3 treatment combination (Table 11). From the above result it realized that application of nitrobenzene increased the fruit length of cucumber. Samad *et al* (2019) also found similar result in bottle gourd. Kohombange *et al* (2017) stated that nitrobenzene application significantly improve the fruit length.

4.11 Diameter of fruits

Statistically significant variation was recorded in terms of diameter of fruits of cucumber due to different nitrobenzene concentration. The maximum diameter of fruits (4.66 cm) was recorded from F_2 treatment, whereas the minimum diameter of fruits (3.37 cm) was found from F_0 treatment (Table 09).

Diameters of cucumber fruits varied significantly in terms of different nitrobenzene application methods. The maximum diameter of fruits (4.18 cm) was found from T_1 treatment which was statistically identical (4.15 cm) to T_3 treatment, while the minimum diameter of fruits (4.07 cm) from T_2 treatment (Table 10).

Combined effects of different nitrobenzene doses and application method showed statistically significant variation in terms of diameter of fruits of cucumber. The maximum diameter of fruits (4.80 cm) was observed from F_2T_3 treatment combination which was statistically identical to F_2T_1 treatment combination, whereas the minimum diameter of fruits (3.27 cm) was recorded from F_0T_3 treatment combination which was statistically similar with F_0T_2 and F_0T_1 treatment combination (Table 11). It was noted that fruit diameter of cucumber increased with the higher concentration and combined application (foliar + basal) of nitrobenzene. This result is similar with the findings of Sultana (2018).

4.12 Individual fruit weight (g)

Statistically significant variation was recorded in individual fruit weight of cucumber due to different nitrobenzene concentration. The maximum individual fruit weight (169.09 g) was recorded from F_2 treatment, whereas the minimum individual fruit weight (135.35 g) was found from F_0 treatment (Table 09).

Individual fruit weight of cucumber varied significantly in terms of nitrobenzene application method. The maximum individual fruit weight (158.47 g) was found from T_3 treatment, while the minimum individual fruit weight (154.78 g) was found from T_2 treatment (Table 10).

Combined effect of different nitrobenzene doses and application methods showed statistically significant variation in terms of individual fruit weight of cucumber. The maximum weight of individual fruits (172.27 g) was observed from F_2T_3 treatment combination, while the minimum individual fruit weight (134.75 g) was recorded from F_0T_2 treatment combination (Table 11). It was observed that the individual fruit weight was gradually increased with the higher level of nitrobenzene concentration up to a limit. This might be due to that nitrobenzene improve physiological activity like photosynthesis and translocation of food materials to the fruits. This result is also in agreement with the findings of Kohombange *et al*. (2019).

4.13 Fruit yield (kg) per plant

Different nitrobenzene concentration showed statistically significant variation in terms of fruit yield per plant of cucumber. The maximum fruit yield per plant (3.10kg) was recorded from F_2 treatment, whereas the minimum fruit yield per plant (1.80 kg) was found from F_0 treatment (Table 12).

Fruit yield per plant of cucumber varied significantly in terms of nitrobenzene application method. The maximum fruit yield per plant (2.69 kg) was found from T_3 treatment, while the minimum fruit yield per plant (2.45 kg) was found from T_1 treatment (Table 13).

Combined effect of different nitrobenzene doses and application methods showed statistically significant variation in terms of fruit yield per plant of cucumber. The maximum fruit yield per plant (3.32 kg) was observed from F_2T_3 treatment combination and the minimum fruit yield per plant (1.78 kg) was recorded from F_0T_3 treatment combination which was statistically identical (1.81 kg and 1.79 kg) to F_0T_1 and F_0T_2 treatment combination respectively (Table 14). The increased fruit yield per plant might be due to increasing concentration of nitrobenzene with balanced foliar application which improves the nutrient use efficiency along with vegetative growth, induces profuse flowering and helped in retention of flower and fruit (Mithila *et al*, 2012).

