GROWTH AND YIELD OF CHILLI AS INFLUENCED BY PLANT GROWTH REGULATORS AND ITS METHOD OF APPLICATION

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DHAKA-1207

JUNE, 2018

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REGISTRATION No. 12-5122

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

MASTER OF SCIENCE (MS)
IN
HORTICULTURE
SEMESTER: JANUARY-JUNE, 2018

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CERTIFICATE

*This is to certify that the thesis entitled "**GROWTH AND YIELD OF CHILLI AS INFLUENCED BY PLANT GROWTH REGULATORSAND ITSMETHOD OF APPLICATION**" 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 (MS) in HORTICULTURE, embodies the results of a piece of bona fide research work carried out by **IFFAT SHARMIN**, Registration. No. 12-05122 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2018
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MYBELOVEDPARENTSFOR

WHOMIHAVEREACHEDHERE

ACKNOWLEDGEMENTS

All the respects, credits, gratefulness and gratuity are goes on the Almighty Allah who enlightened the author's soul as a human being to breadth in the earth and enabled me to accomplish this manuscript.

The author expresses her special warm of thanks, heartiest respect and deepest sense of gratitude, profound appreciation to her supervisor, ***Professor Dr. TahminaMostarin****, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for her sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

The author would like to express profound respect and heartiest gratuity to her co-supervisor ***Professor Dr. Mohammad Humayun Kabir,*** *Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.*

The author would like to express her deepest sense of respect to ***Professor Dr. Mohammad Humayun Kabir****, Chairman, Department of Horticulture for providing the facilities to conduct the experiment and for his valuable advice and sympathetic consideration in connection with the study.*

The author would like to thank Ministry of National Science and Technology for providing financial support by providing NST Fellowship to complete her research work.

It would have been less fun, if, the author does not recognize her parents with warm and special gratefulness and profound gratitude and deepest appreciation, who have brought her on the earth and who lost their joy and happiness for her, have sacrificed and dedicated efforts to educate her to this level.

The Author

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment consisted of two factors. Factor A: Plant growth regulators (three levels) as G_0: Control (Water), G_1: NAA (40 ppm), G_2: Cytokinin (10 ppm) and Factor B: Application method (three levels) as M_1: Seed soaking for 6 hours,M_2: Foliar spray at vegetative stage, M_3: Foliar spray at flower bud initiation stage. The experiment was laid out in a Randomized Complete Block Design with three replications. In case of plant growth regulators, the highest yield (33.56 t/ha) was found from G_1 treatment, whereas the lowest (13.85 t/ha) from G_0 treatment. For application method, maximum yield (27.12 t/ha) was recorded from M_3 treatment, while the minimum yield (19.92 t/ha) from M_1 treatment. Due to combined effect, the highest yield (38.07 t/ha) with net income (1075498) and BCR (3.39) was observed from G_1M_3 treatment combination, while the lowest yield (17.13 t/ha) with net income (147131) and BCR (1.49) from G_0M_1treatment combination. So, economic analysis revealed that the G_1M_3 treatment combination appeared to be the best for achieving the higher growth, yield and economic benefit of chilli.

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LISTS OF ACRONYMS

BARI	=	Bangladesh Agricultural Research Institute
BCR	=	Benefit cost ratio
cm	=	Centimeter
NAA	=	Napthalene Acetic Acid
4-CPA	=	4-chlorophenoxy acetic acid
DAT	=	Days after sowing
et al.	=	and others (*at elli*)
GA_3	=	Gibberellic acid
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MOP	=	Muriate of Potash
PGR	=	Plant growth regulator
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	percent

CHAPTER I
INTRODUCTION

Chilli (*Capsicum frutescens*) is one of the important spices which belongs to the family Solanaceae. It is the second most important Solanaceous crop after tomato throughout theworld (Souvanalat, 1999). It is a self pollinated crop but a few percentage of crosspollination may occur by insect. There are many germplasm of pepper. Among these peepers,*C. frutescens*is hot and *C. annum* is sweet. Hot peppers (chillies) pericarp have high content of crystalline colorless pungent substance known as alkaloid capsaicin ($C_{18}H_{27}NO_3$) (Udoh *et al.,* 2005).*Capsicum frutescens*can be either annual or short-lived perennial plants.It is one of the most valuable vegetable-cum-spicecrops for its aroma, taste, flavour and pungency. Chilli is originated fromMexico. It is grown in tropical and subtropical regions of all parts. Deep, loamy, fertile soil rich in organic matter and temperature between 18 to 30°C are considered good for satisfactory growth. Also need well drained soils with sufficient soil moisture for the growth of the crop.

Chilli is a valuable spice and also most important cash crop in Bangladesh. It is available and used in the form of green, dried and powdered. In Bangladeshi meals, it becomes an essential ingredient. It is quite rich in nutritive values and supposed to contain certain medicinal properties (Chowdhury, 1976). Green chillies are rich in vitamin A and C and the seed contain traces of starch (Saimbhi*et al.,* 1977; Sayed and Bagavandas, 1980). In addition, peppers are a good source of vitamin-B and vitamin B6, carbohydrate, carotene, thiamine, riboflavin and niacin (Srivestav and Sanjeev, 1994). In 100g of chilli contains vit B6 0.23 mg, riboflavin 1.3 mg, carbohydrate 5.9 g, B carotene 115 mg, vit A 10 mg and vit C 102.3 mg (Institute of Nutrition and Food Science). The production of chilli is governed not only by the inherent genetic yield potential but also it is greatly influenced by several environmental factors and cultivation practices.

In Bangladesh, the recent statistics shows that, chilli was grown in 1,83,490 acres of land and the total production was approximately 92,813 metric tons in rabi season during the year 2014-2015 with an average yield of 506 kg/acre (BBS, 2016).But the production of chilli is reduced due to flower and fruit drop, which is caused by physiological and hormonal imbalance in the plants particularly under unfavourable environments. There is a huge potential to increase yield of chilli by reducing flower drops and by increasing fruit set. Studies on the effect of plant growth regulators in solanaceous fruit and vegetable crops have revealed that the application of some of the plant growth regulators has been found effective in reducing the flower and fruit drops there by enhancing production of chilli per unit area and per unit time.

Plant growth regulators (PGRs) natural or synthetic are biochemical substances, which control the physiological functions of plant at a site remote from its place of production and are in minute amounts (Verma and Chand, 2003). The PGRs in specific doses have a great potential for growth, development and yield of crops. There are many synthetic plant growth regulators such as NAA, IBA, Potassium Naphthenate, Cytokinin, Maleic Hydrazide (MH) etc. which have a great impact on the biochemical processes of crops, which improve the quality of yield and physiological processes that gives the maximum crop yield. Among these, NAA and cytokynin is very promising and used on large scale in fruit vegetables crops. Naphthalene acetic acid (NAA) is one kind of synthetic auxin, which plays an important role in stimulating cellular elongation in shoot, apical bud dominance and root initiation (Verma and Chand, 2003).Control flowering, enhancement of growth and productivity due to NAA application are well documented (Bhai and Singh, 1998). Cytokinin stimulates cell-division, induce cell-enlargement, break dormancy, shoot initiation and rejuvenation of mature shoots. Counteract the apical dominance of bud; increase the rate ofprotein synthesis and delaying of senescence.

Although plant growth regulatorshave great potential for growth improvement but their application has to be plannedsensibly in terms of optimal concentration, stage of application and proper application method.Plant growth regulators can be used through different application method such as foliar spray, seed soaking, drenching etc. Foliar spray and seed soaking methods are very useful for using these chemicals. But specific information based on research work on many aspects of chilli crop more particularly application method is still lacking in literature.Considering the stated facts, the present study was undertaken with the following objectives:

1.To study the effect of plant growth regulators on growth and yield of chilli.
2.To determine the actual application method on growth and yield of chilli.
3.To know the combined effect of plant growth regulators and its application method for better growth, maximum yield and economic return of chilli.

CHAPTER II

REVIEW OF LITERATURE

Chilli (*Capsicum frutescens*) is one of the popular solanaceous crop cultivated in Bangladesh. Very few research works have been done for the development of this crop in Bangladesh and other countries of the world. The present study was, therefore, conducted with suggested concentrationsof NAA and cytokinin as seed soaking and foliar spray application method to determine the effectiveconcentrations promoting growth, yield and quality in commercial cultivation of chilli.However, some of the important research findings regarding the effects of plant growth regulators and its application method on the growth, yield and economic benefit of chilli have been presented in this chapter.

2.1 Effect of NAA on growth and yield of chilli

Tapdiya*et al.* (2018) reported that the growth regulators namely NAA and GA_3 foliar spray during flower bud initiation stage was found to be beneficial for increasing the plant height, number of branches per plant and stem girth over seed treatments compared to control. With regards to yield contributing character i.e. fruit setting percentage, fruit length, fruit girth, average fruit weight, number of fruit per plant, number of seeds per fruit, seed weight per fruit, and fruit yield per plant showed increase in foliar spray of NAA 40 ppm than all other treatment including control.

Balraj stated (2002) that the effects of NAA, gibberellic acid and 2,4-D on chilli (*C. annuum*Byagadi) were investigated in a field in Dharwad, Karnataka, India, in the kharif seasons of 1997-98 and 1998-99. The plant growth regulators were sprayed at 35 and 50 days after transplanting (DAT). GA at 20 ppm was the best

treatment for improving plant height and number of branches, while NAA at 20 ppm was the best for improving yield.

Sultana *et al*. (2006) laid out a pot experiment during 2004-2005 rabi season at BARI, Joydebpur, to evaluate the effects of three growth regulators on yield and seed quality of chilli. Treatment of NAA gave significantly highest fruit yield (277.8 g/plant).

Bhalekar*et al.* (2009) stated that the growth promoters like NAA and 4-CPAimproved the source-sink relationship and hormone modified translocation ofphotosynthates, which will help in retention of flowers, fruits and seed filling atlater stages of crop growth.

Salas*et al.* (2009) reported that application of commercial auxin as foliar sprays (0.4 cm_3 L-1) and application in the nutrient solution (0.6 cm3 L-1) in sweetpepper. In order to assess the effect of auxin treatments, the following data werecollected: fruit weight, length of fruit, the early and total yield was significantlymaximum when auxins were applied by fertigation, than foliar applications, while the fruit quality parameters were enhanced when commercial auxins wereapplied by foliar sprays.

Hasanuzzaman*et al.* (2007) found that plant hormones promoted the harvestingof sweet pepper a few days earlier than control. This is might be due to theregulating effect of exogenous application of PGRs that enhanced early floralinitiation, fruit setting and also early maturity.

Chaudhary *et al*. (2006) conducted an experiment in the plain areas ofChitwan to evalute the promising plant growth regulators (PGR) improving growth, development and yield of chilli cultivars Jwala and

Suryamukhi.Suryamukhiranked superior to Jwala for most of the yield attributing characters,howeverJwala was better in vegetative characters than Suryamukhi. Beside this PGRs 2,4-D at 2 ppm was better for fruit set, number of fruits per plant,number of seeds per fruit, seed weight per fruits, 1000 seed weight and fruityield whereas NAA at 40 ppm gave the highest leaf area index (LAI).

Prasad *et al.* (2013) set a field experiment on the effect of GA_3 and NAA wasconducted on tomato cv. Kashi Vishesh during the rabi season of 2011-12. Thedifferent concentration of GA_3 (20, 40, 60 and 80 ppm) and NAA (25, 50, 75and 100 ppm) were sprayed on the crop to evaluate the growth behavior andyield attributes of tomato. It was observed that there was a linear improvement ingrowth parameters like plant height and number of branches per plant with increasing level of GA_3 and NAA. The highest plant height was recorded as 85.3cm and 82.3 cm with the application of GA_3 @ 80 ppm and NAA @ 100 ppm,respectively after 60 days of transplanting. The yield and yield attributes werealso affected significantly with increasing concentrations of GA_3 and NAA. A highest yield of 483.6q/ha and 472.2 q/ha was recorded with the use of GA_3 @80 ppm and NAA @100 ppm, respectively.

Mandal*et al*. (2012) conducted a trial to evaluate the effect of plant growthregulators on growth and fruit yield of okra. The crop was foliar sprayed twice, first at 3-4 leaf stage and second after one month of the first spray with 2, 4-D (5, 10, 15 and20 ppm), NAA (25, 50, 75 and 100 ppm) and CCC (400, 600, 800 and 1000 ppm).The maximum plant height (140.80 cm) and intermodallength (11.80 cm) wererecorded with NAA at 100 and 75 ppm, respectively but the lowest plant height(108.70 cm) and intermodal length 8.65 cm were noted at 1000 ppm CCC. Thenumber of leaves per plant (46.33) was highest under 20 ppm 2, 4-D and themaximum number of branches per plant (6.67) obtained with NAA at 50 ppm.

Chand *et al.* (2014) conducted a trial on plant growth regulators having different more (72.39 cm and 130.74 cm) plant height, number of leaves per plant (16.00 and 23.concentrations and fruit retention levels showed differential response for thegrowth attributes. Among the different interactions, 8 fruits retained plants sprayedwith NAA @ 25 ppm recorded 93) and reduced stem girth (3.02 cms and 3.41 cms)at 60 and 90 days, respectively and it will also took least number of days to maturity(116.40). Among interactions 8 fruits retained plants sprayed with NAA @ 25 ppmrecorded highest (29.80 cm, 19.16 cm) shoot, root lengths, seedling dry weight (24.0mg), vigour index type-I & II (4833 and 2369), field emergence (93%), accelerated ageing response (89%), seed density (0.93 g/cc) and less electrical conductivity (251dS/m).

Samapika*et al*. (2015) reported that the treatment of GA_3 20 ppm + NAA 100ppm was significantly superior in terms of growth parameters *i.e.* vine length (cm), number of primary branches per plant and number of leaves per plant as compared tocontrol and other applied treatments in cucumber.

Singh *et al.* (2015) noted that the highest plant height (85.87cm) was achievedin spray of NAA @ 20 ppm in green chilli cv. N-7478.

Kokare*et al*. (2006) observed that spraying the plant with NAA 200 ppmresulted in increase the number of fruits, fruit girth, fruit yield per plant, fruit yield (t/ha) and ascorbic acid content over the control (sprayed with distilled water) in okra.

Fathima and Balasubramanian (2006) reported that the effect of plant growthregulators like gibberelic acid (GA) and naphthalene acetic acid (NAA) on the qualityof best fibres in *A. esculentus*. The fibre quality was best in GA100 + NAA 50 microgram per ml treatment. Fibre macerate studies showed an increase in fibre length and the slenderness ratio was also high. Proximate analysis of retted

fibres re-vealed lowermoisture and ash content and an increase in wax content. The physico-mechanical properties showed considerable improvement of fibre quality. Considering the abovecriteria, GA 100 + NAA 50 micro gram per mL treatment brought about advantageouschanges for improving the quality of fibers.

Shahid *et al.* (2013) reported that growth regulators were less effective whenapplied individually as compared to their combined use however performance of planttreated with individual PGR was the better than untreated plants. The numbers of podsper plant, pod length, pod fresh and dry weight, seed yield and seed quality (in termsof germination percentage and 1000 seed weight) was maximum in plants receivingfoliar 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.

