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Performance of growth and yield attributes of rice (*Oryza Sativa* L.) varieties influenced by plant growth regulators

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ABSTRACT

A field experiment was conducted to investigate the effect of GA_3 and NAA on growth, biochemical function, yield attributes and yield of six *boro* rice varieties during February-May, 2013. The tested rice varieties were BR-2, Poshusail, Jirasail, BRRI dhan28, Lafaya and Nerica-4 and the treatments were Gibberelic acid (GA_3)-H_1 and Napthelene acetic acid (NAA)-H_2 used as plant growth regulators (@100 ppm) sprayed at two times especially vegetative and pre-flowering stages, as well as water was applied as control (H_0). Morphological parameters were significant due to application of NAA, maximum plant height (136 cm) at Lafaya and the number of tillers plant^{-1} (17.67) was found in BRRI dhan28 applied through 100 ppm NAA. The phyto-chemicals, on which grain yield mostly depends on it, particularly protein, proline and chlorophyll content in flag leaves were greatly affected by the application of NAA in comparison to GA_3. Yield attributes viz. number of panicles hill^{-1}, percentage of filled grains, 1000-grain weight, grain length and width, grain yield, straw yield, biological yield and harvest index were increased in all the selected rice varieties in both 100 ppm GA_3 and NAA. Maximum yield was found in BRRI dhan28 (7.61 tha^{-1}) through application of 100 ppm NAA. Finally it may be concluded that the stimulation rate of NAA was significantly better than the GA_3 in response to growth, phyto-chemical function and yield contributing traits.

Key words: Boro rice, foliar spray, growth, GA_3, NAA, yield.

Rice (*Oryza sativa* L.) is one of the most cultivated important cereal crops for human consumption (Golshani *et al.*, 2010). Bangladesh has the highest population density as compared to any other country in the world, with 1015 living per square kilometer (BBS, 2011). So, rapid population growth puts increasing pressure on more rice production in Asian countries (Liu *et al.*, 2012). But the rice production is not synchronized with population growth resulted in higher demand of food grains. Crop intensification and higher yields are the only way to bridge the increasing gap between food production and consumption in densely populated tropical Asia, because there is little new land available for rice cultivation (Chauhan *et al.*, 1985). In Bangladesh, a total of 11.61 million hectares (*aus*-1.2 million ha, a*man*-5.63 million ha. and *boro*-4.78 million ha.) of lands are used for rice cultivation, which produced 34.75 million tons of rice (2.75 million tons a*us*, 13.30 million tons a*man* and 18.70 million tons *boro*) in the fiscal year of 2011-2012 (BBS, 2012).

Rice hybrids with a yield advantage of 20% were developed in China in the 1970s and are now planted in about 57% of the rice area in the country (Yuan, 2011). Plant growth regulators play vital roles in coordination of many growth and behavioral processes in rice, which regulates the amount, type and direction of plant growth (Rajendra and Jones Jonathan, 2009; Anjum *et al.*, 2011). The use of plant growth regulators, as GA_3 and NAA or their compounds, is becoming popular to ensure efficient production. Remarkable accomplishments of plant growth regulators such as manipulating plant growth and crop yield have been actualized in recent years (Sarkar *et al.*, 2002; Sakamoto *et al.*, 2005; Morinaka *et al.*, 2006; Yan *et al.*, 2011; Zvi and Eduardo, 2011). Plant growth regulators modify growth and development in various ways under different growth conditions. GA3 is responsible for stimulating the production of mRNA molecules in the cells, which in turn improves the chances of fast growth (Richards *et al.*, 2001; Olszewki and Gubler, 2002; Emongor, 2007). Nonstructural carbohydrates (NSC) and crude protein (CP) contents in rice straw were significantly increased by spraying GA3, especially on the 15th days after anthesis, and the fermentation quality of rice straw silage was improved with the increase of NSC and CP contents. Single panicle weight was also significantly increased by spraying GA3 after anthesis (Dong *et al.*, 2012). Naphthalene Acetic Acid (NAA) might be played a significant role to change growth parameters and yield of local and high yielding varieties of rice. Foliar application of some PGRs like GA_3 and NAA increased plant height, number of leavesplant^{-1}, grain size with consequent enhancement in seed yield in different crops (Lee, 1990). NAA is sprayed with 10-1000 ppm in rice at tillering stage which significantly increases root dry weight (Wang *et al.,* 1992). Therefore, enhancing productivity of rice through novel genetic approaches and exogenous plant growth regulators will be necessary.

