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Effect of Napthalene Acetic Acid on Morpho-Physiological and Yield Traits of Three Aromatic Cultivars

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Abstract: ***A field experiment was conducted to study the effect of napthalene acetic acid (NAA) on morpho-physiological, yield and yield characteristics of three aromatic rice cv. Chinigura, Kataribhog and Kalijira. The NAA was applied 0, 50, 100, 150 and 200 ppm at vegetative and pre flowering stages. The NAA spraying of150 ppm had the stimulatory effect on the tiller number hill^{-1}of different aromatic rice variety had also positive effect on chlorophyll-a, total chlorophyll content, calcium and magnesium content of aromatic rice flag leaf of Chinigura and Kalijiracultivars but 100 ppm for Kataribhog. Some yield contributing parameters of aromatic rice such as grain number per panicle, grain weight per panicle and total grain yield were influenced due to the interaction effect of variety and levels of NAA. The highest grain yield was in Chiniguracultivar (2.77t ha^{-1}) twice spraying using 150 ppm NAA. Out of the three rice, Chinigura performed better considering growth, physiological parameters and yield traits. The foliar spraying with 150 ppm NAA had the better stimulation on growth on yield of Chinigura and Kalijira but 100 ppm for Kataribhog. NAA promoted physiological functions and enhanced the growth and yield of aromatic rice cultivars which might be an alternative practice for rice production in Bangladesh.***

Keywords: Aromatic rice, chlorophyll, foliar spray, growth, NAA, yield

1. Introduction

Rice (*Oryza sativa* L.) 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. In Bangladesh, more than four thousand landraces of rice are adopted in different parts of this country (Sajib *et al*., 2012). Some of which have nice quality namely fineness, aroma, taste and protein content. It is generally small in size and has soft texture. It is consumed as the staple food and has been given the highest priority in meeting the demands of its ever-increasing population in Bangladesh. Rice crop is one of the important strategic crops in Egyptian economy. Among the 150 different field crops grown in Bangladesh, rice alone occupies about 77% of the total cultivated area, of which aromatic rice is cultivated only on the 10% of the rice growing area (Anon, 2008). Mainly because of a still-growing population, demand for rice is expected to keep increasing in the coming decades (Pingali *et al*., 1997).

The demand for aromatic rice in recent years has increased to a great extent for both internal consumption and export. Unfortunately, the aromatic rice often has undesirable agronomic characters, such as low yield, susceptibility to pests and diseases, and strong shedding (Faruq *et al.*, 2011).Aromatic rice constitutes a small but an important sub-group of rice. These are rated best in quality and fetch much higher price than high quality non-aromatic rice in international 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 aroma when cooked, aromatic rice commands a higher price than non-aromatic rice.

The introduction of chemical growth regulators has added a new dimension to the possibility for improving the growth and yield of rice corp. Plant growth regulators are synthesized indigenously by plants; however, several studies demonstrated that plants can respond to exogenous application of these chemicals. 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; Islam, 2007; Cho *et al*., 2008). The use of plant growth regulators in the field of agriculture has become commercialized in some advanced counties like Europe, USA and Japan. The current uses for plant growth regulators are not only in a high value horticultural crops but it also increase field crop yield directly either by increasing total biological yield or the harvest index.

Foliar application of NAA has also found to increase plant height, number of leaves per plant, fruit size with consequent enhancement in seed yield in different crops (Lee, 1990). It showed better performance in enhancing the straw and grain yields of rice (Sarker *et al.* 2009).

Most of the aromatic rice varieties in Bangladesh are of traditional type, photoperiod-sensitive and are grown during Aman season (July to December) in the rain fed lowland ecosystem in Bangladesh. The yield of aromatic rice was lower but its higher price and low cost of cultivation generated higher profit margins compared to other varieties grown in the area. The uses of growth substances such as naphthalene acetic acid (NAA) at different concentrations that may increase aromatic rice plant production. It is quite clear that endogenous and exogenous plant growth regulators play an important role in modifying and regulating many physiological processes in plants and these processes are greatly influenced by environmental conditions.

