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Frequent Foliar Sprayings of Salicylic Acid with Elevated Concentrations Enhance Growth, Yield and Fruit Quality of Strawberry (*Fragaria x ananassa* Duch. cv. Festival) Plants

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SALICYLIC ACID regulates several physiological and biochemical processes in plants. The previous studies on strawberry used salicylic acid with low concentrations varied from 0.5 mM to 2.0 mM which was sprayed once, twice or three times. The highest concentrations of salicylic acid with the maximum times of applications gave the highest values of growth and yield parameters. To study the effect of frequent foliar sprayings of salicylic acid with elevated concentrations (0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, or 7.0 mM) applied every 10 days during all the growth stages of strawberry cv. Festival plants, a field experiment was conducted during 2013/2014 and 2014/2015 seasons at the Experimental Farm of Horticulture Department, Faculty of Agriculture, Ain Shams University, Qalubia Governorate, Egypt. Compared with the water-sprayed plants, salicylic acid spraying up to 5.0 mM had positive and significant effects on the vegetative growth parameters, leaf SPAD readings, leaf relative water content, leaf membrane stability index, leaf content of macronutrients, number of fruits/plant, early and total yields/plant, and fruit soluble solids content. Salicylic acid at 4.0 mM gave the highest significant values of the aforementioned parameters. Moreover, increasing salicylic acid concentrations significantly reduced nitrate content in the fruits. In addition, a comparative microscopic examination showed thatsalicylic acid at 4.0 mM increased the cellthickness of both upper and lower epidermis, and the thicknesses of palisade and spongy tissues. Salicylic acid spraying at 4.0 could offer an economic, rapid, applicable, and effective way for enhancing growth, yield and fruit quality of strawberry cv. Festival.

Keywords : Strawberry, Salicylic acid, Relative water content, Membrane stability, Scanning electron microscopy, Nitrate content, Yield.

Introduction

Strawberry (*Fragaria x ananassa* Duch.) is a small popular fruit crop of great nutritional and medicinal value (Maas et al., 1991). In the three decades, strawberry has become one of the very important horticultural vegetable crops for local fresh consumption, exportation, and food processing in Egypt. In Egypt, strawberry cultivated area was 6509 ha with a total production of 283471 tons and average yield of 43.55 tons ha-1 in 2014 (FAOSTAT, 2017). Increasing the production of strawberry with high fruit quality is considered an important aim and this aim could be achieved through the foliar applications of some agro-chemicals like salicylic acid which has widely been used to enhance the growth and productivity of many vegetable crops.

Salicylic acid is an endogenous growth regulator of phenolic nature, which is normally produced in the plants in very small quantities and regulates several physiological, and biochemical processes in the plants such as seed germination, plant growth, flower induction, nutrient uptake and transport, plant water relations, membrane permeability, stomatal conductivity, photosynthesis, and enzyme activities (Hayat et al., 2010).

In the recent years, a number of studies have

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indicated that application of exogenous salicylic acid enhanced the plant growth and productivity of strawberry plants. In this regard, Karlidag et al. (2009a) investigated the effect of foliar spraying of salicylic acid at 1.0 mM once, twice, three, or four times on growth, chlorophyll content, some fruit-quality parameters and yield of strawberry cv. Fern. Salicylic acid at 1.0 mM for three or four times gave the highest values of leaf chlorophyll, leaf elements, early and total yields. In another study, Metwally et al. (2013) studied the effect of foliar application of salicylic acid at 1.0 or 2.0 mM with different number of applications (once, twice or three times) on growth, chlorophyll and mineral content of leaves, some fruit-quality parameters and yield of strawberry cv. Sweet Charlie. Application of salicylic acid at 2.0 mM for three times was the most effective treatment in enhancing growth, fruit quality and yield. Similarly, Kalaki et al. (2014) studied the effect of different concentrations of salicylic acid (0, 0.5 and 1.0 mM) and number of applications (1, 2 and 3 times) on strawberry (*Fragaria × ananassa* Duch cv. Camarosa) plants. The results showed that growth parameters, chlorophyll a, b and total contents significantly increased with increasing the salicylic acid concentration and the number of applications and the highest values were obtained with salicylic acid at 1 mM for three times.

Based on the previous studies on strawberry, the present study was carried out to investigate the effect of salicylic acid with elevated concentrations (0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, or 7.0 mM) applied during all the growth stages of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants.

Materials and Methods

Cultivation and experimental design

This study was conducted to evaluate the frequent foliar sprayings of salicylic acid at different concentrations (0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, or 7.0 mM) on the growth, yield and fruit quality of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants. The study was carried out during the two successive seasons of 2013/2014 and 2014/2015 at the Experimental Farm of Horticulture Department, Faculty of Agriculture, Ain Shams University, Qalubia Governorate, Egypt. According to soil analysis results, soil texture of the experimental site was a sandy loam.

Cold-stored bare rooted strawberry transplants (*Fragaria x ananassa* Duch. cv. Festival) with one well-developed crown of diameter ~10 mm were planted. Festival is an important strawberry cultivar which recently planted widely in Egypt. The transplants were obtained from the Strawberry and Non-Traditional Crops Improvement Center of the Faculty of Agriculture, Ain Shams University. Strawberry transplants were set up in the field on October 1st and 7th in the first and second growing seasons, respectively. The transplants were cultivated at one side of the rows at a distance of 25 cm between plants and 70 cm between rows. The plot area consisted of five rows each of 5 m length.

Salicylic acid was dissolved in absolute ethanol then added drop-wise to distilled water (ethanol/water: 1/1000, v/v) to make the tested concentrations (1, 2, 3, 4, 5, 6, and 7 mM). The pH of all solutions was set to 6.5-7. A surfactant tween 20 (0.5%) was added with the control (deionized water) and all salicylic acid solutions. The plants were sprayed during early morning using a hand-held sprayer. The lower leaf surface was sprayed until wetted as well as upper surface. The volume of the spray was enough to cover completely the whole plant foliage. Foliar applications of salicylic acid at the tested concentrations were performed every 10 days during all growth stages.

The eight treatments were arranged in a completely randomized blocks design with four replicates and each experimental plot was composed of five rows of 2 m in length.

