APPLICATION OF PLANT GROWTH REGULATORS AND NUMBER OF SPRAY ON GROWTH, YIELD AND ECONOMIC BENEFIT OF SWEET PEPPER

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CERTIFICATE

*This is to certify that thesis entitled, "**APPLICATION OF PLANT GROWTH REGULATORS AND NUMBER OF SPRAY ON GROWTH, YIELD AND ECONOMIC BENEFIT OF SWEET PEPPER**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE**, embodies the result of a piece of bona-fide research work carried out by **SHILA AKHTER, Registration no. 10-03910** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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TO

MY BELOVED PARENTS

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APPLICATION OF PLANT GROWTH REGULATORS AND NUMBER OF SPRAY ON GROWTH, YIELD AND ECONOMIC BENEFIT OF SWEET PEPPER

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment consisted of two factors. Factor A: Plant growth regulators (four levels) as G_0: Control, G_1: Gibberellic Acid (GA_3) @ 30 ppm, G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 45 ppm and G_3: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 45 ppm + Gibberellic Acid (GA_3) @ 30 ppm and Factor B: Number of spray (three levels) as N_0: Control (no spray), N_1: Two spray, N_2: Three spray. The experiment was laid out in a Randomized Complete Block Design with three replications. In case of plant growth regulators, the highest yield (27.77 t/ha) was found from G_3 treatment, whereas the lowest (18.87 t/ha) from G_0 treatment. For number of spray the maximum yield (26.0 t/ha) was recorded from N_2 treatment, while the minimum yield (19.87 t/ha) from N_0 treatment. Due to combined effect, the highest yield (31.8 t/ha) with net income (1416558) and BCR (2.46) was observed from G_3N_2 treatment combination, while the lowest yield (17.5 t/ha) with net income (433045) and BCR (1.49) from G_0N_0 treatment combination. So, economic analysis revealed that the G_3N_2 treatment combination appeared to be the best for achieving the higher growth, yield and economic benefit of sweet pepper.

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LISTS OF ABBREVIATIONS

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

CHAPTER I

INTRODUCTION

Sweet pepper (*Capsicum annum*) botanically referred to as the genus *Capsicum* is the member of *Solanaceae* family. Sweet pepper is also known as bell pepper, green pepper or *capsicum.* It is the native to the Tropical South America and Brazil. It has great significance in many countries such as China, Mexico, Turkey, India and Greece. The genus *Capsicum* consists of about 20 species and only four species are under cultivation, out of which *C. pendulum* and *C. pubescens* are restricted to South and Central America. The other two species such as *C. annum* and *C. frutescens* are commonly cultivated throughout the world. All cultivated species of Capsicum have 2n = 24 chromosomes. Sweet pepper is relatively non-pungent or less pungent and it is the world second most important vegetables after tomato. From a nutritional prospective, sweet pepper is rich in vitamins; chiefly, vitamin C and provitamin A. Concentrations of vitamin C is ranged from 63 to 243 (mg 100/g) depending on fruit colour (Howard *et al*., 1994). In a survey on amount of vitamin C in fruits and vegetables, sweet peppers represented the highest fourth out of 42 choices (Frank *et al*., 2001).

Sweet pepper 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 riboflabin and 0.55 mg niacin per 100 mg of edible fruit (Joshi and Singh, 1975).

In recent years, interest and demand for peppers has increased dramatically worldwide and sweet peppers have achieved major economic significance in the global market. Now-a-days efforts are being made to grow sweet pepper in Bangladesh (Paul, 2009). In Bangladesh, some advanced farmers started to grow this crop to meet the local demand of urban areas (Saha and Salam, 2004). But the production of sweet pepper is reduced due to flower and fruit drop which is caused by physiological and hormonal imbalance in the plants particularly under unfavourable environments. The major production problems are flower dropping, poor fruit set and susceptibility to viral diseases. However, growth regulators may be effective to reduce dropping of fruits and may increase fruit number, fruit size and loss of reproductive structures.

Plant growth regulators (PGRs) are extensively used in horticultural crops to enhance plant growth and improve yield by increasing fruit number, fruit set and size. Studies on the effect of plant growth regulators in solanaceous fruit and vegetable crops have revealed that the application of some of the plant growth regulators has been found effective in reducing the flower and fruit drops thereby enhancing production of sweet pepper per unit area and per unit time. The varying responses of sweet pepper to plant growth regulators have been reported by Balraj *et al.* (2002). Improvement in pepper growth and yield under GA_3 application compared to the control was observed. This might be ascribed to more effective utilization of food for reproductive growth (flowering and fruit set), higher photosynthetic efficiency and enhanced source to sink relationship of the plant, reduced respiration, enhanced translocation and accumulation of sugars and other metabolites. Another growth regulators 4-chlorophenoxy acetic acid has been found to be effective in increasing fruit set under higher temperature conditions and also used in reducing pre- harvest fruit drop and resulting in higher number of fruits and yield. On the other hand, number of spray play an important role for producing maximum yield but response to a particular growth regulators depend upon some factors such as: number of spray, plant characteristics, quality of chemical and environment. However, information regarding the effectiveness of PGRs and different number of spray on growth and other physiological parameters of commercial pepper cultivars is very little. A detailed and systemic study is needed to find out the effect of plant growth regulators and number of spray for maximizing the yield of sweet pepper in Bangladesh.

Considering the above situation, the present investigation was undertaken with the following specific objectives-

1. To identify the optimum concentration of growth regulator and effective number of spray for enhancing the fruit yield and quality of sweet pepper.

2. To find out the suitable combination of growth regulators and their number of spray for higher yield of sweet pepper.

3. To analyze the economic benefit of sweet pepper production using different PGR treatment.

CHAPTER II
REVIEW OF LITERATURE

Sweet pepper is one of the most important and widely used vegetables. Due to some advantages, sweet pepper 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, individual fruit weight as well as yield. A very few research works related to sweet pepper cultivation especially emphasis on plant growth regulators as 4-CPA and GA_3 and their effective number of spray have been carried out in Bangladesh. However, literature available in this aspect in the country and abroad were reviewed and it will be contributed a positive justification and for further use in future under the following headings-

2.1 Review in relation to 4-chlorophenoxy acetic acid (4-CPA)

Singh *et al.* (2013) reported that the bio-regulators can effect on growth and yield parameters in sweet pepper under protected condition in Garhwal region.

Changli and Liusheng (2009) stated that application of 4-CPA and boron showed cumulative effect on ascorbic acid content in hot pepper which might facilitate sugar translocation and keeping the level of sugar and starch content in plant tissue. Vitamin C content also related with sugar content as its precursor. The results of this experiment agree that treatment causing a highest content of reducing sugar in the fruits also caused a highest level of vitamin C.

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

Salas *et al.* (2009) reported that application of commercial auxin as foliar sprays ($0.4\ cm^3\ L^{-1}$) and application in the nutrient solution ($0.6\ cm^3\ L^{-1}$) in sweet pepper. In order to assess the effect of auxin treatments, the following data were collected: fruit weight, length of fruit, the early and total yield was significantly maximum when auxins were applied by fertigation, than foliar applications, while the fruit quality parameters were enhanced when commercial auxins were applied by foliar sprays.

Chhillar (2008) found that yield is enhanced with application of 4-CPA in hot pepper.

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

Chaudhary *et al*. (2006) found that flower and fruit setting was prompted in both varieties with application of 4-CPA compared to plants treated with others hormone and control. It was reported that application of 4-CPA improve flower and fruit setting by reducing flower and fruit abscission that contributed the maximum number of flower and fruit per plant.

Balaraj (1999) reported that increased yield by application of growth regulators (NAA and 4-CPA) might be due to appropriate growth of plants, control of abscission layer in full bloom stage and acceleration in fruit maturity by the positive hormonal action.

Doddamani and Panchal (1989) found that higher temperatures in summer months, might have acted as limiting factor in shoot growth and development of hot pepper. Increased plant spread in NAA, 4-CPA and boron applications might be due to enhance cell divisions in the shoot, increased translocation of photosynthates and this might have resulted in improved shoot growth.

Pandita *et al. (1*980) stated that the growth promoters like NAA and 4-CPA increase the source-sink relationship and hormone modified translocation of photosynthates, which will support in better retention of flowers and fruits and seed filling at the later stages of crop growth. There is great potential to improve the yield levels in hot pepper either by reducing the flower drop or by increasing the fruit set.

2.2 Review in relation to 4-CPA on other crops

Baliyan*et al*. (2013) found that, tomato treated with 4-CPA showed the maximum number in flower and fruit set.

Chillar (2008) reported that the effect of plant growth regulators on horticultural crops. He emphasized planofix at 10 ppm in hot pepper and 4 -CPA (4 - Chlorophenoxy acetic acid) 50ppm in tomato at flowering stage increased yield.

Kuo *et al*. (1978) reported that 4-chlorophenoxy acetic acid has been found to be effective in enhancing tomato fruit set under higher temperature conditions.

Younis and Tigani (1977) stated that the growth regulator 4-chlorophenoxy acetic acid (4-CPA) has an important effect on the fruit retention of tomato and other horticultural crops and thus improving the yield substantially. 4-chlorophenoxy acetic acid is a growth regulator used in deducting pre- harvest fruit drop and resulting in higher number of fruits and yield

2.3 Review in relation to Gibberellic acid (GA_3)

Singh *et al.* (2014) studied on hot pepper variety G-4 at SHIATS, Allahabad, They found that the combined application of NAA @ 20 ppm, GA_3 @ 10 ppm and 2,4-D @ 1 ppm significantly improved vegetative growth, yield and quality of hot pepper. Combined application had positive effect on plant growth, development, flowering and yield potential of plants.

Vandana *et al.* (2014) set a field experiment on Sweet Pepper cultivar "Indra" under green house found that maximum height (30.15 cm) with GA_3@ 50ppm and highest number of branches (5.52) with etheral @ 100 ppm. Highest yield/plant (1.84kg) and yield/ha (244.65 q/ha) recorded with GA_3 @ 50 ppm.

Abdullah *et al*. (2011) found that sweet pepper fruits contain on an average 0.7-1.4% w/w capsaicin when plants treated with GA_3 (10 and 50 ppm).

Deshmukh *et al.* (2010) conducted an experiment on chilli variety "Parbhani Tejas" at Yeshwant, Mahavidhyalaya, Nanded and Vegetable was sprayed with four types of growth hormones and two types of fertilizers. They reported that chillifoliar spread with NAA, CCC, GA_3 and urea showed highest ascorbic acid content than other fruits. The lowest ascorbic acid content was recorded 197.67 mg/100g of either treatment followed by SSP respectively.

Kannan *et al*. (2009) reported that application of GA_3 had significant effect on growth, development and yield attributes on peperika chilli.

Dostogir Hossain *et al.* (2006) found that the application of GA_3 at 25 ppm recorded highest number of fruits per plant (15.82). Similarly, GA_3 at 40 ppm performed statistically identical to GA_3 at 25 ppm.

King *et al. (*2006) noted that the plant bio regulators showed significant effect on first flowering, number of flowering per plant. This induction of flowering is may be due to the fact that GA act as a florigen or help the production and transport of other signals. GA also enhanced gene level for flower induction. It was also noted earlier that GA plays a vital role in promotion of flowering in some plants.

An experiment was carried out by Chaudhary *et al*. (2006) in the plain areas of Chitwan to evalute the promising plant growth regulators (PGR) improving growth, development and yield of chilli cultivars Jwala and Suryamukhi. Suryamukhi ranked superior to Jwala for most of the yield attributing characters, however Jwala was better in vegetative characters than Suryamukhi. Beside this PGRs, 2,4-D at 2 ppm was better for fruit set, number of fruits per plant, number of seeds per fruit, seed weight per fruits, 1000 seed weight and fruit yield whereas NAA at 40 ppm gave the highest leaf area index (LAI). GA_3 at 10 ppm exhibited highest number 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% maximum fruit yield over control, respectively. The maximum net profit and B:C ratio were noted 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 experiment in Tamil Nadu, India, to identify 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 stalk length and dry fruit yield) of hot pepper 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 sowing. Results supported that GA_3 at 250 ppm improved the plant height, followed by GA_3 at 100 ppm.

Thapa *et al*. (2003) set a field study in Mohanpur, West Bengal, India during the kharif season of 2002. 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 noted. Treatment with 25 ppm gibberellic acid resulted in the maximum 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), and seed yield (13.42 q/ha).

