The Agriculturists 16(2): 58-64 (2018) **ISSN 2304-7321 (Online), ISSN 1729-5211 (Print)**
A Scientific Journal of Krishi Foundation ***Indexed Journal***
DOI: http://dx.doi.org/ 10.3329/agric.v16i02.40343 Impact Factor: 0.568 (GIF, 2015)

Effects of Plant Growth Regulator on Yield and Economic Benefit of Sweet Pepper (*Capsicum annum* L.)

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Received: 21 October 2018 Accepted: 25 December 2018

Abstract

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Plant growth regulators were applied which had significant effect on yield of sweet pepper **(**Capsicum *annum L.*). 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. 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) was 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) was from N_0 treatment. The results indicated that the highest yield (31.8 t/ha) was observed from G_3N_2 treatment combination, while the lowest yield (17.5 t/ha) was from G_0N_0 treatment combination. Due to combined effect, the highest yield (31.8 t/ha) with net income (Tk/ha 1416558) and BCR (2.46) was observed from G_3N_2 treatment combination, while the lowest yield (17.5 t/ha) with net income (Tk/ha 433045) and BCR (1.49) from G_0N_0 treatment combination. Thus, three times spray with (4-Chloro Phenoxy Acetic Acid + Gibberellic Acid) may be recommended for achieving the higher growth, yield and economic benefit of sweet pepper.

Keywords: Sweet pepper, plant growth regulators, number of spray, yield.

1. Introduction

Sweet pepper (*Capsicum annum L.*) botanically referred to as the genus *Capsicum*is the member of *Solanaceae* family. Sweet pepper is relatively non-pungent or less pungent and it is the world second most important vegetables after tomato (AVRDC, 1989). Recent efforts are being made to grow sweet pepper in Bangladesh (Paul, 2009). 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 (Erickson and Makhart, 2001). The varying responses of sweet pepper to plant growth regulators have been reported by Changli and Liusheng, (2009). Improvement in pepper growth and yield under GA_3 application was observed Vandana and verma, (2014).This might be ascribed to more effective utilization of food for reproductive growth (flowering and fruit set), higher photosynthetic efficiency and enhanced translocation and accumulation of sugars and other metabolites. Another growth regulators

namely, 4-chlorophenoxy acetic acid has been found to be effective in increasing fruit set 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. 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 optimum concentration and the suitable combination of growth regulators and their number of spray for maximizing the yield of sweet pepper in Bangladesh.

2. Materials and Methods

2.1 Experimental site and experimental frame work

The experiment was carried out at the horticulture farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2016 to March 2017. The location of the experimental site was at 23.41°N latitude and 90.22° longitude with an elevation of 8.24 m from sea level. Soil was having the texture of sandy loam with p^H 5.6. Seeds of sweet pepper variety viz KS 2201 (Krishibid seed) was used as experimental material. The experiment was laid out in Randomized Complete Block Design with three replications. Factor- A had four levels of plant growth regulators viz. G_0- control, G_1-GA_3 at 30 ppm, G_2-4-CPA at 45 ppm, G_3-4-CPA @ 45 ppm + GA_3 @ 30 ppm and Factor- B had three levels ofnumber of spray viz. N_0-control (no spray), N_1-Two spray (vegetative+early flowering stage), N_2-three spray (vegetative+early flowering+80% flowering stage).

2.2 Raising of seedling

Seeds were sown in the seedbed on 5 November 2016. The soil of the experimental plot was treated with savin 50WP at 5 kg per ha to protect the young plants from the attack of ants and cutworm. The size of the each plot was 1.5×1.2 m with 36 plots.

2.3 Transplanting of seedling

About 25 days old seedlings were transplanted into the prepared plot on 1 December 2016 with plant to plant spacing 50×30 cm. Fertilizers were applied at 250, 330, 250, 110 and 10 ton per ha for urea, TSP, MP, gypsum, and cow dung, respectively according to BARI (2011). Harvesting of fruits was done by hand picking.

3. Results and Discussion

3.1 Days from transplanting to 1st flowering

No significant variation was observed in terms of initiation of flowering due to imposition of treatments.

3.2 Number of flowers per plant

The maximum number of flowers per plant (32.58) was recorded by the application of G_3 treatment, whereas the minimum number (30.06) was obtained from G_0 treatment (Table 1). Similarly, maximum number of flowers per plant (31.68) was recorded from N_2 treatment while the minimum number (30.64) was found from N_0 treatment (Table 2). The highest number of flowers per plant (33.33) was recorded from G_3N_2 treatment combination, while the lowest number (29.66) was found from G_0N_0 treatment combination (Table 3). So, more flowers are produced where hormones are applied in combination than control. 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 result is in agreement with the findings of Choudhury *et al*. (2013) who 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.

3.3 Number of fruits per plant

Number of fruits per plant of sweet pepper showed significant differences due to the effect

of different plant growth regulators. The maximum number of fruits per plant (12.81) was found from G_3 treatment and the minimum number (9.89) was recorded from G_0 treatment (Table 1).