Research and practice using NAA for rice production is limited in our Bangladesh. Studies in other countries of the world although provides useful information, that cannot be recommended or practiced without trial in our local condition. Therefore, more researches or trials are necessary to investigate the efficacy of NAA on aromatic rice. Thus, the objectives were to study the growth characteristics, physiology and the yield potentials of three aromatic rice cv. Chinigura, Kataribhog and Kalijira spraying different levels of NAA.

2. Materials and Methods

A field experiment was carried out at the research farm of Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during Aman season (July to December), 2016 to ascertain the response of NAA on the aromatic rice cultivars. The experiment was laid out by two factor randomized completely block design (RCBD) with three replications. The treatment factors were a) three aromatic rice varieties namely, Chinigura (V_1), Kataribhog (V_2), Kalijira (V_3) and b) five levels of NAA at the rate of 0 ppm (control) (L_1), 50 ppm (L_2),100 ppm (L_3),150 ppm (L_4) and 200 ppm (L_5) spraying twice at vegetative and pre-flowering stages. Forty-day old healthy seedlings were transplanted on puddle plots on July, 2016 according to the experimental design. Three seedlings of the selected aromatic cultivars were transplanted in each hill with a spacing of 15×20 cm. The Data on different morpho-physiological parameters, yield and yield contributing parameters like plant height, leaf blade length, leaf width, leaf number plant^{-1}, tiller numbers hill^{-1}, were recorded at growth stages. The flag leaf chlorophyll-a, chlorophyll-b, total chlorophyll and total carotenoid content were estimated by acetone extract method following Arnon (1949)while the panicle length, number of effective tiller hill^{-1}, number of non-effective tiller hill^{-1}, grain number panicle^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, 1000grain weight, grain yield ha^{-1}, straw yield ha^{-1}, biological yield, harvest index were recorded during 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.

3. Results and Discussion

Plant height determines the nature of lodging, light application, and air entry and flow. The height of aromatic rice plant at different growth stages was not influenced by the application of NAA (Table 1). At harvesting stage, the highest plant height was observed in Kalijira at 200 ppm NAA (V_3×L_5, 174.4 cm) while the lowest plant height was 134.3 cm in Chinigura spraying at 150 ppm (V_1×L_4 plant). The leaf length of three aromatic rice cultivars at different growth stages was insignificant by the application of NAA presented in Table 1. At harvesting stage, the highest leaf blade length was observed in KataribhogV_2×L_5, 69.0 cm) using 200 ppm but the lowest leaf blade length was 54.7 cm in the same cultivars at 150 ppm NAA.

Plant growth regulators (NAA, GA_3, PBZ and 6-BA) play important roles in plant growth, development, yield and qualities formation (Rajendra and Jones Jonathan, 2009). Zheng*et al.* (2011) revealed that suitable application of NAA, GA_3 or 6-BA could improve the photosynthetic capacity, delay the leaf senescence and promote the rate of rice seed-setting. Table 1 showed that the effect of PGR-NAA on the leaf number of three different cultivars was not remarkable. The maximum number of leaves was obtained from Kalijira than that of Chinigura and Kataribhog varieties due to the application of NAA as plant growth regulators.

Tillering, especially the production of effective tiller is the potential factors for yield and yield components. There was a significant effect different level of NAA on three aromatic rice cultivars found at both vegetative and harvesting stage but the interaction effect of variety and level of NAA were insignificant on the number of tiller hill^{-1}. The maximum number of tiller hill^{-1} (10.67) was obtained in Chinigura spraying with 150 ppm NAA at vegetative and pre-flowering stages which might influence on more grain production. On the other hand, the minimum number of tillers hill^{-1}(6) was emerged from Kataribhog with 150 ppm at harvesting stage.