In both seasons, all cultural practices of cultivation (irrigation, fertilization, weeding, and pest control) were carried out uniformly in all plots as recommended by the Egyptian Ministry of Agriculture for strawberry production during growth season.

Data recorded

A random sample of ten plants from the three inner rows of each experimental plot was taken at 90 days after planting for vegetative growth data. Full expanded leaves from these plant samples were used to measure chlorophyll content, relative water content, membrane stability index, and some macronutrients.

Vegetative growth

Plant length was measured using a meter scale and number of leaves was counted. Average leaf area was calculated as relation between area unit and fresh weight of leaves (Koller, 1972) using the following equation :

$$\text{Leaf area} = \frac{(\text{Disk area x No.of disks x fresh weight of leaves})/}{(\text{Fresh weight of disks})}$$

Leaf area index was calculated as a ratio of foliage area to soil area

The plants were removed with a shovel, to prevent damage to the root system. The excess soil attached to the roots was carefully removed. In the laboratory, the plants were washed and the vegetative growth and root fresh weights were recorded. They were dried in an oven at 70°C until constant weight to record the vegetative growth and root dry weights.

Chlorophyll measurements

A portable chlorophyll meter (SPAD–502, Konica Minolta Sensing, Inc., Japan) was used to measure leaf greenness of the plants. SPAD-502 chlorophyll meter can estimate total chlorophyll amounts in leaves of a variety of species with a high degree of accuracy, which is a non-destructive method (Neufeld et al., 2006). At 90 days after planting, measurements were taken at four locations on each leaf, two on each side of the midrib on the full expanded leaves of randomly selected five plants per plot (Khan et al., 2003).

Leaf relative water content

Leaf relative water content was determined according to the method developed by Barrsand Weatherley (1962). Second leaf of the plants was used for determining relative water content. Fresh weight (FW) was immediately recorded, and then leaves were immediately soaked for 4 hours in distilled water at room temperature under a constant light and saturated humidity to record turgid weight (TW). The samples were then dried for 24 hours at 80 ºC for recording dry weight (DW). Relative water content (RWC) was calculated by the following formula:

$$\text{RWC (\%)} = \frac{\text{FW} - \text{DW}}{\text{TW - DW}} \text{ X 100}$$

Leaf membrane stability index

Leaf membrane stability index (LMSI) was determined by the method of Sairam et al. (1997). Leaf disks (200 mg) were taken in two sets of test tubes containing 10 ml of distilled water. One set was kept at 40ºC in a water bath for 30 min and electrical conductivity (C1) was measured. The second set was incubated at 100ºC for 15 min and electrical conductivity (C2) was measured. MSI was calculated according to the following formula :

$$\text{LMSI (\%)} = \frac{(1\text{- C1})}{\text{C2}} \times 100$$

Analysis of leaf nutrients

Leaf samples from the full expanded leaves were taken at 90 days from transplanting and oven-dried at 70 °C until constant weight. Then they were ground to pass a 1 mm sieve and 0.1 g of the dry samples was taken and digested using a mixture of sulphuric acid (H_2SO_4 98 %) and hydrogen peroxide (H_2O_2 30 %) as described by Allen (1974). All the studied elements were assayed in the digest of the concerned plant samples. Total nitrogen was determined using Kjeldahl method as described by Piper (1950). Phosphorus content was spectrophotometricallymeasured according to Watanabe and Olsen (1965). Potassium, calcium, and magnesium were determined as described by Chapman and Pratt (1961).

Yield components

Marketable fruits were harvested at 2–3 day intervals during the growing season, counted, and weighed to record fruit number/plant and average fruit weight. The early yield/plant was determined as weights of all harvested fruit during the first four harvests. Marketable total yield/plant was calculated.

Fruit quality

Forty full-colouredfruits were collected randomly from each treatment in the middle of the growing season (April in both seasons) as subsamples for fruit quality. Soluble solid content (SSC) was determined using a hand refractomer. Titratable acidity was determined according to A.O.A.C. (2012). The SSC/titratable acidity ratio was calculated. Nitrate content in the fruits was determined according to Al-Moshileh et al. (2004) using the HORIBA LAQUAtwin Nitrate Meter, Spectrum Technologies, Inc., IL, USA.

Leaf anatomy

In the second growing season, eight full expanded leaves from the different treatments at 90 days after planting were used to investigate the ultra-structural variations. The specimens of strawberry leaves were prepared by cutting into pieces (1 cm^2) of the terminal leaflet. Each sample was immersed overnight in 6% sodium hypochlorite, 4.12% sodium chloride and 0.15% sodium hydroxide. Thereafter, the specimens were rinsed with distilled water and left to dry at room temperature. The samples were then mounted in inner side uppermost and in vertically manner on aluminum stubs, coated with gold for 3 min. in an Emscope Sputter Coater. These samples were examined using JEOL JSM-T330A Scanning Electron Microscopy at 15 Kv. The images were analyzed using the SemAfore Software (version 5.21) .

Statistical analysis

All data were subjected to an analysis of variance using the CoStat package program (version 6.303,CoHort Software, USA). The differences among the means were compared using the least significance difference (LSD) at $p \leq 0.05$.

Results and Discussion

Vegetative growth parameters

Data in Fig.1 clearly showed that foliar applications of salicylic acid up to 5.0 mM had positive effects on the vegetative growth parameters of strawberry plants (plant length, number of leaves/plant, average leaf area, leaf area index, and fresh and dry weights of roots and vegetative growth) compared with the water-sprayed plants in both seasons. Salicylic acid at 4.0 mM gave the highest and significant values of the above-mentioned parameters. However, there were no significant differences between spraying of salicylic acid at 4.0 and 3.0 mM in plant length. On the contrary, no significant differences were detected in these growth parameters between the plants sprayed with salicylic acid at 6.0 or 7.0 mM and the water-sprayed plants in both growing seasons. The stimulatory effects of salicylic acid sprayings on vegetative growth parameters of strawberry were reported (Karlidag et al., 2009a and b,Jamali et al., 2011, Kazemi, 2013, Metwally et al., 2013, Qureshi et al., 2013, Kalaki et al., 2014,Ghaderi et al., 2015, Jamali et al., 2015 and Faghih et al., 2017). These stimulatory effects on vegetative growth could be attributed to the positiveeffect of salicylic acid upon the endogenous phytohormones specially the growth promoters, i.e. auxins, gibberellins and cytokinins (Mady, 2014) which promote cell division and cell enlargement (Hayat et al., 2005).

