J. Plant Production,Mansoura Univ., Vol. 9 (12): 1203 - 1214, 2018

Effect of Foliar Application of Putrescine and Salicylic Acid on Yield, Fruit Quality and Storability of "Flame Seedless" Grape (*Vitis vinifera* L.)

Bassiony, S. S.[1];Maha H. Abd El-Aziz[2] and Hayam M. Fahmy[2]
[1]Viticulture Res. Dept. Horticulture Research Institute ARC, Giza, Egypt
[2]Handling Res. Dept.Horticulture Research Institute ARC, Giza, Egypt

ABSTRACT

This work was conducted during 2016 and 2017 seasons in a private vineyard situated at Markaz-Badr El-Beheira Governorate, Egypt. This study aimed to evaluating the potential effects of foliar applications of Putrescine (Pu) at 0.0, 1.0 and 2.0 mM, Salicylic acid (SA) at 0.0, 2.0 and 4.0 mM and the combination among them on yield, fruit quality and storability of Flame seedless grapevine. The vines sprayed with these treatments two timeswhen berry reached about 4-6mm in diameter (pea stage) and again at veraison stage. The obtained results revealed that the combination treatment contained Pu at 2.0 + SA at 4.0mM improved total yield and clusters quality in terms of weight, length and widthas well as berry length, berry diameter, weight, firmness and volume of 100 berries. Moreover, itwas the most effective treatment maintaining the quality characters during cold storageat, 0-2°C and 90-95% RH showing the lowest cluster weight loss, berry shatter, rachis browning, and berry decay as well as Pectin methylesterase activity. Also, itgave the highest berry firmness and removal forcewith maintaining SSC%, acidity, SSC/acid ratio and berries anthocyanin content till 60 days of cold storage, however all combination treatments increased significantly the marketable clusters percent and extended cluster shelf life over control.

INTRODUCTION

Flame seedless cultivar grapevine is one of the most important local table grapes for export markets. Its early yield and berries characterized as a light red color, higher SSC%, medium berry size and lower juice acidity. It is known that, improvement of different berries quality parameters especially size, color and firmness at harvesting time and retarding rachis browning, berry shattering and leaching of color during cold storage is very important for fetching premium prices and increasing economic values.

Polyamines are organic compounds of low molecular weight that are present in different organisms and the most important of these compounds Putrescine (Pu), spermidine, and spermine (Applewhite *et al.,* 2000). Putrescine considered as the primary polyamine in these chain biosynthetic alleyway followed by spermidine and spermine that produced by consecutive accumulation of aminopropyl groups resulting from decarboxylated S-adenosyl methionine. The proliferation of these materials in different plants may clear that, they play a vital role in the regulation of plant development. It may affect synthesis and degradation of DNA and RNA, reduce activities of some enzymes like protease, peroxidase, polygalactouronase, and improve ribosomal formation moreover, maintaining cell membrane (Wang *et al.,* 1993). Also, Putrescine plays an effective role in the improvement of plant growth due to its effects on cell division and enlargement. Moreover, it has a regulatory role in promoting productivity of several plants like grape (Marzouk and Kassem, 2011), sweet pepper (Talaat, 2003) and eggplant (El-Tohamy*et al*., 2008). Moreover, Khosroshahi and Ashari (2008) showed that, foliar application of polyamines enhancing fruit quality throughout various changes in fruit firmness, weight loss, soluble solids content and titratable acidity of strawberry, apricot, peach and sweet cherry fruits.

Although the grape (*Vitis vinifera* L.) is non-climacteric fruit with a moderately low physiological activity, it is very fast perishable and it appears in the losses of firmness, leaching of berries color, rachis browning, increase berry shatter, development of decays and loss in cluster weight, which accelerate the fruit senescence and reduces the ability to storage, for improving this ability, some studies showed that polyamines play an important role as anti-senescence, where "Flame seedless" grapevine sprayed with Pu showed a reduction in color changes, respiration rate, chilling symptoms, increase fruit firmness during cold storage (Valero *et al.,* 2002). In this respect, Serrano *et al.* (2003) indicated that, Plum fruits treated with Putrescine showed a delay and reduction of ethylene production this was associated with enhancing fruit firmness, reducing of weight loss, and delaying of color changes, and extended storage period.