Balraj *et al.* (2002) showed that GA_3 @ 20 ppm was the best treatment for increasing plant height and number of branches, while NAA @ 20 ppm was best for increasing yield. Application of plant growth regulators at both 35 and 50 DAT was the most effective for increasing the growth and yield of the plants.

Pelt and Popham (2002) set an investigation in the Roswell and Artesia area of southeastern New Mexico to identify 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.

Arora *et al*. (2000) conducted a laboratory investigation to determine the effect of GA_3 treatment on the shelf-life of chilli *cv.* Pusa Jwala. Chilli fruits were treated with 0, 50, 100, and 200 ppm GA_3 for 10 minutes. Data on physiological loss in weight (PLW), total chlorophyll and vitamin C content were noted at 5-day-intervals until day 25. PLW increased with increasing period of storage in case of all treatments, with GA_3 at 200 ppm exhibiting the lowest PLW (20.8% on the 25th day of storage, compared with 33.4% in the control). Decay loss increased with increasing period of storage in all treatments. No decay loss was noted on the 5th day of storage, but the highest decay loss on the 25th day of storage was observed in the control (12.7%) compared with GA_3-treated fruits. Total chlorophyll level reduced during storage in all treatments; the maximum chlorophyll content on the 25th day of storage (1.6 mg/100g) was recorded with GA_3 at 200 ppm. Ascorbic acid content improved with increasing period of storage, the maximum (165 mg/100g) being observed with GA_3 at 100 and 200 ppm on the 25th of storage.

Biradar (1999) stated that the highest number of primary branches (8.02) with 100 ppm GA_3 which was on par with 50 ppm GA_3 (7.60) and lowest number of primary branches in water spray.

Deotale *et al. (*1998) noted that GA_3 improved growth activities to plant, enhanced stem elongation and improved yield.

Joshi *et al*. (1975) found that GA_3 has been delay the loss of Chlorophyll and showing a sharp decrease of chlorophyll concentration. Though chlorophyll loss was a common feature, no visually apparent chlorosis or yellowing of the leaves, during PGRs application, was recorded. The chlorophyll fluorescence characteristics were negatively affected by the three growth retardants application.

El-Asdoudi and Ouf (1993) stated that sprayed GA_3 (0, 5, 15 or 30 ppm) and found significant increase in number of fruits per plant by spraying GA_3 (5 ppm) at flowering compared to water spray and other concentrations in pepper.

Abdul *et al*. (1988) found that the maximum plant height and leaf with GA_3 (at 50, 100 and 150 ppm) on sweet pepper.

Narayan (1986) reported that 10 ppm GA_3 sprayed flowered 6.33 days earlier to the control.

Kohli *et al. (1982)* set a field experiment on foliar spray of GA_3 100 ppm was observed more effective in inducing male sterility in pepper carbohydrates and protein content in hot pepper.

Chhonkar and Sen Gupta (1972) found that plant growth sub- growth substances have also been effective on fruit quality. Foliar application of GA_3 50 ppm at fruit setting tended to little amount of ascorbic acid content but seed treatment with NAA at 50-70 ppm increased ascorbic acid content in hot pepper.

2.4 Review in relation to Gibberellic acid (GA_3) on other crops

Ranjeet *et al.* (2014) conducted an experiment was carried out to assess the growth, flowering, fruiting yield and quality traits of Tomato cv. KASHI VISHESH (H-86). The experiment was laid out in randomised block design with three replications for tomato crop consisted of 10 treatments namely, Control, GA_3 20 ppm, GA_3 40 ppm, 60 ppm, NAA 10 ppm, NAA 20 ppm, NAA 30 ppm, 2, 4-D 10 ppm, 2, 4-D 15 ppm and 2, 4-D 20 ppm to find out the effect of the growth, flowering, fruiting, yield and quality of tomato and various horticulture characters namely; plant height (cm), number of branches, number flowers per plant, number of fruits per clusters, number of fruits per plant, average fruit length (cm), average fruit diameter (cm), average fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg), fruit yield per hectare (q), acidity (%) and total soluble solids TSS (0 Brix). However, application of the plant bio regulators had a significant influence on flowering, fruiting, yield and quality traits of tomato and GA_3 gave the maximum yield than other plant growth regulators. So, GA_3 was superior than all other treatments under investigation for response tomato production.

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

A highest yield of 483.6q/ha and 472.2 q/ha was recorded with the use of GA_3 @ 80 ppm and NAA @100 ppm, respectively.

Yahaya and Gaya (2012) set a field trials in the 2008/2009 and 2009/2010 dry seasons to assess the efficacy of various rates of giberrellic acid on the growth and yield of tomato (*Lycopersicon lycopersicum* L.). The treatments consisted of seven rates (0, 50, 100, 150, 200, 250 and 300 ppm) of giberrellic acid. These were laid in a randomized complete block design and replicated three spray. Data were collected on plant height, number of leaves, number of branches, number of flowers and fresh fruit weight. These were subjected to analysis of variance. Where treatment means differed significantly, they were compared using DMRT. Results of the experiment showed that giberrellic acid concentration had significantly ($P \leq 0.05$) increased the growth, yield components and also total yield of tomato. Best results were obtained from plants treated with 300 ppm giberrellic acid compared to all other rates applied. It is suggested that tomato be treated with 300 ppm giberrellic acid for improved yield.

Abbas (2011) conducted an experiment to determine the effect of foliar sprays of different concentrations of Gibberellic acid on growth and some physiological characterizes in Carrot plant (local white cultivar). The experiment treatments conducted on three concentrations of Gibberellic acid (0, 50 and 100 ppm) and the results were found as follows: In using the Gibberellic acid concentration at (50 ppm) led to enhance significantly the studied characteristics particularly plant height, number of branch per plant, number of flower per plant, fresh weight of biological weight gm per plant, shoot dry weight (gm), dry weight of biological weight gm per plant, chlorophyll content ($\mu g/cm^2$), when compared with the other concentrations levels and controlling plants. And GA_3reduced significantly some of the evaluated characteristics as root fresh weight (gm), root dry weight (gm) and soluble carbohydrate which that compared with the controlling plants.

Boyaci *et al.* (2011) conducted an experiment on Eggplants to evaluate the relationship between flower development and gibberellic acid (GA_3) levels in parthenocarpic and non-parthenocarpic eggplant (*Solanummelongena*L.) genotypes. A single crop was grown in an unheated greenhouse at the Bati Akdeniz Agricultural Research Institute, Turkey, and samples were collected from November to March, GA_3levels were evaluated with reverse phase high performance liquid chromatography at five different stages between small buds and small fruits. The results noted that there was no relationship between flower development and GA_3 levels in parthenocarpic and non-parthenocarpic eggplant genotypes.

Masroor *et al.* (2006) set a pot experiment was performed according to a factorial randomized design at Aligarh to determine the effect of 4 levels of gibberellic acid spray (0, 10-8, 10-6 and 10-4 M GA_3) on the growth, yield and quality parameters of 2 tomato cultivars (*Lycopersicon esculentum* Mill.), namely Hyb-SC-3 and Hyb-Himalata. Irrespective of its concentration, spray of gibberellic acid proved efficient for most parameters, especially in the case of Hyb-SC-3.

Shittu and Adeleke (1999) recorded the effects of foliar application of GA_3 (0, 10, 250 or 500 ppm) on growth and development of tomatoes cv, 158-3 grown on pots. Plant height and number of leaves were significantly improved by GA_3 treatment. Plants treated With GA_3 with 250 ppm were the tallest plant the maximum number of leaves.

Saleh and Abdul (1980) reported that GA_3(50 ppm) enhanced plant growth (70 cm),while cycocel @ 250, 500 and 1000 ppm reduced the stem elongation and enhanced the number of branches in tomato as compared to control (62 cm).

2.5Combined effect of 4-CPA and GA_3 on growth and yield of crops

Choudhury *et al.* (2013) set an experiment at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh, to determine the effect of different plant growth regulators on tomato during summer season 2011. Different plant growth regulators (PGR) viz. PGR_0 = Control, PGR_1 = 4-CPA (4-chloro phenoxy acetic acid) @ 20 ppm, PGR_2 = GA_3 (Gibberellic Acid) @ 20 ppm and PGR_3 = 4-CPA + GA_3 @ 20 ppm of each were used in the experiment. The growth, development and yield contributing characters were significantly differed due to different plant growth regulators. The highest plant height at 60 DAT (86.01cm), number of flowers cluster per plant (10.60), number of flowers per plant (39.69), number of fruits per plant (36.54), single fruit weight (74.01 g) and yield (28.40 t ha 1) were recorded in PGR_3 and the lowest for all the parameters were recorded in control (PGR_0) treatment.

EI- Habbasha *et al.* (1999) carried out an experiment with tomato cv. castel rock over two growing seasons (1993-94). The effects of GA_3 and 4-CPA on fruit yield and quality were evaluated. Many of the treatments significantly improved fruit set percentage and total yield, but also the percentages of puffy and parthenocarpic fruits compared to the controls.

Sasaki *et al*. (2005) reported that Tomato plants treated with a mixture of 4-CPA and GA_3 recorded improved fruit set and proportion of normal fruits compared to plants of the same crop treated with 4-CPA alone.

2.6 Review in relation to number of spray

Singh *et al.* (2010) set an experiment to determine the effect of growth regulators (NAA & Ethrel) on growth and yield of hot pepper (*Capsicum annuum* L.) cv. Pusa Jwala during the kharif season. Plants were sprayed at flower bud initiation and 20 days later with 10 treatments. The maximum values for plant height, fruit number, fruit weight, fruit weight per plant and fruit yield were found in treatment combination of 50 ppm NAA and 200 ppm Ethrel.

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

Natesh *et al.* (2005) set an experiment on chilli variety "Byagikaddi" at University of Agriculture Sciences, Dharwad and reported that application of growth regulators at flowering stage enhanced the growth and seed yield of hot pepper. Among them, GA_3 @ 100 ppm spray at flowering stage found maximum fruit and seed yield followed by GA_3 @ 50 ppm and NAA @ 20 ppm, indicating their utility in improving seed production of hot pepper.

Balraj *et al*. (2002) reported that the effects of NAA, gibberellic acid and 2,4-D on chilli (*C. annuum* cv. Byagadi) in a field in Dharwad, Karnataka, India, on the basis of two years data under rainfed conditions at Dharwad to know the effects of different growth regulators (3 growth regulators at 2 concentrations each with the control) and 3 stages of spraying (35, 50 and both 35 and 50 DAT) on growth and yield of pepper. GA_3 20 ppm was reported the best in plant height and number of branches of all orders.

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

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

Belakbir *et al*. (1998) test the effectiveness of different bio regulators in improving sweet pepper yield and quality at SCRI, Scotland. The commercial bio regulators CCC, NAA, GA3 and biozyme were sprayed at flower initiation followed by two additional spray at 30 day intervals. Treatment with NAA produced maximum marketable fruits. GA_3 enhanced Ascordic acid and Citric acid concentration and also enhanced TSS, carotenoid, sucrose, fructose concentration.

Doddamani and Panchal (1989) set a field experiment on effect of plant growth regulators on growth, development and yield of Byadagi chilli*(Capsicum annuum* L.) var. accuminatum. The results showed that increase in plant height (84.87 cm) with 20 ppm NAA sprayed at pre-bloom stage over unsprayed plants (72.07 cm) in hot pepper.

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

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

Sinha (1975) set an experiment on foliar spray of GA_3 50 ppm at fruit setting or NAA 10 ppm either single or double spray at flowering and 5 week later improved the fruit yield in hot pepper. Two foliar spray of triacontanol 2 ppm or atonic 0.08% at 30 days after transplanting and leter at flowering stage were also found that double sprays of NAA 10 ppm at flowering and 5 weeks later reduced flower shedding and results in maximum yield in hot pepper.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out to study the application of plant growth regulators (PGRs) and number of spray on growth, yield and economic benefit of sweet pepper during the period of November, 2016 to March, 2017. The materials and methods used in conducting the experiment have been presented in this chapter under the following heads:

3.1 Description of the experimental site

3.1.1 Location

The research work was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e- Bangla Nagar Dhaka. The experimental field was located at 90°22 longitude and 23°41 N latitude with an elevation of 8.24 m from the sea level.

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 II.