SPAD readings

Foliar application of salicylic acid at concentrations up to 5 mM resulted in significant increases in SPAD readings compared with the water-sprayed plants in both growing seasons (Fig. 2). On the contrary, no significant differences in SPAD readings were detected between the plants sprayed with salicylic acid at 6.0 or 7.0 mM and the water-sprayed plants in both growing seasons. The obtained results coincide with those obtained by Kalaki et al. (2014) who found that chlorophyll a, chlorophyll b and total chlorophyll contents were significantly increased with increasing salicylic acid concentration and the number of the applications. Similar increases in chlorophyll values of strawberry leaves were obtained by foliar application of salicylic acid (Karlidag et al., 2009a,b and Tohma & Esitken, 2011).These increments in SPAD readings may be attributed to the fact that foliar application of salicylic acid decreases chlorophyll degradation (Raskin, 1992).

Leaf relative water content

Compared with the water-sprayed plants, all the tested salicylic acid concentrations significantly increased leaf relative water content in both seasons (Fig.3). Exogenous applications of salicylic acid at 3.0 or 4.0 mM maintained the highest and significant relative water content. The increments among other salicylic acid were not significant. The obtained results are in agreement with those obtained by Karlidag et al.(2009b) who found that the highest salicylic acid concentration used (1.0 mM) induced increases in relative water content in strawberry leaves. Similarly, Ghaderi et al. (2015) found that salicylic acid application at 1.0 mM increased leaf relative water content in strawberry. The stimulatory effect of salicylic acid on leaf relative water content could be attributed to the fact that salicylic acid can increase leaf diffusive resistance and lower transpiration in plants (Yildirim et al., 2008).

Leaf membrane stability index

Figure 4 revealed that all the tested salicylic acid concentrations significantly increased leaf membrane stability index as compared with the water-sprayed plants in both seasons. However, these increases were not significant between the plants sprayed with 1.0 mM and the water-sprayed plants in the first season. Foliar applications of salicylic acid at 3.0, 4.0, or 5.0 mM maintained the highest and significant leaf membrane stability index. These results are in agreement with those obtained by Hayat et al. (2010) who found that salicylic acid application significantly decreased lipid peroxidation and improve membrane stability index both in unstressed as well as stressed *Vigna radiate* plants.

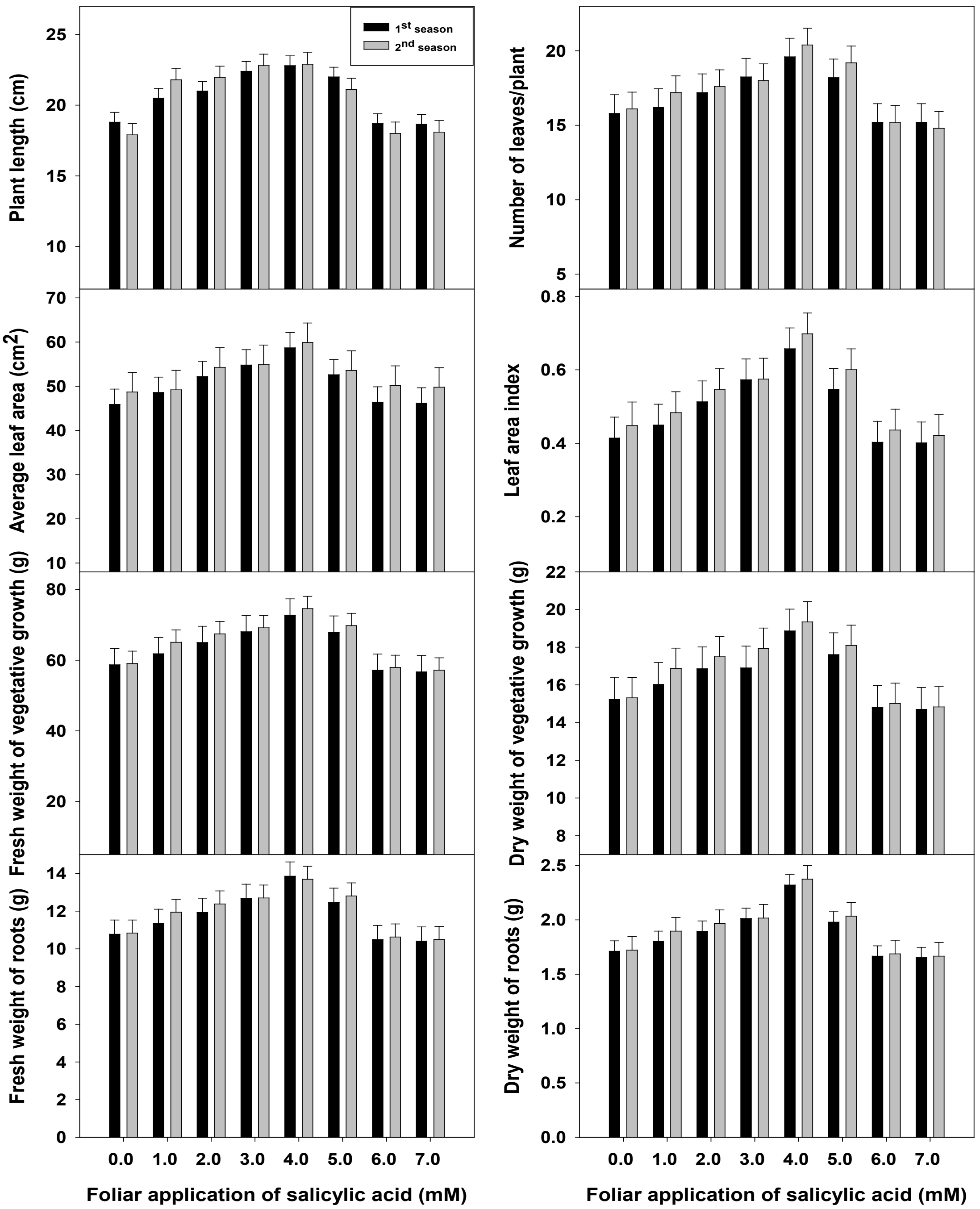


Fig. 1. Effect of foliar applications of salicylic acid concentrations on some vegetative growth parameters of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants in 2013/2014 and 2014/2015 seasons. Vertical bars indicate the LSD value at $p \leq 0.05$.

