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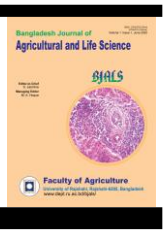

Effect of plant growth regulator- GA_3 on the potential yield of aromatic rice

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ABSTRACT

The experiment was carried out at the research field of Hajee Mohammad Danesh Science and Technology University, during July to December 2018 to evaluate effects on flag leaf nutrient, chlorophyll content, growth and yield of aromatic cultivars under plant growth regulator- GA_3. The experiment comprised of five level of GA_3 *viz.* T_1 (Control), T_2 (50 ppm GA_3), Ts_3 (75 ppm GA_3), T_4 (100 ppm GA_3), T_5 (125 ppm GA_3). There was a significant effect among different level of GA_3 on maximum studied characters. Different level of GA_3 found significant variation on the effective tiller, non-effective tiller, filled grain, unfilled grain, 1000-grain weight, grain yield, straw yield, biological yield and harvest index of rice cultivar was significant. The highest panicle length (28.37 cm), effective tiller hill^{-1} (20.34), filled grain panicle^{-1} (206.93) and 1000 grain weight (10.99) was found in treatment T_5 (125 ppm GA_3) .The highest grain yield (3.41 t ha^{-1}), straw yield (4.28 t ha^{-1}), biological yield (7.69 t ha^{-1}) harvest index (44.37 %) was found in treatment T_5 (125 ppm GA_3). GA_3 (125 ppm) performs the best on the growth, yield and yield components on the selected rice variety (Kalijira). Plant Growth Regulators (PGRs) was significantly influence agronomical, morphological and physiological traits in rice and it was also significantly affected on yield.

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Introduction

Aromatic rice (*Oryza sativa* L.) is known for its characteristic fragrance when cooked. This constitutes a small but special group of rice, which is considered best in quality. Aromatic varieties fetch higher price in rice market than the non-aromatic ones. Cultivation of fine as well as aromatic rice has been gaining popularity in Bangladesh over the recent years, because of its huge demand both for internal consumption and export (Das & Baqui, 2000). Despite the generally favorable agroclimatic conditions, area of aromatic rice is less than 2% of the national rice acreage of Bangladesh. More than four thousand landraces of rice are adopted in different parts of Bangladesh. Only some of these are unique for quality traits including fineness, aroma, taste and protein contents (Kaul *et al.*, 1982).

Plant growth regulators are known to have

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great potential to increase the productivity of rice. Generally, *Boro* rice has gained much importance in Bangladesh, as the average yield per hectare is much higher than that of *Aman*. Plant growth regulators (PGR) are being used as an aid to enhance yield (Nickell, 1982). Naphthalene Acetic Acid (NAA) and Gibberellic Acid (GA_3) are the growth promoting hormones, which may play significant role to change growth characters and yield in HYV and local varieties of rice.

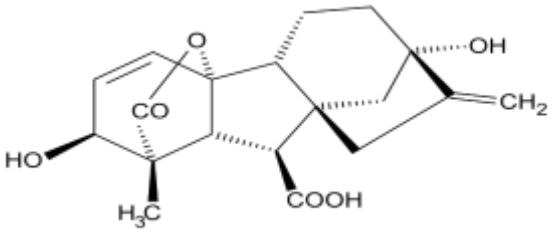
Rice covered an area of 11.53 million ha with a production of 33.54 million M tons while the average yield of rice in Bangladesh is around 2.92 t ha^{-1} (BBS, 2016). In case of *Boro* rice, it covers the largest area of 11788 hectare (41.38% of total rice cultivation area) with a production of 1.86 million tons (55.50%) and the average yield is about 2.91 t ha^{-1} during 2010–11 (BBS, 2016). Besides, based on the rice cultivation, Bangladesh is the fifth largest country of the world (BBS, 2016). Alam *et al*. (2012) also reported that rice covers about 82% of the total cropped land of Bangladesh. It accounts for 92% of the total food grain production in the country and provides more than 50% of the agricultural value addition employing about 44% of total labour forces. According to the latest estimation made by BBS, per capita rice consumption is about 166 kg $year^{-1}$. Rice alone provides 76% of the calorie intake and 66% of total protein requirement and shares about 95% of the total cereal food supply Alam, *et al*. (2012). Rice is not only the foremost staple food but it also provides nearly 48% of the rural employment, about two-third of the total calories supply and about one-half of the protein intake of an average person in the country (Julfiquar *et al*., 2009).

Materials and Methods

A field experiment was carried out at the research farm of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period of July to December 2018to evaluate effects on flag leaf nutrient, chlorophyll content, growth and yield of aromatic cultivars under plant growth regulator- GA_3.