Generally the average yield is much higher in *boro* season than two other growing seasons. So rice production in *boro* season has gained much importance in Bangladesh. There are several studies reports on PGRs in different countries around the world but in our country, it is not elucidated. That's why, more research and trials are necessary to prove the efficacy of PGRs especially GA_3 and NAA. Thus, the present study conducted to investigate the morphology and physiological traits as well as grain yield by using GA_3 and NAA which is promoting approach for rice production in Bangladesh. Hence local farmer are used without any recommended dose which are sometimes harmful to the environment.

MATERIALS AND METHODS

The study was conducted at Agricultural Farm, Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Bangladesh during February to May, 2013. The experiment was laid out in a randomized complete block design with three replications. The treatment factors were a) six rice varieties viz. BR2 (V_1), Pashushail (V_2), Jirashail (V_3), BRRI dhan28 (V_4), Lafaya (V_5), and Nerica-4 (V_6) and b) three levels of plant growth regulators such as GA_3 (H_1) and NAA (H_2) were sprayed twice at the rate of 100 ppm during at vegetative and pre-flowering stages while water was used as a control (H_0). Thirty five days old seedlings were transplanted to the main field in February, 2012 using two seedlings hill^{-1} for hybrid variety and three seedlings hill^{-1} for local variety. A recommended dose (BARC, 2012) of urea, triple super phosphate, muriate of potash, gypsum and zinc (215, 180, 100, 20 and 7.5 kg ha^{-1}) was applied. Urea (kg ha^{-1}) was applied in three splits at 20, 35 and 55 days after transplanting (DAT).

Data on different morpho-physiological, yield and yield contributing parameters like plant height, leaf length, leaf breadth, leaf numberplant^{-1}, tiller numbers hill^{-1} were recorded at growth stages, while the panicle numbershill^{-1}, filled grainspanicle^{-1}, unfilled grains panicle^{-1}, 1000grain weight, grain length, grain width, grain yieldha^{-1}, straw yieldha^{-1}, biological yield, harvest index were recorded during harvest. The data were statistically analyzed to compare treatment means using the MSTAT-C package, (Russell, 1986). If the treatments were significant the differences between pairs of means were compared by LSD followed by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The interaction effect of PGRs on varieties was significantly influenced on morphological characters (Table 1). The plant height was increased in their succession stages at different days after transplanting (DAT) due to age and stimulation of PGRs. The tallest (136.30 cm) plant was recorded in V_5 with NAA treatment but lowest results found in both GA_3 and control treatment before harvesting stage. Similar results were found by several investigators viz. Jahan *et al.,* 2012 and Ghodrat *et al.,* 2013 in rice. Leaf length was also significantly influenced by the application of PGRs in compare to control. At ripening stage, the highest leaf length (57.33 cm) was found in V_5 in association with NAA and lowest data found in V_4 with control treatment. Niknejhad and Pirdashti (2012) revealed that application of GA_3 and Ecormon markedly increased the leaf length. They also found a positive and significant correlation between flag leaf length, flag leaf area and panicle length with grain yield.

