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Salicylic Acid Effects on Growth, Yield, and Fruit Quality of Strawberry Cultivars

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ABSTRACT

The effects of salicylic acid on growth, flowering, yield, yield components, and fruit quality of three strawberry cultivars (Festival, Sweet Charli, and Vertona) were investigated during the 2013-2014 and 2014-2015 growing seasons. Foliar applications of salicylic acid at 0, 1, 2, and 3 mM levels were applied to strawberry cultivars growing outside in a split plot, using a randomized complete block design. Application of a salicylic acid foliar spray at the 3 mM level significantly increased vegetative growth, number of flower clusters, and earliness in the treated strawberry cultivars. Of the treated cultivars, Festival produced the highest fruit yields per plant, along with an extended production season, and lowest percentage of gray mold. The Vertona cultivar had a higher total soluble tissue than the other cultivars, and the Sweet Charli cultivar had the highest titratable acidity.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch), a perennial cool season crop, is popular as a fresh fruit in high demand for the taste, profitability, high yield, and good quality. The production of strawberries, one of the most delicious, nutritive, and refreshing fruits, has gained a strong interest over the past decade (Singh *et al.*, 2007), becoming popular among growers in Egypt for the high return on the investments. The multifarious use of strawberries for local fresh consumption, food processing, and export to Europe potentially makes strawberries one of the most profitable horticultural crops in Egypt (El-Shal *et al.*, 2003).

Salicylic acid (SA), a naturally occurring plant hormone, acts as an important signaling molecule and enhances tolerance of treated plants against biotic stresses (Khan *et al.*, 2012). Salicylic acid also has a vital role in plant growth, ion uptake, and nutrient transport within the plant. As a phenolic compound, salicylic acid is present in many plants and is also involved in local and systemic resistance to fungal pathogens (Meena *et al.*, 2001).

A significant role for salicylic acid has been suggested in plant water relations, photosynthesis, and growth in plants (Arfan *et al.*, 2007). Previous studies have demonstrated that a wide range of responses might appear after exogenous salicylic acid application, including yield increases (El-Tayeb, 2005; Khodary, 2004; Yildirim *et al.*, 2008; Larque-Saavedra and Martin-Mex, 2007), more photo-synthetic activity (Singh and Usha, 2003), higher total anthocyanin levels (Hernandez and Vargas, 1997), inhibition of ethylene biosynthesis (Huang *et al.*, 2004), and protection against biotic and abiotic stresses (Doares *et al.*, 1995; Karlidag *et al.*, 2009).

The fruit of strawberry plants are sensitive to fungal attack due to the well-known perishable structure of the fruit. In addition, the high metabolic activity of the fruit can quickly decrease fruit quality after harvesting (Olias *et al.*, 2000). Lolaei *et al.* (2012) noted that salicylic acid delayed the ripening of strawberry and improved fruit yield and quality. Jamali *et al.* (2011) has reported that a salicylic acid treatment at 2 mM increased root and shoot fresh weights, number of inflorescences, fruit yield, and fruit quality.

A variety of phytopathogenic fungi, bacteria, and viruses (Schestibratov and Dolgov, 2005). Grey mold caused by *Botrytis cinerea*, is a very destructive disease of strawberries in Egypt and worldwide, frequently causing yield losses of 25 percent in unprotected plants. The fungus attacks strawberry flowers, setting fruit, mature fruit, and leaves (Sutton, 1990; Sutton and Peng, 1993), making grey mold a major cause of postharvest losses during storage, transit, and shipment (El-Sghaier *et al.*, 2009). Babalar *et al.* (2007) has reported that salicylic acid treatment effectively reduces fruit ethylene production, prevents fungal decay, and retains overall fruit quality.

Varieties of strawberries differ from each other in nutrient absorption by roots and other factors. For example, Shewfelt (1999) observed significant differences among strawberry varieties in terms of the number of leaves, level of chlorophyll, diameter of crowns, fresh weight of roots, plant yield, and fruit quality.

The current study investigated the effects of foliar treatment of salicylic acid on vegetative growth, fruit yield, fruit quality, and control of grey mold on three strawberry cultivars.

MATERIALS AND METHODS

Plant material. Commonly grown strawberry cultivars in Egypt (Sweet Charli, Festival, and Vertona), that produce fruit characterized as sugary with an excellent flavor, were used in this study. Transplants of the cultivars, obtained from the Non-Traditional Crops Research Station, Nubaria, El-Eheira Governorate, Egypt, were transferred into a field at the Experimental Station Farm, Horticultural Research Institute, South El-Tahrir, El-Beheira Governorate, Egypt, on September 24, 2013, in the first growing season and September 27, 2014, in the second growing season (Table 1). The plants, maintained in a sandy soil using drip irrigation, were treated with salicylic acid spray on the vegetative tissue and fruit every 14 days.

