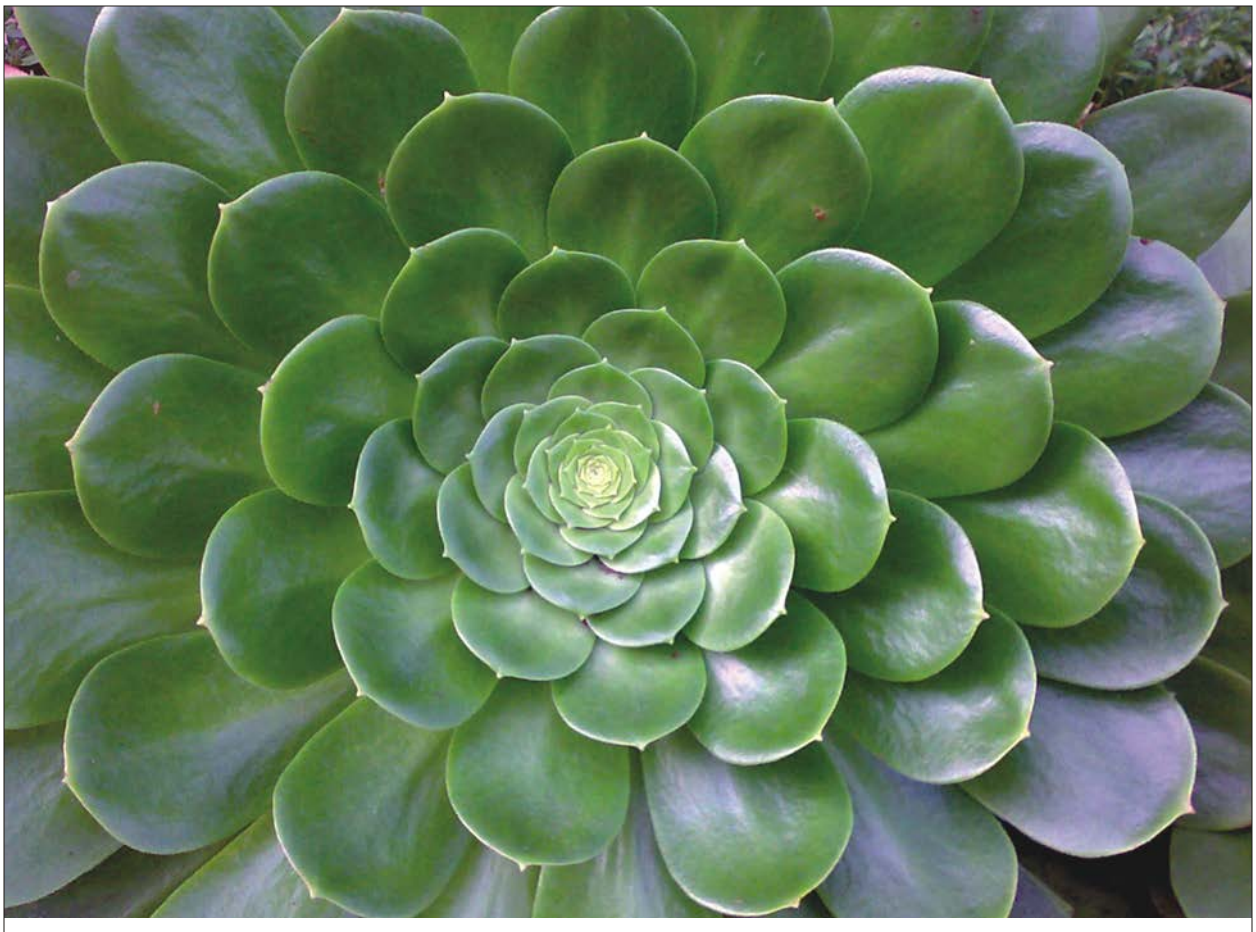

Journal of
Plant Sciences

ISSN 1816-4951

Academic
Journals Inc.

www.academicjournals.com

Journal of Plant Sciences 10 (2): 63-69, 2015
ISSN 1816-4951 / DOI: 10.3923/jps.2015.63.69

