RESPONSE OF BELL PEPPER (*Capsicum annuum*) VARIETIES TO PLANT GROWTH REGULATORS

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JUNE 2013

RESPONSE OF BELL PEPPER (*Capsicum annuum*) VARIETIES TO PLANT GROWTH REGULATORS

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Reg. No.: 06-02084

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, 2013

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CERTIFICATE

This is to certify that the thesis entitled **"Response of Bell Pepper (*Capsicum annuum*) Varieties to Plant Growth Regulators"** 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 in Horticulture**, embodies the result of a piece of *bona fide* research work carried out by **Subrata Kumar Das**, Registration No. **06-02084** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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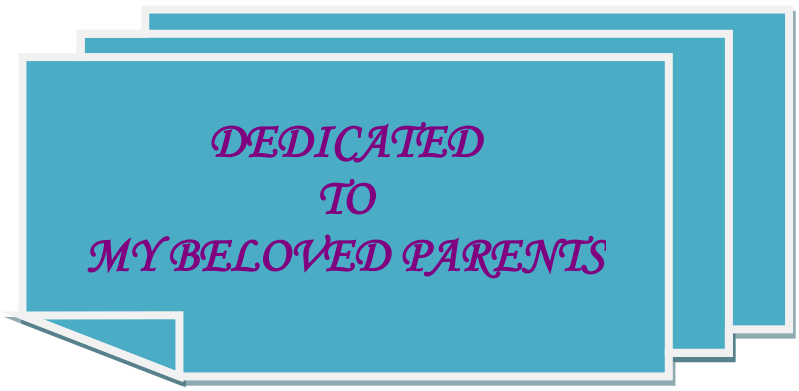
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TO
MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises to Almightly and Kindfull trust on to "Omnipotent Creator" for His never-ending blessing, the author deems it a great pleasure to express his profound gratefulness to his respected parents, who entiled much hardship inspiring for prosecuting his studies, receiving proper education.

The author likes to express his deepest sense of gratitude to his respected supervisor, ***Dr. Mohammad Humayun Kabir****, Assistant Professor, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his scholastic guidance, support, encouragement and valuable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript writing.*

The author also expresses his gratefulness to his respected Co-Supervisor, ***Dr. A. F. M. Jamal Uddin****, Associate Professor, Department of Horticulture, SAU, Dhaka for his constant inspiration, and suggestions throughout the research work and in preparation of the thesis.*

The author expresses his sincere gratitude towards the sincerity of the Chairman, ***Md. Hasanuzzaman Akand****, Professor, Department of Horticulture, SAU, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of the Department of Horticulture, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the study period.*

The author expresses his sincere appreciation to his brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

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RESPONSE OF BELL PEPPER (*Capsicum annuum*) VARIETIES TO PLANT GROWTH REGULATORS

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to determine the response of bell pepper varieties to plant growth regulators. The experiment consisted of two factors: Factor A: Bell pepper (two varieties) V_1: BARI Misti Morich-1 and V_2: Exotic variety (Lamuyo); Factor B: Plant growth regulators (four levels) as G_0: No plant growth regulator (water), G_1: Gibberellic Acid (GA_3) @ 100 ppm, G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm and G_3: Litosen @ 1000 ppm. The experiment was laid out in a Randomized Complete Block Design with three replications. In case of bell pepper varieties, the maximum yield (22.47 t/ha) was attained from V_2, while the minimum yield (20.09 t/ha) from V_1. For plant growth regulators, the highest yield (25.17 t/ha) was recorded from G_2, whereas the lowest (15.33 t/ha) from G_0. Due to the interaction effect of variety and plant growth regulators, the highest yield (26.52 t/ha) was found from V_2G_2, while the lowest yield (14.51 t/ha) from V_1G_0. So, V_2G_2 (combination with Lamuyo and 4-CPA) was found best for growth and yield of bell pepper.

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CHAPTER I

INTRODUCTION

Capsicum or sweet pepper (*Capsicum annuum*) is a flowering plant under the genus Capsicum and belongs to the family Solanaceae. It is relatively non-pungent with thick flesh and is the world's second most important vegetable after tomato (AVRDC, 1989). Tropical South America, especially Brazil is thought to be the original home of pepper (Shoemaker and Teskey, 1995). It is now widely cultivated in Central and South America, Peru, Bolivia, Costa Rica, Mexico, in almost all the European countries, Honkong and India. Most of the peppers cultivated in temperate and tropical areas belong to the botanical spices *Capsicum annuum*, thought to originate in Mexico and Central America. Economically it is the second most important vegetables crop in Bulgaria and is thought to be the original home of pepper (Panajotov, 1998). Small scale cultivation is found in peri-urban areas primarily for the supply to some city markets in Bangladesh (Saha, 2001).

Capsicum is considered a minor vegetable crop in Bangladesh and its production statistics is not available (Hasanuzzaman, 1999). The popularity of sweet pepper is increasing day by day in Bangladesh especially among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. It is rich in capsaicin and has powerful antioxidant properties that may helps works against inflammation. Capsicum has different colors-range from green to yellow, red, orange, purple, and black. Other capsicum include the red, heart-shaped; the pale green, slender and curved bull's horn which range in color from yellow to red and sweet banana pepper which is yellow and banana shaped (Teshm Tadesse Michael *et al*., 1999). Capsicum is chosen because of its higher nutritive value and generally it contains 1.29 mg protein, 11 mg calcium, 870 I.U. vitamin A, 17.5 mg ascorbic acid, 0.6 mg thiamin, 0.03 mg riboflavin and 0.55 mg niacin per 100 g of edible fruit (Joshi and Singh, 1975).

The species *annuum* includes eleven groups which can be divided into two sub group sweet and hot peppers. The genus *Capsicum* contains about 20 species and now five domesticated species *Capsicum annuum, C. frutescens, C. chinense, C. baccatum, C. pubescens* are only recognized. Within *C. annuum,* a tremendous range in size, shape and mature color of fruits has been selected that now forms the basis for the types used in commerce throughout the world. All these species of capsicum have many cultivated varieties suited to different agro-climatic conditions. Crop variety is one of the important factors for the increased production of bell pepper. Many researchers reported that different varieties of crop have different effect for the reducing higher rate of flower/fruit dropping and improving fruit setting condition and as well as marketable yield of bell pepper. Variety plays an important role for producing maximum yield. Different varieties respond differentially to cultivation practices and the prevailing environment condition during the growing season. For that it is necessary to evaluate different variety considering the environmental condition for attaining maximum yield and quality fruits.

Large scale production of bell pepper is limited in Bangladesh due to some problems in the production system and lack of familiarities to the growers. Bell pepper production has some constraints which include flower dropping, poor fruit set, and susceptibility to viral diseases and it is a serious concern for the successful introduction of this crop. Plant growth regulators (PGR's) are organic compounds, which in small amounts, somehow modify a given physiological plant process. It plays an essential role in many aspects of plant growth and development, stem elongation and flower development (Chaudhary *et al.,* 2006; Ouzounidou *et al.,* 2008). Plant growth regulators can be used to modify growth and development in various ways. Some growth regulators affect primarily on vegetative growth; others influence the fruit; still others may induce modifications in vegetative and fruiting parts (Tanimoto, 1987; Leclerc *et al*., 2006). Growth regulators may be effective to reduce fruit setting and dropping problem of bell pepper.

The responses to a particular growth regulator depend upon factors such as the plant, the chemical, and the environment. Fruit per plant, fruit size and weight per fruits was the yield components which is may vary on the application of different PGR's. However, very limited works have been carried out regarding the use of growth regulators on bell pepper in Bangladesh.

The high market price of capsicum fetches is attributed to the heavy demand from the urban consumers as well as from star hotels in metropolitan cities. There is a good demand for export too although the export market needs fruits with longer shelf life, medium sized tetra lobed fruits with attractive dark green colour, mild pungency, good taste and freedom from pesticide residues. However, the supply of quality produce is inadequate due to the low productivity of the crop (Muthukrishnan *et al*., 1986). Some chemicals are generally used to improve fruit set and yield of bell pepper. Abdul *et al*. (1998) reported increased plant height and leaf with GA_3 (at 50, 100 and 150 ppm) on bell pepper. Deka and Shadeque (1996) obtained the highest branches, leaves, fruit set and yield of bell pepper with Cycocel at 500, 1000 of 1500 ppm. Rajmani *et al*. (1990) found increased percentage of fruit set with 2, 4-D (2-5ppm) and tricontanol (1.25-5 ppm) and with chorflurenol on bell pepper, respectively. The varying responses of capsicum to plant growth regulators have been reported by Minraj and Shanmugavelu (1987), Balraj *et al*. (2002) and Joshi *et al*. (1999).

However, considering the above circumstances, the present study was undertaken with the following objectives:

- To know the varietal performance of capsicum under the PGRs treatment.
- To determine the effect of different plant growth regulators on the yield of bell pepper and find out suitable plant growth regulator.
- To find out the suitable combination of variety and growth regulators for higher yield of capsicum.

CHAPTER II

REVIEW OF LITERATURE

Capsicum is considered a minor vegetable crop in Bangladesh and its popularity is increasing day by day among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. Due to some advantages, capsicum cultivation in Bangladesh is becoming more popular and total yearly production is increasing gradually. Although the farmers of Bangladesh are not knowledgeable regarding the procedures of increasing fruit setting, fruit size, individual fruit weight as well as yield. A very few research works related to capsicum cultivation especially emphasis on variety and plant growth regulators have been carried out in Bangladesh. Nevertheless, some of the important and informative works regarding the varietal performance and plant growth regulators so far been done at home and abroad of this crop have been reviewed below under the following headings-

2.1 Review in relation to the germplasm of capsicum

An experiment was carried out at the Bangladesh Agricultural University, Mymensingh by Khan *et al*. (2012) to study the effect of different soil water levels on the physio-morphological features of ten Chilli (*Capsicum annuum* L.) accessions viz. C-0277, C-0297, BM-1, C-0100, BM-2, C-0265, C-0272, C-0275, BM-3, and C-0271. The experiment was set up in pots under glasshouse condition. The water treatments were applied at 4 vegetative growth stages following withholding method (crude method) starting from 25 days after sowing and thereafter at every 7 days interval until final stage. The effects of different water treatments on all the growth parameters studied was significant in case of all accessions and growth stages. The accessions C-0271, C-0277, BM-1, and C-0297 produced higher dry matter.

Omonijo and Afuye (2009) studied the quantitative response of three different types/species of pepper fruit yield to five environmental climatic parameters in the Nigeria Guinea savanna. The results showed that the medium corrugated fruited hot pepper (rodo) had the highest mean yield (750 g/m^2), followed by the small fruited chilli pepper (shombo) (691 g/m^2) and large fruited sweet pepper (tatashe) (578 g/m^2).

Fruit set and yield patterns were studied by Maaike Wubs and Yuntao (2009) in detail in six pepper cultivars. Fruit set differed largely between the cultivars: cultivars with small fruits (fruit fresh weight 20 to 40 g) showed higher fruit set (<50%) than cultivars with large fruits (fruit fresh weight 120 to 200 g; 11% to 19%). The former showed continuous fruit set (four to five fruits/plant/week), whereas the latter showed fluctuations in fruit set. Fluctuations in weekly fruit set, expressed as the ratio between standard deviation of weekly fruit set and the mean of weekly fruit set (CV), were much lower for the cultivars with small fruits (0.44 to 0.49) than for the cultivars with large fruits (1.1 to 1.6). Fluctuations in weekly fruit yield varied between 0.51 and 0.77 for cultivars with small fruits and between 1.04 and 1.45 for cultivars with large fruits.

Two years results of Appireddy *et al*. (2008) revealed that among the five varieties of bell pepper, performance of US Agril 181 was significantly higher in fruit yield (25.42 t/ha in 2005 and 28.82 t/ha in 2006) as compared with other varieties and also gave highest net returns followed by Aishwarya and California Wonder under green house condition.

A field study was carried out by Hasanuzzaman *et al*. (2007) at the Horticulture Research Centre, Bangladesh Agricultural Research Institute, Jopdebpur, Gazipur to determine the performance of different bell pepper (*Capsicum annuum* L.) genotypes in response to synthetic hormones. Ten genotypes viz, CP0039, CP0041, CP0043, CP0044, CP0045, CP0053, CP0054, CP0055, CP0061 and CP0068 and two synthetic hormones were used as treatments in this study.