Table 1: Interaction effect of NAA on morphological parameters of three aromatic rice varieties

Treatment	Plant height (cm)	Leaf blade length (cm)	Leaf numbers	Tiller numbers hill^{-1}
V_1×L_1	144.0ns	56.70ns	9.67ns	6.67ns
V_1×L_2	140.7ns	62.70ns	7.33ns	8.33ns
V_1×L_3	144.4ns	56.00ns	7.67ns	8.67ns
V_1×L_4	134.3ns	59.70ns	7.33ns	10.67ns
V_1×L_5	136.8ns	61.00ns	7.33ns	7.67ns
V_2×L_1	144.3ns	62.30ns	7.33ns	6.33ns
V_2×L_2	146.2ns	59.70ns	7.33ns	7.00ns
V_2×L_3	150.1ns	54.70ns	7.33ns	8.33ns
V_2×L_4	141.7ns	56.70ns	8.33ns	8.67ns
V_2×L_5	148.9ns	69.00ns	8.67ns	6.00ns
V_3×L_1	161.8ns	58.30ns	8.33ns	5.67ns
V_3×L_2	168.4ns	62.70ns	10.33ns	6.00ns
V_3×L_3	163.1ns	59.70ns	7.67ns	7.67ns
V_3×L_4	171.9ns	60.70ns	9.33ns	7.67ns
V_3×L_5	172.4ns	59.70ns	6.33ns	6.67ns
SE	5.63	4.67	1.09	0.65
LSD	16.31	13.54	3.16	1.87

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

Table 2: Interaction effect of NAA on physiological parameters of three aromatic rice varieties

Treatment	Chlorophyll -a	Chlorophyll -b	Total Chlorophyll	Carotenoid
$V_1 \times L_1$	19.08BCDE	6.75ns	30.35ns	4.53ns
$V_1 \times L_2$	21.94ABCD	7.82ns	34.31ns	4.56ns
$V_1 \times L_3$	21.33ABCDE	8.11ns	32.61ns	3.17ns
$V_1 \times L_4$	24.45A	10.13ns	36.29ns	1.71ns
$V_1 \times L_5$	23.37ABC	8.11ns	35.18ns	3.69ns
$V_2 \times L_1$	16.41E	9.24ns	27.78ns	2.13ns
$V_2 \times L_2$	24.35A	9.44ns	38.76ns	4.97ns
$V_2 \times L_3$	24.21AB	10.29ns	39.37ns	4.86ns
$V_2 \times L_4$	23.48AB	7.72ns	34.73ns	3.54ns
$V_2 \times L_5$	17.94DE	8.00ns	29.63ns	3.69ns
$V_3 \times L_1$	18.27CDE	5.94ns	26.18ns	1.97ns
$V_3 \times L_2$	20.24ABCDE	6.82ns	30.36ns	3.29ns
$V_3 \times L_3$	17.84DE	10.41ns	31.30ns	3.05ns
$V_3 \times L_4$	21.45ABCDE	8.88ns	33.31ns	2.99ns
$V_3 \times L_5$	21.46ABCDE	8.01ns	32.52ns	3.05ns
SE	1.54	1.43	2.55	0.86
LSD	4.48	4.15	7.39	2.479

Table 3: Interaction effect of NAA on yield attributes of three aromatic rice varieties

Treatment	Panicle length (cm)	Number of Effective tiller	Non effective tiller	Grain no. panicle^{-1}	1000 grain wt. (g)
$V_1 \times L_1$	22.33ns	6.00ns	1.00ns	188.0C	11.55ns
$V_1 \times L_2$	25.22ns	7.00ns	1.33ns	189.0C	12.47ns
$V_1 \times L_3$	26.11ns	7.67ns	1.00ns	201.0B	12.46ns
$V_1 \times L_4$	30.00ns	9.67ns	1.00ns	239.0A	12.54ns
$V_1 \times L_5$	24.22ns	7.00ns	0.67ns	210.0B	12.22ns
$V_2 \times L_1$	19.56ns	5.33ns	1.00ns	125.3HI	10.07ns
$V_2 \times L_2$	20.56ns	6.33ns	0.67ns	135.3GH	11.88ns
$V_2 \times L_3$	20.67ns	7.67ns	0.67ns	164.3DE	12.54ns
$V_2 \times L_4$	19.89ns	8.00ns	0.67ns	144.3FG	11.84ns
$V_2 \times L_5$	20.55ns	5.33ns	0.67ns	147.0FG	12.02ns
$V_3 \times L_1$	23.00ns	4.33ns	1.00ns	114.7I	10.10ns
$V_3 \times L_2$	22.00ns	5.67ns	0.67ns	143.3FG	10.60ns
$V_3 \times L_3$	21.78ns	7.33ns	1.33ns	153.7EF	11.15ns
$V_3 \times L_4$	22.67ns	6.67ns	0.33ns	173.3D	11.50ns
$V_3 \times L_5$	23.44ns	5.00ns	0.67ns	142.7FG	11.29ns
SE	2.15	0.4	0.33	3.89	0.4
LSD	6.25	1.18	0.95	11.27	1.18

