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Enhancement of growth, yield and fruit quality of sweet pepper (*Capsicum annuum* L.) by foliar application of salicylic acid

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Abstract

The experiment was designed to study on the effect of salicylic acid as a foliar spray on the growth, yield and fruit quality of sweet pepper (*Capsicum annum* L.) in the net house of Sher-e Bangla Agricultural University, Dhaka, Bangladesh and the treatments included @ 0 (control), 0.3, 0.6, 0.9, 1.2, 1.5 and 1.8 mM of salicylic acid. The single factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The vegetative growth, fruit yield and quality of sweet pepper were found positive by the application of salicylic acid. Spraying 1.8 mM salicylic acid showed the highest plant height, branches plant^{-1} and stem diameter; fruit number, weight, length and diameter; vitamin C content and total soluble solid content and also increased the fruit yield compare to control. Therefore, salicylic acid represents the potentiality to enhance fruit yield and quality of sweet pepper.

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Introduction

Sweet pepper (*Capsicum annuum* L.) is a member of the family Solanaceae under the genus Capsicum. It is rich in Vitamin A, C and minerals like Ca, Mg, P and K. Red sweet pepper fruit contain high health-promoting bioactive compounds, like phenolics, carotenoids, and antioxidants, such as beta carotene which serves as provitamin A (Jamiolkowska *et al.*, 2016). Capsicum is the most important summer crop of temperate regions but now a day's effort are being made to grow sweet pepper in Bangladesh (Paul, 2009). Consumers judge the quality of sweet pepper fruit by their physical characters, color and nutritional value, generally preferring such kind of fruits (Jamiolkowska *et al.*, 2016). The use of natural biostimulants, foliar feeding and plant growth regulators has been recently introduced to improve the quality of vegetable products. Foliar fertilization is a common crop-management strategy to maximize yield and fruit quality (Haytova, 2013) and help plants compensate for low soil fertility, nutrient uptake limitations, and nutrient fixation (Dada and Ogunsesu, 2016). Foliar application of salicylic acid may increase the yield of vegetable species by reducing stress-induced growth inhibition (Khan *et al.*, 2015).

Salicylic acid (SA) is a plant phenolic compound, used as a plant growth regulator (Agamy *et al.*, 2013) that promotes various physiological processes, such as germination, growth, photosynthesis, transport and uptake of solutes. Salicylic acid (SA) is a naturally occurring plant hormone that increases the capacity of plants to fight against biotic and abiotic stress (Wang *et al.*, 2010). SA can induce tolerance against high and low temperatures, drought, salinity, ultraviolet light, heavy metal toxicity, diseases and pathogens (Hayat and Ahmad, 2007). Plants treated with SA showed increased vigor of early seedling growth, increased photosynthetic rates, induced stomatal closure, increased water use efficiency and decreased stomatal conductance and transpiration rate (Issak *et al.*, 2013). The application of exogenous SA as a natural phytohormone is effective in some of the qualitative and quantitative characters of pepper plants (Elwan and El-Hamahmy, 2009).

However, the production of sweet pepper is decreased due to physiological and hormonal imbalance. There is plenty of research data on the application of varied technologies on sweet pepper that are obtainable in different countries, however very little or no is documented on the comparative study of foliar application of salicylic acid in Bangladesh. Considering the above-mentioned facts a pot experiment has been selected to assess the influence of the foliar application of salicylic acid on the growth, productivity, yield and fruit quality of sweet pepper in Bangladesh.

Methodology

Experimental site

The pot experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University, Dhaka-1207 from October 2019 to March 2020. The soil of the experimental pot belongs to the general soil type, shallow red-brown terrace soil with silty clay. Soil pH was 5.6 and has organic carbon 0.45%.

Treatments and experimental design

BARI Mistimorich-1 was used as the test crop. This single factor experiment was comprised of seven treatments i.e. 0 (control), 0.3, 0.6, 0.9, 1.2, 1.5 and 1.8 mM of salicylic acid. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of unit pots were 21.