Plant growth regulators (GA_3, PBZ and 6-BA) play important roles in plant growth, development, yield and qualities formation (Ekamber and Kumar, 2007; Rajendra and Jones Jonathan, 2009). Zheng *et al.* (2011) found that suitable application of plant growth regulators (such as NAA, GA_3 or 6-BA) could improve the photosynthetic capacity, delay the leaf senescence and promote the rate of rice seedsetting. Leaf width of the tested rice varieties were significantly influenced by the effect of PGRs which shown in Table 1. Leaf width was gradually increased due to plant growth and application of PGRs. So, the widest leaf (1.53 cm) was found in V_1 with application of NAA whereas V_2, V_3 and V_5 comparatively showed the narrowest leaf due to both PGRs application presented in Table 1. Islam (2008) reported that 100 ppm IAA+ continuous flooded irrigation increased leaf width in rice at 80 DAT over control. The present findings were also confirmed that both leaf length and width were increased as influenced by GA_3 and NAA. Leaf numbers hill^{-1} is another important parameter that indicates more number of leaves higher photosynthesis rate as well as increase the grain yield. The highest leaf population observed in V_1 with H_1 treatment and lowest leaf population found in V_3 with no PGRs application shown in Table 1. The production of effective tiller is the potential factor for yield and yield components of rice. Due to application of PGRs, there were significant variations found among the combinations. The 100 ppm NAA spraying at two growth stages showed the better stimulation to increase the tiller numbers hill^{-1} in different stages of plant growth. The highest number of tillers hill^{-1} (17.67) was obtained from V_4 spraying with 100 ppm NAA where as the lowest number of tillers hill^{-1} (14.00) was recorded from V_6 with control and GA_3 application. Similarly, the increased number of ear bearing tillers was reported due to NAA application by Jahan *et al.* (2012) in rice and Singh & Gill (1985) for wheat and barley. GA_3 also showed better performance than that of control. The variation in number of total tillers hill^{-1} might be due to varietal characters along with the competition of nutrients, light, temperature, etc., among the plants (Tang, 2005).

Grain yield can be greatly affected by reducing or increasing phyto-chemicals for the application of PGRs like GA_3, NAA. In Table2, insignificant differences were found among the varieties except proline and total chlorophyll content. Protein content in flag leaves was insignificant in various combinations of PGRs and varieties. But the highest percentage of protein content in flag leaves at V_3 (10.14%) with control treatments. The lowest result found at $V_5$with NAA treatments (6.80%). Same results found by Awan and Alizai (1989) with application of 100 ppm IAA that significantly increased protein content of rice. Percent starch content in flag leaves was insignificant due to application of PGRs on rice cultivars. Table 2showed that, the highest (61.46 %) percentage of starch content of flag leaves found at $V_1$with control treatments where the lowest (43.40 %)one was found at V_6 with GA_3 treated plot. These results strongly supported with the findings of Singh *et al.* (2010). But in case of proline content, the highest value observed in V_2 with no plant growth regulator spray and lowest one found in V_3, V_4, and V_6 with NAA and GA_3 application and other varieties and treatments were statistically similar with this value. In general, allele-chemicals are known to inhibit plant growth by reducing chlorophyll and protein contents (Terzi and Kocacaliskan, 2009; Singh and Rao, 2003). Roy *et al.* (1993) reported that 30 mM proline is the most effective concentration for improving seed germination and seedling growth in rice plants subjected to salt stress that accepts our study results. Chlorophylls are the most widely distributed plant pigments responsible for the characteristic green color of fruit and vegetables (Almela, 2000). It is important to plants because it is the substance that the chloroplast organelles in the cells that carry out photosynthesis. The interaction effects between variety and PGRs on total chlorophyll content were statistically significant and presented in Table 2. The highest (32.19 mg g-1) amount of total chlorophyll content was found in V_4 with NAA treatment while the lowest (18.19 mg g-1) amount of total chlorophyll content at V_6 with controls treatment. Sunohara *et al.* (1997) observed that the application of auxins (NAA, 2, 4-D and IAA) on corn (maize) growth significantly increased the chlorophyll content leaf. These phyto-chemicals are mostly related to crop growth and development as well as crop yield. PGRs are being used as an aid to enhance crop yield (Sarker *et al.,* 2009). The highest (16.67) number of panicles hill^{-1} was observed in V_4 which was identical to V_2 variety. The lowest (10.33) number was found in V_6. Varieties showed significant differences in respect to percentage of filled and unfilled grains panicle^{-1} at 1% level of probability.

Table 1: Interaction effect of plant growth regulators on morphological parameters of six *boro* rice varieties

