International Journal of Agriculture and Medicinal Plants
Volume 1(1): 1-9, 2020

Morpho-physiological characteristics and yield attributes of three aromatic rice cultivars in response to 6-BAP

Bikash C Sarker*, Pobitra Rani Minjee, Zannata Uma Nisu, Md Jahidul Islam and Md Jafar Ali

Department of Agricultural Chemistry, Faculty of Agriculture, Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh

Research article

Article history

Received: 07.09.2020
Accepted: 10.12.2020

Published:
Online: 31.12.2020

***Corresponding author:**
bikash@hstu.ac.bd

www.isciencepub.com

ABSTRACT

A field experiment was conducted to study the effect of 6-Benzyl aminopurine (6-BAP) on growth, physiology, yield and yield attributes of three aromatic rice cultivars cv. Chinigura, Kataribhog and Kalijira. The 6-BAP was applied 0, 20, 40, 60 and 80 ppm at vegetative and pre flowering stages. There was a significant variation among the cultivars and different levels of 6-BAP on both vegetative and harvesting stage on tillers hill^{-1}, leaf length, root depth, panicle length, effective and non-effective tillers hill^{-1}, grain yield, harvesting index, chlorophyll-a, chlorophyll-b, total chlorophyll content, and proline content except straw yield and 1000-grain weight. The highest plant height (172.9 cm) was in cv. Chinigura with 60 ppm 6-BAP. The highest panicle length was found in Chinigura with 20 ppm 6-BAP and the lowest was found in Kataribhog with control treatment. The maximum number of grains panicle^{-1}(287) was found in Kataribhog treated with 60 ppm 6-BAP and the minimum number of grains (241.1) in Chinigura under the control. The maximum amount of chlorophyll-a (24.59 mg g^{-1} FW) was in Chinigura with 60 ppm 6-BAP and the lowest amount (14.87 mg g^{-1} FW) was recorded in Kataribhog with 20 ppm 6-BAP. The highest amount of total chlorophyll content (25.95 mg g^{-1} FW) was in Chinigura with 60 ppm 6-BAP while the lowest amount (18.35 mg g^{-1}) was in Kalijira with 80 ppm 6-BAP. The highest proline content (0.353 mg g^{-1} FW) was recorded in Chinigura with 20 ppm 6-BAP. The Kataribhog produced the highest yield (1.67 t ha^{-1}) treated with 60 ppm 6-BAP. The spraying 60 ppm 6-BAP had the better stimulation on the growth and yield of Kataribhog while 80 ppm for Chinigura. The study infers that 6-BAP enhanced yield of aromatic rice cv. Chinigura which might be an alternative eco-friendly management practices in rice farming business.

Keywords: Aromatic rice, 6-BAP, chlorophyll, foliar spray, growth, yield

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple cereal food for about half portion of the world's populace. The annual production and consumption in Asia is approximately 90%, but average yield of rice grain in this region is low compared to global average yields (Haider 2018). Bangladesh is the 4th largest rice growing country of the world based on rice growing area and production including coarse and fine aromatic rice (BBS 2016). Aromatic rice contributes a little but unique group of rice and has increased greater significance with the overall increment in the demand for fine quality rice. Now a day, aromatic rice has been introduced to the global market. In recent years, the demand of aromatic rice is gradually increasing markedly for both local and global market. Interestingly, the aromatic rice regularly has unfortunate agronomic characters, for example, low yield, weakness to nuisances and ailments, and solid shedding (Faruq et al. 2011).

Use of the plant growth regulators (PGRs) in rice has been one of the most potential tools for increasing crop production. PGR as either naturally or synthetic compounds that are applied directly to a target plant to alter its physiological processes or its structure to improve quality, increase yields, or facilitate harvesting

To cite this article: Sarker BC, Minjee PR, Nisu ZU, Islam MJ and Ali MJ. 2020. Morpho-physiological characteristics and yield attributes of three aromatic rice cultivars in response to 6-BAP. Intl. J. Agric. Med. Plants. 1(1):1-9.

control, undesirable vegetative growth of crop plants, enhancing fruiting bodies. Similar PGRs are active in different stages of the same plant in different ways. An exogenous application of plant growth regulators affects the endogenous hormonal pattern of the plant, either by supplementation of sub-optimal levels or by interaction with their synthesis, translocation or inactivation of existing hormone levels. Hormones regulate physiological process and synthetic growth regulators may enhance growth and development of field crops thereby increased total dry mass of a field crop (Das and Das 1996, Chibu et al. 2000, Cho et al. 2008).