Influence of Plant Growth Regulators on Yield Contributing Characters and Yield of Bell Pepper (*Capsicum annum*) Varieties

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ABSTRACT

The influences of four levels of plant growth regulators on BARI Misti Morich-1 and Lamuyo varieties of bell pepper were studied at the horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from October 2012 to March 2013. Plant Growth Regulators (PGR) was applied on bell pepper varieties which had significant effect on yield of bell pepper. Among those treatments, growth regulator 4-CPA was more potential to enhance flowering by 4.00 days earlier and it also increased number of flowers plant^{-1} (5%), number of fruits plant^{-1} (35%), fruit setting (26.02%) and yield of fruit per hacter (39%) with the varieties of Lamuyo as compared to the fruit set where hormone was not applied. The variety Lamuyo produces about 10% higher yield than BARI Misti morich-1. Among those, growth regulator, 4-CPA showed best potentiality to solve flower and fruit dropping problem of bell pepper.

Key words: Fruit setting, hormone, metabolic activities, sweet pepper

INTRODUCTION

Bell pepper is a promising horticultural crop in Bangladesh. It is a newly introduced crop in our country generally familiar as capsicum or sweet pepper, belongs to the family Solanaceae. It has medicinal properties and used like a vegetable can be eaten as raw as salad or cooked. It is also frequently added to soups, omelettes, stews, brochettes, rice, pasta and pizza. It is considered as a minor fruit vegetable in Bangladesh and its production statistics is not available (Hasanuzzaman, 1999). Cultivation of this crop has started in small scale in peri-urban areas primarily to the consumers of city markets in Bangladesh (Saha, 2001). Large scale production of bell pepper yet not started due to lack of information about cultivation technique to the growers. Plant growth regulators are organic compounds which modify the physiological process of plant. It plays an essential role in many aspects of plant growth and development, stem elongation and flower development (Chaudhary *et al*., 2006; Ouzounidou *et al*., 2008). It affects primarily on vegetative growth, influence the fruit, may induce modifications in vegetative and fruiting parts (Leclerc *et al*., 2006). The high market price of capsicum is indicating the heavy demand from urban consumers as well as star hotels in metropolitan cities. There is also good scope to export for mitigating words demand of this crop. But it also has major problems of flower dropping, poor fruit set and susceptibility to viral diseases. However, growth regulators may be effective to reduce dropping of bell pepper and may increase fruit number, fruit size and fruit weight. Therefore, few

researches have been carried out regarding the use of growth regulators on bell pepper in Bangladesh. Considering the above circumstances, the present study was undertaken to improve production technology and introducing new variety through varietal performance for reducing flower or fruit dropping of capsicum.

MATERIALS AND METHODS

The experiment was carried out at the horticulture farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2012 to March 2013. The location of the experimental site was at 24.09°N latitude and 90.26°E longitude with an elevation of 8.20 m from sea level. Soil physical and chemical properties of the experimental field is presented in Table 1. The location was characterized by three distinct seasons, winter season from November to February, pre-monsoon or hot season from March to April and monsoon period from May to October.

Four levels of plant growth regulators viz. control, GA_3 at 100 ppm, 4-CPA at 2000 ppm and Litosen at 1000 ppm were tested on the two varieties of bell pepper viz. BARI Misti morich-1 and Lamuyo. BARI Misti morich-1 is our domestic variety and Lamuyo is an exotic variety from France. The chemical composition of Litosen is sodium-5-nitroguaiocol 0.4%, sodium-O-nitrophenol 0.6%, sodium-P-nitrophenol 0.8% and sodium-2-4-dinitrophenol 0.2%. Required amount of PGRs was taken using electronic balance and a stock solution was prepared by dissolving in 1 mL ethanol. Then the stock solution was diluted in distilled water to prepare the working solutions, just before using. Plant growth regulators- gibberellic acid (GA_3), 4-Chloro phenoxy acetic acid (4-CPA) and litosen were applied four times at vegetative stage, flower initiation stage and two times during blooming of flowers by a hand sprayer. The experiment was laid out in Randomized Complete Block Design with three replications. The size of the each plot was 1.5×1.2 m. Seeds were sown in the seedbed on 10 October 2012. The soil of the experimental plot was treated by sevin 50WP at 5 kg ha^{-1} to protect the young plants from the attack of ants and cutworm. Fertilizers were applied at 250, 330, 250, 110, 5 and 10000 kg ha^{-1} for urea, TSP, MP, gypsum, zinc and cowdung, respectively according to BARI (2011). About 30 days old seedlings were transplanted into the prepared plot on 10 November 2012 maintaining the spacing 50×40 cm. Experimental field was protected by net fencing with the support of bamboo. Harvesting of fruits was done by hand picking

