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Effect of Plant Growth Regulator on Growth, Yield and Yield Components of Onion

[1]M.S. Islam, [1]M.O. Islam, [2]M.N. Alam, [2]M.K. Ali and [3]M.A. Rahman
[1]Department of Crop Botany, Bangladesh Agricultural University, Mymenshingh, Bangladesh
[2]Department of Crop Science and Technology, University of Rajshahi, Rajshahi, Bangladesh
[3]Department of Agronomy and Agricultural Extension, University of Rajshahi, Bangladesh

Abstract: A field experiment was conducted in the research field of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during the period from December 2003 to March 2004 to study the effect of GABA on growth and yield attributes of onion (cv. BARI peaj-1). The experimental field was medium fertile and silt loam in texture. Effect of GABA (a mixture of GA_3 and STC4771) sprayed at 30 DAT with 0.0, 0.5, 1.0 and 2.0 mg L^{-1} was investigated. The treatments were laid out in one factorial RCBD design where each treatment was replicated five times. All morphological characters, growth and yield attributes were significantly affected by the application of GABA, which at 1.0 mg L^{-1} produced the highest plant height, leaf length, number of leaves, neck and bulb diameter, bulb length, leaf diameter, root length; fresh weight of bulbs, roots and leaves; splitting of bulbs, leaf and bulb yield of onion. GABA at 1.0 mg L^{-1} was more effective in enhancing growth and yield attributes than 0.5 and 2.0 mg L^{-1}. Application of GABA at 0.5, 1.0 and 2.0 mg L^{-1} increased the bulb yield by 20.18, 28.09 and 7.02%, respectively. The results suggested that GABA at 1.0 mg L^{-1} is suitable for onion or any vegetable crop production but GABA at 2.0 mg L^{-1} may be harmful for plant growth.

Key words: Growth regulator, GABA, growth, yield, yield components, onion, BARI peaj-1

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae, is a bulb crop and one of the important vegetable spice of the world (Thompson and Kelly, 1957). In Bangladesh it is mostly used as spice rather than vegetable. Among the spices grown in Bangladesh, onion ranks first and second in respect of production and cultivation area, respectively (BBS, 2001). It is grown almost in all districts of Bangladesh, but is commonly cultivated in the greater districts of Faridpur, Rajshahi, Dhaka, Mymensingh, Comilla, Jessore, Rangpur and Pabna (Anonymous, 1998). In 2000-2001, about 34008 hectares of land were cultivated for onion in Bangladesh and total production was about 127 thousands ton with an average yield of 3.74 ton per hectare (BBS, 2001). But this yield is very low as compared to other leading onion producing countries of the world such as Korea Republic, Japan, USA, Span and Germany where per hectare yield was reported as 56.52, 47.03, 47.125, 47.67 and 42.34 tons, respectively (FAO, 2002). Since, the annual onion requirement of Bangladesh is about 4,80,000 mtons and the total onion production of Bangladesh is about 127,000 mtons (BBS, 2001), a shortage of 353,000 mtons per year has been prevailing in our country. As a result a large amount of onion are imported from foreign countries. With the gradual increase of population the demand for onion in Bangladesh is increasing day by day. To enhance onion production per hectare, improved and modern agronomic practices should be applied properly. In this connection, application of Plant Growth Regulators (PGRs) might be useful in increasing onion production. Recently, there have been global realization for important role of PGRs in crop production, better growth of crop and yield (Prasad and Paudal, 1994). Many developing countries like Japan, China, Russia, Poland, Korea etc. have already been using PGRs to enhance crop yield.