Salicylic acid treatments. Salicylic acid solutions at concentrations of 1, 2, and 3 mM were prepared by dissolving powdered salicylic acid in hot water that was allowed to cool before applying to the plant material. The salicylic acid and the water treatment control were sprayed to "run-off" on the selected plots of strawberry plants at flowering (40 days after transplanting). The treatments were repeated every two weeks for a total of six applications.

Plant growth. The recommended cultural practices for commercial strawberry production were followed throughout the study. Irrigation was daily, applying water as needed to maintain the plants. To determine plant growth and earliness of flowering, randomly chosen plants from each subplot were labeled and the span of days from transplantation to 25 percent flowering was recorded.

At the full blooming stage, 10 randomly selected plants were collected from each subplot and the number of leaves per plant, the number of crowns per plant, and the leaf area of the plants were recorded. The numbers of flowering clusters per plant were counted at the end of the experimental study.

Table 1. Properties of the field plot soil.

Physical/Chemical	Growing Season	
Properties*	**2013-2014**	**2014-2015**
pH	7.5	8.3
Sand (%)	93.7	93.6
Silt (%)	0.08	0.06
Clay (%)	5.35	5.28
Soil texture class	**Sandy**	**Sandy**
OM (%)	0.08	0.06
$CaCO_3$ (%)	1.43	1.51
Total N (%)	0.007	0.008
Available Nutrients	-	-
P (ppm)	0.35	0.32
K (ppm)	0.23	0.20

*Physical and chemical properties of the experimental sites were measured according to methods described by Black (1965).

Yield components. The fresh weight of strawberry yield was determined in two separate harvests. The early, first fruit harvest was collected by handpicking the berries from ten randomly selected plants within each subplot at each of the four harvests. The late, fresh fruit yield of the strawberry plants was collected after the first four harvests and continued until the end of the growing season. Total fruit yield was recorded as the fresh weight of all harvested strawberries throughout the growing season.

Marketable and non-marketable strawberry yields were calculated at each harvest by separating non-marketable (split, malformed, green-shouldered, damaged, and/or rotted tissue) from marketable berries. The percentage recovery from grey mold was calculated as the weight of non-marketable, untreated berries minus the weight of treated, marketable berries divided by the total weight of berries times 100.

Fruit constituency. Titratable acidity was measured using 10 mL of strawberry fruit juice diluted with 100 mL of distilled water. The mixture was then titrated with 0.1 N sodium hydroxide to a pH 8.1. In addition, the titratable acidity was calculated as a percentage of citric acid (A.O.A.C., 1990).

Total soluble solids in the extracted fruit juice were measured with a refractometer according to the methods of Cox and Pearson (1962). Vitamin C **(**ascorbic acid**)** was measured by titration with potassium iodide (Ranganna, 1986). Free, conjugated, and total phenols in the strawberry fruit were measured according to procedures of Snell and Snell (1953) with Folin reagent. Absorption was measured at 660 mμ with photoelectric colorimeter and the readings were compared with those obtained from pyrogallol standard solution.

Statistical analysis. The strawberry plants were established in split-plots within a randomized complete block design with three replicates. Main plots consisted of the three strawberry cultivars. The different salicylic acid treatments (0, 1, 2 and 3 mM) were randomly distributed as sub-plots.

The experimental results were statistically separated using SAS/STAT software Version 6 (SAS institute Inc., Cary, State, USA). The means were separated using the least significant difference test (LSD) (Snedecor and Cochran, 1967). Correlations were tested using the analytic tools in the Microsoft Office Excel, 2003.

RESULTS

Vegetative growth. The vegetative growth of the Festival cultivar exceeded the other two cultivars, Sweet Charli and Vertona, in the measured vegetative growth in both cropping seasons (Table 2). The number of leaves per plant, the number of crowns per plant, and the leaf area per plant were significantly enhanced by the salicylic acid treatments during both seasons. The foliar spray of 3 mM salicylic acid, as compared with the other treatments, resulted in the highest significant mean value of the studied

Table 2. Effects of foliar application of salicylic acid on vegetative growth of three strawberry cultivars.