Several studies were cleared that exogenous application of polyamines affects fruit quality throughout modify in fruit ethylene production, weight loss, firmness, total soluble solids, and titratable acids. These Polyamines, especially Pu showed a positive effect on different berries and clusters quality parameters of "Thompson seedless" grapevine (Marzouk and Kassem, 2011). Foliar application of Pu on 'Thompson seedless' grapes enhanced the fruit quality and yield by increasing the length of rachis and berry mass also it may be used as an alternative to GA_3, where it reduced the berry drop in relative with GA_3 and control (Koukourikou *et al*., 2015). Moreover, exogenous application of Putrescine reduced fruit decline and increased the shelf life of different fruits like apricot (Martínez-Romero *et al.,* 2002), sweet cherry (Bal, 2012), strawberry (Khosroshahi *et al.,* 2007), and plum (Khan *et al.,* 2008). Foliar spray with Pu at 1 mM, reduced production of ethylene, maintaining fruit firmness, reduced SSC%, titratable acids, weight loss, and delayed the changing in fruit color which extended the storage life of Plum fruits (Serrano *et al.,* 2003).

Salicylic acid (SA) is classified as an endogenous plant growth regulator of phenolic nature and considered as a growth promoter. It has shownan important role in plant growth regulation, development and enhances plant growth under different stresses (Hayat *et al.*, 2010 & Ennab and El-Sayed, 2016). Moreover, Salicylic acid improves plant growth through controlling stomatal regulation, photosynthesis, ion uptake and transport. Also it plays an important role in plant resistance to pathogens via inducing the production proteins that related to a pathogen (Manaa *et al*., 2014). Recently several researchers cleared the advantages of SA applications on fruit quality and storability. Salicylic acid plays a vital minor metabolite in grape berries, where it improved berry quality parameters as color and flavor. Moreover, SA can improve some fruits physical properties as size, weight and firmness (Marzouk and Kassem, 2011 & Shafiee *et al.*, 2010). Additionally, Salicylic acid applications showed a positive effect on reducing clusters weight loss, decay incidence and berry softening rate of "Thompson seedless" grape by reducing the activation of cell wall degrading enzymes as cellulase, xylanase and polygalactouronase during storage (Babalar *et al.*, 2007). Similarly, foliar application of Salicylic acid improved yield, fruit physical and chemical quality characters of apple, kiwi, banana, and jujube (Al-Obeed, 2011). Moreover, SA plays a role in the resistance to pathogens by inducing the production of pathogenesis-related proteins (Renault *et al.,* 1996).

Therefore, in view of the enhancement effects of Putrescine, Salicylic acid, this study was conducted for devaluate the potential effects on yield, berries quality and maintaining the quality of "Flame Seedless" grapes cv. during cold storage at 0-2 °C and 90-95% RH.

MATERIALS AND METHODS

A field experiment was conducted during 2016 and 2017 seasons on ten years old, "Flame seedless" grapevines (*Vitis vinifera* L.) grown in a private vineyard located at Markaz-Badr Beheira Governorate, Egypt. Vines were planted at 2 x 3 meters in row and between rows, respectively. The vines were trained to bilateral cordon, pruned leaving 60 eyes per vine as short pruning (2 bud/ spur) with the modified Y ship supporting system. Drip irrigation system was adopted. Vineyard soil texture was sandy (86% sand, 8% silt and 6% clay), soil pH 7.8 and EC 2.2 dSm-1. Normal cultural practices usually used for vines in this area were adopted. The study was carried out with the aim of evaluating the effect of foliar spray with Putrescine at 0.0, 1.0 and 2.0mM, Salicylic acid at 0.0, 2.0 and 4.0mM and the combination among them on yield and fruit quality at harvest as well as during cold storage. The tested vines were arranged in the randomized complete blocks designed with three replicates (9 treatments x 3 replicates x 3 vines).