4.14 Fruit yield per plot

Statistically significant variation was recorded in terms of fruit yield per plot of cucumber due to different nitrobenzene concentration. The maximum fruit yield per plot (18.59 kg) was recorded from F_2 treatment whereas the minimum fruit yield per plot (10.80 kg) was found from F_0 treatment (Table 12).

Fruit yield per plot of cucumber varied significantly in terms of nitrobenzene application method. The maximum fruit yield per plot (16.16 kg) was found from T_3 treatment, while the minimum fruit yield per plot (14.71 kg) was found from T_2 treatment (Table 13).

Combined effect of different nitrobenzene doses and application methods showed statistically significant variation in terms of fruit yield per plot of cucumber. The maximum fruit yield per plot (19.92 kg) was observed from F_2T_3 and the minimum fruit yield per plot (10.74 kg) was recorded from F_0T_3 treatment combination which was statistically similar (10.90 kg and 10.77 kg) to F_0T_1 and F_0T_2 treatment combination respectively (Table 14).

Table 12: Effect of nitrobenzene concentration on yield of cucumber

Treatment A	Yield/plant(kg)	Yield/plot(kg)	Yield/ha(t)
F_0	1.80d	10.80d	20.01d
F_1	2.40c	14.41c	26.69c
F_2	3.10a	18.59a	34.43a
F_3	3.02b	18.13b	33.57b
CV%	12.87	13.37	11.42
$LSD_{(0.05)}$	0.058	0.33	0.74

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm.

Table 13: Effect of nitrobenzene application method on yield of cucumber

Treatment B	Yield/plant(kg)	Yield/plot(kg)	Yield/ha(t)
T_1	2.59b	15.57b	28.84b
T_2	2.45c	14.71c	27.25c
T_3	2.69a	16.16a	29.93a
CV%	12.87	13.37	11.42
$LSD_{(0.05)}$	0.051	0.28	0.29

Here, T_1: Foliar application, T_2: Soil application, T_3: Combined application

Table 14: Combined effect of nitrobenzene concentration and application method on fruit characters of cucumber

Combination	Yield/plant(kg)	Yield/plot(kg)	Yield/ha(t)
F_0T_1	1.81i	10.90i	20.18i
F_0T_2	1.79i	10.77ij	19.94ij
F_0T_3	1.78i	10.74j	19.90j
F_1T_1	2.39g	14.38g	26.64g
F_1T_2	2.33h	14.03h	25.98h
F_1T_3	2.47f	14.82f	27.45f
F_2T_1	3.14c	18.88c	34.97c
F_2T_2	2.83e	16.97e	31.42e
F_2T_3	3.32a	19.92a	36.90a
F_3T_1	3.02d	18.12d	33.56d
F_3T_2	2.85e	17.09e	31.66e
F_3T_3	3.20b	19.17b	35.49b
CV%	12.87	13.37	11.42
LSD(0.05)	0.10	0.57	1.08

Means in a column followed by same letter do not differ significantly at 5% level. Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

4.15 Fruit yield per hectare

Different nitrobenzene concentration showed significant variation in terms of fruit yield per hectare of cucumber. The maximum fruit yield per hectare (34.43 ton) was recorded from F_2 treatment, whereas the minimum fruit yield per hectare (20.01 ton) from F_0 treatment (Table 12).

Fruit yield per hectare of cucumber varied significantly in terms of nitrobenzene application method. The maximum fruit yield per hectare (29.93 ton) was found from T_3 treatment, while the minimum fruit yield per hectare (27.25 ton) was found from T_2 treatment (Table 13).

Combined effect of different nitrobenzene doses and application methods showed statistically significant variation in terms of fruit yield per hectare of cucumber. The maximum fruit yield per hectare (36.90 ton) was observed from F_2T_3 treatment combination and the minimum fruit yield per hectare (19.90 ton) from F_0T_3 treatment combination which was statistically identical (20.18 ton and 19.94 ton) to F_0T_1 and F_0T_2 treatment combinations respectively (Table 14).

