Agricultural Science; Vol. 2, No. 1; 2020
ISSN 2690-5396 E-ISSN 2690-4799
https://doi.org/10.30560/as.v2n1p263

A Rice Variety (BRRI dhan29) Yield Performance as Influenced by Foliar Application of Salicylic Acid in Bangladesh

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Received: April 20, 2020 Accepted: May 20, 2020 Online Published: May 29, 2020

Abstract

Objective of this study was to examine and evaluate the role of different rates of salicylic acid (SA) as foliar spray on growth and yield performance of BRRI dhan29. The experiment was conducted at Sher-e-Bangla Agricultural University, Bangladesh from November, 2016 to May, 2017 following a randomized complete block design with five rates of SA in six replications. The results showed that the lower rate of SA (upto 0.75 mM) has a positive effect on rice biomass production including effective tiller per hill, filled grain per panicle, grain yield and straw yield. The highest dry matter production at both maximum tillering and panicle initiation stages was found at SA spray rate of 0.5 mM. The highest number of effective tillers per hill (14.7) as well as the highest filled grain (120.4) and grain yield (8.1 t/ha) were found at SA rate of 0.75 mM. However, the maximum biomass production was obtained at SA rate of 0.25 mM. The minimum grain yield (7.0 t/ha) was observed in the control treatment.

Keywords: staple food, biomass production, harvest index, tillering stage, panicle initiation.

1. Introduction

The most important food for the people of Bangladesh is rice (Oryza sativa L.) and it is the staple food for more than two billion people of Asia (Hien et al., 2010). Asia has the largest growing area with top producing countries including China, India, Thailand, Bangladesh and Vietnam (Xiao et al., 2013). It is also the most important source of the food energy for 50% of the Global population (Zhao et al., 2011). Among the most cultivated cereals in the world, rice ranks at second to wheat with over 685 million tones recorded in 2009 (Abodolereza and Racionzer, 2009). Rice is a major cereal consumed by the world population, representing about 30% of world production of grains (Yadav and Jindal, 2008). Rice is grown in more than one hundred countries with a total harvested area of nearly 160 million hectares, producing more than 700 million tons every year (IRRI, 2010). Nearly 640 million tons of rice are grown on Asia, representing 90% of global production (IRRI, 2010).

Rice is the staple food for about 156 million people of Bangladesh (Israt et al., 2016) where it covers about 28.49 million acres in which 34.5 million M tons of rice are produced with an average yield of around 1.2 tons/acre (BBS, 2016). About 82% of the total cropped land in the country is covered by rice (Alam et al., 2012). It accounts for 92% of the total food grain production in Bangladesh which provides more than 50% of the agricultural value addition employing about 48% of total rural labour force. It was estimated that per capita rice consumption in the country reached about 166 kg/year (BBS, 2015). The agricultural sector contribution to GDP was 16.33% in 2013-14 fiscal year (Bangladesh Economic Review, 2015). In the agricultural sector, food crops provides with 10.74 percent in GDP of which rice alone dominates with about 53 percent as well as about one-sixth of the national income comes from rice sector (Rahman et al., 2015).

The population of Bangladesh is growing by two million every year and increases 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, 2011). Meanwhile, total rice area will shrink to 10.3 million hectares and the increased population will require 70 percent more rice in 2025 than the present consumption (Kim and Krishnan, 2002). Therefore, rice yield needs to be increased by 53.3% (Mahamud et al., 2013). Food security remains a major concern in Bangladesh because food requirement is increasing at an alarming rate as a result of the increasing population. Rice yield, in the country is comparatively lower than that of other south East Asian countries because of severe insect infestation, drought, salinity etc. Yield losses up to 50% were recorded on susceptible rice varieties when all the leaf sheaths and leaf blades were infected (Kumar et al., 2012). About 475 million metric tons of rice were produced across the world over 159.6 million hectares with an average yield of 4.4 t/ha in the year 2014-15 and 34.5 million tons in Bangladesh over 11.7 million ha in 2016-17 (USDA, 2015).