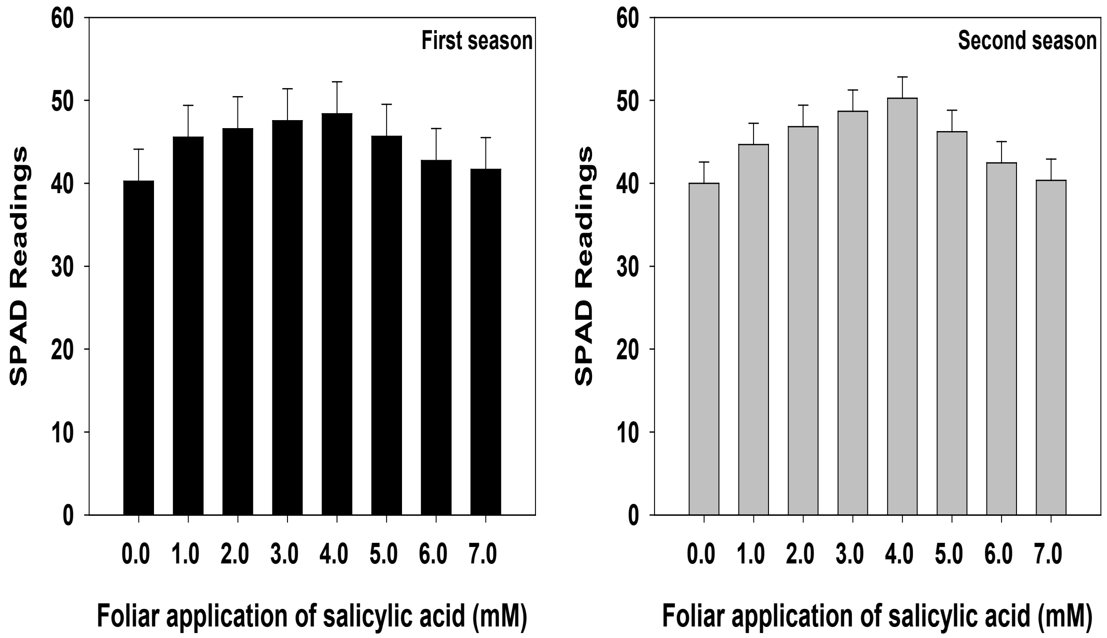


Fig. 2. Effect of foliar applications of salicylic acid concentrations on leaf SPAD readings of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants in 2013/2014 and 2014/2015 seasons. Vertical bars indicate the LSD value at p ≤ 0.05.

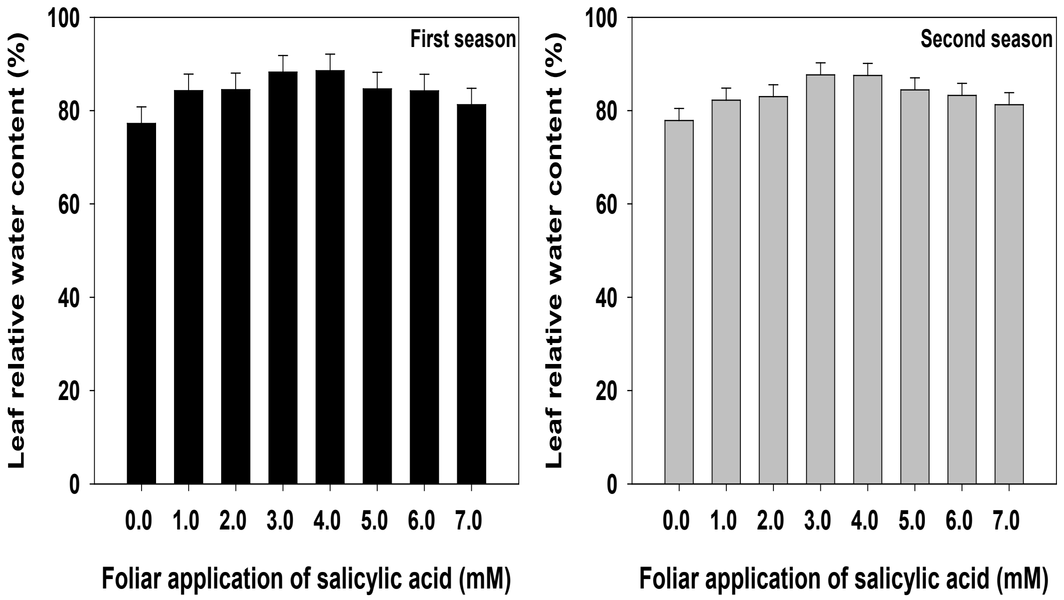


Fig. 3. Effect of foliar applications of salicylic acid concentrations on leaf relative water content of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants in 2013/2014 and 2014/2015 seasons.Vertical bars indicate the LSD value at p ≤ 0.05.

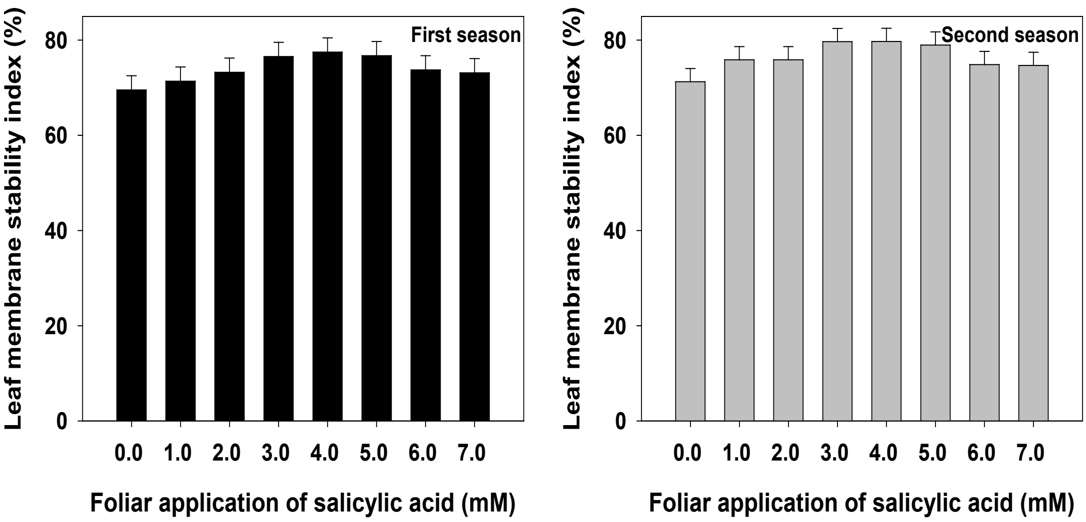


Fig. 4. Effect of foliar applications of salicylic acid concentrations on leaf membrane stability index of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants in 2013/2014 and 2014/2015 seasons. Vertical bars indicate the LSD value at p ≤ 0.05.

