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Effect of plant growth regulators on growth and yield of chili (*Capsicum annuum* L.)

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ABSTRACT

Chili (*Capsicum annuum* L.) is an important food additive with high medicinal value. To investigate the effect of plant growth regulators on chili, seedlings of chili were collected from the local market and grown in the experimental field of the University of Barishal, Bangladesh. Foliar spray of different degrees of plant growth regulators, Gibberellin (50 mg/l, 100 mg/l, 250mg/l, 350 mg/l GA₃) and Cytokinin (50 mg/l, 100 mg/l, 250mg/l, 350mg/l Kn) were applied from 15 days of germination. Data on different growth and yield parameters were collected and analyzed statistically. The result reveals that there is a significant difference in growth and yield related traits in chili due to the application of plant growth regulators. An optimum level of PGRs application shows better performance compare with control. Plant height particularly influenced by GA₃, whereas other attributes like the number of leaves, branches, flowers and fruits are greatly influenced by the application of kinetin.

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INTRODUCTION

Chili (*Capsicum annuum* L.) is a member of the family Solanaceae, cultivated all year round for variable purposes [1,2]. This crop is famous for its pleasant aromatic flavor, pungency and high colouring substance. The placenta of chili fruits contains phenolic acid compound “capsaicin” which is responsible for the pungency in chili. The pigment “capsanthin” gives the bright red colour of chili at the ripening stage [3]. Chili fruit is mainly used as a food additive. In addition, it is also used as traditional medicine, like for the treatment of cough, toothache, sore throat, parasitic infection, wound healing, and also utilized as an antiseptic, antioxidant, and immunomodulator etc. [4, 5, 6].

The inherent genetic yield potential of the cultivars along with several environmental factors and cultivation practices govern the production of chili. Flower and fruit drop caused by physiological and hormonal imbalance in the plants particularly under unfavorable environments, such as extremes of temperature i.e. too low or high temperatures is one of the major problem in chili production [7, 8, 9]. Over 60% of the flowers produced in a chili plant are shed. So, yield can be increased by decreasing flower drop. This problem can be solved by selection of breeding lines which retain large proportion of flowers or physiological manipulations by

spraying of plant growth regulators (PGRs) which reduces the flower drop [10].

Plant growth regulator is an organic compound, either natural or synthetic, that modifies or controls one or more specific physiological processes within a plant. The plant growth regulators are known to enhance the source sink relationship and stimulate the translocation of photo assimilates thereby helping in better retention of flowers and fruits. Besides this, the growth regulators have the ability to cause accelerated growth in plants. Application of PGR in small amounts modifies the growth of plants usually by stimulating or inhibiting part of the natural growth regulatory system. PGRs are known to enhance the source sink relationship and stimulate the translocation of photo assimilates thereby helping better fruit set.

Among the sixty plant growth regulators which are now commercially available several have reached considerable importance in crop production [10]. Among them gibberellin and cytokinin are very important to stimulate vegetative and reproductive growth of plant. GA₃, the most common gibberellins, regulate various developmental processes, including stem elongation, germination, dormancy, flowering and fruit development. Cytokinins promote cell division or cytokines is in plant roots and shoots. They are involved primarily in cell growth and differentiation, but also affect apical dominance,

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axillary bud growth and leaf senescence. Kinetin is a type of cytokinin that promotes cell division.

The average yield of chili in Bangladesh is very low compared to other leading chili growing countries in the world due to improper cultivation management practices. Improvement of existing spice crops through proper cultural management practices need urgent attention to meet increasing demand of edible spices for the fast growing population of Bangladesh.

Therefore, attempt to increase per unit production is necessary. That is why, special attention should be made for increasing the yield per unit area by adopting improved technologies and management practices. To increase the chili production, we need to adapt improve production technology and better agronomic practices and use high yielding adapted varieties.

There are scopes for making breakthrough for improving yield through changes of hormonal behaviors. In this connection, use of plant growth regulators (PGRs) might be a useful alternative to increase crop production. The present study was conducted to select the suitable dose of exact PGR that control the growth and finally increase the chili production in Bangladesh.

MATERIALS AND METHODS

The present study was undertaken at the experimental field of Department of Botany, University of Barisal to study the effect of various growth regulators on growth responses of chili. The soil of the experimental pot will be thoroughly mixed with recommended doses of urea, Triple Super Phosphate (TSP), Muriate of Potash (MP), gypsum and cow dung for the cultivation of chili in Bangladesh. Locally grown chili plantlets were used as plant material in the present experiment. The experiment was laid out in randomized block design with three replication and five treatments. Intercultural operations like irrigation, weeding, mulching and pest control were followed as and when necessary for normal growth and developments of chili plants.