Growth and development of rice plant are significantly influenced by the environmental factors, boitic factors, variety and cultural practices. Salicylic acid (SA) plays notable role regarding growth and development as well as yield components like number of effective tillers, length of panicle, number of filled grain per panicle, weight of 1000 grain etc. of rice plants. Foliar application of salicylic acid increased net photosynthetic rate and proline content in salt stressed plants and may have contributed to the enhanced growth parameters (Khoshbakht and Asgharei, 2015). Salicylic acid treated plants showed greater chlorophyll content compared to untreated plants (Khoshbakht and Asgharei, 2015). It can affect seed germination, cell growth, stomatal opening, expression of genes associated with senescence and fruit production (Klessing et al., 2009) In addition, by detoxification of superoxideradicals SA plays an essential role in preventing oxidative damage in plants (Bowler et al., 1992) and is also involved in calcium signaling (Kawano et al., 2013). Plants treated with SA showed increased photosynthetic rates and water use efficiency, decreased stomatal conductance and transpiration rate (Khan et al., 2003), increased vigor of early seedling growth (Farooq et al., 2008b). Moreover, it was also found that exogenous application of SA could alter antioxidant capacity in plants, providing protection against oxidative damage (Rao et al., 1997; Larkindale & Huang 2004). This phytohormone can directly affect pathogens as well as contribute to the establishment of SAR (Tamaoki et al., 2013)

Salicylic acid is a natural compound that plays a central role in certain physiological processes and defense responses in plants (Shi and Zhu, 2008). Plants pre-treated with SA showed induced stress tolerance and protection against oxidative damage due to various stresses (Larkindale & Knight, 2002). A good number of research works have been conducted at home and abroad on the effect of foliar application of SA on cultivation.

Salicylic acid is more or less unknown in Bangladesh by farmers with regard to crop production. The present study deals with the effect of foliar application of SA on rice productivity.

2. Materials and Methods

2.1 Site, Soil and Weather Condition

The experiment was conducted at Sher-e-Bangla Agricultural University from November 2015 to May 2016. The site was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.6 meter above m.s.l. Soil type was Shallow Red Brown Terrace Soil belonging to "The Modhupur Tract", AEZ-28 (Anon., 1988a). Soil physical and chemical characteristics are displayed in table 1. The climate was subtropical with low temperature and minimum rainfall from November to May that was the main feature of the rabi season. The annual precipitation on site was around 2200 mm with 1300 mm of potential evapo-transpiration. The average maximum and minimum air temperatures reached 30.3 and 21.2 0C, respectively. The average daily temperature was 25.20C. The experiment was conducted during the rabi season, temperatures over crop cycle ranging from 12.20C to 34.50C with a relative humidity from 62 to 82%.

Table 1. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Clay loam
pH	6.2
Organic carbon (%)	0.60
Organic matter (%)	1.03
Total N (%)	0.03
Available P (ppm)	21.00
Exchangeable K (me/100g soil)	0.12
Available S (ppm)	48

2.2 Crop/Planting Material

The rice variety used in the experiment, namely BRRI dhan29, was developed by the Bangladesh Rice Research Institute (BRRI). It is moderately tolerant to leaf blight, sheath blight, with a pedigree line of BR 802-118-4-2 and a crop cycle of about 160 days. Crop average height is 95 cm with medium sized and white colored grains.

2.3 Experimental Design and Treatments

The experiment was set up following a randomized complete block design with six SA applications rates in six replications. Each plot size was 2 m × 2 m. Adjacent replications were 1m distanced with 0.5 m of row spacing. SA application rates tested ranged from 0 to 2.0 mM with 0.25 increment.

Fertilizers were applied equally, irrespective of SA treatments, following recommended rates.

2.4 Growing of BRRI Dhan29

Seeds were collected from BRRI, Joydebpur, Gazipur, Bangladesh and sown on nursery bed on December 10, 2015 for seedling production. Experimental units of were fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate @ 150, 58, 58, 38 and 10 kg/ha respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at the time of seedling transplanting. After seedling recovery, urea was applied in three splits. At first, half of the total amount of urea was applied to the soil during vegetative stage. Half of the remaining urea was applied at tillering stage and half at 7 days before panicle initiation. The nursery bed was watered in one day before seedling transplanting. Seedling of 37 days old were transplanted carefully from the nursery beds on 16 January, 2016. Afterwards, different cultural operations included crop protection practices were achieved to enhance seedling growth and development. At harvest occurred on May 04, 2016, five hills per plot were preselected randomly from which different growth and yield attributes data were collected and 1 m^2 area from middle portion. Each plot was harvested separately, bundled, properly tagged and then brought to the threshing floor for recording grain and straw yield.

