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# EFFECT OF GIBBERELLIC ACID (GA3) ON THE GROWTH AND YIELD OF AROMATIC RICE VARIETIES

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***Abstract:*** An experiment was conducted at the Agronomic research field, Hajee Mohammad Danesh Science and Technology University, HSTU during the period from July to December 2017 to study the effect of Gibberellic Acid (GA3) on the growth and yield of aromatic rice varieties. The experiment was laid out Randomized Completely Block Design (RCBD) with three replications. The experiment was conducted with two factors; Factor A- Gibberellic acid levels, (G1=0 ppm, G2=75 ppm and G3=150 ppm) and Factor B- Aromatic rice varieties (V1=BRRI dhan34, V2= Kataribhog, V3=Kalizira, and V4= Tulshimala). The results revealed that the plant height (cm), number of effective tiller, number non effective tiller, number of panicle, number of filled grain panicle-1 , number sterile grain panicle-1, one thousand grain weight (g), grain yield (t ha-1), straw yield (t ha-1), biological yield (t ha-1), harvesting index (%) were significantly influenced by the treatments. Among the treatments studied, G2 was the best performance treatment; produced highest values were obtained from G2 (75 ppm) treatment. GA2 produced the maximum grain yield (1.58 t ha-1), and GA3 found that produced the maximum straw yield (3.45 t ha-1), while the maximum grain yield (3.15 t ha-1) and straw yield (3.28 t ha1) was the best performance variety V1 (BRRI dhan34).whereas the lowest values for all parameters were recorded from G1 (control treatment). Again, interaction effect between varieties and Gibberellic Acid V1 (BRRI dhan34) with G2 (75 ppm) produces the maximum grain yield (3.30 t ha-1) and the highest straw (3.76 t ha-1) produced G3 (150 ppm) with V3 (Kalizira). Present study indicates that V1(BRRI dhan34).and G2 (75 ppm) and their combination produced the highest values for maximum parameters. Thus, GA3 (75 ppm) would be successfully used for commercial rice production. However, it is important to repeat the experiment over locations and seasons before final recommendation.

**Key words:** Rice, Gibberellic Acid, Growth, Yield

## 1.0 Introduction

Rice (Oryza sativa L.) is one of the most important cereal crops that have been referred as Global Grain because of its use as prime staple food in about 100 countries of the world. Production of rice in Bangladesh may decline marginally 2017 year mainly due to negative impact of flood, according to the latest forecast of the Food and Agriculture Organization (FAO) of the United Nations. FAO projected that annual output of rice in Bangladesh would decline to 34.1 million tones in the current year which was 34.7 million tons in 2016. Thus, rice output is projected to decline by 1.72 per cent. "A sequence of floods also dampened the outlook for Bangladesh, likely translating into a third successive season of little or negative production growth, said the latest food outlook released last month. Bangladesh is now the fourth largest rice producer after China, India and Indonesia. FAO"s latest estimate puts the 2017 aggregate paddy production at 50.8 million tones, slightly below the five-year average.

This is the result of the crop losses incurred to the three episodes of severe flash floods between April and August 2017, which affected northern districts, in particular. Like Rangpur and Rahshahi division (FAO, 2017). Rice is the major crop is interwoven in the cultural, social and economic lives of millions of Bangladeshis and it holds the key for food and nutritional security of the country. It is consumed as the staple food and has been given the highest priority in meeting the demands of its everincreasing population in Bangladesh. In recent years, aromatic rice has been introduced to the global market. Aromatic rice has great potential to attract rice consumer for its taste and deliciousness, and high price to boost up the economic condition of the rice grower in the developing countries like Bangladesh. Because of its natural chemical compounds which give it a distinctive scent or aroma when cooked. Aromatic rice commands a higher price than non-aromatic rice. Gibberellic Acid (GA3) is the most

important growth regulator, which is involved breaking seed dormancy, promotes germination, intermodal length, hypocotyls growth and cell division in cambial zone and increases the size of leaves (Keykha et al., 2014). GA stimulates hydrolytic enzymes that are needed for the degradation of the cells surrounding the radicle and thus speeds germination by promoting seedling elongation growth of cereal seeds (Rood et al., 1990). Keeping the above points in view the present study was undertaken the effect of Gibberellic acid (GA3) on the growth and yield of aromatic rice varieties.

## 2.0 Materials and methods

**Location and characteristics of the soil**

Experimental field (Agronomic Research Field, HSTU, Dinajpur) was located at 25.56o N latitude and 88.41o E longitude at an altitude of 37.5 m above from the mean sea level. The land belongs to the old Himalayan Piedmont Plain Agro Ecological Zone (AEZ-1). The experimental field is a medium high land having sandy loam soil with pH 5.35. The initial soil (0-15 cm depth) test revealed that the soil contained.

**Climatic condition**

The climatic condition of experimental area possesses sub-tropical climate. Usually the rainfall is heavy during aman rice growing season (July to December 2017). The weather condition such as monthly mean temperature (%), maximum and minimum, rainfall (mm), and relative humidity (%) are presented in Appendix-III (August to December 2017) respectively. The mean minimum temperature value and the mean maximum temperature were recorded in (°C) in the Appendix III. The weather data were collected from the Wheat Research Centre (WRC), Nashipur, Dinajpur.

**Experimental treatment**

The treatments included in the experiment were as follows: Factor: A. Concentration of GA3 (3) G1: 0 ppm (control) G2= 75 ppm G3=150 ppm Factor: B. Aromatic Rice Variety (4) V1 =BRRI dhan34 V2 =Kataribhog V3 =Kalizira V4 =Tulsimala.