Foliar application of GA₃ (50 mg/l, 100 mg/l, 250 mg/l, 350 mg/l) and Kinetin (50 mg/l, 100 mg/l, 250 mg/l, 350 mg/l) were applied at 15 days after transplantation and repeat it twice a week up to harvest stage. The spray was done by hand sprayer at morning.

Height of randomly selected plants was measured by scale from ground level to the tip of the main stem of plant at 15, 30 and 90 DAT. The number of branches arising on the main stem in the five randomly selected and tagged plants was recorded at 30, 60 and 90 DAT. The mean number of branches plant-1 was worked out and expressed in number. The number of leaves in the five randomly selected and tagged plants was recorded at 15, 30 and 90 DAT. The number of leaves per plant was worked out and expressed in number. The number of flower and seed was recorded at the same pattern and expressed in number.

The collected data were analyzed statistically and the mean difference was adjudged by Duncan's Multiple Range Test (DMRT).

RESULT AND DISCUSSION

Findings of the study of effect of plant growth regulators on growth and yield of chili are as follows-

Plant Height

The effect of varying concentration of plant growth regulators on plant height has been presented in Table 1. Results show that there is a significant difference in plant height by the different concentration of PGRs (GA₃ and Kn). In general there is an increase in plant height with the age of seedlings. At 15 DAT the tallest plant found in T₂ (100 mg/l GA₃). At 30 DAT and 90 DAT tallest plant was observed in T₄ (350 mg/l GA₃). Overall the highest plant height found in T₄ (350 mg/l GA₃) i.e 47.3 cm per plant followed by T₃ (250 mg/l GA₃) i.e. 39.1, and the lowest plant height found in T₀ (Control) where mean plant height was 29.6 cm per plant. So, a significant increase in plant height is observed by the application of PGR particularly for GA₃, Which resemble the observation of Tamilselvi and Vijayaraghavan (2014) [10], Chaudhary *et al.* (2006) [11] and Shankhwar *et al.* (2017) [12] in chili, Ghait *et al.* (2018) [13] in *Dendranthema grandiflorum*, Gupta *et al.* (2015) [14] in China aster (*Callistephus chinensis* L. Nees) and Henschke *et al.* (2015) [15] in *Helleborus orientalis* 'Red Hybrids' and Ibrahim *et al.* (2010) [16] on croton plants.

The increase in height of GA₃ treated plant might be due to rapid elongation, increased cell division and cell enlargement, which would have increased inter nodal distance.

Number of Leaf

Table 2 represents the effect of PGRs on number of leaf of chili plants used in the present investigation. From table-2 it is observed that there is a significant difference in leaf number with the different degrees of GA₃ and Kn. At 30 DAT highest number of leaf found in T₂ (100 mg/l GA₃) whereas highest number of leaf found in T₆ (100 mg/l Kn) at 15 DAT and 90 DAT of plant age. Over all the highest number of leaf found in T₆ (100 mg/l Kn) i.e 57.1 followed by T₄ (350 mg/l GA₃) i.e 42.9 and T₂ (100 mg/l GA₃) i.e

Table 1: Effect of different plant growth regulators on plant height (cm) of Chili

Treatments	Plant height (cm)			Mean
	15 DAT	30 DAT	90 DAT	
T ₀ (Control)	16.8±3.1	31.0±1.2	41.8±5.9	29.6
T ₁ (50 mg/l GA ₃)	16.9±0.7	36.8±5.9	55.8±7.7	36.5
T ₂ (100 mg/l GA ₃)	18.8±1.7	35.8±4.3	53.4±3.1	36.0
T ₃ (250 mg/l GA ₃)	16.1±0.9	43.0±3.6	58.2±7.2	39.1
T ₄ (350 mg/l GA ₃)	16.9±1.9	53.4±2.4	71.6±7.2	47.3
T ₅ (50 mg/l Kn)	16.9±2.4	33.4±5.8	44.6±5.8	31.6
T ₆ (100 mg/l Kn)	18.3±2.5	32.8±7.5	42.6±5.3	31.2
T ₇ (250 mg/l Kn)	14.1±1.9	26.8±4.3	40.6±2.4	27.2
T ₈ (350 mg/l Kn)	17.2±3.9	37.8±4.2	39.8±2.9	31.6
Mean	16.89	36.76	49.82	34.46
CV (%)	7.87	21.01	21.55	
SEM	0.44	2.57	3.58	
CD at 5%	1.01	5.93	8.26	