2.5 Preparation and Application of Salicylic Acid

The mixture of 6.9 g SA in 100 mL ethanol is called 0.5 M stock solution of SA. 10 mL ethanol in 5 L solution was prepared to apply in T_1 (control). 2.5 mL SA solution was taken from stock solution in 5 L solution for making 0.25 mM SA solution. Similarly 5mL, 7.5 mL, 10 mL and 20 mL SA solution were taken from stock solution in 5 L solution for making 0.5 mM, 0.75 mM, 1.0 mM and 2.0 mM solution respectively. Foliar application of SA was done in rice field in three times. First step was applied on 49 DAT (tillering stage). 2^{nd} application on 84 DAT (panicle initiation stage) and 3^{rd} application on 92 DAT (flowering stage).

2.6 Detailed Procedures of Recording Data

Plant height at harvest

Plant height measured from the ground level to the tip of the tallest panicle was recorded. Plants of 5 hills were measured and averaged for each plot.

Number of tillers per hill

The number of tillers per hill was counted at harvest from ten randomly pre-selected hills and averaged as their number per hill. Only those tillers having three or more leaves were considered for counting.

Effective tillers per hill

The total number of effective tillers per hill was counted as the number of panicle which had at least one grain. The number of effective tillers per hill was recorded and finally averaged for counting effective tillers number per hill.

Ineffective tillers per hill

The total number of ineffective tillers per hill was counted as the tillers which have no panicle on the head. The number of ineffective tillers per hill was recorded and finally averaged for counting ineffective tillers number per m^2.

Panicle length

The length of panicle was measured from basal node of the rachis to apex of each panicle. Each observation was an average of 5 panicles.

Filled grains per panicle

If any kernel was present in grain, the grain was considered to be filled. The total number of filled grains were recorded on five panicles and finally averaged.

Unfilled grains per panicle

Unfilled grains mean the absence of any kernel inside and such grains present on each of five panicles were counted and finally averaged.

Total grains per panicle

Total number of grains per panicle was calculated by summation of filled and unfilled grains per panicle.

Weight of 1000 grains

One thousand cleaned and dried grains (12% moisture) were counted randomly from each sample and weighed by using a digital electric balance with weight expressed in gram.

Grain yield

Grain yield determined from the central 1m^2 area of each plot were sun dried, cleaned, weighed carefully and adjusted at 12% moisture level. Weight of grains of each plot was converted into t/ha. Grain moisture content was measured by using a digital moisture tester.

Straw yield

Straw yield was determined from the central 1 m^2 area of each plot. After grain separation, the sub-samples were oven dried to a constant weight and finally converted to t/ha.

Biological yield

Grain yield together with straw yield was regarded as biological yield and calculated with the following formula:

Biological yield (t/ha) = Grain yield (t/ha) + Straw yield (t/ha)

Harvest Index

Harvest index denotes the ratio of economic yield to biological yield calculated as follows:

$$\text{Harvest Index} = \frac{\text{Grain yield (t/ ha)}}{\text{Biological yield (t/ ha)}} \times 100$$

2.7 Statistical Analysis

The collected data were compiled and analyzed statistically so that the mean differences were adjudged by LSD test using Statistix 10computer package program.

2.8 Collection and Preparation of Initial Soil Samples

The initial soil samples were collected from a 0-15 cm soil depth before land preparation. Samples were collected by means of an auger from different locations covering the whole experimental plot mixed thoroughly to make a composite sample. After collecting soil samples, the plant roots, leaves etc. were picked up and removed. Then the samples were dried and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis.

2.9 Chemical Analysis of Soil Samples

Soil samples were analyzed for both physical and chemical properties determination, following standards methods (Jackson, 1962; Walkley and Black, 1934) in the laboratory of Department of Soil Science of Sher-e-Bangla Agricultural University, Dhaka-1207.