**Design of the experiment**

The experiment was laid out in a Randomized Completely Block Design (RCBD) with three replications. The whole experiment area was divided into three blocks. Each block was subdivided into twelve plots. The size of each unit plot was 4 m ×2.5 m. The total number of unit plots was 36. The replications were separated one from another by 1m. The distance between plots was 0.5 m. The treatments were randomly distributed into the plots of each replication.

**Land preparation**

The land preparation was started 14 days before aromatic rice transplanting the land was prepared thoroughly by ploughing and cross-ploughing with a power tiller. Every ploughing was followed by laddering in order to break the clods and to level the land. All types of weed, stubble and crop residue were removed from the experimental field.

**Weeding**

Weeding was done four times first weeding was done at twenty-five days after transplanting. Next weeding was done at 25 days intervals.

**Irrigation**

The crop field was irrigated according standard recommended. The first day of transplanting is started irrigation because rice is include the crops need more at any stage the schedule of irrigation was done at 3 or 4 days after while the second irrigation is rain because at that time was available a lot of rainfall.

**Insect and diseases control**

There was no major incidence of insects or diseases. But some insect pest control measure was adopted in the experiment. The experiment crop was grown with proper care and agronomic management to ensure satisfactory crop grown and development.

**Harvesting and threshing**

Previous randomly selected five hills, those were considered for the growth analysis collected from each plot to analyze the yield and yield contributing characters. Rest of the crops were harvested when 80% grayish in color. After collecting sample plants, harvesting was done on 10th December 2017. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

**Sample collection**

For convenience of data recording five sample plants plot-1 were selected randomly before harvesting of the crop and then sample plants were harvested, bundled and tagged Page 29 and carefully carried to the Agronomy Field Laboratory threshing floor in order to collect necessary data.

**Collection of experimental data**

Data on the following plant characters and yield components were collected from the sample plants of each plot Plant height (cm), Number of effective tiller/hill, Number of non-effective tiller/ hill, Number of panicle (cm) / hill, Number of filled grain per panicle, 1000-grains weight (g), Grain yield (t ha-1), Straw yield (t ha-1) ix. Biological yield (t ha-1) and Harvesting index (%).

**Plant height (cm)**

The height of plant was recorded at harvest by using centimeter scale. The plant height was measured from the ground level to the tip of the plant of an individual plant. Mean value of five selected plants was calculated for each unit plot and expressed in centimeter (cm).

**Number of effective Tiller**

Number of effective tiller was counted and the data were recorded from randomly selected five plants and mean value was counted and recorded.

**Number of non-effective tiller**

Number of non-effective tiller were counted from 5 randomly selected plants as harvested from each unit plot then averaged.

**Number of panicle (cm)**

Number of panicle was measured from 5 randomly selected plants as harvested from each unit plot then averaged and expressed in centimeter.

**Number of filled grain per panicle**

Sample of filled grain per panicle were taken from each five sample plants to measure the number of grain per pod by counting the number of grains of each pod and then averaged.

**1000-grain weight (g)**

A composite sample was taken from the yield of five plants. The thousand seeds of each plot were counted and weighed with a digital electric balance. The thousand seed weight was recorded in gram (g).

**Grain yield (t ha-1)**

All plants in each plot were harvested at their maturity stage and most probality copied for mustard weighted and recorded in gram (g). The Grain yield was finally converted to ton and expressed in to ton per hectare (t ha-1).

**Straw yield (t ha-1)**

Mature Rice plants were harvested from each plot and seeds and straw were separated and weight of straw was recorded in gram (g). The straw yield was finally converted to ton and expressed in ton per hectare (t ha-1).

**Biological yield (t ha-1)**

Total synthesize product (except root) of a crop per unit volume. It was calculated from the following formula: Biological yield = grain yield+ straw yield.

**Harvest index (%)**

It is the ratio of grain yield to biological yield and was calculated by using the following formula.

$$HI = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

**Data analysis**

The data were analyzed statistically using the analysis of variance (ANOVA) technique with the help of computer using MSTAT-C program. The treatment means were compared using Duncan‟s Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

## 3.0 Results and discussion

**The effect of varieties on morphological, yield and yield contributing characteristics**

**Plant height (cm)**

Significant difference was found in plant height due to the different variety (Table.1). The highest plant height (146.56 cm) was obtained in $V_1$ = (BRRI dhan34) while the lowest (140.4 cm) was found for $V_4$ = (Tulsimal) as shown in (Table 1).

**Number of effective tillers/hill**

There was significant variation among rice varieties (Table 1). The maximum number of effective tillers (12.00) was recorded for $V_1$ = (BRRI dhan34) while the lowest (7.778) was recorded for $V_4$ = (Tulsimala).

**Number of non-effective tillers/hill**

Among varieties there was significant variation in the number of non-effective tillers (Table 1). The maximum number of non-effective tillers (1.444) was recorded in $V_4$ = (Tulsiman) while the minimum (1.000) were recorded from the other varieties.

**Length of panicle**

Significance difference was found for the varietal effect to length of panicle as illustrated in (Table 1).
The maximum Length of panicle (27.44 cm) was recorded in $V_1$ (BRRIdhan34), while the minimum panicle length (21.22cm) was recorded for $V_4$ (Tulsimala).