Experimental materials and treatment arrays

This experiment was conducted by using aromatic rice cultivar. Different doses plant growth regulator (GA_3) were applied in orderto evaluate effects on flag leaf nutrient, chlorophyll content, growth and yield of aromatic cultivars



Chemical structure of Gibberellic acid (GA_3)

Properties of NAA

Properties	
Chemical formula	$C_{19}H_{22}O_6$
Molar mass	346.37 g/mol
Appearance	White powder
Melting point	233 to 235 °C (451 to 455 °F; 506to 508 K) (decomposition)
Solubility in water	5 kg/m³

Experimental design and layout:

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There isonefactor in this experiment.

Factor A: PGRs GA_3

- ✓ T_1:Control (No hormone apply)
- ✓ T_2: 50 ppm
- ✓ T_3:75 ppm
- ✓ T_4:100 ppm
- ✓ T_5:125 ppm

Therefore total number of plots for this experiment was 15. The unit plot size was (3 × 2) m^2. The block to block distance was 1 m and plot to plot distance 50 cm. Plant to plant distance 15 cm and row to row distance 20 cm were maintained.

Land preparation

The experimental field was first plough with a power tiller on first week of August, 2018 and subsequently ploughed twice followed by laddering obtain a desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. All the stubbles and weeds (mutha, chapra, durba etc.) were collected and removed from the field. The land was puddled thoroughly by the application of water mixed

organic matter in the field. After 3-4 days, plots were leveled properly by wooden plank that no water pocket could remain in the puddle field. Finally the land was ready for transplantation.

Fertilizer application

The chemical fertilizers Urea, TSP, MOP and Gypsum were applied @ 215, 180, 100, and 20 kg ha^{-1}, respectively. At the beginning of land preparation one half of urea, full dose of TSP, MOP and Gypsum were applied to the experimental plot.

Transplanting of seedlings

About 40 days healthy seedlings were transplanted on puddle plots on August, 2018 according to the experimental design. Three seedlings for local cultivars were transplanted in each hill with a spacing of 25 × 20 cm.

Preparations and application of plant growth regulators

Plant growth regulator GA_3 solution was prepared and the spraying was done at afternoon by using a hand sprayer with two distinct capacities. The solution of GA_3 0, 50, 75, 100, 125 ppm was prepared by dissolving 0, 50, 75, 100, 125 mg of GA_3 in a 1 liter measuring cylinder in which 5ml of ethanol prior to dilution was made in distilled water. The distilled water was added to make the volume 1 liter to get respective concentration of GA_3 solution. In a similar way, 100 ppm GA_3 solution was made, by taking 100 mg GA_3 in liter volumetric flask and the volume was made up to the mark with distilled water. PGRs were sprayed twice, at vegetative stage and panicle initiation stage.

Irrigation and drainage

The experimental plots were irrigated as and when needed. Excess water was drained out from the plots before 15 days of harvesting to enhance maturity of the crop.

Harvesting and processing

Maturity of crops was determined when some 90% of the grains became golden yellow in color. After attainment of the maturity, the whole plant was cut at ground level by a sickle. After recording some necessary data the harvested crops hill was dried in sun and then in an oven at 65°C.

Parameters studied

The data regarding various relevant parameters were collected accordingly during the experimental period. The parameters studied are-

Yield and yield contributing parameters

- Panicle length
- Effective tiller
- Non effective tiller
- Grain no. per panicle
- Grain weight per panicle
- 1000- grain weight
- Grain yield per plot
- Straw yield per plot
- Biological yield
- Harvest index

Yield and yield contributing parameters

Data were recorded on the following crop characters: plant height, leaf number per hill, leaf length, tiller number per hill, root length per hill, total tiller number, effective tillers, non-effective tillers, panicle number per plant, grain number per panicle, 1000-grain weight and straw weight.

Number of panicles $hill^{-1}$

During harvesting 3 hills were randomly selected from different replication to record the number of panicles per hill.

Effective tiller number

The total numbers of effective tillers per hill were counted and recorded for statistical analysis and finally used for interpretation.

Non effective tiller number

The total numbers of non-effective tillers per hill were counted and recorded.

Filled grainnumber

Filled grain per panicle were counted and recorded in the notebook for statistical analysis and finally used for interpretation.

Unfilled grainnumber

Unfilled per panicle was weighed by electrical balance and recorded for statistical analysis and finally used for interpretation.

1000-grain weight

One thousand clean oven dried grains were counted from the seed stock obtained from hill in each plot and weighed by using an electrical balance.