3.3 Climate

The experimental area belongs to subtropical climatic zone which is characterized by heavy rainfall, high humidity, high temperature and during “kharif’ season (April-August) and scarce rainfall, low humidity, low temperature and short day period during “Rabi” season (October-March). This climate is also characterized by distinct season viz., the monsoon or rainy season extending from May to October, the winter or dry season from November to February and pre-monsoon period from March to April. The meteorological data in respect of temperature, rainfall, relative humidity, average sunshine and for the entire experimental period have been shown in Appendix I.

3.4 Planting materials

Seeds of sweet pepper variety viz. KS 2201 was used as experimental materials. The seeds were collected from the Krishibid seed company.

3.5 Treatment of the experiment

The experiment involved two factors:

Factor A: Plant growth regulators and Factor B: Number of spray

Factor A: Plant growth regulators-

G_0:Control,

G_1: GA_3 @ 30 ppm

G_2: 4-CPA @ 45 ppm

G_3: 4-CPA @ 45 ppm + GA_3 @ 30 ppm

Factor B: Number of spray-

N_0: Control (no spray),

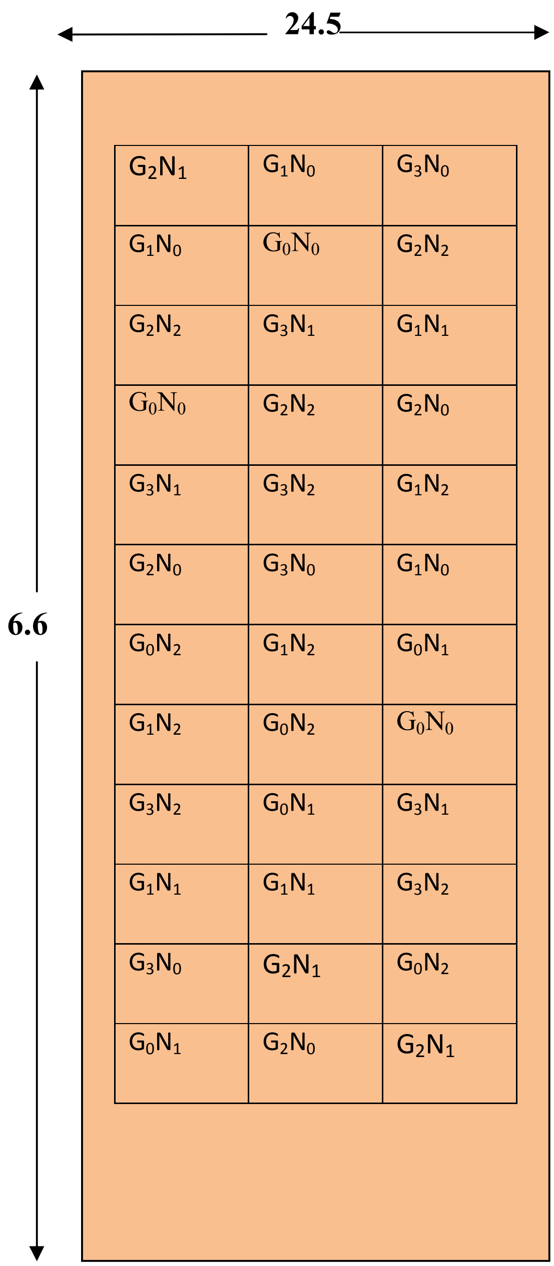
N_1:Two spray(vegetative+early flowering stage),

N_2:Three spray(vegetative+early flowering+80% flowering stage).

According to manufactures recommendation and previous research report GA_3, at 100 mg/L of water, and 4-CPA at 2 ml/L were used with water `and then converted into ppm.`

3.6 Design and layout of the experiment

The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experiment was divided into equal 3 blocks and each consists of 12 plots. Each unit plot was 1.5 m x 1.2 m in size. All together there were 36 unit plots in experiment. Distance between replication was 0.7 m and plot to plot was 0.5 m. The treatments were randomly assigned to each of the block. The layout of the experiment is shown in Figure 1.



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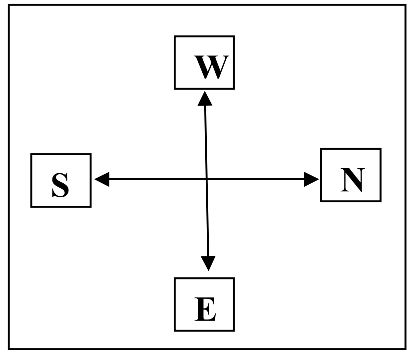


Treatments:

Factor A: Plant growth regulators

G_0: Control
G_1: GA_3 @ 30 ppm
G_2: 4CPA @ 45 ppm
G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

Factor B: Number of spray

N_0: Control (no spray)
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering)

Experiment layout:

Plot to plot distance= 0.5 m
Block to block distance = .7 m
Plot size = 1.5 m×1.2 m
Replication = 3

Fig.1. Layout of the experimental field

3.7 Seedbed preparation

Seedbed was prepared on 2 November 2016 for raising seedlings of sweet pepper and the size of the seedbed was 3m × 1m. The soil was well ploughed. Weeds and stubbles were removed from the seedbed. Cowdung 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 blight, anthracnose, etc.

3.8 Seed sowing

Seeds were sown on 5 November, 2016 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 when needed. No chemical fertilizers were applied for raising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 25 days old seedlings were transplanted into the experimental field on 1 December 2016.

3.10 Preparation of the main field

The plot selected for conducting the experiment was opened in 15 November 2016, with a power tiller and left exposed to the sun for a week to kill soil borne pathogens and soil inhabitant insects. After this the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain 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 finall 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 different pest.

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 quantity 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.

Manure and Fertilizers	Dose/ (ha)	Final land preparation	Application (%)		
			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	--	--

Source: BARI, 2011

3.12 Transplanting

Healthy and uniform sweet pepper seedlings of 25 days old with 5-6 leaves were transplanted in the experimental plots on 01 December, 2016. The seedlings were up rooted 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 one 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 30 cm, respectively and total 12 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. The transplants were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border for gap filling.

3.13 Intercultural operation

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

3.13.1 Gap filling

The transplanted seedlings in the experimental plot were taken 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 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 Application of plant growth regulators

Plant growth regulators as Gibberellic Acid (GA_3) @ 30 ppm, 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 45 ppm of water were applied by a mini hand sprayer.

3.13.3 Weeding

The hand weeding was done 15, 30 and 45, 60 after transplanting to safe 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 keeping the soil from the space between the rows by a small spade.

3.13.5 Irrigation

Light watering was done by a watering cane at every morning and afternoon. Transplanting was continued for a week for establishment of the transplanted seedlings.

3.13.6 Pest and disease control

Insect infestation was a serious problem during the period of seeding establishment. 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 plants were infected by *Alternaria* leaf spot disease caused by *Alternaria brassicae*. To prevent the disease, Rovral @ 2 g 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 up to final harvest based on the marketable size of fruits. Harvesting was done by hand picking.

3.15 Data collection

Five 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 sweet 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) up to 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 sweet 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 of sweet 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 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 Number of flowers/plant

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

3.15.6 Number of fruits/plant

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

3.15.7 Number of marketable fruits/plant

The number of marketable 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 counted when harvesting of fruit 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 was recorded and expressed in centimeter (cm).

3.15.11 Diameter of fruit

The diameter of individual fruit was measured in several directions with Slide callipars 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 (g) 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 multiplying individual fruit weight and number of fruits/plant by a digital weight machine.

3.15.15 Fruit yield/plot

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

3.16 Statistical analysis

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

3.17 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 computed in the calculation. The interests were calculated @ 13% in simple rate. The market price of sweet 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:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of Production per hectare(Tk.)}} \times 100$$

CHAPTER IV

RESULTS AND DISCUSSION

The present research work was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November, 2016 to March, 2017 to evaluate the application of plant growth regulators and number of spray on growth, yield and economic benefit of sweet pepper. The analysis of variance (ANOVA) of the data on yield contributing characters and yield of sweet pepper had been shown in Appendix III-X. The result of the experiment have been presented and discussed in this chapter under the following heading:

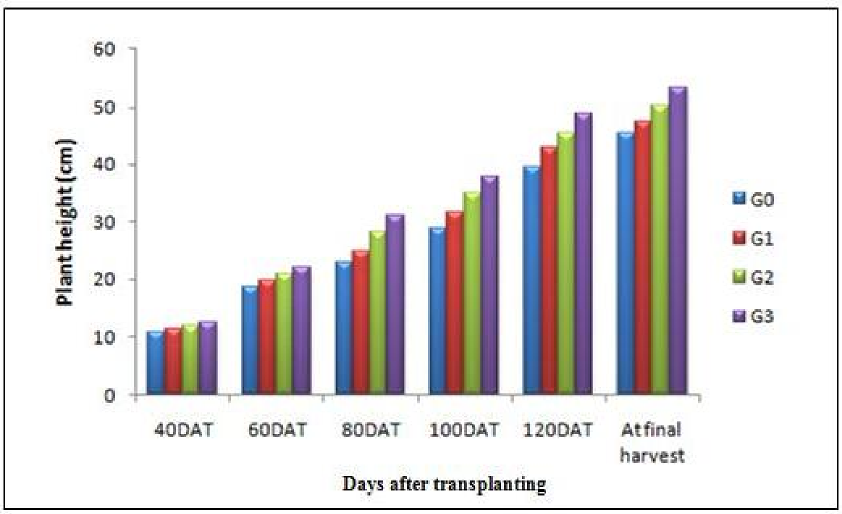
4.1 Plant height

Plant height of sweet pepper varied significantly for different plant growth regulators at 40, 60, 80, 100, 120 DAT and final harvest (Appendix III). At final harvest, the tallest plant (53.11cm) was obtained from G_3 (4-CPA @ 45 ppm + GA_3 @ 30 ppm) treatment, while the shortest plant (45.34 cm) was found from G_0 (control) treatment (Fig. 2 and Appendix III). It revealed that plant growth hormone increased plant height, which might be due to regulating effect of exogenous application of PGRs.

Plant height of sweet pepper was significantly influenced by different number of spray at 40, 60, 80, 100, 120 DAT and final harvest. At final harvest, the tallest plant (51.33 cm) was obtained from N_2 (Three spray-vegetative+early flowering+80% flowering stage) treatment, while the shortest plant (46.35 cm) was found from N_0 (control) treatment (Fig. 3 and Appendix III). The result also indicated that the increasing rate of number of spray significantly increased plant height.

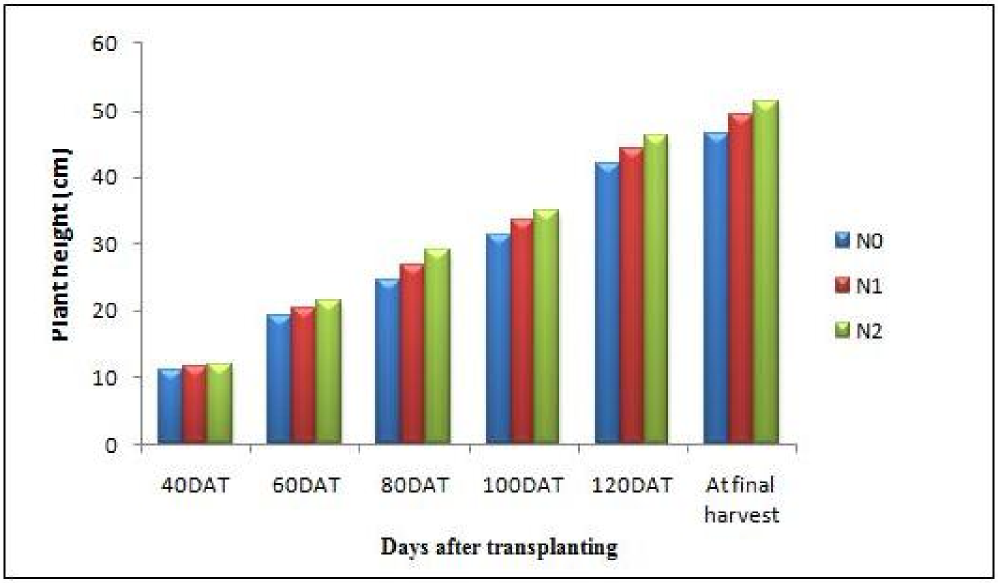
Significant variation was observed due to the combined effect of plant growth regulators and number of spray in terms of plant height of sweet pepper at different days after transplanting (Table 1 and Appendix III). At final harvest the tallest plant (56.46 cm) was observed from G_3N_2 treatment combination. On the other hand, the shortest plant (44.78 cm) was recorded from (control) G_0N_0 treatment combination.