**Number of filled grain panicle$^{-1}$**

In this study significant difference was observed to the number of filled grain panicle$^{-1}$ due to aromatic rice varieties (Table 1). The highest number of filled grain per panicle (241.4) was recorded for $V_1$ (BRRIdhan34) while the lowest (194.2) $V_4$ = (Tulsimala).

**Number of sterile grain per panicle**

Significant effects were found due to the varietal effect to the number of sterile grains panicle$^{-1}$ (Table1). The maximum number of sterile grain panicle$^{-1}$ (17.56) was recorded for $V_4$ (Tulsimala) while the lowest (11.89) was found V1 (BRRI dhan34).

**1000-grains weight**

According to effect of varieties significance difference were found among the thousand grain weight (Table1). The highest gain weight (13.41 g) was recorded for $V_1$ (BRRI dhan3), where the lowest (12.99g) were recorded for $V_4$ (Tulsimal).

**Grain yield (t ha$^{-1}$)**

According to the varietal effect significant difference were observed among the grain yield (Table 1). The highest (3.15 ton ha$^{-1}$) grain yield was observed under V1 (BRRI dhan34), where the lowest (1.67 ton ha$^{-1}$) were recorded for $V_4$ (Tulsimala).

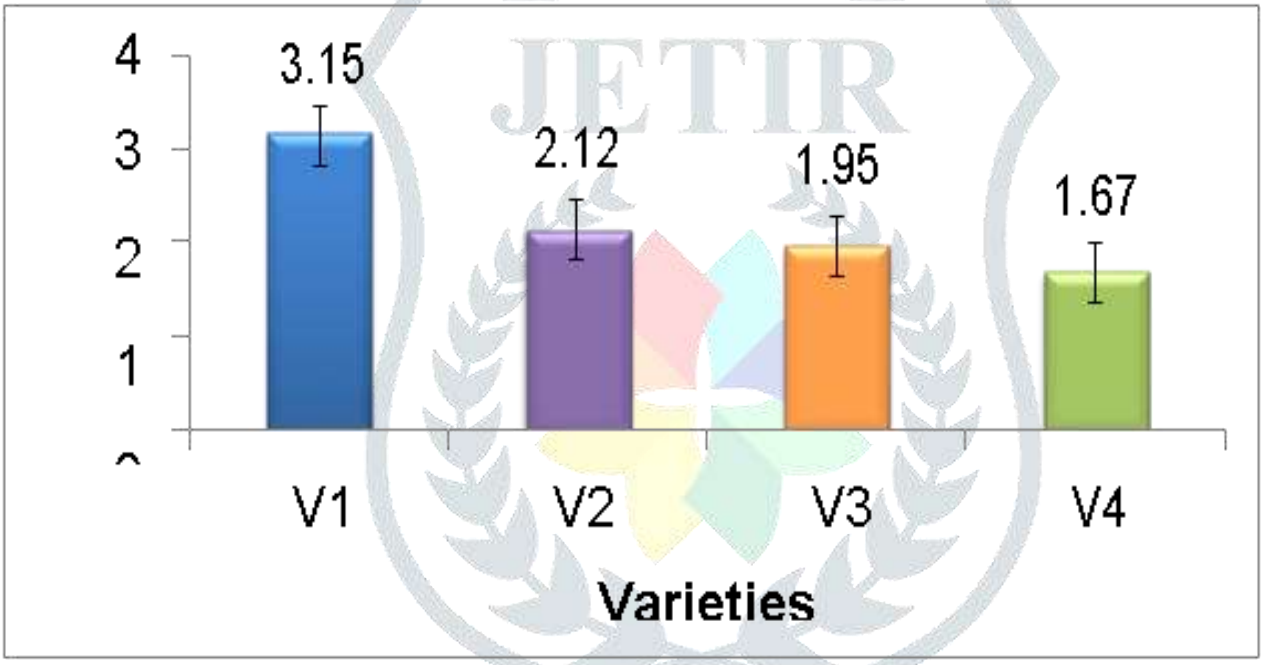


**Fig** 1: **The effect of varieties on grain yield of aromatic rice**

**Straw yield (ton ha$^{-1}$)**

In this study significance difference were observed among the varietal effect to straw yield (Table 1). The maximum straw yield (3.28 ton ha$^{-1}$) was recorded in $V_1$ (BRRI dhan34) while the minimum (3.10 ton ha$^{-1}$) were recorded for $V_4$ (Tulsimal).

**Biological yield (ton ha$^{-1}$)**

According to the varietal effect significance variation were observed among the biological yield (Table1). Maximum biological yield (6.25 ton ha$^{-1}$) was obtained from V1 (BRRIdhan34), while the minimum (4.88 ton ha-$^{1}$) was recorded for V4 (Tulsimala).

**Harvest index (%)**

In the case of harvest index significance difference were also observed according to the effect of varieties (Table 2). The maximum harvest index (50.4 %) was recorded in $V_1$= (BRRIdhan34). While the minimum harvest index (34.7 %) was obtained from $V_4$= (Tulsimala).

