



EXOGENOUS APPLICATION OF GIBBERELLIC ACID (GA₃) IMPROVES FEMALENESS AND FRUIT YIELD OF SNAKE GOURD

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ABSTRACT

An experiment was conducted during the period from July to September, 2018 at Research field of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. The experiment was undertaken to investigate the effect of GA₃ on morphology, flowering, and fruit yield of snake gourd. The experiment consisted of two factors: Factor A: Three levels of GA₃ viz. 0 ppm, 200 ppm and 300 ppm foliar application of GA₃; Factor B: Three snake gourd varieties viz. Surma, Hira and Atrai. Total nine treatment combinations were implemented in Randomized Complete Block Design with three replications. Foliar application of 200 ppm GA₃ was found significantly superior in terms of growth, flowering, yield and yield contributing characters *i.e.* vine length (cm), number of primary branches plant⁻¹, number of nodes plant⁻¹, days required to first male and female flowering, days required for 1st female flowering to harvest, SPAD value of leaves (flowering stage), number of male and female flowers plant⁻¹, number of fruits plant⁻¹, single fruit weight (g), fruit yield plant⁻¹ (kg) and fruit yield (t ha⁻¹) as compared to control and 300 ppm of GA₃. The highest fruit yield (33.03 t ha⁻¹) of snake gourd was recorded in Surma variety under foliar application of 200 ppm GA₃ and lowest fruit yield (5.53 t ha⁻¹) was recorded in Atrai variety under control condition.

Key words: Behavior, flowering fruiting, GA₃, morphology, snake gourd, SPAD

INTRODUCTION

Vegetables are the important sources of vitamins and minerals for human being. In Bangladesh, winter vegetables are usually grown in 51.86% of the total land while 46.97% area is covered by summer vegetables (BBS 2018). Vegetable production is limited during summer season in Bangladesh. Besides, there are lean periods at the end of winter and summer seasons when there is always a scarcity of vegetables in the country. The nutritional problems and vegetable scarcity in Bangladesh during that lean period can be reduced to some extent through improvement of yield following improved production technology of cucurbitaceous crops like snake gourd.

Snake gourd (*Tricosanthes anguina* L.) belongs to the family Cucurbitaceae, sub-family Cucurbitaceae is a tropical or subtropical vine usually grown as a summer vegetable and raised for its strikingly long fruit. From nutritional point of view, snake gourd contains 0.5% protein, 0.3% fat, 0.5% minerals, 0.5% fibre and 3.3% carbohydrates (Gopalan *et al.* 1982). In Asia, its immature fruit is eaten as a vegetable much like the summer squash and in Africa, the reddish pulp of mature snake gourd is used as an economical substitute for tomato (Kew Gardens 2013). It is popular in the cuisines of South Asia and Southeast Asia and is now grown in some home gardens in Africa. The shoots, tendrils and leaves of the

plant are also eaten as vegetables. Snake gourd bears unisexual flowers and sex expression is genetically controlled. It is possible to modify the sex ratio by environmental factors and application of growth regulators. Therefore, there is a vast scope to increase snake gourd production by increasing the number of female flowers as well as fruiting through exogenous application of chemicals and plant growth regulators.

Recently, there has been global realization of the important role of plant growth regulators (PGRs) in agriculture for better growth and yield of crops. Growth regulators are known to have effect on the production of earliest flower, yield (Gedam *et al.* 1998), ratio of male/female flower (Bisaria 1974), number of fruits and weight of fruit (Gopalkrishnan and Choudhury 1978). Application of plant growth regulator for improving the yield and quality of many vegetable crops has been emphasized by several workers (Pundir and Yadav 2001, Bhosle *et al.* 2002, Meena 2008, Tuna *et al.* 2008). PGRs such as auxin and gibberellin include many aspects of plant growth and development that are used in low concentration to change the plant growth usually by stimulating part of the natural growth regulatory system (Dalai *et al.* 2015). Among different PGRs, gibberellic acid (GA_3) has been reported to boost the growth and yield attributes in many crops like cumin (El-Keltawi *et al.* 2000), fenugreek (Alagukannan and Vijaykumar 2003), cucumber and bitter melon (Hossain 2004), squash (Shafeek *et al.* 2016), cucumber (Kumar and Wehner 2012; Kadi *et al.* 2018; Rahman *et al.* 2020) and chickpea (Reja *et al.* 2020).

