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EFFECT OF FOLIAR APPLICATION OF SA ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF *Triticum aestivum* (BARI GOM 27)

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ABSTRACT

The experiment was conducted to study effect of different levels of SA (SA) on yield and yield attributes of *Triticum aestivum* (BARI Gom 27). The experiment included four levels of SA viz. 0 μM, 200 μM, 500 μM and 1000 μM SA. The experiment was laid out in a randomized complete block design having 7 treatments with three replications. The treatment combinations were as follows: T_1 = No recommended irrigation + 0 μM SA, T_2 = recommended irrigation + 0 μM SA, T_3 = No recommended irrigation + 200 μM SA, T_4 = recommended irrigation + 200 μM SA, T_5 = No recommended irrigation + 500 μM SA, T_6 = recommended irrigation + 500 μM SA and T_7 = recommended irrigation + 1000 μM SA. The results revealed that yield and yield contributing characters were significantly influenced by the foliar application of SA. The maximum plant height (85.17 cm) was obtained from the T_4 treatment and spike length (14.80 cm) was obtained from the T_7 treatment. The maximum number of effective tillers per m^2 (297.67), maximum number of grains/spike (42.03), maximum filled grains/spike (39.9), highest 1000 grain weight (56 g), highest grain yield (4.23 t/ha) and straw yield (5.20 t/ha) were found in the treatment T_7. The lowest unfilled grains/spike (2.13) was obtained from the T_7 treatment. On the other hand, in all cases minimum results were observed in the control treatment (T_1). The results showed that grain yield of wheat increased with increasing level of SA up to 1000 μM with recommended irrigations. The yield increasing trend was also observed in the treatments having SA with no recommended irrigations (T_1, T_3, T_5). These results might be due to the foliar application of SA because SA improves the water use efficiency through the reduction of stomatal aperture. The aphid infestation of wheat was completely removed by the foliar application of higher doses of SA (1000 μM). Our results indicated that drought stress regulatory mechanisms could be improved in wheat through the foliar spray of SA. Taken together, it can be concluded that the recommended irrigations with foliar application of SA could be applied to increase wheat yield.

Key words: Wheat, SA, foliar spray, yield

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop and ranks second (after rice) in Bangladesh and first both in acreage production in the world context. Wheat is one of the most important cereal crops in the world, which is grown both in arid and semi-arid regions of the world (Akbar *et al.*, 2001; Tunio *et al.* 2006). Moreover, wheat constitutes 15-20 % of the staple cereal food of Bangladesh, which stands on the second position considering the relative importance of all food crops (Rahman, 1980). Bangladesh produces 13,02,998 metric tons of wheat per annum for 10,61,602 acres of land with an average yield of 3.03 t/ha (BBS 2014).

Salicylic acid (SA) is part of a signaling pathway that is induced by a number of biotic and abiotic stresses. It has been recognized as an endogenous regulatory signal in plants mediating plant defense against pathogens (Raskin, 1992). A lot of data exist on the protective effect of SA against drought (Singh and Usha, 2003), heavy metal toxicity (Metawally *et al.*, 2003), high temperatures (Dat *et al.*, 1998) and paraquat (Ananieva *et al.*, 2002). SA can also play a significant role in plant water relations (Barkosky and Einhelling, 1993), photosynthesis, growth and stomatal regulation (Khan *et al.*, 2003; Arfan *et al.*, 2007; Issak *et al.*, 2013) under abiotic stress conditions. Plants produce proteins in response to abiotic and biotic stress and many of these proteins are induced by phytohormones such as ABA (Jin *et al.*, 2000) and SA (Hoyos and Zhang, 2000). SA is synthesized by many plants (Raskin *et*