Treatment	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf number	Tiller number
$V_1 \times H_0$	92.00 gh	42.33 c-f	1.13 d	4.00 abc	15.33 bc
$V_1 \times H_1$	96.67 fg	46.00 a-e	1.37 b	4.67 a	14.67 bc
$V_1 \times H_2$	102.0 ef	46.67 a-e	1.53 a	4.33 ab	16.33 abc
$V_2 \times H_0$	119.0 bcd	44.67 b-f	1.03 d	4.00 abc	14.00 c
$V_2 \times H_1$	119.7 bc	50.33 abc	1.10 d	3.67 bcd	16.33 abc
$V_2 \times H_2$	122.7 b	51.67 ab	1.10 d	3.33 cd	15.33 bc
$V_3 \times H_0$	85.33 h	43.33 b-f	1.07 d	3.00 d	15.33 bc
$V_3 \times H_1$	84.00 h	44.33 b-f	1.03 d	3.67 bcd	15.33 bc
$V_3 \times H_2$	91.67g h	38.67 ef	1.06 d	3.67 bcd	15.33 bc
$V_4 \times H_0$	85.67 h	36.33 f	1.17 cd	4.00 abc	16.00 abc
$V_4 \times H_1$	86.00 h	38.00 ef	1.30 bc	4.00 abc	16.67 ab
$V_4 \times H_2$	91.00 gh	41.00 def	1.37 b	4.00 abc	17.67 a
$V_5 \times H_0$	122.0 b	46.67 a-e	1.10 d	4.00 abc	14.67 bc
$V_5 \times H_1$	123.0 b	48.67 a-d	1.07 d	4.33 ab	15.00 bc
$V_5 \times H_2$	136.3 a	54.33 a	1.13 d	4.00 abc	15.00 bc
$V_6 \times H_0$	109.3 de	44.00 b-f	1.37 b	4.33 ab	14.33 bc
$V_6 \times H_1$	111.3 cde	43.33 b-f	1.47 ab	4.33 ab	14.00 c
$V_6 \times H_2$	118.3 bcd	51.33 abc	1.43 ab	4.00 abc	15.67 abc
CV (%)	**7.15**	**7.82**	**0.15**	**0.67**	**2.00**
LSD	**13.36**	**2.72**	**0.05**	**10.17**	**0.70**

Mean followed by same letter do not differ significantly at 5% level.

Table 2: Interaction effect of plant growth regulators on physiology of six *boro* rice varieties

Treatment	Percent protein (%)	Percent starch (%)	Proline (%)	Total chlorophyll (%)
$V_1 \times H_0$	8.598 a	61.46 a	1.983 ab	30.05 a
$V_1 \times H_1$	8.213 a	58.39 a	1.997 ab	30.53 a
$V_1 \times H_2$	7.572 a	45.42 a	1.983 ab	30.60 a
$V_2 \times H_0$	9.112 a	54.85 a	2.333 a	23.11 cd
$V_2 \times H_1$	8.598 a	54.44 a	1.920 ab	25.27 bc
$V_2 \times H_2$	8.598 a	52.69 a	1.730 ab	25.97 b
$V_3 \times H_0$	10.14 a	51.24 a	1.680 b	24.10 bcd
$V_3 \times H_1$	8.855 a	51.16 a	2.080 ab	24.36 bc
$V_3 \times H_2$	9.112 a	51.08 a	1.750 ab	24.86 bc
$V_4 \times H_0$	8.727 a	50.37 a	2.260 ab	31.1 a
$V_4 \times H_1$	9.112 a	49.35 a	1.730 ab	31.70 a
$V_4 \times H_2$	8.342 a	48.77 a	1.680 b	32.19 a
$V_5 \times H_0$	7.315 a	47.32 a	2.080 ab	22.99 cd
$V_5 \times H_1$	8.085 a	45.48 a	1.750 ab	25.24 bc
$V_5 \times H_2$	6.802 a	46.17 a	2.260 ab	26.51 b
$V_6 \times H_0$	7.957 a	44.10 a	1.730 ab	18.19 e
$V_6 \times H_1$	8.470 a	43.70 a	1.680 b	19.19 e
$V_6 \times H_2$	7.957 a	44.88 a	2.080 ab	21.67 d
LSD (5%)	**4.06**	**15.1**	**0.54**	**2.37**
CV (%)	**9.2**	**18.18**	**16.69**	**5.49**

Mean followed by same letter do not differ significantly at 5% level.