3. Results and Discussion

3.1 Dry Matter Production as Influenced by SA at Two Growth Stages

A significant variation was observed in the dry matter production of BRRI dhan29 due to the foliar application of different doses of SA at the maximum tillering (MT) and panicle initiation (PI) stages. At MT stage the highest oven dry weight (2.34 t/ha) of dry matter product was found in the T_3 treatment having foliar spray of SA @ 0.5

mM which was statistically different to all other treatments. The lowest oven dry weight (1.67 t/ha) was found in the treatment T_6 with the concentration of SA of 2.0 mM which was statistically similar with the control T_1 having no SA. Again at PI stage the highest oven dry weight (4.72 t/ha) was found in treatment T_3 that was statistically different to all other treatments. The lowest oven dry weight was found in treatment T_6 which was statistically similar to T_1 and T_5 treatments. These results showed that foliar application of SA at lower doses have positive effect on the dry matter production of BRRI dhan29 and agreed with Issak et al. (2017) who showed that, biomass production, dry matter production and yield and yield contributing characters were significantly increased due to the foliar application of SA. This result also revealed that the higher doses of SA up to 2.0 mM have no negative effect on the dry matter production (Figure 1). This was strongly supported by Usharani et al. (2014) who showed that dry matter production increased due to application of SA.

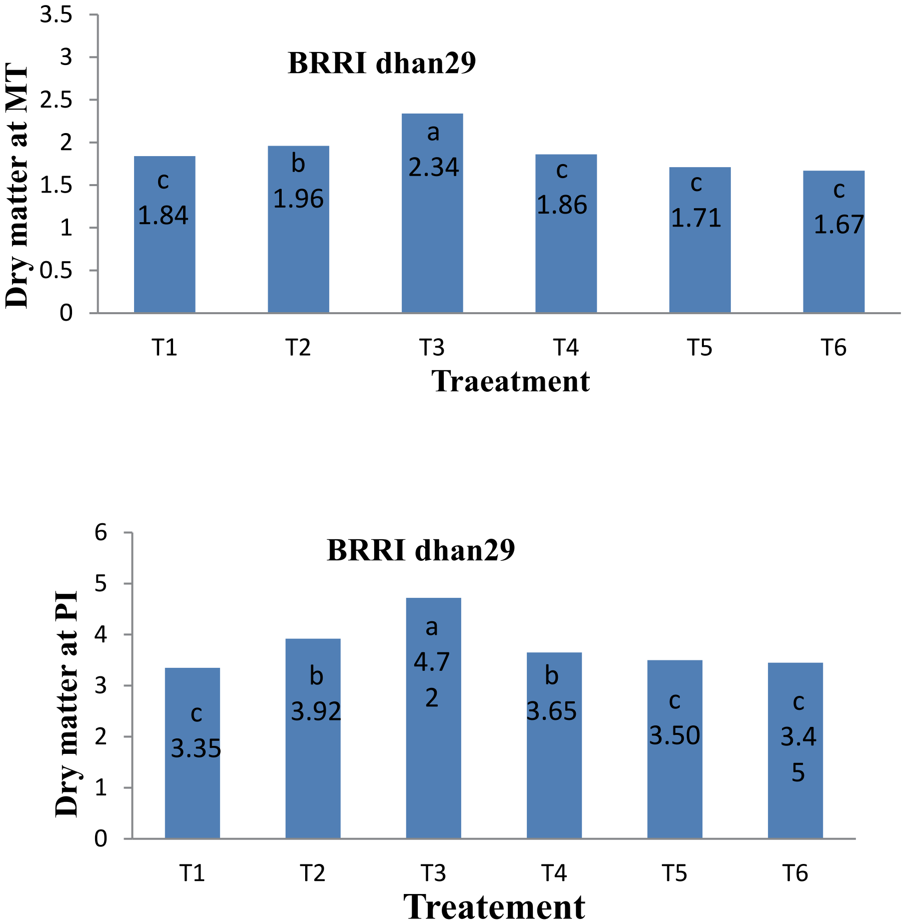


Figure 1. Effect of different doses of salicylic acid on dry matter production at at maximum tillering (MT) stage and panicle initiation (PI) stage of BRRI dhan29 at harvest, Boro 2016, SAU. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT, SAU, 2016.

3.2 Rice Effective Tillers/Hill as Affected by SA at Harvest

The application of different levels of salicylic acid had a significant effect on number of effective tillers per hill (Figure 2). Number of effective tillers increased with the increases of SA levels upto a certain limit. The highest number of effective tillers per hill (14.66) was found in the treatment T_4 due to the application of 0.75 mM salicylic acid which varied significantly from the control T_1 treatment (0 mM SA). The lowest number of effective tillers per hill (12.33) was found in the control T_1 treatment. In producing effective number of tillers/hill the treatments may be arranged as $T_4>T_3>T_2>T_5>T_6>T_1$. These results might be due to the optimum use of irrigation water because foliar application of SA reduces the transpirational water losses and increases the total chlorophyll levels in the leaves. Singh *et al.* (2015) found that foliar application of salicylic acid significantly increases number of effective tillers/hill of rice. Saranja P. (2014) also reported that the exogenous spray of SA had significant effect on number of tillers.