Tomar*et al*. (2016) showed that the combined use of GA_3, NAA and 2, 4-D at specific concentration (GA_3 at 30 ppm, NAA at 30 ppm and 2, 4-D at 5 ppm)considerably increase the weight of fruit and significantly increases total yield up to523 q/h in tomato.

Revanappa*et al.* (1997) laid out a field experiment on chilli cultivars atUniversity of Agriculture Science, Dharwad. They concluded that “Nagavi” emergedas the best chilli variety regarding yield (116.16 q/ha), TSS (8.01 Brix) and netreturns. Among the growth regulator treatments, application of NAA improved yieldand quality by ascorbic acid (109.17 mg/100g fresh weight) of fruit significantly.The treatments of cytokynin could not induce significant changes.

Joshi and Singh (2001) conducted an experiment during the summerseason of 1998, in Uttar Pradesh, India, to evaluate the effect of plant growthregulators, i.e. NAA (20, 40 and 60 ppm), GA_3 (10, 20 and 30 ppm), ethephon (50,100 and 150

ppm), 2, 4-D (2, 4 and 6 ppm) and PP333 [paclobutrazol] (100, 200 and300 ppm) on chilli*cv*. Pant C-1. The highest total leaf area (2970.90 cm^2) was recorded in NAA at 40 ppm. All concentrations of 2,4-D and PP333 showed significant reduction in total leaf areaper plant, due to the herbicidal effects of both growth regulators. The highest shootfresh weight (221.33 g), root fresh weight (47.26 g) and root dry weight (31.80 g)were recorded under 2, 4-D at 4 ppm. The highest shoot dry weight (72.86 g) wasnoted in ethephon at 150 ppm, while the highest pollen variability (81.65%) wasrecorded in PP333 at 300 ppm. All growth regulators significantly increased fruit yieldper plant over the control. The highest fruit yield per plant was recorded in PP33 at300 ppm (282.20), followed by 2,4-D at 2 ppm (276.80g) and NAA at 40 ppm(274.13g). The higher yields in these treatments were due to more number of fruitsper plant, higher percentage of fruit set per plant and higher values for fruit lengthand thickness.

Sanaa *et al.* (2001) found in dry bean crop that increasing levels of NAA increased the fresh and dry weights of the plants, pod setting pod weight and free amino acid content of fruits and seeds.

Tewari *et al.* (2001) reported that seed germination significantly improve with GA_3 @ 100 ppm and NAA @ 10 ppm application. Longer seedlings wereobtained with IAA @ 100 ppm and IBA @ 50 and 100 ppm. All treatments except GA_3 @ 100 ppm improved plant height.

Mehdi *et al.* (2002) conducted an experiment on French bean variety HUR-137 during rabi season at RARS, AAU, Assam to find out the effect of PGR on thedry matter production, flower initiation and pod setting of french bean. By reducing fruit drop (7.15%) NAA recorded highest pod yield (117.65 q/ha) @ 15 ppm whichwas 57% increase as compare to control.

Dry matter accumulation increased andshoots and root ratio decreased due to application of the growth regulators.

Kore *et al*. (2003) recorded significantly higher vine length (303.6 cm) internodal length (10.03 cm) and number of branches (4.13) with NAA (20 ppm)compared to control in bottle gourd.

Kalshyam*et al*. (2011) conducted an experiment on chilli variety "PusaJwala" at CCSU, Meerut and concluded that combined application of that growthhormone and fertilizer each at higher concentration (75 ppm NAA 150 kg N/ha) gavethe maximum growth and yield. The result revealed that plant height 58.43 cm, no. ofbranches/plant 82.65, green fruit yield 68.49 q/ha and dry fruit yield 6.74 q/ha withcombined application of 75 ppm NAA and 150 kg N/ha.

Veishnav*et al.* (2012) studied effect of NAA on chilli at BHU, Varanasiduring Rabi season of 2010-11. They recorded maximum plant height (70.52 cm)and number of branches (8.71) @ 40ppm NAA and genotype NUN-6525 treatmentcombination where as recorded higher values for green fruit plant-1 (179.59g) anddry fruit yield/ plant (38.68 g) with NAA @ 40ppm and genotype NUN-2070 treatmentcombination.

Thapa *et al.* (2013) studied the influence of NAA and GA_3 on qualityattributing character of sprouting Broccoli variety "Italica plank" at BCKV, Mohanpur. They confirmed that NAA (30mg/l) + GA_3 (30mg/l) showed best result with respectto head diameter, plant height, spreading and yield. The plant growth regulatortreatments significantly improved carotene, total sugar and total chlorophyll content,with highest increase have been recorded in case of T1- GA_3 40 mg/l, whereas maximum ascorbic content has been estimated with T9- GA_3 20 mg/l+ NAA 20 mg/l.

Moniruzzaman*et al*. (2014) conducted an experiment on brinjal having sixPGR*Viz*., GA_3 30, 40, 50 ppm and NAA @ 20, 40, 60 ppm respectively and twovarieties*Viz*., "BARI Begun-5" and "BARI Begun-10 during rabi season for determinesuitable dose of PGR for brinjal production. The variety "BARI Begun-5" was earlierto 100% flowering which took 44 days after transplanting which out yielded BARIBegun-10. NAA @ 40 ppm coupled with BARI Begun-5 gave the highest fruit yield49.73 t/ha.

Singh *et al.* (2015) studied on chilli variety G-4 at SHIATS, Allahabad, UP.They confined that the combined application of NAA @ 20 ppm, GA3 @ 10 ppm and2,4-D @ 1 ppm significantly increased vegetative growth, yield and quality of chilli.Combined application had positive effect on plant growth, flowering and yieldpotential of plants.

Mehraj*et al.* (2015) conducted an experiment at Sher-e-Bangla AgricultureUniversity, Bangladesh in okra, recorded that GA_3 and NAA @ 50 ppm both have thepotentiality to increase the yield of okra. They found that foliar application of 50 ppmNAA increase yield (338.1 g/ha, 2.9 kg/plot and 16.4 t/ha).

Singh *et al*. (2000) conducted an experiment on chilli variety "PusaJwala"with three treatments included farmers practice (T1), NAA (T2) and technology option(T3) at KVK, Malda, West Bengal, under rain fed medium to upland sandy loam soilsituation in rabi season. They sprayed NAA at the opening of first flower to lastphase of flowering at 15 days interval. The result showed NAA reducing flower dropand increase in fruit set of chilli. Highest yield of chilli (14.37 q/ha) at NAA @ 40 ppmand followed by (12.32 q/ha) yield with NAA @ 20ppm.

Shahid *et al*. (2013) observed that performance of okra plants treated with individual PGR was better than the untreated plants. The number of leaves and

plant highest was higher in plants when sprayed with GA_3 and NAA @ 200 and 100 ppm, respectively. Their results were signify the role of GA_3 and NAA in okra pod production for fresh consumption as well as for seed yield.

Joshi and Singh (2003) conducted an experiment in Pantnagar, Uttaranchal, India, to study the effect of different plant growth regulators and their concentrations on chilli cv. Pant-1. The treatments comprised: 20, 40 and 60 ppm NAA; 2, 4 and 6 ppm 2,4-D; 10, 20 and 30 ppm GA3; 50, 100 and 150 ppm ethephon; and 100, 200 and 300 ppm PP-333 (paclobutrazol), all applied as foliar spray at flower bud initiation and 20 days after flower bud initiation. NAA at 40 and 60 ppm gave the highest total leaf area per plant (2970.90 cm2) and number of seeds per fruit (45.00), respectively. Ethephon at 150 ppm gave the highest shoot dry weight (72.86 g). The highest fruit dry weight (62.89 g) was obtained with 2 ppm 2,4-D, while the highest shoot fresh weight (221.33 g), root fresh weight (47.26 g) and root dry weight (31.80 g) were obtained with 4 ppm 2,4-D. PP-333 at 300 ppm gave the highest seed weight per fruit (208.33).

Investigations were carried out by Kannan *et al*. (2009) to study the effect of different growth regulators in paprika (*Capsicum annuum* var. longum) cv. KtPl-19 at coconut nursery garden, Tamil Nadu Agricultural University, Coimbatore. The experiment was conducted in randomized block design with three replications. The growth regulators treated consist of Mepiquat chloride (50 and 100 ppm), 2, 4-D (5 and 10 ppm), NAA (25 and 50 ppm), GA3 (25 and 50 ppm) and Nitro benzene (0.1 and 0.2%). The treatment NAA at 50 ppm recorded the greatest fresh fruit yield per plot (6.82 and 5.98 kg) and estimated yield per hectare (12.89 and 12.28 t) during winter and summer respectively.

Singh *et al*. (2005) carried out an investigation to see the effects of different doses of PGRs (control, 25 or 75 ppm IAA, and 25 or 75 ppm NAA) and micronutrient

(control, 2500 ppm Multiplex or 2000 ppm Humaur) mixtures and their interactions on plant growth, number of branches and yield of tomato at 35 and 70 days after transplanting (DAT). Plant growth was not affected significantly by any treatment and interaction, although the effect of Pl (25 ppm IAA) x M2 (Humaur) interaction was better in increasing the plant growth at 75 DAT. The number of branches was signiticantly and highly increased by the application of 75 ppm IAA and 25 ppm NAA. The initiation time of first flowering and first fruiting was significantly and highly increased by the interaction P4 (75 ppm NAA) x M2 (Humaur). Application of 35 ppm IAA and 2000 ppm Humaur was significantly increased the tomato yield. P4 (75 ppm NAA) x M2 (2000 ppm Humaur) was also significantly increased the yield. It can be concluded that addition of PGR and micronutrient in tomato is useful for better production.

Gupta and Gupta (2004) studied the plants were sprayed with 25 or 75 ppm IAA and NAA, alone or in combination with the micronutrient mixtures Multiplex 2500 ppm and 2000 ppm Humaur in a field experiment conducted in Allahahad, India to determine the effects of the treatments on the P content of tomato fruits and products. Application of 75 ppm NAA + multiplex resulted in the highest P content in tomato fruits, as well as in ketchup, and tomato puree and juice during both years.

Gupta *et al*. (2003) observed the response of plant growth regulators and micronutrient mixtures on fruit size, color and yield of tomato (*Lycopersiconesculentum*Mill.) An experiment was conducted by two years (1997-99) in Uttar Pradesh, India to determine the effect of growth regulators (25 ppm IAA and 45 ppm IAA) at 25 and 50 days after transplanting (DAT) and / or Micronutrient mixtures (2500 ppm Multiplex and 2000 ppm Humaur) at 25 and 50 DAT, respectively, on tomato cv. Krishna (F1 hybrid). Among all Treatments, the largest fruit size (6.67 cm diameter), most attractive ripe fruit color (Phantom, 2L -

12) and the highest yield (63.61 t/ha) were observed with 45 ppm IAA + Multiplex micronutrient mixture at the maturity stage during 1998-99. The highest dry matter (12.7%) and ash content (1.0%) were obtained upon treatment with 45 ppm IAA + Humaur micronutrient mixture.

Gupta *et al*. (2002) conducted an experiment on the effect of, IAA and NAA (35 and 75 ppm, respectively, at 25 and 50 days after transplanting) and the micro nutrients mixtures Multiplex and Humaur (2500 and 2000 ppm, respectively), on the tomato cultivar Krishna was evaluated in Karnataka, India during 1997-98 and 1998-99. The application of auxins and micronutrients significantly improved the fruit size (length 6.32 cm and diameter 6.78), dry matter, ash content, longest root length and yield of The greatest fruit size and yield were obtained with 75 ppm NAA + multiplex; while the highest dry matter and ash content were recorded for 75 ppm NAA + Humaur.

Rai *et al*. (2002) conducted an experiment that application of IAA at 75 ppm along with Multiplex at 2500 ppm resulted in highest plant height and yield, and IAA at 75 ppm alone in the highest number of branches. Application of IAA at 25 ppm + Multiplex at 2500 ppm superior for ascorbic acid content. Maximum chlorophyll content and acidity were obtained with NAA at 75 ppm along with Humaur at 2000 ppm IAA at 75 ppm + Humaur at 2000 ppm were the best for total soluble solids and carotenoid content. NAA at 75 ppm along with Multiplex at 2500 ppm gave the highest sugar content.

Perez and Ramirez (1980) carried out an experiment with the application of IAA at 25 and 35 ppm on tomato. They found increased fruit size quality with minimum seeds.

Younis and Tigani (1977) carried out an experiment with IAA application on tomato cv. John Moran plants. They observed that when IAA was applied to field grown tomato plants, 2 applications of IAA at 10 ppm increased the fruit set significantly.

Kaushik *et al*. (1974) reported that 10 ppm of IAA increased the number and weight of fruits per plant significantly.

Singh and Upadhayaya (1967) studied the effect of IAA and NAA on tomato and reported that the regulators activated growth, increased the fruit set, size and yield of fruit and induced parthenocarpic fruit. The chemicals could be applied on seeds, roots whole plants or flowers, but foliar application was very effective for increasing the size of fruit and the yield.

Mukharji and Roy (1966) found that application of IAA had protected the flower and premature fruit drop and increased length of size fruit in tomato plant.

Leopold (1964) observed that with the increase in concentration of auxin there was a comparable increase in percentage of flower cluster.

Tiwari and Singh (2014) reported that number of branches increased by Alar 100ppm, NAA 40ppm and Ethephon 100ppm while 2,4 D 10 and 5 ppm ; CIPA 20 ppm and Ethephon 100 ppm showed early maturity of fruits. More 5 number of fruits per plant was recorded in CIPA 20 ppm, 2-4 D 5 ppm and NAA 40 ppm.

Maurya *et al.* (2013) conducted an experiment to study the effect of NAA i.e., (N_0: control, N_1: 20 ppm, N_2:40 ppm, N_3:60 ppm, N_4: 80 ppm) on tomato crop using three cultivars (V_1 : Tomato Hybrid-2258, V_2: TM-1, V_3 : TM-3). The observations were recorded on seven parameters which consist of yield and quality parameters.

It is evident that irrespective of varieties the NAA application increased the yield and quality attributes in tomato crop. The fruit yield increased by about 30% with application of NAA (40 ppm) under field condition. The application of 40 ppm NAA and cultivar TM-1 was found to be better. On the basis of these results, it can be suggested that NAA has beneficial role on yield and quality of tomato.

Singh *et al.* (2011) carried out an experiment find out the effect of different doses of NAA (N_0 0 ppm, $N_1$50 ppm, N_2 100ppm and $N_3$120 ppm) on vegetative growth, yield and quality of three tomato cultivars viz., NUN-1560 (V_1), NUN-964 (V_2) and NUN-963 (V_3). The results revealed that cultivars, NAA doses and their interaction effect were significant regarding yield and yield contributing characters and quality parameters. The highest plant height (cm), number of branches per plant, number of fruit clusters per plant, number of fruits per plant, fruit length (cm), fruit width (cm), fruit yield per ha (q), storability (day) and total soluble solids (TSS) were recorded with N_1 (NAA 50 ppm) in all the three cultivars.