**Table 1. The effect of varieties on yield and yield contributing characters of aromatic rice**

| Variety | Plant height (cm) | Number of effective tillers/hill | Number of non-effective tillers/hill | Length of panicle (cm) | Number of filled grain per panicle (No.) | Number of sterile grain per panicle (No.) | 1000 Grain weight (gm) | Straw yield ton/ha | Biologicl yield ton/ha | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| V1 | 146.46 a | 12.00 a | 1.000 b | 27.44 a | 241.4 a | 11.89 c | 13.43 a | 3.28c | 6.25 a | 50.4 a |
| V2 | 140.17 c | 9.111 c | 1.000 b | 23.22 b | 217.1 b | 14.78 b | 13.41 b | 3.10 a | 5.4 b | 39.2 b |
| V3 | 142.56 b | 10.00 b | 1.000 b | 23.78 b | 216.6 b | 14.67 b | 12.99 b | 3.22 b | 5.17 c | 37.7 c |
| V4 | 111.26 d | 7.778 d | 1.444 a | 21.22 c | 194.2 c | 17.56 a | 13.12 b | 3.24 d | 4.88 c | 34.7 d |
| LSD | 1.779 | 0.5364 | 0.2208 | 0.7171 | 5.819 | 0.8495 | 0.7394 | 0.06913 | 0.1071 | 1.072 |
| CV % | 1.27 | 5.64 | 20.23 | 3.07 | 2.74 | 5.90 | 5.72 | 2.16 | 2.36 | 3.54 |
| Level of significance | * | * | * | * | * | * | * | * | * | * |

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test

**The effect of Gibberellic acid on yield and yield components of aromatic rice varieties**

**Plant height (cm)**

According to effect of gibberellic acid ($GA_3$) significant difference were also obtained where the highest plant height (157.5 cm) were recorded under the application of 150 ppm of gibberellic acid. While the lowest plant height (125.2 cm) were recorded for the control (0 ppm) (Table 2).

**Number of effective tillers/hill**

According to the effect of gibberellic acid application significance difference were also shown for the number of effective tillers in each plant. As shown in (Table 2). Maximum numbers (11.25) of effective tillers plant $^{-1}$ were recorded for the application of 75 ppm concentration of gibberellic acid where the lowest number (8.250) of effective tillers plant $^{-1}$ were recorded for the control one.

**Number of non-effective tillers/hill**

There was no significance difference according to the gibberellic acid effect to the non- effective tillers plant $^{-1}$ as shown in (Table 2).

**Length of panicle**

According to the effect of gibberellic acid to the panicle length significance difference were also found as (Table 2) shows. Maximum panicle length (26.00 cm) were found after the application 150 ppm ($G_3$), where the lowest were recorded for the control (application of 0 ppm). Due to the interaction effect of varieties and gibberellic acid to the panicle length, significance differences were also found as (Table 2) illustrates.

**Number of filled grain panicle$^{-1}$**

According to the effect of gibberellic acid to the number of filled grain panicle$^{-1}$, significant differences were also found (Table 2). Maximum number of filled grain panicle$^{-1}$ (235.10) was recorded for 75 ppm ($G_2$) application, where the minimum number of filled grain panicle$^{-1}$ (196.40) was recorded for the control treatment (0 ppm).

**Number of sterile grain per panicle**

According to the effect of gibberellic acid concentrations to the number of sterile grains panicle$^{-1}$ significance difference were also found (Table 2). The highest number of sterile grains panicle$^{-1}$ was recorded for application of 0 ppm (control treatment) where the lowest were recorded for the application of 75 ppm ($G_2$).

**1000-grains weight (g)**

Thousand grain weights were also significantly influenced by the different concentrations (Table 2). The 75 ppm ($G_2$) concentration gave the highest thousand grain weight (13.58 g), where the lowest were recorded after the control one.

**Grain yield (t ha$^{-1}$)**

According to the effect of gibberellic acid significant difference were also observed among the grain yield (Table 2). Maximum grain yield (3.04 ton ha$^{-1}$) was observed for $G_2$ (75 ppm), while the minimum grain yield (1.46 ton ha$^{-1}$) was recorded for the control treatment (0 ppm).

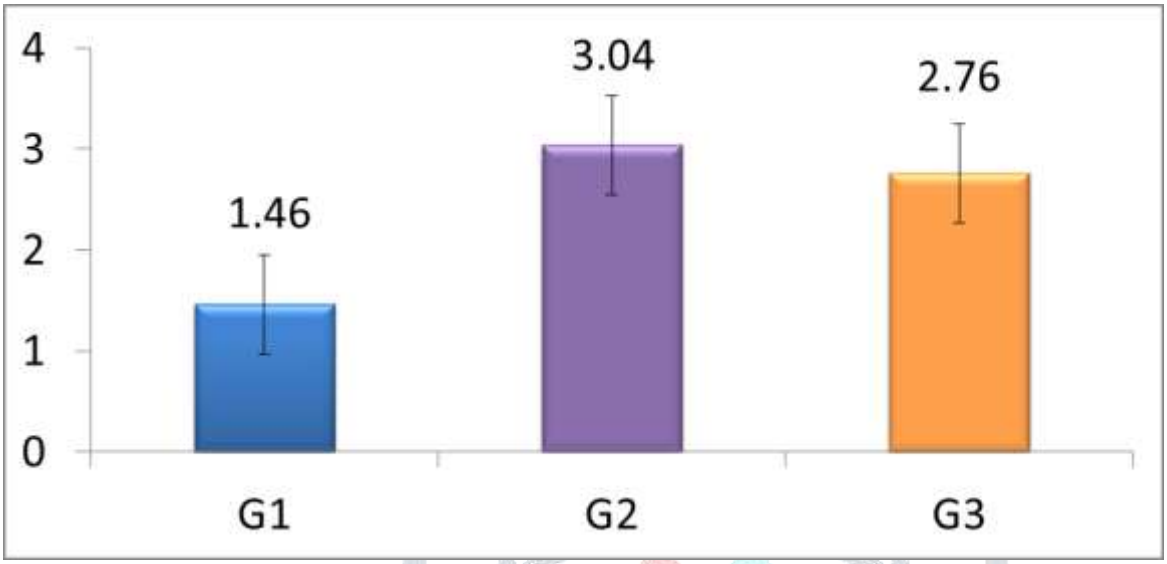


**Fig 2: The effect of gibberellic acid on yield and yield contributing characters of aromatic rice**

**Straw yield (t ha$^{-1}$)**

According to gibberellic acid had significant effects on straw yield of rice (Table 2). The maximum straw yield (3.45 t ha$^{-1}$) was recorded for $G_2$ (75 ppm), while the lowest were recorded in the control treatment (2.85).