Grain yield (t ha^{-1})

Grain obtained from each plot was sun dried and weighed carefully. Then it was converted into yield ha^{-1}.

Straw yield (t ha^{-1})

Straw obtained from the selected hill of each unit plot were sun dried and weighed to record the straw yield $plot^{-1}$ and finally to t ha^{-1}.

Biological yield (t ha^{-1})

Grain yield and straw yield are all together regarded as biological yield. Biological yield was calculated using the following formula:
Biological yield= Grain yield + Straw yield

Harvest index (%)

Harvest index is the ratio of economic yield and biological yield, and the ultimate partitioning of dry matter between grain and vegetative parts is indicated by HI, the economic yield of rice is its grain, biological yield of a crop is the TDM at final harvest (Davald and Hamblin, 1976).
Harvest index was calculated on the basis of grain yield and straw yield using the following formula (Gardener *et al.*, 1985):

$$\text{Harvest index (\%)} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \times 100$$

Statistical analysis

The collected data were complied and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTATC and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance (Russell 1986).

Results and Discussion

Effect of different level of GA_3 on yield and yield contributing characters of aromatic rice

Panicle Length

There was a significant effect among different level of GA_3 on the panicle length of rice cultivar. Result revealed that the highest panicle length (28.37 cm) was found in treatment T_5 (125 ppm GA_3) and the lowest panicle length (23.33 cm) was found T_1(Control) at vegetative stage (Table 1). Khanam (2016) revealed that highest panicle length was obtained from Kataribhog rice variety while 50 ppm 6-BAP was applied. Rahman (2013) showed that all the varieties produced lower number of panicle $hill^{-1}$ in controlled plants than those of PGR treated plants. He observed the highest number of panicle $hill^{-1}$ using NAA applied plots, intermediate due to GA_3 over control. Tao and Shiying (1992) reported that treatment with ABT increased panicle numbers. Zhou (2005) reported that 20% spikelet of a panicle are enclosed in the sheath of flag leaf in most *indica* CMS lines their three internodes are shorter than those of pollen parents, especially the top most internodes. He also observed that GA_3 enhance panicle and stigma exertion. Adjust plant height of both parents. Moreover, he reported that the best time for first spraying is when 2-5% panicles have emerged out of bracts and 4-5 in consecutive days, time 7 am to 11 am or 4 pm to 7 pm.

Effective tiller

There was a significant effect among different level of GA_3 on the number of effective tiller $hill^{-1}$of rice cultivar. Result revealed that the highest number of effective tiller $hill^{-1}$(20.34) was found in treatment T_5 (125 ppm GA_3) and the lowest

Table 1. Effect of different level of GA_3 on yield contributing characters of aromatic rice

Treatment	Panicle length (cm)	Effective tiller (no.)	Non effective tiller (no.)	Filled grain panicle^{-1} (no.)	Non-filled grain panicle^{-1} (no.)	1000 grain weight (g)
T_1	23.33d	9.32d	1.33a	150.34e	32.65a	10.07
T_2	27.48b	11.55c	0.89b	183.45b	15.33d	10.80
T_3	26.28c	13.67b	0.78c	176.93c	22.89c	10.84
T_4	26.72c	11.67c	0.56d	168.49d	18.11b	10.39
T_5	28.37a	20.34a	0.33e	206.93a	10.32e	10.99
LS	*	**	*	**	*	NS
$LSD_{(0.05)}$	0.74	1.80	1.11	3.02	1.32	2.7
Cv (%)	5.21	7.09	5.56	6.67	8.65	1.65

number of effective tiller hill^{-1}(9.32) was found T_1 (Control) (Table 1). Akter (2012) revealed that highest effective tillers hill^{-1} was found while 150 ppm NAA was applied as treatment with the residual effect of 2 ton lime. Khanam (2016) found highest number of effective tillers hill^{-1} from Kataribhog rice variety while 1000 ppm 6-BAP was applied and highest number of non-effective tillers hill^{-1} at controlled level of 6-BAP.

Non-effective tiller

There was a significant effect among different level of GA_3 on the number of non-effective tiller hill^{-1} of rice. Result revealed that the highest number of non-effective tiller hill^{-1} (1.33) was found in treatment T_5 (125 ppm GA_3) and the lowest number of non-effective tiller hill^{-1} (0.33) was found T_1 (Control) (Table 1).

