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ROLE OF SALICYLIC ACID AS FOLIAR SPRAY ON HYDRIDE RICE (BRRI Hybrid dhan3) CULTIVATION IN BANGLADESH

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The experiment was conducted to study the effect of salicylic acid (SA) as foliar spray on yield and yield contributing characters of BRRI Hybrid dhan3.The experiment was laid out in a randomized complete block design (RCBD) with three replications and six treatment combinations as, T_1: 0 µM SA, T_2: 200 µM SA, T_3: 400 µM SA, T_4: 600 µM SA, T_5: 800 µM SA and T_6: 1000 µM SA. The results revealed that biomass production, dry matter production and yield and yield contributing characters were significantly increased due to the foliar application of SA. At the maximum tillering (MT) stage, the highest biomass production (15.0 t/ha) and dry matter production was observed in T_3 treatment. Treatments T_4, T_5 and T_6 showed significant variation on the effective tillers/hill. The maximum effective tillers/hill were found in the treatment T_6. The percentages of spikelet sterility were decreased with increasing the level of SA and the percentage of filled grains/panicle were increased with increasing level of SA. The insect infestation was reduced with increasing level of SA to up to 1000 µM. The maximum grain yield (9.21 t/ha) and straw yield (9.22 t/ha) was found in the treatment T_6 which was identical to T_5. On the other hand, in all cases the lowest results were found in the control treatment. The result showed that grain yield of rice increased with increasing level of SA to up to 1000 µM (T_6 treatment). Our results suggest that foliar spray of SA might be applied to increase the yield of hybrid rice in Bangladesh.

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INTRODUCTION

Based on rice cultivation, Bangladesh is the 5th largest country in the world (BBS, 2012). The population of Bangladesh is growing by two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.3 million tons of rice for the year 2020 (BRRI, 2016). During this time total rice cultivating area will also shrink to 10.3 million hectares. Rice yield therefore, needs to be increased by 53.3% (Mahamud*et al*., 2013). In Bangladesh, food security has been and will remain a major concern because food requirement is increasing at an alarming rate due to increasing population. Rice yield, in general, is comparatively lower than that of other Southeast Asian countries because of the severe insect infestation, drought, salinity etc. Yield loss of up to 50% has been recorded in susceptible rice varieties when all the leaf sheaths and leaf blades were infested (Kumar *et al.,* 2012). The crop is suffering from number of fungal, bacterial, viral and mycoplasmal diseases. Among them the fungal diseases like blast (*Pyriculariaoryzae*), brown spot (*Bipolarisoryzae*), stem rot (*Sclerotiumoryzae*), sheath blight (*Rhizoctoniasolani*), sheath rot (*Sarocladiumoryzae*), bacterial diseases such as bacterial blight (*Xanthomonasoryzaepv oryzae*) and viral diseases such as tungro (rice tungro virus) are most important (Sarkar et al*.,* 2014). However, in order to defend themselves against these attacks, plants have evolved various constitutive and inducible mechanisms, one such mechanism being the accumulation of large quantities of salicylic acid. Salicylic acid, a phenolic compound, is associated with stress tolerance in plants. Previous studies reported that SA can induce tolerance against high and low temperatures, drought, salinity, ultraviolet light, heavy metal toxicity, diseases and pathogens (Raskin, 1992; Yalpani et al., 1994; Dat et al., 1998; Metwally et al., 2003; Sakhabutdinova et al., 2003; Hayat and Ahmad, 2007; Horváth et al., 2007, Farooq et al., 2008; Hussain *et al*., 2008). In addition, SA plays an essential role in preventing oxidative damage in plants by detoxifying superoxide radicals (Bowler *et al*., 1992) and is also involved in calcium signaling (Kawano et al., 1998). Plants treated with SA showed increased vigor of early seedling growth (Farooq et al., 2008), increased photosynthetic rates, induced stomatal closure, increased water use efficiency, and decreased stomatal conductance and transpiration rate (Khan et al., 2010; Issak et al*.*, 2013). Moreover, there is evidence that exogenous application of SA can alter antioxidant capacity in plants (Rao et al., 1997), thereby providing protection against oxidative damage (Larkindale and Huang 2004), and inducing stress tolerance.