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al., 1990) and is accumulated in the plant tissues under the impact of unfavorable abiotic factors, contributing to the increase of plants resistance to salinization (Ding *et al,*. 2002, Kang and Saltveit, 2002). Several insect pests infest wheat and cause enormous damage during two important growth stages (heading and flowering) (Freier *et al.*, 2007). Wheat aphids are devastating insect pests of wheat (Steffey and Grey, 2012). Management of wheat aphids is difficult due to their rapid reproduction and extremely short life cycle. SA is known to affect various physiological and bio-chemical activities of plants and may play a key role in regulating their growth and productivity (Hayat *et al.*, 2010). At present, some negative impacts are appearing in wheat production due to climatic change effect in our country. In this case, foliar application of SA will be helpful in wheat cultivation under drought condition. SA is considered to be an endogenous growth regulator of phenolic nature that enhances the leaf area and dry mass production. It enhances germination and seedling growth of wheat. Growth characteristic and photosynthetic rate is increased in wheat, when foliar application of SA is done. However, SA effectively protects the plants against drought stress induced oxidative stress, tissue dehydration and metabolic disturbance which improves plant and yield under drought stress. The aim of this study was carried out to examine effect of foliar application of SA on the yield and yield attributes, water use efficiency, and insect-infestation of wheat.

MATERIALS AND METHODS

The research work was carried out at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2014 to March 2015. The soil of the experimental plots belonged to the Agro Ecological Zone Madhupur Tract (AEZ-28). The farm belongs to the General soil type, Deep Red Brown Terrace Soil" under Tejgaon series. The experiment was single factorial with seven treatments. The treatment combinations of this experiment were as follows: T_1 = No Recommended Irrigation+0 μM SA, T_2 = Recommended Irrigation+ 0μM SA, T_3 = No Recommended Irrigation+ 200 μM SA, T_4 = Recommended Irrigation+ 200 μM SA, T_5 = No Recommended irrigation+ 500 μM SA, T_6 = Recommended Irrigation+ 500 μM SA, T_7 = Recommended Irrigation+ 1000 μM SA. The experiment was laid out in a Randomized Complete Block design (factorial). The size of a unit plot was 4 m x 2 m. The distance between two adjacent replications (block) was 1m and row to row distance was 0.5 m. Two irrigations were applied; first irrigation was applied at 20 DAS (Days after sowing) and second irrigation was applied at 50 DAS as recommended irrigation. Foliar application of SA was done at 20 DAS, 35 DAS, and 50 DAS in wheat field. SA was applied at 20 and 50 DAS after the application of irrigations. The crop sampling was done at the time of harvest. The plant heights, spike length, no of grain per spike, filled grain per spike, unfilled grain per spike, 1000 grain weight, grain yield and straw yield were recorded separately. Total number of plants from $1m^2$ area from each plot was counted at the time of harvest. Grain and straw weight of the demarcated area ($5m^2$) of each plot was taken and then converted to the yield in t/ha. The data collected on different parameters were statistically analyzed to obtain the level of significance using the Windows based software Statistic 10.

RESULTS AND DISCUSSION

Effect of SA as foliar spray on the plant height of wheat

Under the present study, the plant height was significantly influenced by the different treatment combinations. The results revealed that the maximum plant height (85.17 cm) was observed from the treatment T_4 (recommended irrigation with 200 μM SA) whereas the minimum plant height (75.10 cm) was obtained from the treatment T_1 (no recommended irrigation with no SA) (Fig.1). However, foliar application of SA did not influence the plant height of wheat. There were no significant differences among the plant height obtained from the treatments T_2, T_4, T_6 and T_7. Here, it was also observed that lower dose of SA had a positive effect on plant height in the T_4 (200 μM SA) and T6 (500 μM SA) treatments but not at higher dose in the treatment T_7 (10000 μM SA) (Fig.1). Higher dose reduced plant height but not at significant level up to 10000 μM SA. Plant height increased due to application of SA (Ibrahim *et al.*, 2014 & Amin *et al.* 2008).

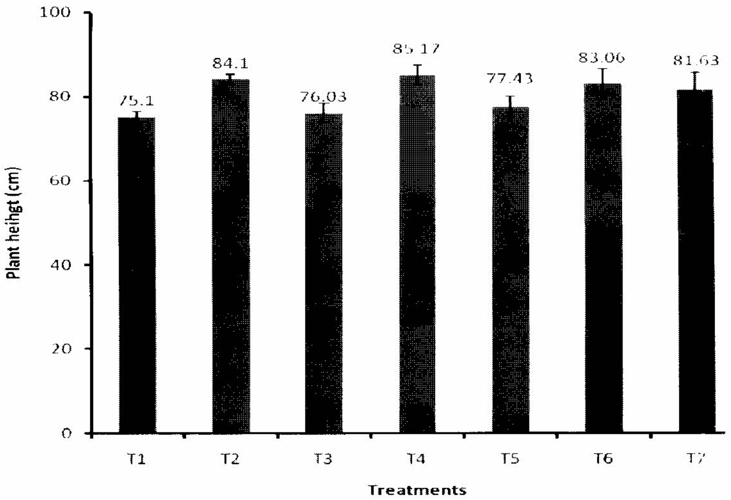

Fig. 1. Effect of different levels of SA on plant height of wheat (BARI GOM 27)