Genotype CP0039 produced the highest leaves (63.64), branches (7.36), plant height (24.23 cm), fruit (19) per plant and seed (150) per fruit. Highest fruit yield (18.69 t ha^{-1}) was obtained from CP0045. Fruit weight was maximum (18.58 g) in CP0061. Seeds extracted from CP0041 fruits had highest (92%) germination. On the contrary, the lowest seed germination (22%) was recorded in CP0045.

A field evaluation of thirteen chilli genotypes was conducted by Dahal *et al*. (2006) to identify the most appropriate chilli genotypes at western terai of Nepal. Ten heat resistant genotypes introduced from AVRDC, Taiwan to Nepal and three commercial cultivars of Nepal were planted at 50×30 cm spacing in paired row plot. All the management practices were carried out uniformly for all the treatments. Genotype CCA-119A was the earliest for 50% green fruit maturity. Fruit set percent varied significantly with the average of 18.81%. Fruit length, fruit diameter and ascorbic acid content also varied greatly. Ascorbic acid content (mg/100 g) ranged from 32.86 in CCA-984A to 173.7 in NS-1701. Wide variations were observed in yield potential of the genotypes ranging total fruit number per plant from 5.61 to 71 and in total fruit yield 7.97 to 95.33 q/ha. The genotype Mr. Lee No. 3 selex produced maximum marketable fresh fruit yield (90.69 q/ha) which was 234.5% higher than that of Jwala (check). Genotypes Susan's Joy, CCA-119A and CCA-3288 had also 122.98, 49.06 and 25.48% higher marketable yield respectively than that of Jwala. Higher yield in genotypes Mr. Lee No. 3 selex and CCA-119A were found with better fruit set, better fruit size and more fruit number per plant while the genotype Susan's Joy and CCA-3288 had higher yield mainly due to their predominantly larger fruit size.

Eighteen genotypes of *C. annuum* were evaluated by Hari *et al*. (2005) for growth and yield characters in Andhra Pradesh, India. Among these, MCA 24, LCA 414 and MCA 32 were superior in terms of the 9 growth attributes. KTPI-19 attained early maturity compared to the other cultivars. MCA 32 showed the highest value for fruit number/plant; MCA 30 for fruit length; MCA 29 for fruit diameter; MCA 24 for fruit weight and yield/plant; and LCA 406 for seed number/fruit.

Sharma *et al*. (2004) found that growing of capsicum cv. California Wonder under green house produced more number of fruits (15.03), fruit weight (723.28 g) and more yield (5.35 kg/m^2). It also registered maximum plant height (56 cm), number of branches (5.86) and number of leaves (80.76) compared to open field condition. They attributed this to 4.7^{0}C higher temperature and higher RH values in green house than in open field conditions.

Elite chilli cultivars from Sri Lanka (MI-2 and KA-2) were evaluated by Reddy and Sadashiva (2003) in farmers' fields in southern India. Arka Lohit served as the control. The cultivars differed significantly in different environments for green fruit yield per plot, fruit length, fruit width and days to harvest. Genotype × environment interaction was not significant for any of the characters studied. Arka Lohit showed superiority in yield (382.5 kg/plot), followed by MI-2 (343.75 kg/plot) and KA-2 (291.88 kg/plot) in 2000. A similar trend was observed in 1999. Although MI-2 and KA-2 were determinate and highly suitable for fresh green fruit yield, KA-2 was highly suitable for favourable environments. On the other hand, MI-2 exhibited good yield potential, earliness, acceptable fruit type in the market, stability and was highly suitable for unfavourable environments.

Fifty-two chilli (*C. annuum* and *C. frutescens*) genotypes (cultivars and advanced breeding lines) grown in Jorhat, Assam, India by Dipendra and Gautam (2002) for fruit yield and component characters. The genotypes significantly varied for all the parameters evaluated. Plant height was greatest in Asamia Jalakia (71.21 cm). The number of primary branches was highest in Nadharia (7.83) and Kala J. Long (7.83). Balijuri (190.67), Nadharia (202.83) and Kala J. Long (198.50) had the highest number of leaves per plant. Specific leaf weight was highest in Balijuri (6.62 mg/cm^2). The number of days to first flowering was lowest in Soalkuchi (51.83). Khoti Jalakia had the highest number of flowers (662.67) and fruits (278.17) per plant, and fruiting percentage (42.00%). Fruit drop incidence was lowest in Singhasan (0.90%). Jayanti recorded the greatest fruit length (9.71 cm). Fruit diameter was greatest in Tupura Jalakia (1.83 cm), Thupuka Jalakia (1.81 cm) and Bogori Jalakia (1.64 cm).

The greatest fresh and dry fruit weights were recorded for Jab Jalakia (4.60 and 1.10 g), Ou Jalakia-II (4.43 and 1.03 g), Ou-Jalakia-I (3.96 and 0.81 g), Kala J. Long (4.48 and 0.94 g) and LCA-206 (3.92 and 0.94 g). Balijuri had the highest fruit yield per plant (679.23 g).

Nagalakshmi *et al.* (2001) reported that the capsicum variety Green Gold grown under naturally ventilated polyhouse produced four fold increase in yield over open conditions (80 and 20.2 t/ha, respectively). Improved growth and yield components like increased plant height (92.3 cm), number of branches per plant (8.3), number of fruits per plant (13.6), fruit weight (120.4 g), reduced days to flowering (29.4) and days to fruiting (55.6) contributed for increased yield under greenhouse condition.

A field experiment was conducted by Nawalagatti *et al*. (1999) at Dharwad, Karnataka, India, during the rainy seasons to find out the differences in yield and quality parameters of 4 chilli cultivars (Byadagi, Sankeshwar, G-3 and Jwala), 6 lines (GPC-80, GPC-69, GPC-77, GPC-6, GPC-10 and KDSC-110-10) and 2 hybrids (H-1 and H-2). Among the lines, GPC-69 and GPC-10 recorded significantly low capsaicin contents. The ascorbic acid and oleoresin contents were highest in the hybrids followed by the cultivars and were least in the lines, indicating large genotypic variation among the various quality parameters studied.

Muniz and Almedia (1998) observed that, among six capsicum cultivars evaluated for commercial yields, number of fruits per plant, fruit weight and size, the most productive cultivars were Ruby King, Early Calwonder and Ikeda (15.8-19.5, 15.5-19.5 and 16.6-18.4 tonnes per ha, respectively). The cultivar Nara gave lowest yield (12.0-12.7 t/ha).

Nimje *et al*. (1990) observed that among the three capsicum varieties tried viz., California Wonder, Yolo Wonder and HW Wonder, variety California Wonder was found to be best suited for greenhouse cultivation as it yielded 445 q/ha under greenhouse as against only 164 q/ha under open field conditions.

2.2 Review in relation to different plant growth regulators

Rana *et al*. (2011) reported that application of Miyobi increased plant height, branch and leaf number, root length, root number, root weight, stem weight, total dry matter, chlorophyll content and photosynthesis in leaves, fruits plant^{-1} and fruit yield over control. Reverse trend was also observed in fruit size. Most of the morphological, biochemical, yield attributes were increased with increasing Miyobi concentration up to 0.8 mgL^{-1} followed by a decline. These results indicate that application of Miyobi @ 1.1 mgL^{-1} may be toxic for plant growth and development. Control, where only water was sprayed, showed the lowest of the above parameters. The higher fruit yield was recorded in 0.5 and 0.8 mgL^{-1} with being the highest in 0.5 mgL^{-1} (369.8 g plant^{-1}) due to increased number of fruits plant^{-1}. The lowest fruit yield was recorded in control (260.3 g plant^{-1}) due to inferiority in yield attributes. However, application of Miyobi at 0.8 mgL^{-1} was more costly than 0.5 mgL^{-1}. Therefore, Miyobi with 0.5 mgL^{-1} may be applied for increased fruit yield of chili for further recommendation few more field trials will require.

A study was conducted by Ouzounidou *et al*. (2010) at the Institute of Food Technology, National Agricultural Research Foundation, Lycovrissi, Greece to study the pre- and post-harvest physiology and quality responses of green pepper (*Capsicum annuum* L. cv 'Standar p.13/0211003-01-Agris') on exogenous Gibberellic acid-GA3 (100 μM), Prohexadione-Calcium (100 mg l-1), Cycocel (100 mg l-1) and Ethephon (100 mg l-1) applied as foliar sprays, were investigated. Among PGRs, GA_3 @ 100μM was effective in promoting flowering and better for vegetative characteristics.

An experiment was conducted by Singh *et al*. (2010) with chilli (*Capsicum annuum*) cv. Pusa Jwala during the kharif season in Meerut, Uttar Pradesh, India.

Plants were sprayed at flower bud initiation and 20 days later with the following treatments: T_1: NAA at 25 ppm + Ethrel [ethephon] at 100 ppm, T_2: NAA at 25 ppm + Ethrel at 150 ppm, T_3: NAA at 25 ppm + Ethrel at 200 ppm, T_4: NAA at 50 ppm + Ethrel at 100 ppm, T_5: NAA at 50 ppm + Ethrel at 150 ppm, T_6: NAA at 50 ppm + Ethrel at 200 ppm, T_7: NAA at 75 ppm + Ethrel at 100 ppm, T_8: NAA at 75 ppm + Ethrel at 150 ppm, T_9: NAA at 75 ppm + Ethrel at 200 ppm, and T_{10}: control (water spray). The highest values for plant height (58.50 and 57.30 cm), fruit number (96.66 and 98.00), fruit length (10.73 and 10.20 cm), fruit weight (2.74 and 2.71 g), fruit weight per plant (273.13 and 265.58 g) and fruit yield (109.51 and 106.23 q/ha) were recorded in T_6, whereas the lowest values for these parameters were recorded in the control.

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), GA_3 (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.

A field study was carried out by Hasanuzzaman *et al*. (2007) at the Horticulture Research Centre Farm, Bangladesh Agricultural Research Institute, Jopdebpur, Gazipur to determine the performance of different bell pepper (*Capsicum annuum* L.) genotypes in response to synthetic hormones. Ten genotypes and two synthetic hormones Milstim and Litosen along with control (fresh water) were used as treatments in this study. It was found that, due to hormonal treatments significant variation exists among the genotypes in respect of morphological characters, physiological parameters, fruit yield and seeds per fruit.

Genotype CP0039 plants treated Milstim and Litosen produced 20 and 18 fruits per plant resulting 20.37 t ha^{-1} and 19.93 t ha^{-1} yield, respectively. Lowest fruit bearing (4-fruits/plant) and yield (4.14 t ha^{-1}) were recorded in control plants of CP0068.

Both Milstim and Litosen treated plants performed better than control plants regarding fruit bearing and yield.

An investigation was carried out by Chaudhary *et al*. (2006) in the plain areas of Chitwan to determine the promising plant growth regulators (PGR) promoting growth and yield of chilli cultivars Jwala and Suryamukhi. Suryamukhi ranked superior to Jwala for most of the yield attributing characters, whereas Jwala was better in vegetative characters than Suryamukhi. Among PGRs, 2,4-D at 2 ppm was better for fruit set, number of fruits per plant, fruit length, number of seeds per fruit, seed weight per fruits, 1000 seed weight and fruit yield where as NAA at 40 ppm gave the highest leaf area index (LAI). PGRs were ineffective in promoting flowering and fruiting during winter season. GA_3 at 10 ppm exhibited maximum amount of ascorbic acid content. The treatments, 2 ppm 2,4-D, 5 ppm triacontanol, 40 ppm NAA and 10 ppm GA_3 produced 28.75%, 25.70%, 13.61% and 2.30% higher fruit yield over control, respectively. The highest net profit and B:C ratio were recorded in case of 2 ppm 2,4-D. The use of GA_3 as foliar spray was not economical.

Lone *et al*. (2005) conducted an investigation in Tamil Nadu, India, to determine the effect of plant growth regulators on the growth (plant height and number of branches) and yield parameters (number of fruits per plant, fruit length, fruit girth, fruit stalk length and dry fruit yield) of chilli cv. K-2. Treatments comprised: GA_3 (100 and 250 ppm), kinetin (10 and 25 ppm), paclobutrazol (100 and 150 ppm), NAA (20 and 40 ppm) and ethrel [ethephon] (100 and 150 ppm) at 30, 60, 90 and 120 days after planting. Results revealed that GA_3 at 250 ppm increased the plant height, followed by GA_3 at 100 ppm. Plants treated with paclobutrazol at 150 ppm recorded the highest number of branches, yield and yield attributes.