In this study SA is important in plant growth and development and is also associated with stress tolerance in plants. Plants pre-treated with SA (Larkindale and Knight, 2002) showed induced stress tolerance and protection against oxidative damage due to various stresses. Despite the importance of these chemicals in stress tolerance, little is known about their effects on rice morphology, phenology and physiology. The research presented herein addresses the effects of SA on rice morphology, phenology and physiology, under non-stress conditions. Thus, studies that seek this information, besides aiming to learn which products can be used to stimulate grain yield and yield contributing characters, should be encouraged. Within this context, the aim of this study was carried out to examine the performance of hybrid rice with foliar application of SA.

MATERIALS AND METHODS

The experiment was carried out in a typical rice growing soil of Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka, during robi season of 2014-2015. The experimental area was under the Agro Ecological Zone, Madhupur Tract (AEZ-28) and the general soil type was Red Brown Terrace Soil under the Tejgaon soil series. The soil characteristics were silty clay loam with pH 6.3. The experimental area is under the subtropical climate. Bangladesh Rice Research Institute (BRRI) is developed some hybrid rice variety among them BRRI Hybrid dhan3 was used as the planting material. The experiment was laid out in a Randomized Complete Block Design (factorial) with six treatments and three replications. The treatments were as follows: T_1: 0 µM SA; T_2: 200 µM SA; T_3: 400 µM SA; T_4: 600 µM SA; T_5: 800 µM SA; T_6:1000 µM SA. The size of a unit plot was 3 m × 3 m.

Total plots in the experimental field were 18. Thirty seven days old seedlings were uprooted carefully from the seedbed and transplanted in the experimental plots. Two healthy seedlings were transplanted in each hill. Intercultural operations were done for ensuring and maintaining the normal growth of the crop. After transplanting 5-6 cm water was maintained in each plot through irrigation during the growth period. The crop was infested with some common weeds, which were controlled by uprooting and removed them three times from the field during the period of experiment. There were some incidence in insects specially rice stem borer, grasshopper, rice bug etc. which were controlled by spraying Diaginon 50EC. Three foliar sprays of SA were done in the rice field. First spray was applied at 30 DAT (days after transplanting) at the early tillering stage, 2nd at 60 DAT at the early panicle initiation (PI) stage and the 3rd at 90 DAT at the flowering stage. The crop sampling was done at the time of harvest. At each harvest, $1m^2$ of each plot was selected randomly for grain and straw yield calculation. Finally harvest them carefully and converted the yield into t/ha. At harvest randomly ten hills were collected from each plot for recording the yield contributing parameters. The plant heights, panicle length, number of grain/panicle, 1000 grain weight and yield were recorded separately. Ten hills from each plot were collected at maximum tillering (MT) stage and then weighted by using a digital electric balance. The data collected on different parameters were statistically analyzed to obtain the level of significance using the windows based software Statistix10 trial.

RESULTS AND DISCUSSION

SA influence on biomass production of BRRI Hybrid dhan3 at the maximum tillering (MT) stage

A significant variation was observed in the biomass production of BRRI Hybrid dhan3 due to the foliar application of SA at the early tillering stage. Fresh weight production was increased with increasing the level of SA up to the 400 µM and then decreased due to the higher doses of SA up to the 1000 µM. The maximum fresh weight production (15 t/ha) was observed in the T_3 treatment which was significantly different than all other treatments and the minimum fresh weight production (12.75 t/ha) was observed in the control treatment (T_1) which was statistically identical to the treatments T5 and T6 (Table 1). However, the reductions of the biomass production in the treated plants were not less than control treatment (T_1). Although higher doses of SA (1000 µM) is used in the treatment T_6 and found the biomass production (12.77 t/ha) which was statistically similar to the control treatment. Farooq *et al.,* (2009) found that seedling fresh weight increased by the application of salicylic acid.

Role of SA on dry matter production of BRRI Hybrid dhan3 at MT stage

Dry matter production of BRRI Hybrid dhan3 was significantly different among the treatment combinations (Table 1). The highest oven dry weight (2.74 t/ha) was found in the T3 treatment having foliar spray of SA at 400 µM which was significantly different from all other treatments and the lowest oven dry weight (2.01 t/ha) was found in the treatment T5 having 800 µM of SA which was statistically similar to the treatments T2 (2.18 t/ha), T4 (2.16 t/ha) and T6 (2.11 t/ha) including control treatment T1 (2.14 t/ha). This results indicate that foliar application of SA at lower doses have positive effect on the dry matter production of BRRI Hybrid dhan3 and the higher doses of SA up to 1000 µM have no negative effect on the dry matter production (Table 1). Dry mass production increased due to application of SA (Usharani *et al*., 2014).