T_1 = No Recommended irrigation+0 μM SA; T_2 = Recommended irrigation+0 μM SA; T_3 = No Recommended irrigation+200 μM SA; T_4 = Recommended irrigation+200 μM SA; T_5 = No Recommended irrigation+500 μM SA; T_6 = Recommended irrigation+500 μM SA, T_7 = Recommended irrigation+1000 μM SA

Role of SA as foliar spray on the number of effective tillers/m²

Statistically significant variation was recorded in the total number of effective tillers per square meter of BARI GOM 27 due to the different treatments. The maximum effective tillers per square meter (297.67) were recorded from the treatment T_7 and the minimum effective tillers per square meter (220.33) were observed from the T_1 treatment (Fig. 2). The tiller numbers increased with increasing the level of SA in the treatments T_4, T_6 and T_7 compared with T_2, having recommended

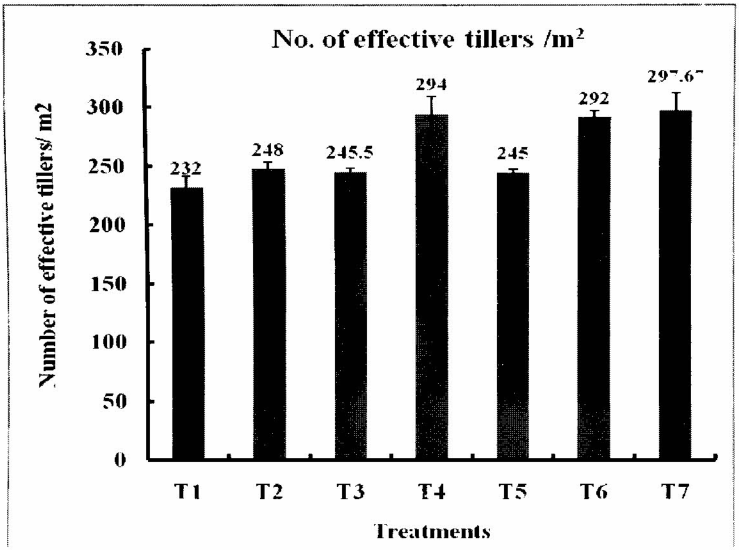

Fig. 2. Effect of different levels of SA on the number of effective tillers/m² of wheat

irrigations, but no significant differences were observed. The increasing trend of tiller numbers were also observed with increasing the level of SA in the treatments T_3 and T_5 compare with T_1, having no recommended irrigations. However, no significant differences were also observed among the treatments having no recommended irrigations. These results suggest that SA could play a vital role as a stress reducing component in wheat cultivation. Total number of effective tillers increased significantly due to application of SA (Amin *et al.* 2008).

SA-influenced number of filled grain/spike of wheat

Filled grains per spike varied significantly due to different treatment combinations. SA at 200 μM increased the field grains (37.77) per spike in the T_3 treatment compared to T_1 and T_5 (Fig. 3) treatments having no recommended irrigations. Under the recommended irrigation condition, filled grains per spike were significantly increased with increasing the level of SA in the treatments T_4, T_6, and T_7 compared to T2 treatments. The maximum number of field grains per panicle were observed in the treatment T_7 (39.90) and the minimum number of filled grains were recorded in the T_5 (34.13) treatment (Fig.3). Our results indicate that foliar application of SA under the recommended irrigations could increase the yield potentiality through increasing the number of field grains per spike in wheat.