Leaf macronutrients

In both growing seasons, foliar applications of salicylic acid with concentrations up to 5 mM had positive and significant effects on the accumulation of N, Ca, and Mg in strawberry leaves compared with those of the water-sprayed plants, and the concentrations of 3.0 or 4.0 mM gave the highest and significant values (Fig. 5). On the other hand, all the tested salicylic acid concentrations significantly increased P and K percent in the leaves compared the water-sprayed plants, and the concentrations of 4.0 or 5.0 mM gave the highest and significant values. These results coincide with Karlidag et al. (2009a) who found that exogenous application of salicylic acid at the used concentration (1.0 mM) for three or four times gave the highest values of all nutrients in the leaves of strawberry cv. Fern plants. Moreover, Jamali and Eshghi (2015) found that salicylic acid application at 0.5 or 1.0 mM increased N, P, K, Ca, Mg, Fe, and Zn in shoot and root of strawberry cv. Selva plants. The increments in leaf content of nutrients due to salicylic acid applications are linked with the increments in plant growth parameters. In addition, the increases of Ca2+ in the leaves resulted from salicylic acid treatments are related with the maintenance of membrane integrity which resulted in increases in membrane stability index (Fig. 4). Moreover, the increases in Mg2+ are related with the increments of SPAD readings (Fig. 2), since magnesium is considered as the central atom of chlorophyll.

Yield components

Figure 6 clearly showed that all the tested concentrations of salicylic acid increased number of fruits and early marketable yield/ plant in both growing seasonssignificantly. On the other hand, spraying with the concentrations up to 5 mM significantly increased total marketable yield/ plant compared with the water-sprayed plants. The plants sprayed with salicylic acid at 4.0 mM produced the highest significant number of fruits, and early and total marketable yields per plant. On the contrary, salicylic acid concentrations had no effect on the average fruit weight. Earlier studies on strawberry showed that exogenous application of salicylic acid at the highest concentration and the highest number of applications resulted in the highest early and total yields of strawberry (Karlidag et al., 2009a, Metwally et al., 2013 andKalaki et al., 2014). These increases in yield components of strawberry could be a reflection of the marked increases in the vegetative growth parameters due to salicylic acid applications (Fig. 1) which gave a chance to the plant to carry more flowers and hence more fruits.