Crop husbandry

Healthy seeds were sown in a seed bed @ 0.23 g m^{-2} on 7^{th} October, 2019. A total of 21 pots were prepared and their weight was recorded. Each pot was (30 cm inner diameter) containing 8 kg of air-dried soil. The potting soil was fertilized with cow dung 80 g pot^{-1}, urea 2 g pot^{-1}, triple superphosphate (TSP) 2.8 g pot^{-1}, murate of potash (MoP) 2 g pot^{-1}, gypsum 0.88 g pot^{-1} and zinc sulfate 0.04 g pot^{-1} corresponding to 10-ton cow dung ha^{-1}, 250 kg urea ha^{-1}, 350 kg TSP ha^{-1}, 250 kg MoP ha^{-1}, 110 kg gypsum ha^{-1} and 5 kg zinc sulfate ha^{-1} as a source of NPKSZn. The half amount of cow dung was applied before the final preparation of pots and rest ½ amount of cow dung, TSP, MoP, gypsum, zinc sulfate and 1/3rd of urea were applied within two installments after 25 and 50 days after transplanting. The 30 days old seedlings were transplanted in the main pot on November 7, 2019.

Application of salicylic acid as a foliar spray

In this experiment, a salicylic acid solution was applied in three installments. 1st spray was done at 20 days after transplanting, 2nd spray was done after 40 DAT and 3rd spray was done after 60 DAT with a hand sprayer.

Data collection

Data on the following parameters were recorded during the period of the experiment such as: Plant height (cm), Number of branches plant^{-1}, Stem diameter (mm), Days to 50 % flowering, Number of fruits plant^{-1}, Individual fruit weight (g), Fruit length (cm), Fruit diameter (cm), Yield plant^{-1} (g),Vitamin C content (mg/100g fw) and Total soluble solids (%).

Statistical analysis

The data obtained for different parameters will be statistically analyzed following computer-based software Statistix 10 and mean separation will be done by LSD at 5% level of significance (Gomezm and Gomez, 1984).

Results and discussion

Plant height (cm)

Foliar application of salicylic acid increased the plant height of sweet pepper as compared with the control treatment. Among the treatment variations, 1.8 mM SA showed the highest (86.20 cm) plant height than other treatments whereas the control showed the lowest (62.83 cm) plant height (Fig. 1).

In agreement with our results, Yahaya *et al.*, (2017) mentioned that foliar application of salicylic acid increased the plant height of sweet pepper plants.

Table 1. Effect of foliar spray salicylic acid on Days to 50% flowering, No. of fruits plant^{-1}, Individual fruit weight, Fruit length and Fruit diameter of sweet pepper.

Treatments	Days to 50% flowering	No. of fruits plant^{-1}	Individual fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
Control	88.40 a	6.02 e	67.97 g	5.17 d	5.00 c
0.3 mM SA	81.17 ab	7.10 de	75.81 f	5.63 cd	5.23 bc
0.6 mM SA	78.52 abc	8.03 cd	79.58 e	6.20 cd	5.50 abc
0.9 mM SA	76.47 bc	8.73 bc	83.77 d	6.73 bc	5.83 abc
1.2 mM SA	74.97 bc	9.03 bc	88.48 c	7.43 ab	6.07 ab
1.5 mM SA	72.33 bc	10.13 b	92.73 b	7.83 ab	6.23 a
1.8 mM SA	70.18 c	12.03 a	95.67 a	8.40 a	6.47 a
$LSD_{(0.05)}$	10.06	1.47	2.91	1.15	0.98
CV (%)	7.30	9.45	1.96	9.56	9.64

Values followed by the same letter(s) did not differ significantly at 5% level of probability.

Number of branches plant^{-1}

Branches plant^{-1} of sweet pepper varied significantly due to the foliar spray of salicylic acid. Salicylic acid @ 1.8 mM resulted in the highest branches plant^{-1} (6.85) and at control treatment lowest branches plant^{-1} (3.47) was observed (Fig. 2).

Similar results were reported by Fathy *et al.*, (2000) for an increased number of branches plant^{-1} with exogenous application of SA in plants.

Stem diameter (mm)

The stem diameter of the sweet pepper plant was found significant compared to the control treatment due to foliar spray of salicylic acid. The highest stem diameter (17.09 mm) was observed at 1.8 mM SA and the lowest stem diameter (11.31 mm) was observed at control (0 mM SA) treatment (Fig. 3). This corroborates with the findings of Yildirim *et al.*, (2009) who reported that the highest stem diameter was observed @ 0.5 mM exogenous application of salicylic acid.