**Biological yield (t ha$^{-1}$)**

According to effect of gibberellic acid concentrations, significance differences were also observed in this study among the biological yield (Table 2). Maximum biological yield (5.03 ton ha$^{-1}$) was obtained after the application of 75 ppm ($G_2$) of gibberellic acid concentrations, while the lowest one (4.09 ton ha$^{-1}$) was recorded under the control treatment.

**Harvest index (%)**

According to the effect of gibberellic acid concentration significance variations were also obtained in the case of harvest index (Table 2). Maximum harvest index (31.4 %) were obtained after the application of 75 ppm gibberellic acid concentrations, while the lowest harvest (30.3 %) were obtained from application of zero gibberellic acid concentrations.

**Table 2. The effect of gibberellic acid on yield and yield contributing characters of aromatic rice**

| GA | Plant height (cm) | Number of effective tillers/hill | Number of non-effective tillers/hill | Length of panicle (cm) | Number of filled grain per panicle (No.) | Number of sterile grain per panicle | 1000 Grain weight (gm) | Straw yield ton/ha | Biological yield ton/ha | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | (No.) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| GA1 | 125.2 c | 8.250 c | 1.167 a | 21.92 c | 196.4 c | 16.50 a | 13.01 c | 2.85 c | 4.09 c | 30.3 |
| GA2 | 146.6 b | 11.25 a | 1.000 b | 23.83 b | 235.1 a | 13.00 c | 13.58 a | 3.45 a | 5.03 a | 31.4 |
| GA3 | 157.5 a | 9.667 b | 1.167 a | 26.00 a | 220.5 b | 14.67 b | 13.12 b | 3.17 b | 4.59 b | 30.9 |
| LSD | 1.480 | 0.44 | 0.18 | 0.59 | 4.84 | 0.70 | 0.64 | 0.05 | 0.08 | 0.89 |
| CV % | 1.27 | 5.64 | 9 | 3.07 | 2.74 | 5.90 | 5.72 | 2.16 | 2.36 | 3.54 |
| Level of significance | * | * | * | * | * | * | * | * | * | NS |

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test* = Significant at 5% Level of significance NS = Non significance

**The interaction effect of gibberellic acid and varieties on yield contributing characteristics and yield of aromatic rice**

**Plant height**

Due to the interaction effect the significance difference were also found as shown in Table 3. The combination of $V_1$ x $G_3$ (BRRI dhan3 combined with 150ppm of $GA_3$) produced the highest plant height (114.0 cm) where the lowest plant were recorded from the combination of $V_4$ x $G_1$ (Tulsimal combined with 0ppm of $GA_3$) (101.7). Jamal *et al.* (2012) evaluated the effect of $GA_3$ on strawberry by using; 0 ppm, 75 ppm, 100 ppm and 150 ppm. They reported that 75 ppm were recorded for the tallest plant (31.4cm), the maximum number of leaves (11.1). Jabber and Alam (2002) carried out an experiment on growth and yield contributing characters by seed soaking of different boro rice cultivars with 0 ppm, 20 ppm and 30 ppm of TIBA, IAA, 6-Benzale and ABT-6. The treatment at 20ppm gave the best result. This treatment significantly increased the plant height compared to that of control. Abd-El-Fattah (1997) observed that foliar spray of GA3 increased plant height in aromatic rice. In another field experiment conducted on sunflower to study the effect of foliar spray of growth regulators (20 mg $L^{-1}$ each) in different combinations at 20 and *25* days after sowing, it was observed that IBA+ GA3 increased plant height (Kamaraj *et al.*, 1999).Talukdar and Paswan (1996) reported that all applied concentrations of GA3 significantly increased plant height in chrysanthemum with 40 mg L-1 being the most effective treatment. Soaking okra seeds in aqueous solution of 75 or 150 mg $L^{-1}$ GA3 for 24 hours at $25^0$ C significantly increased plant height compared to control (Kumer*et al*. 1996).

**Number of effective tillers plant $^{-1}$**

The interaction effect between the varieties and gibberellic acid concentration were also shown a significant difference (Table 3). The combination of $V_1$ (BRRI dhan34) and 75 ppm concentration of gibberellic acid were recorded as the highest number (14.33) of effective tillers where the lowest number (8.66) of effective tillers were recorded after the combination of $V_3$ (Kalizira) and $G_1$ ppm. control treatment. Deotale *et al*. (1998) reported that when soybean seeds were treated with 0-150 mg $L^{-1}$ GA3, the highest number of branches plant$^{-1}$was obtained at 100 mg $L^{-1}$. Uddin (1999) reported that the highest number of branches plant$^{-1}$was obtained at 150 and 200 mg $L^{-1}$ of GA3.

Number of non-effective tillers plant $^{-1}$

According to the interaction effect; the combination of V4 and $G_1$ (Tulshimala applied with no gibberellic acid) were recorded as highest number of non-effective tillers (1.66), which means only the varietal effect were significant were the application of gibberellic acid concentrations didn‟t have any effect to the number non-effective tillers plant $^{-1}$ (Table 3).