Strawberry cultivars	Salicylic acid treatments	Vegetative characteristics					
		2013/2014			2014/2015		
		No. crowns/ plant	No. leaves/ plant	Leaf area/ plant	No. crowns/ plant	No. leaves/ plant	Leaf area/ plant
Festival	0 mM (water)	4.82	23.23	353.58	5.15	22.53	364.40
	1 mM	5.99	25.29	372.68	6.23	24.98	362.45
	2 mM	6.01	27.96	394.04	5.74	28.28	390.04
	3 mM	6.21	30.08	405.25	5.96	31.67	410.28
Sweet Charli	0 mM (water)	3.42	19.74	325.98	2.92	20.62	320.75
	1 mM	4.50	22.86	330.05	3.61	21.81	331.96
	2 mM	4.94	24.94	357.48	4.19	25.31	361.63
	3 mM	5.34	27.19	387.93	4.97	26.44	390.72
Vertona	0 mM (water)	3.84	22.12	334.66	4.21	22.37	335.32
	1 mM	4.30	23.24	393.18	5.29	21.59	346.23
	2 mM	5.85	26.38	379.10	5.15	27.44	379.92
	3 mM	6.39	29.56	397.14	6.01	28.79	375.51
$L.S.D._{(0.05)}$		0.15	0.43	0.19	0.44	0.42	19.80

$L.S.D._{(0.05)}$ = Least significant difference at 0.05 probability level.

vegetative growth characters.

The interaction among the strawberry cultivars and salicylic acid levels on the studied vegetative growth characters of strawberry plants reflected significant differences among all vegetative growth characters. The cv. Festival strawberry plants sprayed with 3 mM salicylic acid produced the highest significant mean values for the number of leaves per plant, crown numbers per plant, and leaf area per plant in both growing seasons.

Flowering traits. The cv. Festival produced the most flowers per plant, but strawberry cv. Sweet Charli and cv. Vertona flowered earlier in both seasons (Table 3). The salicylic acid treatments initiated earlier flowering and the number of flowering clusters per plant significantly as compared with the effects of the previous year.

The salicylic acid treatment at the rate of 3 mM also induced earliness and more flower clusters than the control and other salicylic acid treatments. The cultivars Sweet Charli and Vertona flowered earlier than the Festival Cultivar in both growing seasons. All the tested strawberry cultivars showed earliness in flowering in both seasons after being sprayed with 3 mM salicylic acid.

Yield components. Salicylic acid treatment of the strawberry cultivars increased early, late, and total fresh weight yield per unit area (Table 4). Total yield per plant and early and late yields per unit area responded to all levels of salicylic acid. The highest level of salicylic acid treatment enhanced yield the most. The cv. Festival had a larger response to the salicylic acid than the cultivars Sweet Charli and Vertona in both growth seasons.

In addition, the salicylic acid treatments were able to reduce the non-marketable fruit yield per unit area, enhancing total final yield (Table 5). The most significant infections of grey mold and non-marketable yield were associated with Sweet Charli and Vertona cultivars in both seasons, but salicylic acid had a more positive effect on non-marketable fruit as compared with the Festival cultivar. Recovery of non-marketable fruit yield by use of the salicylic acid treatment ranged from 58-65%.

Table 3. Effects of foliar application of salicylic acid on flowering characteristics of three Strawberry cultivars.

Strawberry cultivars	Salicylic acid treatments	Flowering characteristics			
		2013/2014		2014/2015	
		Days to flowering	No. flowering clusters	Days to flowering	No. flowering clusters
Festival	0 mM (water)	58.23	6.76	57.89	6.57
	1 mM	55.33	7.90	55.61	7.46
	2 mM	51.28	8.94	50.46	8.41
	3 mM	48.96	9.90	49.59	9.81
Sweet Charli	0 mM (water)	55.40	5.45	55.22	5.83
	1 mM	52.84	7.36	53.69	7.66
	2 mM	50.43	7.91	51.28	7.82
	3 mM	46.67	8.82	47.69	9.12
Vertona	0 mM (water)	56.26	6.26	55.87	6.67
	1 mM	53.14	6.95	52.93	7.17
	2 mM	50.11	7.89	49.27	8.84
	3 mM	48.63	8.93	47.16	8.87
$L.S.D._{(0,o5)}$		0.11	0.16	0.26	0.23

$L.S.D._{(0.05)}$ = Least significant difference at 0.05 probability level.

Table 4. Effects of foliar applications of salicylic acid on a per plant yield.