Deb *et al.* (2009) found significant response of NAA (25 ppm) with respect to number of fruits/plant, fruit weight/plant, total soluble solid (TSS) and vitamin C and yield was obtained over the control (Saha*et al.*,2009).

Yadav *et al*. (2001) observed that NAA application increased total soluble solid percentage significantly.

2.2 Effect of cytokinin on growth and yield of chilli

Awan *et al.* (2015) reported that maximum plant height at 40 DAS wasrecorded for the combined effect of NAA and BAP at a concentration of 1000 µM(each), while BAP alone at 100 µM concentration showed maximum plant height at60 DAS. Maximum number of leaves was shown by NAA (10 µM) both at 40 and 60DAS. Increase in leaf length was observed for NAA (10 µM) and BAP (100

μM) bothat 40 and 60 DAS. Significant increases in root length were recorded where maximumroot length was in plots treated with BAP (1000 μM) applied 40 DAS while themixture of BAP (10 μM) and NAA (10000 μM) induced significant increases in rootlength when applied 60 DAS. Maximum fresh weight of shoot was observed for NAA(1000 μM) and BAP (1000 μM) while maximum shoot dry weight was observed inplots treated with NAA and BAP at a concentration of (1000 μM) each. Similarly, asignificant effect of plant growth regulators was observed on root dry weight wherehighest dry weight was noted in the plants treated with NAA at the rate of 1000 μM in spinach.

Petrenko and Biryukova (1977) deduced that kinetin increased the concentration of carotenoids which protect chlorophylls against photo-oxidation process. Endogenous cytokinins accumulate in the buds of pea seedlings 6 and 24 hours after stem decapitation (Li and Li, 1996) and exogenous cytokinins release the buds from the inhibition of the cotyledon (Procházka*et al.*, 1997).

2.3 Effect of application method on growth and yield of chilli

Patel *et al.* (2016) conducted a field experiment on chilli cultivar “KashiAnmol” at SHIATS, Allahabad, UP. They applied two methods of application of PGRone was soaking seed and another foliar application. They found seed yield per plant(8.30g), seed yield per fruit (0.35g) and fresh weight of fruits per plant (39g) withNAA @ 40 ppm. Foliar spray of 40 ppm NAA at bud initiation stage increase in seedyield and quality parameters.

Singh *et al.* (2010) set an experiment to determine the effect of growth regulators(NAA &Ethrel) on growth and yield of hot pepper (*Capsicum annuum* L.) cv.PusaJwala during the kharif season. Plants were sprayed at flower bud initiationand 20 days later with 10 treatments. The maximum values for plant

height, fruitnumber, fruit weight, fruit weight per plant and fruit yield were found intreatment combination of 50 ppm NAA and 200 ppm Ethrel.

Bhalekar*et al.* (2009) set a field experiment to determine the effect of plantgrowth regulator and micronutrients on growth and yield of hot pepper(*Capsicum annum* L.) during summer season, including 10 treatments. Foliarspraying of the plant growth regulator (NAA) and micronutrients (Boron &Zinc) at flowering stage improved the growth and yield of hot pepper. Amongthe treatments, NAA at 20 ppm spray at flowering stage reported the maximumfruit yield compared to control.

Natesh*et al.* (2005) set an experiment on chilli variety “Byagikaddi” atUniversity of Agriculture Sciences, Dharwad and reported that application ofgrowth regulators at flowering stage enhanced the growth and seed yield of hot pepper. Among them, GA_3 @ 100 ppm spray at flowering stage found maximum fruit and seed yield followed by GA_3 @ 50 ppm and NAA @ 40 ppm, indicatingtheir utility in improving seed production of hot pepper.

Goudappalavar (2000) found that significantly maximum plant height was recorded (115.7 cm) with the application of 100 ppm NAA at 50 percentsprayed at flowering stage when compared to control (70.6 cm) in tomato plant.

Kubal (1999) found that the highest number of branches and lowest dry weightof leaves in sweet pepper plants by NAA at 20 ppm when applied four times as foliar spray, at 20 days intervals starting from transplanting under Konkancondition in sweet pepper.

Belakbir*et al*. (1998) test the effectiveness of different bio regulators inimproving sweet pepper yield and quality at SCRI, Scotland. The commercialbio regulators

CCC, NAA, GA3 and biozyme were sprayed at flower initiationfollowed by two additional spray at 30 day intervals. Treatment with NAAproduced maximum marketable fruits. GA_3 enhanced ascordic acid and Citricacid concentration and also enhanced TSS, carotenoid, sucrose, fructoseconcentration.

Pandita*et al.* (1989) reported that planofix a commercial formulation of NAAwhen sprayed twice at the rate of 10 ppm produced maximum number of branchand stem thickness in hot pepper plant under north-Indian conditions.

Yamgar and Desai (1987) reported that NAA and Planofix at 10 ppm producedmaximum number of flowers per plant as compared to higher concentrations i.e.20, 30,40 and 50 ppm. Similarly, they reported that earlier spraying (20th days after transplanting) was superior over late spraying (40th and 60th day aftertransplanting) and decreased the fruit drop in hot pepper.

Singh *et al*.(2013) set an experiment on foliar spray of GA3 50 ppm at fruit setting orNAA 10 ppm either single or double spray at flowering and 5 week laterimproved the fruit yield in hot pepper. Two foliar spray of triacontanol 2 ppm oratonic 0.08% at 30 days after transplanting and later at flowering stage were alsofound that double sprays of NAA 10 ppm at flowering and 5 weeks laterreduced flower shedding and results in maximum yield in hot pepper.

Singh and Mukherjee (2002) conducted a field trial (Rajasthan, Indiaduring the kharif season of 1997-98) which indicated that yield and yield attributes ofchilli (*Capsicum annuum* var. longum) *cv*. RCH-1 were greatly influenced by thefoliar sprays of urea (0.5, 1 and 1.5%) and naphthalene acetic acid [NAA] (25, 50and 75 ppm). Increasing concentrations of urea and naphthalene acetic acidincreased percent fruit set, fruit weight, percent dry yield and yield ha-1 anddecreased fruit drop percentage, whereas time taken to 50% flowering wasdecreased by the higher

concentrations of naphthalene acetic acid. The maximumyield was obtained with the treatment of 1.5% urea (193.06 q/ha) and 75 ppm NAA.

Khurana *et al*. (2004) also reported higher yield in chilli after the spray ofNAA and inferred that the higher yield was due to appropriate growth of plants,control of abscission layer in full bloom stage and acceleration in full development bythe positive hormonal actions.

Pargi*et al.* (2014) conducted a pot experiment on tomato crop at SHIATS,Allahabad. They applied 5 levels of NAA spray (10, 20, 30, 40 and 50 ppm NAA) onthe bud initiation stage and found maximum yield of tomato with NAA @ 50 ppmfollowed by NAA @ 30 ppm.

Arora (2014) studied a research that was undertaken during summer season of 2010-11 at HorticultureResearch Farm of GocharMahavidhyalaya, Rampur Maniharan, Saharanpur, U. P. on chilli cv. PANT C-1to find out the most suitable concentration, time and method of application of plant growth regulators forgrowth, flowering, fruit set, yield and quality in chilli. Among different concentrations of plant growthregulators, 45 ppm NAA was found superior to all other treatments in respect of most of the plant growthand flowering characters, while, among methods of application, seedling root dip for 30 minutes alongwith double spray at flower bud initiation stage and 20 days later to it, was found superior for plantgrowth and quality. Improved yield and yield characters were observed in treatment combination 45ppm NAA used as seedling root dip for 30 minutes along with double spray. Applications of plant growth regulators promoted fruit set and thus, yield by influencing the percentage of short styled flowers in chilli cv. PANT C-1.

Sanyal*etal.(*1995) studied that the effects of plant growth regulators (IAA or NAA at 15, 25 or 50 ppm or GA_3 at 50, 75 or 100 ppm) and methods of plant growth regulator application on the quality of tomato fruits. Plant growth regulators had profound effects on fruit length, weight and sugar: acid ratio. The effects of presoaking seeds and foliar application of plant growth regulators were more profound than presoaking alone.

Kar *et al.* (1993) applied IAA, NAA (both at 15, 25 or 50 ppm.) or GA_3 (50, 75 or 100 ppm.) to tomato cv. Pusa Early Dwarf by presoaking seeds with or without a foliar spray 30 days after transplanting. Plant growth, flowering, fruit retention and yield were evaluated. There was no consistent trend in response with increasing rates of plant growth regulator. Overall, the application as a seed presoak + spray gave the best fruit retention and yield.

Akhtar *et al.* (1997) conducted an experiment to study the effect of different rates of NAA (0, 25, 50, 75 and 100 ppm) on two tomato lines (TM 0111 and TM 0367). Different concentrations of NAA, when sprayed on flower clusters, had significant effects on fruit bearing, individual fruit weight, size and yield per plant and per hectare. The highest yield (11.21 t/ha) was obtained when the plants were sprayed with 25 ppm NAA. The yield reduced gradually as NAA rate increased from 50 to 100 ppm. The effects of plant growth regulators (IAA or NAA at 15, 25 or 50 ppm or GA3 at 50, 75 or 100 ppm) and methods of plant growth regulator application (presoaking seeds for 24 h before sowing or presoaking seeds + foliar spray 30 days after transplanting) on the quality of tomato fruits were investigated. Plant growth regulators had profound effects on fruit length, weight and sugar: acid ratio. The effects of presoaking seeds + foliar application of plant growth regulators were more profound than presoaking alone.

CHAPTER III
MATERIALS AND METHODS

This chapter illustrates information concerning methodology that was used in the execution of the experiment. It comprises a short description of experimental site, climatic condition, materials used for the experiment, treatments of the experiment, collection of data presented under the following headings:

3.1 Experimental site

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka-1207 (Appendix I) during the period of rabi season from October 2017 to March 2018. The experimental site is situated between 23°75′ N latitude and 90°34′ E longitude and at an elevation of 8.4 m from sea level (Anon., 1989).

3.2. Soil of the experimental field

Soil of the study site was shallow red brown terrace soil belonging to Tejgaon series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) (Appendix II). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in AppendixIII.

3.3 Climatic condition

Experimental site was located in the subtropical monsoon climatic zone, heavy rainfall occurred during the months of April to September (Kharif season) and scantly of rain fall during the rest of the year (Rabi season). Information regarding average monthly temperature as recorded by Bangladesh Meteorological

Department (climate division) during the period of study has been presented in Appendix IV.

3.4 Plant materialscollection

Hybrid seed of chilli (Variety-Anmol) was used as planting materials in the experiment. The seeds were collected from Mirpur that is packed and marketed by Kalash Seeds Pvt. Ltd.

3.5 Treatment of the experiment

Two factors of treatments included in the experiment were as follows:

Factor A: Plant growth regulators

In experiment, three plant growth regulators were used. These were-

Factor A: Plant growth regulators-

G_0: Control (Water)

G_1: NAA (40 ppm)

G_2: Cytokinin (10 ppm)

Factor B: Application method

Three different levels of application method were used on experiment given below-

M_1: Seed soaking with plant growth regulators for 6 hours

M_2: Foliar spray with plant growth regulators at vegetative stage

M_3: Foliar spray with plant growth regulators at flower bud initiation stage

Treatment combinations:

There were 9 (3×3) treatment combinations such as G_0M_1, G_0M_2, G_0M_3, G_1M_1, G_1M_2, G_1M_3, G_2M_1, G_2M_2 and G_2M_3.

3.6 Design and layout of theexperiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 15.8 m x 6.8 m was divided

into three equal blocks. Each block was consists of 9 plots. There were 27 units plots in the experiment. The size of each plot was 1.6 m x 1.2 m, which accommodated 12 plants at a spacing 40 cm x 40 cm. The distance between two blocks and two plots were kept 0.5 m and 0.5 m respectively. The layout of the experiment is shown in Fig 1.

3.7 Cultivation procedure of chilli

3.7.1 Seedbed preparation

The seedbed was prepared for raising seedlings of chilli 13 October‟ 2017 and the size of the seedbed was 3m × 1m. For making seedbed, to obtain good tilth the soil was well ploughed and converted into loose friable and dried masses. Stubbles and dead roots were removed. At the rate of 5 kg well rotted cow dung was applied to the prepared seedbed. To protect the seedlings plants from the attack of mole crickets, ants and cutworm soil was treated by sevin 50 WP @ 5 kg/ha. To prevent some seed borne diseases such as leaf spot, blight, anthracnose, etc. seeds were treated by Vitavax-200 @ 5 g/kg seed.

3.7.2 Seed sowing

Seeds were sown on 16 October, 2017 in the seedbed. Sowing was done thinly in lines. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering by water can. Thereafter to maintain the required temperature and moisture the beds were covered with dry straw. The cover of dry straw was removed immediately after emergence of seed sprout.

3.7.3 Raising of seedlings

Several times light watering and weeding were done. For raising of seedlings no chemical fertilizers was applied. Seedlings were not attacked by any kind of insect

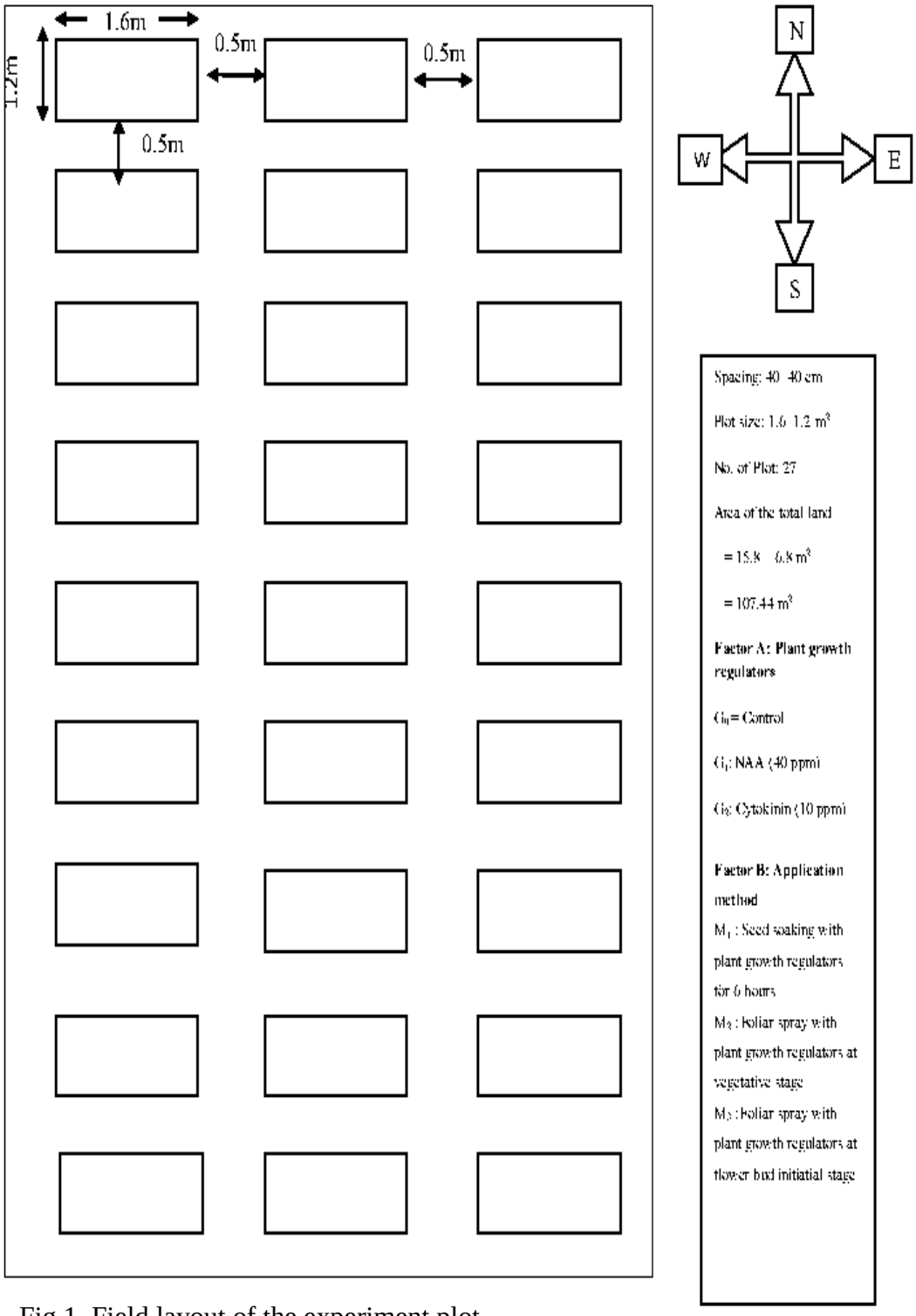

Fig 1. Field layout of the experiment plot

or disease. Twenty five days old healthy seedlings were transplanted into the experimental field on 10 November, 2017.