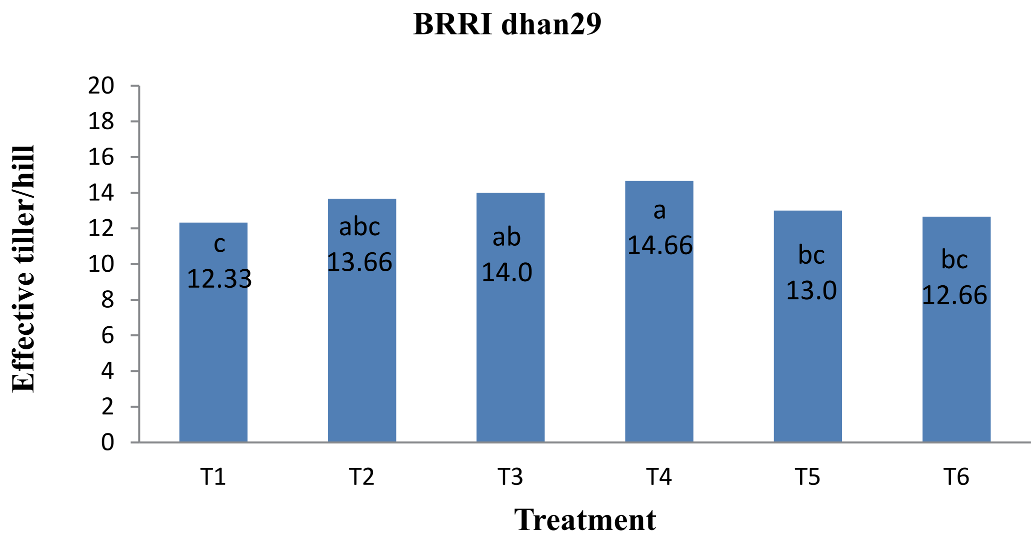


Figure 2. Effect of different doses of salicylic acid on number of effective tillers/hill of BRRI dhan29 at harvest, Boro 2016, SAU. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT, SAU, 2016

3.3 Rice Filled Grain/Panicle as Affected by SA at Harvest

The foliar application of different levels of salicylic acid had a significant effect on filled grains per panicle (Figure 3). The highest number of grain per panicle (120.4) was found in the T_4 treatment having foliar application of 0.75 mM salicylic acid and this result was statistically different from all other treatments. The lowest number of filled grain per panicle (105.23) was found in the T_1 treatment having 0 mM salicylic acid. According to the filled grains/panicle the treatments may be arranged as $T_4>T_3>T_2>T_5>T_6>T_1$. This result suggests that foliar application of SA could help to increase the grain yield of BRRI dhan29. Singh *et al.,* (2015) and Usharani, *et al*., (2014) showed that filled grain/panicle increased significantly by the application of salicylic acid.

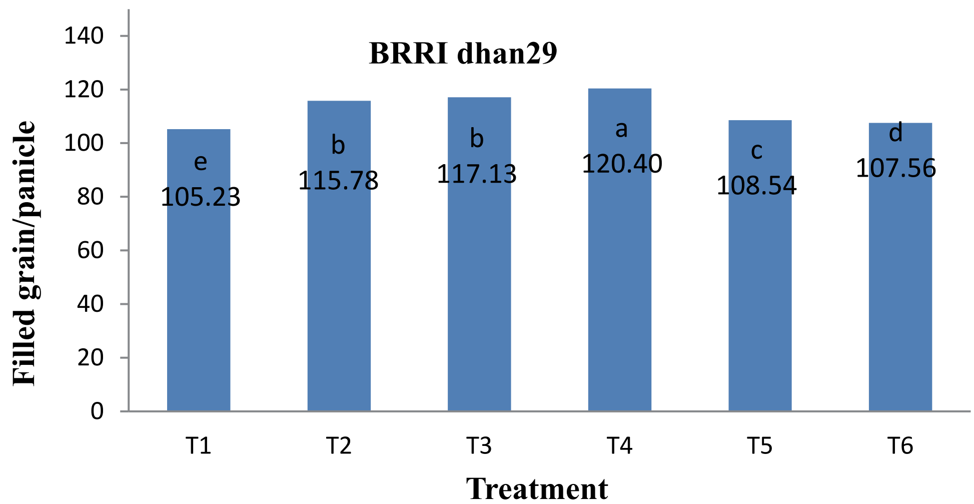


Figure 3. Effect of different doses of salicylic acid on rice filled grain per panicle at harvest, Boro 2016, SAU. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT, SAU, 2016