Days to 50% flowering

Foliar spray of salicylic acid had a significant influence on days to 50% flowering of sweet pepper (Table 1). For 50% flowering maximum days (88.40) were taken by control (0 mM SA) treatment and minimum days (70.18) were taken by treatment (1.8 mM SA).

Table 2. Effect of foliar spray salicylic acid on Fruit yield plant^{-1}, Vitamin C content and total soluble solids content of sweet pepper.

Treatments	Fruit yield plant^{-1} (g)	Vitamin C (mg/100 g FW)	Total soluble solids (%)
Control	407.2 f	161.40	5.03 c
0.3 mM SA	542.5 ef	168.20	5.83 bc
0.6 mM SA	641.7 de	172.63	6.07 abc
0.9 mM SA	733.8 cd	174.93	6.27 ab
1.2 mM SA	801.2 c	179.57	6.60 ab
1.5 mM SA	941.0 b	182.89	6.83 ab
1.8 mM SA	1154.5 a	185.08	7.13 a
$LSD_{(0.05)}$	139.0	ns	1.17
CV (%)	10.47	9.12	10.59

Values followed by the same letter(s) did not differ significantly at 5% level of probability.

No. of fruits plant^{-1}

The application of salicylic acid significantly increased the number of fruits plant^{-1} of sweet pepper compared to the control treatment. Results indicated that maximum fruits plant^{-1} (12.03) was observed in 1.8 mM SA and minimum fruits plant^{-1} (6.02) was observed in control (0 mM SA) treatment (Table 1). These results were supported by Bakundi *et al.*, (2017) indicated that fruits number plant^{-1} of sweet pepper was increased by various exogenous applications of salicylic acid.

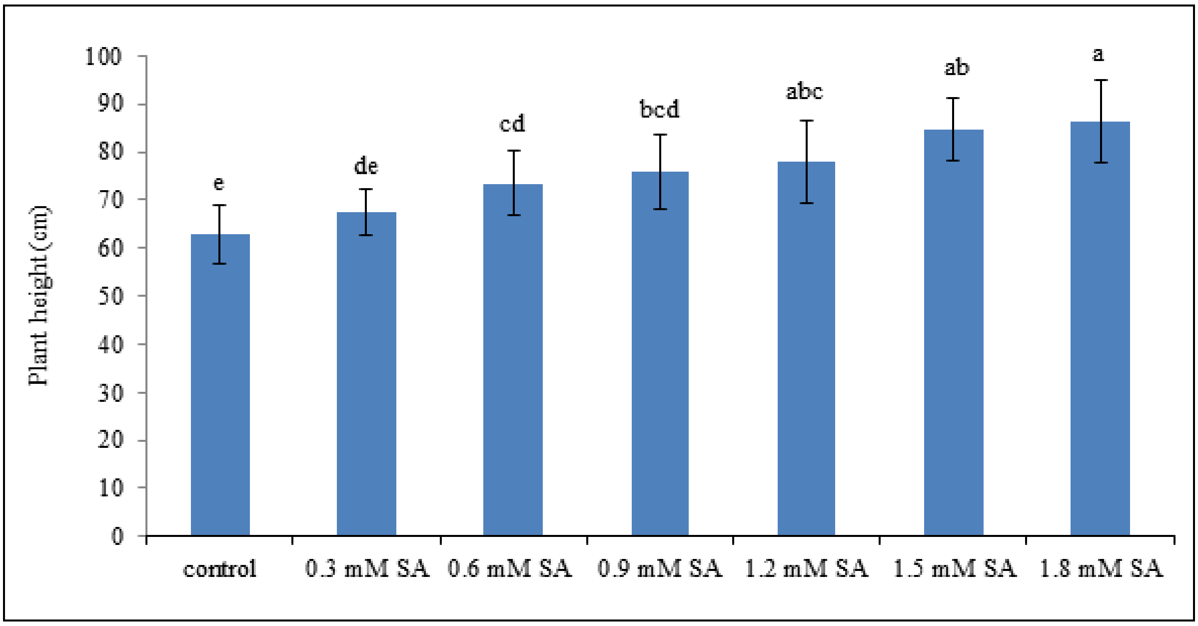

Fig. 1. Effect of foliar spray of salicylic acid on plant height of sweet pepper.