Table 3: Interaction effect plant growth regulators on yield attributes and yield of six *boro* rice varieties

Treatm nt	Panicle hill^{-1}	Filled grain (%)	Unfilled grain (%)	1000-grain weight (g)	Grain length (cm)	Grain width (cm)	Grain yield t ha^{-1}	Straw yield t ha^{-1}	Biological yield t ha^{-1}	Harvest index
Interaction effect										
$V_1 \times H_0$	12.67def	87.66cd	12.34ab	26.83g	0.64c	0.31b	6.89c	7.44bc	14.33b	48.10 b
$V_1 \times H_1$	13.67cde	93.32abc	6.68bcd	27.67g	0.47c	0.33ab	7.11bc	7.38c	14.49 b	49.07ab
$V_1 \times H_2$	16.00ab	96.71a	3.29d	28.17g	0.68bc	0.33ab	7.26ab	7.38c	14.65b	49.60a
$V_2 \times H_0$	13.33cde	92.92abc	7.08bcd	34.50bcd	0.58c	0.35ab	5.27d	6.62ef	11.90 c	44.33cde
$V_2 \times H_1$	15.67ab	94.88ab	5.11cd	35.33abc	0.60c	0.35ab	5.41d	6.53efg	11.94c	45.31c
$V_2 \times H_2$	16.00ab	92.75abc	7.24bcd	35.33abc	0.62c	0.37a	5.49d	6.55efg	12.05c	45.28c
$V_3 \times H_0$	13.67cde	82.93d	17.07a	22.83h	0.63c	0.22d	5.32d	6.77e	12.10c	43.95cde
$V_3 \times H_1$	14.33bcd	87.95cd	12.05ab	22.33h	0.63c	0.25cd	5.33d	7.36cd	12.03c	44.35cde
$V_3 \times H_2$	15.00abc	90.43bc	9.56bc	23.00h	0.66bc	0.23d	5.43d	6.71e	12.14 c	44.71cd
$V_4 \times H_0$	15.00abc	92.75abc	7.25bcd	30.67f	0.93ab	0.22d	7.43ab	8.07a	15.50 a	47.92b
$V_4 \times H_1$	15.00abc	92.12abc	7.88bcd	31.33f	0.93ab	0.21d	7.56a	7.90ab	15.51a	49.05ab
$V_4 \times H_2$	16.67a	94.39ab	5.61cd	32.00ef	0.92ab	0.23d	7.61a	7.79abc	15.35 a	49.25ab
$V_5 \times H_0$	13.33cde	91.10abc	8.90bcd	31.17f	0.70abc	0.32ab	5.20d	6.86de	12.07c	43.10ef
$V_5 \times H_1$	13.67cde	89.90bc	10.10bc	32.50def	0.71abc	0.31b	5.25d	6.78e	12.04c	43.61de
$V_5 \times H_2$	15.00abc	94.15ab	5.85cd	34.00cde	0.72abc	0.32ab	5.33d	6.77e	12.11c	44.03cde
$V_6 \times H_0$	10.33g	89.49bc	10.51bc	35.83abc	0.92ab	0.30bc	4.47e	6.17fgh	10.65 d	42.01f
$V_6 \times H_1$	11.00fg	91.44abc	8.56bcd	36.33ab	0.93ab	0.30bc	4.42e	6.07gh	10.50 d	42.12f
$V_6 \times H_2$	12.33 ef	95.50ab	4.50cd	37.00a	0.96a	0.31b	4.69e	6.01h	10.71d	43.84 de
CV%	**7.46**	**3.98**	**43.96**	**4.08**	**22.17**	**7.75**	**3.63**	**4.43**	**2.48**	**1.85**
Lsd	**1.73**	**6.06**	**6.06**	**2.10**	**0.27**	**0.05**	**0.35**	**0.51**	**0.53**	**1.40**

Mean followed by same letter do not differ significantly at 5% level.

The highest number of filled grains was found in V_2 which was similar to V_1, V_4, V_5, and V_6 and the lowest in V_3. The highest number of unfilled grains panicle^{-1} was (12.90%) observed in V_3. The highest 1000 grain weight was found in V_6 while the lowest in V_3. Similarly, the highest grain length was observed in V_6 where the lowest width was in V_2. The grain length and breadth varied markedly which was evidently attributed by the genetically make-up. The highest grain, straw and biological yield was found in V_4 and the lowest was found in V_6. The highest harvest index was at V_1 and the lowest was found at V_6.The panicle numbers hill^{-1} was increased by using GA_3 and NAA compared to control. The highest number of panicle hill^{-1} was observed in NAA applied plants while intermediate to GA_3 over control. Hao *et al*. (2000) revealed that application of NAA, 2, 4-D, increased panicle length and number of panicles. The maximum number of panicle per hill was found in V_4 (16.67) due to H_2 treatment which was statistically similar to $V_1 \times H_2$ and $V_2 \times H_2$ respectively. Tao and Shiying (1992) reported that treatment with ABT increased panicle numbers. The lowest number of panicles hill^{-}1was recorded in V_6 (10.33) without PGRs. The interaction effect of PGRs and varieties was significant for the percentage of unfilled grains.