Fruit quality

In both growing seasons, all the tested

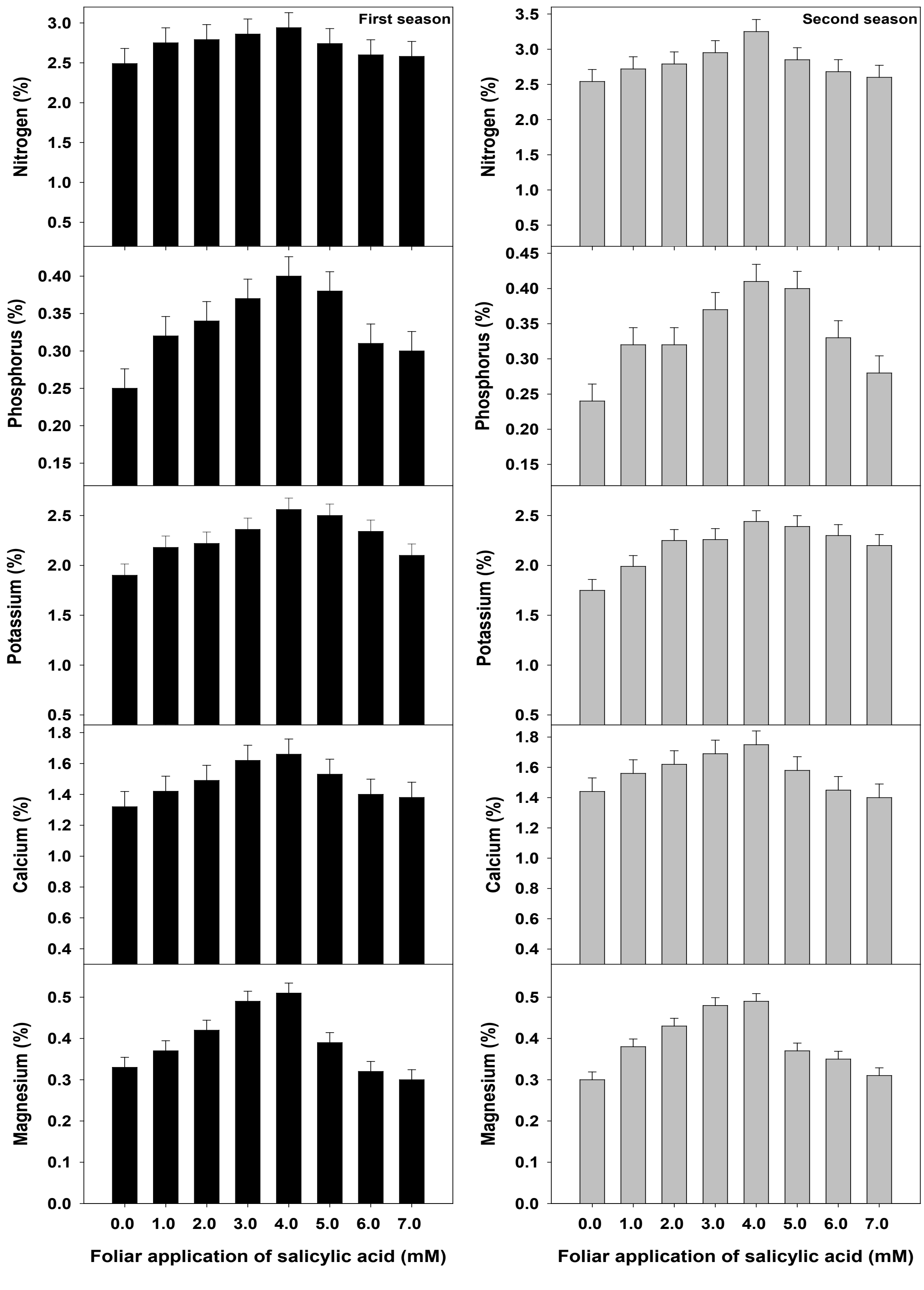


Fig. 5. Effect of foliar applications of salicylic acid concentrations on leaf nutrients content of strawberry (*Fragariaxananassa* Duch. cv. Festival) plants in 2013/2014 and 2014/2015 seasons.Vertical bars indicate the LSD value at p ≤ 0.05.

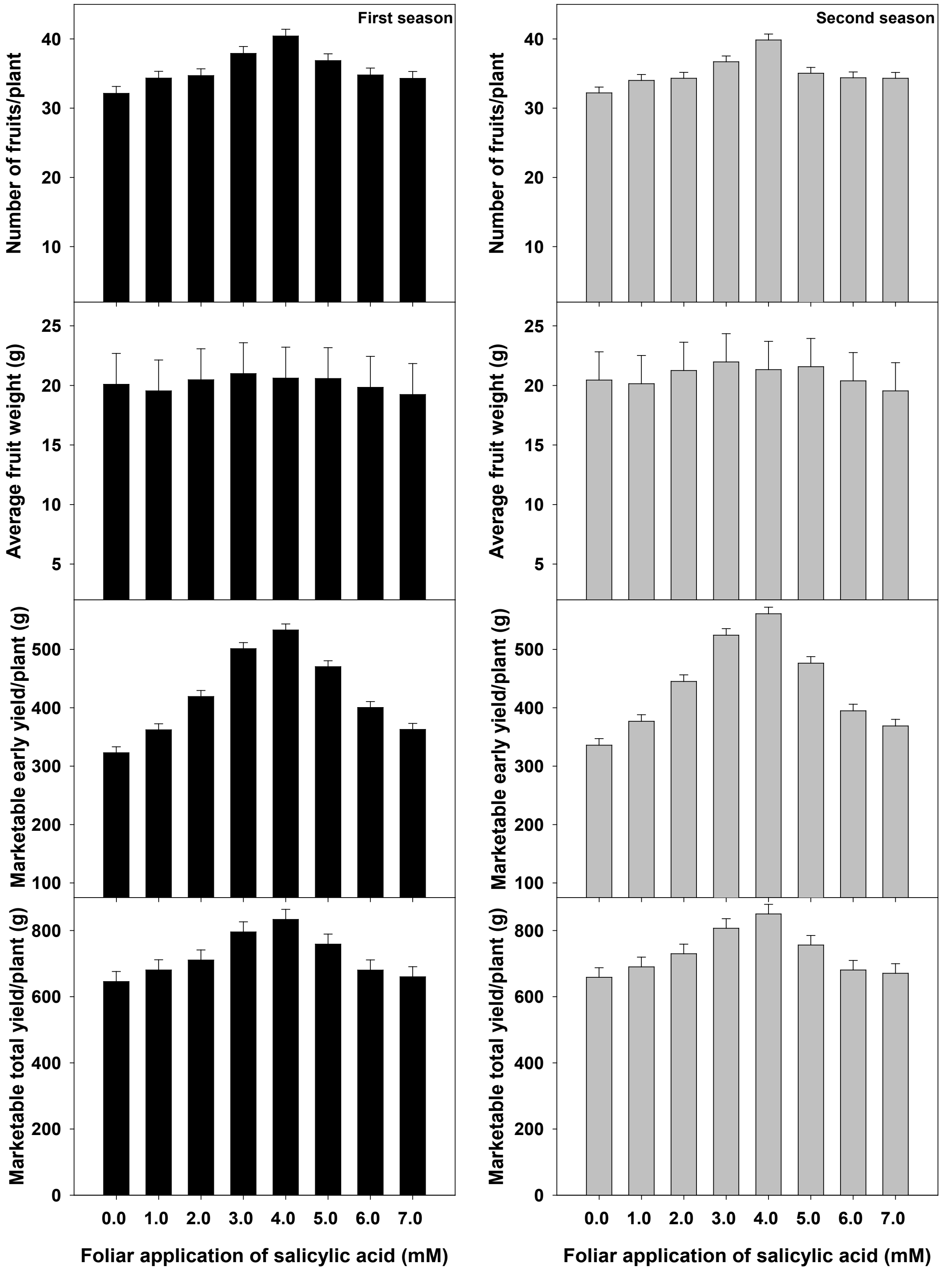


Fig. 6. Effect of foliar applications of salicylic acid concentrations on yield components of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants in 2013/2014 and 2014/2015 seasons.Vertical bars indicate the LSD value at p ≤ 0.05.

concentrations of salicylic acid increased the soluble solids content in the fruits significantly compared with those obtained from the water-sprayed plants. The concentrations of 4.0 or 5.0 mM gave the highest and significant values (Fig. 7). In this regard, foliar application of salicylic acid increased total soluble content in strawberry fruits (Karlidag et al., 2009a, Kazemi, 2013, Qureshi et al., 2013, Jamali et al., 2015 and Aghaeifard et al., 2016).