GABA is newly formulated plant growth regulator, marketed in Japan in 1979 by the BAL Planning Co., Ltd. The producer company has been keeping its composition highly hidden. Therefore, information regarding their structure and biochemical properties are not well known to all except few provided by the company. GABA (a mixture of GA_3 and STC4771) has significant and stable effect on plant growth. The mixture consists of 1% gibberelic acid (GA_3) and 0.05% STC4771. GA_3 influences growth by promoting elongation of internode and stem of plant. On the other hand, STC which is derived from SABA (Kamuro *et al*., 2001) counteract the physiological action of GA_3. Treatment with GA_3 was found to increase

Corresponding Author: Dr. Md. Nurul Alam, Department of Crop Science and Technology, University of Rajshahi, Rajshahi-6205, Bangladesh

dry weight (Hore *et al*., 1998) as well as total yield (Maske *et al*., 1998). In a study, Hoque (2002) reported that 0.33 mL L^{-1} of GABA enhanced growth, yield and yield contributing characters of wheat in Bangladesh. Similar reports have also been stated by Sekh (2002), Dakua (2002) and Chowdhury (2003) in rice, lentil and barley, respectively. So, the present research designed to study the effect of various concentrations of GABA on growth and yield attributes of onion in Bangladesh.

MATERIALS AND METHODS

A field experiment was conducted in the research field of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh from December 2003 to March 2004 to investigate the effect of GABA at different concentrations (0.0, 0.5, 1.0 and 2.0 mg L^{-1}) on growth and yield attributes of BARI peaj-1 in Old Brahmaputra Floodplain (FAO, 1988) soils. The initial soil (0-18 cm depth) contained texture-silt loam, pH = 6.9, organic carbon = 0.55%, total N = 0.06%, available P = 8.88 ppm, exchangeable K = 0.09 meq/100 g soil, available S = 50.5 ppm and available Zn = 1.5 ppm. Soil analysis was done for particle size distribution by hydrometer method and other parameters by ASI method (Hunter, 1984). The treatments were laid out in Randomized Complete Block Design (RCBD) with five replications. The unit plot size was 4.0×2.5 m and distance between two plots maintained as 0.5 m. Each plot was applied 10 kg cowdung, 250 g Urea, 200 g TSP, 170 g MP and 80 g gypsum. The total amount of cowdung, TSP, gypsum, 50% of urea and MP were applied during land preparation as basal. The remaining 50% of urea and MP were applied two equal splits i.e., at 25 and 50 Days After Transplanting (DAT). Healthy and disease free seedling of aged 50 days were transplanted at 1.5 cm depth by spacing 20×15 cm. Plant growth regulator (GABA) was collected from Prof. Dr. Yasuo Kamuro, Marketing Director, the BAL planning company, Japan. GABA spraying was done once at 30 DAT. The crop was harvested on 30 March 2004 at 90 DAT as plants attained maturity by showing drying out most of the leaves and weakening of necks. At each sampling 20 plants were selected from a side of each plot randomly and were uprooted carefully. Data on the growth of morphological features were recorded at 15 days interval from 45 to 90 DAT and also yield attributes at harvest. Data were analyzed statistically by MSTAT-C by Ressel (1996).

RESULTS AND DISCUSSION

Effect of GABA on plant height: Different concentrations of GABA enhanced plant height differently and induced significant variation measured from 45 to 90 DAT (Table 1). Data revealed that during the growth period the plant height gradually increased with the advancement of growth period and reached to peak at 75 DAT. After 75 DAT it began to decreased due to the senescence and drying out of the tip of the leaves. At 45 DAT, GABA at 1 mg L^{-1} significantly enhanced plant growth over higher and lower concentrations of 2.0 and 0.5 mg L^{-1}, respectively, as well as over control. Similar trend in plant height was revealed in later growth periods. Among the treatments the maximum plant height (55.72 cm) was obtained at GABA 1.0 mg L^{-1} treatment followed by GABA at 0.5 mg L^{-1} (53.76 cm) and GABA at 2.0 mg L^{-1} (52.32 cm) at 75 DAT. Plants under control treatment showed the lowest height (48.98 cm) at same DAT.

Sekh (2002) reported that GABA promoted seedling growth and increased plant height in rice plant. Chowdhury (2003), Haque (2002) and Abdullah (2002) reported that different concentrations of GABA increased plant height differently compared to control.