Role of SA on the yield contributing characters of BRRI Hybrid dhan3

Plant height

The plant height of BRRI Hybrid dhan3 varied significantly due to the foliar spray of SA. The tallest plant (87 cm) was found in T3 treatment having 400 µM of SA and it was statistically identical to the treatments T2, T4 and T5 (Table 2). The shortest plant height (82.40 cm) was found in the treatment T6 due to the application of 1000 µM of SA. There were no significant differences between the treatment T1 and T6 (Table 2). These results indicate that lower doses have a positive role on plant height of BRRI Hybrid dhan3 and higher doses up to 1000 µM have no negative effect on the plant height at harvesting stage. Singh et al*.,* (2015) and Usharani *et al*., (2014) found that foliar application of SA increases plant height of rice significantly.

Number of effective tillers/hill

The application of different levels of SA had a significant effect on number of effective tillers per hill. Number of effective tillers increased with the increased levels of SA. The highest number of effective tillers per hill (13.67) was found in the treatment T6 due to the application of 1000 µM SA which was statistically similar to the treatments T3, T4 and T5 (Table 2). The lowest number of effective tillers per hill (11.83) was found in the control T1 treatment. These results might be due to the optimum use of irrigation water because foliar application of SA reduces the transpiration water losses and increases the total chlorophyll levels in the leaves. Singh *et al.* (2015) found that foliar application of SA significantly increases number of effective tillers/hill of rice. Sardoei et al., (2014) reported that the exogenous spray of SA had significant effect on number of tillers.

Table 1. Role of SA as foliar spray on the biomass and dry matter production of BRRI Hybrid dhan3 at MT stage

Treatments	Biomass production at MT stage (t/ha)	Dry matter production at MT stage (t/ha)
T1=0 µM SA	12.75 c	2.14 b
T2=200 µM SA	13.69 b	2.18 b
T3=400 µM SA	15.00 a	2.74 a
T4=600 µM SA	14.20 b	2.16 b
T5=800 µM SA	12.86 c	2.01 b
T6=1000 µM SA	12.77 c	2.11 b
$LSD_{0.05}$	0.55	0.30
SE (±)	0.25	0.11
Level of significance	**	*
CV (%)	2.22	7.28

** = Significant at 1% level of probability, * = Significant at 5% level of probability
Figures in a column having common letter (s) do not differ significantly at 5% level of significance by DMRT

Table 2. Role of SA on plant height, effective tillers/hill and 1000 grain weight of BRRI Hybrid dhan3 at harvesting stage

Treatments	Plant height (cm)	Effective tillers/hill	1000 grain weight (g)
T1=0 µM SA	82.80 b	11.83 b	29.33 b
T2=200 µM SA	84.03 ab	12.27 ab	30.00 ab
T3=400 µM SA	87.00 a	12.83 ab	32.00 ab
T4=600 µM SA	86.20 a	13.25 a	32.67 ab
T5=800 µM SA	83.93 ab	13.27 a	33.67 ab
T6=1000 µM SA	82.40 b	13.46 a	34.83 a
$LSD_{0.05}$	3.15	1.35	4.93
SE (±)	1.00	0.61	2.21
Level of significance	*	*	*
CV (%)	2.05	5.79	8.45

** = Significant at 1% level of probability, * = Significant at 5% level of probability
Figures in a column having common letter (s) do not differ significantly at 5% level of significance by DMRT

1000 grain weight (g)

The 1000 grain weight of BRRI Hybrid dhan3 showed significant difference due to the foliar application of different levels of SA. The maximum 1000 grain weight (34.83 g) was found in the treatment T6 having 1000 µM SA which was statistically similar to the treatment T3, T4 and T5. The lowest 1000 grain weight (29.33 g) was found in the control treatment (T1) which was statistically similar to the treatment T2, T3, T4 and T5 (Table 2). Ibrahim *et al.,* (2014) showed 1000 grain weight increased significantly by the application of salicylic acid.