Hence it may be inferred that the increase in plant height may be due to the effect on stem elongation by rapid cell elongation and multiplication of cells in sub-apical meristem by application of plant growth regulators. The rapid growth that occurs is a result of both the greater number of cells formed and elongation of individual cells. It was also supported by Choudhury *et al.* (2006) where they stated that the growth and yield contributing characters were significantly differed due to different plant growth regulators. The maximum plant height was obtained when 4-CPA and GA_3 are combinedly applied than their single application in tomato.



here,
G_0: Control, G_1: GA_3 @ 30 ppm G_2: 4CPA @ 45 ppm G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

Fig. 2: Effect of plant growth regulators on plant height at different days after transplanting of sweet pepper.



here,
N_0: No spray, N_1: Two spray (vegetative + early flowering),
N_2: Three spray (vegetative + early flowering + 80% flowering)

Fig. 3: Effect of number of spray on plant height at different days after transplanting of sweet Pepper.

Table 1. Combined effect of plant growth regulators and number of spray on plant height of sweet pepper

Treatments	Plant height (cm)					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
G_0N_0	10.55 f	18.14 h	22.16 k	28.41 k	38.72 i	44.78 k
G_0N_1	10.76 ef	18.73 gh	22.76 j	28.96 j	39.25 k	45.22 j
G_0N_2	10.93 e	19.12 fg	23.86 h	29.28 i	40.14 j	46.05 h
G_1N_0	10.85 e	18.74 gh	23.44 i	30.19 h	40.55 i	45.58 i
G_1N_1	11.29 d	19.84 ef	24.34 g	31.45 g	42.99 g	47.4 g
G_1N_2	11.8 c	20.84 cd	27.05 e	32.66 f	44.74 f	49.32 e
G_2N_0	11.34 d	19.55 ef	25.16 f	32.55 f	42.24 h	46.25 h
G_2N_1	11.9 c	21.04 c	28.34 d	35.05 d	45.15 e	50.71 d
G_2N_2	12.32 b	22.26 b	30.84 c	37.48 c	48.25 c	53.48 c
G_3N_0	11.85 c	20.24 de	27.35 e	34.29 e	46.10 d	48.80 f
G_3N_1	12.35 b	22.09 b	31.45 b	38.26 b	49.14 b	54.08 b
G_3N_2	13.00 a	23.48 a	33.97 a	40.56 a	51.2 a	56.46 a
CV%	6.68	7.82	10.70	8.26	9.05	5.46
LSD (0.05)	0.29	0.74	0.35	0.28	0.26	0.23

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

G_0: Control
G_1: GA_3@30 ppm
G_2: 4CPA@45 ppm
G_3: 4CPA@45 ppm + GA_3@30 ppm

N_0: No spray
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering)

4.2 Number of branches per plant

Significant variation was recorded for different plant growth regulators of sweet pepper in terms of number of branches per plant at 40, 60, 80, 100, 120 DAT and final harvest (Table 2 and Appendix IV). At final harvest, the maximum number of branches per plant (9.25) was recorded from G_3 (4-CPA @ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum number (7.67) was found from (control) G_0 treatment.

Table 2.Effect of plant growth regulators on number of branches per plant of sweet pepper

Treatment	Number of branches per plant					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
G_0	1.16 d	1.33 d	2.92 d	4.83 d	5.77 d	7.67 d
G_1	1.31 c	1.61 c	3.33 c	5.60 c	6.29 c	8.20 c
G_2	1.44 b	1.90 b	4.07 b	6.14 b	7.02 b	8.65 b
G_3	1.55 a	2.27 a	4.84 a	6.69 a	7.74 a	9.25 a
CV%	6.46	8.13	7.12	10.54	5.41	7.67
LSD (0.05)	0.09	0.11	0.14	0.09	0.11	0.09

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

here,
G_0: Control, G_1: GA_3 @ 30 ppm, G_2: 4CPA @ 45 ppm, G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

Number of branches per plant of sweet pepper varied significantly for different number of spray at different days after transplanting (Table 3 and Appendix IV). At final harvest, the maximum number of branches per plant (8.86) was obtained from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the shortest plant (8.08) was found from (control) N_0 treatment. The result also indicated that the increasing rate of number of spray significantly increased the number of branches. This result is in agreement with the findings of Pandita *et al.* (1989).

Table 3. Effect of number of spray on branches per plant of sweet pepper

Treatment	Number of branches per plant					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
N_0	1.23 b	1.43 c	3.26 c	5.12 c	5.99 c	8.08 c
N_1	1.39 a	1.86 b	3.84 b	5.92 b	6.84 b	8.39 b
N_2	1.47 a	2.04 a	4.26 a	6.41 a	7.28 a	8.86 a
CV%	6.46	8.31	7.12	10.54	5.41	7.67
LSD (0.05)	0.08	0.09	0.12	0.08	0.09	0.07

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

there,
N_0: No spray, N_1: Two spray (vegetative + early flowering),
N_2: Three spray (vegetative + early flowering + 80% flowering)

Plant growth regulators and number of spray showed significant variation due to the combined effect on number of branches per plant of sweet pepper at 40, 60, 80, 100, 120 DAT and final harvest (Appendix IV). At final harvest the maximum number of branches per plant (9.64) was recorded from G_3N_2 treatment combination, whereas the minimum number of branches per plant (7.35) was observed from G_0N_0 treatment combination (Table 4). It was observed in present study that plant growth regulators increase number of branches per plant of sweet pepper. It can be said that plant growth regulators play a vital role in several physiological processes, *viz*, photosynthesis, respiration, energy store, transfer, cell division which will significantly enhance the axillary stalk or branching of plants. This result is in agreement with the findings of Bhosle *et al.* (2002) where they reported that, treatment with 25 ppm 4-CPA and 45 ppm GA_3 resulted in the highest number of primary branches of tomato cultivars.

Table 4. Combined effect of plant growth regulators and number of spray on number of branches per plant of sweet pepper

Treatments	Number of branches per plant					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
G_0N_0	1.11 g	1.23 i	2.76 g	4.09 i	5.50 i	7.35 j
G_0N_1	1.17 fg	1.36 hi	2.89 fg	4.76 h	5.74 h	7.66 i
G_0N_2	1.23 efg	1.42 hi	3.12 ef	5.67 f	6.09 g	8.01 g
G_1N_0	1.18 fg	1.32 hi	2.97 fg	4.83 h	5.75 h	7.83 h
G_1N_1	1.31 def	1.62 fg	3.35 e	5.76 f	6.35 f	8.10 g
G_1N_2	1.43 bcd	1.87 de	3.66 d	6.22 de	6.78 e	8.68 d
G_2N_0	1.28 def	1.45 gh	3.27 e	5.49 g	6.10 g	8.34 f
G_2N_1	1.49 abc	2.04 cd	4.20 c	6.25 d	7.18 d	8.52 e
G_2N_2	1.56 ab	2.21 c	4.76 b	6.67 c	7.77 c	9.10 c
G_3N_0	1.38 cde	1.73 ef	4.06 c	6.08 e	6.63 e	8.82 d
G_3N_1	1.62 a	2.43 b	4.96 b	6.89 b	8.11 b	9.29 b
G_3N_2	1.66 a	2.66 a	5.50 a	7.09 a	8.19 a	9.64 a
CV%	6.46	8.13	7.12	10.54	5.41	7.67
LSD (0.05)	0.17	0.19	0.24	0.16	0.19	0.16

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

G_0: Control
G_1: GA_3@30 ppm
G_2: 4CPA@45 ppm
G_3: 4CPA@45 ppm + GA_3@30 ppm

N_0: No spray
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering)

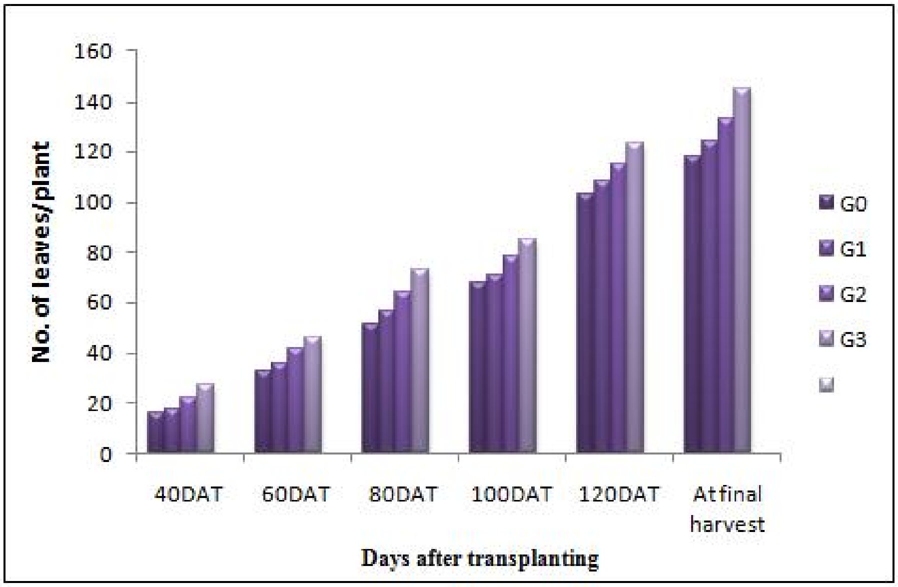
4.3 Number of leaves per plant

Number of leaves per plant is an important parameter of crop plant because of its physiological role in photosynthetic activities. Number of leaves per plant of sweet pepper showed statistically significant differences on different plant growth regulators at 40, 60, 80, 100, 120 DAT and final harvest (Fig. 4 and Appendix V). At final harvest, the maximum number of leaves per plant (144.68) was recorded from G_3 treatment (4-CPA @ 45 ppm + GA_3 @ 30 ppm), while the minimum number (118.23) was found from (control) G_0 treatment.

Number of leaves per plant of sweet pepper was obtained statistically significant differences for different number of spray at 40, 60, 80, 100, 120 DAT and final harvest (Appendix V). At final harvest, the maximum number of leaves per plant (135.9) was recorded from N_2 treatment (Three spray- vegetative + early flowering+ 80% flowering), while the minimum number (123.49) was obtained from (control) N_0 treatment (Fig. 5).

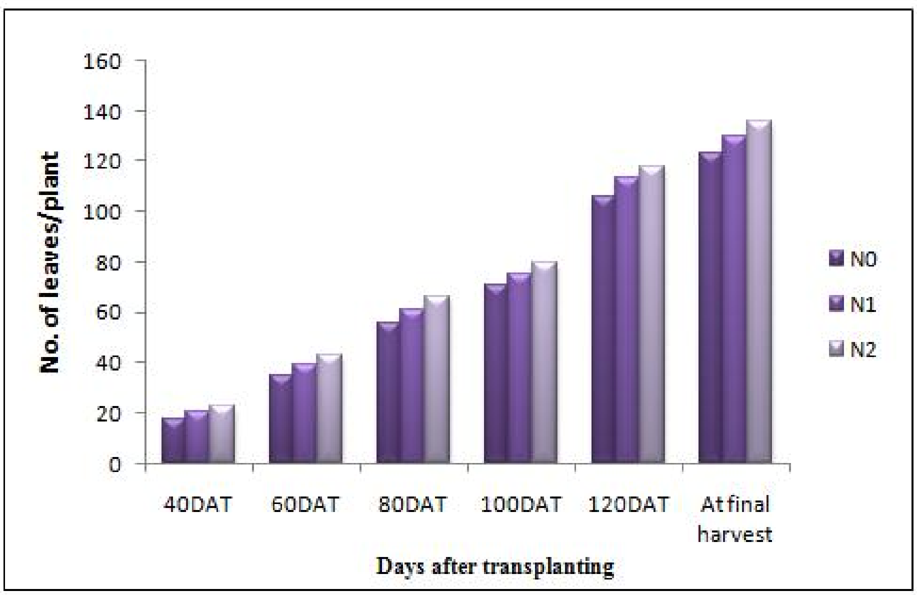
Combined effect of plant growth regulators and number of spray showed significant variation on number of leaves per plant of sweet pepper at 40, 60, 80, 100, 120 DAT and final harvest (Appendix V). At final harvest, the maximum number of leaves per plant (151.63) was recorded from G_3N_2 treatment combination, whereas the minimum number of leaves per plant (116.10) was observed from G_0N_0 treatment combination (Table 5).