At present, the farmers of our country started to use growth regulators to increase the yield of their vegetables as per recommendation of some commercial trader. Very few researches were conducted to improve growth and yield of snake gourd through exogenous application of plant growth regulators. Farmers need to know about growth regulators with proper dose and effective measures to improve growth and yield performance of snake gourd. Keeping these facts in mind, a field experiment was conducted to investigate the effect of different doses of gibberellic acid (GA_3) on morphology, flowering and fruit yield of three snake gourd varieties in order to find out the optimum dose of GA_3 for better yield of snake gourd.

MATERIALS AND METHODS

The experiment was conducted during July 2018 to September 2018 at the research field of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The experimental site is located at 25°39' N latitude and 88°41' E longitude with an elevation of 37.58 meter above the sea level. The experimental field is a medium high land belonging to the non-calcareous dark gray floodplain soil under the agro-ecological zone “Old Himalayan Piedmont Plain” (AEZ-1). The experiment consisted of two factors; factor A: Three levels of GA_3 (0 ppm, 200 ppm and 300 ppm GA_3) and factor B: Three snake gourd varieties (Surma, Hira and Atrai). The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 2.5 m × 2 m having plot-plot and block-block distance of 0.5 m and 1.0 m, respectively. The space between two blocks and two plots were made as drain having a depth of about 25 cm. There was one pit in every plot. The area of each pit was 25 cm × 25 cm. There was 20 cm depth in pits and 40 cm distance from the border of the plots. The pits were prepared with necessary manures and fertilizers as recommended by FRG (2012).

Three seeds were sown directly in each pit at 1.5 to 2 cm depth. When the seedlings attained 10-15 cm height and hard enough then one healthy seedling was selected to keep in each pit and others were thinned out. The GA₃ solutions of 0, 200 and 300 ppm concentrations were prepared by dissolving 0, 200 and 300 mg of GA₃ in 10 ml methanol prior to dilution with distilled water. Then distilled water was added to make the volume 1 liter to get 0, 200 and 300 ppm GA₃ solution, respectively. The prepared solution was applied in four installments. 1st spray was done at 2 to 3 leaf (fully expanded) stage of seedlings. The remaining three sprays were done at 7, 14 and 21 days after 1st spray to the leaves and twigs of the plants with a hand sprayer.

Necessary intercultural operations, plant protective measures and recommended production technology were followed for growing the crop. Data were collected on vine length, number of primary branches plant⁻¹, number of nodes plant⁻¹, SPAD value of leaf, days required to first male and female flowering, days required for first female flowering to harvest of fruits, total number of male and female flowers plant⁻¹, number of fruits plant⁻¹, individual fruit weight, fruits yield plant⁻¹ and fruits yield (t ha⁻¹). The recorded data were analyzed by partitioning the total variance with the help of a computer package “Statistix 10” program and the mean differences were adjusted by the Tukey's Test.

RESULTS AND DISCUSSION

Morphological traits

The interaction effect of variety and GA₃ significantly influenced the vine length, number of primary branches plant⁻¹ and number of nodes plant⁻¹ of snake gourd (Table 1). Maximum vine length in all varieties was observed under 200 ppm GA₃ compared to 300 and 0 ppm. Variety Surma attained the maximum vine length (171.33 cm) under 200 ppm GA₃, whereas the minimum vine length (152.43 cm) was found in Atrai variety under 0 ppm GA₃. Moderate vine length was observed in all variety under 300 ppm GA₃. Maximum number of primary branches plant⁻¹ in all varieties was found under 200 ppm GA₃ followed by 300 ppm and the lowest primary branches plant⁻¹ was observed in 0 ppm condition. Maximum number of primary branches plant⁻¹ (8.00) was found in Surma, whereas minimum number of primary branches plant⁻¹ (5.53) was recorded from variety Atari at control condition. The maximum number of primary branches plant⁻¹ (13.00) was recorded in Surma under application of 200 ppm GA₃ which was statistically similar to Surma (12.33) under 300 ppm GA₃ and Hira (11.67, 11.00) under 200 ppm and 300ppm GA₃ application. Foliar application of GA₃ significantly increased the number of nodes plant⁻¹ in all varieties but the magnitude of increasing was not similar for all varieties and all levels of GA₃. However, maximum number of nodes plant⁻¹ in all varieties was observed under 200 ppm GA₃ compared to 300 and 0 ppm. Variety Surma attained the maximum number of nodes plant⁻¹ (58.33) under 200 ppm GA₃ applied condition, whereas the minimum number of nodes plant⁻¹ (30.67) was found Atrai variety under 0 ppm GA₃. Moderate number of nodes plant⁻¹ was observed in all variety under 300 ppm GA₃ applied condition. Foliar application of GA₃ during stem elongation positively affected the morphology of snake gourd as GA₃ has a positive regulatory effect on vegetative growth of plant. Growth regulators increased rate of photosynthesis thus resulting in the cell elongation and rapid cell division in the growing portion which ensure longest stem and more branching in plant. Similar positive effect of GA₃ on vine length was reported in cucumber (Shafeek *et al.* 2016, Kadi *et al.* 2018 and Rahman *et al.* 2020). Wazed (2007) recorded corresponding results on vine length and number of primary branches plant⁻¹ of snake gourd by using plant growth regulators (Indole acetic acid). These findings support the