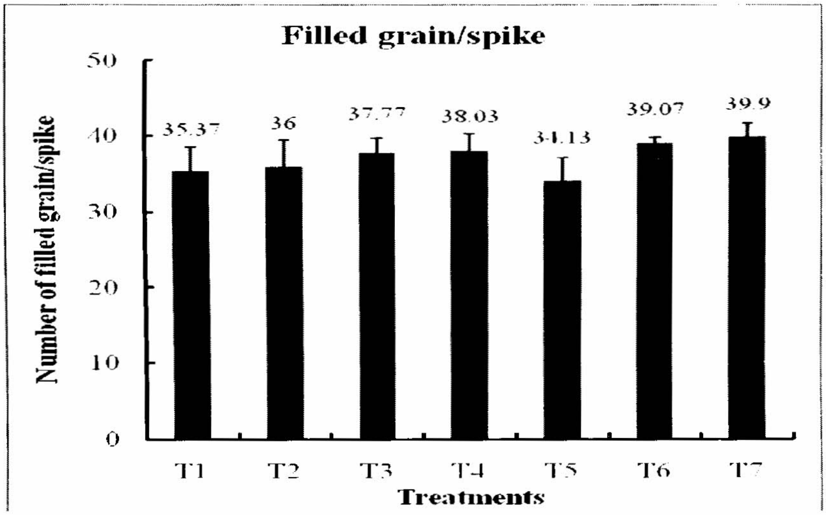

Fig. 3. Effect of different levels of SA on filled grains per spike of wheat

Role of SA as foliar spray on number of unfilled grain/spike of wheat

Number of unfilled grain per spike of BARI GOM 27 differ significantly among the treatments. The maximum number of unfilled grains per spike (3.0) was recorded from T_1 treatment which was statistically similar with T_5 (2.7) treatments having no recommend irrigations (Fig.4). Recommended irrigations with SA as foliar applications reduced the number of unfilled grains per panicle in the treatments T_4, T_6, and T_7 compare to T2 treatments. The minimum number of unfilled grain per spike was recorded in the treatment T_7 having 1000 μM of SA with recommended irrigations. This result suggests that SA could play important role in the reduction of spikelet sterility of wheat.

Role of SA as foliar spray on spike length of wheat

The spike length was significantly influenced by the treatments. Results revealed that the longest spike length (14.80 cm) was recorded from the T_7 treatment having 1000 μM SA with recommend irrigations and the shortest spike length (12.93 cm) was recorded from the T_1 treatment having no recommend irrigations (Table 1). Spike length was increased with increasing the level of SA in both conditions with or without recommended irrigations. Spike length significantly different in the treatments T_3 and

T_5 compared to T_1 treatment having no recommend irrigations. Here, it can be suggested that SA had a contribution to longer spike length and it was clearer in the no recommend irrigation condition. Amin *et. al.* (2008) observed that foliar application of salicylic at 100 ppm (724 μM) and 200 ppm (1448 μM) promoted spike length of wheat plants.