3.7.4 Preparation of the main field

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller on 25 October 2017. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was made ready.

3.7.5 Application of manure and fertilizers

Fertilizer	Quantity	Application method
Cowdung	10 t/ha	Basal dose
Urea	210 kg/ha	15, 25 and 35 DAT
TSP	330 kg/ha	Basal dose
MP	200 kg/ha	½ basal dose + rest ½ (15 and 25 DAT)

Source: Razzak *et al.* (2011).

3.7.6 Transplanting

To minimize the damage of roots seedbed was watered before uprooting the seedlings. Care was taken at the time of uprooting so that root damage became less and some soil remained with the roots. Twentyfive days-old healthy seedlings were transplanted at the spacing of 40 cm × 40 cm in the experimental plots on 10 November 2017. Thus the 12 plants were accommodated in each unit plot.

Planting was done in the afternoon. Light irrigation was given immediately after transplanting around each seedling for their better establishment. The transplanting seedlings were shaded for five days to protect them from scorching sunlight watering was done up to five days until they became capable of establishing on their own root systems.

3.8 Intercultural operations

3.8.1 Gap filling

Gap filling of seedlings was done by healthy seedlings of the same stock where initial planted seedling failed to survive.

3.8.2 Application of plant growth regulators

Plant growth regulators as NAA @ 40 ppm, cytokinin @ 10 ppm of water were applied 3 timesby a mini hand sprayer at 15 days interval.

3.8.3 Weeding

The plants were kept under careful observation. Three times weeding were done during cropping period at 25, 55, 75 DAT for proper growth and development of the plants.

3.8.4 Earthing up

Earthing up was done by taking the soil from the space between the rows on 2, December 2017.

3.8.5 Irrigation

Irrigation was given by observing the soil moisture condition. Five times irrigation were done during crop period and continued up to final harvesting for proper growth and development of plants.

3.8.6 Plant protection

The established plants were affected by aphids. Diazinon 60EC (15cc/10 liter) was applied against aphids and other insects. Chilli plants infected with anthracnose and die back were controlled by spraying cupravit (3g/L) at 15 days interval. Few plants found to be infected by bacterial wilt were uprooted.

3.8.7 Harvesting

Depending on the maturity, mature green fruits were harvested at weekly intervals. Harvesting was started at 65 days after transplanting (DAT) and continued upto final harvest.

3.9 Data collection

In the net plot area, treatment wise five plants were randomly selected and tagged for recording biometric as well as yield observations. Data on the following parameters were recorded from the sample plants during the course of experiment.

3.9.1 Plantheight (cm)

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants was recorded at 30 days interval starting from 30 days of planting up to 90 days to observe the growth rate of plants. The average height was computed and expressed in centimeters.

3.9.2 Number of branches perplant

The number of primary branch per plant was manually counted at 30 days interval from tagged plants. The average of primary branches from five plants were computed and expressed in average number of primary branch per plant.

3.9.3 Number of leaves perplant

The number of leaves per plant was measured with a meter scale from five selected plants at 30, 60 and 90 days after transplanting on tagged plants. Data were recorded as the average of 5 plants selected at random.

3.9.4 Days from transplanting to 1st flowering

Difference between the dates of transplanting to the date of 1st floweremergence of a plot was counted and recorded.

3.9.5 Days from transplanting to 50% flowering

Difference between the dates of transplanting to the date of flowering of a plot was counted as days to 50% flowering. Days to 50% flowering was recorded when 50% flowers of a plot were at the flowering stage.

3.9.6 Number of flowers per plant

The number of flowers per plant was counted from each plot after flowering and recorded per plant basis.

3.9.7 Number of fruit per plant

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

3.9.8 Plant canopy (cm)

The canopy of plant was manually counted at 50 days after transplanting from tagged plants. The average of five plants were computed and expressed in average canopy of plant.

3.9.9 Length offruit (cm)

The length of fruit was measured with a meter scale from the neck of the fruit to the bottom of fruits from each plot and there average was taken and expressed incm.

3.9.10 Diameter of fruit (cm)

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

3.9.11 Individual fruitweight (g)

The weight of individual fruit was measured with a digital weighing machine from fruits from each selected plots and there average was taken and expressed in gram (g).

3.9.12 Yield perplant (g)

An electric balance was used to measure the weight of fruits per plant. The total fruit yield of each plant measured separately during the harvest period and was expressed in gram(g).

3.9.13 Yield perplot (kg)

An electric balance was used to measure the weight of fruits per plot. The total fruit yield of each unit plot measured separately during the harvest period and was expressed in kilogram (kg).

3.9.14 Yield per hectare (ton)

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

3.9.15 Ascorbic acidcontent (mg/100g)

2, 6 - dichlorophenol indophenols (visual titration method) determined vitamin C content of green fruit of chilli as described by Plummer (1971). For the estimation of ascorbic acid the following reagents were used.

Reagents

i. 3% Metaphosphoric acid (HPO_3) - It was prepared by dissolving 30 g of HPO3 and 80 ml glacial acetic acid in distilled water and one liter volume was made up.

ii. Standard ascorbic acid solution - By dissolving ascorbic acid in 3% metaphosphoric acid solution was made 10% of L- ascorbic acid solution was made.

iii. Dye solution - It was prepared by dissolving 260 mg of sodium salt of 2, 6 - dichlorophenol indophenol in one liter of distilled water.

Procedure

Standardization of dye solution

Five ml of Meta phosphoric acid was diluted with 5 ml of standard ascorbic acid solution. A micro burette was loaded with dye solution and the mixed solution was titrated with dye solution using phenolphthalein as indicator to the pink colored end point which lasted for at least 15 sec. Dye factor was calculated using the following strand: $Dye\ \text{factor} = \frac{0.5}{\text{Titrate}}$

Preparation of sample

In a 100 ml beaker, five grams of fresh fruit of chilli was taken with 50 ml 3% metaphosphoric acid and then it was transferred to a blender and homogenized with same concentration of metaphosphoric acid. After blending then it was filtered and centrifuged at 2000 rpm for 5 minutes.

In 100 ml volumetric flask homogenized liquid was transferred and volume was made up to the mark with 3% metaphosphoric acid.

Titration

In a conical flask 5 ml of the aliquot was taken and titrated with 2, 6-dicholophenol indophenols dye, phenolphthalein was used as indicator to a pink colored end point, which persisted at least 15 seconds. The ascorbic acid content (Vitamin C) of the sample was calculated by using the following strand:

Ascorbic acid (mg /100gm) $= \frac{T \times D \times V1}{V2 \times W} \times 100$

Where,

T = Titrate value (ml)

D = Dye factor

V_1= Volume to be made (ml)

V_2= Volume of extract taken for titration (ml)

W = Weight of sample taken for estimation (g)

3.10 Statistical analysis

The data collected on different characters were statistically analyzed using MSTAT-C software. The mean values of all the characters were evaluated and analysis of variance was performed by 'F' test. The significance of the difference among the treatments means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3.11 Economic analysis

The cost of production was calculated to find out the most economic combination of growth regulator and application method. All input cost like the cost for land lease and interests on running capital were computed in the calculation. The

interests were calculated @ 13% in simple rate. The market price of chilli was considered for estimating the return. Analyses were done according to the procedure of Alam*et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

Net income : Gross income – total cost of production

BCR = Gross return per hectare (Tk.) ÷ Cost of production per hectare (Tk.)

CHAPTER IV
RESULTS AND DISCUSSION

The present research work was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from October, 2017 to March, 2018 to investigate the growth and yield of chilli as influenced by plant growth regulators and its method of application. Therefore, it was carried out to see the performance of chilli at varying treatments combinations of plant growth regulators with application method in respect of yield. The analysis of variance (ANOVA) of the data on different growth and yield components had been presented in Appendix V-IX.The results have been presented and discussed, and possible interpretations have been drawn under the following headings:

4.1 Plant height (cm)

Plant height is a significant growth contributing character of chilli plant. Plant height was significantly influenced by plant growth regulators. (Appendix V). At 90 DAT, the tallest plant (52.18 cm) was obtained from G_1 (40 ppm) treatment, while the shortest plant (41.83 cm) was found from G_0 (control) treatment (Fig. 2 and Appendix V). It revealed that plant growth hormone increased plant height, which might be due to regulating effect of exogenous application of PGRs. Rai *et al*. (2002) conducted an experiment that application of IAA increased the plant height significantly. Gupta *et al*. (2001) studied with tomato plants were treated with NAA and supported the results.

Plant height of chilli was significantly influenced by different application method at 30, 60 and 90 DAT (Appendix V). At 90 DAT, the tallest plant (49.14 cm) was

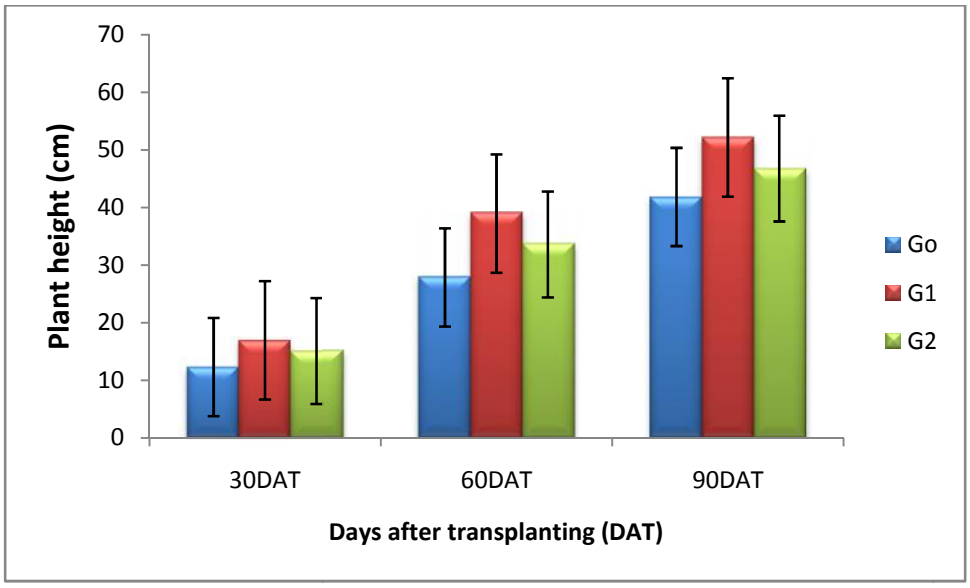

Fig. 2Effect of plant growth regulators on plant height at different days after transplanting of chilli

Where, G_0= Control, G_1 = NAA (40 ppm) , G_2 = Cytokinin (10 ppm)

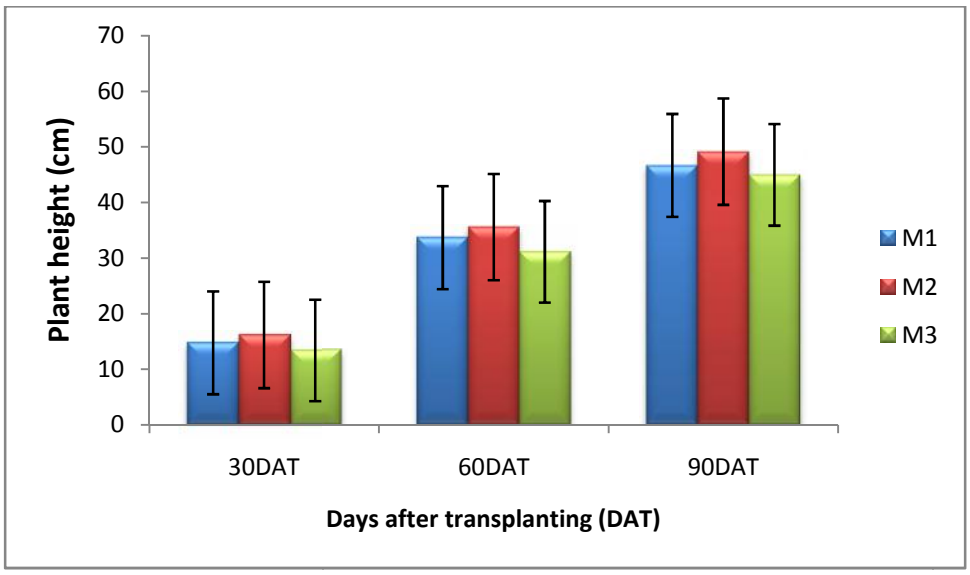

Fig.3Effect of application method on plant height at different days after transplanting of chilli

Where,M_1: Seed soaking with plant growth regulators for 6 hours
M_2: Foliar spray of plant growth regulators at vegetative stage
M_3: Foliar spray of plant growth regulators at flower bud initiation stage

obtained from M_2 (foliar spray of plant growth regulators at vegetative stage) treatment, while the shortest plant (44.97 cm) was found from M_3 (foliar spray of plant growth regulators at flower bud initiation stage) treatment (Fig. 3 and Appendix V).

Combined effect of Plant growth regulators and its application method significantly affected by plant height under the present study (Table 1 and Appendix V). Different plant height was viewed different with different treatment combination at days after transplanting (DAT). At 90 DAT, the tallest plant (54.50 cm) was observed from G_1M_2 (NAA 40 ppm with foliar spray at vegetative stage) treatment combination. On the other hand, the shortest plant (40.00 cm) was recorded from G_0M_3 (control with foliar spray at flower bud initiation stage) treatment combination (Table 1). Singh *et al.,* (2012) who noted the increasing in plant height with application of different concentration of auxin as foliar sprays (NAA 50 ppm) in capsicum under protected condition in Garhwal region, Himachal Pradesh. Kannan *et al.* (2009) reported that the greatest plant height was observed at NAA 40 ppm spraying at vegetative stage.