Plant height increment is the result of cell expansion, cell elongation and cell division. The exogenously applied GABA might have activated the endogenous hormonal activates which ultimately led to leaf elongation in onion plant.

Effect of GABA on leaf length: Leaf length increased with the increasing growth period after transplanting of seedlings and continued up to 75 DAT and then declined due to senescence and drying out of the tip of the leaves. Different concentrations of GABA had significant effect on leaf length (Table 1). Among the concentration of GABA, 1.0 mg L^{-1} enhanced the highest leaf length (36.12 cm) followed by leaf length (34.24 cm) at 0.5 mg L^{-1}. The lowest value of leaf length (31.59 cm) was at control. This finding agreed to the report of Hoque (2002), where the highest leaf length was obtained by spraying GABA over control.

Effect of GABA on number of leaves per plant: The number of leaves, as recorded at 45, 60, 75 and 90 DAT, increased with the advancement of growth period after transplanting up to 75 DAT and then declined due to drying of older leaves in both experiments. It was affected significantly by different concentrations of GABA. Number of leaves increased in all concentrations of GABA compared to control (Table 2). However, GABA at 1.0 mg L^{-1} produced the highest number of leaves (13.23) and the lowest (10.69) was in control at 75 DAT. The present results agreed with the report of Dakua (2002) and Hoque (2002), who stated that GABA enhanced number of leaves in lentil and wheat plant.

Table 1: Effect of GABA on plant height and leaf length of onion at different days after transplanting

	Average plant height (cm) at				Average leaf length (cm) at			
Treatments	45 DAT	60 DAT	75 DAT	90 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Control	44.26c	47.58c	48.98c	47.02c	26.36c	29.30b	31.59c	30.40d
GABA 0.5 mg L^{-1}	49.70b	52.13b	53.76ab	52.14ab	31.70a	32.90a	34.24b	33.82b
GABA 1.0 mg L^{-1}	51.06a	54.21a	55.72a	54.64a	31.83a	34.33a	36.12a	35.14a
GABA 2.0 mg L^{-1}	48.60b	51.53b	52.32b	51.13b	30.40b	30.53b	33.25b	32.82c
LSD at 5% level	1.125	1.462	2.029	2.683	0.5631	1.845	1.378	0.4872
CV (%)	4.69	4.06	4.79	3.80	4.36	2.96	4.96	4.07

In a column, values having same letter(s) do not differ significantly at 5% level by Duncan's New Multiple Range Test (DMRT); DAT = Days After Transplanting, GABA = A mixture of 1% gibberelic acid (GA_3) and 0.05% STC4771, LSD = Least Significant Difference, CV = Co-efficient of Variance

Table 2: Effect of GABA on of leaves plant and neck diameter of onion at different days after transplanting

	Average No. of leaves plant^{-1} at				Average neck diameter (cm) at			
Treatments	45 DAT	60 DAT	75 DAT	90 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Control	5.10c	7.94c	10.69d	9.10d	1.07c	1.652b	1.86b	2.02b
GABA 0.5 mg L^{-1}	6.13b	10.33a	12.17b	10.63b	1.36b	1.966a	2.10a	2.25a
GABA 1.0 mg L^{-1}	6.63a	10.56a	13.23a	11.54a	1.54a	1.92a	2.21a	2.40a
GABA 2.0 mg L^{-1}	5.93b	8.96b	11.56c	10.16c	1.25b	1.79ab	1.90b	2.21a
LSD at 5% level	0.4872	0.4379	0.5879	0.4379	0.1385	0.1949	0.1849	0.1849
CV (%)	5.93	3.368	3.59	3.07	7.71	7.78	6.63	6.10

In a column, values having same letter(s) do not differ significantly at 5% level by Duncan's New Multiple Range Test (DMRT); DAT = Days After Transplanting, GABA = A mixture of 1% gibberelic acid (GA_3) and 0.05% STC4771, LSD = Least Significant Difference, CV = Co-efficient of Variance