Panicle length (cm)

The panicle length of BRRI Hybrid dhan3 was significantly affected by the different levels of SA. The highest panicle length (25.49 cm) was found in the T3 treatment having foliar application of 400 µM SA and there was no significant differences with the control treatment, T1 (Table 3). The lowest panicle length (23.58 cm) was found in T2 treatment having foliar application of 200 µM SA, however, it was statistically similar to the control. These results indicate that foliar application of SA at 200-1000 µM has no positive or negative effect on panicle length of BRRI Hybrid dhan3 (Table 3).

Total spikelet number /panicle

The influence of SA on the number of spikelet/panicle significantly varied. Under the present study, number of spikelet/panicle was significantly influenced by SA. The highest number of grain per panicle (166.7) was found in the T6 treatment due to the application of 1000 µM SA (Table 3) which was statistically similar with the treatments, T5 and T1 (control). The lowest number of spikelet per panicle (158.3) was found in the T3 treatment (Table 3) having SA at 400 µM which was statistically identical to T2 and T4 treatments.

Filled grain/ panicle

The foliar application of different levels of SA has a significant effect on filled grains per panicle. The highest number of filled grain per panicle (156.2) was found in the T6 treatment having foliar application of 1000 µM SA and it was statistically similar with the treatments T4 and T5 (Table 3) indicating that higher doses of SA (600-000 µM) have a positive role on the spikelet fertility of BRRI Hybrid dhan3. The lowest number of filled grain per panicle (141.23) was found in the T1 treatment and it was statistically similar to T2 and T3 treatments (Table 3). This result suggests that foliar application of SA could help to increase the filled grain yield of BRRI Hybrid dhan3. Singh *et al.,* (2015) and Usharani *et al*., (2014) showed that filled grain/panicle increased significantly by the application of salicylic acid.

Table 3. Effect of foliar application of SA on panicle length and number of spikelet /panicle of BRRI Hybrid dhan3

Treatments	Panicle length (cm)	No. of Spikelet/ panicle	Filled grain/ panicle	% Filled grain increased over control
T1=0 µM SA	24.83 ab	165.70 a	141.2 b	-
T2=200 µM SA	23.58 b	160.10 b	143.1 b	1
T3=400 µM SA	25.49 a	158.27 b	145.8 b	3
T4=600 µM SA	24.07 b	160.6 b	151.1 a	7
T5=800 µM SA	24.00 b	165.8 a	153.2 a	8
T6=1000 µM SA	24.63 ab	166.7 a	156.2 a	11
$LSD_{0.05}$	1.27	7.85	9.26	
SE (±)	0.403	2.49	2.94	
Level of significance	NS	*	**	
CV (%)	2.86	2.68	3.46	

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant
Figures in a column having common letter (s) do not differ significantly at 5% level of significance by DMRT

Table 4. Effect of foliar application of SA on spikelet sterility (%) of BRRI Hybrid dhan3

Treatments	Unfilled grain/ panicle	Spikelet sterility (%)
T1=0 µM SA	24.5 a	15
T2=200 µM SA	17.00 abc	12
T3=400 µM SA	12.47 ab	8
T4=600 µM SA	11.03 bc	7
T5=800 µM SA	11.50 bc	7
T6=1000 µM SA	10.67 c	7
$LSD_{0.05}$	1.48	
SE (±)	0.472	
Level of significance	*	
CV (%)	6.93	

* = Significant at 5% level of probability
Figures in a column having common letter (s) do not differ significantly at 5% level of significance by DMRT

Table 5. Effect of different treatments on number of stem borer affected rice panicle/plot (9m2)

Treatments	Number of stem borer affected panicle/plot (9m2)
T1=0 µM SA	11.67 a
T2=200 µM SA	10.00 a
T3=400 µM SA	7.333 b
T4=600 µM SA	7.667 b
T5=800 µM SA	4.333 c
T6=1000 µM SA	3.333 c
$LSD_{0.05}$	1.68
SE (±)	0.534
Level of significance	**
CV (%)	12.52

** = Significant at 1% level of probability
Figures in a column having common letter (s) do not differ significantly at 5% level of significance by DMRT

Unfilled grain/panicle

The application of different levels of SA had significant effect on the unfilled grains per panicle. The lowest number of unfilled grain per panicle (10.7) was found due to application of 1000 µM SA in the treatment T6 (Table 4). The highest number of unfilled grain per panicle (24.5) was found in control (Table 4). These results showed that number of unfilled grains per panicle was decreased with increasing levels of SA as foliar application. Mohammed R.A. (2011) reported that number of unfilled grains per panicle was decreased due to the application of SA.