An experiment was conducted by Joshi and Singh (2003) 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 GA_3; 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 cm^2) 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).

The effects of plant growth regulators (25, 50 or 100 ppm gibberellic acid and NAA) on the growth and seed yield of chilli cv. Suryamukhi were determined by Thapa *et al*. (2003) in a field experiment conducted in Mohanpur, West Bengal, India during the kharif season of 2002. Treatment with 25 ppm gibberellic acid resulted in the highest plant height (102.20 cm), number of primary branches per plant (10.73), number of fruits per plant (107.53), fruit length (4.51 cm), number of seeds per fruit (40.23), 1000-seed weight (5.24) and seed yield (13.42 q/ha), whereas treatment with 50 ppm NAA resulted in the highest seed yield per plant (18.31 g).

Pelt and Popham (2002) conducted a study in the Roswell and Artesia area of southeastern New Mexico to determine the efficacy of plant growth regulator (PGR) and plant growth enhancer (PGE) application on the production of paprika and cayenne pepper (*C. annuum*) cultivars. The peppers used for the 1997 study were paprika cultivars B-18 and Sonora, and the cayenne cv. Durkee. All trials in 1998 were conducted on paprika cv. B-18. The PGRs investigated during 1997 were PGR-IV (at 0.14 litre/ha), an IBA and gibberellic acid (GAA) combination product, and Cytoplex (at 0.28 litre/ha), an IBA/GAA/cytokinin combination product.

The PGRs investigated during 1998 were PGV-IV and Early Harvest (at 0.22 litre/ha), an IBA/GAA/cytokinin product. The PGE investigated in both years was Crop+2 (at 2.34 litre/ha) in combination with CytoRed (at 2.34 litre/ha), which are both mixes of fermentation products with macro- and micronutrients.

The results indicate that application of PGRs or the PGEs tested can improve yields of paprika or cayenne peppers under production conditions. The consistent increases in yield occurring without reduction in quality, warrant their use in production of paprika and cayenne.

The effects of triacontanol-containing plant growth regulators on the yield and quality of chilli (*Capsicum annuum*) were investigated by Muralidharan *et al*. (2002) in a field experiment in Tamil Nadu, India. The treatments comprised of 0.1% Vipul and 0.05% Miraculan at 200, 250 and 300 ml/ha; 0.05% Vipul granules at 20, 25 and 30 kg/ha; and Planofix at 50 ppm. All the plant growth regulators gave higher dry pod yield and quality compared to the control, with 300 ml vipul/ha recording the highest dry pod yield (3.22 t/ha), capsaicin content (4.67 mg/100 g), and ascorbic acid content in ripe fruits (126) and dry pods (65.1).

The effects of NAA, gibberellic acid and 2,4-D on chilli (*C. annuum* cv. Byagadi) were investigated by Balraj *et al*. (2002) in a field in Dharwad, Karnataka, India,. The plant growth regulators were sprayed at 35 and 50 days after transplanting (DAT), and at both 35 and 50 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. Application of plant growth regulators at both 35 and 50 DAT was the most efficient for improving the growth and yield of the plants. Yield was highest when NAA at 20 ppm was applied at 35 and 50 DAT.

From the discussion of above reviewed literature it is revealed that variety itself and different growth regulators have significant effect on growth, yield contributing characters and yield of capsicum.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October 2012 to March 2013 to study the response of bell pepper varieties in response to plant growth regulators. This chapter includes a brief description of the location of experimental site, soil and climate condition, materials used for the experiment, design of the experiment, intercultural operations, data collection procedure and procedure of data analysis that were used for conducting the experiment**.**

3.1 Experimental site

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experiment was carried out during rabi season. The location of the study site is situated in $23^0 74^/$N latitude and $90^0 35^/$E longitude (Anon., 1989). The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargaon, Dhaka).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and details soil characteristics are presented in Appendix I.

3.3 Climatic condition of the experimental site

The experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.4 Planting materials

Two capsicum varieties viz. BARI Misti morich-1 and "Lamuyo" (exotic variety from France) were used as experimental materials. The seeds of variety BARI Misti morich-1 were collected from the Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydepur, Gajipur and seeds of exotic variety were collected from Manik Seed Company, 145, Siddique bazar, Dhaka-1000.

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Bell pepper (two varieties) as

i V_1: BARI Misti Morich-1

ii. V_2: Lamuyo (Exotic variety from France)

Factor B: Plant growth regulators (four levels) as

i. G_0: No plant growth regulator (water)
ii. G_1: Gibberellic Acid (GA_3) @ 100 ppm (according to previous research report)
iii. G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm (according to manufacturer recommendations)
iv. G_3: Litosen (Sodium-5-Nitroguaiocol----0.4%, Sodium-0-Nitrophenol----0.6%, Sodium-P-Nitrophenol----0.8%, Sodium-2-4-Dinitrophenol----0.2%) @ 1000 ppm (according to previous research report)

There were 8 (2 × 4) treatment combinations such as V_1G_0, V_1G_1, V_1G_2, V_1G_3, V_2G_0, V_2G_1, V_2G_2 and V_2G_3.

According to manufactures recommendation and previous research report GA_3, 4-CPA and Litosen are used as 100 mg/L of water, 2 ml/L of water and 1 ml/L of water respectively and then converted into ppm.

3.6 Design and layout of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 148.02 m^2 with length 15.6 m and width 9.5 m which was divided into three equal blocks. Each block was divided into 8 plots where 8 treatments combination were allotted at random. There were 24 unit plots altogether in the experiment. The size of the each plot was 1.5 m × 1.2 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. Seeds were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 40 cm, respectively. The layout of the experiment is shown in Figure 1.

3.7 Seedbed preparation

Seedbed was prepared on 1 October 2012 for raising seedlings of capsicum and the size of the seedbed was 3m × 1m. For making seedbed, the soil was well ploughed. Weeds, stubbles and dead roots were removed from the seedbed. Cow dung was applied to the prepared seedbed @ 10 t/ha. The soil was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworms. Seeds were treated by Vitavex-200 @ 5g/1kg seeds to protect some seed borne diseases such as leaf spot, blight, anthracnose, etc.

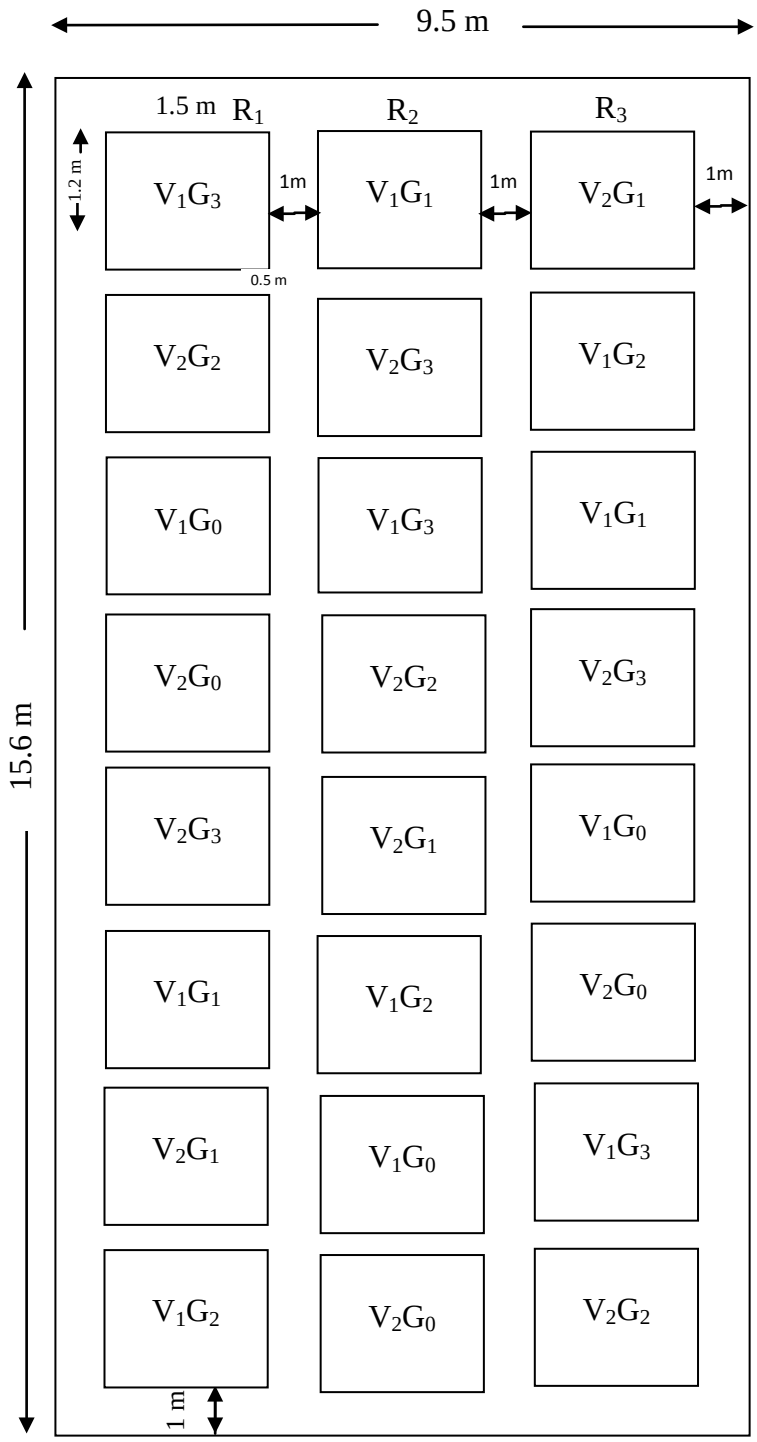
3.8 Seed sowing

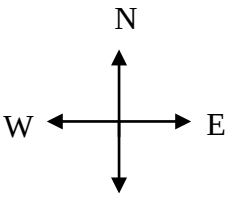
Seeds were sown on 10 October, 2012 in the seedbed. Sowing was done in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering by watering can. Thereafter, the beds were covered with polythene to maintain required temperature and moisture.

3.9 Raising of seedlings

Light watering and weeding were done several times as per needed. No chemical fertilizers were applied for raising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 30 days old seedlings were transplanted

into the experimental field on 10 November 2012.





Plot size: 1.5 m × [illegible] m

Plant to plant: 50 cm

Row to row distance: 40 cm

Between block: 1.0 m

Factors A:

V_1: BARI Misti Morich-1

V_2: Lamuyo (Exotic variety from France)

Factors B:

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

3.10 Preparation of the main field

The plot selected for conducting the experiment was opened in the first week of November 2012, with a power tiller and left exposed to the sun for a week to kill soil born pathogens and soil inhabitant insects. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. Weeds, crop residues and stables were removed from the field. The basal dose of manure and fertilizers were applied at the finally ploughing. The plots were prepared according to design and layout of the experiment. The soil of the plot was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworm.

3.11 Application of manure and fertilizers

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MoP, gypsum and zinc oxide, respectively were applied. Half of the quantity of cowdung was applied during final land preparation. The remaining half of cowdung, the entire amount of TSP, gypsum, zinc oxide and one third of urea and MoP were applied during pit preparation. Urea and MoP were applied in two equal installments at before flowering and fruit setting. The dose and method of application of fertilizer are shown in Table 1.

Table 1. Dose and method of application of fertilizers in capsicum field

Manure and Fertilizers	Dose (ha)	Application (%)			
		Final land preparation	Installments		
			Pit preparation	Before flowering	Fruiting stage
Cowdung	10 ton	50.00	50.00	--	--
Urea	250 kg	--	33.33	33.33	33.33
TSP	330 kg	--	100.00	--	--
MoP	250 kg	--	33.33	33.33	33.33
Gypsum	110 kg	--	100.00	--	--
Zinc	5 kg	--	100.00	--	--

Source: Krishi Projukti Hatboi, BARI, 2011

3.12 Transplanting

Healthy and uniform capsicum seedlings of 30 days old seedlings with 5-6 leaves were transplanting in the experimental plots on 16 November, 2012. The seedlings were uploaded carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered on hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 40 cm, respectively and total 9 plants were accommodated in each plot. The young transplants were shaded by banana leaf sheath during day time to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border if the experimental plots for gap filling.