Table 4: Interaction effect of NAA on yield of three aromatic rice varieties

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$V_1 \times L_1$	1.93DE	3.43ns	5.37ns	36.12ns
$V_1 \times L_2$	2.17BCD	3.36ns	5.53ns	39.25ns
$V_1 \times L_3$	2.33B	3.27ns	5.60ns	41.73ns
$V_1 \times L_4$	2.77A	3.67ns	6.23ns	44.64ns
$V_1 \times L_5$	2.23BC	2.93ns	5.17ns	43.23ns
$V_2 \times L_1$	1.62FG	3.07ns	4.69ns	34.66ns
$V_2 \times L_2$	1.87EF	3.07ns	4.93ns	37.82ns
$V_2 \times L_3$	2.3BC	2.83ns	5.13ns	44.80ns
$V_2 \times L_4$	2.03CDE	3.07ns	5.10ns	39.87ns
$V_2 \times L_5$	1.90 DE	3.13ns	5.03ns	37.56ns
$V_3 \times L_1$	1.57G	3.10ns	4.67ns	33.64ns
$V_3 \times L_2$	1.83EF	3.10ns	4.93ns	37.42ns
$V_3 \times L_3$	1.93DE	3.30ns	5.23ns	37.07ns
$V_3 \times L_4$	2.07BCDE	3.43ns	5.50ns	37.56ns
$V_3 \times L_5$	1.93DE	3.33ns	5.267ns	36.78ns
SE	0.09	0.19	0.23	1.55
LSD	0.25	0.55	0.65	4.5

Leaf chlorophyll content is one of the important physiological traits closely related to photosynthetic ability in rice (Teng et al., 2004).There was a statistical significant relationship among the varieties, levels and interaction on chlorophyll-a content of aromatic rice leaves (Table 2). Among the studied rice cultivars, Chinigura shows the better performance while applying 150 ppm (L4) NAA. The maximum amount of Chlorophyll-a wasfound in $V_1 \times L_4$ (24.45 mg g$^{-1)}$ followed by $V_2 \times L_2$ (24.35 mg g^{-1}) and the lowest amount of chlorophyll-a was in $V_3 \times L_3$ (17.84 mg g^{-1}) followed with $V_3 \times L_1$ (18.27 mg g^{-1}), respectively. No significant relationship was found in chlorophyll-b among the varieties and the levels of NAA. The $V_3 \times L_3$ had the maximum chlorophyll-b (10.41 mg g^{-1}) while the $V_3 \times L_1$ synthesized the minimum amount (5.94 mg g^{-1}) in their flag leaf. No significant relationship was found in the production of total carotenoid content (Table 2) among the varieties and the levels of NAA. The highest amount of carotenoid content (4.97 mg g^{-1}) was observed in $V_2 \times L_2$ treatments and the lowest amount (1.71 mg g^{-1}) was in $V_1 \times L_4$ treatment. The highest amount of total chlorophyll content (39.37 mg g^{-1}) in $V_2 \times L_3$ treatments while the lowest amount of total chlorophyll content (26.81 mg g^{-1}) at $V_3 \times L_1$ treatments. Undoubtedly, understanding the genetic mechanisms underlying the leaf chlorophyll content across different developmental stages of rice has significant implications for improving photosynthetic ability in rice. It might positively affect on biological yield of aromatic rice.