Number of stem borer affected panicle/plot (9m2)

The application of different levels of SA had a significant effect on the number of stem borer affected plants. The lowest number of affected panicle per plot (3.33) was found in the treatment T6 and this might be due to the application of 1000 µM SA (Table 5). The highest number of affected panicle per plot (11.7) was found in the control treatment T1 (Table 5). Number of stem borer affected plants was decreased gradually with increasing levels of SA to up to 1000 µM. This result suggests that foliar application of SA could be effective on rice stem borer infestation management. Insect infestation reduced significantly due to application of SA (Singh et al. 2015).

Grain yield

Grain yield increased with increasing levels of SA as a foliar application at the different stages of BRRI Hybrid dhan3. The maximum grain yield was found in the treatment T6 having 1000 µM SA and it was statistically identical to the treatment T5 having 800 µM SA. On the other hand minimum grain yield was found in the control which was similar to the treatments T2 and T3. Among the treatment combinations T4 and T6 treatments significantly increased the grain yield. Compare to the control treatment grain yield was increased 5.56% to 31.38% due to the foliar application of SA in the BRRI Hybrid dhan3 (Table 6). Although recommended grain yield of BRRI Hybrid dhan3 is recorded 9.00 t/ha at the research satiation but here it was found 7.01 t/ha. However foliar application of salicylic acid could be helpful to recover the yield gap, increasing the grain yield and reduction of insect-pest infestation. Sharafizad et al*.,* (2012) showed that dosage of SA significantly affected total grain yield. Dry mass production increased due to application of SA (Usharani et al., 2014 and Mohammed, R.A. 2011).

Straw yield (t /ha)

The effect of different levels of SA on straw yield of BRRI Hybrid dhan3 was significantly different. The straw yield of BRRI Hybrid dhan3 increased significantly due to foliar application of SA**.** The maximum straw yield (9.22 t/ha) was observed from the T6 treatment having 1000 µM SA which was statistically similar to T5 treatment (Table 6). The minimum straw yield (7.23 t/ ha) was obtained from the control treatment T1 (having no SA) which was statistically identical to the treatments T2, T3, and T4. When compared with the control straw yield was increased 7.8% to 27.47% due to the foliar application of SA in the BRRI Hybrid dhan3 (Table 10). Usharani et al., (2014) showed highest straw yield from the application of salicylic acid.

Table 6. Role of foliar application of SA on grain and straw yield of BRRI Hybrid dhan3

Treatments	Grain yield (t/ha)	% Increase over control	Straw yield (t/ha)	% Increase over control
T1=0 µM SA	7.01e		7.233c	-
T2=200 µM SA	7.40de	5.56	7.797bc	7.80
T3=400 µM SA	7.75cd	10.55	7.720bc	6.73
T4=600 µM SA	8.21bc	17.12	8.013bc	10.78
T5=800 µM SA	8.6ab	23.40	8.513ab	17.70
T6=1000 µM SA	9.21a	31.38	9.220a	27.47
$LSD_{0.05}$	1.02	-	1.09	-
SE (±)	0.324	-	0.345	-
Level of significance	**	-	*	-
CV (%)	6.94	-	7.40	-

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant
Figures in a column having common letter (s) do not differ significantly at 5% level of significance by DMRT

CONCLUSIONS

The research was conducted to improve our understanding of hybrid rice responses to foliar spray of SA. Our results indicated that foliar applications of SA have beneficial effects on hybrid rice cultivation. Application of SA did not influence the plant height, panicle length and total number of grain/panicle, however did influence biomass and dry matter production, effective tillers/hills, 1000 grain weight, filled grain/panicle, unfilled grain/panicle, number of insect infested panicle/plot, grain yield and straw yield. Our results can be due to the SA-induced increment of membrane integrity that might be increased the amount of photosynthates and transported to the grains, thereby increased the number of filled grains per panicle, hence increased spikelet fertility. In conclusion, yield, the final manifestation of all the physiological processes, increased as a result of SA application under non-stress conditions. In hybrid rice cultivation SA as foliar spray might be useful as a yield modifying tool.

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