4.16 Economic analysis

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

Gross return

The combination of sowing time and phosphorus showed different gross returns. The highest gross return (922500 Tk./ha) was obtained from F_2T_3 treatment combination and the second highest gross return (887250 Tk./ha) was found in F_3T_3. The lowest gross return (497500 Tk./ha) was obtained from F_0T_3 treatment combination (Table 15).

Net return

In case of net return different treatment combinations showed different net return. The highest net return (571940 Tk. /ha) was found from the F_2T_3 treatment combination and the second highest net return (535577 Tk./ha) was obtained from the F_3T_3 treatment combination. The lowest (151948Tk. /ha) net return was obtained F_0T_3 treatment combination (Table 15).

Table15. Cost and returns of cucumber cultivation as influenced by different treatments

Combination	Total cost of production	Yield /ha (t)	Gross Return (tk)	Net Return (tk)	Benefit cost ratio
F_0T_1	339987	20.18	504500	164513	1.484
F_0T_2	334422	19.94	498500	164078	1.491
F_0T_3	345552	19.90	497500	151948	1.439
F_1T_1	343882	26.64	666000	322118	1.937
F_1T_2	338332	25.98	649500	311168	1.919
F_1T_3	349447	27.45	686250	336803	1.964
F_2T_1	344995	34.97	874250	529255	2.456
F_2T_2	339430	31.42	785500	446070	2.317
F_2T_3	350560	36.90	922500	571940	2.632
F_3T_1	346108	33.56	839000	492892	2.424
F_3T_2	340543	31.66	791500	450957	2.324
F_3T_3	351673	35.49	887250	535577	2.523

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

Benefit cost ratio

The combination of sowing time and phosphorus highest benefit cost ratio (2.632) was noted from F_2T_3 treatment combination and the second highest benefit cost ratio (2.523) was estimated from F_3T_3 treatment combination. The lowest benefit cost ratio (1.439) was obtained from F_0T_1 treatment combination (Table 15). From an economic point of view, it was apparent from the above results that the F_2T_3 treatment combination was more profitable than the rest of the combination.

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

A field experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November, 2019 to March, 2020 to study the effect of nitrobenzene on growth, flowering, fruit setting and yield of cucumber in winter. The experiment was considered by two factors. Factor A: nitrobenzene concentrations (4 levels) i.e., control, nitrobenzene@500ppm, nitrobenzene@600ppm, and nitrobenzene@700ppm; Factor B: nitrobenzene application methods (3 levels): foliar application, soil application and combined i.e. foliar + soil application. There were on the whole 12 (3 x 4) treatment combinations. The experiment was laid out in the double factorial Randomized Complete Block Design (RCBD) with three replications. After the emergence of seedlings, various intercultural operations were accomplished for better growth and development of the plant.

Data were collected on vine length of plant (cm), number of leaves per plant and number of branches per plant at different days after sowing, number of male flowers, number of female flowers, male and female flower ratio, number of fruits per plant, individual fruit length (cm), single fruit girth (cm), individual weight of fruit (g), yield (kg/plant), yield (kg/plot) and yield (t/ha). All collected data of the present study were analyzed statistically and the mean differences were adjudged by least significance difference (LSD) test.

A statistically significant variation was recorded in terms of all the characters related to growth and yield of cucumber. In consideration of nitrobenzene concentration in terms of stem length at harvest the maximum (175.65 cm) was recorded from F_2 treatment and the minimum (124.44 cm) was recorded from F_0 treatment. In terms of stem length in relation with different nitrobenzene application methods at harvest the maximum (158.05 cm) stem length was recorded from T_3 treatment and the minimum (153.88 cm) was recorded from T_2 treatment. In consideration of the combined effect of nitrobenzene concentration and application method at harvest the highest (178.41 cm) stem length was recorded from the treatment combination F_2T_3 and the minimum (122.98 cm) was recorded from the treatment combination of F_0T_1.