**Length of panicle**

The combination of $V_1$ and $G_3$ (BRRI dhan34 applied with 150 ppm concentration of gibberellic acid) were shown as the highest panicle length (29.33 cm), where the lowest panicle length were recorded for the combination of $G_1$ and $V_4$ (Tulshimala) applied with no gibberellic acid).

**Number of filled grain panicle$^{-1}$**

According to the interaction effect significant difference were also found to the number of filled grain panicle$^{-1}$ (Table 3). The combination of V1 and G2 (BRRI dhan34 applied with 75 ppm concentration of gibberellic acid) were recorded as the highest number (261.0) of filled grins panicle$^{-1}$, where the lowest number of filled grains panicle$^{-1}$ were recorded for the combination of $V_4$ $G_1$ (Tulshimala applied with no gibberellic acid). Haque (2002) observed that concentration of 0.33 mgl$^{-1}$ of $GA_3$ produced the highest filled grains (41.4) significantly higher over the treatment of $GA_3$ in rice. Awan and Alizai (1989) observed that application of 100 ppm of $GA_3$ on rice plants at panicle emergence stage significantly increased number of grains per panicle over untreated control. Singh *et al.* (1984) reported that application of 25 ppm $GA_3$ on rice showed effective on enhancing to the number of grains panicle$^{-1}$ and 1000 grain weight.

**Number of sterile grain per panicle**

The interaction effect of gibberellic acid and the varieties of aromatic rice, showed significant difference in the number of sterile grains panicle$^{-1}$ (Table3). The highest number of sterile grains panicle$^{-1}$ were found under the combination of $V_4$ and $G_1$ (Tulshimala applied with no gibberellic acid, where lowest number of sterile grains panicle$^{-1}$ were recorded for the combination of $V_1$ and $G_2$ (BRRI dhan34 applied with 75ppm concentration of gibberellic acid).

**1000 Grain weight**

According to the interaction effect between the gibberellic acid concentrations and the four varieties of aromatic rice, significance difference were also obtained towards the thousand grain weight (Table 3). The combination between $V_1G_3$ (BRRI dhan34 applied with 150 ppm concentration of gibberellic acid) were observed as the highest thousand grain weight (14.58 g), where combination between $V_1$ and $G_1$ (BRRI dhan34 applied with no gibberellic acid) were recorded as lowest (12.86 g).Singh *et al.* (1984) reported that application of 25 ppm $GA_3$ on rice showed effective on enhancing to the number of grains panicle$^{-1}$ and 1000 grain weight. Liupeng (1997) observed in a pot trial that rice plant sprayed with 120 ppm $GA_3$ at 5% panicle emergence stage increased 1000-grain weight. Increase in seed weight was found in grass pea with 25 mg L$^{-1}$ of GA3 (Rahman *et al.*, 1989). Increased 1000-grain weight was also reported in onion (Wagh and Deore. I 995).

**Grain yield (t ha$^{-1}$)**

According to interaction effect between the varieties and the application of gibberellic acid concentration among the grain yield, significant variations were also observe (Table 3). The combination between $V_1$ and $G_2$ (BRRI dhan34) applied with 75 ppm concentration of gibberellic acid. were observed as the highest grain yield (3.37 ton ha$^{-1}$), where combination between $V_4G_1$ (Tulshimala applied with no gibberellic acid) were observed as the lowest grain yield (1.52 ton ha$^{-1}$).