Effect of GABA on neck diameter: Neck diameter investigated from 45 to 90 DAT in both experiment was gradually increased. It was significantly influence by GABA at different concentrations (Table 2). Among the different concentrations of GABA, 1.0 mg L^{-1} produced the highest (2.40 cm) neck diameter during whole growth period and followed by 0.5 mg L^{-1}. At 45 DAT, neck diameter was 1.54, 1.36, 1.25 and 1.07 cm at 1.0, 0.5, 2.0 mg L^{-1} and control, respectively. However, at harvest neck diameter was similar under different concentrations of GABA and these values were significantly higher over that under control.

Effect of GABA on bulb diameter: The effect of GABA on bulb diameter was found significant at 45, 60, 75 and 90 DAT (Table 3). Different concentrations of GABA affected bulb diameter differently. From 45 to 90 DAT, the highest bulb diameter (6.46 cm) was obtained at 1.0 mg L^{-1}, followed by 0.5 mg L^{-} and the lowest diameter was for control treatments. These results indicated that the concentration of GABA is a factor influencing in bulb diameter of onion.

Effect of GABA on bulb length: Bulb length of onion was increased over control due to application of GABA and this effect was revealed from 45 to 90 DAT. Different concentrations of GABA affected bulb length significantly over the control. GABA at 1.0 mg L^{-1} concentration produced the highest bulb length (4.25 cm), followed by 0.5 mg L^{-1} (4.15 cm) and then 2.0 mg L^{-1} (3.85 cm) at 90 DAT (Table 3). Under control treatment bulb length was the lowest in same DAT. This result indicated that GABA of 1.0 mg L^{-1} was the best for bulb length than control and other concentration of GABA.

Effect of GABA on leaf diameter: Different concentrations of GABA enhanced leaf diameter differently. After 15 days of spraying (at 45 DAT), GABA enhanced leaf diameter significantly over control (Table 4). GABA at 1.0 mg L^{-1} gave the highest (0.556 cm) leaf diameter followed by lower and higher concentration. At 75 DAT, the highest leaf diameter was 0.55 cm for 1.0 mg L^{-1} of GABA followed by 0.48 cm for 2.0 mg L^{-1} and 0.47 cm for 0.5 mg L^{-1}. The lowest value (0.41 cm) was obtained for the control treatment in same DAT.

Effect of GABA on number of roots: Number of roots per plant recorded from 45 to 90 DAT, indicated that GABA stimulated growth significantly over control. GABA at 1.0 and 2.0 mg L^{-1} enhanced root number per plant over lower concentration of GABA and over control. This growth trend of root was similar from 60 to 90 DAT of harvest. At 75 DAT, number of roots were 38.8, 37.9, 36.7 and 30.7 for 2.0, 1.0, 0.5 mg L^{-1} and control, respectively. The lowest number of roots was found in control (Table 5).

Effect of GABA on root length: Length of root in onion gradually increased with aging also investigated from 45 to 90 DAT in both experiment. GABA enhanced root length from 60 DAT. The length of root was highest for GABA at 1.0 mg L^{-1} at 90 DAT, followed by 2.0 and 0.5 mg L^{-1}, respectively. The length of root, were 5.81, 5.7 and 4.53 cm for 1.0, 2.0 and 0.5 mg L^{-1} of GABA,

Table 3: Effect of GABA on bulb diameter and bulb length of onion at different days after transplanting

	Average bulb diameter (cm) at				Average bulb length (cm) at			
Treatments	45 DAT	60 DAT	75 DAT	90 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Control	1.82b	3.56b	3.79c	4.29d	1.74c	2.72a	2.90c	3.31b
GABA 0.5 mg L^{-1}	2.166a	4.012a	4.51b	5.17b	2.14b	2.923a	3.24b	4.14a
GABA 1.0 mg L^{-1}	2.293a	4.17a	6.12a	6.46a	2.26a	2.966a	3.53a	4.25a
GABA 2.0 mg L^{-1}	2.07a	3.92a	4.38b	4.70c	2.09b	2.846a	3.13b	3.85a
LSD at 5% level	0.2179	0.2824	0.3112	0.09744	0.09744	0.3749	0.1153	0.4930
CV (%)	7.61	5.21	4.94	3.33	3.53	9.52	4.55	8.93