The treatments were:

T_1- foliar spray with tap water (Control)
T_2- foliar spray with Putrescine at 1.0mM (Pu_1)
T_3- foliar spray with Putrescine at 2.0mM (Pu_2)
T_4- foliar spray with Salicylic acid at 2.0mM (SA_1)
T_5- foliar spray with Salicylic acid at 4.0mM (SA_2)
T_6- foliar spray with (Pu_1) + (SA_1)
T_7- foliar spray with (Pu_1) + (SA_2)
T_8- foliar spray with (Pu_2) + (SA_1)
T_9- foliar spray with (Pu_2) + (SA_2)

The tested vines were sprayed with the above-mentioned treatments twice: the first one when berry reached about 4-6 mm in diameter (pea stage) and the second one at veraison stage when 10% of berries/ cluster in about 50% of clusters per vine became soft and reached the color break (Champa *et al*., 2015). The sprays were done in the morning until runoff. The surfactant Triton B was used at 0.05 % to obtain better retention and penetration of all treatments.

Flame seedless clusters were harvested in both seasons when berry juice reached SSC about 16% according to Tourkey *et al.* (1995). At harvesting time, bunches sample were taken randomly from each replicate then it directly translocated to the laboratory of Sakha Horticulture Research Station, Kafr El-sheikh Egypt. The harvested clusters were divided into two groups; the first one was used for achieving the initial quality parameters at the picking date. However, the second one was packed in 40 x25 x15cm carton boxes dimensions. Each treatment was represented by three carton boxes each one contains 2kg of clusters. Five clusters per carton boxes were weighted and labeled at the picking date for determine the cluster weight loss every 15 days of cold storage. All boxes were stored in cold room at 0-2 ºC and 90-95 % RH. Three carton boxes per treatment were taken out every 15 days of storage to evaluating the different fruit quality parameters. All over cold storage period, the quality parameters were repeated at 15, 30,45and 60 days.

For achieving the purpose of this study, the following parameters were done

1.Yield and fruit physical characters

At picking date, cluster number/ vine, average cluster weight (g), cluster length and cluster width were determined. Also, the total yield/ feddan were calculated according the equation:

Yield /feddan(tons) = (yield/vine (kg) x number of vines/ feddan)/ 1000.

A coefficient of cluster compactness was determined by dividing the number of berries per cluster/ cluster length in fifteen clusters per treatment. Berry length and diameter (mm) were determined in ten berries per cluster using a digital vernal clipper. The weight of 100 berries (g) was measured using digital balance and volume (ml) of the same berries was determined using water displacement method. Also, main rachis diameter (mm), secondary rachis diameter (mm) and pedicels diameter (mm) was estimated using digital vernal clipper.

2.Picking date and cold storage parameters

A.Fruit physical characters

Ten berries/ cluster of five clusters per replicate were used for determine both berry firmness and berry removal force in gram-force (gf) using push and pull dynamometer apparatus model FDP1000 with 1mm thump. The data of the two parameters were transformed into Newton power units according to El-Abbasy *et al.* (2015) using a transformation factor (1gram-force= 0.00980665 Newton). Berry shatter (%) and berry decay (%) was determined as percent per cluster weight.

The physiological loss in cluster weight was determined every 15 days of cold storage period using the five labeled clusters of each carton boxes according the following equation:

$$\textbf{Cluster weight loss\%} = \frac{\text{Initial cluster weight - Weight after storage}}{\text{Initial cluster weight}} X100$$

Where: Weight after storage = cluster weight after each storage periods (15, 30, 45 and 60 day).

Rachis browning index was estimated every 15 days of cold storage according to Crisosto *et al.* (2002) using the following scale: 1= healthy (all rachis is green including the pedicels), 2= slight (rachis in a good color but pedicels showed browning), 3= moderate (secondary rachis as well as pedicels became brown) and 4= severe (all rachis became brown).

B. Marketable clusters and shelf life

Marketable clusters (%) were determined based on the percent of sound cluster weight without any decayed berries after storage of the initial fresh weight.