Strawberry cultivars	Salicylic acid treatments	Component characteristics					
		2013/2014			2014/2015		
		Total Yield (kg/plant)	Early Yield (kg/m^2)	Late Yield (kg/m^2)	Total Yield (kg/plant)	Early Yield (kg/m^2)	Late Yield (kg/m^2)
Festival	0 mM (water)	0.607	0.850	3.483	0.607	0.838	3.476
	1 mM	0.615	0.921	3.698	0.643	0.905	3.736
	2 mM	0.621	1.031	3.912	0.629	1.081	3.886
	3 mM	0.716	1.093	3.998	0.715	1.112	3.998
Sweet Charli	0 mM (water)	0.601	0.862	3.414	0.604	0.886	3.431
	1 mM	0.623	0.912	3.540	0.626	0.936	3.526
	2 mM	0.643	0.960	3.629	0.647	0.969	3.671
	3 mM	0.670	1.050	3.795	0.672	0.950	3.781
Vertona	0 mM (water)	0.565	0.712	3.329	0.560	0.738	3.283
	1 mM	0.589	0.802	3.388	0.591	0.831	3.412
	2 mM	0.605	0.876	3.457	0.611	0.893	3.481
	3 mM	0.660	0.919	3.807	0.612	0.940	3.743
L.S.D.$_{(0,o5)}$		N.S.	N.S.	0.10	N.S.	0.31	0.15

L.S.D. $_{(0.05)}$ = least significant difference at the level of probability at 0.05 level

N.S. - not significantly different at 0.05 level

Table 5. Effects of foliar salicylic acid applications on yield and component characteristics of three strawberry cultivars.

Strawberry cultivars	Salicylic acid treatments	Component characteristics							
		2013/2014				2014/2015			
		Total yield (kg/m^2)	Marketable yield (kg/m^2)	Non-marketable yield (kg/m^2)	R%*	Total yield (kg/m^2)	Marketable yield (kg/m^2)	Non-marketable yield (kg/m^2)	R%*
Festival	0 mM (water)	3.143	3.938	0.398	---	4.357	3.967	0.362	---
	1 mM	4.612	4.345	0.267	33.30	4.640	4.400	0.245	35.45
	2 mM	4.943	4.736	0.210	47.37	4.974	4.760	0.207	45.95
	3 mM	5.112	4.969	0.157	60.67	5.107	4.950	0.160	57.97
Sweet Charli	0 mM (water)	4.298	3.824	0.474	---	4.317	3.890	0.426	---
	1 mM	4.445	4.198	0.255	41.75	4.469	4.198	0.269	49.22
	2 mM	4.593	4.388	0.202	55.92	4.640	4.438	0.205	53.00
	3 mM	4.788	4.626	0.164	65.42	4.805	4.645	0.160	62.45
Vertona	0mM (water)	4.040	3.555	0.483	---	4.019	4.710	0.481	---
	1 mM	4.186	3.881	0.305	37.42	4.229	3.864	0.364	26.27
	2 mM	4.326	4.112	0.207	56.15	4.369	4.157	0.210	56.37
	3 mM	4.600	4.548	0.171	64.72	4.724	4.550	0.176	63.45
L.S.D.$_{(0,o5)}$		0.045	N.S.	N.S.	1.70	0.11	0.12	N.S.	4.40

*R% = Percentage recovery from grey mold

L.S.D. $_{(0.05)}$ = least significant difference at the level of probability at 0.05 level.

N.S. - not significantly different at 0.05 level.

The Festival cultivar had a significantly higher mean value for vitamin C content and the lowest percentage of water content in the fruit in both seasons. The Vertona cultivar had a significantly higher mean value of total soluble solids than the other treated cultivars in both seasons. Sweet Charli cultivar had a significant mean value of titratable acidity characters.

Salicylic acid application during both study seasons had significant effects on variable fruit quality (water content, vitamin C, T.S.S, and titratable acidity) of the three tested strawberry cultivars. In both seasons, water content and titratable acidity were affected and decreased compared with untreated (control) tested cultivars (Table 6). The most pronounced effects occurred with high levels of salicylic acid in both seasons. T.S.S and vitamin C, however, were significantly increased with the increase in the salicylic acid rates in both seasons.

The combination effects between strawberry cultivars and salicylic levels resulted in no significant effects on vitamin C and titratable acidity in either season. In contrast, significant interaction effects on fruit water content and T.S.S. were observed in both seasons. Applications of the highest rates of salicylic acid in the strawberry cv. Festival gave the best results on water content and T.S.S. in both seasons.