In a column, values having same letter(s) do not differ significantly at 5% level by Duncan's New Multiple Range Test (DMRT); DAT = Days After Transplanting, GABA = A mixture of 1% gibberelic acid (GA_3) and 0.05% STC4771, LSD = Least Significant Difference, CV = Co-efficient of Variance

Table 4: Effect of GABA on leaf diameter of onion at different days after transplanting

	Average leaf diameter (cm) at			
Treatments	45 DAT	60 DAT	75 DAT	90 DAT
Control	0.441b	0.491d	0.412c	0.431c
GABA 0.5 mg L^{-1}	0.544a	0.541c	0.475b	0.465b
GABA 1.0 mg L^{-1}	0.553a	0.570b	0.556a	0.531a
GABA 2.0 mg L^{-1}	0.450b	0.587a	0.488b	0.462b
LSD at 5% level	0.01378	0.00496	0.0147	0.0144
CV (%)	3.84	3.14	3.94	4.55

In a column, values having same letter(s) do not differ significantly at 5% level by Duncan's New Multiple Range Test (DMRT); DAT = Days After Transplanting, GABA = A mixture of 1% gibberelic acid (GA_3) and 0.05% STC4771, LSD = Least Significant Difference, CV = Co-efficient of Variance

Table 5: Effect of GABA on root growth of onion at different days after transplanting

	Average number of roots plant^{-1} at				Average root length (cm) at			
Treatments	45 DAT	60 DAT	75 DAT	90 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Control	25.00c	28.00c	30.70c	31.25c	3.03b	3.35c	3.69b	3.92c
GABA 0.5 mg L^{-1}	27.93a	34.86b	36.70b	37.00ab	3.71a	3.99b	4.10b	4.53b
GABA 1.0 mg L^{-1}	26.33b	37.83a	37.90a	37.50a	3.64a	4.70a	5.08a	5.81a
GABA 2.0 mg L^{-1}	27.76a	37.43a	38.86a	35.24a	3.44a	4.10b	5.37a	5.70a
LSD at 5% level	0.689	1.381	1.086	1.125	0.2756	0.4134	0.6101	0.2578
CV (%)	3.87	3.90	3.19	5.30	5.79	7.41	9.71	3.73

In a column, values having same letter(s) do not differ significantly at 5% level by Duncan's New Multiple Range Test (DMRT); DAT = Days After Transplanting, GABA = A mixture of 1% gibberelic acid (GA_3) and 0.05% STC4771, LSD = Least Significant Difference, CV = Co-efficient of Variance

Table 6: Effect of GABA on yield and yield attributes of onion at harvest

Treatments	Fresh wt. of bulb (g)	Fresh Wt. of leaves (g)	Splitted bulb (%)	Leaf yield (t ha^{-1})	Bulb yield (t ha^{-1})	Bulb yield increased over control (%)
Control	50.29d	15.50d	42.35b	3.82c	12.39d	-
GABA 0.5 mg L^{-1}	60.47b	20.49b	54.67d	5.04b	14.89b	20.18
GABA 1.0 mg L^{-1}	65.01a	23.09a	59.38a	5.68a	15.87a	28.09
GABA 2.0 mg L^{-1}	53.82c	19.00c	47.65c	4.68b	13.26c	7.02
LSD at 5% level	2.436	0.9326	1.866	0.3774	0.7446	
CV (%)	3.08	3.47	4.65	5.70	3.83	

In a column, values having same letter(s) do not differ significantly at 5% level by Duncan's New Multiple Range Test (DMRT); DAT = Days After Transplanting, GABA = A mixture of 1% gibberelic acid (GA_3) and 0.05% STC4771, LSD = Least Significant Difference, CV = Co-efficient of Variance

respectively. Control treatment gave the lowest (3.92 cm) length of root (Table 5). Sekh (2002) observed similar effects. He found that GABA enhanced root length (11.67 cm) over control (9.20 cm) in aman rice.