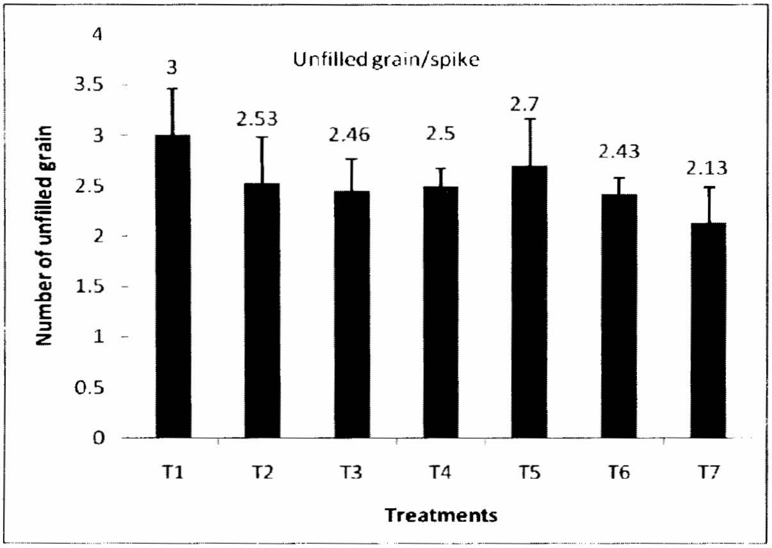

Fig. 4. Effect of different levels of SA on filled grains per spike of wheat

Table 1. Effect of treatments on thousand grain weight and spike length of wheat

Treatments	Spike length (cm)	1000 grain weight (g)
T_1= No RI + 0 μM SA	12.93 e	45.00 d
T_2= RI + 0μM SA	14.17 bc	53.67 abc
T_3= No RI + 200 μM SA	13.47 de	47.87 cd
T_4= RI + 200 μM SA	14.50 ab	54.87 ab
T_5= No RI + 500 μM SA	13.57 cd	49.33 bcd
T_6= RI + 500 μM SA	14.73 ab	55.00 ab
T_7= RI + 1000 μM SA	14.80 a	56.00 a
$LSD_{0.05}$	0.632	5.91
SE (±)	0.29	1.92
Level of significance	*	**
CV (%)	2.53	6.44

** = 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

Role of SA as foliar spray on weight of 1000 grain of wheat

Foliar application of different levels of SA to the different growth stages of wheat showed significant differences on 1000 grain weight (Table 2). The highest 1000 grain weight (56 g) was observed in the treatment T_7, which was statistically identical with the treatments T_2, T_4, and T_6 having recommended irrigations. On the other hand, 1000 grain weight was also statistically identical in the treatments T_1, T_3 and T_5 having no recommend irrigations. However, in both condition with or without irrigations, increasing trend of the 1000 grain weight was observed due to the foliar application of SA (Table 2). Ibrahim *et al.* (2014) found that exogenous application of 0 ppm (362 μM) and 100 ppm (724 μM) SA resulted in significant increase in 1000 grain weight.

Table 2. Effect of treatments on grain yield, straw yield, biological yield and harvest index of wheat

Treatments	Grain yield (t/ha)	Straw yield (t/ha)
T1= No RI + 0 μM SA	1.84 e	2.87 d
T2= RI + 0μM SA	3.11 c	4.08 bc
T3= No RI + 200 μM SA	2.31 d	3.46 cd
T4= RI + 200 μM SA	3.72 b	5.02ab
T5= No RI + 500 μM SA	2.44 d	3.26 cd
T6= RI + 500 μM SA	4.11 ab	5.16a
T7= RI + 1000 μM SA	4.24a	5.20a
$LSD_{0.05}$	0.413	0.982
SE (±)	0.134	0.319
Level of significance	**	**
CV (%)	7.49	13.30

** = 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

Role of SA as foliar spray on grain yield (t/ha) of wheat

The grain yield of wheat increased significantly due to the foliar application of SA at different growth stages. The highest grain yield (4.24 t/ha) was found from the treatment T_7 having 1000 μM SA (Table 2) with recommend irrigations which was statistically identical with the treatment T6 having 500 μM SA with recommend irrigations. The lowest grain yield (1.84 t/ha) was obtained from the treatment T_1 having no SA with no recommended irrigations, which was significantly different from the treatments T_3 and T_5 having no recommended irrigations. In the recommended irrigation condition, foliar application of SA increased grain yield 19.60%, 31.80%, and 35.98% in the treatments T_4, T_6, and T_7 compared to the treatment T_2 respectively (Table 4). On the other hand, under no recommended irrigation condition, foliar application of SA also increased grain yield 25.38% and 32.45% in the treatments T_3 and T_5 compare to the treatment T_1, respectively (Table 3). It was also found that foliar application of SA @ 1000 μM was more effective than other doses to increase the wheat grain yield. These results suggested that foliar application of SA had a significant role on the increment of wheat grain yield, even though in the drought stressed conditions (T_3, T_5). It is suggested that SA with decreasing evapotranspiration and increasing root development and let root to absorb more nutrients under drought stress, using this treatment resulted in increased grain production compared to control. Ibrahim *et al.* (2014) found that exogenous application of 50 ppm (362 μM) and 100 ppm (724 μM) SA resulted in significant increasing grain yield, straw yield. Sharafiza *et.al.* (2012) was also found that application of 0.7 mM and 2.7 mM of SA increased the grain yield of wheat.