Application of 6-BAP found to increase plant height, number of leaves plant^{-1}, natural product measure with resulting upgrade in seed yield in various plants. The uses of growth substances such as 6-benzyl aminopurine (6-BAP), NAA, GA_3 and some others at different concentrations increased aromatic rice grain production (Sarker et al. 2020). It is certain that endogenous and exogenous plant development controllers assume a vital job in adjusting and directing numerous physiological procedures in plants and these procedures are significantly affected by natural conditions. Although some exploration works were done and a few high yielding aromatic rice cultivars were released by Bangladesh Rice Research Institute, our indigenous cultivars were given less attention and their yielding ability was not studied well by using plant growth regulators. Research on aromatic rice using 6-BAP is limited in Bangladesh. Findings in using different PGRs for increasing rice yield in some countries that certainly provide valuable information; those can't be prescribed without preliminary field trial in Bangladesh. Therefore, more researches are necessary to investigate the efficacy of 6-BAP on aromatic rice production. Thus, the objective is to study the growth characteristics, physiology and yield potentials of three selected aromatic rice cultivars in response to 6-BAP.

MATERIALS AND METHODS

A field study was conducted at the research farm of the Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh during *Aman* season (July to December, 2017). The experimental area possesses subtropical climatic condition. The air temperature was relatively high (25-32ºC) at the beginning of the season and was decreasing (20-26ºC) with advancement of the season towards aman with occasional gusty winds. The experiment was laid out in a factorial randomized complete block design (RCBD) with three replications. The experiment comprised three aromatic rice cultivars namely, Chinigura (V_1), Kataribhog (V_2), Kalijira (V_3) and five levels of 6-BAP at the rate of 0 ppm (T_1, control), 20 ppm (T_2), 40 ppm (T_3), 60 ppm (T_4) and 80 ppm (T_5) spraying twice at vegetative and pre-flowering stages. The solution of BAP 0, 20, 40, 60, and 80 ppm was prepared by dissolving 0, 20, 40, 60, and 80 mg of 6-BAP powder in a litre measuring cylinder in which 5 mL of ethanol prior to dilution was made in distilled water for quick miscible. Forty-day old healthy seedlings were transplanted on puddle plots on 10 July, 2017 according to the experimental design. Three seedlings of the selected aromatic cultivars were transplanted in each hill with a spacing of 15 cm×20 cm.

The data on different growth parameters like plant height, leaf number plant^{-1}, leaf blade length, tillers hill^{-1} were recorded at seedling, vegetative and harvesting stages. The physiological characteristics like flag leaf chlorophyll-a, chlorophyll-b, total chlorophyll and total carotenoid content were estimated by acetone extract method following Arnon (1949) while proline at flowering stage was estimated by Bates et al. (1973). The yield and yield contributing parameters- panicle length, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, grains panicle^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, 1000-grain weight, grain yield (t ha^{-1}), straw yield (t ha^{-1}), and harvest index (%) were recorded at harvest. The data were statistically analyzed to compare treatment means using the MSTAT-C package. If the treatments were significant the differences between pairs of means were compared by LSD followed by DMRT.

RESULTS AND DISCUSSION

The height of rice plant at different growth stages was markedly influenced by the application of 6-BAP in aromatic rice cultivars which have been presented in Table 1. Result shows that highest plant height was 125.1 cm in $V_1 \times T_4$ at their vegetative stage. At harvest, the highest plant height was observed in $V_1 \times T_4$ and $V_1 \times T_3$ (172.9 cm) which was statistically identical to $V_1 \times T_1$ and $V_1 \times T_2$ (168.7 and 170.4 cm), respectively. The lowest plant height (143.1 cm) was recorded in $V_2 \times T_1$. The plant height of V_1 was more taller than V2 followed by V3 plants. The shorter plant is an important desirable index for lodging resistance and remains stand against strong wind. Khanam (2016) reported that application of 6-BAP showed better performance on plant height of Kataribhog than those of other two cultivars (Chinigura and Kalijira) studied at both vegetative and harvesting stages.