From the results of the present study indicated that combined effect of 4-CPA and GA_3 with three number of spray combination might have induced better growing condition which ultimately led to the production of more leaves per plant. Plant growth regulators enhanced the number of leaves which ultimately increased the leaf number of sweet pepper.



here,
G_0: Control, G_1: GA_3 @ 30 ppm, G_2: 4CPA @ 45 ppm, G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

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



here,
N_0: No spray, N_1: Two spray (vegetative + early flowering) ,
N_2: Three spray (vegetative + early flowering + 80% flowering)

Fig 5: Effect of number of spray on number of leaves per plant at different days after transplanting of sweet pepper.

Table 5. Combined effect of plant growth regulators and number of spray on number of leaves per plant of sweet pepper

Treatments	Number of leaves per plant					
	40 DAT	60 DAT	80 DAT	100 DAT	120 DAT	At final harvest
G_0N_0	14.77 k	31.72 i	48.77 i	65.73 j	100.95 i	116.10 k
G_0N_1	15.78 j	32.46 k	51.16 k	67.25 i	102.67 hi	118.11 j
G_0N_2	16.46 i	34.27 i	53.38 i	70.35 g	105.15 g	120.48 i
G_1N_0	15.16 j	33.16 j	52.24 j	68.21 hi	103.26 h	118.34 j
G_1N_1	17.18 h	35.28 h	55.46 h	59.48 gh	108.26 f	122.28 h
G_1N_2	19.31 f	39.12 e	61.67 f	73.77 f	113.92 e	131.07 f
G_2N_0	18.47 g	36.77 g	58.316 g	73.23 f	107.31 f	134.40 g
G_2N_1	21.38 e	40.81 d	63.21 e	77.71 d	116.56 d	133.14 e
G_2N_2	25.16 c	46.27 c	70.13 c	84.31 c	120.27 c	140.43 c
G_3N_0	22.26 d	38.34 f	64.71 d	76.18 e	112.62 e	135.12 d
G_3N_1	28.34 b	48.21 b	74.32 b	87.17 b	125.70 b	147.27 b
G_3N_2	30.32 a	52.54 a	80.12 a	90.85 a	131.55 a	151.63 a
CV%	7.25	8.98	8.16	9.97	11.68	10.58
LSD (0.05)	0.26	0.16	0.17	1.47	1.79	1.30

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

G_0: Control
G_1: GA_3@30 ppm
G_2: 4CPA@45 ppm
G_3: 4CPA@45 ppm + GA_3@30 ppm

N_0: No spray
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering)

4.4 Days from transplanting to 1st flowering

No significant variation was observed in terms of days from transplanting to 1st flowering of sweet pepper for different plant growth regulators (Appendix VI). The minimum days from transplanting to 1st flowering (49.16 days) was found from (control) G_0, while the maximum (51.98 days) from G_3 treatment (4-CPA @ 45 ppm + GA_3 @ 30 ppm) (Table 6).

Table 6. Effect of plant growth regulators on yield contributing character of sweet pepper

Treatments	Days from transplanting to1st flowering	Number of flowers per plant	Number of fruits per plant	Number of marketable fruits per plant	Fruit Setting (%)	Days from transplanting to 1st harvest
G_0	49.16	30.06 d	9.89 d	5.37 d	31.45 d	121.52 a
G_1	50.25	30.65 c	10.46 c	5.93 c	34.09 c	117.80 b
G_2	51.38	31.51 b	11.56 b	6.52 b	36.65 b	113.44 c
G_3	51.98	32.58 a	12.81 a	7.24 a	39.09 a	107.99 d
CV%	11.43	7.45	8.62	5.81	4.88	5.39
LSD (0.05)	NS	0.04	0.06	0.06	0.05	0.07

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

here,
G_0: Control, G_1: GA_3 @ 30 ppm, G_2: 4CPA @ 45 ppm, G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

Days from transplanting to 1st flowering of sweet pepper showed no statistically significant variation for different number of spray for sweet pepper (Table 7 and Appendix VI). The minimum days from transplanting to 1st flowering (49.96 days) was found from (control) N_0 treatment, while the maximum (51.41 days) was attained from N_2 treatment (Three spray- vegetative + early flowering+ 80% flowering).

Table 7. Effect of number of spray on yield contributing characters of sweet pepper

Treatments	Days from transplanting to1st flowering	Number of flowers per plant	Number of fruits per plant	Number of marketable fruits per plant	Fruit Setting (%)	Days from transplanting to 1st harvest
N_0	49.96	30.64 c	9.90 c	5.58 c	32.27 c	118.39 a
N_1	50.71	31.29 b	11.33 b	6.27 b	35.99 b	114.76 b
N_2	51.41	31.68 a	12.03 a	6.94 a	37.86 a	112.42 c
CV%	11.43	7.45	8.62	5.81	4.88	5.39
LSD (0.05)	NS	0.35	0.05	0.05	0.04	0.06

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

here,
N_0: No spray, N_1: Two spray (vegetative + early flowering) ,
N_2: Three spray (vegetative + early flowering + 80% flowering)

Combined effect of plant growth regulators and number of spray showed no statistically significant variation for days from transplanting to 1st flowering (Appendix VI). The minimum days from transplanting to 1st flowering (48.86 days) was found from G_0N_0 treatment combination, while the maximum (52.84 days) was observed from G_3N_2 treatment combination (Table 8. and Appendix VI).

4.5 Number of flowers per plant

Number of flowers per plant of sweet pepper showed significant differences due to the effect of different plant growth regulators (Appendix VI). The maximum number of flowers per plant (32.58) was recorded from G_3 (4-CPA@ 45 ppm + GA_3 @ 30 ppm) treatment, whereas the minimum number (30.06) was obtained from (control) G_0 treatment (Table 6. and Appendix VI). It was noticed that application of 4-CPA + GA_3 enhanced flower production, reduced flower abscission that contributed the maximum number of flower per plant compared to plants treated with others hormone and control. This might be occured due to application of auxin at the time of flowering and resulted lower flower drop. This result is in agreement with the findings of Choudhury *et al.* (2013) where they found that, the highest number of flowers per plant (39.69) were obtained in combined application of 20 ppm 4-CPA and 20 ppm GA_3 in summer tomato plant.

Significant variation was recorded due to the effect of different number of spray of sweet pepper on number of flowers per plant (Appendix VI). The maximum number of flowers per plant (31.68) was recorded from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum number (30.64) was found from (control) N_0 treatment (Table 7).

Number of flowers per plant showed significant variation due to the combined effect of plant growth regulators and number of spray (Appendix VI). The maximum number of flowers per plant (33.33) was recorded from G_3N_2 treatment combination, while the minimum number (29.66) was found from G_0N_0 treatment combination (Table 8).

4.6 Number of fruits per plant

Plant growth regulators significantly influenced on number of fruits per plant of sweet pepper (Appendix VI). The maximum number of fruits per plant (12.81) was found from G_3 (4-CPA@ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum number (9.89) was recorded from (control) G_0 treatment (Table 6).Maximum number of fruit was recorded in plant growth regulators (4-CPA + GA_3) treated plants compared to control. This result is in agreement with the findings of EI- Habbasha *et al.* (1999) where he found that GA_3 and 4-CPA has the effect on fruit yield and increase the number of fruit in tomato plant.

Number of spray showed significant variation on total number of fruits per plant (Appendix VI). The maximum number of fruits per plant (12.03) was obtained from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum number (9.90) was obtained from (control) N_0 treatment (Table 7). Natesh *et al.* (2005) reported that GA_3 @ 100 ppm spray at flowering stage recorded higher fruit of hot pepper.

Significant variation was observed due to the combined effect of plant growth regulators and number of spray in terms of total number of fruits per plant (Appendix VI). The maximum number of fruits per plant (14.13) was recorded from G_3N_2 treatment combination, while the minimum number (8.92) was found from G_0N_0 treatment combination (Table 8).

4.7 Number of marketable fruits per plant

Number of marketable fruits per plant showed significant variation due to different plant growth regulators of sweet pepper (Appendix VI). The maximum number of marketable fruits per plant (7.24) was found from G_3 (4-CPA@ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum number (5.37) was found from (control) G_0 treatment (Table 6). Chhonkar and Sen Gupta (1972) reported that plant growth sub- growth substances affect fruit quality and resulted in the maximum number of marketable yield of tomato variety.

Different number of spray significantly influenced on number of marketable fruits per plant of sweet pepper (Table 7 and Appendix VI). The maximum number of marketable fruits per plant (6.94) was found from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum number (5.58) from (control) N_0 treatment. From the results of the present study indicated that different number of spray can affect the fruit quality.

Significant variation was observed due to the combined effect of plant growth regulators and number of spray in terms of number of marketable fruits per plant. The maximum number of marketable fruits per plant (8.10) was recorded from G_3N_2 treatment combination, while the minimum number (5.04) from G_0N_0 treatment combination (Table 8 and Appendix VI).

4.8 Fruit setting

Fruit setting (%) of sweet pepper varied significantly for different plant growth regulators (Table 6 and Appendix VI). The maximum fruit setting (39.09%) was found from G_3 (4-CPA @ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum fruit setting (31.45%) was found from (control) G_0 treatment.

Fruit setting (%) of sweet pepper showed significant variation due to the effect of different number of spray (Table 7 and Appendix VI). The maximum fruit setting (37.86%) was found from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum (32.27%) was recorded from (control) N_0 treatment.

Combined effect of plant growth regulators and number of spray showed significant variation in terms of fruit setting (Appendix VI). The maximum fruit setting (42.39%) was observed from G_3N_2 treatment combination, while the minimum (30.08%) was found from G_0N_0 treatment combination (Table 8).It was observed in present study that plant growth regulators enhanced the source-sink relationship and hormone modified translocation of photosynthates, which will help in better retention of flowers and fruits and seed filling at the later stages of crop growth. There is great potential to increase the yield levels in sweet pepper either by reducing the flower drop or by increasing the fruit set. This might be occurs due to application of auxin at the time of flowering and resulted lower flowers drop that enhance fruit setting and contributed higher percentage of fruit setting. This result is in agreement with the findings of Hasanuzzaman *et al*. (2007). Kuo *et al*. (1978) also reported that 4-chlorophenoxy acetic acid has been found to be effective in improving tomato fruit set under higher temperature conditions This result also is in agreement with the findings of Sasaki *et al.* (2005) where he obtained that the tomato plants treated with a mixture of 4-CPA and GAs showed increased fruit set and proportion of normal fruits compared to plants of the same crop treated with 4-CPA alone.

Table 8. Combined effect of plant growth regulators and number of spray on yield contributing characters of sweet pepper

Treatments	Days from transplanting to1st flowering	Number of flowers per plant	Number of fruits per plant	Number of marketable fruits per plant	Fruit Setting (%)	Days from transplanting to 1st harvest
G_0N_0	48.86	29.66 g	8.92 k	5.04 j	30.08 l	122.28 a
G_0N_1	49.15	29.98 fg	9.12 j	5.32 i	31.72 k	121.54 b
G_0N_2	49.46	30.54 def	10.12 i	5.75 h	33.14 h	120.74 c
G_1N_0	49.33	30.15 efg	9.61 j	5.37 i	31.87 j	119.42 d
G_1N_1	50.18	30.81 de	10.54 g	5.87 g	34.22 f	117.74 e
G_1N_2	51.25	30.99 cd	11.21 e	6.55 d	36.17 e	116.23 g
G_2N_0	50.72	31.00 cd	10.23 h	5.79 gh	33.00 i	117.58 f
G_2N_1	51.36	31.68 b	11.79 d	6.38 e	37.22 d	113.51 i
G_2N_2	52.07	31.85 b	12.65 c	7.39 c	39.73 c	109.23 j
G_3N_0	50.95	31.73 b	12.65 c	6.12 f	34.10 g	114.27 h
G_3N_1	52.15	32.69 a	13.47 b	7.51 b	40.79 b	106.23 k
G_3N_2	52.84	33.33 a	14.13 a	8.10 a	42.39 a	103.47 l
CV%	11.43	7.45	8.62	5.81	4.88	5.39
LSD (0.05)	NS	0.692	0.01	0.09	0.08	0.14

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

G_0: Control
G_1: GA_3@30 ppm
G_2: 4CPA@45 ppm
G_3: 4CPA@45 ppm + GA_3@30 ppm

N_0: No spray
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering)

4.9 Days from transplanting to 1st harvest

Days from transplanting to 1st harvest of sweet pepper varied significantly due to different plant growth regulators (Table 6 and Appendix VI). The minimum days from transplanting to1st harvest (107.99) was found from G_3 (4-CPA @ 45 ppm + GA_3 @ 30 ppm) treatment, while the maximum days (121.52) was recorded from (control) G_0 treatment. Hasanuzzaman *et al*. (2007) reported that, plant hormones promoted the harvesting of sweet pepper a few days earlier than control. This is might be due to the regulating effect of exogenous application of PGRs that influences early floral initiation, fruit setting and helps to early maturity.