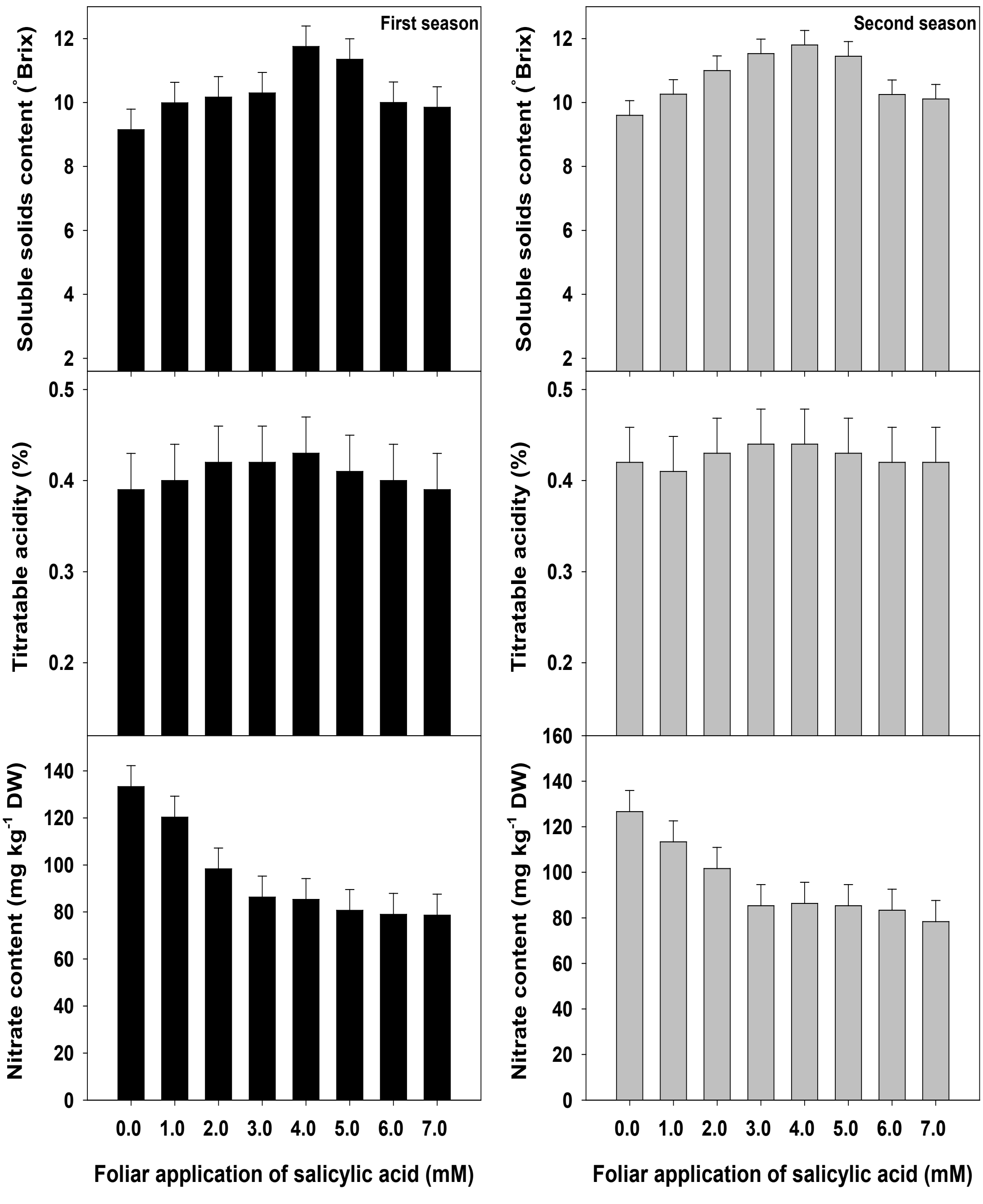


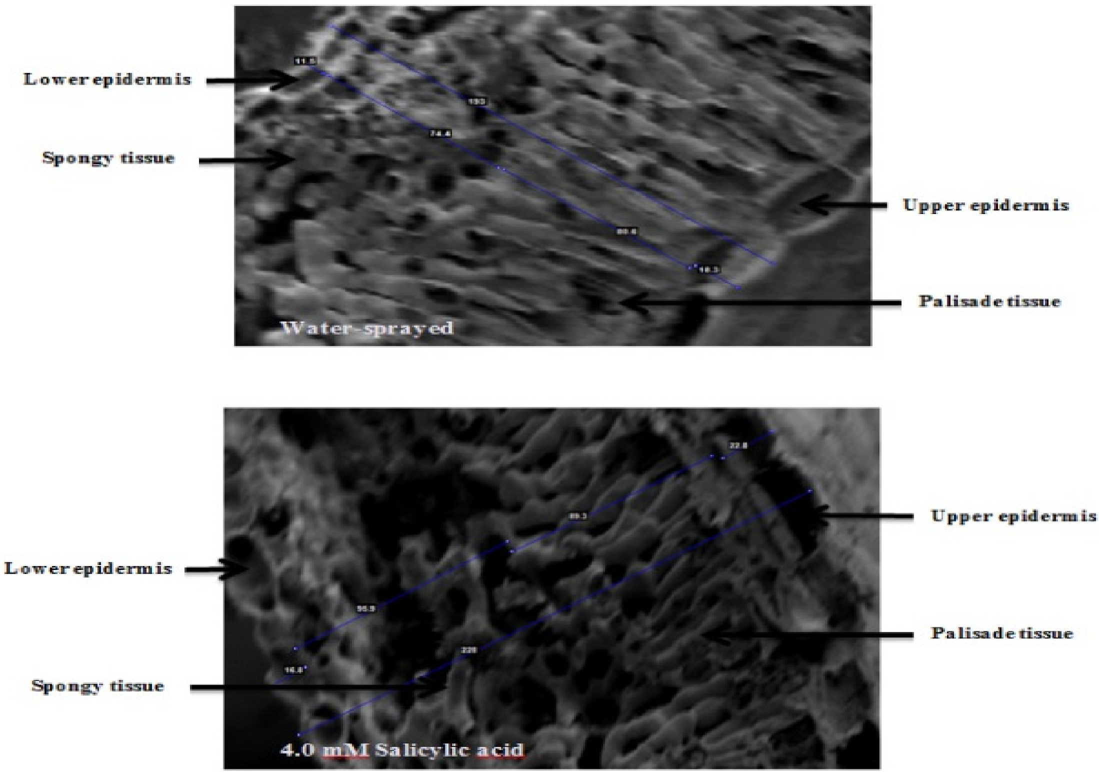
Fig. 7. Effect of foliar applications of salicylic acid concentrations on fruit quality of strawberry (*Fragaria x ananassa* Duch. cv. Festival) plants in 2013/2014 and 2014/2015 seasons.Vertical bars indicate the LSD value at p ≤ 0.05.

