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Effects of salicylic acid on yield and quality characters of tomato fruit (Lycopersicum esculentum Mill.)

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ABSTRACT: In other to study the effects of salicylic acid on yield quantity and quality of tomato, an experiment was carried out based on randomized complete blocks design with four replications at research center of Shirvan Agricultural Faculty in 2011. Foliar application of five concentrations of salicylic acid (0, 10^{-2}, 10^{-4}, 10^{-6}, 10^{-8} M) were used. Results showed that application of salicylic acid affected tomato yield and quality characters of tomato fruits so that tomato plants treated with salicylic acid 10^{-6} M significantly had higher fruit yield (3059.5 g per bush) compared to non-treated plants (2220 g per bush) due to an increase in the number of bunch per bush. Results also indicated that application of salicylic acid significantly improved the fruit quality of tomato. Application of salicylic acid increased the amount of vitamin C, lycopene, diameter of fruit skin and also increased rate of pressure tolerance of fruits. Fruit of tomato plants treated with salicylic acid 10^{-2}M significantly had higher vitamin C (32.5 mg per 100 g of fruit fresh weight) compared to non treated plants (24 mg per 100g fruit fresh weight). Salicylic acid concentration 10^{-2} M also increased the diameter of fruit skin (0.54 mm) more than two fold compared to control (0.26 mm). Fruit Brix index of tomato plants treated with salicylic acid 10^{-2}M significantly increased (9.3) compared to non-treated plants (5.9). These results suggest that foliar application of salicylic acid may improve quantity and quality of tomato fruits
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Key words: Brix, Salicylic acid, Tomato, Vitamin C, Yield.

INTRODUCTION

Salicylic acid (SA) or ortho-hydroxy benzoic acid 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). Salicylic acid is considered to be an endogenous growth regulator of phenolic nature that enhanced the leaf area and dry mass production in corn and soybean (Khan et al., 2003). Enhanced germination and seedling growth were recorded in wheat, when the grains were subjected to pre-sowing seed-soaking treatment in salicylic acid (Shakirova, 2007). Fariduddin et al. (2003) reported that the dry matter accumulation was significantly increased in Brassica juncea, when lower concentrations of salicylic acid were sprayed. However, higher concentrations of salicylic acid had an inhibitory effect. Khodary (2004) observed a significant increase in growth characteristic, pigment contents and photosynthetic rate in maize, sprayed with salicylic acid. Eraslan et al. (2007) also reported that exogenous application of salicylic acid, enhanced growth, physiological process and antioxidant activity of carrot plants grown under salinity stress.

Flowering is another important parameter that is directly related to yield and productivity of plants. Salicylic acid has been reported to induce flowering in a number of plants. Different plant species including ornamental plant Sinningia speciosa flowered much earlier as compared to the untreated control, when they received an exogenous foliar spray of salicylic acid (Martin-Max et al., 2005) In cucumber and tomato, the fruit yield enhanced significantly when the plants were sprayed with lower concentrations of salicylic acid (Larque-Saavedra and Martin-Mex 2007). It was reported that the foliar application of salicylic acid to soybean also enhanced the flowering and pod formation (Kumar et al., 1999).

Tomato (Lycopersicon esculentum Mill) is a member of the Solanaceae family. It is considered a major vegetable crop in many parts of the world including Iran. Tomato is a rich source of lycopene and vitamins. Lycopene may help counteract the harmful effects of substances called free radicals which are thought to contribute to number of types of cancer.

In recent years, some studies have indicated that salicylic acid can enhance the plant growth, yield and quality (Khodary, 2004). Therefore, this study was conducted to determine if application of tomato seedlings with salicylic acid improve yield and quality of tomato fruits.

MATERIAL AND METHODS

An experiment was carried out based on randomized complete blocks design with four replications at research farm of Shirvan Agricultural faculty in 2011 to investigate the effect of salicylic acid concentrations on yield quantity and quality of tomato (Lycopersicon esculentum) plants. A nursery was prepared in greenhouse condition and tomato seeds (var. Mobil) were sown in early March to raise seedlings for transplanting. Seedlings were transplanted to the field in early May. Considering fertilizer requirement and results of soil analysis, 250 kg ha^{-1} urea and 150 kg ha^{-1} triple super phosphate were used. Urea fertilizer was used at three stages. Fifty kg of urea was used at transplanting time, 100 kg at six-leaf stage and 100 kg at early reproductive stage. The distance between the plants in the rows was 40 cm and distance between rows was 150 cm. Five different salicylic acid concentrations including 0 M (distilled water as control), 10^{-2} M, 10^{-4} M, 10^{-6} M and 10^{-8} M were used. Different salicylic acid concentrations prepared with distilled water. The pH of all solutions was set to 6.5-7. Two weeks after transplanting, tomato seedlings were sprayed with different salicylic acid concentrations by two week interval for five times.

Fruit soluble solids (Brix index) were determined by refractometer methods using a digital refractometer (model 060279, Belgium) (A.O.A.C, 1970). Ascorbic acid (vitamin C) was determined by titrimetric method using 2, 6- dichloroindophenol (A.O.A.C. 1970). Lycopene content in fruit was estimated as described by Sadasivan and Manikam (1992). Fruit firmness was measured by penetrometer (0) and diameter of fruit skin was measured by a digital calipers.

The data for all characters were analysed using the analysis of variance procedure of Statistical Analysis System (SAS) software, version 6.12. Means were compared by Duncan's multiple range tests at the 0.01 probability level for all comparisons.