Table 1: Physical and chemical properties of the experimental soil

Constituents	Values
Physical properties and mechanical fractions	
Sand (2.0-0.05 mm) (%)	22.30
Silt (0.05-0.002 mm) (%)	56.90
Clay (<0.002 mm) (%)	20.80
Textural class	Silt loam
Particle density (g cc^{-1})	2.6
Bulk density (g cc^{-1})	1.45
Porosity	44.23
Soil properties	Values
Chemical analysis	
pH (1:2.5 soil-water)	5.9
Organic matter (%)	1.09
Total nitrogen (%)	0.06
Available K (ppm)	15.63
Available P (ppm)	9.88
Available S (ppm)	8.06

and harvest was started at 80 DAT and continued up to final harvest based on the marketable sized of fruits. Data on days to 1st flowering, number of flowers, fruits plant^{-1}, fruit setting percentage calculated by using the formula:

$$\text{Fruit setting} = \frac{\text{Number of fruits plant}^{-1}}{\text{Number of flowers plant}^{-1}} \times 100$$

Days to 1st harvest, length of fruit, diameter of fruit, thickness of paricarp, individual fruit weight, fruit yield plant^{-1} and fruit yield per hacter were collected.

Statistical analysis: The mean values of all the parameters were analyzed by analysis of variance and means separation was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Days to 1st flowering: Plant growth regulators were influenced significantly on days to 1st flowering of bell pepper varieties. Flowering was earlier in those plants where PGRs was applied and take minimum times. 4-CPA at 2000 ppm performed more effectively on flowering than others and enhance flowering by 7.66 and 4.00 days earlier with the varieties of BARI Misti morich-1 and Lamuyo, respectively compared with the control (Table 2). This is might be due to regulating effect of exogenous application of PGRs that influences early floral initiation. It was also reported by Hasanuzzaman *et al*. (2007), Devadanam *et al*. (2007), Dogra *et al*. (2012), Sudhakar and Kumar (2012) and Sarkar *et al*. (2014a) where they stated that, PGRs promotes vegetative growth, increases the photosynthetic and metabolic activities causing more transport and utilization of photosynthetic products resulting early flowering in gladiolus.

Number of flowers and fruits plant^{-1}: Plant growth regulators significantly affect the number of flowers and fruits of bell pepper varieties. Number of flowers and fruits plant^{-1} was increased about 9 and 33% in BARI Misti morich-1 and about 5 and 35% in Lamuyo, respectively when 4-CPA applied at 2000 ppm compared with the control (Table 2). Flower and fruit setting was

Table 2: Yield contributing characters of bell pepper varieties as influenced by plant growth regulators

Treatments					
Variety	PGRs	Days to 1st flowering	No. of flowers plant^{-1}	No. of fruits plant^{-1}	Days to 1st harvest
BARI Misti morich-1	Control	57.33^{a}	29.67^{c}	5.33^{d}	122.33^{a}
	GA_3 at 100 ppm	53.67^{b}	30.33^{bc}	7.00^{c}	113.67^{abc}
	4-CPA at 2000 ppm	49.67^{de}	32.67^{a}	8.00^{ab}	101.67^{d}
	Litosen at 1000 ppm	50.33^{cde}	31.33^{abc}	7.33^{bc}	109.67^{bcd}
Lamuyo	Control	52.67^{bc}	31.67^{ab}	5.67^{d}	119.33^{ab}
	GA_3 at 100 ppm	51.67^{bcd}	32.67^{a}	7.67^{bc}	109.33^{bcd}
	4-CPA at 2000 ppm	48.67^{e}	33.33^{a}	8.67^{a}	103.67^{cd}
	Litosen at 1000 ppm	50.00^{cde}	32.67^{a}	8.00^{a}	107.00^{cd}
$LSD_{(0.05)}$		2.623	1.838	0.896	9.976
Level of significance		0.01	0.05	0.05	0.05
CV (%)		4.89	4.30	7.10	5.14