Days from transplanting to 1st harvest of sweet pepper varied significantly due to different number of spray (Table 7 and Appendix VI). However, minimum days from transplanting to 1st harvest (112.42) was attained from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the maximum days (118.39) was found from (control) N_0 treatment.

Significant variation was obtained due to the combined effect of plant growth regulators and number of spray in terms of days from transplanting to 1st harvest (Appendix VI). The minimum days from transplanting to 1st harvest (103.47) was recorded from G_3N_2 treatment combination, while the maximum days (122.28) was found from G_0N_0 treatment combination (Table 8).

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4.10 Length of fruit

Application of plant growth regulators showed significant variation on length of fruits (Table 9 and Appendix VII). The maximum length of fruit (7.59 cm) was found from G_3 (4-CPA@ 45 ppm + GA_3 @ 30 ppm) treatment, where the minimum length (6.14 cm) was found from (control) G_0 treatment. Plant growth regulators have possibility to increase fruit length. Prasad and Kumar (2003) stated that plant growth regulators promote the cell wall loosening processes providing a state of extensive flexibility within the cell leading ultimately in plant growth. Choudhury *et al*. (2013) also found that, plant growth regulators have great potentiality to facilitate the fruit length of summer tomato. This result also is in agreement with the findings of Hasanuzzaman *et al*. (2007).

Table 9.Effect of plant growth regulators on yield contributing characters and yield of sweet 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)
G_0	6.14 d	4.25 d	5.42 d	52.70 d	283.56 a	3.40 d	18.80 d
G_1	6.71 c	4.55 c	5.67 c	53.73 c	318.94 c	3.89 c	21.24 c
G_2	7.13 b	4.88 b	5.97 b	55.38 b	361.80 b	4.34 b	24.11 b
G_3	7.59 a	5.33 a	6.33 a	57.38 a	416.90 a	5.03 a	27.70 a
CV%	6.31	8.87	9.35	10.93	9.34	10.25	9.63
LSD (0.05)	0.06	0.07	0.07	0.05	0.36	0.09	0.06

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

here,
G_0: Control, G_1: GA_3 @ 30 ppm, G_2: 4CPA @ 45 ppm, G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

Different number of spray showed significant variation for length of fruit (Table 10 and Appendix VII). The maximum length of fruit (7.39 cm) was recorded from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum length (6.29 cm) was found from (control) N_0 treatment. From the results of the present study indicated that different number of spray can affect the fruit quality.

Table 10. Effect of number of spray on yield contributing characters and yield of sweet pepper of sweet 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)
N_0	6.29 c	4.42 c	5.42 c	53.40 c	298.34 c	3.58 c	19.87 c
N_1	6.99 b	4.74 b	5.89 b	55.08 b	347.02 b	4.16 b	23.11 b
N_2	7.39 a	5.09 a	6.16 a	55.95 a	390.54 a	4.73 a	26.00 a
CV%	6.31	8.87	9.35	10.93	9.34	10.25	9.63
LSD (0.05)	0.05	0.06	0.06	0.02	0.31	0.08	0.05

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

here,
N_0: No spray, N_1: Two spray (vegetative + early flowering) ,
N_2: Three spray (vegetative + early flowering + 80% flowering)

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Significant variation was observed due to the combined effect of plant growth regulators and number of spray in terms of length of fruit (Appendix VII). The maximum length of fruit (8.11 cm) was found from G_3N_2 treatment combination, while the minimum length (5.75 cm) was found from G_0N_0 treatment combination (Table 11).

4.11 Diameter of fruit

Significant variation was recorded for diameter of fruit of sweet pepper for different plant growth regulators (Appendix VII). The maximum diameter of fruit (5.33 cm) was observed from G_3 (4-CPA @ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum diameter (4.25cm) was observed from (control) G_0 treatment (Table 9).

Diameter of fruit varied significantly due to different number of spray of sweet pepper (Table 10 and Appendix VII). The maximum diameter of fruit (5.09 cm) was found from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum diameter (4.42 cm) was recorded from (control) N_0 treatment.

Different plant growth regulators and number of spray varied significantly due to the combined effect in terms of diameter of fruit (Appendix VII). The maximum diameter of fruit (5.71 cm) was observed from G_3N_2 treatment combination, while the minimum diameter (4.1 cm) was recorded from G_0N_0 treatment combination (Table 11).

4.12 Pericarp thickness

Pericarp thickness of sweet pepper varied significantly for different plant growth regulators (Table 9 and Appendix VII). The higher pericarp thickness (6.33 mm) was recorded from G_3 (4-CPA @ 45 ppm + GA_3 @ 30 ppm) treatment, while the lower thickness (5.42 mm) was observed from (control) G_0 treatment.

Different number of spray showed significant variation on pericarp thickness (Table 9 and Appendix VII). The maximum pericarp thickness (6.16 mm) was recorded from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum thickness (5.50 mm) was observed from (control) N_0 treatment.

Significant variation was observed due to the combined effect of plant growth regulators and number of spray in terms of pericarp thickness (Appendix VII). The maximum pericarp thickness (6.70 mm) was found from G_3N_2 treatment combination, while the minimum thickness (5.19 mm) was recorded from G_0N_0 treatment combination (Table 11).

4.13 Individual fruit weight

Different plant growth regulators showed significant variation on individual fruit weight of sweet pepper (Table 9 and Appendix VII). The maximum weight of individual fruit (57.38 g) was recorded from G_3 (4-CPA@ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum weight (52.70 g) was observed from (control) G_0 treatment.

Table 11. Combined effect of plant growth regulators and number of spray on yield contributing characters and yield of sweet 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)
G_0N_0	5.75 h	4.10 g	5.19 h	52.02 k	262.71 l	3.15 i	17.50 k
G_0N_1	6.12 g	4.19 f	5.40 g	52.66 j	280.69 k	3.37 h	18.67 j
G_0N_2	6.54 f	4.49 e	5.67 f	53.44 h	307.30 i	3.68 g	20.43 h
G_1N_0	6.15 g	4.24 f	5.35 g	52.84 i	283.73 j	3.40 h	18.90 i
G_1N_1	6.75 e	4.50 e	5.67 f	53.56 g	314.38 g	3.76 g	20.93 f
G_1N_2	7.23 d	4.91 d	5.99 de	54.79 f	358.70 d	4.50 d	23.89 d
G_2N_0	6.45 f	4.51 e	5.56 f	53.65 g	310.63 h	3.73 g	20.72 g
G_2N_1	7.25 d	4.88 d	6.09 d	55.95 d	356.89 e	4.27 e	23.79 d
G_2N_2	7.69 c	5.23 c	6.26 c	56.54 c	417.89 c	5.02 c	27.82 c
G_3N_0	6.82 e	4.86 d	5.88 e	54.94 e	336.30 f	4.05 f	22.38 e
G_3N_1	7.83 b	5.41 b	6.41 b	58.15 b	436.13 b	5.23 b	29.05 b
G_3N_2	8.11 a	5.71 a	6.70 a	59.05 a	478.27 a	5.73 a	31.87 a
CV%	6.31	8.87	9.35	10.93	9.34	10.25	9.63
LSD (0.05)	0.10	0.13	0.12	0.09	0.63	0.16	0.11

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

G_0: Control
G_1: GA_3@30 ppm
G_2: 4CPA@45 ppm
G_3: 4CPA@45 ppm + GA_3@30 ppm

N_0: No spray
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering)

Significant variation was found on individual fruit weight for different number of spray (Table 10 and Appendix VII). The maximum weight of individual fruit (55.95 g) was found from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum weight (53.40 g) was recorded from (control) N_0 treatment.

Significant variation was recorded due to the combined effect of plant growth regulators and number of spray in terms of individual fruit weight (Appendix VII). The maximum weight of individual fruit (59.05 g) was attained from G_3N_2 treatment combination, while the minimum weight (52.02 g) was found from G_0N_0 treatment combination (Table 11).From the results of the present study indicated that combined effect of 4-CPA and GA_3 with three number of spray combination might have induced better growing condition which ultimately led to increase individual fruit weight per plant. An increase in average fruit weight treated with plant growth regulators may further attributed to the reason that plants remain physiologically more active to build up sufficient food stock for the developing flowers and fruits.

4.14Yield per plant

Yield per plant of sweet pepper varied significantly on different plant growth regulators (Table 9 and Appendix VII). The maximum yield per plant (416.90 g) was recorded from G_3 (4-CPA@ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum, yield per plant (283.56 g) was found from (control) G_0 treatment. Nkansah (1995) stated that mulch and 4-chloro phenoxy acetic acid (4-CPA) interaction on growth and yield of eggplant *(Solanum aethiopicum*L.). Kannan *et al*. (2009) reported that application of GA_3 had significant effect on growth and yield attributes on peperika hot pepper.

Different number of spray showed significant variation on yield per plant (Appendix VII). The maximum yield per plant (390.54 g) was observed from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum yield per plant (298.34 g) was recorded from (control) N_0 treatment (Table 10). This result is in agreement with the findings of Georgia *et al. (*2010) where he noted that spraying with gibberellic acid, two times at two weeks intervals and three weeks after seed germination, maximum the yield and achieves acceptable quality of sweet pepper. This result also is in agreement with the findings of Bhalekar *et al.* (2009) where he revealed that NAA at 20 ppm spray at flowering stage recorded higher fruit yield compared to control.

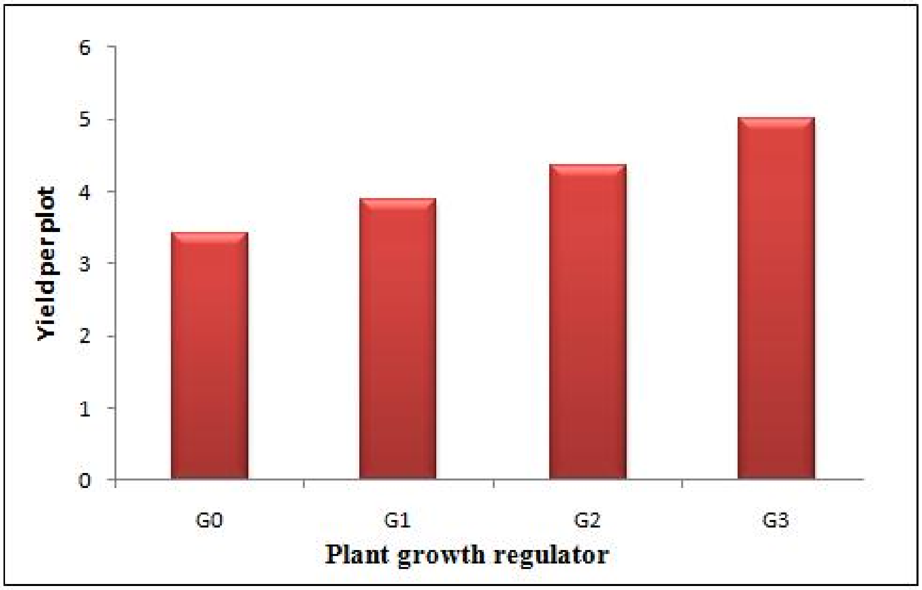
Combined effect of plant growth regulators and number of spray varied significantly due to the in terms of yield per plant (Appendix VII). The highest yield per plant (478.27g) was attained from G_3N_2 treatment combination, while the lowest yield per plant (262.71 g) was found from G_0N_0 treatment combination (Table 11).

4.15 Yield per plot

Yield per plot of sweet pepper showed significant for different growth regulators (Table 9 and Appendix VII). The maximum yield per plot (5.03 kg) was recorded from G_3 (4-CPA @ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum yield per plot (3.40kg) was recorded from (control) G_0 treatment (Fig. 6).