Khanam (2016) found highest number of non-effective tillers hill^{-1} from Kataribhog rice at controlled level. Harshan and Gill (1985) reported that spraying of 100 ppm NAA on wheat and barley had decrease to a great extent the number of non-effective tiller hill^{-1} as compared to control. Ling and Ma (1998) studied on winter wheat with endogenous growth regulator IAA and demonstrated that non effective tiller was decrease by IAA.

Filled grain panicle^{-1}

The effect among different level of GA_3 on the number of filled grain panicle^{-1} of rice cultivar was significant. Result revealed that the highest number of filled grain panicle^{-1} (206.93) was found in treatment T_5 (125 ppm GA_3)and the lowest number of filled grain panicle^{-1} (150.34) was found T_1(Control) (Table 1). In this study 150 ppm NAA on kalijira variety showed better performance on grain no. per panicle of rice variety. Chinigura variety showed better performance at 100 ppm, Kataribhog showed better performance at 100 ppm and Kalijira showed better performance at 150 ppm of NAA than that of other levels. Roxy (2016) reported that 50 ppm BAP increased the grain number per panicle of Kataribhog rice variety.

Unfilled grain panicle^{-1}

The effect among different level of GA_3 on the number of unfilled grain panicle^{-1} of rice cultivar was significant. Result revealed that the highest number of unfilled grain panicle^{-1} (32.65) was found in treatment T_1 (Control) and the lowest number of filled grain panicle^{-1} (10.32) was found T_5 (125 ppm GA_3)(Table 1).

1000-grain weight

There was a significant effect among different level of GA_3 on the 1000 grain weight of rice cultivar. Result revealed that the highest 1000 grain weight (10.99) was found in treatment T_5 (125 ppm GA_3) and the lowest 1000 grain weight (10.07) was found T_1 (Control) (Table 2).

Roxy (2016) reported that 50 ppm BAP increased the 1000-grain wt. of Kataribhog rice variety. Khanam (2016) also reported that Kataribhog produced the highest 1000-grain weight while 50 ppm 6-BAP was applied. Kabir *et al.* (2004) studied with rice new cv. Begunbitchi, Chinigura and Kalijira and reported that Chinigura produced the highest 1000-grain weight. Akter *et al.* (2012) revealed that 100 ppm NAA with 1.0 ton lime residual effect showed the best performance in all yield contributing characters in kataribhog rice such as number of filled grain, 1000-grain weight and yield production. Bakhsh*et al.* (2012) revealed that the highest number of panicles, spikelets panicle^{-1}, normal kernels,1000-grain weight, paddy yield and water productivity was recorded by applying naphthalene acetic acid @

Table 2. Effect of different level of GA_3 on yield characters of aromatic rice

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})	% Harvest index
T_1	2.07e	3.48d	5.55e	37.33e
T_2	3.05b	4.08b	7.13b	42.81b
T_3	2.79c	4.00b	6.79c	41.09c
T_4	2.53d	3.94c	6.47d	39.10d
T_5	3.41a	4.28a	7.69a	44.37a
LS	**	**	**	*
$LSD_{(0.05)}$	0.19	0.09	0.23	1.55
Cv (%)	4.22	7.52	6.63	2.54

90 mL ha^{-1} and I_2 (75 cm) level of irrigation water (10 irrigations).Khan *et al*. (2011) revealed that application of growth regulator (NAA) at the rate of 90 ml ha^{-1} at panicle initiation stage resulted in highest number of 88 and 90 % normal kernel, 23.00 and 23.20 g 1000-grain weight during 2004 and 2005, respectively. Liuping *et al*. (1998) in an experiment with growth regulators such as NAA on wheat found that among growth regulators, NAA was the most effective to increase 1000-grain weight.

Grain yield (t ha^{-1})

The effect among different level of GA_3 on the grain yield of rice cultivar was significant. Result revealed that the highest grain yield (3.41 t ha^{-1}) was found in treatment T_5 (125 ppm GA_3) and the lowest grain yield (2.07 t ha^{-1}) was found T_1 (Control) (Table 2). Roxy (2016) reported that 50 ppm 6-BAP increased the grain yield of Katari rice variety. Khanm (2016) reported that 100 ppm 6-BAP produced highest grain yield and yield components of rice. Akter (2012) revealed that 100 ppm NAA with 1.0 ton lime was the best for yield and yield contributing characters in kataribhog rice. Bakhsh *et al*. (2012) reported that application of NAA increased the grain yield and yield components of rice. Liu et al. (2012) obtained similar result. Singh *et* al. (1985) observed that spraying of planofix (NAA) on wheat plant, significantly increased grain yields, which supported the result of the present study.