3.13 Intercultural operation

After raising seedlings, various intercultural operations, such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the capsicum seedlings.

3.13.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Planted earlier on the border of the experimental plots same as planting time treatment. Those seedlings were transplanted with a big mass of soil with roots to minimize transplanting stock. Replacement was done with healthy seedling having a boll of earth. The transplants were given shading and watering for 7 days for their proper establishment.

3.13.2 Collection and application of plant growth regulators

Plant growth regulators were collected from fertilizer and insecticide market of Norsingdi Sadar, Norsingdi and applied as per treatment. Gibberellic Acid (GA_3) @ 100 ppm, 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm and Litosen @ 1000 ppm of water were applied at four times during vegetative stage, flower initiation stage and 2 times at blooming flowers by a mini hand sprayer.

3.13.3 Weeding

The hand weeding was done 15, 30 and 45, 60 after transplanting to keep the plots free from weeds.

3.13.4 Earthing up

Earthing up was done at 20 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

3.13.5 Irrigation

Light watering was given by a watering cane at every morning and afternoon. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings.

3.13.6 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seeding in the field. In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some of plants were infected by *Alternaria* leaf spot diseases caused by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2 gm per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field.

3.14 Harvesting

Harvesting of fruits was started at 80 DAT and continued upto final harvest based on the marketable sized of fruits. Harvesting was done by hand picking.

3.15 Data collection

Three plants were randomly selected for data collection from the middle rows of each unit plot for avoiding border effect, except yields of fruits, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth, yield attributes and yields.

3.15.1 Plant height

Plant height of bell pepper was measured from sample plants in centimeter from the ground level to the tip of the longest stem and mean value was calculated. Plant height was also recorded starting from 40 days after transplanting (DAT) upto 120 days at 20 days interval and at final harvest to observe the vegetative growth rate of plants.

3.15.2 Number of branches per plant

The total number of branches per plant was counted from each selected plant of bell pepper. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 40 DAT to 120 DAT at 20 days interval and at final harvest.

3.15.3 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 40 DAT to 120 DAT at 20 days interval and final harvest.

3.15.4 Days from transplanting to 1st flowering

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

3.15.5 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.

3.15.6 Number of flowers/plant

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

3.15.7 Number of fruits/plant

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

3.15.8 Fruit setting (%)

Fruit setting was calculated by using the following formula and recorded -

$$\% \text{ Fruit setting} = \frac{\text{Number of fruits per plant}}{\text{Number of flowers per plant}} \times 100$$

3.15.9 Days from transplanting to 1st harvest

Difference between the dates of transplanting to the 1st harvest of a plot was counted as days to 1st harvest. Days to 1st harvest was recorded when harvest of fruit were started.

3.15.10 Length of fruit

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

3.15.11 Diameter of fruit

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

3.15.12 Pericarp thickness

The thickness of paricarp of individual fruit was measured in one side to another side of pericarp from five selected fruits with a meter scale and average of pericarp thickness recorded and expressed in millimeter (mm).

3.15.13 Individual fruit weight

The weight of individual fruit was recorded in gram (gm) by a beam balance from all fruits of selected three plants and converted individually.

3.15.14 Fruit yield/plant

Fruit yield per plant was recorded in gram by a multiplying individual fruit weight and number of fruits/plant by a digital weight machine.

3.15.15 Fruit yield/plot

Yield of bell pepper per plot was recorded as the whole fruit per plot and was expressed in kilogram.

3.15.16 Fruit yield/hectare

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

3.16 Statistical analysis

The data obtained for different characters were statistically analyzed using MSTAT-C software. The mean values of all the characters were evaluated and analysis of variance was performing by the '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 (Gomez and Gomez, 1984).

3.17 Economic analysis

The cost of production was calculated to find out the most economic combination of variety and growth hormone. All input cost like the cost for land lease and interests on running capital were computing in the calculation. The interests were calculated @ 13% in simple rate. The market price of bell pepper 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:

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

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the response of bell pepper varieties in response to plant growth regulators. Data on growth, yield contributing characters and yields were recorded. A summary of the analysis of variance (ANOVA) of the data on different characters have been presented in Appendix III-VII. The results have been discussed and possible interpretations are given under the following sub-headings:

4.1 Plant height

Different varieties of bell pepper showed significant variation for plant height at 40, 60, 80, 100, 120 DAT and final harvest (Appendix III). At 40, 60, 80, 100, 120 DAT and final harvest, the longer plant (14.58, 24.58, 35.69, 41.33, 52.20 and 57.16 cm, respectively) was recorded from V_1 (BARI Misti Morich-1), while the shorter plant (13.63, 22.70, 32.85, 38.69, 48.91 and 53.49 cm, respectively) was observed from V_2 (Exotic variety-Lamuyo) (Figure 2). Different varieties produced different plant height on the basis of their varietal characters and crop variety is one of the important factors. Hasanuzzaman *et al*. (2007) reported that Genotype CP0039 produced the highest plant of 24.23 cm. Sharma *et al*. (2004) reported that capsicum cv. California Wonder produced longest plant of 56 cm.

Plant height of bell pepper varied significantly for different plant growth regulators at 40, 60, 80, 100, 120 DAT and final harvest (Appendix III). At 40, 60, 80, 100, 120 DAT and final harvest, the tallest plant (14.96, 25.23, 36.77, 42.14, 53.50 and 58.39 cm, respectively) was obtained from G_2 (4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm) which was statistically similar (14.77, 24.85, 35.85, 41.62, 52.47 and 56.93 cm, respectively) with G_3 (Litosen @ 1000 ppm) and followed (13.65 cm, 23.00 cm, 33.73 cm, 40.22 cm, 49.71 cm and 54.18 cm) by G_1 (Gibberellic Acid (GA_3) @ 100 ppm), respectively, while the shortest plant (13.03, 21.48, 30.73, 36.06, 46.54 and 51.80 cm, respectively) was found from G_0

i.e. control condition (Figure 3). It was revealed that plant growth hormone increased plant height. Abdul *et al*. (1998) reported increased plant height with GA_3 (at 50, 100 and 150 ppm) on bell pepper. Lone *et al*. (2005) revealed that GA_3 at 250 ppm increased the plant height, followed by GA_3 at 100 ppm.

Significant variation was observed due to the interaction effect of varieties and plant growth regulators in terms of plant height of bell pepper at 40, 60, 80, 100, 120 DAT and final harvest (Appendix III). The tallest plant (14.96 cm, 25.57, 37.01, 43.48, 54.18 and 59.40 cm) was observed from V_1G_2 at 40, 60, 80, 100, 120 DAT and final harvest, respectively. On the other hand, the shortest plant (12.39, 20.06, 25.68, 31.45, 41.78 and 47.72 cm) was recorded from V_2G_0 at 40, 60, 80, 100, 120 DAT and final harvest, respectively (Table 2). Hasanuzzaman *et al*. (2007) reported that, due to hormonal treatments significant variation exists among the genotypes in respect of morphological characters.

4.2 Number of branches per plant

Significant variation was recorded for different varieties of bell pepper in terms of number of branches per plant at 40, 60, 80, 100, 120 DAT and final harvest (Appendix IV). At 40, 60, 80, 100, 120 DAT and final harvest, the maximum number of branches per plant (1.58, 2.41, 3.48, 4.65, 5.80 and 7.02) was observed from V_1, while the minimum number (1.40, 1.88, 3.10, 4.27, 5.18 and 6.62) was found from V_2 (Table 3). Management practices influence the number of branches per plant but variety itself manipulated the number of branches per plant. Hasanuzzaman *et al*. (2007) reported that Genotype CP0039 produced the highest branches (7.36). Sharma *et al*. (2004) reported that capsicum cv. California Wonder under green house produced maximum number of branches (5.86) compared to open field condition.

Table 2. Interaction effect of varieties and plant growth regulators on plant height of bell pepper

Treatment	Plant height (cm)					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
V_1G_0	13.50 ab	22.89 bc	35.79 a	40.66 ab	51.30 ab	55.88 abc
V_1G_1	14.92 a	24.50 ab	34.51 a	42.35 ab	52.13 a	55.66 bc
V_1G_2	14.96 a	25.57 a	37.01 a	43.48 a	54.18 a	59.40 a
V_1G_3	14.93 a	25.37 ab	35.46 a	41.51 ab	52.56 a	57.70 ab
V_2G_0	12.57 b	20.06 d	25.68 b	31.45 c	41.78 c	47.72 d
V_2G_1	12.39 b	21.51 cd	32.95 a	38.08 b	47.29 b	52.71 c
V_2G_2	14.95 a	24.88 ab	36.53 a	40.80 ab	52.81 a	57.38 ab
V_2G_3	14.61 a	24.34 ab	36.25 a	41.73 ab	52.38 a	56.16 abc
$LSD_{(0.05)}$	1.353	2.373	5.325	4.174	4.382	3.214
Level of significance	0.05	0.05	0.05	0.01	0.01	0.05
CV(%)	5.48	5.73	8.87	5.96	4.95	5.32

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

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Table 3. Effect of varieties and plant growth regulators on number of branches per plant of bell pepper

Treatment	Number of branches per plant					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
Variety						
V_1	1.58	2.41	3.48	4.65	5.80	7.02
V_2	1.40	1.88	3.10	4.27	5.18	6.62
$LSD_{(0.05)}$	0.088	0.149	0.225	0.182	0.308	0.398
Level of significance	0.01	0.01	0.01	0.01	0.01	0.05
Plant growth regulator						
G_0	1.33 c	1.73 c	2.13 d	3.80 c	4.33 c	6.07 b
G_1	1.47 b	2.03 b	2.83 c	4.33 b	5.13 b	6.47 b
G_2	1.60 a	2.48 a	4.30 a	4.93 a	6.37 a	7.53 a
G_3	1.57 ab	2.33 a	3.90 b	4.77 a	6.13 a	7.20 a
$LSD_{(0.05)}$	0.124	0.211	0.318	0.257	0.436	0.563
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.62	7.87	7.79	4.64	6.40	6.67

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

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Plant growth regulators showed significant differences for number of branches per plant of bell pepper at 40, 60, 80, 100, 120 DAT and final harvest (Appendix IV). At 40, 60, 80, 100, 120 DAT and final harvest, the maximum number of branches per plant (1.60, 2.48, 4.30, 4.93, 6.37 and 7.53, respectively) was recorded from G_2 which was statistically similar (1.57, 2.33, 4.06, 4.77, 6.13 and 7.20, respectively) to G_3 and also closely followed (1.47, 2.03, 2.83, 4.33, 5.13 and 6.47, respectively) by G_1, respectively, while the minimum number (1.33, 1.73, 2.13, 3.80, 4.33 and 6.07) was found from G_0 i.e. control condition (Table 3). Deka and Shadeque (1996) obtained the highest branches of bell pepper with Cycocel at 500, 1000 of 1500 ppm.

Interaction effect of variety and plant growth regulators showed statistically significant variation in terms of number of branches per plant of bell pepper at 40, 60, 80, 100, 120 DAT and final harvest (Appendix IV). The maximum number of branches per plant (1.67, 2.63, 4.47, 5.00, 6.40 and 7.60, respectively) was obtained from V_1G_2 at 40, 60, 80, 100, 120 DAT and harvest, respectively. On the other hand, the minimum number of branches per plant (1.13, 1.27, 1.73, 3.13, 3.53 and 5.33) was recorded from V_2G_0 at 40, 60, 80, 100, 120 DAT and final harvest, respectively (Table 4).

4.3 Number of leaves per plant

Number of leaves per plant of bell pepper showed statistically significant differences on different varieties at 40, 60, 80, 100, 120 DAT and final harvest (Appendix V). At 40, 60, 80, 100, 120 DAT and final harvest, the maximum number of leaves per plant (30.07, 53.08, 74.92, 89.95, 131.12 and 153.48, respectively) was recorded from V_1, while the minimum number (26.10, 48.43, 69.48, 84.18, 123.17 and 142.75 at same days of observation respectively) was obtained from V_2 (Figure 4). Hasanuzzaman *et al*. (2007) reported that Genotype CP0039 produced the highest leaves (63.64). Sharma *et al*. (2004) reported that capsicum cv. California Wonder under green house produced maximum number of leaves (80.76) compared to open field condition.