RESULTS AND DISCUSSION

Analysis of variance showed that foliar application of salicylic acid significantly ($P < 0/01$) affected tomato yield and quality characters of tomato fruits (Table 1). Tomato seedlings treated with salicylic acid 10^{-6} M had significantly higher yield (3059.5 g per bush) compared to untreated control (2222 g per bush). However, there was no significant difference among salicylic acid 10^{-2} M, 10^{-8} M and control (Table 2). This increasing of yield closely linked to increase the number of bunch per bush (Table 2). These results are supported by those of Kumar et al. (1999) who found that foliar application of salicylic acid to soybean enhanced the flowering, pod formation and consequently yield of soybean. It was reported that salicylic acid application promotes cell division and cell enlargement (Hayat et al., 2005). Foliar application of salicylic acid increased the leaf area of sugarcane (Zhou et al., 1999). According to Shakirova et al. (2003) the positive effect of salicylic acid on growth and yield can be due to its influence on other plant hormones. Salicylic acid altered the auxin, cytokinin and ABA balances in wheat and increased the growth and yield under both normal and saline conditions. Increasing of yield under foliar application of salicylic acid could be ascribed to the well-known roles of salicylic acid on photosynthetic parameters and plant water relations. Fariduddin et al. (2003) reported that exogenous application of salicylic acid enhanced the net photosynthetic rate, internal CO_2 concentration and water use efficiency in Brassica juncea. Application of salicylic acid increased the fruit lycopene content so that tomato transplants treated with salicylic acid 10^{-2} M had significantly higher lycopene content (6.4 mg per 100 g fruit fresh weight) compared to untreated control (4.23.mg per 100 g fruit fresh weight). However, there were no significant differences among different salicylic acid concentrations (Table 2). Moharekar et al. (2003) reported that salicylic acid activated the synthesis of carotenoids and xanthophylls. Masroor et al. (2006) also reported that foliar application of gibberelic acid significantly increased lycopene content of tomato fruits. The highest fruit vitamin C was obtained in tomato plants treated with salicylic acid 10^{-2} M (32.5 mg per 100 g fruit fresh weight) compared to control plants (24 mg per 100 g fruit fresh weight).

Similar observations were also made in tomato plants raised from the seeds soaked in salicylic acid and was presumed to be due to the enhanced activation of some enzymes such as ascorbate peroxidase.

Table 1. Analysis of variance for quantity and quality characters of tomato plants under salicylic acid treatments

S.O.V	df	Yield per bush	Number of bunch per bush	Rate of pressure tolerance	Diameter of fruit skin	Licopene	Vitamin C	Brix index
Replication	3	0.18^{ns}	14.73^{ns}	0.20^{ns}	0.009^{ns}	0.42^{ns}	29.23^{ns}	0.12^{ns}
Treatment	4	1.37^{*}	132.80^{**}	1.12^{**}	0.04^{**}	3.51^{ns}	48.00^{ns}	7.36^{**}
Error	12	0.30	6.23	0.16	0.006	1.38	15.53	0.14
CV%		20.19	10.99	19.24	19.47	20.91	13.96	5.40

*, ** significantly at the 5% and 1% levels of probability respectively and ns (non significant)

Table 2. Mean comparison of the effects of salicylic acid on yield and quality characters on tomato

Treatment	Yield per bush (g)	Number of bunch per bush	Lycopene mg/100g	Diameter of fruit skin (mm)	Vitamin C mg/100g	Brix index	Rate of pressure tolerance kg/cm
10^{-2}	2360.8b	2.57c	6.36a	0.54a	32.51a	6.96b	2.82a
10^{-4}	2965.8a	4.65c	6.34a	0.45ab	31a	9.3a	2.07b
10^{-6}	3059.5a	5.37c	5.06b	0.45ab	26.83ab	6.52bc	2.35ab
10^{-8}	2467.8b	8.25b	4.23b	0.38b	26.71ab	6.2cd	2bc
Control	2220.5c	11.64a	4.04b	0.26c	24.01b	5.9d	1.37c

Mean fallowed by similar letters in each column, are not significantly at the 5% level of probability

Exogenous application of salicylic acid increased the amount of fruit soluble solids materials (Brix index). Plants treated with salicylic acid had significantly higher Brix index compared to non-treated plants (control). Tomato plants treated with salicylic acid concentration 10^{-4} M had significantly the highest (9.2) Brix index (Table 2). This can be attributed to the role of salicylic acid to improve membrane permeability, absorption and utilization of mineral nutrients. Some researches indicated that salicylic acid increased membrane permeability would facilitate absorption and utilization of mineral nutrients and transport of assimilates. This would also contribute towards enhancing the capacity of the treated plants for biomass production as is reflected in the observed increase in fresh and dry weight of plants (Ansari, 1996). Chandra et al. (2007) reported that application of salicylic acid increased total soluble sugar and soluble protein of cowpea plants.

CONCLUSION

Salicylic acid is considered to be a potent plant hormone because of its diverse regulatory roles in plant metabolism. It is well-established fact that salicylic acid potentially generates a wide array of metabolic responses in plants and also affects the photosynthetic parameters which enhance plant growth and yield. It may, therefore be concluded that the sustained increase in the observed parameters expectedly culminated in maximization of the process of biomass accumulation leading to higher productivity, lycopene, vitamin C content of tomato fruit and as well as fruit Brix index.

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