Marketable cluster (%) = (weight of the sound clusters after storage/ weight of clusters at picking date) x100

C. Berries chemical parameters

Soluble solids content (SSC %) of berry juice was estimated by hand refractometer apparatus. The titratable acidity (%) of berries juice was determined in mg of tartaric acid equivalent by NaOH (0.1N) in 100 ml of berries juice (A.O.A.C., 1995). SSC/ acid ratio was calculated. Total anthocyanin pigments of berry were determined according to Ranganna (1986) using Ethanolic HCL solvent and absorbance was recorded using spectrophotometer at 535 nm wavelength, then it expressed as mg/ 100g fresh weight. In addition, total sugars of berries (%) were determined as described by Dubois *et al.* (1956) using 80% ethanol. Moreover, Pectin methylesterase activity (PME) was determined as described by Anthon and Barrett (2006) using 50g of berries sample ground in equal volume of a solution (50% 2M NaCl and 50 % 10mM phosphate buffer with pH 7.5). Samples were filtrated then added to 2.5ml of 0.5% pectin solution. When sample solution drops down to pH 7, amount of 0.1M NaOH was added until pH reached 7.5. A time for the solution to drop down to pH 7 again was recorded. PME activity is expressed in µmol of hydrophilic ester conformed as an indicator for PME activity per 50 g of berry fresh weight during one minute (µmol/ g Fw/ min). The results were calculated as µmol /100g of fresh weight per hour (unit/ h).

Statistical analysis

The field and postharvest experiments were ranged as randomized complete block design with three blocks. All data were analyzed for variance as described by Snedecor and Cochran (1980). The treatment means were compared using Duncan's multiple range test DMRT (Duncan, 1955). Pearson Correlation Coefficient was estimated for some selected quality parameters for assessing the relationship among them.

RESULTS AND DISCUSSION

1. Yield and cluster characters

It is obvious from data in Table (1) that, foliar application with Putrescine and Salicylic acid alone or in combination significantly increased yield/ feddan, cluster weight, cluster length and cluster width of "Flame seedless" grapevines compared to control in both seasons. The vines sprayed with T_9 (Pu at 2.0mM +SA at 4.0mM) produced the highest values of these parameters compared with others. On the other hand, vines of control showed the lowest significant values in both seasons. This enhancement of total yield could be reflected to increasing cluster weight and length as showed in Table (2) which cleared that, there are highly positive correlation between total yield with cluster weight (0.95^{**}) and cluster length (0.92^{**}). Here we can point out that, increasing yield as a result of treatments might be reflected to the effect of these substances increasing berry weight. These results were supported by those of Kassem *et al.* (2011) on "Flame seedless" and Koukourikou *et al.* (2015) on "Thompson seedless" grapevine, they reported that foliar spray with Putrescine and Salicylic acid increased vine yield and improved cluster physical characters. Moreover, Ali *et al.* (2014) summarized that, foliar spray of Pu at 1, 2 and 3 mM and SA at 2 and 3 mM on 'Florida King' peach cultivar trees increased fruit weight and total yield.

Table1. Effect of Putrescine and Salicylic acid sprays on yield, cluster weight, length and width of "Flame seedless" grape during 2016 and 2017 seasons.

Treatments	Yield/feddan(ton)		Cluster weight(g)		Cluster length(cm)		Cluster width(cm)	
	2016	2017	2016	2017	2016	2017	2016	2017
T_1	6.34^{c}	6.75^{c}	315.70^{h}	329.33^{h}	17.15^{c}	16.83^{e}	15.43^{d}	16.45^{e}
T_2	6.75^{bc}	7.11^{bc}	357.35^{f}	371.54^{g}	18.47^{bc}	17.85^{de}	17.35^{c}	18.44^{cd}
T_3	7.23^{abc}	7.42^{bc}	394.71^{e}	405.63^{f}	18.88^{abc}	18.23^{de}	18.75^{ab}	19.68^{bc}
T_4	6.72^{bc}	7.18^{bc}	333.25^{g}	433.87^{e}	18.10^{bc}	17.41^{de}	17.43^{c}	17.56^{de}
T_5	6.82^{bc}	7.21^{bc}	351.26^{f}	442.58^{e}	18.33^{bc}	18.21^{de}	18.33^{bc}	19.45^{bc}
T_6	7.38^{abc}	8.25^{abc}	420.52^{d}	480.25^{d}	19.23^{abc}	19.45^{cd}	18.85^{ab}	19.70^{bc}
T_7	7.85^{ab}	8.72^{ab}	455.45^{c}	512.47^{c}	20.72^{ab}	21.51^{bc}	18.87^{ab}	20.08^{b}
T_8	7.99^{ab}	9.55^{a}	486.35^{b}	526.86^{b}	20.86^{ab}	22.40^{b}	19.55^{a}	20.56^{ab}
T_9	8.54^{a}	9.70^{a}	503.58^{a}	548.98^{a}	21.45^{a}	24.85^{a}	19.67^{a}	21.77^{a}