Table 4. Interaction effect of varieties and plant growth regulators on number of branches per plant of bell pepper

Treatment	Number of branches per plant					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
V_1G_0	1.53 ab	2.20 c	2.53 d	4.47 bcd	5.13 c	6.81 abc
V_1G_1	1.53 ab	2.27 bc	3.47 c	4.40 cd	5.40 bc	6.60 bc
V_1G_2	1.67 a	2.63 a	4.47 a	5.00 a	6.40 a	7.60 a
V_1G_3	1.60 a	2.53 ab	3.80 bc	4.73 abc	6.27 a	7.20 abc
V_2G_0	1.13 c	1.27 e	1.73 e	3.13 e	3.53 d	5.33 d
V_2G_1	1.40 b	1.80 d	2.20 d	4.27 d	4.87 c	6.33 c
V_2G_2	1.53 ab	2.33 abc	4.13 ab	4.87 a	6.33 a	7.47 ab
V_2G_3	1.53 ab	2.13 c	4.00 ab	4.80 ab	6.00 ab	7.20 abc
$LSD_{(0.05)}$	0.175	0.298	0.450	0.363	0.617	0.797
Level of significance	0.05	0.05	0.01	0.01	0.01	0.05
CV(%)	6.62	7.87	7.79	4.64	6.40	6.67

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

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Number of leaves per plant of bell pepper differed significantly due to the effect of different plant growth regulators at 40, 60, 80, 100, 120 DAT and final harvest (Appendix V). At 40, 60, 80, 100, 120 DAT and final harvest, the maximum number of leaves per plant (33.00, 55.07, 81.30, 94.70, 136.30 and 160.40, respectively) was found from G_2 which was statistically similar (30.87, 53.90, 76.10, 90.84, 132.40 and 155.13, respectively) with G_3 and closely followed (24.93, 49.17, 68.00, 84.83, 123.13 and 142.97) by G_1, respectively, while the minimum number (23.53, 44.90, 63.40, 78.03, 116.75 and 133.97, respectively) from G_0 i.e. control condition (Figure 5). Abdul *et al*. (1998) reported increased no. of leaf with the application of GA_3 (at 50, 100 and 150 ppm) on bell pepper.

Variety and plant growth regulators showed significant variation due to the interaction effect on number of leaves per plant of bell pepper at 40, 60, 80, 100, 120 DAT and final harvest (Appendix V). The maximum number of leaves per plant (33.33, 55.67, 83.80, 95.20, 138.60 and 161.53, respectively) was recorded from V_2G_2 at 40, 60, 80, 100, 120 DAT and final harvest, respectively, whereas the minimum number of leaves per plant (16.27, 34.60, 51.00, 70.80, 108.57 and126.20, respectively) was observed from V_2G_0 at 40, 60, 80, 100, 120 DAT and final harvest (Table 5).

4.4 Days from transplanting to 1st flowering

Days from transplanting to 1st flowering showed statistically significant variation due to the effect of different varieties of bell pepper (Appendix VI). The minimum days from transplanting to 1st flowering (50.75 days) was found from V_2, while the maximum (52.75 days) was attained from V_1 (Table 6). Days to 1st flowering varied for different varieties might be due to genetical influences.

Significant variation was observed in terms of days from transplanting to 1st flowering of bell pepper for different plant growth regulators (Appendix VI). The minimum days from transplanting to 1st flowering (50.17 days) was found from G_3 which was statistically similar (51.17 days) to G_2, while the maximum (53.00 days) from G_0 which was statistically identical (52.67 days) with G_1 (Table 6).

Table 5. Interaction effect of varieties and plant growth regulators on number of leaves per plant of bell pepper

Treatment	Number of leaves per plant					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
V_1G_0	30.80 ab	55.20 a	75.80 abc	85.27 cd	124.93 ab	141.73 b
V_1G_1	26.80 bc	49.53 a	70.73 bc	88.47 bc	134.20 a	154.27 a
V_1G_2	33.33 a	54.47 a	78.80 ab	94.20 ab	134.00 a	159.27 a
V_1G_3	29.33 ab	53.13 a	74.33 abc	91.87 ab	131.33 a	156.40 a
V_2G_0	16.27 d	34.60 b	51.00 d	70.80 e	108.57 c	126.20 c
V_2G_1	23.07 c	48.80 a	65.27 c	81.20 d	112.07 bc	131.67 c
V_2G_2	32.67 a	55.67 a	83.80 a	95.20 a	138.60 a	161.53 a
V_2G_3	32.40 a	54.67 a	77.87 ab	89.53 abc	133.47 a	153.87 a
$LSD_{(0.05)}$	4.749	7.034	9.798	5.592	14.06	8.941
Level of significance	0.01	0.01	0.01	0.01	0.05	0.01
CV(%)	9.66	7.91	7.75	5.67	6.31	5.45

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

V_1: BARI Misti Morich – 1 V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water) G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm G_3: Litosen @ 1000 ppm

Table 6. Effect of varieties and plant growth regulators on yield contributing characters of bell pepper

Treatment	Days from transplanting to 1st flowering	Days from transplanting to 50% flowering	Number of flowers per plant	Number of fruits per plant	Days from transplanting to 1st harvest
Variety					
V_1	52.75	90.67	31.00	6.92	111.83
V_2	50.75	93.17	32.58	7.50	109.83
$LSD_{(0.05)}$	1.312	1.258	0.919	0.448	--
Level of significance	0.01	0.01	0.01	0.01	NS
Plant growth regulator					
G_0	53.00 a	95.17 a	30.67 b	5.50 c	120.83 a
G_1	52.67 a	92.83 b	31.50 b	7.33 b	111.50 b
G_2	51.17 ab	90.50 c	33.00 a	8.34 a	108.33 bc
G_3	50.17 b	89.17 c	32.00 a	7.67 b	102.67 c
$LSD_{(0.05)}$	1.855	1.779	1.300	0.634	7.054
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.89	4.56	4.30	7.10	5.14

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

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Interaction effect of variety and plant growth regulators varied significantly for days from transplanting to 1st flowering (Appendix VI). The minimum days from transplanting to 1st flowering (48.67 days) was found from V_2G_0, while the maximum (57.33 days) was observed from V_1G_0 (Table 7).

4.5 Days from transplanting to 50% flowering

Different varieties of bell pepper showed statistically significant variation for days from transplanting to 50% flowering (Appendix VI). The minimum days from transplanting to 50% flowering (90.67) was found from V_1, while the maximum days (93.17) was recorded from V_2 (Table 6).

Days from transplanting to 50% flowering of bell pepper varied significantly for different plant growth regulators (Appendix VI). The minimum days from transplanting to 50% flowering (89.17) was found from G_3 which was statistically similar (90.50) to G_2 and closely followed (92.83) by G_1, while the maximum days (95.17) was recorded from G_0 i.e. control condition (Table 6).

Significant variation was observed due to the interaction effect of variety and plant growth regulators in terms of days from transplanting to 50% flowering (Appendix VI). The minimum days from transplanting to 50% flowering (85.33) was obtained from V_1G_3, while the maximum days (96.67) was found from V_1G_0 (Table 7).

4.6 Number of flowers per plant

Significant variation was recorded due to the effect of different varieties of bell pepper on number of flowers per plant (Appendix VI). The higher number of flowers per plant (32.58) was recorded from V_2, while the lower number (31.00) was obtained from V_1 (Table 6).

Table 7. Interaction effect of varieties and plant growth regulators on yield contributing characters of bell pepper

Treatment	Days from transplanting to 1st flowering	Days from transplanting to 50% flowering	Number of flowers per plant	Number of fruits per plant	Days from transplanting to 1st harvest
V_1G_0	57.33 a	96.67 a	29.67 c	5.33 d	122.33 a
V_1G_1	53.67 b	92.00 b	30.33 bc	7.00 c	113.67 abc
V_1G_2	49.67 de	88.67 c	32.67 a	8.00 ab	109.67 bcd
V_1G_3	50.33 cde	85.33 d	31.33 abc	7.33 bc	101.67 d
V_2G_0	48.67 e	93.67 b	31.67 ab	5.67 d	119.33 ab
V_2G_1	51.67 bcd	93.67 b	32.67 a	7.67 bc	109.33 bcd
V_2G_2	52.67 bc	92.33 b	33.33 a	8.67 a	103.67 cd
V_2G_3	50.00 cde	93.00 b	32.67 a	8.00 a	107.00 cd
$LSD_{(0.05)}$	2.623	2.517	1.838	0.896	9.976
Level of significance	0.01	0.01	0.05	0.05	0.05
CV(%)	4.89	4.56	4.30	7.10	5.14

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

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Number of flowers per plant of bell pepper showed significant differences due to the effect of different plant growth regulators (Appendix VI). The highest number of flowers per plant (33.00) was recorded from G_2 which was statistically similar (32.00) to G_3 and closely followed (31.50) by G_1, whereas the lowest number (30.67) was attained from G_0 i.e. control condition (Table 6). Chaudhary *et al.*, 2006 reported that plant growth regulators play an essential role in flower development.

Number of flowers per plant showed significant variation due to the interaction effect of varieties and plant growth regulators (Appendix VI). The highest number of flowers per plant (33.33) was recorded from V_2G_2, while the lowest number (29.67) was found from V_1G_0 (Table 7).

4.7 Number of fruits per plant

Different varieties of bell pepper showed significant variation on number of fruits per plant (Appendix VI). The higher number of fruits per plant (7.50) was obtained from V_2, while the lower number (6.92) was obtained from V_1 (Table 6). Different varieties responded differently for number of fruits to input supply, method of cultivation and the prevailing environment during the growing season. Hasanuzzaman *et al*. (2007) reported that lowest fruit bearing (4-fruits/plant) were recorded in control plants of CP0068.

Plant growth regulators significantly influenced on number of fruits per plant of bell pepper (Appendix VI). The highest number of fruits per plant (8.34) was found from G_2 which was closely followed (7.67 and 7.33) by G_3 and G_1, while the lowest number (5.50) was recorded from G_0 i.e. control condition (Table 6).

Significant variation was observed due to the interaction effect of varieties and plant growth regulators in terms of number of fruits per plant (Appendix VI). The highest number of fruits per plant (8.67) was recorded from V_2G_2, while the lowest number (5.33) was observed from V_1G_0 (Table 7).

4.8 Fruit setting

Fruit setting of bell pepper showed significant variation due to the effect of different varieties (Appendix VI). The maximum fruit setting (22.99%) was found from V_2, while the minimum (22.26%) was attained from V_1 (Figure 6). Dahal *et al*. (2006) reported that fruit set percent varied significantly with the average of 18.81% for genotype CCA-119A.

Fruit setting of bell pepper varied significantly for different plant growth regulators (Appendix VI). The maximum fruit setting (25.26%) was found from G_2 which was statistically similar (24.00% and 23.31%) with G_3 and G_1, respectively, while the minimum fruit setting (17.93%) was recorded from G_0 i.e. control condition (Figure 7). Deka and Shadeque (1996) obtained the fruit set of bell pepper with Cycocel at 500, 1000 of 1500 ppm. Rajmani *et al*. (1990) reported that increased percentage of fruit set with 2, 4-D (2-5ppm) and tricontanol (1.25-5 ppm) and with chorflurenol on bell pepper, respectively.

Interaction effect of varieties and plant growth regulators showed significant variation in terms of fruit setting (Appendix VI). The maximum fruit setting (26.02%) was observed from V_2G_2, while the minimum (17.95%) was found from V_1G_0 (Figure 8).

4.9 Days from transplanting to 1st harvest

Different varieties of bell pepper showed significant effect on days from transplanting to 1st harvest (Appendix VI). However, minimum days from transplanting to 1st harvest (109.83) was attained from V_2, while the maximum days (111.83) was found from V_1 (Table 6).

Days from transplanting to 1st harvest of bell pepper varied significantly due to different plant growth regulators (Appendix VI). The minimum days from transplanting to 1st harvest (102.67) was found from G_3 which was statistically similar (108.33) to G_2 and closely followed (111.50) by G_1, while the maximum days (120.83) was recorded from G_0 i.e. control condition (Table 6).