Result showed that the leaf blade length was insignificant at their vegetative stage but harvesting stage. The leaf blade length of three aromatic rice cultivars at harvesting stage was influenced by the application of 6-BAP which have been presented in Table 1. The longest leaf blade (60.45 cm) was observed in $V_1 \times T_5$ which was at par with $V_1 \times T_4$ (60.44 cm) while the shortest leaf blade (51.22 cm) was 51.22 cm in ($V_3 \times T_5$) which was also statistically identical with $V_3 \times T_1$ (51.67 cm).

Table 2 shows the number of leaves produced by the three aromatic rice cultivars in the present study. There was no significant effect of 6-BAP on the number of leaves in three different cultivars. The root depth of three aromatic rice cultivars at different growth stages was influenced by the application of 6-BAP which are shown in Table 2. Among the aromatic rice cultivars, Kataribhog and Chinigura showed better performance to extend root in the soil and 6-BAP treatments had no significant effect. The highest root depth was observed 20.67cmin $V_1 \times T_3$ while the lowest root depth was 14.11 cm in $V_3 \times T_3$ plants. Khanam (2016) revealed that highest root depth was obtained from Kataribhog rice cultivar spraying at 200 ppm 6-BAP.

The major chlorophylls in flag leaf of aromatic rice is chlorophyll-a, which has a methyl group at C-3 carbon, and chlorophyll-b, which a formal group is bonded to the same carbon atom. Table 3shows that, there is a significant effect among the cultivars, levels and interaction on chlorophyll-a, chlorophyll-b, total chlorophyll and proline content of flag leaves in studied three cultivars of aromatic rice. Cultivar Chinigura contained the highest chlorophyll-a among the three cultivars studied and spraying of 60 ppm showed the better stimulating effect. The maximum amount of chlorophyll-a was in V1×T4 (24.59 mg g-1FW) and the lowest amount was found inV2 × T2 (14.87 mg g-1FW).

Chlorophyll-b absorbs energy from wavelengths of green light at 640 nm. It is the accessory pigment that collects energy and passes it on to chlorophyll-a. It also regulates the size of antenna and is more absorbable than chlorophyll-a. Thus, chlorophyll-a is the primary photosynthetic pigment while chlorophyll-b is the accessory pigment that collects energy. Therefore, the amounts of chlorophyll-b in flag leaves of rice plant have a significant impact on the production of photosynthate resulting in grain production. Maximum chlorophyll-b was 5.913 mg g-1 FW in V3×T1 which was statistically identical with V1×T1 (4.04 mg g-1) and the lowest amount was found in V2×T5 (3.68 mg g-1 FW).

Table 1. Plant height and leaf blade length of three aromatic rice cultivars under different levels of 6-BAP

Treatment	Plant height		Leaf blade length	
	Vegetative stage	Harvesting stage	Vegetative stage	Harvesting stage
V1×T1	122.0 abc	168.7 ab	32.31	58.11 abc
V1×T2	119.7 bc	170.4 ab	31.77	58.44 ab
V1×T3	118.3 c	172.9 a	29.21	58.56 ab
V1×T4	125.1 a	172.9 a	30.98	60.44 a
V1×T5	123.3 abc	167.0 b	31.68	60.45 a
V2×T1	122.5 abc	143.1 f	31.14	53.56 cd
V2×T2	120.3 abc	148.9 c-f	30.03	57.67 abc
V2×T3	121.2 abc	152.1 c	31.20	57.22 abc
V2×T4	120.3 abc	150.2cde	30.66	56.67 abc
V2×T5	124.6 ab	144.4 ef	30.38	57.22 abc
V3×T1	121.3 abc	147.3 c-f	31.29	51.67 d
V3×T2	122.1 abc	147.4 c-f	30.30	54.22 bcd
V3×T3	124.6 ab	145.6 def	30.73	56.45 abc
V3×T4	120.2 abc	150.3 cd	30.49	56.22 abc
V3×T5	119.4 bc	148.0 c-f	29.32	51.22 d
LSD	4.467	5.087	3.255	4.103
CV %	2.91	1.96	6.33	4.34
Level of significance	*	*	ns	*

Mean followed by the same letter (ns) did not differ significantly at 5% level of DMRT. Where, *= 5% level of significance, ns= not significant

The interaction effect between cultivars and 6-BAP levels regarding total chlorophyll content also statistically significant which is presented in Table 3. Among the BAP levels applied, 60 ppm (T_4) BAP showed the better performance on Chinigura. From the interaction, the highest total chlorophyll content was 25.95 mg g^{-1} with $V_1 \times T_4$ and the lowest value was $V_3 \times T_5$ (18.35 mg g^{-1}) which was statistically identical with $V_2 \times T_3$ (18.72 mg g^{-1} FW).