Hence it may be recorded that the increase in plant height may be due to the effect on stem elongation by rapid cell elongation and multiplication of cells in sub-apical meristem by application of plant growth regulators. The rapid growth occurs is a result of both the greater number of cells formed and elongation of individual cells**.** It was also supported by Choudhury *et al.* (2006) where they stated that the growth and yield contributing characters were significantly differed due to different plant growth regulators.

Table 1. Combined effect of plant growth regulators and its method of application on plant height at different days after transplanting of chilli

Treatment combinations	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
G_0M_1	12.33e	28.53de	41.90f
G_0M_2	13.93d	30.40cd	43.60e
G_0M_3	10.67f	24.67e	40.00g
G_1M_1	16.77b	38.73ab	51.90b
G_1M_2	18.60a	40.80a	54.50a
G_1M_3	15.47c	37.33ab	50.13c
G_2M_1	15.20c	33.80bc	46.20d
G_2M_2	16.00bc	35.53bc	49.33c
G_2M_3	14.07d	31.40cd	44.77e
CV %	6.42	8.67	8.25
LSD (0.05)	0.96	5.20	1.42

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note G_0:Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators at flower bud initiation stage

4.2 Number of branches perplant

From the result of the experiment it was observed that significant variation was found for different plant growth regulators of chilli in terms of number of branches per plant at 30, 60 and 90 DAT (Table 2 and Appendix V). At 90 DAT, the maximum number of branches per plant (17.33 cm) was recorded from G_1(NAA 40 ppm) treatment, while the minimum number (14.11 cm) was found from (control) G_0treatment which was statistically identitcal to G_2 (15.44 cm). Tiwari and Singh (2014) reported that number of branches increased by NAA 40 ppm. Singh *et al*. (2005) found that number of branches significantly increased by the

application of IAA at 75 ppm. Rai *et al*. (2002) found the highest number of branches due to the application of 75 ppm IAA.

Number of branches per plant of chilli varied significantly for different method of application at different days after transplanting (Table 2 and Appendix V). At 90 DAT, the maximum number of branches per plant (16.00 cm) was obtained from M_2 treatment (foliar spray of plant growth regulators at vegetative stage), while the shortest plant (15.44 cm) was found from (Seed soaking with plant growth regulators for 6 hours) $M_1$and M_3 (foliar spray at plant growth regulators at flower bud initiation stage) treatments (Table 2).

Plant growth regulators and its method of application performed significant variation due to the combined effect on number of branches per plant of chilli at 30, 60 and 90 DAT (Appendix V). At 90 DAT the maximum number of branches per plant (18.33 cm) was recorded from G_1M_2 (NAA 40 ppm with foliar application at vegetative stage) treatment combination which was statistically similar withG_1M_1 (17.00 cm), G_1M_3 (16.67 cm), G_2M_1 (15.33 cm) and G_2M_3 (16.00 cm) treatment combinations.On the other hand, the minimum number of branches per plant (13.67 cm) was observed from G_0M_3 (control with foliar application at flower bud initiation stage) treatment combination (Table 2) which was statistically similar to G_0M_1 (14.00 cm), G_0M_2 (14.67 cm) and G_2M_2 (15.00 cm) treatment combination. It was found in present study that plant growth regulators increase number of branches per plant. It can be easily observed that plant growth regulators play a vital role in several physiological processes, *viz*, photosynthesis, respiration,energy store, transfer, cell division which will significantly enhance the axillary stalk or branching of plants.

Table 2. Effect on number of branches per plant at different days after transplanting of chilli

Treatments	Number of branches per plant		
	30 DAT	60 DAT	90 DAT
Effect of plant growth regulators			
G_0	3.56c	8.78c	14.11b
G_1	6.11a	12.56a	17.33a
G_2	5.00b	11.00b	15.44b
LSD (0.05)	0.69	1.03	1.76
Effect of application method			
M_1	5.00	10.78ab	15.44b
M_2	5.55	11.44a	16.00a
M_3	4.11	10.11b	15.44b
LSD (0.05)	NS	0.98	0.48
Combined effect of plant growth regulators and its method of application			
G_0M_1	3.67	9.00de	14.00bc
G_0M_2	4.00	9.67cd	14.67bc
G_0M_3	3.00	7.67e	13.67c
G_1M_1	6.00	12.33ab	17.00ab
G_1M_2	7.00	13.33a	18.33a
G_1M_3	5.33	12.00ab	16.67abc
G_2M_1	5.33	11.00bc	15.33abc
G_2M_2	5.67	11.33bc	15.00bc
G_2M_3	4.00	10.67bcd	16.00abc
CV %	12.68	11.58	8.45
LSD (0.05)	NS	1.79	3.06

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

NoteG_0: Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators atflower bud initiation stage

4.3 Number of leaves perplant

In general, leaf is considered as an important functional unit of plant which contributes to the formation of yield. Number of leaves per plantshowed statistically significant variation on plant growth regulators at 30, 60 and 90 DAT (Appendix VI). At 90 DAT, the maximum number of leaves per plant (61.11)was recorded from G_1 treatment (NAA 40 ppm), while the minimum number (48.11) was found from G_0(control) treatment (Fig. 4 and Appendix VI). These results are agreement with that reported by Natesh*et al*. (2005), Kalshyam*et al.* (2011) and Vaishnav *et al.* (2012).

Significant variation was found in chilli in terms of number of leaves per plant at 30, 60 and 90 DAT due to different application methodAppendix VI). At 90 DAT, the maximum number of leaves per plant (57.89) was recorded from M_2 treatment (foliar spray of plant growth regulators at vegetative stage) while the minimum number (52.00) was obtained from M_3 (foliar spray at plant growth regulators at flower bud initiation stage) treatment which was statistically identical to M_1 (Seed soaking with plant growth regulators for 6 hours) treatment (Fig.5 and Appendix VI).

Number of leaves per plant performed significant variation among combination of plant growth regulators and its application method (Appendix VI). At 90 DAT, the maximum number of leaves per plant (63.67) was recorded from G_1M_2(NAA 40ppm with foliar spray at vegetative stage) treatment combination, whereas the

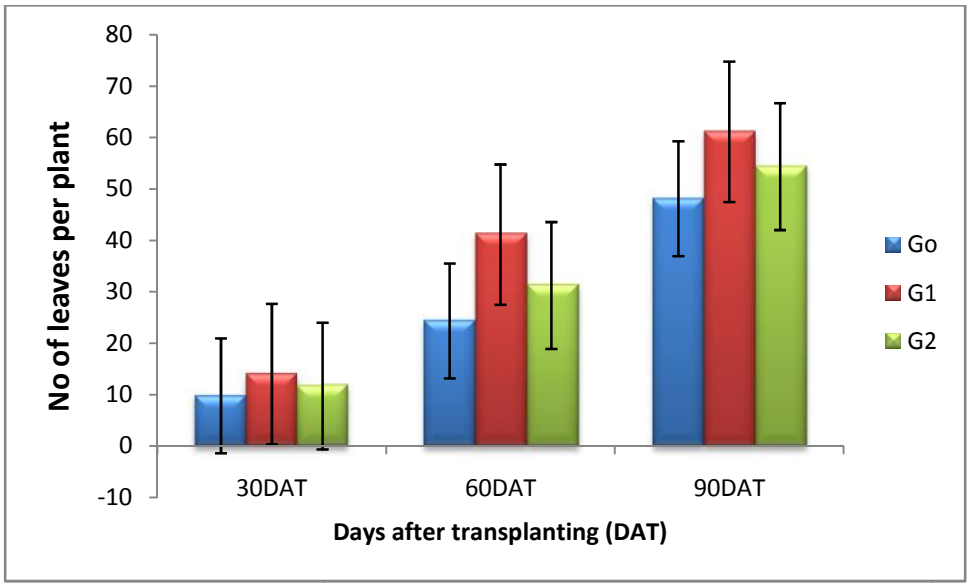

Fig. 4Effect of plant growth regulators on number of leaves per plant at different days after transplanting of chilli

Where, G_0= Control G_1 = NAA (40 ppm) G_2 = Cytokinin (10 ppm)

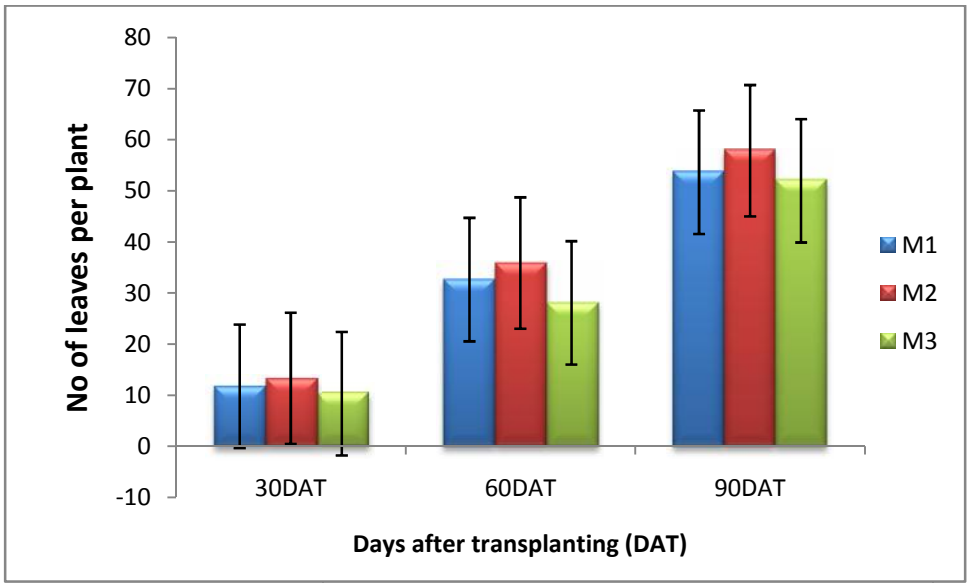

Fig.5 Effect of application method on number of leaves per plant at different days after transplanting of chilli.

where, M_1: Seed soaking with plant growth regulators for 6 hours
M_2: Foliar spray of plant growth regulators at vegetative stage
M_3: Foliar spray of plant growth regulators at flower bud initiation stage

Table 3. Combined effect of plant growth regulators and its application method on number of leaves per plant at different days after transplanting of chilli

Treatment combinations	Number of leaves per plant		
	30 DAT	**60 DAT**	**90 DAT**
G_0M_1	9.67de	24.67de	47.00d
G_0M_2	11.00cd	27.33cd	51.33c
G_0M_3	8.67e	21.00e	46.00d
G_1M_1	14.00ab	41.67a	60.33b
G_1M_2	15.33a	46.00a	63.67a
G_1M_3	12.67bc	35.67b	59.33b
G_2M_1	11.67c	31.67bc	53.67c
G_2M_2	13.67ab	34.33b	58.67b
G_2M_3	9.67de	27.67cd	50.67c
CV %	9.98	9.16	10.97
LSD (0.05)	1.71	5.68	3.18

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note G_0:Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm)M_3: Foliar spray of plant growth regulators atflower bud initiation stage

minimum number of leaves per plant (46.00) was found from G_0M_3 (control with foliar spray at flower bud initiation stage) treatment combination which was statistically identical to G_0M_1treatment combination(Table 3).

From the results of the present research indicated that combined effect of NAA with its foliar spray at vegetative stage might have induced better growing condition that ultimately led to more leaves production.

4.4 Days from transplanting to 1st flowering

Different plant growth regulators had significant influence on days from transplanting to 1st flowering of chilli (Appendix VII). The minimum days from transplanting to 1st flowering (50.83 days) was found from G_1 (NAA 40 ppm), while the maximum (63.00 days) from G_0 treatment (control) (Table4).It is recorded that when NAA has been applied @ 20 ppm the initiation of flowering was earlier by almost one week. Similar finding was recorded by Desai (1987).

Days from transplanting to 1st flowering of chilli showed statistically significant difference for different application method (Appendix VII). The minimum days from transplanting to 1st flowering (55.41 days) was recorded from M_2 (Foliar spray of plant growth regulators at vegetative stage) treatment, while the maximum (59.33 days) was attained from M_3 treatment (Foliar spray at flower bud initiation stage) (Table 4).

Combined effect of plant growth regulators and application method showed statistically significant variation for days from transplanting to 1st flowering (Appendix VII). The minimum days from transplanting to 1st flowering (48.50 days) was found from G_1M_2 (NAA 40 ppm with foliar spray at vegetative stage) treatment combination, while the maximum (64.00 days) was observed from G_0M_3 (control with foliar spray at flower bud initiation stage) treatment combination (Table 4 and Appendix VII).From presented data it can be observed that NAA has positive effect on early flower initiation. This is an important factor considered by the farmers as they can be able to harvest their product by one week earlier, which leads to fetch more prices in the market.

4.5 Days from transplanting to 50% flowering

It was observed from the result of the experiment that days from transplanting to 50% flowering showed statistically significant variation amongdifferent plant growth regulators (Appendix VII). The minimum days from transplanting to 50% flowering (90.17 days) was found from G_1 (NAA 40 ppm) treatment, while the maximum days (103.67 days) was attained from G_0 (control) (Table 4) treatment.Data recorded on days from transplanting to 50% flowering was in agreed with the findings of Singh and Mukherjee(2002).

Chilli varied significantly for different application method in terms of days from transplanting to 50% flowering (Appendix VII). The minimum days from transplanting to 50% flowering (94.50 days) was observed from M_3 (Foliar spray at flower bud initiation stage), while the maximum days (98.83 days) was recorded from M_1 (Seed soaking with plant growth regulators for 6 hours) treatment, which was statistically identical to M_2 (Foliar spray of plant growth regulators at vegetative stage) (Table 4).

In terms of days from transplanting to 50% flowering, significant variation was observed due combined effect of plant growth regulators and its application method (Appendix VII). The minimum days from transplanting to 50% flowering (87.50 days) was showed in G_1M_3 (NAA 40 ppm with foliar spray at flower bud initiation stage) treatment combination, while the maximum days (105.50 days) was found from G_0M_1 (control with seed soaking with plant growth regulators for 6 hours) treatment combination which was statistically identical to G_0M_2 (Table 4).

4.6 Number of flowers per plant

Application of different plant growth regulators showed significant effect on number of flowers per plant of chilli (Appendix VII). The maximum number of flowers per plant (434.12) was recorded from G_1 (NAA 40 ppm) treatment, whereas the minimum number (136.62) was obtained from G_0 (control) treatment (Table 4). It was noticed that application of NAA enhanced flower production, reduced flower abscission that contributed the maximum number of flowers per plant compared to plants that treated with others hormone and control. This might be occured dueto auxin application at the time of flowering which resulted lower flower drop. Chaudhary *et al.*, 2006 reported that plant growth regulators play an essential role in flower development. Gupta and Gupta (2000) applied the auxins and supported the results. Kar *et al.* (1993) applied NAA on tomato and agreed with the results.

