Response of Wheat to Salicylic Acid

Ziasmin[1], Mohammad Mahbub Islam[1], Kamal Uddin Ahmed[1], Shahidul Islam[1], Suraya Parvin[2]

[1]Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[2]Bangladesh Agricultural Research council, Dhaka, Bangladesh

Abstract-Pot experiment was conducted to examine the effect of different levels of salicylic acid (SA) to wheat during November 2015 to March 2016. In this experiment three different levels of SA were used. The different levels of SA were; S_0 = 0 mM, S_1= 0.2 mM and S_2 = 0.4 mM. The experimental results showed that different levels of SA showed significant influence on morphological, yield contributing character and yield of wheat. The foliar application of SA in higher doses at S_2 = 0.4 mM increased plant height (63.60 cm), leaf number (10.94), tillers number (2.71), effective tiller numbers plant^{-1} (2.22), Membrane Stability (71.53%), spike length (10.45cm), number of spikelet spike^{-1} (18.10), number of effective spikelet spike^{-1} (14.63), number of grains spike^{-1} (35.78), grain yield plant^{-1} (1.9 g) and 100 grain weight (4.20 g) compared to S_0 = 0 mM and S_1= 0.2 mM doses of SA. Therefore, it is suggesting that higher doses of SA increased yield of wheat by improving morphological and yield contributing character.

Index terms-Wheat; Salicylic acid; Yield

1. Introduction

Agriculture is the source of food and one of the largest sectors of economy all over the world. Wheat (*Triticum aestivium* L.) is one of the most important cereal crops under Poaceae family grown throughout the world including Bangladesh. It is one of the most important winter crop which is sensitive to temperature. It was reported in 2016 that the world production of wheat was 749 million tons, making it the second most-produced cereal after maize (1.03 billion tons) (FAO, 2016; FAOSTAT, 2016). In Bangladesh, average yield and total production of wheat has been estimated 3.086 m t/ha & 13, 47,926 metric tons, respectively (BBS 2015). It is being a staple food of millions of people which contains large amount carbohydrates and protein. In Bangladesh wheat production rate is very low due to lack of using plant growth regulators (PGRs) like Salicylic acid, Jasmonic acid, amino acid, sugar, nutrient supply etc. It is well known that, Salicylic acid (SA) is an endogenous plant growth regulator which participates the regulation of physiological process of plants as well as defense mechanism. SA is a well-known naturally occurring signaling molecule that affects various physiological and biochemical activities of plants. SA is phenolic compound involved in the regulation of growth and development of plants, and their responses to biotic and abiotic stress factors (Raskin, 1992; Khan *et al.*, 2012a,b,c 2013b; Muira and Tada, 2014). The exogenous application of SA enhanced the photosynthetic rate and also maintain the stability of membranes thereby improved the growth of barley plants (El-Tayeb, 2005). SA lowered the level of active oxygen species and therefore the activities of SOD and peroxidase (POX) were also lowered in the roots of young wheat seedlings (Shakirova *et al.*, 2003). Therefore, this experiment was conducted to examine the influence of different levels of SA on morphological, yield contributing character and yield of wheat.

2. Method and Materials

This was a pot experiment conducted in the net house at the field laboratory of Agricultural Botany Department, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 23º74´N latitude and 90º35´E longitude with an elevation of 8.2 meter from sea level under the agro-ecological zone of Modhupur tract, AEZ-28 during November 2015 to March 2016 to examine the influence of different levels of SA on morphological, yield contributing character and yield of wheat variety BARI Gom 24 is known as variety, Prodip. The experiment was laid out in single factors in Completely Randomized Design (CRD) with five replications. Treatments of the experiment were S_0 = 0 mM SA (Control), S_1 = 0.2 mM SA and S_2 = 0.4 mM SA. The total pot number was 3×5=15. Each earthen pot was 35 cm in diameter and 30 cm in height. The soil was put into the pot which contains 10 kg soil per pot. All pots were filled on 30 November 2015. Weeds and stubbles were completely removed from the soil. Salicylic acid (SA) was sprayed exogenously at 0, 0.2 mM and 0.4 mM concentrations which were maintained by adding 0, 0.03 g and 0.06 g SA respectively per liter of water and 0.1% of Tween-20 was used as an adhesive material. At 35, 45 and 55 day after sowing (DAS) the SA solution was sprayed by a hand sprayer at 10.00 -12.00 am. After the germination of seeds, various intercultural operations such as irrigation, weeding, top dressing of fertilizer and plant protection measures were accomplished for better growth and development of the wheat seedlings.