Regarding proline content in flag leaves, there were significant differences among the varieties, BAP levels as well as interactions (Table 3). Spraying 20 ppm of BAP at pre-flowering stage, Chinigura produced more proline in comparison to others two varieties. From the

Table 2. Leaf number, root depth and tiller number of three aromatic rice cultivars under different levels of 6-BAP

Treatment		Leaf number		Root depth	Tillers hill^{-1}
		Vegetative stage	Harvesting stage	Harvesting stage (cm)	Harvesting stage
Cultivars	V1	3.735	4.509	18.78 a	17.20 b
	V2	3.735	4.486	17.44 a	19.33 a
	V3	3.533	4.509	14.78 b	17.89 b
	LSD	0.1689	0.3702	1.343	1.194
	CV %	6.18	10.99	10.57	8.8
6-BAP levels	T1	3.668	4.739	18.00 a	16.63 b
	T2	3.631	4.516	16.81 a	17.93 b
	T3	3.631	4.369	16.15 a	18.22 b
	T4	3.668	4.293	17.56 a	19.93 a
	T5	3.741	4.590	16.48 a	18.00 b
	LSD	0.2181	0.478	1.734	1.542
	CV %	6.18	10.99	10.57	8.8
Interaction	V1×T1	3.667	4.777	18.22 a-e	15.33 c
	V1×T2	3.780	4.660	18.89 abc	17.22 bc
	V1×T3	3.670	4.333	20.67 a	17.44 bc
	V1×T4	3.780	4.220	18.33 a-d	19.22 ab
	V1×T5	3.777	4.553	17.78 a-f	16.78 bc
	V2×T1	3.780	4.663	18.45 a-d	18.89 ab
	V2×T2	3.557	4.443	16.44 b-g	19.22 ab
	V2×T3	3.670	4.440	16.11 c-g	19.33 ab
	V2×T4	3.780	4.220	19.78 ab	21.00 a
	V2×T5	3.890	4.663	16.45 b-g	18.22 abc
	V3×T1	3.557	4.777	14.89 efg	15.67 c
	V3×T2	3.557	4.443	15.11 d-g	17.33 bc
	V3×T3	3.553	4.333	14.11 g	17.89 bc
	V3×T4	3.443	4.440	14.56 fg	19.55 ab
	V3×T5	3.557	4.553	15.22 d-g	19.00 ab
	LSD	0.3777	0.8279	3.004	2.67
	CV %	6.18	10.99	10.57	8.8

Mean followed by the same letter (ns) did not differ significantly at 5% level of DMRT interaction, the maximum proline content was 0.353 mg g^{-1} found in $V_1 \times T_2$ and the lowest was 0.2633 mg g^{-1} in $V_2 \times T_4$ which was statistically identical with $V_2 \times T_3$ (0.277 mg g^{-1} FW), $V_2 \times T_5$ (0.270 mg g^{-1} FW), and $V_3 \times T_3$ (0.273 mg g^{-1} FW), respectively. NAA while cv. Kataribhog showed better performance at 100 ppm and Kalijira showed better performance at 200 ppm of NAA, respectively (Sarker et al. 2020).

Number of effective tillers hill^{-1}: There was a significant variation among the cultivars and levels of aromatic rice on the production of effective tiller hill^{-1}. Among the cultivars, cv. Kataribhog had the higher number of effective tiller hill^{-1} while spraying with 60 ppm (T_4) 6-BAP at vegetative and pre flowering stages. From the interaction, the maximum number of effective tiller hill^{-1} was found in $V_2 \times T_4$ (18.78) and the lowest number of tiller hill^{-1} was in $V_1 \times T_1$ (14.22) in the controlled plot. Khanam (2016) reported that the highest number of effective tillers hill^{-1}wasfrom Kataribhog rice cultivar while 100 ppm 6-BAP was applied.