In a column, means followed by the same letter are not significantly different at the 5% level by DMRT.
T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

2. Cluster compactness and rachis characters

Data in Table (3) cleared that, foliar application of Pu and SA alone or in combination significantly enhanced cluster compactness and all rachis parameters in terms of the diameter of main rachis, secondary rachis and pedicels diameters of "Flame seedless" grape clusters in both seasons. All combination treatments (T_6,T_7, T_8 and T_9) showed the lowest significant values of cluster compactness coefficient in both seasons except T_6 which showed moderate values in the second one. On the contrary, the vines of control produced the highest values in both seasons. The reduction in cluster compactness coefficient might due to the increase rachis elongation (Koukourikou *et al.* (2015). The vines sprayed with Pu (T_2 and T_3) alone and combined with SA (T_6, T_7, T_8 and T_9) treatments recorded the highest significant values of main rachis and pedicels diameters. However, the vines treated with T_3, T_8 and T_9 showed the highest significant values of secondary rachis diameter. This trend was true during both seasons. On the contrary, vines treated with T_4, T_5 and control cleared the lowest values of all the above characters in both seasons. The obtained results are in harmony with those of Koukourikou *et al.* (2015) reported that, Putrescine foliar applications on "Thompson seedless" vines at 10 mg L^{-1} during three times (pre-bloom, full-bloom and post-bloom stages) significantly enhanced rachis weight, length and dimensions.

3. Berry physical characters

A. Length, diameter, weight and volume of 100 berries

From data of Table (4) it could be noticed that, foliar spray with Putrescine and Salicylic acid alone or in combinations enhanced berry characters of "Flame seedless" grapevine as compared to control. The combination treatments were more effective in this respect, where vines received T_7, T8 and T_9 treatments produced the highest significant values of berry length and diameter in both seasons except T_7 in the second one. The highest significant values of weight and volume of 100 berries were recorded with vines that received T_9 treatment during both seasons. However, vines of control (T_1) showed the lowest values of whole the above-mentioned berry characters in both seasons. The positive effect of these treatments may be related to active cell division in the initial stages of fruit development. This active cell division possibly needs sufficient polyamines. This cell division gives way to cell enlargement which enhanced different fruit quality characters and finally increases total yield. Whereas, decreasing in polyamines during the late stage of fruit maturity conceders as a signal for fruit ripening (Malik and Singh, 2004). Moreover, application of Salicylic acid showed an effective role enhancing the productivity of different crops via increasing the total leaf area and pigments of photosynthesis these positive effects were reflected on cluster and berry physical properties (Hayat *et al.,* 2010). These results are supported by those of Kassem *et al.* (2011) who summarized that, the spray with Putrescine during different stages of cluster growth increased berry weight, length and width moreover, enhanced berries quality grade (marketable) of "Flame seedless" grapevines.

Table 2.The Pearson Correlation Coefficient (r) among some chosen quality parameters of "Flame seedless" grape as affected by Putrescine and Salicylic acid sprays