Effect of GABA on fresh weight of bulb: Fresh weight of bulb per plant at harvest was affected by different concentrations of GABA. All the concentrations of GABA significantly enhanced fresh weight of bulbs (Table 6). The highest fresh weight of bulb (65.01 g) was obtained due to application of GABA at 1.0 mg L^{-1} followed by the treatments of GABA at 0.5 mg L^{-1} (60.47 g) and at 2.0 mg L^{-1} (53.29 g). The lowest weight of bulb (50.29 g) was observed in the control treatment. These results indicated that different concentrations of GABA were differently effective for bulb growth and GABA at 1.0 mg L^{-1} was the most suitable.

Effect of GABA on fresh weigh of leaves: Fresh weight of leaves per plant was significantly influenced by different treatments. GABA affected mean fresh weight significantly over control. The highest (23.09 g) mean fresh weight was obtained at 1.0 mg L^{-1} GABA followed by 0.5 and 2.0 mg L^{-1} of GABA (Table 6). The lowest fresh weight of leaves (15.50 g) was obtained in control treatment. Sekh (2002) observed that GABA enhanced leaf fresh weight in aman seedlings.

Effect of GABA on splitting of bulbs: Different concentrations of GABA had significant effect on bulb splitting. Among all the treatments the maximum percentage of splitted bulbs (59.38%) was attained for GABA at 1.0 mg L^{-1} treatment followed by 54.67% for GABA at 0.5 mg L^{-1} concentration. The lowest value of splitted bulbs (42.35%) was observed under control treatment (Table 6).

Effect of GABA on leaf yield (t ha^{-1}): The effect of different concentrations of GABA on leaf yield was significantly different (Table 6). Leaf yield varied from 3.84 to 5.68 t ha^{-1} under different concentration of GABA. Among the concentrations, GABA at 1.0 mg L^{-1} produced the highest leaf yield (5.68 t ha^{-1}) followed by GABA at 0.5 mg L^{-1} (5.04 t ha^{-1}) and at 2.0 mg L^{-1} (4.68 t ha^{-1}). The lowest yield was in untreated control (3.82 t ha^{-1}). Chowdhury (2003) expressed similar report from his experimental result in barley.

Effect of GABA on bulb yield (t ha^{-1}): A highly significant difference in the bulb yield per hectare was found due to the effect of different concentrations of GABA (Table 6). GABA at 1.0 mg L^{-1} gave the highest (15.87 t ha^{-1}) yield followed by GABA at 0.5 mg L^{-1} (14.89 t ha^{-1}) and at 2.0 mg L^{-1} (13.26 t ha^{-1}). The lowest yield was obtained in control (12.39 t ha^{-1}). Thus GABA at 1.0 mg L^{-1} was more suitable for getting the higher bulb yield in onion. Hoque (2002) found that GABA increased yield in wheat over untreated control. The present study are in partial agreement with the findings of Hore *et al.* (1998) and Maskae *et al.* (1998).

Increase of yield might be due to enhance CO_2 fixation (increase chlorophyll), photosynthesis and effective partitioning of assimilates due to effect of GABA occurs in the developing reproductive organs as reported by Chowdhury (2003).

The yield response or relative bulb yield increase over control have been presented in Table 6. The highest bulb yield increase of 28.09% by the application of GABA at 1.0 mg L^{-1} and followed by 20.18% to GABA at 0.5 mg L^{-1}.

The results suggested that GABA at 1.0 mL g^{-1} is more suitable for maximum growth and bulb yield of onion than other treatments.

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