Number of non-effective tiller: Spraying different levels of 6-BAP on non-effective tillers hill^{-1} was significant which presented in Table 4. The non-effective tillers hill^{-1} reduced due to effect of 6-BAP. Result showed that maximum non-effective tiller was in $V_2 \times T_4$ (2.22) which was statistically identical with $V_2 \times T_5$ (2.22). The result was in agreement with Khanam (2016) that the highest number of non- effective tillers hill^{-1} from Kataribhog rice at control treatment.

Table 3. Chlorophyll and proline content of flag leaf of three aromatic rice cultivars under different levels of 6-BAP

Treatments		Chl-a	Chl-b	Total chlorophyll	Proline
		(mg g^{-1} FW)			
Cultivars	V1	19.49 a	5.389 a	23.53 a	0.3293 a
	V2	16.24 b	4.481 b	20.61 b	0.2807 b
	V3	16.15 b	4.539 b	19.87 b	0.2940 b
	LSD	1.368	0.5755	1.703	0.02365
	CV %	10.57	16.02	10.67	12.58
Treatments (6-BAP levels)	T1	16.74 b	4.729 ab	21.23 ab	0.3000 ab
	T2	16.06 b	5.166 a	20.85 b	0.3256 a
	T3	17.02 b	4.759 ab	20.70 b	0.2978 ab
	T4	19.44 a	5.223 a	23.22 a	0.2989 ab
	T5	17.20 b	4.139 b	20.68 b	0.2844 b
	LSD	1.766	0.7430	2.199	0.03054
	CV %	10.57	16.02	10.67	12.58
Interaction	V1×T1	17.90 bc	5.620 ab	24.42 ab	0.3100 a-d
	V1×T2	17.16 bc	5.360 abc	21.52 bcd	0.3533 a
	V1×T3	19.65 b	5.913 a	23.59 abc	0.3433 abc
	V1×T4	24.59 a	5.357 abc	25.95 a	0.3500 ab
	V1×T5	18.15 bc	4.693 a-d	22.18 a-d	0.2900 bcd
	V2×T1	15.44 c	4.207 bcd	19.98 bcd	0.2900 bcd
	V2×T2	14.87 c	5.450 abc	20.12 bcd	0.3033 a-d
	V2×L3	15.20 c	4.523 a-d	18.72 d	0.2767 d
	V2×T4	18.21 bc	4.543 a-d	22.74 a-d	0.2633 d
	V2×T5	17.48 bc	3.683 d	21.50 bcd	0.2700 d
	V3×T1	16.89 bc	4.067 cd	19.29 cd	0.3000 a-d
	V3×T2	16.13 bc	4.687 a-d	20.92 bcd	0.3200a-d
	V3×T3	16.21 bc	4.133 bcd	19.80 cd	0.2733 d
	V3×T4	15.53 c	5.770 a	20.98 bcd	0.2833 cd
	V3×T5	15.98 c	4.040 cd	18.35 d	0.2933 a-d
	LSD	3.058	1.287	3.808	0.053
	CV %	10.57	16.02	10.67	12.58

Mean followed by the same letter (ns) did not differ significantly at 5% level.

Grains panicle^{-1}: There is a significant effect of 6-BAP on the cultivars and grain –number per panicle was statistically varied due to application of different levels of 6-BAP. Among the cultivars, Kataribhog spraying with 40 ppm 6-BAP (T_4) showed the better performance to produce grain number per panicle. The interaction effect of 6-BAP and cultivars was also significant for producing grain number per panicle (Table 4). The highest number of grains panicle^{-1} (287.0) was observed at $V_2 \times T_4$ while the lowest one (241.1) was recorded in$V_3 \times T_1$ .In this study 40 ppm BAP on cv. Chinigura showed better performance on

Table 4. Effect of cultivar, 6-BAP levels and their interaction on yield contributing characters of aromatic rice