Characters	Yield/ feddan	Cluster weight	Cluster length	Berry firmness	Berry removal force	Berry shatter	Berry decay	Weight Loss%	PME activity	SSC %	Acidity %	SSC/acid ratio	Anthocyanin
Yield/feddan	1												
Cluster weight	0.95**	1											
Cluster length	0.92**	0.83*	1										
B. firmness	-0.25	-0.53	0.67	1									
B. removal force	-0.33	-0.34	0.75	0.92**	1								
Berry shatter %	0.43	0.62	0.24	-0.85*	-0.94**	1							
Berry decay %	0.51	0.35	-0.55	-0.92**	-0.91**	0.94**	1						
Weight Loss	0.41	0.55	0.35	-0.95*	-0.87	0.92**	0.92**	1					
PME activity	0.22	0.32	0.21	0.96*	-0.76	0.89*	0.95**	0.92**	1				
SSC %	-0.36	-0.45	0.23	-0.52	-0.24	0.75	0.78	0.74	0.72	1			
Acidity %	0.45	0.52	-0.22	0.48	0.45	-0.68	-0.55	-0.63	-0.82*	-0.46	1		
SSC/acid ratio	-0.55	-0.57	-0.39	0.25	-0.52	0.55	0.67	0.57	0.67	0.82*	-0.75	1	
Anthocyanin	-0.62	-0.23	-0.27	-0.21	0.68	0.63	0.28	0.26	0.33	0.89**	-0.75*	0.78*	1

***and **=significance at 0.05 and 0.01, respectively.**

Table 3.Effect of Putrescine and Salicylic acid sprays on cluster compactness and diameter of the main rachis, secondary rachis and pedicels of "Flame seedless" grape during 2016 and 2017 seasons

Treatments	CompactnessCoefficient		Main rachisdiameter(mm)		Secondary rachisdiameter (mm)		Pedicelsdiameter(mm)	
	2016	2017	2016	2017	2016	2017	2016	2017
T_1	1.22^{a}	1.32^{a}	5.56^{b}	6.02^{b}	2.65^{c}	3.24^{e}	2.23^{b}	2.53^{c}
T_2	1.12^{ab}	1.21^{ab}	7.13^{a}	7.45^{a}	3.62^{b}	3.89^{bc}	2.87^{a}	2.92^{b}
T_3	1.06^{abc}	1.11^{bc}	7.86^{a}	7.93^{a}	4.21^{a}	4.25^{a}	2.95^{a}	3.21^{a}
T_4	0.97^{bc}	1.02^{bc}	5.42^{b}	6.13^{b}	2.72^{c}	3.42^{e}	2.31^{b}	2.46^{c}
T_5	0.95^{bc}	1.05^{bc}	5.65^{b}	6.21^{b}	2.85^{c}	3.47^{e}	2.37^{b}	2.62^{c}
T_6	0.85^{c}	1.05^{bc}	7.23^{a}	7.58^{a}	3.78^{b}	3.85^{cd}	2.81^{a}	3.04^{a}
T_7	0.87^{c}	0.97^{c}	7.33^{a}	7.47^{a}	3.68^{b}	3.81^{cd}	2.78^{a}	2.98^{a}
T_8	0.91^{c}	0.93^{c}	7.62^{a}	7.88^{a}	4.15^{a}	4.35^{a}	2.90^{a}	3.15^{a}
T_9	0.85^{c}	0.95^{c}	7.57^{a}	7.78^{a}	4.22^{a}	4.45^{a}	2.88^{a}	3.11^{a}

In a column, means followed by the same letter are not significantly different at the 5% level by DMRT.

T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

Table. 4. Effect of Putrescine and Salicylic acid sprays on berries length, diameter, weight and volume of "Flame seedless" grape during 2016 and 2017 seasons

Treatments	Berry length(mm)`		Berry diameter(mm)		Weight of 100berries(g)		Volume of 100berries(ml)	
	2016	2017	2016	2017	2016	2017	2016	2017
T_1	17.54^{c}	18.01^{d}	16.25^{e}	17.02^{d}	242.23^{g}	234.45^{h}	175^{i}	218^{f}
T_2	18.46^{bc}	18.76^{cd}	17.67^{cd}	17.94^{cd}	267.54^{f}	256.26^{f}	211^{h}	233^{e}
T_3	18.67^{bc}	18.88^{cd}	18.57^{cd}	18.20^{cd}	285.73^{de}	272.47^{e}	225^{g}	245^{d}
T_4	18.10^{bc}	18.22^{cd}	17.43^{d}	17.90^{cd}	262.36^{f}	242.73^{dh}	232^{f}	219^{f}
T_5	18.19^{bc}	18.24^{cd}	17.75^{cd}	18.07^{cd}	278.52^{e}	248.53^{fg}	242^{e}	221^{f}
T_6	19.80^{ab}	19.55^{c}	18.85^{c}	18.75^{c}	292.46^{d}	285.43^{d}	267^{d}	252^{c}
T_7	20.56^{a}	21.34^{b}	22.57^{a}	20.32^{b}	335.35^{c}	321.62^{c}	275^{c}	258^{bc}
T_8	21.34^{a}	22.24^{a}	22.43^{a}	21.45^{a}	355.23^{b}	334.45^{b}	283^{b}	263^{b}
T_9	21.45^{a}	22.85^{a}	22.56^{a}	21.76^{a}	385.31^{a}	364.37^{a}	325^{a}	292^{a}