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, PGRs: Plant growth regulators

prompted in both varieties with application of 4-CPA compared to plants treated with others hormone and control. It was noticed that application of 4-CPA enhance flower and fruit setting by reducing flower and fruit abscission that contributed higher number of flower and fruit plant^{-1}. Chaudhary *et al*. (2006) and Hasanuzzaman *et al*. (2007) reported that plant growth regulators play an essential role in flower development. This might be occurs due to application of auxin at the time of flowering and resulted lower flowers drop. This result is in agreement with the findings of Baliyan *et al*. (2013) and Sasaki *et al*. (2005) where they reported that, tomato treated with 4-CPA showed higher in flower and fruit set. Sarkar *et al*. (2014b) and Choudhury *et al*. (2013) also reported that, plant growth regulators has great potential to facilitate the flower and fruit setting as well as yield of summer tomato.

Days to 1st harvest: Application of plant growth regulators significantly reduced the days required to 1st harvest. Both the varieties were more sensitive to 4-CPA spray than the other treatments. Minimum days required for 1st harvest about 101.67 days in BARI Misti morich-1 and 103.67 in Lamuyo whereas, others take comparatively more time (Table 2). 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. This result is in agreement with the findings of Hasanuzzaman *et al*. (2007) where he reported that, plant hormones promoted the harvesting of bell pepper a few days earlier than control.

Fruit setting percentage: Plant growth regulators showed significant variation in terms of fruit setting percentage. The maximum fruit setting was about 24.50% in BARI Misti morich-1 and 26.02% in Lamuyo when the plants treated with 4-CPA, while it was minimum about 18% in control (Fig. 1). 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). This result also is in agreement with the findings of Deka and Shadeque (1996) obtained the fruit set of bell pepper with cycocel at 500, 1000 of 1500 ppm. Rajmani *et al*. (1990) reported that percentage of fruit set was increased with 2, 4-D (2-5 ppm) and tricontanol (1.25-5 ppm). Dahal *et al*. (2006) also reported that fruit set percent varied significantly with the average of 18.81% for genotype CCA-119A.

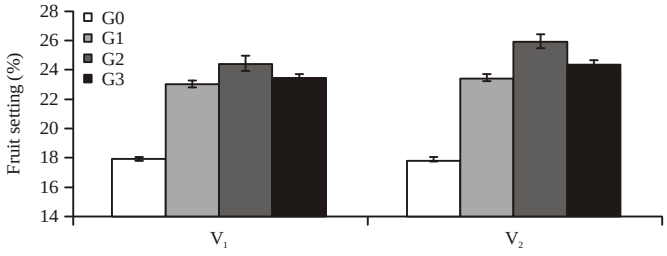

Fig. 1: Effects of plant growth regulators on fruit setting percentage of bell pepper, V_1: BARI misti morich-1, G_0: Control (water), G_1: GA3 at 100 ppm, V_2: Exotic variety (Lamuyo), G_2: 4-CPA at 2000 ppm and G_3: Litosen at 1000 ppm

Table 3: Influence of plant growth regulators on yield contributing characters and yield of bell pepper