3.4 Rice Unfilled Grain and 1000-Grain Weight as Affected by SA at Harvest

Table 2. Role of foliar application of salicylic acid on unfilled grain and 1000-grain weight of BRRI dhan29 at harvest, Boro 2016, SAU.

Treatment (dose)	Unfilled grains/ panicle	1000-grain weight
T1	3.39a	29.18a
T2	3.1bc	30a
T3	2.97c	32a
T4	2.3d	32.9a
T5	2.45d	29.71a
T6	3.21b	29.53a
$LSD_{0.05}$	0.1503	1.5824
Level of significance	**	*
CV (%)	2.85	2.85

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

*= Nonsignificant at 1% level of probability ** = Significant at 1% level of probability

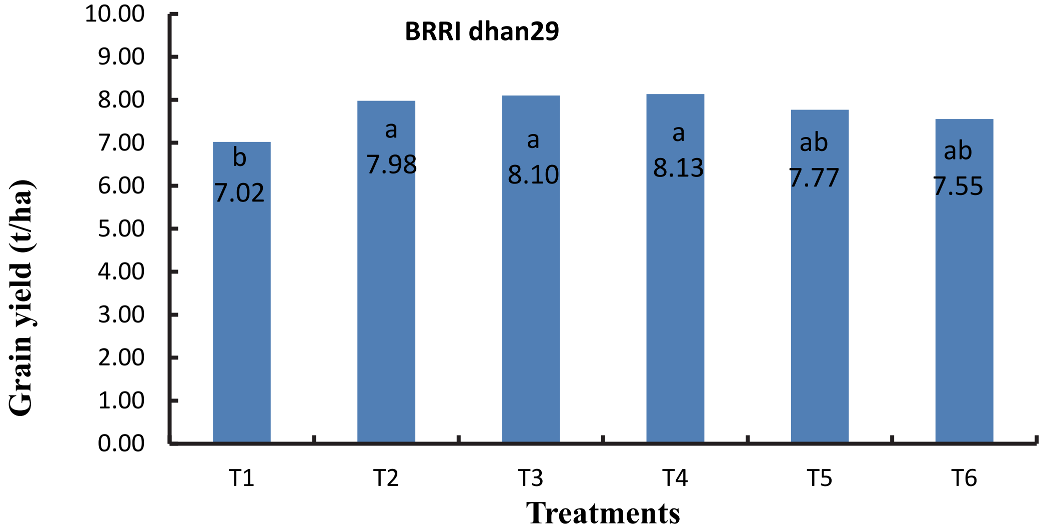
The application of different levels of salicylic acid had a significant effect on the unfilled grain per panicle (Table 2). The lowest number of unfilled spikelet per panicle (2.3) was found in application of 0.75mM salicylic acid under the treatment T_4 and that was statistically different from other treatments. The highest number of unfilled spikelet per panicle (3.39) was found in the control treatment T_1that was statistically different from other treatments. Sterility (%) also decreased with increases of salicylic acid level. These results showed that number of unfilled spikelet per panicle was decreased with increases of level of salicylic acid as foliar application. Mohammed, R.A. (2011) reported that number of unfilled spikelet per panicle was decreased due to foliar application of salicylic acid.

It was found that 1000-grain weight was statistically insignificant with compare to the T_1 treatment (control) (Table 2). The maximum 1000 grain weight (32.9 g) was found in the treatment T_4 having 0.75 mM salicylic acid which was statistically similar to all other treatments. The lowest 1000 grain weight (29.18 g) was found in the control treatment T_1. Though there was no statistical difference among the treatments, there were increase results due to foliar spray of SA. It was observed that, as the level of salicylic acid foliar application increases the 1000-grain weight increases insignificantly. Ibrahim, *et al.,* (2014) showed 1000 grain weight increased due to the application of salicylic acid. Chen, *et al.* (2017) also indicated that the mean grain-filling rate and grain weight of the inferior grains were significantly increased under the SA200 (200mgL^{-1}).