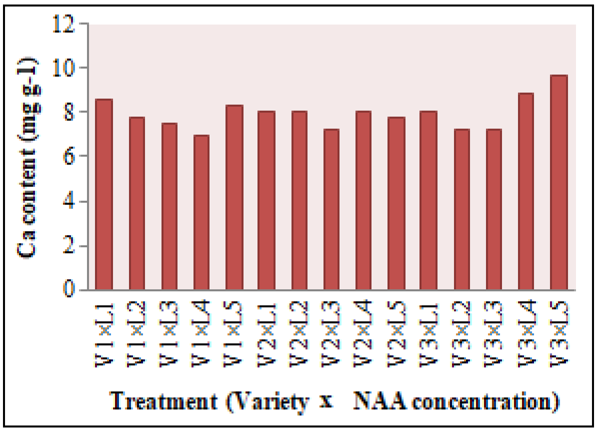

Figure 1: Calcium content of flag leaf of three aromatic rice varieties under different levels of NAA

A marked variation was found in flag leaf calcium content of aromatic rice as applied various concentration of NAA. The highest calcium content was found $V_3 \times L_5$ (9.61 mg g^{-1}) followed by $V_3 \times L_5$ (8.81 mg g^{-1}) while the lowest calcium content was found in $V_1 \times L_4$ (6.94 mg g^{-1}). The Kalijira variety showed better performance at controlled level while Kataribhog showed better performance at 150 ppm and Kalijira showed better performance at 200 ppm of NAA, respectively.

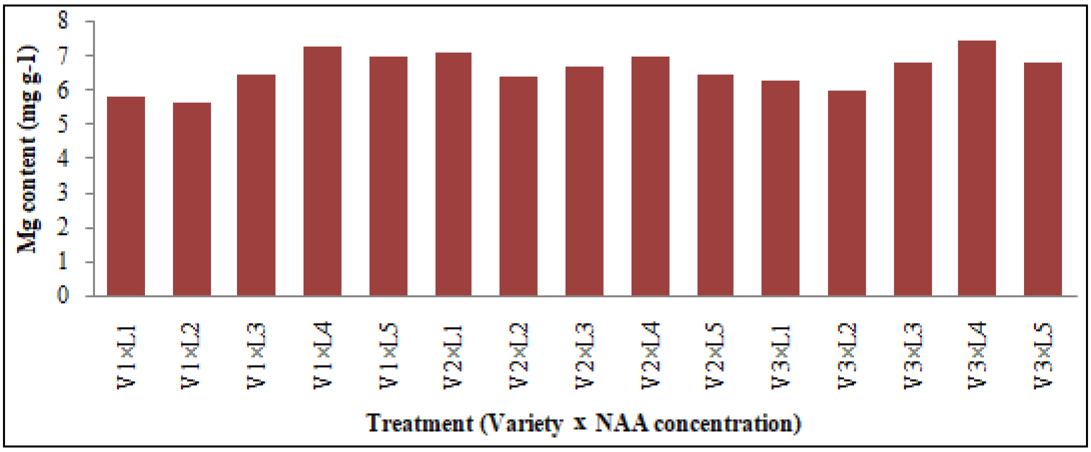

Figure 2: Magnesium content of flag leaf of three aromatic rice varieties under different levels of NAA

Magnesium is an integral part of chlorophyll and thus, linked with photosynthesis and growth. The test in Mg content in different aromatic rice leaves among regarding experimental treatments is presented in Figure 3. A significant variation was found in flag leaves magnesium content of Aromatic rice in relation to applied levels of NAA. The highest Mg content was recorded in $V_3 \times L_4$ (7.497 mg g^{-1}) followed by $V_1 \times L_4$ (7.3 mg g^{-1}). On the other hand, the lowest Mg content was recorded in $V_1 \times L_2$ (5.667 mg g^{-1}). Chinigura flag leaf showed better performance at controlled level while Kataribhog showed better performance at 150 ppm and Kalijira showed better performance at 200 ppm of NAA, respectively. In this study 150 ppm NAA on kalijira variety showed better performance on magnesium content of rice leaf.