Table 1. Main effect of plant growth regulators on flower and fruit setting in 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

In a column means having similar letter(s) are significantly different per 0.05 level of probability

Table 2. Main effect of number of spray on flower and fruit setting in 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

In a column means having similar letter(s) are significantly differents per 0.05 level of probability

Table 3. Combined effect of plant growth regulators and number of spray on yield contributing characters and yield of sweet pepper

Treat ments	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

In a column means having similar letter(s) do not differ significantly at 0.05 level of probability.

Similarly the maximum number of fruits per plant (12.03) was obtained from N_2 treatment, while the minimum number (9.90) was obtained from N_0 treatment (Table 2). Combine effect shows that the maximum number of fruits per plant (14.13) was recorded from G_3N_2 treatment, while the minimum number (8.92) was found from G_0N_0 treatment (Table 3). Maximum number of fruit was recorded in plant growth regulators (4-CPA + GA_3) treated plants compared to control. This might be occurred due to application of auxin at the time of flowering which resulted lower flower drop and maximum number of fruits per plant.

3.4 Number of marketable fruits per plant

Application of plant growth regulators significantly enhanced fruit quality of sweet pepper. The maximum number of marketable fruits per plant (7.24) was found from plants under G_3 treatment, while the minimum number (5.37) was obtained from G_0 treatment (Table 1). The maximum number of marketable fruits per plant (6.94) was found from N_2 treatment, while the minimum number (5.58) from N_0 treatment (Table 2). From the results of the present study indicated that different number of spray can affect the fruit quality. The maximum number of marketable fruits per plant (8.10) was recorded from G_3N_2 treatment combination, while the minimum number (5.04) was for G_0N_0 treatment (Table 3). Application of plant growth regulators significantly enhanced fruit.

3.5 Fruit setting percentage

The maximum fruit setting (39.09%) was obtained from G_3 treatment, while the minimum fruit setting (31.45%) was found from G_0 treatment (Table 1). The maximum fruit setting (37.86%) was found from N_2 treatment, while the minimum (32.27%) was recorded from N_0 treatment (Table 2).The highest fruit setting (42.39%) was observed from G_3N_2 treatment combination, while the lowest (30.08%) was found from G_0N_0 treatment combination (Table 3). This result 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 GA_3 showed increased fruit set and proportion of normal fruits compared to plants of the same crop treated with 4-CPA alone.

3.6 Days from transplanting to 1st harvest

The minimum days from transplanting to1st harvest (107.99) was found from G_3 treatment, while the maximum days (121.52) was recorded from G_0 treatment (Table 1). However, minimum days from transplanting to 1st harvest (112.42) was attained from N_2 treatment, while the maximum days (118.39) was found from N_0 treatment (Table 2). 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 3). Hasanuzzaman *et al*. (2007) reported that, plant hormones promoted the harvesting of sweet pepper a few days earlier than control.

3.7 Length and diameter of fruits

The maximum length (7.59 cm) and diameter of fruit (5.33 cm) were found from G_3 treatment, where the minimum length (6.14 cm) and the minimum diameter (4.25cm) were found from G_0 treatment (Table 4). Plant growth regulators have possibility to increase fruit length and diameter. This result is in agreement with the findings of Hasanuzzaman *et al*. (2007). The maximum length (7.39 cm) and diameter of fruit (5.09 cm) were recorded from N_2 treatment, while the minimum length (6.29 cm) and minimum diameter (4.42 cm) were found from N_0 treatment (Table 5). From the results of the present study indicated that different number of spray can affect the fruit quality.The maximum length of fruit (8.11 cm) and diameter of fruit (5.71 cm) were found from G_3N_2 treatment combination, while the minimum length (5.75 cm) and diameter (4.1 cm) were found from G_0N_0 treatment combination (Table 6).

Table 4. Main 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 hectare (ton)
G_0	6.14 d	4.25 d	5.42 d	52.70 d	283.56 a	18.80 d
G_1	6.71 c	4.55 c	5.67 c	53.73 c	318.94 c	21.24 c
G_2	7.13 b	4.88 b	5.97 b	55.38 b	361.80 b	24.11 b
G_3	7.59 a	5.33 a	6.33 a	57.38 a	416.90 a	27.70 a
CV%	6.31	8.87	9.35	10.93	9.34	9.63

In a column means having similar letter(s) are significantly differents per 0.05 level of probability

Table 5. Main effect of 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 hectare (ton)
N_0	6.29 c	4.42 c	5.42 c	53.40 c	298.34 c	19.87 c
N_1	6.99 b	4.74 b	5.89 b	55.08 b	347.02 b	23.11 b
N_2	7.39 a	5.09 a	6.16 a	55.95 a	390.54 a	26.00 a
CV%	6.31	8.87	9.35	10.93	9.34	9.63

In a column means having similar letter(s) are significantly different per 0.05 level of probability