Significant increases and similar trends were noted with the salicylic acid applications in the total, free, and conjugated phenols of fruits in both seasons (Table 7). The cv. Festival, the most responding strawberry cultivar to salicylic acid application, was subjected to further investigation for phenolic contents in both seasons. Interaction between the strawberry cultivars and salicylic acid application produced significant differences in the free, conjugated, and total phenols in the first season only. In contrast, no significant differences in the free and

Table 6. Effect of foliar application of salicylic acid concentration on fruit quality characteristics of three strawberry cultivars and their interaction during 2013/2014 and 2014/2015 growing seasons.

Strawberry cultivars	Salicylic acid treatments	Fruit quality characteristics							
		2013/2014				2014/2015			
		WC (%)	VC (µg/g f.wt)	T.S.S. (%)	T.A. (%)	WC (%)	VC (µg/g f.wt)	T.S.S. (%)	T.A. (%)
Festival	0 mM (water)	91.94	28.80	7.14	0.695	92.49	22.60	7.79	0.683
	1 mM	90.18	32.60	8.23	0.605	91.38	34.40	8.51	0.615
	2 mM	89.93	34.20	9.17	0.546	90.21	34.00	6.86	0.529
	3 mM	89.43	35.30	10.20	0.489	89.95	36.20	10.96	0.422
Sweet Charli	0 mM (water)	92.93	29.60	7.06	0.718	92.51	28.90	7.29	0.695
	1 mM	91.18	31.60	8.27	0.606	91.04	32.80	8.27	0.618
	2 mM	90.89	33.90	9.29	0.553	90.65	34.60	9.75	0.582
	3 mM	89.69	34.90	10.56	0.499	89.49	35.40	9.95	0.505
Vertona	0 mM (water)	95.96	27.60	8.81	0.652	94.20	27.00	9.22	0.656
	1 mM	91.37	29.00	10.39	0.515	91.40	29.60	10.89	0.536
	2 mM	91.17	31.90	11.44	0.498	90.93	34.20	12.11	0.483
	3 mM	90.12	33.90	12.41	0.419	89.94	35.60	12.77	0.377
L.S.D.$_{(0.05)}$		0.22	N.S.	0.17	N.S.	0.10	N.S.	0.46	N.S.

L.S.D. $_{(0.05)}$ = least significant difference at the level of probability at 0.05 level.
N.S. - not significantly different at 0.05 level.
WC – water content, VC – vitamin C, T.S.S. – total soluble solids, T.A. – titratable acidity

Table 7. Effects of foliar salicylic acid applications on conjugated, free, and total phenols of three strawberry cultivars and their interaction during growing seasons.

Strawberry cultivars	Salicylic acid treatments	Conjugated, free and total phenols					
		2013/2014			2014/2015		
		Conjugated phenols (µg/g f.wt)	Free phenols (µg/g f.wt)	Total phenols (µg/g f.wt)	Conjugated phenols (µg/g f.wt)	Free phenols (µg/g f.wt)	Total phenols (µg/g f.wt)
Festival	0 mM (water)	0.247	0.685	0.933	0.255	0.668	0.923
	1 mM	0.385	1.664	2.050	0.323	1.586	1.979
	2 mM	0.435	1.722	2.217	0.514	1.816	2.330
	3 mM	0.583	2.111	2.694	0.574	2.190	2.764
Sweet Charli	0 mM (water)	0.257	0.675	0.933	0.269	0.691	0.956
	1 mM	0.332	1.496	1.835	0.353	1.614	0.968
	2 mM	0.456	1.882	2.378	0.475	1.915	2.390
	3 mM	0.614	1.966	2.081	0.640	1.224	1.864
Vertona	0 mM (water)	0.220	0.555	0.776	0.218	0.567	0.785
	1 mM	0.296	1.317	1.613	0.285	1.341	1.627
	2 mM	0.214	1.543	1.857	0.332	1.615	1.948
	3 mM	0.498	2.115	2.613	0.502	2.227	2.730
L.S.D.$_{(0.05)}$		N.S.	0.21	0.20	N.S.	N.S.	N.S.

L.S.D. $_{(0.05)}$ = least significant difference at the level of probability at 0.05 level.
N.S. - not significantly different at 0.05 level.

total phenols were noted in the second season. No significant interaction, however, was observed in the conjugated phenols in both seasons. The present study demonstrated that foliar spray with 3 mM salicylic acid on strawberries provided the best fruit yield for tested cultivars in this study.