There is a significant effect among the varieties of aromatic rice on panicle length but no significant effect was found between the interaction of varieties and levels due to application of various levels of NAA (Table 3). Among the varieties Chinigura showed the better performance. The maximum number of panicle per hill was found in $V_1 \times L_4$ treatment (30) and the lowest number of panicle $hill^{-1}$ was in $V_2 \times L_1$ (19.56). The Chinigura variety showed better performance at 150 ppm while Kataribhog showed better performance at 100 ppm and Kalijira showed better performance at 200 ppm of NAA, respectively. The maximum number of effective tiller $hill^{-1}$ was found in $V_1 \times L_4$ treatment (9.67) and the lowest number of panicle $hill^{-1}$ was in $V_3 \times L_5$ (5). The Chinigura variety showed better performance at 150 ppm, the Kataribhog showed better performance at 100 ppm and the Kalijira showed better performance at 100 ppm of NAA than that of other levels. Spraying of different levels of NAA on non-effective tiller number $hill^{-1}$ was insignificant (Table 3). Result showed that non effective tiller of three different cultivars among different levels are average both vegetative and harvesting stage.

The interaction effect of PGRs and varieties was also significant for grain number per panicle (Table 3). The highest number of grains per panicle were observed at $V_1 \times L_4$ (239) followed by $V_1 \times L_5$ and $V_1 \times L_3$ (210 and 201) respectively. The $V_3 \times L_1$ (114.7) showed the lowest performance in controlled plants.

The foliar application of 150 ppm NAA on the Kalijira cultivar showed better performance on grain number per panicle. The Chiniguraand Kataribhog cultivar performed better while spraying 100 ppm. NAA stimulated the grain production per panicle in three aromatic rice cultivars in the present study. The interaction effect of different levels of NAA and cultivars was also significant for grain weight per panicle (Table 3). The highest grain weight per panicle was observed at $V_1 \times L_4$ (2.99 g) followed by $V_1 \times L_5$ and $V_1 \times L_3$ (2.56 g and 2.5 g), respectively. The $V_3 \times L_1$ (10.1 g) showed the lowest performance in both controlled and NAA treated plants. The highest weight of 1000 grains was observed at $V_1 \times L_4$ (12.58 g) and the $V_3 \times L_1$ (10.1g) plants showed the lowest performance in both controlled and PGR treated plots.

All the tested cultivars produced lower yield in controlled plants than those of NAA treated plants (Table 4). The highest grain yield was found in $V_1 \times L_4$ (2.77 t ha^{-1}) followed by $V_1 \times L_5$ and $V_1 \times L_2$ (2.23 t $ha^{-1}$and 2.167 t ha^{-1}), respectively. The lowest grain yield was found in $V_3 \times L_1$ (1.567 t ha^{-1}). In the present study, the Chinigura rice variety produced highest grain yield in150 ppm NAA. The 150 ppm had stimulatory effect on grain production of Chinigura and Kalijira cultivar but the Kataribhog perform better at 100 ppm regarding grain yield.

The highest straw yield was obtained from $V_1 \times L_4$ (3.467 t ha^{-1}) and the lowest yield was found in $V_3 \times L_1$ (3.1 t ha^{-1}). The maximum biological yield was $V_1 \times L_4$ (6.233t ha^{-1}) and the lowest yield was found in $V_3 \times L_1$ (4.667 t ha^{-1}). The harvest index (HI) is an important yield determining character which can through idea along partitioning efficiency. The highest harvest index $V_1 \times L_4$ (44.64 %) and the lowest HI was found in $V_3 \times L_1$ (33.64%).

4. Conclusion

It is concluded that growth parameters and physiological activities of aromatic rice cultivars were increased by the twice application of NAA. The 150 ppm NAA had enhancing effect on aromatic rice cv. Chinigura and Kalijira while Kataribhog produced higher grain applying 100 ppm and may be recommended for the farmers' level due to increased amount of chlorophyll synthesis, more effective tiller number, grain number per panicle and grain yield. The results also inferred that the spraying of 150 ppm NAA at vegetative and pre-flowering stage has stimulatory effects on different physiological traits and finally affects the yield and yield attributes. NAA, a plant growth regulator might be useful to increase aromatic rice production which is an environment-friendly tool for agricultural management practices.

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