3. Result and Discussion

Plant height (cm)

It is well known that, salicylic acid (SA) is an endogenous plant growth regulator which participates the regulation of physiological process of plants as well as defense mechanism. Numerous author stated that SA treatment enhances the plant growth in terms of root, shoot, length and biomass production. Growth stimulating effects of SA has been previously reported in soybean (Gutierrez-coronado *et al.*, 1998), wheat (Shakirova *et al.*, 2003). However little is known about the influence of SA to change the morphological characters of wheat including plant height in our climatic and edaphic condition. Therefore, I used different concentrations of SA to find the contribution of SA on change in plant height of wheat. The experiment results showed a significant effect on plant height of wheat with SA at 60 DAS (Table 1). The tallest plant height was recorded 63.6 cm from S_2 or 0.4 mM SA whereas the smallest plant height 61.55 cm from S_0 or control. The increase of plant height of wheat dependents on different concentrations: higher concentration showed better results than lower concentration. Kang *et al.*, 2012 reported that, SA increase plant height, dry mass and less wilting of leaves in wheat plant.The positive effect of foliar application of SA on the growth parameters and water status have also been reported under stress conditions (Khodary, 2004; Hussein *et al.*, 2007 ;). All together these results suggest that SA increased plant height of wheat as other growth promoting substances.

Number of leaves per plant

The leaf number is a fundamental morphological character for plant growth and development as leaf is the main photosynthetic organ. SA is a well-known naturally occurring signaling molecule that affects various physiological and biochemical activities of plants. Salicylic acid is a plant growth regulator that plays a significant role in abiotic stress. Usage of Salicylic acid had showed significant variation on the number of leaves per plant of wheat at 60 DAS (table 1). The highest number of leaves per plant was recorded 10.94 from S_2 or 0.4 mM SA and lowest number of leaves per plant was recorded 9.6 from S_0 or control. The increase of leaf numbers of wheat dependents on different concentrations: higher concentration showed better results than lower concentration. Farahbakhsh and Saiid (2011) who reported that high concentration of SA (200 ppm) caused an increase of 74.94% in leaf area and number of leaf. Zhou *et al.* (1999) also indicate that SA increases the leaf number in sugarcane plants. From these results it was found that SA increased leaves per plant of wheat.

Number of Tiller per plant

It is well known that, Salicylic acid (SA), a group of phenol compounds, is an endogenous growth regulator. SA and other salicylates are known to affect various physiological and biochemical activities of plants and may play a key role in regulating their growth and productivity (Hayat *et al.*, 2010). In present study, Usage of Salicylic acid had showed significant variation on the number of tiller per plant of wheat at 60 DAS (Table 1). The highest number of tillers per plant was recorded 2.71 from S_2 or 0.4 mM SA and lowest number of tillers per plant was recorded 2.24 from S_0 or control. Similarly Shakirova *et al.* (2003) found that the positive effect of SA on number of tillers plant^{-1} of wheat can be increased due to its influence on the other plant hormones. Azimi *et al.* (2013) also reported that SA had significant effects on number of tiller per m^2 and maximum tiller was observed at 1.5mM across SA treatments. So, these results suggest that SA increases tiller per plant of wheat as other growth promoting substances.

Number of Effective Tiller plant^{-1}

Variation of the number of effective tiller plant^{-1} of wheat at 60 DAS had been influenced significantly by the Application of SA (Table 1). The highest number of effective tillers per plant was recorded 2.22 from S_2 or 0.4 mM SA and lowest number of effective tillers per plant was recorded 1.86 from S_0 or control. Azimi *et al.* (2013) reported that SA had significantly effects on number of tiller per m^2 and maximum tiller was observed at 1.5mM across SA treatments. So, these results suggest that SA increases effective tiller per plant of wheat which consistent with many other previous findings.