Significant variation was recorded due to the effect of different application method on number of flowers per plant (Appendix VII). The maximum number of flowers per plant (322.75) was attained from M_3 treatment (Foliar spray of plant growth regulators at flower bud initiation stage), while the minimum number (234.44) was found from (seed soaking with PGRs for 6 hours) M_1 treatment (Table4).

Number of flowers per plant showed significant difference due to the combined effect of plant growth regulators and its method of application(Appendix VII). The highest number of flowers per plant (500.29) was recorded from G_1M_3 (NAA 40 ppm with foliar spray at flower bud initiation stage) treatment combination, while the lowest number (206.69) was found from G_0M_1 (control with seed soaking with plant growth regulators for 6 hours) treatment combination (Table4). It can be said that plant growth regulators modify plant physiological process using in smallamount and plays an essential role in plant growth, elongation and flower development.

Table 4. Effect of plant growth regulators and its application method on yield contributing characters ofchilli

Treatments	Days from transplanting to 1st flowering	Days from transplanting to 50% flowering	Number of flowers per plant	Number of fruits per plant
Effect of plant growth regulators				
G_0	63.00a	103.67a	136.62c	83.05c
G_1	50.83c	90.17c	434.12a	410.60a
G_2	58.17b	96.67b	258.81b	217.86b
LSD (0.05)	0.41	1.16	5.03	8.14
Effect of application method				
M_1	57.33b	98.83a	234.44c	193.06c
M_2	55.41c	97.17a	272.35b	235.14b
M_3	59.33a	94.50b	322.75a	283.31a
LSD (0.05)	0.73	1.22	4.76	3.87
Combined effect of plant growth regulators and its application method				
G_0M_1	63.00b	105.50a	206.69i	159.35i
G_0M_2	62.00c	104.50a	234.36h	175.35h
G_0M_3	64.00a	101.00b	278.80g	195.45g
G_1M_1	51.00h	92.50e	431.71c	376.48c
G_1M_2	48.50i	90.50e	472.36b	395.01b
G_1M_3	53.00g	87.50f	500.29a	410.32a
G_2M_1	58.00e	98.50c	314.92f	289.35f
G_2M_2	55.50f	96.50cd	362.33e	310.07e
G_2M_3	61.00d	95.00d	399.17d	336.16d
CV %	12.34	10.75	8.32	9.56
LSD (0.05)	0.71	2.01	2.06	1.24

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

NoteG_0:Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators atflower bud initiation stage

4.7 Number of fruits perplant

Different Plant growth regulators showed significant difference on number of fruits per plant of chilli (Appendix VII). The maximum number of fruits per plant (410.60) was attained from G_1 (NAA 40 ppm) treatment, while the minimum number (83.05) was recorded from G_0(control) treatment (Table 4).Maximum number of fruit was found in plant growth regulators (NAA) treated plants compared to control. Singh and Lal (2001) conducted a field experiment and found the maximum number of fruits per plant by using NAA. Deb *et al.* (2009) found significant response of NAA with respect to number of fruits per plant. Gupta and Gupta (2000) applied the auxins and found the similar results.

In chilli significant variation observed on different method of application on total number of fruits per plant (Appendix VII). The maximum number of fruits per plant (283.31) was obtained from M_3 treatment (Foliar spray of plant growth regulators at flower bud initiation stage), while the minimum number (193.06) was obtained from M_1(Seed soaking with plant growth regulators for 6 hours) treatment (Table 4).

Number of fruits per plant performed significant variation among combination of plant growth regulators and application method (Appendix VII). The maximum number of fruits per plant (410.32) was recorded from G_1M_3 (NAA 40 ppm with foliar spray at flower bud initiation stage) treatment combination, while the minimum number (159.35) was found from G_0M_1(control with seed soaking with plant growth regulators for 6 hours) treatment combination (Table 4).

4.8 Plant canopy (cm)

Plant growth regulators had significant effect on plant canopy of chilli (Appendix VIII). The highest plant canopy (66.80cm) was attained from G_1(NAA 40 ppm) treatment while the lowest (57.26cm) was observed from G_0(Control) treatment (Table 5). Kar *et al.* (1993) applied NAA on tomato and found increased plant canopy.

Significant variation was observed due to various application method of plant canopy (Appendix VIII). The highest plant canopy (63.59cm) was attained from M_2(Foliar spray of plant growth regulators at vegetative stage) treatment, whereas the lowest plant canopy (60.07 cm) was observed from M_3 (Foliar spray of plant growth regulators at flower bud initiation stage) treatment (Table 5).

Combined effect of plant growth regulators and its application method showed significant variation on plant canopy of chilli (Appendix VIII). The highest plant canopy (68.97cm) was recorded from G_1M_2 (NAA 40 ppm with foliar spray at vegetative stage) treatment combination while the lowest plant canopy (55.30cm) was observed in G_0M_3 treatment combination which was statistically similar to G_0M_1 treatment combination (Table 5).

4.9 Length of fruit (cm)

Application of different PGRs showed significant effect on fruit length of chilli (Appendix VIII). Maximum (8.74 cm) fruit length was found in G_1 (NAA 40 ppm) treatment, whereas minimum fruit length was recorded from G_0 (7.86 cm) or control treatment (Table 5). Plant growth regulators have possibility to increase

length of fruit.The findings was also supported by Hasanuzzaman*et al*.(2007) and Gurudayal*et al*. (2017).

Significant variation was found due to different method of application in respect of fruit length of chilli (Appendix VIII). However, maximum (8.44 cm) fruit length was found in M_3 (Foliar spray of plant growth regulators at flower bud initiation stage) treatment which was statistically identical to M_2 (Foliar spray of plant growth regulators at vegetative stage) whereas minimum (8.06 cm) fruit length was recorded in M_1 (Seed soaking with plant growth regulators for 6 hours) treatment (Table 5).

Combined effect of plant growth regulators and its method of application performed different on fruit length of chilli (Appendix VIII). Maximum (8.98 cm) fruit length was recorded in G_1M_3 treatment combination which was statistically identical to G_1M_2 (8.85), whereas minimum (7.70 cm) fruit length was recorded in G_0M_1 treatment combination which was statistically similar to G_0M_2 (7.86 cm) and G_0M_3 (8.02 cm) (Table 5). Tapdiya*et al*. (2013) observed that, foliar spray of NAA 40 ppm at flower bud initiation stage increased the fruit length.

4.10 Diameter of fruit (cm)

Application of different plant growth regulators varied significantly on diameter of fruit at harvest (AppendixVIII). The maximum diameter of fruit of chilli (0.78 cm) was observed from G_1 (NAA 40 ppm) treatment while the minimum (0.61 cm) was showed in G_0 (control) treatment (Table 5).

Different types of application method found significant influence on diameter of fruit (AppendixVIII). The maximum diameter of fruit of chilli (0.72 cm) was observed in M_3 (Foliar spray of plant growth regulators at flower bud initiation stage) treatment and the minimum (0.66 cm) was measured in M_1 (Seed soaking with plant growth regulators for 6 hours) treatment (Table 5).

Combined effect of plant growth regulators and its application method showed significant effect on diameter of fruit (Appendix VIII). The maximum diameter of fruit (0.81 cm) was recorded from the treatment combination of G_1M_3 which was statistically identical to G_1M_2 treatment combinations, while the treatment combination of G_0M_1 gave the minimum (0.60 cm) diameter of fruit (Table 5) which was statistically identical to the treatment combination of G_0M_2.

4.11 Individual fruitweight (g)

Different plant growth regulators showed significant variation on individual fruit weight of chilli(Appendix VIII). The maximum weight of individual fruit (6.03 g) was recorded from G_1 (NAA 40 ppm) treatment, while the minimum weight (4.63 g) was observed from G_0(control) treatment (Table 5).

From the result of the experiment it was observed that statistically significant variation was found among different application method in respect of individual fruit weight of chilli (Appendix VIII). The maximum weight of individual fruit (5.67 g) was found from M_3 (Foliar spray of plant growth regulators at flower bud initiation stage) treatment while the minimum weight (4.93 g) was recorded from M_1(Seed soaking with plant growth regulators for 6 hours)treatment which was statistically identical with M_2(Foliar spray of plant growth regulators at vegetative stage)treatment (Table 5).

Table 5. Effect of plant growth regulators and its application method on yield contributing characters of chilli

Treatments	Plant Canopy (cm)	Length of fruit (cm)	Diameter of fruit (cm)	Individual fruit weight (g)
Effect of plant growth regulators				
G_0	57.26c	7.86c	0.61c	4.63c
G_1	66.80a	8.74a	0.78a	6.03a
G_2	61.35b	8.23b	0.68b	5.09b
LSD (0.05)	1.32	0.21	0.05	0.28
Effect of application method				
M_1	61.75b	8.06b	0.66c	4.93b
M_2	63.59a	8.32a	0.70b	5.16b
M_3	60.07c	8.44a	0.72a	5.67a
LSD (0.05)	1.21	0.19	0.03	0.38
Combined effect of plant growth regulators and its application method				
G_0M_1	57.48fg	7.70d	0.60e	4.40e
G_0M_2	59.00ef	7.86cd	0.61e	4.68de
G_0M_3	55.30g	8.02bcd	0.63d	4.82de
G_1M_1	66.54b	8.39b	0.73b	5.42bc
G_1M_2	68.97a	8.85a	0.79a	5.82b
G_1M_3	64.90bc	8.98a	0.81a	6.86a
G_2M_1	61.23de	8.11bc	0.64d	4.96cd
G_2M_2	62.80cd	8.24bc	0.70c	4.99cd
G_2M_3	60.00e	8.33b	0.71bc	5.33bc
CV %	10.66	11.43	9.27	9.56
LSD (0.05)	2.28	0.37	0.02	0.48

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

NoteG_0:Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators at flower bud initiation stage

Significant variation was recorded due to the combined effect of plant growth regulators and application method of individual fruit weight (Appendix VIII). The maximum weight of individual fruit (6.86 g) was attained from G_1M_3 treatment combination, while the minimum weight (4.40 g) was found from G_0M_1 treatment combination (Table 5) and it was statistically similar to G_0M_2 and G_0M_3 treatment combination. From the results of the present study indicated that combined effect of NAA 40 ppm with foliar spray at flower bud initiation stage might have induced better growth condition and ultimately led to increase individual fruit weight per plant. Similar results were noticed by Revanappa*et al.* (1998) reported that average fruit weight (2.60 g) in summer and (2.66 g) in kharif was highest in NAA 20 ppm foliar spray at flower bud initiation stage followed by lower concentration of NAA 10 ppm. An increase in average fruit weight treated with PGRs may further attributed so that plants remain physiologically more active to build up sufficient food for the developing flowers andfruits.

4.12 Yield per plant (g)

Yield is the main achievement for performing production of a crop. Nutrients are the most essential part for achieving best yield of chilli. Highest and quality yield is the main target ofproducing crop. Under the present study, yield per plant of chilli was significantly affected by different plant growth regulators (Appendix IX). The highest yield per plant (516.66 g) was found from G_1 (NAA 40 ppm) while the lowest yield per plant (177.25 g) was observed from G_0 (Control) treatment (Table 6).

Table 6. Effect of plant growth regulators and its application method on yield contributing characters of chilli

Treatments	Yield per plant (g)	Yield per plot (kg)	Yield per hectare (ton)	Ascorbic acid content (mg/100 g)
Effect of plant growth regulators				
G_0	177.25c	2.19c	13.85c	69.48c
G_1	516.66a	6.21a	33.56a	89.93a
G_2	332.44b	3.98b	22.89b	78.48b
LSD (0.05)	9.06	0.24	2.02	3.98
Effect of application method				
M_1	289.33c	3.54c	19.92c	75.33c
M_2	335.97b	4.03b	23.26b	79.29b
M_3	401.05a	4.81a	27.12a	83.26a
LSD (0.05)	7.21	0.29	1.34	1.08
Combined effect of plant growth regulators and its application method				
G_0M_1	274.17i	3.29i	17.13i	65.15h
G_0M_2	318.33h	3.82h	19.89h	69.89g
G_0M_3	353.33g	4.24g	22.08g	73.40fg
G_1M_1	456.66c	5.18c	28.54c	85.17c
G_1M_2	534.27b	6.41b	33.38b	89.35b
G_1M_3	609.16a	7.31a	38.07a	95.27a
G_2M_1	377.50f	4.53f	23.59f	75.66ef
G_2M_2	398.33e	4.78e	24.89e	78.64de
G_2M_3	423.33d	5.08d	26.46d	81.13d
CV %	10.78	12.45	10.38	7.11
LSD (0.05)	2.10	0.18	0.14	1.71

In a colum means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability

Note G_0:Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators at flower bud initiation stage

Statistically significant difference was showed among different application methods in terms of yield per plant in chilli (Appendix IX). The highest yield per plant (401.05 g) was found from M_3 (Foliar spray of plant growth regulators at flower bud initiation stage) treatment, while the lowest yield per plant (289.33 g) was recorded from M_1(Seed soaking with plant growth regulators for 6 hours)treatment (Table 6).

Combined effect of plant growth regulators and application methods varied significantly due to in respect of yield per plant (Appendix IX). The highest yield per plant (609.16 g) was attained from G_1M_3 treatment combination, while the lowest yield per plant (274.17g) was found from G_0M_1 (Table 6) treatment combination. This result also is in agreement with the findings of Bhalekar*et al.* (2009) where he revealed that NAAsprayatfloweringstagerecordedhigherfruityieldcomparedtocontrol.

4.13 Yield perplot (kg)

It was observed from the result of the experiment that the yield per plot was significantly varied statistically for differentgrowth regulators (Appendix IX). The maximumyield per plot (6.21 kg)wasrecorded from G_1 (NAA 40 ppm) treatment, while the minimum yield per plot (2.19 kg) was recorded from G_0(control) treatment (Table 6).Kannah*et al.*(2009) conducted an experiment and found that NAA gave greatest fruit yield per plot (6.82 kg). These results are supported by the findings Joshi and Singh *et al*. (2001), Kiranmayi*et al*. (2014), Vandana and Verma *et al*. (2014).

Yield per plot was significantly influenced by various application method (Appendix IX). The maximum yield per plot (4.81 kg) was recorded from M_3 treatment (Foliar spray of plant growth regulators at flower bud initiation stage),

while the minimum yield per plot (3.54 kg) was recorded from M_1 (Seed soaking with plant growth regulators for 6 hours) treatment (Table 6).

Plant growth regulators and its method of application varied significantly due to their combined effect in terms of yield per plot (Appendix IX). The maximum yield per plot (7.31 kg) was observed from G_1M_3 treatment combination, whilethe minimum yield per plot (3.29 kg) was recorded from G_0M_1treatment combination (Table6).

4.14 Yield perhectare (ton)

Yield per hectare was significantly influenced by application of different plant growth regulators under the present study (Table 6 and Appendix IX). The highest yield per hectare (33.56 ton) was observed from G_1(NAA 40 ppm) treatment, while the lowest yield per hectare (13.85 ton) was recorded from G_0(control) treatment (Fig. 6). Pargi*et al.* (2014) conducted a pot experiment on tomato and found maximum yield of tomato with NAA @ 40 ppm followed by NAA @ 30 ppm. Singh *et al*. (2000) conducted an experiment and he also got the maximum yield per hectare @ NAA 40 ppm. These results proved that the maximum growth, yield and yield attributes were found with plant growth regulators thancontrol.