3.5 Rice Grain and Straw Yields as Affected By SA

The influence of salicylic acid on grain yield was significantly varied among the treatments. Figure 4 shows the effects of different level of salicylic acid on grain yield of BRRI dhan29. The maximum grain yield (8.13 t/ha) was found in the treatment T_4 having 0.75 mM salicylic acid which differed statically from all other treatments and this result revealed that the grain yield of treatment T_4 had 15.84% higher yield over control (Treatment T_1). Here Treatment T_1 (control) shows the lowest yield (7.02 t/ha). Treatment T_2, T_3 and T_4 did not differ significantly but they differ significantly with control (Treatment T_1). Treatment T_5 and T_6 are statistically identical to the treatment T_2 having the highest yield. According to grain yield treatments can be arranged as $T_4>T_3>T_2>T_5>T_6>T_1$. This result is strongly supported by Mohammed, A. R. (2011). He showed that SA treated plants gave 13.5% higher grain yield compared to controlled plants. The increasing result may cause due to the increased tiller per hill, increased filled grain per panicle, increased amount of chlorophyll content which helps the plant to produce more food. Ultimately the grain yield increases. Saranraj, P. (2014) also showed that the application of SA can increase grain yield. Sharafizad *et al.,* (2012) showed that dosage of SA significantly affected total grain yield.

The foliar application of different levels of salicylic acid had a significant effect on straw yield. Figure 4 shows that the foliar application of salicylic acid on BRRI dhan29 gave higher straw yield compared to control (Treatment T_1). Here the lowest straw yield (9.84 t/ha) was found in treatment T_6 (2 mM SA) which was statistically identical to control (T_1) having 9.89 t/ha yield. Treatment T_6 had the lowest result may be due to the higher dose of salicylic acid. The highest yield (11.66 t/ha) was found in treatment T_2 which differs significantly to control (T_1). Treatments T_3, T_4 and T_5 was statistically identical to the control (treatment T_1) but they had higher yield compared to control. The treatments can be arranged according to straw yield as T_2>T_4>T_3>T_5>T_6>T_1. This increased result caused may be due to the increased level of chlorophyll content as well as increased dry matter content. This result is strongly supported by Saranraj P (2014) who showed that application of SA can increase straw yield even upto 74.53% over control. Usharani *et al*., (2014) also showed highest straw yield was achieved by the application of salicylic acid.



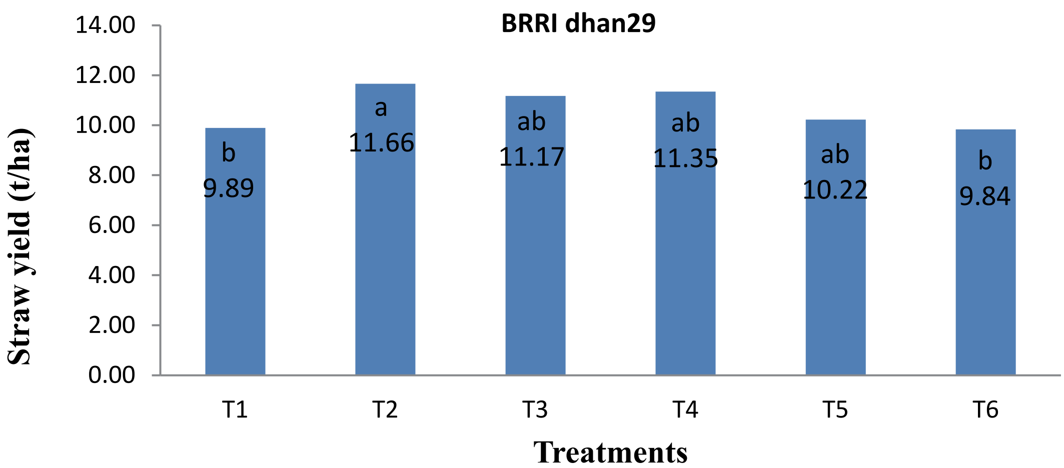


Figure 4. Effect of different doses of salicylic acid on grain and straw yield of BRRI dhan29 at harvest, Boro 2016, SAU. Bars with different letters are significantly different at $p \leq 0.05$ applying DMRT, SAU, 2016

3.7 Rice Biological Yield and Harvest Index as Affected By SA

salicylic acid provided substantial increases in seed yield.