Table:1. Data on plant height, leaf number, tiller number and effective tiller number of wheat at 60 DAS as influenced by different levels of salicylic acid

Salicylic acid level	Plant height	Leaf No.	Tiller No.	Effective tiller No.
S_0	61.55c	9.60b	2.24c	1.86b
S_1	62.91b	10.68a	2.45b	2.01b
S_2	63.60a	10.94a	2.71a	2.22a
Lsd(0.01)	0.07	0.45	0.35	0.23
Cv%	7.11	4.51	8.50	9.58

Spike Length (cm)

Spike Length was significantly influenced by the Application of Salicylic Acid (Table 1). The highest Spike Length was recorded 10.45cm from S_2 or 0.4 mM SA and lowest Spike Length was recorded 9.72 cm from S_0 or control. SA and other salicylates are known to affect various physiological and biochemical activities of plants and may play a key role in regulating their growth and productivity (Hayat *et al.*, 2010). So, it was clear that with application of SA correspondingly increase Spike Length.

Number of Spikelet per spike

Number of Spikelet per spike had been influenced significantly by the Application of Salicylic Acid (Table 2). The highest Number of Spikelet spike^{-1} was recorded 18.10 from S_2 or 0.4 mM SA and lowest Number of Spikelet spike^{-1} was recorded 15.98 from S_0 or control. The Number of Spikelet spike^{-1}significantly increased with the increase of Salicylic Acid. Aldesuquy *et al.* (2012) stated that mechanism of SA induced yield enhancement might be an increase in the number of spikelets because SA has the capacity to both directly or indirectly regulate yield. These results are in a good agreement with those obtained by Khan *et al.* (2003) with maize and soybean. From the study of results it was found that higher concentration of SA increases Number of Spikelet spike^{-1} than lower concentration in wheat.

Number of Effective Spikelet per spike

Number of Effective Spikelet spike^{-1} had been influenced significantly by the Application of Salicylic Acid (Table 2). The highest Number of Effective Spikelet spike^{-1} was recorded 14.63 from S_2 or 0.4 mM SA and lowest Number of Effective Spikelet spike^{-1} was recorded 12.90 from S_0 or control. The Number of Spikelet spike^{-1} significantly increased with the increase of Salicylic Acid. Aldesuquy *et al.* (2012) stated that mechanism of SA induced yield enhancement might be an increase in the number of spikelets because SA has the capacity to both directly or indirectly regulate yield.

Number of Grain spike^{-1}

Number of Grain spike^{-1} had been influenced significantly by the Application of Salicylic Acid (Table 2). The highest Number of Grain spike^{-1} was recorded 35.78 from S_2 or 0.4 mM SA and lowest Number of Grain spike^{-1} was recorded 30.57 from S_0 or control. Abdelkader *et al.*, (2012) stated that SA promotes crop production and counteracts the yield components inhibition caused by abiotic stresses, including drought stress in wheat plants. So it can easily understand that the Number of Grain per spike significantly increased with the increasing level of Salicylic Acid.

Table: 2. Data on spike length, number of spikelet, number of effective spikelet and number of grain spike^{-1} of wheat as influenced by different levels of salicylic acid

Salicylic acid level	Spike Length (cm)	Number of Spikelet spike^{-1}	Number of Effective Spikelet spike^{-1}	Number of Grain spike^{-1}
S_0	9.72c	15.98a	12.9c	30.57a
S_1	10.15b	17.15a	13.85b	33.83ab
S_2	10.45a	18.1b	14.63a	35.78b
Lsd(0.01)	0.35	1.50	2.1	1.97
Cv%	5.19	4.50	4.8	5.6

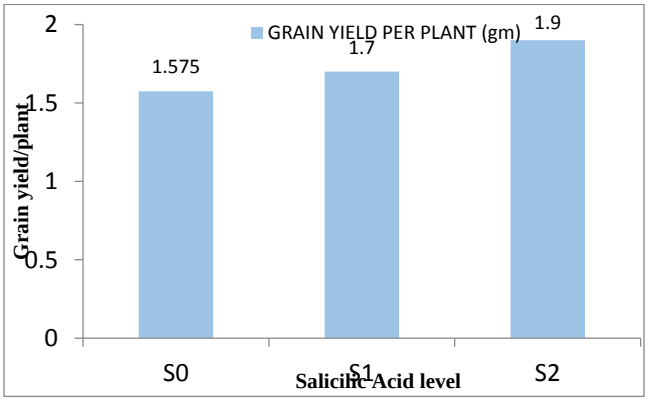
Grain Yield Plant^{-1} (gm)