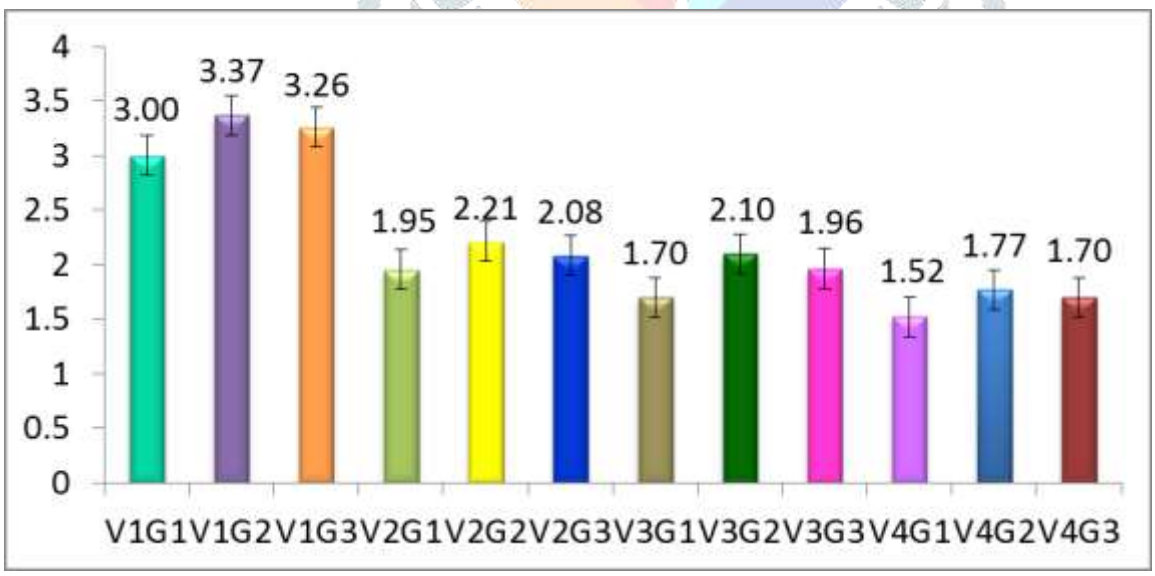


**Fig 3. Interaction effect of varieties and gibberellic acid on grain yield of aromatic rice**

Roy and Nasiruddin (2011) conducted an experiment to evaluate the effect of $GA_3$ on growth and yield of rice. Single factor experiment consisted of three concentrations of $GA_3$, viz., 0, 50, and 100 ppm. Significantly the minimum number of days to head formation and maturity was recorded with 50 ppm $GA_3$ and 50 ppm $GA_3$ gave the highest diameter cm of rice head while the lowest diameter cm of rice head was found in control (0 ppm GA3) treatment. The results revealed that the application of different concentrations of $GA_3$ as influenced independently on the growth and yield of rice. Significantly the highest yield (45.22kg/plot and 104.66 t/ha) was found from 50 ppm $GA_3$. Akand, *et al.* (2015) carried out an experiment to evaluate the effect of $GA_3$ on growth and yield of rice they used 0 ppm, 70 ppm, 90 ppm and 110ppm. They found out that 90 ppm of $GA_3$ gave the maximum (20.11cm) thickness and highest yield (62.55 t/ha) and $G_0$ gave the minimum thickness (18.21cm) and lowest yield (49.16 t/ha). Akter*et al.* (2007) conducted an experiment in pot house at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during Julay 2003 to December 2004 to evaluate the effects of Gibberellic Acid ($GA_3$) on growth, and yield of rice var. Binasarisha-3. Four concentrations viz., 0, 25, 50 and 75 ppm of $GA_3$ were sprayed on canopy at 30 days after sowing. They found that different levels of $GA_3$ significantly influenced the plant height, number of grain per

plot /plant, number of seeds, number of filled grain and harvest index. Results also revealed that $GA_3$ at 50 ppm significantly increased plant height, number of fertile grain plant, number of panicale per plant, dry matter yield, number of seeds per plant and harvest index, while the number of panicle plant was significantly increased with the application of 75 ppm $GA_3$. The highest grain yield plant was recorded from the application of 50 ppm $GA_3$ at optimum harvest date. The grain seed yield plant was positively correlated with plant height, number of seed grains number of fertile rice plant and % of setting rice plant. Jamal *et al.* (2012) evaluated the effect of $GA_3$ on rice by using; 0 ppm, 50 ppm, 75 ppm and 100 ppm. They reported that 75 ppm showed the best performance on growth and yield of rice. Application of $GA_3$ also increased the sweetness of the berries in comparison to control. Singh*et al* (2009) conducted an experiment aimed to study the effect of gibberellic acid ($GA_3$) on yield, floral and morphological traits in rice. The dose of 70 g/ha of GA3 was found optimum for increased seed yield and seed setting. Ranjan (2011) carried an experiment to study the effect of plant growth regulators using gibberellic acid ($GA_3$) on the physiological efficiency of *Boro* rice. The physiological parameters and their relation with growth and yield attributes were analysed in the experiment. The experiment consisted of four treatments *viz*., T1: application of 10 ppm $GA_3$ at early tillering stage, T2: application of 10 ppm $GA_3$ at panicle initiation, T3: application 10 ppm $GA_3$ at early tillering + at panicle initiation and T4: control. It was revealed that $GA_3$ applied on boro rice at different stages of growth had improved significantly the physiological traits namely biomass allocation, chlorophyll contents, reducing, non-reducing and total sugars, stomatal characters with significant effect on growth parameters leading to enhancement in grain yield. $GA_3$ applied at early tillering + panicle initiation stage was found to be superior over other treatments. Gibberellic acid treatment significantly increased the NR activity and made 17.68% higher photosynthetic contribution after flowering thereby enhanced 12.5% higher grain yield over control.

**Straw yield (t ha$^{-1}$)**

According to interaction effect between the varieties and gibberellic acid concentration among straw yield, significant difference were also observed (Table 3). The maximum straw yield were obtained under the combination between $V_3G_3$ (Kalizira) applied with 150 ppm concentration of gibberellic acid. (3.76 t ha$^{-1}$) while the lowest were also recorded under the combination of $V_4G_1$. (Tulshimala) combined with zero gibberellic acid. (2.23 t ha$^{-1}$).

**Biological yield (t ha$^{-1}$)**

According to the effect of interaction between the varieties and gibberellic acid concentrations significance difference were also observed among the biological yield (Table 3). The combination between $V_1$ and $G_2$ (BRRI dhan34) applied with 75 ppm concentration of gibberellic acid. were observed as the highest biological yield (5.16 to ha-$^{1}$), while the lowest (4.82 to ha$^{-1}$) biological yield were recorded under the combination of $V_4$ $G_1$ (Tulshimala) combined with zero gibberellic acid).

**Harvest index (%)**

In the case of interaction effect between the varieties and gibberellic acid concentrations significance difference were also observed among the harvest index (Table 3). The combination between $V_1$ and $G_2$ (BRRI dhan34) applied with 75 ppm concentration of gibberellic acid, were observed as the highest harvest index (35.4 %), while the owest(27.6%) harvest index were recorded under the combination of $V_2$ $G_3$ (Kataribhog) combined with zero gibberellic acid). Hoque (2001) noted that harvest index was increased by foliar spray of 100 mg L$^{-1}$ of GA3 on Aromatic rice. According to Poehlman (1991), a high harvest index does not contribute to high yields; high yield is determined by the physiologic processes leading to a high net accumulation of photosynthetic and its partitioning into plant and seed.