influencing role of plant growth regulators on cucurbits that is in a line with our observation of the present study.

Table 1. Interaction effect of variety and gibberellic acid (GA₃) on morphological traits and SPAD value of snake gourd

Snake gourd varieties	Levels of GA ₃	Vine length (cm)	Primary branches plant ⁻¹	Number of Nodes plant ⁻¹	SPAD Value
Surma	0 ppm	160.67 c	8.00 b	55.33	39.20 d
	200 ppm	171.33 a	13.00 a	58.33 a	51.00 a
	300 ppm	169.93 a	12.33a	56.66 ab	50.67 a
Hira	0 ppm	157.47 d	5.67 bc	39.67 d	35.33 f
	200 ppm	168.10 b	11.67 a	46.33 c	47.00 b
	300 ppm	166.43 b	11.00 a	45.00 c	46.33 b
Atrai	0 ppm	152.43 e	5.33 c	30.67 f	37.33 e
	200 ppm	158.60 d	6.67 bc	36.67 e	41.67 c
	300 ppm	157.83 d	6.33 bc	36.33 e	40.67 cd
Level of significance		**	**	**	**
CV (%)		2.38	9.38	2.25	1.28

In a column, means having similar letter (s) did not differ significantly at 5% level by Tukey. ** Significant at 1% probability level.

SPAD value of leaf at flowering stage

SPAD value of leaf of snake gourd was significantly varied by the interaction effect of variety and GA₃ (Table 1). Highest SPAD value in all varieties was observed under 200 ppm GA₃ compared to 0 and 300 ppm. 200 ppm GA₃ application showed the highest SPAD value of leaf at flowering stage. The maximum number of SPAD value of leaf at flowering stage (51) was found in the variety Surma under the application of GA₃ 200 ppm concentration which is statistically significant with the same variety (50.67) under application of 300 ppm concentration. The minimum number of SPAD value of leaf at flowering stage (35.33) was found in the variety Hira under 0 ppm GA₃ application. SPAD value indicates the greenness of leaf which is directly related to chlorophyll content. Similar findings in soybean were also found by Khan *et al.* (2003). He reported that the chlorophyll content of soybean leaves was increased due to application of gibberellic acid.

Flowering attributes

The interaction effect of variety and GA₃ was significant on days to 1st male flowering, days to 1st female flowering, days required for 1st female flowering to harvest, total number of male flowers plant⁻¹ and total number of female flowers plant⁻¹ of snake gourd (Table 2). Maximum days required for 1st male flowering was observed in Surma with 200 ppm GA₃ which was statistically similar with Hira @ 200 ppm and 300 ppm GA₃ application and at per with Surma getting 200 ppm GA₃. Minimum days required for male flowering was observed in Surma (29.00) which was statistically similar to variety Hira (30.00) and Atrai

under 0 ppm GA₃ applied condition. Foliar application of GA₃ delayed the 1st male flowering in all the snake gourd varieties. Under foliar application of 200 ppm GA₃, the snake gourd varieties Surma, Hira, Atari attained at 1st male flowering stage about 4, 3, 1 days later, respectively compared to control. However, the maximum number of days (33.33) required for 1st male flowering was recorded both varieties Surma and Hira. Maximum number of days (37.33) required for 1st female flowering was recorded from varieties Hira and Atrai under 0 ppm GA₃ applied condition. Minimum number of days (30.33) required for 1st female flowering was recorded from Surma under 300 ppm GA₃ applied condition which was at par with 200 ppm GA₃ in same variety. Under foliar application of GA₃ all the snake gourd varieties required shorter time (30.33 and 31.67) to attain 1st female flowering compared to 0 ppm GA₃ (35.67). Under foliar application of 200 ppm of GA₃, the snake gourd varieties Surma, Hira, Atari attained their 1st female flowering stage about 4, 1 and 1 days earlier, respectively compared to control. Under application of 300 ppm GA₃ recorded earlier flowering about 5, 3, 1 days for Surma, Hira and Atari varieties, respectively.