Table 3. SA-influenced grain yield increment of BARI Gom27 under no recommended irrigation condition

Treatments	Grain yield (t/ha)	% Grain yield Increased over T1
T_1= No RI + 0 μM SA	1.840	---
T_3= No RI + 200 μM SA	2.307	25.38
T_5= No RI + 500 μM SA	2.437	32.45

Table 4. Role of SA on grain yield increment of BARI Gom27 under recommended irrigation condition

Treatments	Grain yield (t/ha)	% Grain yield Increased over T_2
T_2= RI + 0μM SA	3.113	---
T_4= RI + 200 μM SA	3.720	19.60
T_6= RI + 500 μM SA	4.107	31.80
T_7= RI + 1000 μM SA	4.237	35.98

Role of SA as foliar spray on straw yield (t/ha) of wheat

The straw yield of wheat increased significantly due to addition of SA up to the 1000 μM SA. The highest straw yield (5.20 t/ha) was observed from the treatment T_7 having 1000 μM SA with recommended irrigations. The highest straw yield was statistically identical with the treatments T6 (5.16 t/ha) and T_4 (5.02 t/ha) having SA levels 500 μM and 200 μM with recommended irrigations (Table 2). The lowest straw yield (2.87 t/ha) was obtained from the treatment T_1 having no SA with no recommended irrigations, which was statistically identical with the treatments T_3 and T_5. In the recommended irrigation condition, foliar application of SA increased straw yield 23.04%, 26.47%, and 27.45% under the treatments T_4, T_6, and T_7 compared to the treatment T_2, respectively (Table 6). On the other hand, under no recommended irrigation condition, foliar application of SA also increased grain yield by 20.56% and 13.59% under the treatments T_3 and T_5 compare to the treatment T_1, respectively (Table 5). Here, it can be stated that foliar application of SA @ 1000 μM was more effective to increase the straw yield of wheat than other doses (Table 2). Ibrahim *et al.* (2014) found that exogenous application of 50 ppm (362 μM) and 100 ppm (724 μM) SA resulted in significant increment of straw yield in wheat.

Table 5. Role of SA on straw yield increment of BARI Gom27 under no recommended irrigation condition

Treatments	Straw yield (t/ha)	% Straw yield Increased over T1
T_1= No RI + 0 μM SA	2.87 d	-
T_3= No RI + 200 μM SA	3.46 cd	20.56
T_5= No RI + 500 μM SA	3.26 cd	13.59

Table 6. Role of SA on grain yield increment of BARI Gom27 under recommended irrigation condition

Treatments	Straw yield (t/ha)	% Straw yield Increased over T1
T_2= RI + 0μM SA	4.08 bc	----
T_4= RI + 200 μM SA	5.02ab	23.04
T_6= RI + 500 μM SA	5.16a	26.47
T_7= RI + 1000 μM SA	5.20a	27.45

Role of SA as foliar spray on biological yield (t/ha) of wheat

Significant response was observed in biological yield due to foliar application of different levels of SA on BARI GOM 27. The biological yield was varied from 4.713 to 9.443 t/ha. The highest biological yield (9.443 t/ha) was obtained from the treatment T_7 which was statistically identical with the treatments T_4 and T_6 (Table 2). The lowest biological yield (4.71 t/ha) was obtained in the T_1 treatment which was statistically identical with the treatments T_3 and T_5. Biological yield was significantly increased in the treatments T_4, T_6, and T_7 (having recommend irrigations with SA) compared to the treatment T_2 (having recommended irrigations with no SA). Ibrahim *et al.* (2014) found that exogenous application of 50 ppm (362 μM) and 100 ppm (724 μM) SA resulted in the significant increment of biological yield (Sharafizad *et al.*, 2012). Biological yield increased significantly due to application of SA.

CONCLUSION

The results showed that grain yield of wheat increased with increasing level of SA up to 1000 μM. The overall results of the present study demonstrated that wheat might be grown successfully to get maximum yield with the foliar application of 1000 μM SA. Treatment T7 showed the maximum grain yield of wheat it might be due to the strong management of wheat aphids in the treatment T7 having 1000 μM of SA as foliar application at different stages of wheat. Wheat aphids are devastating insect pest of wheat (Steffey & Grey, 2012) and a very clear picture was found in the wheat aphid management with the 1000 μM SA. No aphids were found in the treatment T7 whereas all the treatments were affected by wheat aphid and maximum aphids were observed in the control treatment T1. However, before making conclusion concerning the appropriate dose of SA, the study needs further investigation in the other Agro Ecological Zones (AEZs) of Bangladesh for country-wide recommendation for controlling aphids and successful wheat production.

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