41.1 whereas lowest number found in T_7 (250 mg/l Kn) i.e 35.9. This observation supported by the findings of Seema *et al.* (2011) [17] in *Raphanus sativus* and Ghait *et al.* (2018) [13] in *Dendranthema grandiflorum*. According to this it may be assumed that optimum level of kinetin decreases the peroxidase activity which delayed the leaf senescence. Positive role of Kn in reducing peroxidase activity and delay senescence was noticed earlier in *Cajanus cajan* by Mukherjee and Rao in 2007 [18].

Number of Branches

A significant difference found in number of branches with the application of PGRs, which has been shown in Table 3. After 30 days highest number of branch (7.75) was found in T_2 (100 mg/l GA_3) whereas maximum number of branches 12.5 and 18.5 was found in T_6 (100 mg/l Kn) at 60 and 90 DAT respectively. In the mean, the highest number (12.75) was found in T_6 (100 mg/l Kn) followed by 11.5 in T_2 (100 mg/l GA_3) and the lowest number found 7.42 in T_4 (350 mg/l GA_3). The result goes no line with that observed by Ghait *et al.* (2018) [13] on *Dendranthema grandiflorum* and Mohamed in 2017 [19] on aster plant (*Symphytotri chumnovi-belgii* L.) cv. Purple Monarch. Possible causes of this type of findings can be explained by the theory of Wickson and Thimann (1958) [20]

Table 2: Effect of different plant growth regulators on leaf number of Chili

Treatment	No. of leaf			
	15 DAT	30 DAT	90 DAT	Mean
T_0 (Control)	14.50±3.3	48.0±8.0	51.75±7.9	38.08
T_1 (50 mg/l GA_3)	15.25±4.6	57.75±6.1	50.25±2.7	41.08
T_2 (100 mg/l GA_3)	15.75±5.9	74.4±9.5	78.25±7.5	41.1
T_3 (250 mg/l GA_3)	14.50±2.8	48.2±5.2	49.0±5.7	37.23
T_4 (350 mg/l GA_3)	14.00±1.8	50.2±11.5	64.5±4.0	42.9
T_5 (50 mg/l Kn)	14.00±0.8	49.75±7.9	46.5±4.1	36.75
T_6 (100 mg/l Kn)	19.50±5.6	70.25±12.8	81.5±7.4	57.1
T_7 (250 mg/l Kn)	14.50±2.0	46.5±9.8	46.75±3.5	35.9
T_8 (350 mg/l Kn)	15.00±6.8	52.75±5.1	50.75±7.5	39.5
Mean	15.20	55.31	57.69	42.7
CV (%)	11.18	18.51	23.7	
SEM	0.567	3.41	4.56	
CD at 5%	1.30	7.86	10.51	

Table 3: Effect of different plant growth regulators on number of branches of Chili

Treatment	No. of branches			
	30 DAT	60 DAT	90 DAT	Mean
T_0 (Control)	5.50±2.0	8.50±1.4	10.5±0.5	8.17
T_1 (50 mg/l GA_3)	5.25±0.4	6.25±0.8	14.75±0.8	8.75
T_2 (100 mg/l GA_3)	7.75±1.9	9.50±0.7	17.25±1.8	11.5
T_3 (250 mg/l GA_3)	7.25±0.8	9.0±1.6	15.0±1.8	10.41
T_4 (350 mg/l GA_3)	6.75±1.2	7.0±1.3	8.5±0.5	7.42
T_5 (50 mg/l Kn)	6.00±2.1	8.50±1.8	15.75±0.4	10.08
T_6 (100 mg/l Kn)	7.00±2.0	12.5±2.1	18.75±1.0	12.75
T_7 (250 mg/l Kn)	6.75±2.3	10.0±1.3	14.0±4.3	10.25
T_8 (350 mg/l Kn)	7.00±0.7	9.5±1.8	14.0±4.7	10.17
Mean	6.58	8.97	14.28	9.94
CV (%)	12.59	20.02	22.09	
SEM	0.28	0.59	1.05	
CD at 5%	0.65	1.36	2.42	

where they drew attention to the fact that under the influence of kinetin many buds form on a single tobacco tissue fragment without seeming to inhibit each other's growth.