Significant variation was obtained due to the interaction effect of varieties and plant growth regulators in terms of days from transplanting to 1st harvest (Appendix VI). The minimum days from transplanting to 1st harvest (101.67) was found from V_1G_3, while the maximum days (122.33) was recorded from V_1G_0 (Table 7).

4.10 Length of fruit

Different varieties of bell pepper showed significant variation for length of fruit (Appendix VII). The maximum length of fruit (7.41 cm) was recorded from V_2, while the minimum length (6.96 cm) was found from V_1 (Table 8).

Different plant growth regulators showed significant variation on length of fruits (Appendix VII). The maximum length of fruit (7.80 cm) was found from G_2 which was statistically similar (7.60 cm) to G_3 and closely followed (7.18 cm) by G_1, where the minimum length (6.17 cm) was observed from G_0 i.e. control condition (Table 8).

Significant variation was observed due to the interaction effect of variety and plant growth regulators in terms of length of fruit (Appendix VII). The maximum length of fruit (8.07 cm) was found from V_1G_2, while the minimum length (5.73 cm) was observed from V_1G_0 (Table 9).

4.11 Diameter of fruit

Diameter of fruit varied significantly due to different varieties of bell pepper (Appendix VII). The maximum diameter of fruit (5.40 cm) was recorded from V_2, while the minimum diameter (4.80 cm) was obtained from V_1 (Table 8).

Significant variation was recorded for diameter of fruit of bell pepper for different plant growth regulators (Appendix VII). The maximum diameter of fruit (5.52 cm) was found from G_2 which was statistically similar (5.33 cm) to G_3 and closely followed (4.96 cm) by G_1, while the minimum diameter (4.57 cm) was recorded from G_0 i.e. control condition (Table 8).

Table 8. Effect of varieties and plant growth regulators yield contributing characters and yield of bell pepper

Treatment	Length of fruit (cm)	Diameter of fruit (cm)	Pericarp thickness (mm)	Individual fruit weight (g)	Yield per plant (g)	Yield per plot (kg)
Variety						
V_1	6.96	4.80	5.86	57.79	401.80	3.62
V_2	7.41	5.40	6.38	59.64	449.41	4.05
$LSD_{(0.05)}$	0.396	0.168	0.293	1.708	31.05	0.280
Level of significance	0.05	0.01	0.01	0.05	0.01	0.01
Plant growth regulator						
G_0	6.17 c	4.57 c	5.65 c	55.60 b	306.50 c	2.76 c
G_1	7.18 b	4.96 b	6.05 bc	58.94 a	432.70 b	3.89 b
G_2	7.80 a	5.52 a	6.51 a	60.37 a	503.45 a	4.53 a
G_3	7.60 ab	5.33 a	6.27 ab	59.95 a	459.77 ab	4.14 ab
$LSD_{(0.05)}$	0.561	0.238	0.414	2.416	43.92	0.396
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.31	4.79	5.46	4.32	8.33	8.33

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

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Table 9. Interaction effect of varieties and plant growth regulators yield contributing characters and yield of bell pepper

Treatment	Length of fruit (cm)	Diameter of fruit (cm)	Pericarp thickness (mm)	Individual fruit weight (g)	Yield per plant (g)	Yield per plot (kg)	Yield per hectare (ton)
V_1G_0	5.73 c	4.06 e	5.25 c	54.27 c	290.20 d	2.61 d	14.51 d
V_1G_1	6.45 bc	4.71 d	5.72 bc	58.30 ab	408.10 c	3.67 c	20.41 c
V_1G_2	8.07 a	5.33 bc	6.34 ab	59.57 ab	476.56 ab	4.29 ab	23.83 ab
V_1G_3	7.61 a	5.08 c	6.12 ab	59.00 ab	432.33 bc	3.89 bc	21.62 bc
V_2G_0	6.61 b	5.09 c	6.05 ab	56.93 bc	322.79 d	2.91 d	16.14 d
V_2G_1	7.91 a	5.21 c	6.38 a	59.57 ab	457.30 bc	4.12 bc	22.87 bc
V_2G_2	7.54 a	5.70 a	6.68 a	61.17 a	530.34 a	4.77 a	26.52 a
V_2G_3	7.59 a	5.58 ab	6.41 a	60.90 a	487.20 ab	4.39 ab	24.36 ab
$LSD_{(0.05)}$	0.793	0.337	0.586	3.417	62.11	0.559	3.105
Level of significance	0.01	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	6.31	4.79	5.46	4.32	8.33	8.33	8.33

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

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Different varieties and plant growth regulators varied significantly due to the interaction effect in terms of diameter of fruit (Appendix VII). The maximum diameter of fruit (5.70 cm) was recorded from V_2G_2, while the minimum diameter (4.06 cm) was observed from V_1G_0 (Table 9).

4.12 Pericarp thickness

Different varieties of bell pepper showed significant variation on pericarp thickness (Appendix VII). The maximum pericarp thickness (6.38 mm) was observed from V_2, while the minimum thickness (5.86 mm) was found from V_1 (Table 8).

Pericarp thickness of bell pepper varied significantly for different plant growth regulators (Appendix VII). The maximum pericarp thickness (6.51 mm) was found from G_2 which was statistically similar (6.27 mm) with G_3 and closely followed (6.05 mm) by G_1, while the minimum thickness (5.65 mm) was attained from G_0 i.e. control condition (Table 8).

Significant variation was found due to the interaction effect of varieties and plant growth regulators in terms of pericarp thickness (Appendix VII). The maximum pericarp thickness (6.68 mm) was recorded from V_2G_2, while the minimum thickness (5.25 mm) was observed from V_1G_0 (Table 9).

4.13 Individual fruit weight

Significant variation was recorded on individual fruit weight for different varieties of bell pepper (Appendix VII). The higher weight of individual fruit (59.64 g) was observed from V_2, while the lower weight (57.79 g) was found from V_1 (Table 8).

Different plant growth regulators showed significant variation on individual fruit weight of bell pepper (Appendix VII). The highest weight of individual fruit (60.37 g) was recorded from G_2 which was statistically similar (59.95 g and 58.94 g) to G_3 and G_1, while the lowest weight (55.60 g) was found from G_0 i.e. control condition (Table 8).

Significant variation was observed due to the interaction effect of variety and plant growth regulators in terms of individual fruit weight (Appendix VII). The highest weight of individual fruit (61.17 g) was attained from V_2G_2, while the lowest weight (54.27 g) was observed from V_1G_0 (Table 9).

4.14 Yield per plant

Different varieties of bell pepper showed significant variation on yield per plant (Appendix VII). The higher yield per plant (449.41 g) was found from V_2, while the lower yield per plant (401.80 g) was observed from V_1 (Table 8). Yield varied for different varieties might be due to genetical and environmental influences as well as management practices.

Yield per plant of bell pepper varied significantly on different plant growth regulators (Appendix VII). The highest yield per plant (503.45 g) was found from G_2 which was statistically similar (459.77 g) to G_3 and closely followed (432.70 g) by G_1, while the lowest yield per plant (306.50 g) was recorded from G_0 i.e. control condition (Table 8). Rana *et al*. (2011) reported that the application of Miyobi produced higher fruit yield in 0.5 and 0.8 mgL^{-1} with being the highest in 0.5 mgL^{-1} (369.8 g $plant^{-1}$).

Interaction effect of variety and plant growth regulators varied significantly due to the in terms of yield per plant (Appendix VII). The highest yield per plant (530.34 g) was attained from V_2G_2, while the lowest yield per plant (290.20 g) was found from V_1G_0 (Table 9).

4.15 Yield per plot

Significant variation was recorded for different varieties of bell pepper in terms of yield per plot (Appendix VII). The higher yield per plot (4.05 kg) was recorded from V_2, while the lower yield per plot (3.62 kg) was found from V_1 (Table 8).

Yield per plot of bell pepper showed significant differences for different growth regulators (Appendix VII). The highest yield per plot (4.53 kg) was found from

G_2 which was statistically similar (4.14 kg) to G_3 and closely followed (3.89 kg) by G_1, while the lowest yield per plot (2.76 kg) was observed from G_0 (Table 8).

Varieties and plant growth regulators varied significantly due to their interaction effect in terms of yield per plot (Appendix VII). The highest yield per plot (4.77 kg) was recorded from V_2G_2, while the lowest yield per plot (2.61 kg) was found from V_1G_0 (Table 9).

4.16 Yield per hectare

Yield per hectare showed significant variation for different varieties of bell pepper (Appendix VII). The highest yield per hectare (22.47 ton) was attained from V_2, while the lowest yield per hectare (20.09 ton) was recorded from V_1 (Figure 9). Appireddy *et al*. (2008) reported that performance of US Agril 181 was significantly higher in fruit yield (25.42 t/ha in 2005 and 28.82 t/ha in 2006) as compared with other varieties and also gave highest net returns followed by Aishwarya and California Wonder under green house condition when they worked with five capsicum varieties. Muniz and Almedia (1998) observed that the most productive cultivars were Ruby King, Early Calwonder and Ikeda and they produced 15.8-19.5, 15.5-19.5 and 16.6-18.4 tonnes per ha, respectively.

Significant variation was recorded for yield per hectare of bell pepper for different hectare growth regulators (Appendix VII). The highest yield per hectare (25.17 ton) was recorded from G_2 which was statistically similar (22.99 ton) to G_3 and closely followed (21.64 ton) by G_1, while the lowest yield per hectare (15.33 ton) was observed from G_0 i.e. control condition (Figure 10). Deka and Shadeque (1996) obtained the highest yield of bell pepper with Cycocel at 500, 1000 of 1500 ppm.

Interaction effect of variety and hectare growth regulators showed significant variation in terms of yield per hectare (Appendix VII). The highest yield per hectare (26.52 ton) was found from V_2G_2, while the lowest yield per hectare (14.51 ton) was observed from V_1G_0 (Table 9). Hasanuzzaman *et al*. (2007) reported that, due to hormonal treatments significant variation exists among the genotypes in respect of fruit yield and genotype CP0039 plants treated Milstim and Litosen produced resulting 20.37 t/ha and 19.93 t ha^{-1} yield, respectively.

4.17 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of bell pepper were recorded for unit plot and converted into cost per hectare (Appendix VII). Price of bell pepper was considered as per market rate. The economic analysis presented under the following headings-

4.17.1 Gross return

The combination of variety and plant growth regulators showed different values in terms of gross return under the trial (Table 10). The highest gross return (Tk. 1,591,200) was obtained from the treatment combination V_2G_2 and the second highest gross return (Tk. 1,461,600) was found in V_2G_3. The lowest gross return (Tk. 870,600) was obtained from V_1G_0.

4.17.2 Net return

In case of net return, different treatment combination showed different levels of net return under the present trial (Table 10). The highest net return (Tk. 1,031,941) was found from the treatment combination V_2G_2 and the second highest net return (Tk. 894,271) was obtained from the combination V_1G_2. The lowest (Tk. 358,801) net return was obtained V_1G_0.

Table 10. Cost and return of bell pepper cultivation as influenced by variety and plant growth regulators

Treatment	Cost of production (Tk./ha)	Yield of bell pepper (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost Ratio
V_1G_0	511799	14.51	870600	358801	1.70
V_1G_1	541462	20.41	1224600	683138	2.26
V_1G_2	535529	23.83	1429800	894271	2.67
V_1G_3	547394	21.62	1297200	749806	2.37
V_2G_0	535529	16.14	968400	432871	1.81
V_2G_1	565192	22.87	1372200	807008	2.43
V_2G_2	559259	26.52	1591200	1031941	2.85
V_2G_3	571124	24.36	1461600	890476	2.56

Market price of bell peeper: @ Tk. 60,000/ton

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh to determine the response of bell pepper varieties in response to plant growth regulators. The experiment consisted of two factors: Factor A: Bell pepper (two varieties) asV_1: BARI Misti Morich-1 and V_2: Exotic variety (Lamuyo); Factor B: Plant growth regulators (four levels) as G_0: No plant growth regulator (water), G_1: Gibberellic Acid (GA_3) @ 100 ppm, G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm and G_3: Litosen @ 1000 ppm. There were 8 (2 × 4) treatments combination. Two factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on growth, yield contributing characters and yields were recorded and significant variation was observed.