DISCUSSION

A positive influence of salicylic acid on vegetative growth characteristics of strawberries are in agreement with those reported by Khodary *et al.* (2004), Szepsi *et al.* (2005), and Stevens *et al.* (2006) on tomato, Gunes *et al.* (2005) on maize, El-Tayeb *et al.* (2005) on barley, Amin *et al.* (2007) on onion, and Yildirim *et al.* (2008) on cucumber. The positive effect of salicylic acid could explain that SA plays an important role in the regulation of a number of vital processes and growth in plants (Raskin, 1992). As a natural phenolic compound in many plants, salicylic acid is an important component in the plant signal transduction pathway. In addition, salicylic acid is involved in local and systemic resistance to fungal pathogens (Meena et al., 2001).

The salicylic acid treatment levels affected the phenolic levels of three strawberry cultivars, reflecting significant differences among the vegetative growth of the strawberry plants. The strawberry plant cv. "Festival" sprayed with 3 mM salicylic acid showed the highest significant mean values for number of leaves per plant, crown numbers per plant, and leaf area per plant in both growing seasons. Similar results were obtained by Rao and Shantoram (2000), Martin-Mex et al. (2005), Gad et al. (2007), and El-Korany and Mohamed (2008). The obtained results complement those reported by Hancock (1999).

Previous studies implied that salicylic acid treatment improved fruit quality. For example, Sayyari *et al.* (2009) reported that the amount of acidity and T.S.S. were influenced by salicylic acid treatment in pomegranate. Chandra *et al.* (2007) reported that salicylic acid application increased total soluble sugar and soluble protein in cowpea plants. Babalar *et al.* (2007) reported that salicylic acid at all concentrations effectively reduced fruit ethylene production and fungal decay and retained overall quality. Ball (1997) observed that constituent levels of vitamin C, pH, T.S.S., and titratable acidity of pepper fruits treated with salicylic acid concentrations were higher than those of control fruit. The titratable activity decreases in fruit due to the break-up of acids to sugars during respiration. Han and Li (1997) have reported that apples treated with salicylic acid had increased titratable activity content at the end of storage. Kazemi, et *al*. (2011, 2013) noted that fruit treated with salicylic acid had the maximum vitamin C content. Ghasemnezhad, *et al*. (2010) reported that the decrease of total phenolic levels might be due to breakdown of cell structure as senescence begins during the storage period. The effect of salicylic acid treatments on maintenance of total phenolic content may plausibly be attributed to the delay in senescence process.

Bhupinder and Usha (2003) observed salicylic acid as a growth regulator that participates in regulating physiological processes in plants. Salicylic acid stimulates flowering in a range of plants, increasing flower life, and controlling ion uptake by roots and stomatal conductivity. The mechanism of action for salicylic acid was reported by Oata (1975) and Pieterse and Muller (1977) who concluded that salicylic acid induced flowering by acting as a chelating agent. This result was supported by Raskin, *et al*. (1987) who confirmed that salicylic acid functioned as endogenous growth regulator for flowering and florigenic effects. The current study complements those reported by Rao and Shantoram (2000), Martin-Mex *et al*. (2005), Gad *et al*. (2007), and El-Korany and Mohamed *et al.* (2008).

In the current study, salicylic acid played an important role in regulating a number of vital processes, including plant growth and increased the vegetative growth characters. A previous study reported that salicylic acid treatment of strawberry plants increased chlorophyll content by 11% compared with untreated plants (Jamali *et al.*, 2011), reflecting improved fruit yield (Raskin, 1992). In addition, salicylic acid promotes local and systemic resistance to fungal pathogens (Meena *et al.*, 2001). The results of the current study generally match the results reported by other researchers (Rao and Shantoram, 2000; Martin-Mex *et al.*, 2005; Gad *et al.*, 2007).

Comparisons of treatment combinations produced a similar trend from salicylic acid treatments on all the tested cultivars, resulting in the absence of any interaction effects between the two main factors: total yield per plant and non-marketable yields during both seasons, and early and marketable yields for the first season. Similar results were observed earlier by Jamali *et al*. (2011), Lolaei *et al*. (2012), Kazemei *et al.* (2013), Khademi and Ershadi *et al.* (2013).

The results of this research show the presence of some interaction between the two studied factors on late and total yield per square meter, and R% (percentage of recovery of grey mold) in both seasons. The combinations of Festival cultivar sprayed with 3 mM of salicylic acid resulted in the highest yield value and the components characters. Similar results were also recorded by EL-Korany and Mohamed (2008).

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