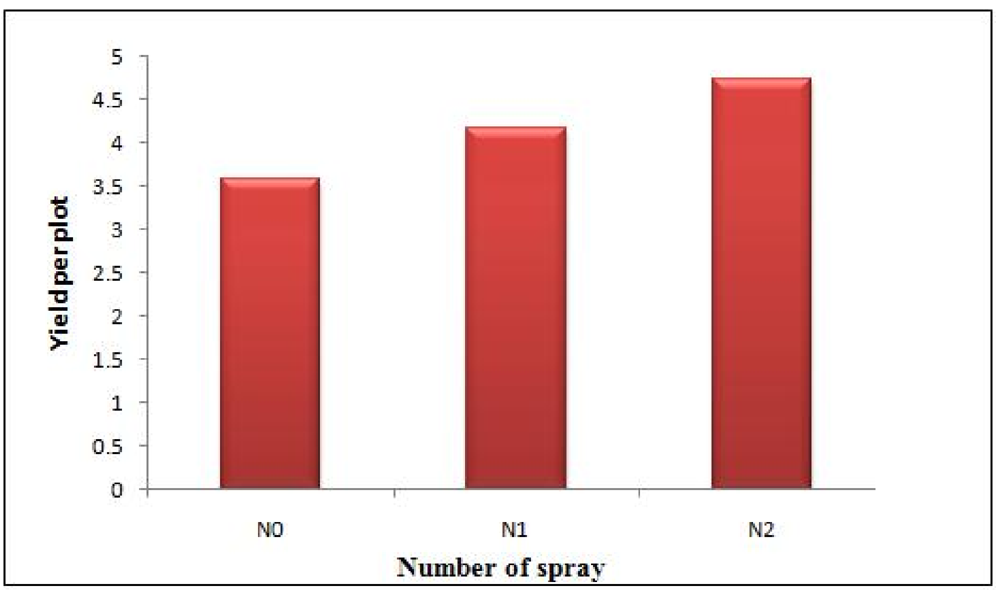
Significant variation was found for different number of spray of sweet pepper in terms of yield per plot (Table 10 and Appendix VII). The maximum yield per plot (4.73 kg) was found from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum yield per plot (3.58kg) was recorded from (control) N_0 treatment (Fig. 6).

Plant growth regulators and number of spray varied significantly due to their combined effect in terms of yield per plot (Appendix VII). The maximum yield per plot (5.73 kg) was observed from G_3N_2 treatment combination, while the minimum yield per plot (3.15 kg) was recorded from G_0N_0 treatment combination (Table 11).



here,
G_0: Control, G_1: GA_3 @ 30 ppm, G_2: 4CPA @ 45 ppm, G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

Fig 6: Effect of plant growth regulators on yield per plot at different days after transplanting of sweet pepper



here,
N_0: No spray, N_1: Two spray (vegetative + early flowering) ,
N_2: Three spray (vegetative + early flowering + 80% flowering)

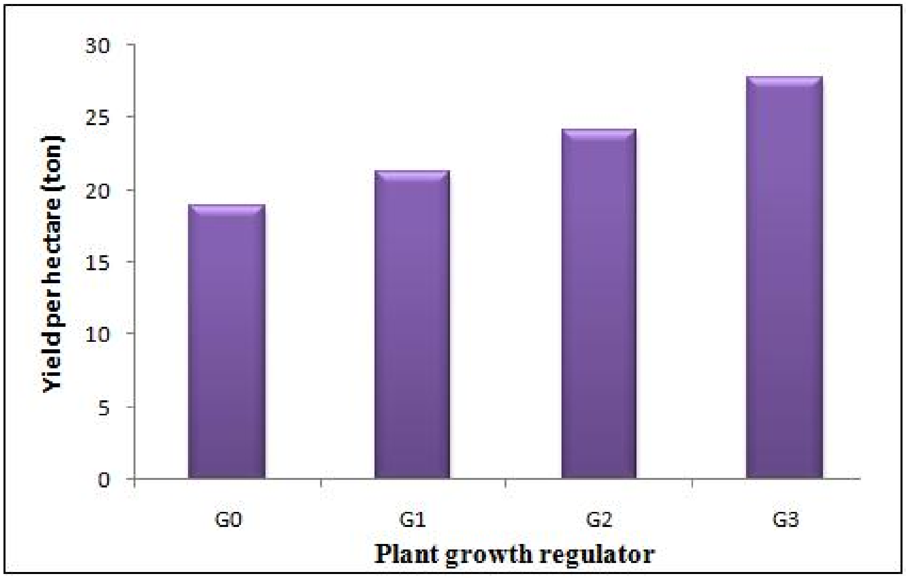
Fig 7: Effect of number of spray on yield per plot at different days after transplanting of sweet pepper

4.16 Yield per hectare

Significant variation was observed for yield per hectare of sweet pepper due to application of different plant growth regulators (Table 9 and Appendix VII). The maximum yield per hectare (27.70 ton) was observed from G_3 (4-CPA@ 45 ppm + GA_3 @ 30 ppm) treatment, while the minimum yield per hectare (18.80 ton) was recorded from (control) G_0 treatment (Fig. 8). Uddain *et al.* (2009) studied on the effect of different plant growth regulators (NAA, GA_3 and 2,4- D) on growth and yield of tomato. The results revealed that the maximum growth, yield and yield attributes were found with PGRs than control.

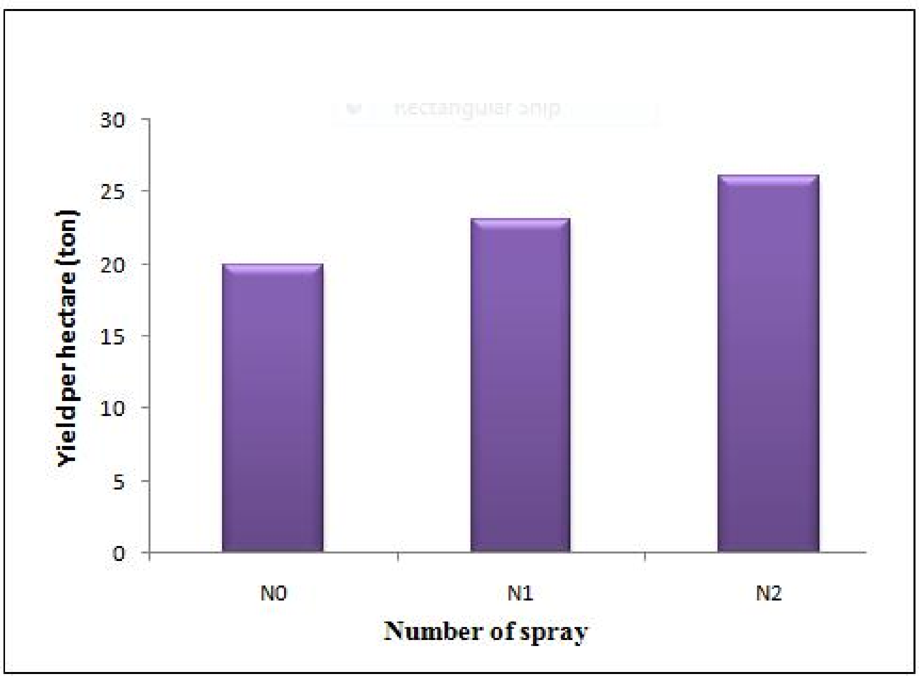
Yield per hectare showed significant variation for different number of spray of sweet pepper (Table 10 and Appendix VII). The highest yield per hectare (26.00 ton) was recorded from N_2 treatment (Three spray- vegetative+ early flowering+ 80% flowering), while the minimum yield per hectare (19.87 ton) was observed from (control) N_0 treatment (Fig. 9).

Combined effect of plant growth regulators and number of spray showed significant variation in terms of yield per hectare (Appendix VII). The maximum yield per hectare (31.87 ton) was recorded from G_3N_2 treatment combination, while the minimum yield per hectare (17.50ton) was found from G_0N_0 treatment combination (Table 8). Hasanuzzaman *et al*. (2007) reported that, due to hormonal treatments significant variation exists in respect of fruit yield.



here,
G_0: Control, G_1: GA_3 @ 30 ppm, G_2: 4CPA @ 45 ppm, G_3: 4CPA @ 45 ppm + GA_3 @ 30 ppm

Fig 8: Effect of plant growth regulators on yield per hectare (ton) at different days after transplanting of sweet pepper



here,
N_0: No spray, N_1: Two spray (vegetative + early flowering) ,
N_2: Three spray (vegetative + early flowering + 80% flowering)

Fig 9: Effect of number of spray on yield per hectare (ton) at different days after transplanting of sweet pepper

4.17 Economic analysis

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

4.17.1 Gross return

The combination of plant growth regulators and number of spray showed different values in terms of gross return under the trial (Appendix X). The highest gross return (Tk. 2385000) was found from the treatment combination G_3N_2 and the second highest gross return (Tk. 2175000) was obtained in G_2N_2. The lowest gross return (Tk. 1312500) was obtained from G_0N_0.

4.17.2 Net return

In case of net return, different treatment combination showed different levels of net return under the present trial (Appendix X). The highest net return (Tk. 1416558) was obtained from the treatment combination G_3N_2 and the second highest net return (Tk. 1218423) was found from the combination G_2N_2. The lowest (Tk. 433045) net return was found from G_0N_0 treatment combination.

4.20.3 Benefit Cost Ratio

The combination of different plant growth regulators and number of spray application for benefit cost ratio was different in all treatment combination (Appendix-X). The highest benefit cost ratio (2.46) was found from the treatment combination G_3N_2 and the second highest benefit cost ratio (2.27) was found from G_2N_2 treatment combination. The lowest benefit cost ratio (1.49) was found from the G_0N_0 (control) treatment combination. From the economic point of view, it was apparent from the above results that the treatment combination of G_3N_2 was more profitable than rest of treatment combinations.

Appendix-X: Economic performances regarding gross return, net return and benefit cost ratio (BCR) of sweet pepper

Treatment	Cost of production (Tk / ha)	Yield (t /ha)	Gross return |(Tk /ha)	Net return (Tk /ha)	BCR
G_0N_0	879455	17.5	1312500	433045	1.49
G_0N_1	879455	18.6	1395000	433045	1.49
G_0N_2	879455	20.4	1530000	433045	1.49
G_1N_0	926915	18.9	1417500	490585	1.53
G_1N_1	944711	20.9	1567500	622789	1.66
G_1N_2	956577	23.8	1785000	828423	1.87
G_2N_0	915050	20.7	1552500	637450	1.69
G_2N_1	920982	23.7	1777500	856518	1.93
G_2N_2	926915	27.8	2085000	1158085	2.25
G_3N_0	932847	22.3	1158085	225238	2.24
G_3N_1	956577	29.0	2175000	1218423	2.27
G_3N_2	968442	31.8	2385000	1416558	2.46

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh to study the application plant growth regulators (PGRs) and different number of spray for higher growth, yield and economic benefit of sweet pepper. In the experiment, the treatments consist of four levels of Plant growth regulators and three levels of number of spray. Factor A: Plant growth regulators (four levels) as G_0: No plant growth regulator (water), G_1: Gibberellic Acid (GA_3) @ 30 ppm, G_2: 4-Chloro Phenoxy Acetic Acid (4-CPA) @ 45 ppm and G_3: Gibberellic Acid (GA_3) @ 30 ppm + 4-Chloro Phenoxy Acetic Acid (4-CPA) ppm. Factor B: Number of spray (three levels) as N_0: Control (No spray), N_1: Two spray (vegetative + early flowering), N_2: Three spray (vegetative + early flowering + 80% flowering).

The two factors experiment was laid out in randomized complete block (RCBD) design with 3 replications. The total number of treatments were twelve and the numbers of plots were thirty six. Data were collected on the following parameters- plant height, number of branches per plant, number of leaves per plant, first flowering initiation, number of flowers per plant, number of total fruit per plant, number of marketable fruit per plant, fruit setting %, length of fruit, diameter of fruit, pericarp thickness, individual fruit weight, fruit yield per plant, fruit yield per plot, fruit yield ton per hectare. The data were analyzed statistically by variances (ANOVA) of data on different characters and yield of sweet pepper.