In consideration of nitrobenzene concentration in terms of number of leaves and branches, maximum value was recorded from F_2 treatment and the minimum value was recorded from F_0 treatment. In consideration of nitrobenzene application method, the maximum value was recorded from T_3 treatment and the minimum was recorded from T_2 treatment. In consideration of the combined effect of nitrobenzene concentration and nitrobenzene application method, highest value was recorded from the treatment combination F_2T_3 and the lowest value was recorded from the treatment combination of F_0T_1 and F_0T_2.

Total number of male flowers showed a significant variation in relation with different nitrobenzene concentration. The highest (26.63) male flower was recorded from F_2 treatment and the lowest (23.41) was recorded from F_1 treatment. In the nitrobenzene application method, the maximum number of male flowers (26.00) was recorded from T_3 treatment and the minimum (25.27) was recorded from T_2 treatment. The lowest (22.66) number of male flowers was recorded from the treatment combination F_1T_1 and the highest (27.08) was recorded from the treatment combination of F_2T_3.

On the other hand, the lowest (18.38) total number of female flowers was recorded from F_0 treatment and the highest (25.61) total number of female flowers was recorded from F_2 treatment. The minimum (22.56) number of female flowers was recorded from T_2 treatment and the maximum (23.27) was recorded from T_3 treatment. The highest (26.33) total number of female flowers was recorded from the treatment combination F_2T_3 and the lowest (18.16) was recorded from the treatment combination of F_0T_2. The highest value (1.45) in ratio of male and female flowers was found from the treatment combination F_0T_2 and lowest (1.01) in the F_3T_2.

In consideration of nitrobenzene concentration from terms of fruit number, fruit length, fruit diameter and individual fruit weight the highest value was recorded from F_2 treatment and the minimum value was recorded from F_0 treatment. In terms of different nitrobenzene application methods, the maximum value was recorded from T_3 treatment and the minimum from T_2 treatment. In consideration of the combined effect of nitrobenzene concentration and application method, lowest value was recorded from the treatment combination F_0T_3 and the highest value was recorded from the treatment combination of F_2T_3.

The lowest (20.01 t/ha) yield was recorded from F_0 treatment and the highest (34.43 t/ha) yield was recorded from F_2 treatment among different nitrobenzene concentrations. In terms of yield in relation with different nitrobenzene application methods the minimum (27.25 t/ha) yield was recorded from T_2 treatment and the maximum (29.93 t/ha) was recorded in T_3. Significant combined effect was recorded between nitrobenzene concentration and application method in consideration of yield under the present trial. The highest (36.90 t/ha) yield was recorded from the treatment combination F_2T_3 and the lowest (19.90 t/ha) was recorded from the treatment combination of F_0T_3.

In the combination of nitrobenzene concentration and application method highest gross return (Tk. 922500.00) was obtained from the treatment combination of F_2T_3 and the lowest gross return (Tk. 497500) was obtained in the control condition. In the combination of nitrobenzene concentration and application method the highest benefit cost ratio (2.632) was obtained from the treatment combination of F_2T_3 and the second highest benefit cost ratio (2.523) was acquired in F_3T_3. The lowest benefit cost ratio (1.439) was obtained in control condition.

5.2 Conclusion

From the results of the study, following conclusion and recommendations may be followed:

i) Treatment F_2 (nitrobenzene @ 600ppm) was superior to others; the concentration 600ppm nitrobenzene may be used to get desirable yield of cucumber.

ii) The treatment T_3 (foliar+soil application method), showed better performance on growth and yield of cucumber.

iii) The treatment combination F_2T_3 (nitrobenzene @ 600ppm with foliar + soil application) may be used to get more fruits per plant and total yield of cucumber. It may provide best substantial benefit to the farmers. So it may be recommended to the farmer level for cucumber cultivation in winter season.

SOME THESIS RELATED PICTURES

Pic. 01: Field Lay Out

Pic. 02: Plants at 25 DAS

Pic. 03: First Female Flower

Pic. 04: First Fruit Formation

Pic. 05: Collecting Data from 3rd Harvest

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APPENDICES

Appendix I: Monthly recorded air temperature, rainfall, relative humidity and sunshine hours during the period from November 2019 to March 2020.