Individual fruit weight (g)

The individual fruit weight of sweet pepper was significantly increased by foliar treatments of salicylic acid (Table 1). Salicylic acid at 1.8 mM concentration gave the highest individual fruit weight (95.67 g) and the control (0 mM SA) treatment showed the lowest individual fruit weight (67.97 g). Hanieh *et al.*, (2017) also reported that salicylic acid application to sweet pepper under greenhouse conditions induced positive effects on fruit weight and the number of fruit plant^{-1} therefore total fruit weightplant^{-1} also increased.

Fruit length (cm)

Salicylic acid treatment showed a significant increment in fruit length of sweet pepper as compared with the control treatment (Table 1). Results showed that among the different SA concentration, 1.8 mM SA showed the highest fruit length (8.40 cm) and the control treatment showed the lowest fruit length (5.17 cm). Ali *et al.*, (2014) also found similar results that foliar application of salicylic acid significantly improved fruit physical characteristics like fruit length of stone fruits.

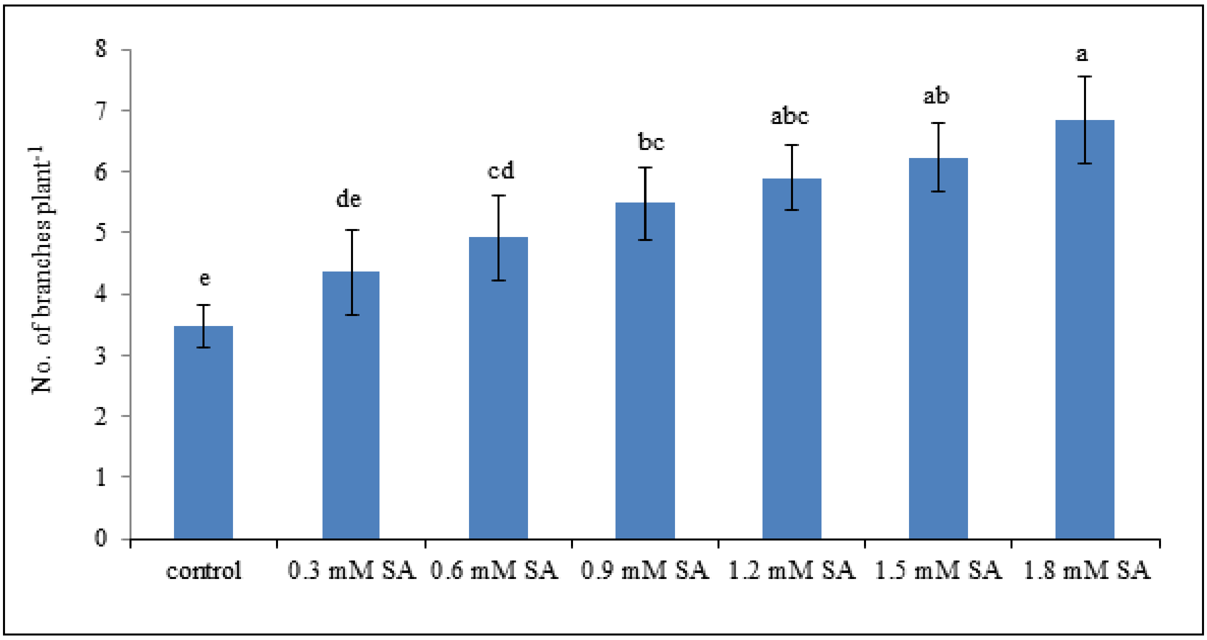

Fig. 2. Effect of foliar spray of salicylic acid on branches plant^{-1}of sweet pepper.

Fruit diameter (cm)

Foliar application of salicylic acid increased the fruit diameter of sweet pepper (Table 1). The highest fruit diameter (6.47 cm) was observed at 1.8 mM SA and the lowest fruit diameter (5.00 cm) was observed at control (0 mM SA) treatment.

These results were supported by El-Yazeid *et al.*, (2011) who observed that the different sprayed salicylic acid treatments increased fruit physical characters such as the diameter of sweet pepper fruits.