The percentage of unfilled grain was highest (17.07%) in $V_3 \times H_0$ treatment but the lowest (3.29%) in $V_1 \times H_2$ plants. The highest percentage of filled grain was observed in $V_1 \times H_2$ and $V_6 \times H_2$ (96.71 and 95.50%), respectively. The lowest percentage of filled grain was observed in $V_3 \times H_0$ (82.93%). Reports revealed that the increases in number of grains per panicle in various plants *viz.* rice (Grewal and Gill, 1986), wheat and barley (Singh and Gill, 1985) and maize (Jahan *et al.,* 2012).Table 3 showed that the highest weight of 1000 grains was observed in V_6 spraying with NAA.The V3$\times H_1$, $V_3 \times H_0$ and $V_3 \times H_2$ (22.33 g, 22.83 g, 23.00 g) produced the lowest 1000grain weight. Liuping *et al*. (1998) revealed that, NAA was the most effective to increase 1000 grain weight.The highest grain length was found in V_6 (0.96 cm) spraying for H_2 treatment. The minimum rice grain length was observed at $V_1 \times H_1$, $V_2 \times H_0$, and $V_2 \times H_2$ treatments respectively. On the other hand, the highest grain width was found in $V_2 \times H_2$treatment (0.37 cm). The V_1, V_2, and V_5 varieties comparatively showed higher grain width than other treatments. The lowest grain width was found in $V_3 \times H_0$, $V_3 \times H_1$, $V_3 \times H_2$, $V_4 \times H_0$ and $V_4 \times H_1$, respectively which was statistically similar (Table 3).A significant variation was observed among the six varieties in case of grain yield. The highest (7.61 t ha^{-1}) yield was found in $V_4 \times H_2$ plants followed by $V_4 \times H_1$, (Table 3). The statistically similar result was also found in $V_1 \times H_2$ and $V_4 \times H_0$ plants. The lowest (4.42 t ha^{-1}) yield was recorded in $V_6 \times H_1$ which was statistically similar to $V_6 \times H_0$ and $V_6 \times H_2$, respectively. Similar results were reported by several investigators using PGRs in rice *viz.* Sarker *et al.*, 2009, Jagadeeswari *et al.*, 2004, Gavino *et al.*, 2008, Adam *et al.*, 2011. The highest straw yield (8.07 t ha^{-1}) was obtained from BRRI dhan28, without GA_3 and NAA application i.e. in controlled condition. The lowest straw yield (6.01 t ha^{-1}) was obtained from Nerica-4 at twice spraying of NAA. Balki and Padole (1982) also showed the similar result in wheat plant.

The maximum biological yield (15.51 t ha^{-1}) was obtained from the V_4 where the V_6 showed the lowest biological yield (10.50 tha^{-1}) spraying with GA_3. The harvest index (HI) was significantly influenced by the interaction effect of varieties and plant growth regulators. The highest harvest index (49.60 %) was recorded in BR2 variety by applying 100 ppm NAA but the lowest harvest index (42.01%) was obtained from the Nerica-4 without any GA_3 or NAA. The yield was increased in V_4 by spraying both PGRs due to the correlation of several yield components and decreased the percentage of unfilled grains panicle^{-1}. Moreover, the increased yield plant^{-1} was not only achieved by spraying NAA but also increased the assimilative area; resulting photosynthesis possibility was more during the growth period.

CONCLUSION

From this study, it is clear that the application of GA_3 and NAA were more stimulative over control treatments. The results also infer that the spraying of 100 ppm NAA at vegetative and pre-flowering stage has stimulatory effects on different physiological traits and finally affects the yield and yield attributes. Thus, we concluded that, the performance of NAA at the rate of 100 ppm showed better than that of GA_3in the selected rice varieties for higher grain yield.

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