Table 6. Interaction of plant growth regulators and number of spray on yieldcontributing characters and yield of sweet pepper

Treat ment	Length of fruit (cm)	Diameter of fruit (cm)	Pericarp thickness (mm)	Individual fruit weight (g)	Yield per plant (g)	Yield per hectare (ton)	Net return (Tk /ha)	BCR
G_0N_0	5.75 h	4.10 g	5.19 h	52.02 k	262.71 l	17.50 k	433045	1.49
G_0N_1	6.12 g	4.19 f	5.40 g	52.66 j	280.69 k	18.67 j	433045	1.49
G_0N_2	6.54 f	4.49 e	5.67 f	53.44 h	307.30 i	20.43 h	433045	1.49
G_1N_0	6.15 g	4.24 f	5.35 g	52.84 i	283.73 j	18.90 i	490585	1.53
G_1N_1	6.75 e	4.50 e	5.67 f	53.56 g	314.38 g	20.93 f	622789	1.66
G_1N_2	7.23 d	4.91 d	5.99 de	54.79 f	358.70 d	23.89 d	828423	1.87
G_2N_0	6.45 f	4.51 e	5.56 f	53.65 g	310.63 h	20.72 g	637450	1.69
G_2N_1	7.25 d	4.88 d	6.09 d	55.95 d	356.89 e	23.79 d	856518	1.93
G_2N_2	7.69 c	5.23 c	6.26 c	56.54 c	417.89 c	27.82 c	1158085	2.25
G_3N_0	6.82 e	4.86 d	5.88 e	54.94 e	336.30 f	22.38 e	225238	2.24
G_3N_1	7.83 b	5.41 b	6.41 b	58.15 b	436.13 b	29.05 b	1218423	2.27
G_3N_2	8.11 a	5.71 a	6.70 a	59.05 a	478.27 a	31.87 a	1416558	2.46
CV%	6.31	8.87	9.35	10.93	9.34	9.63	433045	1.49

In a column means having similar letter(s) do not differ significantly at 0.05 level of probability.

3.8 Paricarp thickness

The higher pericarp thickness (6.33 mm) was recorded from G_3 treatment, while the lower thickness (5.42 mm) was observed from G_0 treatment (Table 4).The maximum pericarp thickness (6.16 mm) was recorded from N_2 treatment, while the minimum thickness (5.50 mm) was observed from N_0 treatment (Table 5). 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 6).

3.9 Individual fruit weight

The maximum weight of individual fruit (57.38 g) was recorded from G_3 treatment, while the minimum weight (52.70 g) was observed from G_0 treatment (Table 4). The maximum weight of individual fruit (55.95 g) was found from N_2 treatment, while the minimum weight (53.40 g) was recorded from N_0 treatment (Table 5). 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 6).

3.10 Fruit yield

The maximum yield per plant (416.90 g) and yield per hectare (27.70 ton) were recorded from G_3 treatment, while the minimum, yield per plant (283.56 g) and fruit yield per hectare (18.80 ton) were found from G_0 treatment (Table 4). Kannan *et al*. (2009) reported that application of GA_3 had significant effect on growth and yield attributes on peperika hot pepper. The maximum yield per plant (390.54 g) and hectare (26.00 ton) were observed from N_2 treatment, while the minimum yield per plant (298.34 g) and yield per hectare (19.87 ton) were recorded from N_0 treatment (Table 5). The highest yield per plant (478.27g) and yield per hectare (31.87 ton) was attained from G_3N_2 treatment combination, while the lowest yield per plant (262.71 g) and yield per hectare (17.50 ton) were found from G_0N_0 treatment combination (Table 6). From the results of the study indicated that plant growth regulators can affect the fruit quality. Hasanuzzaman *et al*. (2007) reported that, due to hormonal treatments significant variation exists in respect of fruit yield. The results revealed that the maximum growth, yield and yield attributes were found with PGRs than control.

3.11 Net return

In case of net return, different treatment combination showedvarious levels of net return under the present trial. The highest net return (Tk. 1416558) was obtained from the treatment combination G_3N_2 and the lowest (Tk. 433045) was found from G_0N_0 treatment combination (Table 6).

3.12 Benefit Cost Ratio

The highest benefit cost ratio (2.46) was found from the treatment combination of G_3N_2 and the lowest (1.49) was found from the G_0N_0 treatment combination. From the economic point of view, it was apparent that the treatment combination of G_3N_2 was more profitable than others.

4. Conclusions

Considering the results of this experiment, it may be concluded that the plant growth regulators (4-CPA @ 45 ppm + GA_3 @ 30 ppm) and three sprays would give better performance than others. However, the experiment should be carried out with more variables in different AEZs to reconfirm the recommendation.

5. Acknowledgements

This study was done under Sher-e Bangla Agricultural University, Dhaka-1207. The authors acknowledge the funding support of the project for National Science and Technology (NST) Fellowship.

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