Table 2. Interaction effect of variety and gibberellic acid (GA₃) on flowering attributes of snake gourd

Snake gourd varieties	Levels of GA ₃	Days to 1 st male flowering	Days to 1 st female flowering	Days to 1 st female flowering to harvest	Male flowers plant ⁻¹	Female flowers plant ⁻¹
Surma	0 ppm	29.00 c	35.67 bc	26.33 ab	76.67 c	17.67 def
	200 ppm	33.33 a	31.67 d	23.67 de	67.00 d	22.33 a
	300 ppm	33.00 ab	30.33 d	23.33 c	64.67 d	21.33 ab
Hira	0 ppm	30.00 c	37.33 a	27.33 a	82.33 b	16.33 ef
	200 ppm	33.33 a	36.33 ab	25.33 bcd	77.33c	20.33 abc
	300 ppm	33.33 a	34.33 c	24.33 cde	75.67 c	19.33 bcd
Atrai	0 ppm	30.33 bc	37.33 a	27.33 a	86.67 a	15.67 f
	200 ppm	31.67 ab	36.33 ab	26.33 ab	76.33 c	18.33 cde
	300 ppm	31.33 abc	36.33 ab	25.67 abc	75.33 c	18.00 cdef
Level of significance		*	**	*	**	*
CV (%)		3.12	3.45	2.34	3.36	4.46

In a column, means having similar letter (s) did not differ significantly at 5% level by Tukey. ** and * indicate significant at 1% and 5% probability level, respectively.

It was also showed that the variety Surma needed lowest days required from 1st female flowering to harvest. 200 ppm GA₃ application showed the lowest days required from 1st female flowering to harvest. Under 0 ppm GA₃ applied condition maximum number of days (27.33) required from 1st female flowering to harvest was recorded from Hira and Atari. Under foliar application of GA₃ all the snake gourd varieties required shorter time (23.67 to 25.67) to attain 1st female flower to harvest compared to control (26.33 to 27.33). Under foliar application of GA₃ at 200 ppm concentration, the snake gourd varieties Surma, Hira and Atari attained their female flowering to harvest about 3, 2, 1 days was recorded earlier, respectively as compared to 0 ppm GA₃ application. Foliar application of GA₃ at 300 ppm concentration, the snake

gourd varieties Surma, Hira, Atari attained their 1st female flowering to harvest at about 3, 3 and 2 days was earlier, respectively as compared to 0 ppm GA₃ condition. Maximum number of male flowers plant⁻¹ in all varieties was observed under 0 ppm GA₃ compared to 200 and 300 ppm. Variety Atrai gave the maximum number of male flowers plant⁻¹ (86.67) under 0 ppm GA₃ applied condition whereas the minimum number of male flowers plant⁻¹ (64.67) was found in Surma variety under 300 ppm GA₃. Moderate number of male flowers plant⁻¹ in all varieties were observed under 200 ppm GA₃. Maximum number of female flowers plant⁻¹ in all varieties was observed under 200 ppm GA₃ compared to 0 and 300 ppm. Variety Surma produced the maximum number of female flowers plant⁻¹ (22.33) under 200 ppm GA₃ applied condition whereas the minimum number of female flowers plant⁻¹ (15.67) was found in Atrai variety under 0 ppm GA₃. Moderate number of female flower plant⁻¹ was observed in all variety under 300 ppm GA₃. Differential degrees of flowering among the snake gourd varieties might be due to genetic variability of snake gourd. The earliness in 1st female flowering in snake gourd under GA₃ application might be due to effect of gibberellic acid on changing the direction of sexual differentiation in potentially male buds to female buds resulted in enhanced female flowering and reduced male flowering. The results of the present study are in an agreement with the results reported by Dalai *et al.* (2016) and Rahman *et al.* (2020) in cucumber. They concluded that foliar application of GA₃ significantly induced the early flowering and increased the femaleness in cucumber which is also a popular cucurbit as like as snake gourd.