Table 3. Effect of different doses of salicylic acid on grain, straw, biological yield and harvest index of BRRI dhan29, Boro 2016, SAU.

Treatments	Grain yield (t/ha)	Straw (t/ha)	Biological yield (t/ha)	Harvest index (%)
T1	7.02 b	9.89 b	16.91	41.51
T2	7.98 a	11.66 a	19.64	40.63
T3	8.10 a	11.17ab	19.27	42.03
T4	8.13 a	11.35ab	19.48	41.74
T5	7.77ab	10.22ab	17.99	43.19
T6	7.55ab	9.84 b	17.39	43.42
$LSD_{0.05}$	0.9003	1.62		
SE (±)	0.3091	0.556		
Level of significance	**	**		
CV (%)	9.76	12.75		

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD. ** = Significant at 1% level of probability

Table 4. Grain yield and straw increase over control of BRRI dhan29, Boro 2016, SAU.

Treatments	Grain yield (t/ha)	% Increase over control	Straw yield (t/ha)	% Increase over control
T1	7.02 b	-	9.89 b	--
T2	7.98 a	13.65	11.66 a	17.9
T3	8.10 a	15.36	11.17ab	12.94
T4	8.13 a	15.84	11.35ab	14.76
T5	7.77ab	10.66	10.22ab	3.34
T6	7.55ab	7.6	9.837 b	-0.54
$LSD_{0.05}$	0.9003	-	1.6207	-
SE (±)	0.3091	-	0.556	-
Level of significance	**		**	
CV (%)	9.76		12.75	

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

** = Significant at 1% level of probability

Significant response was observed in the biological yield of BRRI dhan29 due to foliar application of different level of salicylic acid (Table 3). The biological yield was varied from 16.91 - 19.64 t/ha. The highest biological yield (19.64 t/ha) was obtained in the T2 treatment. On the other hand, lowest biological yield (16.91 t/ha) was obtained from the T1 treatment. In terms of biological yield the treatments may be arranged as T2>T4>T3>T6>T5>T1. It was observed that, as the rate of foliar application of salicylic acid increases biological yield also increases.

Harvest index (HI) is the ratio of seed yield to total above ground plant yield. Significant response was not observed in the harvest index due to the foliar application of different levels of salicylic acid on BRRI dhan29 (Table 3). From the results, it was found that the highest harvest index (43.42%) was obtained from the treatment T6 and the lowest index (40.63%) was obtained in the T2 treatment whereas, treatment T1 having the harvest index 41.51%. Tavares, et al. (2014) reported that

3.8 Soil Properties as Influenced by SA

The value of pH, organic carbon and organic matter of post-harvest soils did not differ significantly due to the foliar application of SA. The pH, organic carbon and organic matter remain almost similar among all the six treatments (Table 5).

Table 5. Effect of different doses of salicylic acid on pH of post harvest soils of BRRI dhan29, Boro 2016, SAU.

Treatments	pH of Post-Harvest Soils	Organic carbon of Post-Harvest Soils	Organic matter of Post-Harvest Soils
T1	6.3a	0.61a	1.05a
T2	6.3a	0.62a	1.07a
T3	6.2a	0.62a	1.07a
T4	6.2a	0.63a	1.07a
T5	6.4a	0.60a	1.03a
T6	6.2a	0.61a	1.04a
Initial soil pH	6.2		
Initial soil organic carbon		0.60	
Initial soil organic matter			1.03
$LSD_{0.05}$	0.0920	0.0380	0.0663
Level of significance	*	*	*
CV%	0.81	3.41	3.46

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD. *= Non significant at 1% level of probability

4. Conclusion

Application of salicylic acid has a profound effect on effective tillers/hills, 1000 grain weight, filled grain/panicle, unfilled grain/panicle, grain yield, straw yield and biological yield but not on pH, organic matter, organic carbon of post-harvest soil. Decreased respiration rates and increased membrane integrity as a result of salicylic acid application might have increased the amount of photo synthates transported to the grains, thereby increasing the number of filled grains per panicle, hence increased spikelet fertility. So foliar application of lower doses of the salicylic acid (0.75 mM) is highly recommended for rice production compared to the control treatment $T_{1.}$

Acknowledgement

Authors are grateful to the ministry of science and technology, Bangladesh for providing financial support to conduct the research work.

Conflict of interest

The authors have no conflict of interest to report.

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