In case of plant growth regulators the highest plant height (53.11 cm) was observed from G_3 treatment, while the shortest plant (45.34 cm) was recorded from G_0 treatment at final harvest. The highest number of branches per plant (9.25) was recorded from G_3 treatment, while the minimum number (7.67) was recorded from G_0 treatment. At final harvest, the highest number of leaves per plant (144.68) was recorded from G_3 treatment, again the lowest number (118.23) was recorded from G_0 treatment. No significant variation was found from transplanting to 1^{st} flowering. The maximum number of flowers per plant

(32.58) was observed from G_3 treatment, whereas the minimum number (30.06) was found from G_0 treatment. The maximum number of fruits per plant (12.81) was observed from G_3 treatment, while the minimum number (9.89) was found from G_0 treatment. The maximum number of marketable fruits per plant (7.24) was found from G_3 treatment, while the minimum number (5.37) was observed from G_0 treatment. The highest fruit setting (39.09%) was recorded from G_3 treatment, while the lowest fruit setting (31.45%) was observed from G_0 treatment. The lowest days from transplanting to 1st harvest (107.99) was recorded from G_3 treatment and the highest days (121.52) was observed from G_0 treatment. The highest length of fruit (7.59 cm) was found from G_3 treatment, again the lowest length (6.14 cm) was recorded from G_0 treatment. The highest diameter of fruit (5.33 cm) was recorded from G_3 treatment, while the lowest diameter (4.25 cm) was found from G_0 treatment. The highest pericarp thickness (6.33 mm) was recorded from G_3 treatment, while the lowest thickness (5.42 mm) was found from G_0 treatment. The maximum weight of individual fruit (57.38 g) was found from G_3 treatment and the minimum weight (52.70 g) was recorded from G_0 treatment. The maximum yield per plant (416.90 g) was observed from G_3 treatment whereas, the minimum yield per plant (283.56 g) was found from G_0 treatment. The maximum yield per plot (5.03 kg) was recorded from G_3 treatment and the minimum yield per plot (3.40 kg) was recorded from G_0 treatment. The maximum yield per hectare (27.70 ton) was observed from G_3 treatment, whereas the minimum yield per hectare (18.80 ton) from G_0 treatment.

For different number of spray, the longer plant (51.33 cm) was observed from N_2 treatment, while the shorter plant (46.35 cm) from N_0 treatment at final harvest. The highest number of branches per plant (8.86) was recorded from N_2 treatment, while the lowest number (8.08) from N_0 treatment. The highest number of leaves per plant (135.90) was observed from N_2 treatment, while the lowest number (123.49) from N_0 treatment. No significant variation was observed from transplanting to 1st flowering. The highest number of flower per plant (31.68) was recorded from N_2 treatment, while the lowest number (30.64) from N_0 treatment. The highest number of fruits per plant (12.03) was recorded from N_2 treatment, while the lowest number (9.90) from N_0 treatment. The highest number of marketable fruits per plant (6.94) was found from N_2 treatment, while the lowest number (5.58) from N_0 treatment. The highest fruit setting (37.86%) was recorded from N_2 treatment, while the lowest (32.27%) from N_0 treatment. The lowest days from transplanting to 1st harvest (112.42) were recorded from N_2 treatment, while the highest days (118.39) from N_0 treatment. The highest length of fruit (7.39 cm) was observed from N_2 treatment, while the lowest length (6.29 cm) was observed from N_0 treatment. The highest diameter of fruit (5.08 cm) was found from N_2 treatment, while the lowest diameter (4.42 cm) was recorded from N_0 treatment. The highest pericarp thickness (6.16 mm) was recorded from N_2 treatment, while the lowest thickness (5.50 mm) was recorded from N_0 treatment. The highest weight of individual fruit (55.95 g) was recorded from N_2 treatment, while the lowest weight (53.40 g) was recorded from N_0 treatment. The highest yield per plant (390.54 g) was recorded from N_2 treatment, while the lowest yield per plant (298.34 g) was recorded from N_0 treatment. The highest yield per plot (4.73 kg) was observed from N_2 treatment, while the lowest yield per plot (3.58 kg) was recorded from N_0 treatment. The highest yield per hectare (26.00 ton) was observed from N_2 treatment, while the lowest yield per hectare (19.87 ton) from N_0 treatment.

Due to the combined effect of plant growth regulators and number of spray, the tallest plant (56.46 cm) was recorded from G_3N_2 treatment combination at final harvest whereas the shortest plant (44.78cm) from G_0N_0 treatment combination. The highest number of branches per plant (9.64) was recorded from G_3N_2 treatment combination at final harvest and the lowest number (7.35) from G_0N_0 treatment combination. The highest number of leaves per plant (151.63) was obtained from G_3N_2 treatment combination at final harvest, whereas the lowest number (116.10) from G_0N_0 treatment combination. No significant variation was found for the days from transplanting to 1st flowering. The maximum number of flowers per plant (33.33) was obtained from G_3N_2 treatment combination, while the minimum number (29.66) from G_0N_0 treatment combination. The maximum number of fruits per plant (14.13) was found from G_3N_2 treatment combination, while the minimum number (8.92) from G_0N_0 treatment combination. The maximum number of marketable fruits per plant (8.10) was recorded from G_3N_2 treatment combination, while the minimum number (5.04) from G_0N_0 treatment combination. The highest fruit setting (42.39%) was recorded from G_3N_2 treatment combination and the lowest (30.08%) from G_0N_0 treatment combination. The lowest days from transplanting to 1st harvest (103.47) was recorded from G_3N_2 treatment combination, while the highest days (122.28) from G_0N_0 treatment combination. The highest length of fruit (8.11 cm) was recorded from G_3N_2 treatment combination, while the lowest length (5.75 cm) from G_0N_0 treatment combination. The highest diameter of fruit (5.71 cm) was found from G_3N_2 treatment combination, while the lowest diameter (4.10 cm) from G_0N_0 treatment combination. The highest pericarp thickness (6.70 mm) was obtained from G_3N_2 treatment combination, while the lowest thickness (5.19 mm) from G_0N_0 treatment combination. The maximum weight of individual fruit (59.05 g) was obtained from G_3N_2 treatment combination, while the minimum weight (52.02 g) from G_0N_0 treatment combination. The maximum yield per plant (478.27 g) was recorded from G_3N_2 treatment combination, while the minimum yield per plant (262.71 g) from G_0N_0 treatment combination. The maximum yield per plot (5.73 kg) was found from G_3N_2 treatment combination, while the minimum yield per plot (3.15 kg) from G_0N_0 treatment combination. The maximum yield per hectare (31.87ton) was recorded from G_3N_2 treatment combination, while the minimum yield per hectare (17.50 ton) from G_0N_0 treatment combination. The maximum gross return (Tk. 2385000) was found from the treatment combination G_3N_2 treatment combination and the minimum gross return (Tk. 1312500) from G_0N_0 treatment combination. The maximum net return (Tk. 1416558) was recorded from G_3N_2 treatment combination and the minimum (Tk. 433045) net return was found G_0N_0 treatment combination. The maximum benefit cost ratio (2.46) was recorded from G_3N_2 treatment combination and the minimum benefit cost ratio (1.49) was recorded from G_0N_0 treatment combination.

Conclusion:

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

1. In the experiment, plant growth regulators (4-CPA @ 45 ppm + GA_3 @ 30 ppm) was superior than the others.

2. Number of spray was played an important role on the growth and yield of sweet pepper. In respect of all, three number of spray showed better performance than others.

3. The treatment combination of G_3N_2 (4-CPA @ 45 ppm +GA_3 @ 30 ppm with three number of spray) showed best potentiality of 31.87 t/ha with TK. 1416558 net income and 2.46 BCR.

Considering the situation of the present experiment, further study might be conducted in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances. The experiment was however, conducted in one season only and hence the results should be considered as a tentative. It is imperative that similar experiment should be carried out with more variables to reconfirm the recommendation.

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APPENDICES

Appendix I: Monthly records of temperature, rainfall, and relative humidity of the experiment site during the period from November 2016 to March 2017

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2016	November	29.5	18.6	24.0	69.5	0.0	233.2
	December	26.9	16.2	21.5	70.6	0.0	210.5
2017	January	24.5	13.9	19.2	68.5	1.0	194.1
	February	28.9	18.0	23.4	61.0	2.0	121.5
	March	33.6	29.5	31.6	72.7	3.0	127.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-121

Appendix II: 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
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
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: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix III: Analysis of variance of the data on plant height at different days after transplanting (DAT) of sweet pepper as influenced by different plant growth regulators and number of spray

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	34.18	23.04	45.38	0.11	0.50	4.26
Growth regulators (B)	3	124.40**	126.64**	132.33**	9.54**	19.34*	64.86**
Number of spray (B)	2	111.87**	113.00**	125.01**	11.63**	21.65*	86.43**
Interaction (A×B)	6	80.17*	59.76*	129.67**	7.81*	15.68*	31.98*
Error	22	26.97	19.45	38.02	5.01	9.29	4.26

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

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

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	4.89	5.53	66.81	0.35	0.49	3.02
Growth regulators (A)	3	29.14**	57.38**	88.24**	7.77**	13.38**	26.48*
Number of spray (B)	2	37.03**	63.58**	95.99**	12.09**	17.01**	29.09*
Interaction (A×B)	6	14.58*	31.05*	67.77*	4.03*	12.70*	22.28*
Error	22	4.26	11.57	21.54	1.15	4.71	7.45

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

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

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	0.79	8.90	20.70	0.04	5.47	249.51
Growth regulators (A)	3	44.89**	87.87**	94.12**	1.26*	101.37**	1406.03**
Number of spray (B)	2	49.28**	85.62**	104.00**	4.09**	125.43**	5201.43**
Interaction (A×B)	6	19.00*	55.52*	78.95*	1.41*	61.43*	411.14*
Error	22	6.05	17.93	31.06	0.64	21.99	132.67

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

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

Source of variation	Degrees of freedom	Mean square					
		Days from transplanting to 1st flowering	Number of flowers per plant	Number of fruits per plant	Number of marketable fruits per plant	Fruit setting (%)	Days from transplanting to 1st harvest
Replication	2	1.21	2.29	2.11	0.02	9.99	443.5
Growth regulators (A)	3	6.27^{NS}	29.64*	64.25**	6.19**	97.01**	2409.3**
Number of spray (B)	2	7.17^{NS}	24.81**	75.81**	9.88**	82.57*	45510.2**
Interaction (A×B)	6	2.92^{NS}	19.77*	35.81*	3.69*	44.30*	6428.8**
Error	22	6.24	7.14	23.23	1.0	15.55	535.4

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

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

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	0.18	1.21	0.46	1.0	2.55	2.32	1.88
Growth regulators (A)	3	1.50**	12.68**	4.71*	8.21**	98.94**	33.39**	24.98*
Number of spray (B)	2	1.25**	78.06**	5.99*	5.51**	89.95**	29.19*	22.54*
Interaction (A×B)	6	1.49**	10.94**	4.35*	3.41*	48.77*	20.60*	18.34*
Error	22	0.19	1.92	1.45	1.14	15.44	6.87	5.08

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

Appendix VIII: Cost of production of sweet pepper per hectare

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		
G_0N_0	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	0	648360
G_0N_1	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	0	648360
G_0N_2	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	0	648360
G_1N_0	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	40000	688360
G_1N_1	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	55000	703360
G_1N_2	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	65000	713360
G_2N_0	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	30000	678360
G_2N_1	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	35000	683360
G_2N_2	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	40000	688360
G_3N_0	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	45000	693360
G_3N_1	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	65000	713360
G_3N_2	200000	180000	65000	98000	80000	4600	9500	6400	4010	850	75000	723360

G_0: Control
G_1: GA_3@30 ppm
G_2: 4CPA@45 ppm
G_3: 4CPA@45 ppm + GA_3@30 ppm

N_0: No spray
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering)

Appendix IX: Overhead cost (B)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 15,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
G_0N_0	97500	32418	101177	231095	879455
G_0N_1	97500	32418	101177	231095	879455
G_0N_2	97500	32418	101177	291095	879455
G_1N_0	97500	34418	106637	238555	926915
G_1N_1	97500	35168	108683	241351	944711
G_1N_2	97500	35668	110049	243217	956577
G_2N_0	97500	33918	105272	236690	915050
G_2N_1	97500	34168	105954	237622	920982
G_2N_2	97500	34418	106637	238555	926915
G_3N_0	97500	34668	107319	239487	932845
G_3N_1	97500	35668	110049	243217	956577
G_3N_2	97500	36168	111414	245093	968442

G_0: Control
G_1: GA_3@30 ppm
G_2: 4CPA@45 ppm
G_3: 4CPA@45 ppm + GA_3@30 ppm

N_0: No spray
N_1: Two spray (vegetative + early flowering)
N_2: Three spray (vegetative + early flowering + 80% flowering

Plate 1: Photograph of sweet pepper field

Plate 2: Photograph of weeding

G_3N_2 G_2N_2 G_1N_1 G_0N_0

Plate 3: Photograph of difference between treatments.