Due to different types of application method significant difference was found in chilli (Table 6 and AppendixIX). The highest yield per hectare (27.12 ton) was recorded fromM_3 treatment (Foliar spray of plant growth regulators at flower bud initiation stage), while the minimum yield per hectare (19.92 ton) was observed from M_1 (Seed soaking with plant growth regulators for 6 hours) treatment (Fig. 7).

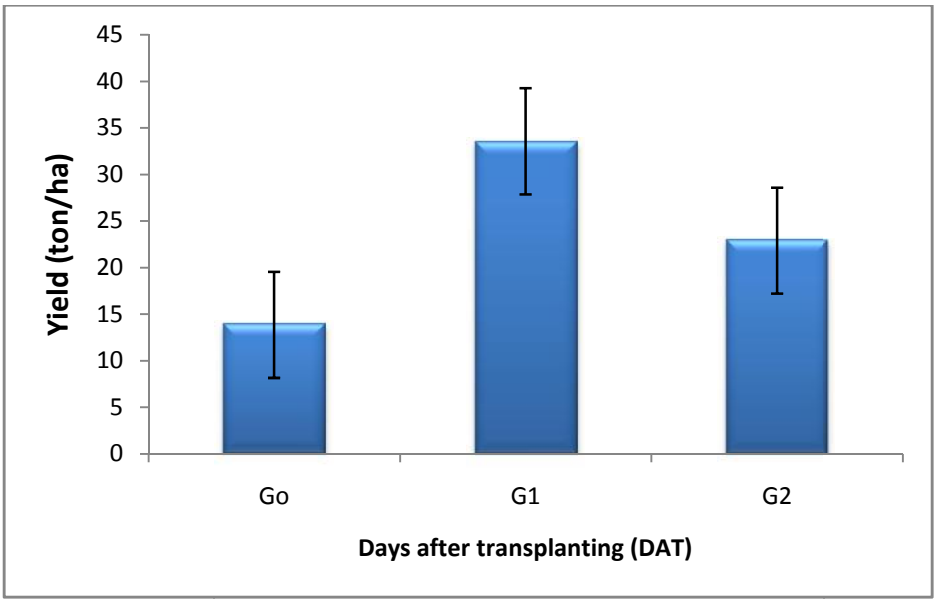

Fig. 6Effect of plant growth regulators on yield per hectare (ton) at different days after transplanting

Where, G_0= Control G_1 = NAA (40 ppm) G_2 = Cytokinin (10 ppm)

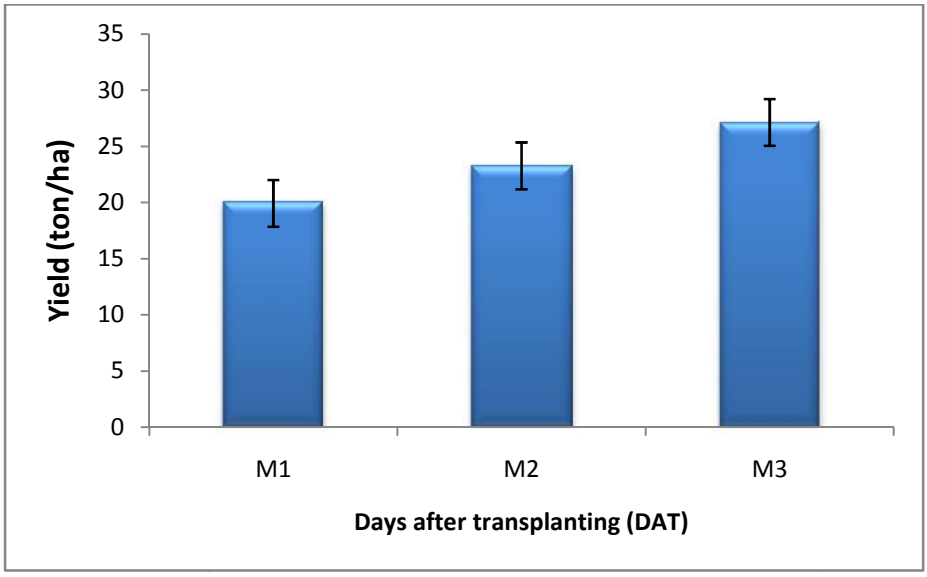

Fig. 7Effect of application method on yield per hectare (ton) at different days after transplanting

where, M_1: Seed soaking with plant growth regulators for 6 hours
M_2: Foliar spray of plant growth regulators at vegetative stage
M_3: Foliar spray of plant growth regulators at flower bud initiation stage

Combined effect of plant growth regulators and its method of application had significant effect on yield per hectare (Appendix IX). The maximum yield per hectare (38.07 ton) was recorded from G_1M_3 treatment combination, while the minimum yield per hectare (17.13 ton) was found from G_0M_1 treatment combination (Table 6). Hasanuzzaman*et al*. (2007) showed that, due to hormonal treatments significant variation presents in case of fruityield.

4.15 Ascorbic acid content (mg/100g)

Chilli an important food nutrient and chili is an important source of Ascorbic acid. It was observed from the result of the experiment that ascorbic acid contents of chilli was varied significantly among different plant growth regulators (Appendix IX). Maximum vitamin-C (89.93 mg/100 g) was found in G_1 (NAA 40 ppm) treatment whereas minimum (69.48 mg/100 g) from G_0 (Control) treatment (Table 6). This result was also supported by Sarker*et al.* (2009). According to the study, maximum concentration of vitamin-C was found in G_1.

Vitamin-C in chilli showed variation in application method (Appendix IX). Maximum vitamin-C (83.26 mg/100 g) was obtained from M_3 treatment (Foliar spray of plant growth regulators at flower bud initiation stage),whereas minimum vitamin-C (75.33 mg/100 g) was found in M_1 (Seed soaking with plant growth regulators for 6 hours) treatment (Table 6).

Combination of plant growth regulators and its application method significantly affects vitamin-C content in chilli fruit (Appendix IX). Maximum vitamin-C content in chilli (95.27 mg/100 g) was obtained from G_1M_3 treated plant,while

minimum vitamin-C content was obtained (65.15 mg/100 g) from G_0M_1treated plant (Table 6).

4.16 Economicanalysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of chilli were calculated on per hectare basis. Price of chilli was considered as per market rate. The cost and return were worked out and the data were presented in Table 7 and appendix X and XI.

4.16.1 Gross return

The combination of plant growth regulators and its application method showed different values in terms of gross return under the trial (Table 7). The highest gross return (Tk. 1524000) was found from the treatment combination G_1M_3 and the second highest gross return (Tk. 1334400) was obtained in G_1M_2 treatment combination. The lowest gross return (Tk. 448800) was obtained fromG_0M_1 treatment combination.

4.16.2 Netreturn

In case of net return, different treatment combination showed different levels of net return under the present trial (Table 7). The highest net return (Tk. 1075498) was obtained from the treatment combination G_1M_3 and the second highest net return (Tk. 887644) was found from the combination G_1M_2. The lowest (Tk. 147131) net return was found from G_0M_1 treatmentcombination.

4.16.3 Benefit Cost Ratio

The combination of different plant growth regulators and its method of application for benefit cost ratio was different in all treatment combination (Table 7). The

highest benefit cost ratio (3.39) was found from the treatment combination G_1M_3 and the second highest benefit cost ratio (2.98) was found from G_1M_2 treatment combination. The lowest benefit cost ratio (1.49) was found from the G_0M_1 (control) treatment combination. From the economic point of view, it was apparent from the above results that the treatment combination of G_1M_3 was more profitable than rest of treatmentcombinations.

Table 7. Economic performances regarding gross return, net return andbenefit cost ratio (BCR) of chilli

Treatment	Cost of production (Tk / ha)	Yield (ton /ha)	Gross retun (Tk /ha)	Net return (Tk /ha)	BCR
G_0M_1	301669	17.13	448800	147131	1.49
G_0M_2	301669	19.89	554000	252331	1.84
G_0M_3	301669	22.08	660400	358731	2.19
G_1M_1	439637	28.54	1168800	729163	2.66
G_1M_2	446756	33.38	1334400	887644	2.98
G_1M_3	448502	38.07	1524000	1075498	3.39
G_2M_1	458994	23.59	773600	314606	1.69
G_2M_2	472860	24.89	902800	426940	1.91
G_2M_3	484724	26.46	1071200	586476	2.21

Market price of chilli @ 40 Tk/kg
Net return = Gross return - Total cost of production
Benefit cost ratio (BCR) = Gross return ÷Total cost of production

CHAPTER V
SUMMARY AND CONCLUSION

A field experiment was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh to study the growth and yield of chilli as influenced by plant growth regulators and its method of application. The experiment consisted of two factors. Factor A: Plant growth regulators (Three levels) as G_0: Control, G_1: NAA (40 ppm), G_2: Cytokinin (10 ppm). Factor B: (three levels) as M_1: Seed soaking with plant growth regulators for 6 hours, M_2: Foliar spray of plant growth regulators at vegetative stage, M_3: Foliar spray of plant growth regulators at flower bud initiation stage.

The two factors experiment was laid out in randomized complete block (RCBD) design with 3 replications. The total number of treatments were nine and the numbers of plots were twenty seven. Data were collected on the following parameters- plant height, number of branches per plant, number of leaves per plant, days from transplanting to first flowering, days from transplanting to 50% flowering, number of flowers per plant, number of fruits per plant, plant canopy, length of fruit, diameter of fruit, individual fruit weight, fruit yield per plant, fruit yield per plot, fruit yield per hectare and vitamin-C content. Collected data were analyzed statistically by variances (ANOVA) of data on different yield contributing characters ofchilli.

In case of plant growth regulators the highest plant height (52.18 cm) was observed from G_1 treatment, while the shortest plant (41.83 cm) was recorded from G_0 treatment at final harvest. The highest number of branches per plant (17.33) was recorded from G_1 treatment, while the minimum number (14.11) was recorded from G_0 treatment. At final harvest, the highest number of leaves per plant (61.11) was recorded from G_1 treatment, again the lowest number(48.11) was recorded from G_0 treatment. The minimum days from

transplanting to 1st flowering (50.83 days) was found from G_1 treatment, while the maximum (63.00 days) from G_0 treatment. The minimum days from transplanting to 50% flowering (90.17 days) was found from G_1 treatment, while the maximum days (103.67 days) was recorded from G_0treatment. The maximum number of flowers perplant (434.12) was recorded from G_1 treatment, whereas the minimum number (136.62) was obtained from G_0 treatment. The maximum number of fruits per plant (410.60) was found from G_1 treatment, while the minimum number (83.05) was recorded from G_0 treatment. The highest plant canopy (66.80 cm) was attained from G_1 treatment while the lowest (57.26 cm) was observed from G_0 treatment. Maximum (8.74 cm) fruit length was found in G_1 (NAA 40 ppm) treatment whereas minimum fruit length was recorded from G_0(7.86 cm) treatment. The maximum diameter of fruit of chilli (0.78 cm) was observed from G_1 treatment while the minimum (0.61 cm) was recorded from G_0 treatment. The maximum weight of individual fruit (6.03 g) was recorded from G_1treatment, while the minimum weight (4.63 g) was observed from G_0treatment. The highest yield per plant (516.66 g) was found from G_1 while the lowest yield per plant (177.25 g) was observed from G_0 treatment. The maximum yield per plot (6.21 kg) was recorded from G_1 treatment, while the minimum yield per plot (2.19 kg) was recorded from G_0 treatment. The maximum yield per hectare (33.56 ton) was observed from G_1 treatment, while the minimum yield per hectare (13.85 ton) was recorded from G_0 treatment.Maximum vitamin-C (89.26 mg/100 g) was obtained fromG_1treatment, whereas minimum vitamin-C (69.48 mg/100 g) was found inG_0treatment.

For different application method, the longer plant (49.14 cm) was obtained from M_2 treatment, while the shorter plant (44.97 cm) was found from M_3 treatment at final harvest. , the maximum number of branches per plant (16.00 cm) was obtained from M_2 treatment, while the shortest plant (15.44 cm) was found from M_1 and M_3 treatment. The maximum number of leaves per plant

(57.89) was recorded from M_2 treatment, while the minimum number (52.00) was obtained from M_3 treatment at harvest. The minimum days from transplanting to 1st flowering (55.41 days) was found from M_2 treatment, while the maximum (59.33 days) was attained from M_3 treatment. The minimum days from transplanting to 50% flowering (94.50 days) was found from M_3, while the maximum days (98.83 days) was recorded from M_1 treatment. The maximum number of flowers per plant (322.75) was recorded from M_3 treatment, while the minimum number (234.44) was found from M_1 treatment. The maximum number of fruits per plant (283.31) was obtained from M_3 treatment, while the minimum number (193.06) was obtained from M_1 treatment. The highest plant canopy (63.59cm) was attained from M_2 treatment whereas the lowest plant canopy (60.07 cm) was observed from M_3 treatment. The maximum (8.44 cm) fruit length was found in M_3 treatment whereas minimum (8.06 cm) fruit length was recorded in M_1 treatment. The maximum diameter of fruit of chilli (0.72 cm) was observed in M_3 treatment and the minimum (0.66 cm) was measured in M_1 treatment. The maximum weight of individual fruit (5.67 g) was found from M_3 treatment while the minimum weight (4.93 g) was recorded from M_1treatment. The highest yield per plant (401.05 g) was found from M_3 treatment, while the lowest yield per plant (289.33 g) was recorded from M_1 treatment. The maximum yield per plot (4.81 kg) was recorded from M_3 treatment, while the minimum yield per plot (3.54 kg) was recorded from M_1 treatment. The highest yield per hectare (27.12 ton) was recorded from M_3 treatment, while the minimum yield per hectare (19.92 ton) was observed from M_1 treatment. Maximum vitamin-C (83.26 mg/100 g) was obtained from M_3 treatment, whereas minimum vitamin-C (75.33 mg/100 g) was found in M_1 treatment.