In a column, means followed by the same letter are not significantly different at the 5% level by DMRT.

T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

B. Berry removal force

Data of Table (5) showed that, foliar applications with all treatments enhanced berry removal force as compared to control (T_1) at picking date. The combination (T_6, T_7, T_8 and T_9) treatments reached the highest values without significant differences among them at picking date during both seasons except T_6 treatment in the second one. During storage time, berry removal force tended to reduce with the incidence of storage time. At the end of storage period (60 days), the highest values were observed with T_8 and T_9 treatments in both seasons. The lowest values of this character were recorded with control (T_1) at harvest time in both seasons. By the end of the storage period, there was no significant difference between control (T_1) and (T_2) treatments. These results were supported by the correlation data presented in Table (2) where, it showed a highly negative correlation between berry removal force vs. berry shatter (-0.94^{**}), berry decay (-0.92^{**}) and negative correlation vs. Pectin methylesterase enzyme (PME) activity (-0.87) and weight loss % (-0.76). The effect of both Pu and SA might due to inhibiting the formation of abscission layers that reduced fruit drop (Ponce *et al.*, 2002). These findings are in harmony with that of Champa *et al.* (2014) and Koukourikou *et al.* (2015) they concluded that, Pu applied pre or postharvest treatments enhanced different cluster quality parameters of "Thompson seedless" and "Flame seedless" at picking date and during cold storage including berry attachment. Moreover, Lo'ay, (2017) reported that, foliar spray with SA at 4 mM on "Superior seedless" vines was significantly effective in berry separation force.

Table 5. Effect of Putrescine and Salicylic acid sprays on berry removal force and firmness (Newton)of "Flame seedless" grape during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