Table 3. Interaction effect of variety and gibberellic acid (GA₃) on fruit yield of snake gourd

Snake gourd varieties	Levels of GA ₃	Fruits plant ⁻¹	Single fruit wt. (g)	Fruit yield plant ⁻¹ (kg)	Fruit yield (t ha ⁻¹)
Surma	0 ppm	13.33 cd	116.33 c	1.55 d	7.73 d
	200 ppm	23.00 a	287.33 a	6.61 a	33.03 a
	300 ppm	20.00b	287.00 a	5.74 b	28.68 b
Hira	0 ppm	12.00 cd	114.33 c	1.37 d	6.86 d
	200 ppm	14.67 c	160.33 b	2.35 c	11.77 c
	300 ppm	14.67 c	159.67 b	2.34 c	11.70 c
Atrai	0 ppm	10.67 d	103.67 d	1.11 d	5.53 d
	200 ppm	13.67 c	157.00 b	2.14 c	10.72 c
	300 ppm	13.67 c	157.00 b	2.14 c	10.72 c
Level of significance		**	**	**	**
CV (%)		6.62	2.74	6.38	6.38

In a column, means having similar letter (s) did not differ significantly at 5% level by Tukey.

**Significant at 1% probability level.

Fruiting characteristics

Number of fruits plant⁻¹

The interaction effect of variety and GA₃ significantly varied the number of fruits plant⁻¹, individual fruit weight, fruits yield plant⁻¹ and fruits yield (t ha⁻¹) of snake gourd (Table 3). Maximum number of fruits plant⁻¹ in all varieties was observed under 200 ppm GA₃ compared to 0 and 300 ppm. Variety Surma

attained the maximum number of fruits plant⁻¹ (23.00) under 200 ppm GA₃ applied condition whereas the minimum number of fruits plant⁻¹ (10.67) was observed Atrai variety under 0 ppm GA₃ applied condition. Moderate number of fruits plant⁻¹ was found in all variety under 300 ppm GA₃ applied condition. Maximum individual fruit weight in all varieties was observed under 200 ppm GA₃ compared to 0 and 300 ppm. Result showed that all the varieties attained maximum fruit weight under 200 ppm GA₃ applied condition which is statistically similar to 300 ppm GA₃. Maximum individual fruit weight (g) was attained by variety Surma (287.33 g) under 200 ppm GA₃. Minimum individual fruit weight (g) was found (103.67 g) by variety Atrai under 0 ppm GA₃ foliar application. Results of the present study exposed that all the varieties attained maximum fruit yield plant⁻¹ (kg) at 200 ppm GA₃ applied condition. Maximum fruit yield plant⁻¹ (kg) was attained by variety Surma (6.61 kg) under 200 ppm GA₃. Minimum fruit yield plant⁻¹ (kg) was found (1.11 kg) by variety Atrai under 0 ppm GA₃ foliar application. Results of all the present study revealed that all the snake gourd varieties produced maximum fruit yield (t ha⁻¹) under 200 ppm GA₃ applied condition compared to 300 and 0 ppm GA₃. Variety Surma produced maximum fruit yield (33.03 ton ha⁻¹) under 200 ppm GA₃ applied condition, whereas the minimum fruit yield (5.53 ton ha⁻¹) was recorded in Atrai variety under 0 ppm GA₃ used condition.

The results of the present study showed that gibberellic acid significantly influenced both the vegetative and reproductive growth especially the flowering behavior of snake gourd plants. It increases the femaleness and promoted the number, size and weight of fruit plant⁻¹ which ensured improved fruit yield plot⁻¹ resulted in increased in final yield of snake gourd. Plant growth regulators increased rate of photosynthesis, accelerated translocation and efficiency of utilization of photosynthates thus resulting in cell elongation and rapid cell division which increase fruit length and girth results in increased fruit weight. GA₃ increases acceleration of reserve mobilization in fruit. It also stimulates the source capacity as well as sink size resulted in increasing of fruit weight. Increased yield plant⁻¹ in snake gourd in the present study was also due to higher number of fruit plant⁻¹. Rahman *et al.* (2020), Kadi *et al.* (2018), Shafeek *et al.* (2016), Farhana (2015) and Wazed (2007) also reported GA₃ induced increment in fruit yield of cucurbitaceous crop. These findings support our findings of the present study.

CONCLUSION

Considering the findings of the present experiment, it can be concluded that foliar application of gibberellic acid (GA₃) positively influenced the morphology, flowering, yield attributes and yield of snake gourd. Among the three concentrations of GA₃, 200 ppm was more effective in improving the morphological, floral and yield traits of snake gourd. The order of positive response of snake gourd variety in relation to foliar application of GA₃ was Surma > Hira > Atrai.

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