Year	Month	Average air temperature (^{0}C)		Total rainfall (mm)	Average humidity (%)	Total sunshine hours
		Max.	Min.			
2019	November	29.6	19.2	34.4	53	8
-	December	26.4	14.1	12.8	50	9
2020	January	25.4	12.7	7.7	46	9
-	February	28.1	15.5	28.9	37	8.1
-	March	32.5	20.4	65.8	38	7

Source: Dhaka meteorology center

Appendix II. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Source: Soil Resources Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	28
% Silt	42
% clay	30
Textural class	Silty clay
pH	5.47 –5.63
Organic matter (%)	0.83%
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix III. Analysis of variance of the data on vine length of cucumber as influenced by different nitrobenzene concentration and application method

Source of variation	Degrees of freedom (df)	Mean Square of Plant Height		
		30 DAS	45 DAS	Harvest
Replication	2	0.021	0.02	0.0176
Factor A (F)	3	400.445**	1067.40 **	4911.03 **
Factor B (T)	2	13.027 **	46.51**	56.50 **
A x B	6	2.571**	1.06**	11.30 **
Error	22	0.005	0.01	0.01

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix IV. Analysis of variance of the data on leaf number of cucumbers as influenced by different nitrobenzene concentration and application method

Source of variation	Degrees of freedom (df)	Mean Square of leaf number		
		30 DAS	45 DAS	Harvest
Replication	2	0.075	0.006	0.005
Factor A (F)	3	204.942 **	171.224**	423.285**
Factor B (T)	2	27.965**	14.754 **	17.922 **
A x B	6	6.836 **	6.448 **	6.019 **
Error	22	0.016	0.029	0.022

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix V. Analysis of variance of the data on branch number of cucumbers as influenced by different nitrobenzene concentration and application method

Source of variation	Degrees of freedom (df)	Mean Square of branch number		
		30 DAS	45 DAS	Harvest
Replication	2	0.01563	0.0990	0.0017
Factor A (F)	3	6.09722 **	27.2847 **	27.2847 **
Factor B (T)	2	0.57813**	0.9427 **	1.0642 **
A x B	6	0.19618 **	0.0747 **	0.2633 **
Error	22	0.02131	0.0137	0.0131

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VI. Analysis of variance of the data on floral character of cucumbers as influenced by different nitrobenzene concentration and application method

Source of variation	Degrees of freedom (df)	Mean Square of floral character		
		Male flower	Female flower	Ratio
Replication	2	0.0017	0.1069	0.00042
Factor A (F)	3	19.2471 **	95.7432 **	0.34616 NS
Factor B (T)	2	1.8663 **	1.7308 **	0.00005 NS
A x B	6	1.3547 **	0.1706 *	0.00324 NS
Error	22	0.0226	0.0179	1.674

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix VII. Analysis of variance of the data on fruit character of cucumbers as influenced by different nitrobenzene concentration and application method

Source of variation	Degrees of freedom (df)	Mean Square of fruit characters			
		Fruit number	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
Replication	2	0.0747	0.0080	0.00336	0.01
Factor A (F)	3	51.0671 **	16.6756 **	2.70045 **	2091.94**
Factor B (T)	2	3.4653 **	0.6027 **	0.03510 **	41.69**
A x B	6	0.8935 **	0.4650 **	0.03697 **	3.99**
Error	22	0.0159	0.0087	0.00646	0.01

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix VIII. Analysis of variance of the data on yield of cucumbers as influenced by different nitrobenzene concentration and application method

Source of variation	Degrees of freedom (df)	Mean Square of Yield Parameters		
		Yield /plant (kg)	Yield/plot (kg)	Yield/ha (t)
Replication	2	0.00221	0.065	0.215
Factor A (F)	3	3.31802 **	119.134 **	408.549 **
Factor B (T)	2	0.17910 **	6.368 **	21.827 **
A x B	6	0.03706**	1.366**	4.671 **
Error	22	0.00024	0.008	0.026