In case of bell pepper variety, at 40, 60, 80, 100, 120 DAT and harvest, the longer plant (14.58 cm, 24.58 cm, 35.69 cm, 41.33 cm, 52.20 cm and 57.16 cm) was recorded from V_1, while the shorter plant (13.63 cm, 22.70 cm, 32.85 cm, 38.69 cm, 48.91 cm and 53.49 cm) from V_2. At 40, 60, 80, 100, 120 DAT and harvest, the maximum number of branches per plant (1.58, 2.41, 3.48, 4.65, 5.80 and 7.02) was observed from V_1, while the minimum number (1.40, 1.88, 3.10, 4.27, 5.18 and 6.62) from V_2. At 40, 60, 80, 100, 120 DAT and harvest, the maximum number of leaves per plant (30.07, 53.08, 74.92, 89.95, 131.12 and 153.48) was recorded from V_1, while the minimum number (26.10, 48.43, 69.48, 84.18, 123.17 and 142.75) from V_2. The minimum days from transplanting to 1st flowering (50.75) were found from V_2, while the maximum days (52.75) from V_1. The minimum days from transplanting to 50% flowering (90.67) was found from V_1, while the maximum days (93.17) from V_2. The maximum number of flowers per plant (32.58) was recorded from V_2, while the minimum number (31.00) from V_1. The maximum number of fruits per plant (7.50) was recorded from V_2, while the minimum number (6.92) from V_1.

The maximum fruit setting (22.99%) was found from V_2, while the minimum (22.26%) from V_1. The minimum days from transplanting to 1st harvest (109.83) were attained from V_2, while the maximum days (111.83) from V_1. The maximum length of fruit (7.41 cm) was recorded from V_2, while the minimum length (6.96 cm) was found from V_1. The maximum diameter of fruit (5.40 cm) was recorded from V_2, while the minimum diameter (4.80 cm) was obtained from V_1. The maximum pericarp thickness (6.38 mm) was observed from V_2, while the minimum thickness (5.86 mm) was found from V_1. The maximum weight of individual fruit (59.64 g) was observed from V_2, while the minimum weight (57.79 g) was found from V_1. The maximum yield per plant (449.41 g) was found from V_2, while the minimum yield per plant (401.80 g) was observed from V_1. The maximum yield per plot (4.05 kg) was recorded from V_2, while the minimum yield per plot (3.62 kg) was found from V_1. The maximum yield per hectare (22.47 ton) was attained from V_2, while the minimum yield per hectare (20.09 ton) from V_1.

For plant growth regulators, at 40, 60, 80, 100, 120 DAT and harvest, the tallest plant (14.96 cm, 25.23 cm, 36.77 cm, 42.14 cm, 53.50 cm and 58.39 cm) was obtained from G_2, while the shortest plant (13.03 cm, 21.48 cm, 30.73 cm, 36.06 cm, 46.54 cm and 51.80 cm) was found from G_0. At 40, 60, 80, 100, 120 DAT and harvest, the maximum number of branches per plant (1.60, 2.48, 4.30, 4.93, 6.37 and 7.53) was recorded from G_2, while the minimum number (1.33, 1.73, 2.13, 3.80, 4.33 and 6.07) was found from G_0. At 40, 60, 80, 100, 120 DAT and harvest, the maximum number of leaves per plant (33.00, 55.07, 81.30, 94.70, 136.30 and 160.40) was found from G_2, again the minimum number (23.53, 44.90, 63.40, 78.03, 116.75 and 133.97) was recorded from G_0. The minimum days from transplanting to 1st flowering (50.17) was obtained from G_3, while the maximum days (53.00) was found from G_0. The minimum days from transplanting to 50% flowering (89.17) was found from G_3, while the maximum days (95.17) was recorded from G_0. The highest number of flowers per plant (32.58) was recorded from G_2, whereas the lowest number (31.00) was attained

from G_0. The highest number of fruits per plant (8.34) was found from G_2, while the lowest number (5.50) was recorded from G_0. The maximum fruit setting (25.26%) was found from G_2, while the minimum fruit setting (17.93%) was recorded from G_0. The minimum days from transplanting to 1st harvest (102.67) was found from G_3 and the maximum days (120.83) was recorded from G_0. The maximum length of fruit (7.80 cm) was found from G_2, again the minimum length (6.17 cm) was observed from G_0. The maximum diameter of fruit (5.52 cm) was found from G_2, while the minimum diameter (4.57 cm) was recorded from G_0. The maximum pericarp thickness (6.51 mm) was found from G_2, while the minimum thickness (5.65 mm) was attained from G_0. The highest weight of individual fruit (60.37 g) was recorded from G_2 and the lowest weight (55.60 g) was found from G_0. The highest yield per plant (503.45 g) was found from G_2 whereas the lowest yield per plant (306.50 g) was recorded from G_0. The highest yield per plot (4.53 kg) was found from G_2 and the lowest yield per plot (2.76 kg) was observed from G_0. The highest yield per hectare (25.17 ton) was recorded from G_2, whereas the lowest yield per hectare (15.33 ton) from G_0.

Due to the interaction effect of variety and plant growth regulators, the tallest plant (14.96 cm, 25.57 cm, 37.01 cm, 43.48 cm, 54.18 cm and 59.40 cm) was observed from V_1G_2, whereas the shortest plant (12.39 cm, 20.06 cm, 25.68 cm, 31.45 cm, 41.78 cm and 47.72 cm) from V_2G_0. The maximum number of branches per plant (1.67, 2.63, 4.47, 5.00, 6.40 and 7.60) was obtained from V_1G_2 at 40, 60, 80, 100, 120 DAT and harvest, respectively and the minimum number (1.13, 1.27, 1.73, 3.13, 3.53 and 5.33) from V_2G_0. The maximum number of leaves per plant (33.33, 55.67, 83.80, 95.20, 138.60 and 161.53) was recorded from V_2G_2 at 40, 60, 80, 100, 120 DAT and harvest, respectively, whereas the minimum number (16.27, 34.60, 51.00, 70.80, 108.57 and126.20) from V_2G_0 at 40, 60, 80, 100, 120 DAT and harvest. The minimum days from transplanting to 1st flowering (48.67) was found from V_2G_0, while the maximum days (57.33) from V_1G_0. The minimum days from transplanting to 50% flowering (85.33) was obtained from V_1G_2, while the maximum days (96.67) from V_1G_0.

The highest number of flowers per plant (33.33) was recorded from V_2G_2, while the lowest number (29.67) from V_1G_0. The highest number of fruits per plant (8.67) was recorded from V_2G_2, while the lowest number (5.33) from V_1G_0. The maximum fruit setting (26.02%) was observed from V_2G_2 and the minimum (17.95%) from V_1G_0. The minimum days from transplanting to 1st harvest (101.67) was found from V_1G_3, while the maximum days (122.33) from V_1G_0. The maximum length of fruit (8.07 cm) was found from V_1G_2, while the minimum length (5.73 cm) from V_1G_0. The maximum diameter of fruit (5.70 cm) was recorded from V_2G_2, while the minimum diameter (4.06 cm) from V_1G_0. The maximum pericarp thickness (6.68 mm) was recorded from V_2G_2, while the minimum thickness (5.25 mm) from V_1G_0. The highest weight of individual fruit (61.17 g) was attained from V_2G_2, while the lowest weight (54.27 g) from V_1G_0. The highest yield per plant (530.34 g) was attained from V_2G_2, while the lowest yield per plant (290.20 g) from V_1G_0. The highest yield per plot (4.77 kg) was recorded from V_2G_2, while the lowest yield per plot (2.61 kg) from V_1G_0. The highest yield per hectare (26.52 ton) was found from V_2G_2, while the lowest yield per hectare (14.51 ton) from V_1G_0.

The highest gross return (Tk. 1,591,200) was obtained from the treatment combination V_2G_2 and the lowest gross return (Tk. 870,600) from V_1G_0. The highest net return (Tk. 1,031,941) was found from V_2G_2 and the lowest (Tk. 358,801) net return was obtained V_1G_0. The highest benefit cost ratio (2.85) was noted from V_2G_2 and the lowest benefit cost ratio (1.70) was obtained from V_1G_0.

Conclusion:

Considering the findings of the experiment, it may be concluded that:

1. Exotic variety (Lamuyo) was superior than BARI Misti Morich-1.
2. Plant growth hormone 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm was superior than the others.
3. The treatment combination of V_2G_2 (Exotic variety-Lamuyo + 4-Chloro Phenoxy Acetic Acid- (4-CPA) @ 2000 ppm) showed best potentiality.
4. Further studies at different agro-ecological zone of Bangladesh are needed for precise recommendation.

REFERENCES

Abdul, K.S., Saleh, M.M.S and Omar. S.J. 1988. Effects of gibberellic acid and cycocel on the growth flowering and fruiting characteristics of pepper. *Iraqi.J.Agril. Sci.*, **6**(2):7/8.

Alam, M. S., Iqbal, T. M. T., Amin, M. and Gaffar, M. A. 1989. Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T. M. Jubair Bin Iqbal, Sirajgonj. pp. 231-239.

Anonymous. 1989. Annual Report 1987-88. Bangladesh Agricultural Research Council. p. 45.

Appireddy, G.K., Saha, S., Mina, B.L., Kundu, S., Selvakumar, G., Gupta, H.S. 2008. Effect of organic manures and integrated nutrient management on yield potential of bell pepper (*Capsicum annum*) varieties and on soil properties. *Archives of Agron. Soil Sci*., **54**(2): 127-137.

AVRDC.1989. Tomato and the pepper production in the tropics. AVRDC., Taiwan. 585p.

Balraj, R., Kurdikeri, M.B. and Revan, A. 2002. Effect of growth regulators on growth and yield of chilli *(Capsicum annuum*) at different pickings. *Indian J. Hort*., **59**(1): 84-88.

Balraj, R., Kurdikeri, M.B. and Revanappa. 2002. Effect of growth regulators on growth and yield of chilli (*Capsicum annuum* L.) at different pickings. *Indian J. Hort*., **59** (1): 84-88.

Bangladesh Agricultural Research Institute. (2011). Krishi Projukti Hatboi, 5th edition, 1st part. December-2011. pp. 484.

Chaudhary, B. R., Sharma, M.D., Shakya S.M. and Gautam, D.M. 2006. Effect of plant growth regulators on growth, yield and quality of chilly (*Capsicum annuum* L.) at Rampur, Chitwan. *J. Inst. Agric. Anim. Sci.*, **27**: 65-68.

Chaudhary, B.R., Sharma, M.D., Shakya, S.M. and Gautam, D.M. 2006. Effect of plant growth regulators on growth, yield and quality of chilli (*Capsicum annuum* L.) at rampur, chitwan. *J. Inst. Agric. Anim. Sci*., **27**: 65-68.

Dahal, K.C., Sharma, M.D., Dhakal, D.D. and Shakya, S. M. 2006. Evaluation of heat tolerant chilli (*Capsicum annuum* L.) genotypes in western terai of nepal. *J. Inst. Agric. Anim. Sci*., **27**: 59-64.

Deka, P.C. and Shadeque, A. 1996. Effect offoliar sprays of cycocel (CCC) on the growth andyield of bell pepper. *Hort. J*., **9**(2): [4]-147.

Dipendra, G. and Gautam, B.P. 2002. Evaluation of chilli (*Capsicum* spp.) germplasm for fruit yield and component characters. *J. Appl. Hort. Lucknow*., **4**(1): 41-44.

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

FAO. 1988. Production Year Book. Food and Agriculture Organizations of the United Nations. Rome, Italy. 190-193.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedure for Agricultural Research (2^{nd} edn.). *Int. Rice Res. Inst., A Willey Int. Sci*., pp. 28-192.

Hari, G.S., Rao, P.V. and Reddy, Y.N. 2005. Evaluation of different germplasm on growth and yield in irrigated paprika (*Capsicum annuum* L.). *Res. Crops*., **6**(2): 261-265.

Hasanuzzaman , S.M., Hossain, S.M.M., Ali , M. O., Hossain, M.A. and Hannan, A. 2007. Performance of Different Bell Pepper (*Capsicum annuum* L.) Genotypes in Response to Synthetic Hormones. *Int. J. Sustain. Crop Prod*., **2**(5): 78-84.

Hasanuzzaman, S.M. 1999. Effect of hormone on yield of bell pepper (*Capsicum annum* L.) MS thesis, BAU, Mymensingh.