Treatments		Length of	Diameter	Pericarp	Individual	Yield	Yield
Variety	PGRs	fruit (cm)	of fruit (cm)	thickness (mm)	fruit weight (g)	(g plant^{-1})	(t ha^{-1})
BARI Misti morich-1	Control	5.73^{c}	4.06^{e}	5.25^{c}	54.27^{c}	290.20^{d}	14.51^{d}
	GA_3 at 100 ppm	6.45^{bc}	4.71^{d}	5.72^{bc}	58.30^{ab}	408.10^{c}	20.41^{c}
	4-CPA at 2000 ppm	8.07^{a}	5.33^{bc}	6.34^{ab}	59.57^{ab}	476.56^{ab}	23.83^{ab}
	Litosen at 1000 ppm	7.61^{a}	5.08^{c}	6.12^{ab}	59.00^{ab}	432.33^{bc}	21.62^{bc}
Lamuyo	Control	6.61^{b}	5.09^{c}	6.05^{ab}	56.93^{bc}	322.79^{d}	16.14^{d}
	GA_3 at 100 ppm	7.91^{a}	5.21^{c}	6.38^{a}	59.57^{ab}	457.30^{bc}	22.87^{bc}
	4-CPA at 2000 ppm	7.54^{a}	5.70^{a}	6.68^{a}	61.17^{a}	530.34^{a}	26.52^{a}
	Litosen at 1000 ppm	7.59^{a}	5.58^{ab}	6.41^{a}	60.90^{a}	487.20^{ab}	24.36^{ab}
$LSD_{(0.05)}$		0.793	0.337	0.586	3.417	62.11	3.105
Level of significance		0.01	0.05	0.05	0.05	0.05	0.05
CV (%)		6.31	4.79	5.46	4.32	8.33	8.33

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, PGRs: Plant growth regulators

Length and diameter of fruit: Plant growth regulators significantly increased fruit length and diameter of bell pepper. Maximum fruit length and diameter was recorded in plant growth regulators treated plants compared to control (Table 3). Plant growth regulators have possibility to increase fruit length and diameter. 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. Sarkar *et al*. (2014a) and Choudhury *et al*. (2013) also reported that, plant growth regulators have great potentiality to facilitate the fruit length and diameter of summer tomato. This result also is in agreement with the findings of Hasanuzzaman *et al*. (2007).

Pericarp thickness of fruit: Significant variation was found due to the influence of plant growth regulators in terms of pericarp thickness. The maximum pericarp thickness of fruit was recorded with the plant growth regulators treated plans, while it was minimum control (Table 3).

Individual fruit weight: Application of plant growth regulators significantly increases single fruit weight of bell pepper. Application of 4-CPA increased the single fruit weight about 8.89% in BARI Misti morich-1 and 6.93% in Lamuyo as compared to the fruit set where hormone was not applied (Table 3). Single fruit weight might be increased due to plant hormones. Auxins are known to improve the capabilities of plants relevant to water economy in such a manner that physiological behavior of plants is modified significantly (Prasad and Kumar, 2003). Hasanuzzaman *et al*. (2007), Sarkar *et al*. (2014b) and Choudhury *et al*. (2013) also reported that, application of plant growth regulators significantly increased single fruit weight of summer tomato.

Yield of fruit plant^{-1}: Application of plant growth regulators significantly increases yield of fruit plant^{-1}. Application of 4-CPA increased the yield of fruit plant^{-1} about 39% as compared to the fruit set where hormone was not applied (Table 3). This might be occurs due to higher number of fruit setting and single fruit weight plant^{-1} that increased by plant hormones. Which was also in good agreement with the findings of Rajmani *et al*. (1990), Lyngdon and Sanyal (1992) and Hasanuzzaman *et al*. (2007), they reported the highest fruit yield plant^{-1} with plant growth regulators on bell pepper.

Yield per hacter: Significant variation was found due to application of plant growth regulators in respect of yield per hacter. Application of 4-CPA increased the yield of fruit per hacter about 39%

as compared to control (Table 3). Higher yield might be due to lesser flower and fruit drop that leading to higher setting of fruit plant^{-1} ultimately contributed to yield per hacter. The variety Lamuyo produces about 10% higher yield than BARI Misti morich-1. Application of 4-CPA has positive effect on yield of bell pepper. This result is in agreement with the findings of Hasanuzzaman *et al*. (2007) and Appireddy *et al*. (2008) where they reported that, plant growth regulators increase the yield of bell pepper. Baliyan *et al*. (2013) and Sarkar *et al*. (2014a) also reported that plant growth regulators increases has great potentiality to facilitate the flower and fruit setting as well as yield per hacter of summer tomato.

CONCLUSION

The exotic variety (Lamuyo) performed better than domestic variety (BARI Misti Morich-1). All growth regulators used in this study had a good contribution to reduce flower and fruit dropping problem and to increased fruit setting percentage of bell pepper. Among those, growth regulator, 4-CPA showed best potentiality to improve yield of bell pepper by solving flower and fruit dropping problem.

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