**Table 3: Interaction effect of varieties and gibberellic acid to yield and yield contributing characters of aromatic rice**

| Interaction Variety × ($GA_3$) | Plant height (cm) | Number of effective tillers (No.) | Number of non-effective tillers (No.) | Length of panicle (cm) | Number of filled grain per panicle (No.) | Number of sterile grain per panicle (No.) | 1000 Grain weight (gm) | Straw yield ton/ha | Biological yield ton/ha | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| V1GA1 | 101.7 d | 10.00 cd | 1.0 b 0 | 26.00 bc | 222.7 c | 13.67 ef | 12.86 bc | 3.3 fg 2 | 4.82 gh | 31.1 |
| V1GA2 | 109.3 b | 14.33 a | 1.0 b 0 | 27.0 b 0 | 261.0 a | 10.00 h | 14.87 bc | 3.33 def | 5.16 b | 35.4 |
| V1GA3 | 114.0 a | 11.67 b | 1.0 b 0 | 29.33 a | 24 b 0 | 12.00 g | 14.58 a | 3.4 cd 4 | 5.00 f | 31.2 |
| V2GA1 | 122.0 e | 7.66 f | 1.0 b 0 | 21.6 f 7 | 197.3 f | 16.67bc | 13.93 bc | 2.9 d 6 | 4.26 h | 30.5 |
| V2GA2 | 144.7 c | 10.33 c | 1.0 b 0 | 23.00 e | 23 b 4 | 13.00 fg | 15.27 ab | 3.5 c 6 | 5.12 d | 30.4 |
| V2GA3 | 154.7 b | 9.33 cde | 1.0 b 0 | 25.00cd | 219.3cd | 14.67 de | 12.87 bc | 3.6 b 7 | 5.07 ef | 27.6 |
| V3GA1 | 124.0 e | 8.66 e | 1.0 b 0 | 21.67 f | 193.3 f | 16.33 bc | 12.81 bc | 2.90 de | 4.13 c | 29.7 |
| V3GA2 | 143.0 c | 11.33 b | 1.0 b 0 | 24.00 de | 235.3 b | 13.33ef g | 13.80 bc | 3.5 b 3 | 5.13 i | 31.1 |
| V3GA3 | 155.3 b | 10.00cd | 1.0 b 0 | 25.67 c | 221.0 c | 14.33de f | 12.3 c 7 | 3.7 a 6 | 5.22 a | 27.9 |
| V4GA1 | 142.0 e | 6.66 g | 1.66 a | 18.3 g 3 | 172.3 g | 19.33 a | 12.93 bc | 2.23 i | 3.16 k | 29.4 |
| V4GA2 | 145.3 c | 9.00 de | 1.00 b | 21.33 f | 209.3 de | 15.67 cd | 13.70ab c | 2.9 h 3 | 4.26 h | 31.2 |
| V4GA3 | 156.0 b | 7.66 f | 1.66 a | 24.00 de | 201.0 ef | 17.67 b | 12.73 bc | 2.6 f 3 | 3.89 g | 32.3 |
| LSD | 3.081 | 0.92 | 0.38 | 1.242 | 10.08 | 1.47 | 1.28 | 0.11 | 0.18 | 1.86 |
| CV % | 1.27 | 5.64 | 20.23 | 3.07 | 2.74 | 5.90 | 5.72 | 2.16 | 2.36 | 3.54 |
| Level of significance | * | * | * | * | * | * | * | * | * | * |

In a column, figure bearing same or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test * = Significant at 5% Level of significance

## Conclusions

An experiment was conducted at the Agronomic research field, Hajee Mohammad Danesh Science and Technology University, HSTU Bangladesh. During the period from July to December 2017 find out the effect of variety, Gibberellic acid grain yield in rice. The experiment included four varieties (V1=BRRI dhan34, $V_2$= Kataribhog, $V_3$=Kalizira, and $V_4$= Tulshimala). Three levels of Gibberellic acid. 0, 75ppm and 150ppm.respectively, the experiment was laid out in Randomized Completely Block Design (RCBD) with three replications. The whole experiment area was divided into three blocks. Each block was subdivided into twelve plots. The size of each unit plot was 4 m ×2.5 m. The total number of unit plots was 36. The replications were separated from one another by 1m. The distance between plots was 0.5 m. The treatments were randomly distributed into the plots of each replication. Data on growth and yield contributing parameters were recorded and the collected data were statistically analyzed to evaluate the treatment effects. The summary of results has been presented in this chapter, and data recorded were plant height, number of effective tiller, number of non-effective tiller, number of panicle, number of filled grain per panicle, number of sterility grain per panicle, 1000-grain weight, grain yield, straw yield, biological yield and harvest index. All the data were statistically analyzed and mean differences were adjudged by Duncan's Multiple Range Test (DMRT). So, from the present study it may be concluded that The significant variations existed among the varieties in respect of yield contributing characters and RRRI dhan34 and Kataribhog performed the superior and inferior results, respectively and ranked as RRRI

dhan34> Kalizira> Tulshimala > Kataribhog. BRRI dhan34 along with 75 ppm of concentration was significantly produced higher yield and yield contributing characters of aromatic rice among all of the treatment combinations. It may be concluded that application of $GA_3$ 75 ppm could be an appropriate, feasible and economic strategy for increasing the yield of aromatic rice cultivation in Bangladesh.

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