As for the titratable acidity, no significant differences were detected among the fruits obtained from the plants sprayed with different concentrations. Similarly, salicylic acid treatments had no effect on titratable acidity of strawberry fruits in earlier studies (Karlidag et al., 2009a, Metwally et al., 2013 and Aghaeifard et al., 2016).

On the contrary, increasing salicylic acid concentrations significantly reduced the nitrate content in the fruits in both seasons. The reductions of nitrate content were not significant in the fruits of the plants sprayed with salicylic acid at 3.0, 4.0, 5.0, 6.0, or 7.0 mM. These reductions in nitrate content could be attributed to the effects of salicylic acid on the activity of nitrate reductase and nitrite reductase enzymes. Nitrate reductase activity was increased with salicylic acid in mungbean (Dar et al., 2007), and cucumber (Singh el al., 2010). Also, Jain and Srivastava (1981) found that salicylic acid increased nitrite reductase in maize. It is well known that nitrate reductase reduces nitrate (NO^-_3) to nitrite in the cytosol (Campbell, 1988) and nitrite moves into plastids where subsequently it is reduced to NH_4^+ by nitrite reductase enzyme.

Leaf anatomy

Based upon the obtained results, a comparative microscopic examination was performed between the leaves obtained from the control (water-sprayed plants) and those obtained from plants with the most prominent response (plants sprayed with salicylic acid at 4.0 mM). The microscopic measurements of the transverse sections of the terminal-leaflet blade presented in Fig. 8 revealed that spraying salicylic acid at concentration of 4.0 mM increased the thickness of the cells of both upper and lower epidermis compared with those of the water-sprayed plants. Moreover,



Treatments	Upper epidermis	Palisade tissue	Spongy tissue	Lower epidermis
Water-sprayed	18.3 µm	80.6 µm	74.4 µm	11.5 µm
4.0 mM Salicylic acid	22.8 µm	89.3 µm	95.9 µm	16.8 µm
% to water-sprayed	**24.59**	**10.79**	**28.90**	**46.09**

Fig. 8. Transverse sections through the blade of terminal leaflet of strawberry leaves sprayed with water or 4.0 mM salicylic acid.

the thicknesses of palisade and spongy tissues were increased by spraying salicylic acid at 4.0 mM as compared to the water-sprayed plants. The obtained results are in coincidence with those of Gomaa et al. (2015) who found that foliar application of salicylic acid increased the thicknesses of palisade and spongy tissues and the thickness of lamina of Egyptian lupine. Similar results were reported on bean (Nour et al., 2012). The increases in the thickness of the cell of leaf tissues (Fig. 8) may be attributed to the cell swelling resulting from the increments of leaf relative water content (Fig. 3). Moreover, the mesophyll tissue (palisade and spongy tissues) is characterized by high concentration of chloroplast and as consequence leaf thickness increasing could be considered as a good indicator and a reliable index to photosynthetic efficiency. In this regard, microscopic data (Fig. 8) are linked with the increments in SPAD readings in the plants treated with salicylic acid (Fig. 2).

Conclusion

In conclusion, this study demonstrated that foliar spraying of salicylic acid with elevated concentrations during all growth stages induced positive effects on growth parameters, some physiological parameters, marketable fruit yield and fruit quality of strawberry cv. Festival. Spraying salicylic acid at 4.0 could offer an economic, rapid, applicable, and effective way for enhancing growth, yield and fruit quality of strawberry cv. Festival.

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تكرار مرات الرش بحمض الساليسيليك بتركيزات مرتفعة تحسن النمو والمحصول وجودة الثمار لنباتات صنف الفراولة فيستيفال

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حمض الساليسيليك ينظم العديد من العمليات الفسيولوجية والبيوكيمائية فى النبات. الدراسات السابقة على الفراولة إستخدمت حمض الساليسيليك بتركيزات منخفضة تراوحت من ٠,٥ الى ٢,٠ ملليمول رشاً على النباتات مرة واحدة أو مرتان أو ثلاث مرات وقد أعطت التركيزات الأعلى وعدد الرشات الأكثر أفضل التأثيرات على قياسات النمو الخضرى والمحصول. ولدراسة تأثير تعدد عدد مرات الرش بحمض الساليسيليك بتركيزات مرتفعة (٠,٠ , ١ ,٢ , ٣ ,٤ , ٥ أو ٧ ملليمول) خلال جميع مراحل نمو نبات الفراولة صنف فيستيفال أجريت تجربة حقلية خلال الموسمين ٢٠١٤/٢٠١٣ و ٢٠١٥/٢٠١٤ فى المزرعة التجريبية لقسم البساتين بكلية الزراعة جامعة عين شمس بمحافظة القليوبية مصر. وقد أثبتت النتائج أن الرش الورقي بحمض الساليسيليك حتى تركيز ٥ ملليمول مقارنة بالرش بالماء كان له تأثير إيجابي ومعنوي على قياسات النمو الخضري وقراءات الكلوروفيل بالأوراق والمحتوى المائي للأوراق ودليل ثبات الأغشية الخلوية ومحتوى الأوراق من العناصر الكبرى وعدد الثمار على النبات ومحصول الثمار المبكر والكلي للنبات ومحتوى الثمار من المواد الصلبة الذائبة. أعطى رش حمض الساليسيليك بتركيز ٤ مللليمول أعلى قيم معنوية للقياسات سابقة الذكر. علاوة على ذلك فزيادة تركيز الرش بحمض الساليسيليك قد أدت إلى إنخفاض معنوي لتركيز النترات بالثمار بالإضافه الى ذلك نتائج الفحص الميكروسكوبي للأوراق أظهرت أن رش حمض الساليسيليك بتركيز ٤ ملليمول أدى إلى زياده فى سمك الخلايا لطبقتى البشره العليا والسفلى للأوراق وسمك الأنسجة العمادية والأسفنجية مقارنة بالرش بالماء. وبالتالي فإن الرش بحمض ساليسيليك بتركيز ٤ ملليمول يمكن أن توفر وسيلة اقتصادية وسريعة وقابلة للتطبيق وفعالة لتحسين النمو والمحصول وجودة الثمار لصنف الفراولة فيستيفال.