Fruit yield plant^{-1} (g)

Data in Table (2) indicate that significant increases in fruit yield of sweet pepper have existed with the foliar applications of salicylic acid compared to control treatment. Application of salicylic acid @1.8 mM the fruit yield was highest (1154.5 g) whereas in control (0 mM SA) the fruit yield was lowest (407.2 g). Such increments in fruit yield due to treating the plants with salicylic acid might be connected with their effect on increasing the fruit yield traits (such as fruit number, length, diameter and weight) and vegetative growth parameters which affect plant growth and in turn increased its productivity. Many reports supporting this result such as Ibrahim *et al.*, (2019) who found that sweet pepper plants sprayed with salicylic acid significantly increased fruit yield and its components than the plants without salicylic acid treatments. Also, the application of salicylic acid significantly influenced on yield and its components of maize (Abdel-Wahed, *et al.*, 2006).

Vitamin C (mg/100 g FW)

Vitamin c content of sweet pepper was not influenced significantly although there was some apparent difference in vitamin c content in different salicylic acid treatments (Table 2). Contrary to present results, findings of Peng and Jiang (2006) reported that salicylic acid application to Chinese water chestnut fruits enhanced the amount of vitamin c content compared to the control.

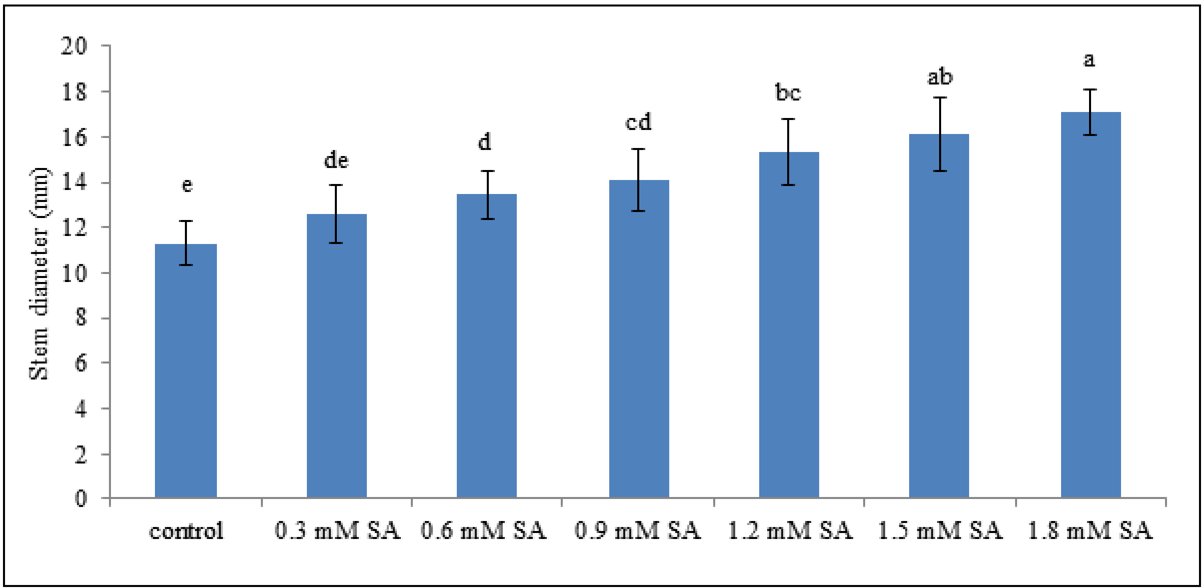

Fig. 3. Effect of foliar spray of salicylic acid on the stem diameter of sweet pepper.

Total soluble solids (%)

Salicylic acid treatments increased the amount of total soluble solids in sweet pepper fruits. The highest total soluble solids (7.13%) were observed at 1.8 mM SA and the lowest total soluble solids (5.03 %) were observed at control (0 mM SA) treatment. Salicylic acid is reported to improve total soluble solids in various fruits including strawberry (Karlidag *et al.*, 2009) and banana fruits (Srivastava and Dwivedi, 2000).

Conclusion

The growth, yield contributing parameters, fruit yield and nutritional quality are positively correlated with salicylic acid.

Sweet pepper plants applied with 1.8 mM salicylic acid showed the highest vegetative growth such as plant height, branches plant^{-1} and stem diameter; fruit yield components, such as fruit number, weight, length and diameter; fruit quality traits, such as vitamin C content and total soluble solid content and also increased the fruit yield, then the plants in all other treatments.

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