Joshi, M.C. and Singh, D.P.1975. Chemical composition in bell pepper. *Indian Hort*., 20: 19-21.

Joshi, N.C. and Singh, D.K. 2003 Effect of plant bioregulators on growth and yield of chilli (*Capsicum annuum* L.). *Progressive Hort.,* **35**(2): 212-215.

Joshi, N.C., Singh, D.K. and Jain, S.K. 1999. Response of plant bioregulators on growth and yield of chilli during summer season. *Adv. Hort. & Fores*., **7**: 95-99.

Kannan, K., Jawaharlal, M. and Prabhu, M. 2009. Effect of growth regulators on physiological parameters in paprika cv. Ktpl-19. *American Eurasian J. Sustainable Agri*., **3**(4): 732-736.

Khan, M.A.I., Hoque, M.A., Farooque, A.M., Habiba, U. and Rahim, M.A. 2012. Physio-morphological features of chilli accessions under moisture stress conditions. *Bangladesh J. Agril. Res*., **37**(2): 263-269.

Leclerc, M., Caldwell, C. and Lada, R. 2006. Effect of plant growth regulators on propaguleformation in *Hemerocallis* spp., and *Hosta* spp. *Hort Sci.*, **41**: 651-653.

Lone, M.T., Haripriya, K. and Maheswari, T.U. 2005. Influence of plant growth regulators on growth and yield of chilli (*Capsicum annuum* L.) cv. K 2. *Crop Res. Hisar*., **29**(1): 111-113

Maaike Wubs A. and Yuntao, M. 2009. Fruit Set and Yield Patterns in Six Capsicum Cultivars. *Hort Sci*., **44**(5):1296–1301.

Minraj, N. and Shanmugavelu, K.G. 1987. Studies on the effect of triacontanol on growth, flowering, yield, quality and nutrient uptake in chillies (*Capsicum annuum* L.). *S. Indian Hort*., **35** (4): 362-366.

Muniz. J.O. and Almedia, J., De, I.L. 1998, Performance of capsicum cultivars, *Hort. Brasileira*., **6** (1): 18-19.

Muralidharan, R., Saravanan, A. and Muthuvel, P. 2002. Effect of plant growth regulators on yield and quality of chilli (*Capsicum annuum* Linn.). *South Indian Hort*., **50**(1/3): 254-257.

Muthukrishnan, C.R., Thangaraj, T. and Chattergee, R., 1986, Chilli and Capsicum. In: Vegetable Crops of India, p. 343.

Nagalakshmi, S., Nandakumar, N., Palaniswamy, D. and Sreenarayana, V. V., 2001. Naturally ventilated polyhouse for vegetable cultivation, *South Indian Hort*., **49** (special): 345-346.

Nawalagatti, C.M., Chetti, M.B. and Hiremath, S.M. 1999. Evaluation of chilli (*Capsicum annuum* L.) genotypes for quality parameters. *Crop Res. Hisar*., **18**(2): 218-221.

Nimje, P.M., Wajman, O.D. and Shyam, M. 1990. Greenhouse technology for vegetable crop production, Proc. of XI Int.

Omonijo, A.G. and Afuye, G.G. 2009. Environmental climatic factors in different types of pepper fruit yield in the Nigeria Guinea savanna. *American Eurasian J. Sustain. Agric*., **3**(3): 604-608.

Ouzounidou, G., Ilias, I., Giannakoula, A. and Papadopoulou, P. 2010. Comparative study on the effects of various plant growth regulators on growth, quality and physiology of *Capsicum annuum* L. *Pak. J. Bot*., **42**(2): 805-814.

Ouzounidou, G., P. Papadopoulou, A. Giannakoula and I. Ilias. 2008. Plant growth regulators treatments modulate growth, physiology and quality characteristics of *Cucumis melo* L. plants. *Pak. J. Bot.,* 40: 1185-1193.

Panajotov, N.D. 1998. Sweet Pepper response to the application of the plant growth regulator a tonic. *New Zealand J. crop & Hort. Sci*., 26(2): 34-39.

Pelt, R.S. and Popham, T.W. 2002. Effects of three commercially available plant growth regulators and one plant growth enhancer on pepper (*Capsicum annuum* L.) yield and pigment content. *J. Veg. Crop Prod*., **8**(1): 53-61.

Rajmani, K., Sundararajan, S.and Veeraravathatham, D. 1990. Effect of triacontanol, 2, 4-D and boron on yield of certain chilli cultivar. *South India Hort*., **38** (5): 253-257.

Rana, M.I.K., Mondal, M.M.A. Prodhan, A.K.M.A. and Azam, M.G. 2011. Effect of Foliar Application of Miyobi Growth Regulators on Morpho-Physiological Attributes and Yield in Chili. *J. Environ. Sci. & Natural Resources*., **4**(2): 111-114.

Reddy, K.M. and Sadashiva, A.T. 2003. Studies on yield stability in chilli (*Capsicum annuum* L.). *Indian J. Hort*., **60**(2): 183-187

Saha, S.R. 2001. Heat tolerance in sweet pepper. PhD thesis, BSMRAU, Gazipur.

Sharma, H.G., Narendra-Agarwal., Dubey, P. and Dixit, A, 2004. Comparative performance of capsicum under controlled environment and open field condition. *Ann. Agric. Res*., **25**(4): 638-640.

Shoemaker, J.S. and Teskey, B.J.E.1995. Practical Horticulture. John Willy and Sons, Inc. New York. p. 371.

Singh, K.V., Singh, B. and Braj, M. 2010. Response of growth regulators on growth and yield of chilli (*Capsicum annuum* L.). *Progressive Agric*., **10**(1): 200-201.

Tanimoto, E. 1987. Gibberellin-dependent not elongation in *Lactuca sativa*: recovery from growth retardant-suppressed elongation with thickening by low concentration of GA3. *Plant Cell Physiol.*, **28**: 963-973.

Teshm Tadesse Michael, A., Thomas, J.R. and Heilmn, M.D. 1999. Nutrient conductivity effects on sweet pepper plants grown using a nutrient technique. *New Zealand J. crop & Hort. Sci*., 5(1): 45-49.

Thapa, U., Pati, M.K., Chattopadhay, S.B., Chattopadhyay, N. and Sharangi, A.B. 2003. Effect of growth regulators on growth and seed yield of chilli (*Capsicum annuum* L.). *J. Interacademicia*., **7**(2): 151-154.

UNDP. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome. pp. 212.

APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	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
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2012

Appendix II. Monthly record of air temperature, rainfall, relative humidity, rainfall and Sunshine of the experimental site during the period from October 2012 to March 2013

Month (2012)	*Air temperature (°c)		*Relative humidity (%)	*Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2012	24.32	17.22	75	13	7.2
November, 2012	25.82	16.04	78	00	6.8
December, 2012	22.40	13.50	74	00	6.3
January, 2013	24.50	12.40	68	00	5.7
February, 2013	27.10	16.70	67	30	6.7
March. 2013	31.40	19.60	54	11	8.2

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height at different days after transplanting (DAT) of bell pepper as influenced by different varieties and plant growth regulators

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm) at					
		40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	Final harvest
Replication	2	0.513	0.580	1.246	0.051	0.919	3.870
Variety (A)	1	5.368**	21.258**	48.476*	41.871**	65.021**	80.703**
Growth regulators (B)	3	5.048**	18.135**	43.105**	45.662**	58.319**	51.407**
Interaction (A×B)	3	1.905*	3.145*	36.595*	41.123**	36.372**	14.003*
Error	14	0.597	1.836	9.246	5.680	6.260	3.369

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

Appendix IV. Analysis of variance of the data on number of branches per plant at different days after transplanting (DAT) of bell pepper as influenced by different varieties and plant growth regulators

Source of variation	Degrees of freedom	Mean square					
		Number of branches per plant					
		40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	Final harvest
Replication	2	0.012	0.030	0.127	0.007	0.122	0.040
Variety (A)	1	0.202**	1.654**	0.882**	0.882**	2.282**	0.973*
Growth regulators (B)	3	0.086**	0.664**	5.877**	1.539**	5.295**	2.674**
Interaction (A×B)	3	0.033*	0.118*	0.904**	0.615**	0.699**	0.812*
Error	14	0.010	0.029	0.066	0.043	0.124	0.207

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

Appendix V. Analysis of variance of the data on number of leaves per plant at different days after transplanting (DAT) of bell pepper as influenced by different varieties and plant growth regulators

Source of variation	Degrees of freedom	Mean square					
		Number of leaves per plant at					
		40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	Final harvest
Replication	2	4.502	16.287	16.740	16.562	44.085	26.262
Variety (A)	1	94.407**	129.735**	177.127*	199.526**	378.408*	691.227**
Growth regulators (B)	3	125.091**	130.571**	386.200**	316.116**	471.147**	853.718**
Interaction (A×B)	3	86.033**	171.099**	282.162**	67.758**	265.598*	151.391**
Error	14	7.355	16.134	31.302	10.196	64.434	26.065

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

Appendix VI. Analysis of variance of the data on yield contributing character of bell pepper as influenced by different varieties and plant growth regulators

Source of variation	Degrees of freedom	Mean square					
		Days from transplanting to 1st flowering	Days from transplanting to 50% flowering	Number of flowers per plant	Number of fruits per plant	Fruit setting (%)	Days from transplanting to 1st harvest
Replication	2	1.625	1.542	0.390	0.167	0.881	0.167
Variety (A)	1	24.000**	37.500**	15.026**	2.053**	9.184*	24.000
Growth regulators (B)	3	10.500**	41.944**	5.710**	8.816**	62.684**	346.778**
Interaction (A×B)	3	36.111**	29.500**	3.820*	1.041*	8.680*	11.444**
Error	14	2.244	2.065	1.102	0.262	4.045	32.452

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

Appendix VII. Analysis of variance of the data on yield contributing character and yield of bell pepper as influenced by different varieties and plant growth regulators

Source of variation	Degrees of freedom	Mean square						
		Length of fruit (cm)	Diameter of fruit (cm)	Pericarp thickness (mm)	Individual fruit weight (g)	Yield per plant (g)	Yield per plot (kg)	Yield per hectare (kg)
Replication	2	0.305	0.013	0.021	0.135	578.98	0.047	1.447
Variety (A)	1	1.201**	2.152**	1.628**	20.702*	13601.75**	1.102**	34.004**
Growth regulators (B)	3	3.165**	1.050**	0.804**	28.032**	42929.50**	3.477**	107.32**
Interaction (A×B)	3	1.193**	0.131**	1.092**	6.529*	2159.36*	1.013*	10.398*
Error	14	0.205	0.037	0.112	3.807	1257.71	0.102	3.144

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

Appendix VIII. Per hectare production cost of bell pepper

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)
						TSP	MoP	TSP	Gypsum	Zinc		
V_1G_0	100000	70000	40000	45000	60000	4400	8910	5500	3885	800	0	338495
V_1G_1	100000	70000	40000	45000	60000	4400	8910	5500	3885	800	25000	363495
V_1G_2	100000	70000	40000	45000	60000	4400	8910	5500	3885	800	20000	358495
V_1G_3	100000	70000	40000	45000	60000	4400	8910	5500	3885	800	30000	368495
V_2G_0	100000	70000	60000	45000	60000	4400	8910	5500	3885	800	0	358495
V_2G_1	100000	70000	60000	45000	60000	4400	8910	5500	3885	800	25000	383495
V_2G_2	100000	70000	60000	45000	60000	4400	8910	5500	3885	800	20000	378495
V_2G_3	100000	70000	60000	45000	60000	4400	8910	5500	3885	800	30000	388495

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm

Appendix VIII. Cont'd

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)]
V_1G_0	97500	16925	58880	173304	511799
V_1G_1	97500	18175	62292	177967	541462
V_1G_2	97500	17925	61610	177034	535529
V_1G_3	97500	18425	62975	178899	547394
V_2G_0	97500	17925	61610	177034	535529
V_2G_1	97500	19175	65022	181697	565192
V_2G_2	97500	18925	64340	180764	559259
V_2G_3	97500	19425	65705	182629	571124

V_1: BARI Misti Morich – 1

V_2: Exotic variety (Lamuyo)

G_0: No plant growth regulator (water)

G_1: Gibberellic Acid (GA_3) @ 100 ppm

G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 2000 ppm

G_3: Litosen @ 1000 ppm