Number of Flower

Effect of PGRs on flowering of chili is shown in Fig. 1. Number of flower per plant increases with the application of PGRs up to an optimum level (250 mg/l of GA_3 and kn) in both the case of GA_3 and kinetin. Treatment T_7 (250 mg/l Kn) shows the highest number of flower at 30, 60 and 90 DAT. Maximum number of flower (18.0) was found in T_7 (250 mg/l Kn) at 60 DAT followed by 15.5 in T_6 (100 mg/l Kn) in compare with control (T_0) where the mean number of flower per plant was found 7.0. A dramatic increase in number of flower was observed when plant growth regulators applied. The result resembles the findings of Ghait *et al.* (2018) in *Dendranthema grandiflorum* [13], Askari and Mortazaeinezhad (2016) in *Rosa hybrida* L. cv. "Yellow Finesse" [21].

Number of Fruit

Number of fruit is also significantly differing when plant growth regulators applied. From Table 4 it is found that better fruit setting response was found in T_6 (100 mg/l Kn). In

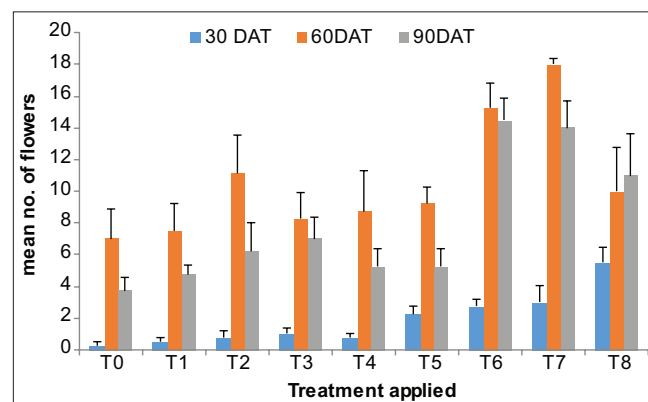


Figure 1: Effect of different plant growth regulators on number of flowers of Chili

Table 4: Effect of different plant growth regulators on number of fruit of Chili

Treatment	No. of fruit			
	45 DAT	60 DAT	90 DAT	Mean
T_0 (Control)	0.25±0.4	5.75±3.9	10.0±3.5	5.3
T_1 (50 mg/l GA_3)	0.75±0.4	6.75±4.6	10.0±2.4	5.83
T_2 (100 mg/l GA_3)	1.25±0.5	9.75±2.4	10.75±2.3	7.25
T_3 (250 mg/l GA_3)	2.0±1.3	7.25±1.7	12.5±1.5	7.25
T_4 (350 mg/l GA_3)	1.0±0.3	6.0±1.4	9.75±3.9	5.58
T_5 (50 mg/l Kn)	1.0±0.8	6.25±2.1	11.5±2.4	6.25
T_6 (100 mg/l Kn)	2.75±1.5	10.75±2.3	17.75±3.5	10.42
T_7 (250 mg/l Kn)	2.0±1.4	7.25±1.2	12.75±2.5	7.33
T_8 (350 mg/l Kn)	2.25±0.9	7.25±1.4	11.5±2.1	7.0
Mean	1.47	7.44	11.82	6.91
CV (%)	55.32	22.89	20.86	
SEM	0.27	0.56	0.82	
CD at 5%	0.62	1.29	1.89	

overall expression highest number was 10.42 that found in T₆ (100 mg/l Kn) followed by 7.33 in T₇ (250 mg/l Kn) and 7.25 in both the T₂ (100 mg/l GA₃) and T₃ (250 mg/l GA₃). This result go with the findings of Lou *et al.* (2012) in *Eriobotrya japonica* [22], Mukherjee and Kumar (2007) in *Cajanus cajan* L. [23] where they found a better fruit setting after application of kinetin.

CONCLUSION

Result of the present study suggests that the application of optimum degree of plant growth regulators GA₃ and Kn improve the growth and reproduction of chili. Particularly kinetin has a great positive impact on growth and yield of chili.

AUTHOR CONTRIBUTION STATEMENT

All of the authors conceived and designed the program. Anolisa and Md. Al-Imran conducted the experiments including statistical analyses and wrote the manuscript. Subroto K. Das mainly supervised the experiments. Subroto K. Das, Riyad Hossen and A.T.M. Rafiqul Islam co-ordinate the study and gave suggestion in preparing manuscript.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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