*Significant at 0.05 level of probability; **Significant at 0.01 level of probability and NS Non-significant

Appendix IX. Per hectare production cost of cucumber

A. Input cost

Treatment	Labor cost	Ploughing cost	Seed Cost	Irrigation cost	Sticking cost	Manures and fertilizers				Insect Cides And Pesticides	Nitro Benzene cost	Sub Total (A)
						K. comp.	Urea	TSP	MP			
F0T1	55000	35000	7500	40000	50000	30000	2400	2640	1500	10000	000	234040
F0T2	50000	35000	7500	40000	50000	30000	2400	2640	1500	10000	000	229040
F0T3	60000	35000	7500	40000	50000	30000	2400	2640	1500	10000	000	239040
F1T1	55000	35000	7500	40000	50000	30000	2400	2640	1500	10000	3500	237540
F1T2	50000	35000	7500	40000	50000	30000	2400	2640	1500	10000	3500	232540
F1T3	60000	35000	7500	40000	50000	30000	2400	2640	1500	10000	3500	242540
F2T1	55000	35000	7500	40000	50000	30000	2400	2640	1500	10000	4500	238540
F2T2	50000	35000	7500	40000	50000	30000	2400	2640	1500	10000	4500	233540
F2T3	60000	35000	7500	40000	50000	30000	2400	2640	1500	10000	4500	243540
F3T1	55000	35000	7500	40000	50000	30000	2400	2640	1500	10000	5500	239540
F3T2	50000	35000	7500	40000	50000	30000	2400	2640	1500	10000	5500	234540
F3T3	60000	35000	7500	40000	50000	30000	2400	2640	1500	10000	5500	244540

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

B. Overhead cost (Tk./ha).

Treatments	Cost of lease of land for 6 months (12% of value of land Tk. 1250000/year)	Miscellaneous cost (tk. 5% of the input cost)	Interest on the running capital for 6 months (tk. 12% of cost/year)	Subtotal (Tk.) (B)	Total cost of Production (Tk./ha) [Input cost (A)+ overhead cost (B)]
F_0T_1	75000	11702	19245	105947	339987
F_0T_2	75000	11452	18930	105382	334422
F_0T_3	75000	11952	19560	106512	345552
F_1T_1	75000	11877	19465	106342	343882
F_1T_2	75000	11627	19165	105792	338332
F_1T_3	75000	12127	19780	106907	349447
F_2T_1	75000	11927	19528	106455	344995
F_2T_2	75000	11677	19213	105890	339430
F_2T_3	75000	12177	19843	107020	350560
F_3T_1	75000	11977	19591	106568	346108
F_3T_2	75000	11727	19276	106003	340543
F_3T_3	75000	12227	19906	107133	351673

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.

Appendix X. Per Hectare Return

Treatment	Cost of production (Tk./ha)	Yield of Cucumber (t/ha)	Gross Return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
F_0T_1	339987	20.18	504500	164513	1.484
F_0T_2	334422	19.94	498500	164078	1.491
F_0T_3	345552	19.90	497500	151948	1.439
F_1T_1	343882	26.64	666000	322118	1.937
F_1T_2	338332	25.98	649500	311168	1.919
F_1T_3	349447	27.45	686250	336803	1.964
F_2T_1	344995	34.97	874250	529255	2.456
F_2T_2	339430	31.42	785500	446070	2.317
F_2T_3	350560	36.90	922500	571940	2.632
F_3T_1	346108	33.56	839000	492892	2.424
F_3T_2	340543	31.66	791500	450957	2.324
F_3T_3	351673	35.49	887250	535577	2.523

Here, F_0: Control, F_1: Nitrobenzene @ 500ppm, F_2: Nitrobenzene @ 600ppm, F_3: Nitrobenzene @ 700ppm and T_1: Foliar application, T_2: Soil application, T_3: Combined application.