Straw yield (t ha^{-1})

There was a significant effect among different level of GA_3 on the straw yield of rice cultivar. Result revealed that the highest straw yield (4.28 t ha^{-1}) was found in treatment T_5 (125 ppm GA_3) and the lowest straw yield (3.48 t ha^{-1}) was found T_1 (Control) (Table 2). Rahman (2013) and Akter (2012) also found no positive effect of NAA

application on straw yield. Roxy (2016) revealed that 200 ppm NAA reduced the straw yield of Kataribhog rice cultivar. Khanam (2016) reported that the straw yield of kataribhog was significantly increased at the controlled level. Zahir *et al.* (2007) stated that maximum straw yield (5.3 t ha^{-1}) was recorded in IAA-blended N-enriched compost plus 60 kg ha^{-1} N fertilizer which was at par with kinetin-treated N-enriched compost plus 60 kg ha^{-1} N fertilizer and full dose of N fertilizer.

Biological yield

A significant effect was among the different level of GA_3 on the biological yield of rice cultivar was significant. Result revealed that the highest biological yield (7.69 t ha^{-1}) was found in treatment T_5 (125 ppm GA_3) and the lowest biological yield (5.55 t ha^{-1}) was found T_1 (Control) (Table 2). Roxy (2016) found that the maximum biological yield (6.25 t ha^{-1}) that was obtained from the 50ppm 6-BAP.Khanam (2016) reported that 100 ppm 6-BAP produced maximum biological yield of Kataribhog rice.Rahman (2013) was obtained maximum biological yield (15.51 t ha^{-1}) from the combination of variety BRRI dhan28 with 100 ppm GA_3. The lowest biological yield (10.50t ha^{-1}) was obtained from the combination of variety Nerica-4 and 100 ppm ofGA_3.

Harvest index

Harvest index (HI) is an important yield determining character, which can through idea along partitioning efficiency. There was a significant effect among different level of GA_3 on the harvest index of rice cultivar. Result revealed that the highest harvest index (44.37 %) was

found in treatment T_5 (125 ppm GA_3) and the lowest harvest index (37.33 %) was found T_1 (Control) (Table 2). Roxy (2016) found that the highest harvest index 39.24% at 50ppm 6-BAP.Khanam (2016) reported that 100 ppm 6-BAP produced highest harvest index. Rahman (2013) found the highest harvest index (49.60 %) which obtained from BRRI dhan2 with 100 ppm NAA and the lowest harvest index (42.01%) which obtained from the Nerica-4 without GA_3 or NAA. Akter (2012) revealed that 100 ppm NAA application obtained highest harvest index. HI is the measure of the efficiency of conversion of photosynthate into economic yield of a crop plant (Dutta and Mondal, 1998).

Conclusion

The experiment comprised of five level of GA_3*viz*. T_1 (Control), T_2 (50 ppm GA_3), T_3 (75 ppm GA_3), T_4 (100 ppm GA_3), T_5 (125 ppm GA_3).The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Least Significant Difference adjusted the mean differences among the treatments at 5% level of significance. Different level of GA_3 found significant variation on the effective tiller, non-effective tiller, filled grain, unfilled grain, 1000-grain weight, grain yield, straw yield, biological yield and harvest index of rice cultivar was significant. The highest panicle length (28.37 cm), effective tiller hill^{-1} (20.34), filled grain panicle^{-1} (206.93) and 1000 grain weight (10.99) was found in treatment T_5 (125 ppm GA_3) and the lowest panicle length (23.33 cm), effective tiller hill^{-1} (9.32), 1000 grain weight (10.07) was found T_1 (Control) at vegetative stage. The highest grain yield (3.41 t ha^{-1}), straw yield (4.28 t ha^{-1}), biological yield (7.69 t ha^{-1}) harvest index (44.37 %) was found in treatment T_5 (125 ppm GA_3) and the lowest grain yield (2.07 t ha^{-1}), straw yield (3.48 t ha^{-1}), biological yield (5.55 t ha^{-1}) and harvest index (37.33 %) was found T_1 (Control).GA_3 (125 ppm) performs the best on the growth, yield and yield components on the selected rice variety (Kalijira) and the highest grain yield (3.41 t ha-1) and harvest index (44.37 %) was found in treatment T_5 (125 ppm GA_3).Plant Growth Regulators (PGRs) and various chemical concentrations significantly influence agronomical, morphological and physiological traits in rice and it was observed that at limited concentrations they stimulate rapid cell division resulting faster vegetation and reproductive growth. The treatment combination T_5 i.e., (125 ppm GA_3) gave the best effects as compared to all other treatment combinations. However, further investigations are necessary to confirm these findings under various set of agronomic and climatic conditions.

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