Treatments		Panicle length (cm)	Number of effective tillers	Number of non effective tillers	Grains panicle^{-1}	1000-grain weight. (g)
Cultivars	V1	28.63 a	15.78 b	1.421 b	263.9 ab	10.93 ns
	V2	27.69 ab	17.31 a	2.022 a	274.0 a	10.73 ns
	V3	27.27 b	16.31 ab	1.576 b	255.1 b	11.00 ns
	LSD	1.151	1.163	0.3687	10.94	0.3922
	CV %	5.52	9.44	29.47	5.54	4.81
Treatments (6-BAP levels)	T1	26.55 b	15.30 b	1.333 b	254.6 b	10.78 ns
	T2	28.52 a	16.04 b	1.889 a	263.1 ab	10.78 ns
	T3	28.42 a	16.78 ab	1.442 ab	275.6 a	10.67 ns
	T4	28.46 a	18.04 a	1.888 a	268.5 ab	11.22 ns
	T5	27.37 ab	16.19 b	1.813 ab	259.8 b	11.00 ns
	LSD	1.487	1.501	0.4760	14.13	0.5064
	CV %	5.52	9.44	29.47	5.54	4.81 ns
Interaction	V1×T1	27.00 bc	14.22 d	1.113 b	257.4 abc	10.67 ns
	V1×T2	30.22 a	15.33 bcd	1.887 ab	269.0 abc	11.00 ns
	V1×T3	29.15 ab	16.22 a-d	1.220 b	276.1 ab	11.00 ns
	V1×T4	29.14 ab	17.78 ab	1.443 ab	265.7 abc	11.00 ns
	V1×T5	27.66 abc	15.33 bcd	1.443 ab	250.1 bc	11.00 ns
	V2×T1	25.78 c	17.11 a-d	1.777 ab	264.1 abc	10.67 ns
	V2×T2	28.45 abc	17.22 a-d	2.003 ab	263.7 abc	10.33 ns
	V2×T3	29.45 ab	17.45 abc	1.887 ab	277.0 ab	10.33 ns
	V2×T4	27.67 abc	18.78 a	2.223 a	287.0 a	10.33 ns
	V2×T5	27.11 bc	16.00 a-d	2.220 a	278.0 ab	11.33 ns
	V3×T1	26.89 bc	14.55 cd	1.110 b	241.1 c	11.00 ns
	V3×T2	26.89 bc	15.56 bcd	1.777 ab	256.6 bc	11.00 ns
	V3×T3	26.67 bc	17.67 a-d	1.220 b	263.8 abc	11.00 ns
	V3×T4	28.56 abc	17.56 abc	1.997 ab	262.9 abc	10.67 ns
	V3×T5	27.33 abc	17.22 a-d	1.777 ab	251.3 bc	11.33 ns
	LSD	2.575	2.600	0.8245	24.47	0.8771
	CV %	5.52	9.44	29.47	5.54	4.81

Mean followed by the same letter (ns) did not differ significantly at 5% level.

Table 5. Effect of cultivars, 6-BAP levels and their interaction on yield and harvest index of aromatic rice

	Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
Cultivars	V1	0.8775 c	3.016	22.49 c
	V2	1.394 a	2.989	31.62 a
	V3	1.124 b	2.962	27.48 b
	LSD	0.1229	0.2828	1.789
	CV %	14.47	12.66	8.79
Treatments (6-BAP levels)	T1	0.9998 b	2.833	26.11 a
	T2	1.074 b	3.000	26.30 a
	T3	1.171 ab	2.992	27.84 a
	T4	1.296 a	3.231	28.34 a
	T5	1.120 b	2.889	27.38 a
	LSD	0.1587	0.3652	2.309
	CV %	14.47	12.66	8.79
Interaction	V1×T1	0.8053 ef	2.805	22.46 de
	V1×T2	0.8887 def	3.055	22.48 de
	V1×T3	0.9443 c-f	3.083	23.44 cde
	V1×T4	0.9993 c-f	3.250	23.48 cde
	V1×T5	0.7497 f	2.888	20.57e
	V2×T1	1.111 cde	2.805	28.56 b
	V2×T2	1.194 cd	2.972	28.66 b
	V2×T3	1.500 ab	2.916	33.63 a
	V2×T4	1.666 a	3.278	33.80 a
	V2×T5	1.500 ab	2.972	33.46 a
	V3×T1	1.083 cde	2.888	27.31 bc
	V3×T2	1.138 cd	2.972	27.78 bc
	V3×T3	1.068 cde	2.977	26.28 bcd
	V3×T4	1.222 bc	3.167	27.92 b
	V3×T5	1.111 cde	2.805	28.10 b
	LSD	0.2748	0.6325	3.999
	CV %	14.47	12.66	8.79

Mean followed by the same letter (ns) did not differ significantly at 5% level.

grains panicle^{-1}of rice cultivar. Cultivar Kataribhog showed better performance at 60 ppm and Kalijira showed better performance at 40 ppm 60 ppm of 6-BAP than that of other levels. Sarker et al. (2020) stated that 150 ppm NAA on Kalijira showed better performance on grainspanicle^{-1} of rice cultivar than those of cv. Chinigura and cv. Kalijira. Similar result was reported by Roxy (2016) who noted that50 ppm BAP increased the grainspanicle^{-1} in Kataribhog.