Due to the combined effect of plant growth regulators and its application method, at final harvest, the tallest plant (54.50 cm) was observed from G_1M_2 treatment combination. On the other hand, the shortest plant (40.00 cm) was

recorded from G_0M_3 treatment combination. The highest number of branches per plant (18.33 cm) was recorded from G_1M_2treatment combination whereas the lowest number of branches per plant (13.67 cm) was observed from G_0M_3 treatment combination. At final harvest, the highest number of leaves per plant (63.67) was recorded from G_1M_2 treatment combination, whereas the lowest number of leaves per plant (46.00) was observed from G_0M_3 treatment combination. The highest days from transplanting to 1st flowering (48.50 days) was found from G_1M_2 treatment combination, while the lowest (64.00 days) was observed from G_0M_3 treatment combination. The minimum days from transplanting to 50% flowering (87.50 days) was obtained from G_1M_3treatment combination, while the maximum days (105.50 days) was found from G_0M_1 treatment combination. The highest number of flowers per plant (500.29) was recorded from G_1M_3 treatment combination, while the lowest number (206.69) was found from G_0M_1 treatment combination. The maximum number of fruits per plant (410.32) was recorded from G_1M_3 treatment combination, while the minimum number (159.35) was found from G_0M_1 treatment combination. The highest plant canopy (68.97 cm) was recorded from G_1M_2 treatment combination, while the lowest plant canopy (55.30cm) was observed in G_0M_3 treatment combination. The maximum (8.98 cm) fruit length was recorded in G_1M_3 treatment combination whereas minimum (7.70 cm) fruit length was recorded in G_0M_1 treatment combination. The highest diameter of fruit (0.81 cm) was recorded from the treatment combination of G_1M_3, while the treatment combination of G_0M_1 gave the lowest (0.60 cm) diameter of fruit. The maximum weight of individual fruit (6.86 g) was attained from G_1M_3 treatment combination, while the minimum weight (4.40 g) was found from G_0M_1 treatment combination. The highest yield per plant (600.16g) was attained from G_1M_3 treatment combination, while the lowest yield per plant (274.17g) was found from G_0M_1 treatment combination. The maximum yield per plot (7.31 kg) was observed from G_1M_3 treatment combination, whilethe minimum yield per plot (3.29 kg) was recorded from G_0M_1treatment combination. The maximum yield per hectare (38.07 ton) was recorded from G_1M_3 treatment

combination, while theminimum yield per hectare (17.13 ton) was found from G_0M_3 treatment combination. Maximum vitamin-C content in chilli (95.27 mg/100 g) was obtained from G_1M_3 treated plantwhile minimum vitamin-C content was obtained (65.15 mg/100 g) from G_0M_1 treated plant.The maximum gross return (Tk. 1524000) was found from the treatment combination G_1M_3treatment combination and the minimum gross return (Tk. 448800) from G_0M_1 treatment combination. The maximum net return (Tk. 1075498) was recorded from G_1M_3 treatment combination and the minimum (Tk. 147131) net return was found G_0M_1 treatment combination. The maximum benefit cost ratio (3.39) was recorded from G_1M_3 treatment combination and the minimum benefit cost ratio (1.49) was recorded from G_0M_1 treatmentcombination.

Conclusion:

Considering the above result of this experiment, the following conclusion and recommendation can be drawn:

1. Plant growth regulator (NAA 40 ppm) was superior than theothers.
2. Application method was played a vital role on the growth and yield of chilli. In respect of all, foliar spray of plant growth regulators at flower bud initiation stage showed better performance thanothers.
3. The treatment combination of G_1M_3 (NAA 40 ppm with foliar spray at flower bud initiation stage) is the appropriate practice for chilliproduction.

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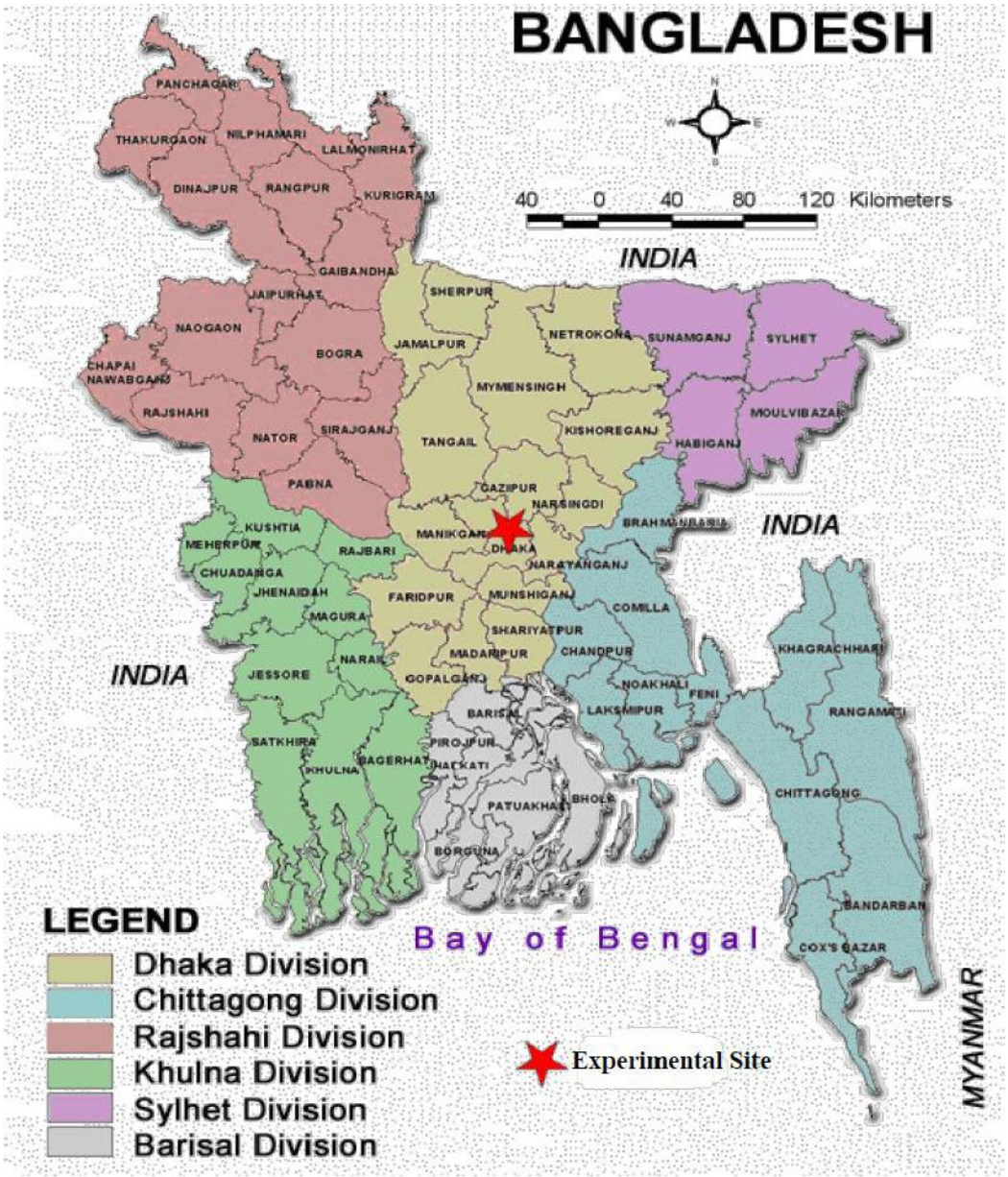
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II: Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticultural 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
Drainage	Well drained

Appendix III. mechanical and chemical analysis of soil in the experimental plot

A. Mechanicalanalysis

Constituents	Percentage (%)
Sand	27
Silt	43
Clay	30

Source: Soil Resource Development Institute (SRDI)

B. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.45
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (%)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Monthly records of Temperature, Rainfall, and Relative humidity of the experiment site during the period from October, 2017 to March, 2018

Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)
	Max.	Min.	Mean		
October, 2017	28.46	18.19	23.33	73.46	69
November, 2017	26.5	17.9	22.2	68.5	0
December, 2017	25.6	15.2	20.4	71.6	0
January, 2018	24.5	13.9	19.2	68.5	0
February, 2018	28.9	18.0	23.4	61.0	3
March, 2018	33.6	29.5	31.6	72.7	11

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

Appendix V: Analysis of variance of the data on yield contributing parameters ofchillishowing on plant height & number of branches per plant at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of					
		Plant height (cm)			Number of branches per plant		
		30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Replication	2	9.991	443.5	0.184	2.554	2.321	14.176
Factor A (Growth regulators)	2	97.014**	2409.3**	1.504**	98.936**	33.389**	124.404**
Factor B (Application Method)	2	52.570*	45510.2**	1.251**	9.951 NS	29.186*	111.871**
A x B	4	44.302*	6428.8**	1.488**	4.768 NS	20.602*	80.167*
Error	16	15.549	535.4	0.196	15.443	6.867	26.971

*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 yield contributing parameters of chilli showing on number of leaves perplant at different days after transplanting

Source of variation	Degrees of freedom (df)	Mean Square of		
		Number of leaves per plant		
		30 DAT	60 DAT	90 DAT
Replication	2	1.208	0.458	1.003
Factor A (Growth regulators)	2	12.686**	4.714*	8.215**
Factor B (Application Method)	2	78.063**	5.989*	5.517**
A x B	4	10.935**	4.353*	3.415*
Error	16	1.917	1.452	1.136

* 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 yield contributing parameters of chilli showing on days from transplanting to 1st flowering, days from transplanting to 50% flowering, number of flowers per plant, number of fruits per plant

Source of variation	Degrees of freedom (df)	Mean Square of			
		Days from transplanting to 1st flowering	Days from transplanting to 50% flowering	Number of flowers per plant	Number of fruits per plant
Replication	2	8.902	20.701	13.042	4.887
Factor A (Growth regulators)	2	87.875**	94.121**	126.647**	29.143**
Factor B (Application Method)	2	85.623**	104.005**	113.002**	37.028**
A x B	4	55.516*	78.951*	59.758*	14.582*
Error	16	17.932	31.059	19.452	4.259

*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 contributing parameters of chilli showing on plant canopy, length of fruit, diameter of fruit, individual fruit weight at harvest

Source of variation	Degrees of freedom (df)	Mean Square of			
		Plant Canopy (cm)	Length of fruit (cm)	Diameter of fruit (cm)	Individual fruit weight (g)
Replication	2	16.382	0.108	0.503	4.257
Factor A (Growth regulators)	2	132.332**	9.543**	19.348*	64.867**
Factor B (Application Method)	2	125.010**	11.631**	21.646*	86.432**
A x B	4	129.268**	7.807*	15.677*	31.977*
Error	16	38.018	2.064	5.009	9.296

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

Appendix IX: Analysis of variance of the data on yield contributing parameters ofchilli showing on yield per plant, yield per plot, yield per hectare, vitamin-C content at harvest

Source of variation	Degrees of freedom (df)	Mean Square of			
		Yield per plant (g)	Yield per plot (kg)	Yield per hectare (ton)	Vitamin-C (mg/100 g)
Replication	2	5.533	26.809	15.353	0.486
Factor A (Growth regulators)	2	57.377**	188.242**	227.767**	13.380**
Factor B (Application Method)	2	46.576**	195.986**	122.098**	17.015**
A x B	4	31.049*	67.771*	114.026*	12.704*
Error	16	11.566	21.538	30.152	4.713

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

Appendix X: Production cost of chilli per hectare
Input cost (A)

Treatment Combination	Labour Cost (Tk.)	Ploughing Cost (Tk.)	Seed Cost (Tk.)	Insecticide/ Pesticides (Tk.)	Cowdung (Tk.)	Manure and fertilizers cost (Tk.)			Hormone cost (Tk.)	Sub Total (Tk.) (A)
						Urea	MP	TSP		
G_0M_1	21000	80000	55000	50000	60000	6200	6500	10000	0	245200
G_0M_2	21000	80000	55000	50000	60000	6200	6500	10000	0	245200
G_0M_3	21000	80000	55000	50000	60000	6200	6500	10000	0	245200
G_1M_1	21000	80000	55000	50000	60000	6200	6500	10000	32000	277200
G_1M_2	21000	80000	55000	50000	60000	6200	6500	10000	38000	283200
G_1M_3	21000	80000	55000	50000	60000	6200	6500	10000	42000	287200
G_2M_1	21000	80000	55000	50000	60000	6200	6500	10000	50000	295200
G_2M_2	21000	80000	55000	50000	60000	6200	6500	10000	60000	305200
G_2M_3	21000	80000	55000	50000	60000	6200	6500	10000	70000	315200

G_0: Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2:Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators at flower bud initiation stage

Cowdung and Fertilizer rate:
Cowdung: 5 Tk/kg, Urea: 25 Tk/kg, TSP:30 Tk/kg, MP: 30 Tk/kg
Labour cost: 200 Tk/head/day

Appendix XI: Overhead cost (B)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 15,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
G_0M_1	98000	12260	46209	156469	301669
G_0M_2	98000	12260	46209	156469	301669
G_0M_3	98000	12260	46209	156469	301669
G_1M_1	98000	13860	50577	162437	439637
G_1M_2	98000	14160	51396	163556	446756
G_1M_3	98000	14360	51942	164302	448502
G_2M_1	98000	14760	53034	165794	458994
G_2M_2	98000	15260	54400	167660	472860
G_2M_3	98000	15760	55764	169524	484724

G_0: ControlM_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2:Cytokinin (10ppm) M_3: Foliar spray of plant growth regulators at flowerbud initiation stage

Appendix XII. Effect on plant height of Chilli at different days after transplanting

Treatments	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
Effect of plant growth regulators			
G_0	12.31c	27.86c	41.83c
G_1	16.94a	38.95a	52.17a
G_2	15.08b	33.57b	46.76b
LSD (0.05)	0.55	2.98	0.99
Effect of application method			
M_1	14.76b	33.68ab	46.66b
M_2	16.17a	35.57a	49.14a
M_3	13.40c	31.13b	44.96c
LSD (0.05)	0.49	2.76	0.77
Combined effect of plant growth regulators and its method of application			
G_0M_1	12.33e	28.53de	41.90f
G_0M_2	13.93d	30.40cd	43.60e
G_0M_3	10.66f	24.66e	40.00g
G_1M_1	16.76b	38.73ab	51.90b
G_1M_2	18.60a	40.80a	54.50a
G_1M_3	15.46c	37.33ab	50.13c
G_2M_1	15.20c	33.80bc	46.20d
G_2M_2	16.00bc	35.53bc	49.33c
G_2M_3	14.06d	31.40cd	44.76e
CV %	6.42	8.67	8.25
LSD (0.05)	0.96	5.20	1.42

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

Note G_0:Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators atflower bud initiation stage

Appendix XIII. Effect on number of leaves per plant of Chilli at differentdays after transplanting

Treatments	Number of leaves per plant		
	30 DAT	60 DAT	90 DAT
Effect of plant growth regulators			
G_0	9.77c	24.33c	48.11c
G_1	14.00a	41.11a	61.11a
G_2	11.66b	31.22b	54.33b
LSD (0.05)	0.99	3.28	1.81
Effect of application method			
M_1	11.77b	32.66a	53.66b
M_2	13.33a	35.88a	57.88a
M_3	10.33c	28.11b	52.00b
LSD (0.05)	0.89	3.12	1.75
Combined effect of plant growth regulators and its method of application			
G_0M_1	9.66de	24.66de	47.00d
G_0M_2	11.00cd	27.33cd	51.33c
G_0M_3	8.66e	21.00e	46.00d
G_1M_1	14.00ab	41.66a	60.33b
G_1M_2	15.33a	46.00a	63.66a
G_1M_3	12.66bc	35.66b	59.33b
G_2M_1	11.66c	31.66bc	53.66c
G_2M_2	13.66ab	34.33b	58.66b
G_2M_3	9.66de	27.66cd	50.66c
CV %	9.98	9.16	10.97
LSD (0.05)	1.71	5.68	3.18

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

Note G_0:Control M_1: Seed soaking with plant growth regulators for 6 hours
G_1: NAA (40 ppm) M_2: Foliar spray of plant growth regulators at vegetative stage
G_2: Cytokinin (10 ppm) M_3: Foliar spray of plant growth regulators at flower budinitiation stage