Grain Yield per Plant had been influenced significantly by the Application of Salicylic Acid (Figure 1). The highest amount of Grain Yield per Plant was recorded 1.9 gm from S_2 or 0.4 mM SA and lowest amount of Grain yield plant^{-1} was recorded 1.57 gm from S_0 or control. Zhou *et al.(*1999) reported that maize stem injected with SA produced 9% more grain weight. These results are consistent with the present morphological and yield contributing characters such as plant height, number of leaves Plant^{-1}, tillers Plant^{-1} , effective tillers Plant^{-1}, number of spikelet spike^{-1}, number of effective spikelet spike^{-1} and number of grains spike^{-1}. From this experiment it was found that the Grain yield plant^{-1} of wheat increase is concentration dependent, higher concentration showed better results than lower concentration.

100 Grain Weight (gm)

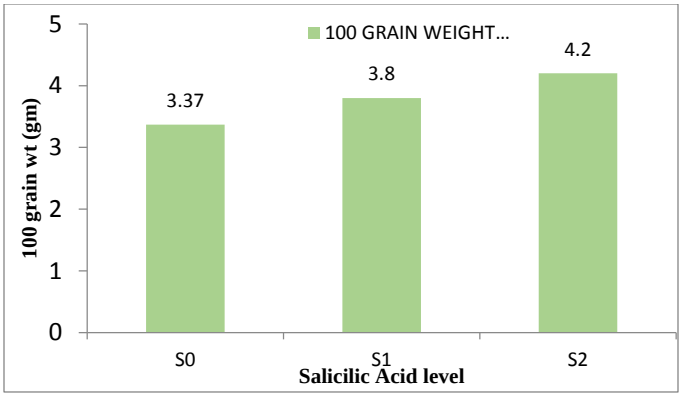
It is well known that, Salicylic acid (SA) is an endogenous growth regulator which participates the regulation of physiological process of plants as well as defense mechanism and growth. However little is known about the influence of SA to increase the 100 Grain Weight of wheat in our climatic and edaphic condition. Therefore I used different concentrations of SA to find the contribution of SA on change in 100 Grain Weight of wheat. 100 Grain Weight had been influenced significantly by the Application of Salicylic Acid

(Figure 2). The highest amount of 100 Grain Weight was recorded 4.20 gm from S_2 or 0.4 mM SA and lowest amount of 100 Grain Weight was recorded 3.37 gm from S_0 or control. The amount of 100 Grain Weight was significantly increased with the increase of Salicylic Acid. Some studies have indicated that salicylic acid can enhance the plant growth, yield and quality (Khodary, 2004). El-Tayeb (2005) reported that SA pretreatment increased grain weight in the barley seedlings. These results are consistent with the present morphological and yield contributing characters such as plant height, number of leaves Plant^{-1}, tillers Plant^{-1}, effective tillers Plant^{-1}, number of spikelet spike^{-1}, number of effective spikelet spike^{-1} and number of grains spike^{-1} (Table 1 and 2). These results suggest that higher doses of SA increased 100 Grain Weight of wheat than lower doses.



S_0 = no Salicylic acid, S_1 = 0.2 mM SA, S_2 = 0.4 mM SA

Figure-1. Effect of different levels of Salicylic Acid on Grain Yield Plant^{-1}of wheat (LSD 0.01=0.23).



S0 = no Salicylic acid, S1 = 0.2 mM SA, S2 = 0.4 mM SA

Figure 2. Effect of different levels of Salicylic Acid on 100 Grain Weight of wheat (LSD 0.01=0.59)

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Authors

First Author-Ziasmin, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh(ziasminbscag@gmail.com)
Second Author- Mohammad Mahbub Islam, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh (mahbubislam_sau@yahoo.com)
Third Author- Kamal Uddin Ahmed, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh(kuahamed@yahoo.com)
Fourth Author- Shahidul Islam, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh(sislam475@gmail.com)
Fifth Author- Suraya Parvin , Bangladesh Agricultural Research council, Dhaka, Bangladesh (parvin.su1980@gmail.com)

Corresponding Author-Ziasmin (ziasminbscag@gmail.com)