1000-Grain weight: There is a no significant effect of 6-BAP on 1000-grain weight either in the varieties or levels also among the interaction of cultivars and levels (Table 4). 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 aromatic rice cv. Begunbitchi, Chinigura and Kalijira and reported that Chinigura produced the highest 1000-grain weight. Rahman et al. (2012) revealed that 100 ppm NAA with 1.0 ton lime residual effect showed the best performance of yield contributing characters in

Kataribhog rice such as number of filled grain, 1000-grain weight and grain yield.

Grain yield: The studied aromatic rice cultivars and different levels of 6-BAP were interacted significantly with each other in respect to grain yield which was presented in Table 5. There was also a significant effect among the cultivars and different levels of 6-BAP. All the cultivars produced lower yield in controlled plants than those of BAP treated plants. Among the cultivars, Kataribhog applying 60 ppm 6-BAP showed the better stimulating effect on grain production. Kataribhog produced the highest grain yield (1.67 t ha^{-1}) using 60 ppm BAP while the lowest yield (0.75 t ha^{-1}) was obtained in Kalijira under control. It was observed that the average yield of grain was relatively lower than the national average (1.90 t ha^{-1}) might be due to sudden stormy wind and heavy showering resulting lodging and poor grain formation. In the present study, 6-BAP effect was variable on the three aromatic rice cultivars regarding the grain yield. Chinigura showed better performance at 80 ppm, while Kataribhog and Kalijira performed at 60 ppm, respectively. Application of 6-BAP significantly increased yield and yield components of aromatic rice (Roxy 2016, Khanam 2016).

Straw yield: There is no significant effect of BAP on straw yield of the aromatic rice cultivars (Table 3). Several authors found that there was no positive effect of BAP (Roxy 2016) and NAA (Rahman et al. 2017) application on straw yield of different rice cultivars.

Harvest index (%): The harvest index (%) is an important yield determining character which can through idea along partitioning efficiency. Table 5 showed that harvest index was not influenced due to the interaction effect of cultivar, and levels of 6-BAP.Among the cultivars, Kataribhog showed the better performance and BAP treatments had no significant effect of %HI. From the interaction, the highest harvest index $V_2 \times T_4$ (33.80%) which was statistically similar with $V_2 \times T_3$ (33.66 %) and $V_2 \times T_5$ (33.46 %), respectively. The lowest %HI was found in $V_1 \times T_5$ (20.5 7%). Roxy (2016) found that the highest harvest index 39.24% at 50 ppm 6-BAP. Khanam (2016) reported that 100 ppm 6-BAP produced highest harvest index. Rahman (2017) found the highest harvest index (49.60%) which obtained from BRRI dhan28 with 100 ppm NAA and the lowest harvest index (42.01%) which obtained from the Nerica-4 without GA_3 or NAA.

CONCLUSION

It is concluded that growth and physiological parameters of aromatic rice cultivars were increased by the twice application of 6-BAP. Most of the yield and yield contributing parameters quantitatively increased by the concentration of 60 ppm BAP on Kataribhog rice cultivar than that of Chinigura and Kalijira. In regard to all parameters, application of 60 ppm BAP on Kataribhog rice cultivar performed the best regarding the yield and yield components. It is concluded that aromatic rice Kataribhog and Kalijira showed better performance at 60 ppm while Chinigura showed better performance at 80 ppm and may the recommended for the farmers' level BAP, a growth regulator might be useful to increase aromatic rice production which is an environment-friendly tool for agricultural management practices. BAP, a plant growth regulator might be useful to increase aromatic rice production which is an environment-friendly tool for fine rice farming practices.

REFERENCES

Almela L, Fernandez-Lopez JA and Roca MJ. 2000. High-performance liquid chromatographic screening of chlorophyll derivatives produced during fruit storage. Journal of Chromatography. 870: 483-489.

Arnon DI. 1949. Copper enzymes in isolated chloroplasts, polyphenol oxidase in *Beta vulgaris* L. Plant Physiology. 24: 1-15.

Bakhsh I, Awan IU, Baloch MS, Khan EA and Khakwani AA. 2012. Effect of plant growth regulator (NAA) and irrigation regimes on yield of transplanted coarse rice. Sarhad Journal of Agriculture. 28(4): 539-544.

Bates LS, Waldren RP and Teare ID. 1973. Rapid determination of free proline for water stress studies. Plant and Soil. 39: 205-207.

BBS (Bangladesh Bureau of Statistics). 2016. The Year Book of Agricultural Statistics of Bangladesh. Stat. Div. Ministry of Planning.Govt. Peoples Republic of Bangladesh, Dhaka. pp. 96.

Chibu H, Shibayama H, Mitsutomi M and Arima S. 2000.Effects of chitosan application on growth and chitinase activity in several crops.Marine and Highland Bioscience Center Report. 12: 27-35.

Cho MH, No HK and Prinyawiwatkul W. 2008. Chitosan treatments affect growth and selected quality of sunflower sprouts. Journal of Food Science. 73: 570-577.

Das BC and Das TK. 1996. Studies on the response of GA_3, NAA and Ethrel on the vegetative growth and yield of pumpkin. Orisssa Journal of Horticulture. 24: 74-78.

Faruq G, Yin YH, Masitah A, Afnierna N, Majid NA, Khalid N and Osman M. 2011. Analysis of aroma and yield components of aromatic rice in Malaysian tropical environment. Australian Journal of Crop Science. 5(11): 1318-1325.

Haider IK. 2018. Appraisal of biofertilizers in rice: To supplement inorganic chemical fertilizer. Rice Science.25: 357–362.

Kabir ME, Kabir MR, Jahan MS and Das GG. 2004. Yield performance of three aromatic fine rice in a coastal medium high land. Asian Journal of Plant Sciences. 3(5): 561-563.

Khanam N. 2016. Growth, leaf chemical parameters and yield of aromatic rice cv. Chinigura under different levels of 6-BAP. M.S. Thesis. Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

Lee HS. 1990. Effect of pre-sowing seed treatment with GA_3 and IAA on flowering and yield components of groundnut. Korean Journal of Crops Science. 35(1): 1-9.

Liu Y, Chen W, Ding Y, Wang Q, Li G and Wang S. 2012. Effect of gibberellic acid (GA_3) and naphthalene acetic acid (NAA) on the growth of unproductive tillers and the grain yield of rice (*Oryza sativa* L.). African Journal of Agricultural Research. 7(4): 534-539.

Rahman MS, Sarker BC, Roy B and Habib MA. 2017. Performance of growth and yield attributes of rice (*Oryza sativa* L.) varieties influenced by plant growth regulators. Journal of Innovative Agriculture. 4(2): 20-28.

Roxy A. 2016. Effect of different levels of 6-BAP on growth, chemical properties and yield performance of aromatic rice cv. Kataribhog. M.S Thesis. Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

Sarker BC, Sharmin N, Bhadhury SK and Nisu ZU. 2020. Effect of naphthalene acetic acid on morpho-physiological and yield traits of three aromatic cultivars. International Journal of Science and Research. 9(1): 519-523.

Sarker BC, Roy B, Fancy R, Rahman W and Jalal S. 2009. Response of root growth and yield of rice (BRRI dhan28) under different irrigation frequencies and plant growth regulator. Journal of Science and Technology. 7: 143-148.

Singh PK, Misra CH and Sharma CL. 2003. Effect of foliar gibberellic acid on seed set and yield contributing character in hybrid rice. New Agriculturist. 14(1/2): 71-74.

Tonucci LH and Von-Elbe JH. 1992. Kinetics of the formation of zinc complexes of chlorophyll derivatives. Journal of Agricultural and Food Chemistry. 40: 2341-2344.

Yang L, Weiping C, Yanfeng D, Qiangsheng W, Ganghua L and Shaohua W. 2012. Effect of Gibberellic acid (GA_3) and α-naphthalene acetic acid (NAA) on the growth of unproductive tillers and the grain yield of rice (*Oryza sativa* L.). African Journal of Agricultural Research. 7(4): 534-539.

Zahir A, Zahir M, Iqbal M, Arshad M and Khalid M. 2007. Effectiveness of IAA, GA_3 and Kinetin blended with recycled organic waste for improving growth and yield of wheat (*Triticum aestivum* L.). Pakistan Journal of Botany. 39(3): 761-768.