Treatments	2016						2017					
	Cold storage periods in days						Cold storage periods in days					
	0	15	30	45	60	Mean	0	15	30	45	60	Mean
Berry removal force (Newton)												
T_1	2.9^{b}	2.5^{b}	2.2^{c}	2.1^{e}	1.9^{d}	2.3^{E}	2.1^{e}	1.8^{e}	1.5^{e}	1.3^{e}	0.8^{d}	1.5^{E}
T_2	3.5^{ab}	2.9^{b}	2.5^{c}	2.2^{de}	1.9^{d}	2.6^{D}	2.8^{d}	2.2^{de}	1.9^{d}	1.4^{e}	1.0^{d}	1.9^{D}
T_3	4.2^{ab}	3.5^{ab}	3.3^{abc}	3.1^{bc}	2.5^{c}	3.3^{B}	4.0^{bc}	3.4^{c}	3.2^{bc}	2.8^{cd}	2.2^{c}	3.1^{BC}
T_4	4.0^{ab}	2.8^{b}	2.5^{bc}	2.3^{de}	2.1^{cd}	2.7^{CD}	3.8^{c}	3.4^{c}	3.0^{c}	2.6^{d}	2.2^{c}	2.9^{C}
T_5	4.1^{ab}	3.6^{ab}	3.2^{abc}	2.8^{cd}	2.4^{c}	3.2^{B}	3.0^{d}	2.4^{d}	2.0^{d}	1.5^{e}	1.0^{d}	1.9^{D}
T_6	4.4^{a}	4.1^{a}	3.7^{ab}	3.3^{abc}	2.9^{b}	3.7^{AB}	4.3^{ab}	3.9^{b}	3.5^{b}	3.1^{bc}	2.8^{b}	3.5^{B}
T_7	4.7^{a}	4.2^{a}	3.9^{a}	3.5^{ab}	3.1^{ab}	3.9^{A}	4.5^{a}	3.7^{bc}	3.4^{b}	3.1^{b}	2.8^{b}	3.5^{B}
T_8	4.7^{a}	4.5^{a}	4.1^{a}	3.8^{a}	3.4^{a}	4.1^{A}	4.8^{a}	4.5^{a}	4.2^{a}	3.8^{a}	3.6^{a}	4.2^{A}
T_9	4.7^{a}	4.5^{a}	4.2^{a}	3.7^{a}	3.5^{a}	4.1^{A}	4.8^{a}	4.6^{a}	4.2^{a}	3.9^{a}	3.6^{a}	4.2^{A}
Mean	4.1^{A}	3.6^{AB}	3.3^{B}	2.9^{B}	2.6^{B}		3.8^{A}	3.3^{AB}	3.0^{B}	2.6^{C}	2.2^{D}	
Berry Firmness (Newton)												
T_1	1.4^{d}	1.1^{e}	0.9^{e}	0.7^{d}	0.4^{c}	0.9^{C}	1.3^{d}	1.2^{d}	1.0^{d}	0.8^{d}	0.7^{d}	1.0^{D}
T_2	1.8^{cd}	1.5^{d}	1.2^{d}	1.0^{cd}	0.9^{bc}	1.3^{B}	1.7^{c}	1.4^{cd}	1.1^{d}	0.9^{cd}	0.8^{cd}	1.2^{CD}
T_3	1.9^{c}	1.7^{cd}	1.4^{cd}	1.2^{c}	1.0^{bc}	1.4^{B}	1.8^{c}	1.6^{c}	1.4^{c}	1.3^{c}	1.0^{c}	1.4^{C}
T_4	1.7^{cd}	1.5^{d}	1.2^{d}	1.0^{cd}	0.9^{bc}	1.3^{B}	1.6^{cd}	1.3^{cd}	1.1^{d}	1.0^{cd}	0.8^{cd}	1.2^{CD}
T_5	1.7^{cd}	1.6^{cd}	1.4^{cd}	1.2^{c}	1.0^{bc}	1.4^{B}	1.5^{cd}	1.3^{cd}	1.1^{d}	0.9^{cd}	0.8^{cd}	1.1^{CD}
T_6	2.2^{bc}	1.9^{bc}	1.5^{cd}	1.2^{c}	1.1^{bc}	1.6^{AB}	2.6^{b}	2.3^{b}	2.1^{b}	1.9^{b}	1.6^{b}	2.1^{B}
T_7	2.4^{ab}	2.0^{ab}	1.7^{bc}	1.4^{bc}	1.2^{b}	1.7^{AB}	2.7^{b}	2.4^{b}	2.2^{ab}	2.0^{ab}	1.9^{ab}	2.2^{AB}
T_8	2.6^{a}	2.1^{ab}	1.9^{b}	1.7^{ab}	1.4^{ab}	1.9^{A}	2.9^{a}	2.7^{a}	2.4^{a}	2.2^{a}	1.9^{a}	2.4^{A}
T_9	2.7^{a}	2.2^{a}	2.1^{a}	1.9^{a}	1.8^{a}	2.2^{A}	3.1^{a}	2.9^{a}	2.5^{a}	2.2^{a}	2.0^{a}	2.5^{A}
Mean	2.0^{A}	1.7^{AB}	1.5^{B}	1.3^{B}	1.1^{C}		2.1^{A}	1.9^{AB}	1.6^{B}	1.5^{B}	1.3^{B}	

In a column under each character, means followed by the same letter are not significantly different at the 5% level by DMRT.
T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1),
T5=Salicylic acid at 4.0 mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

C. Berry firmness

Data of Table (5) cleared that, berry firmness were enhanced with the application of Putrescine and Salicylic acid alone as well as combinations compared to control at picking date and also during cold storage period in both seasons. The vines received the combination (T_8 and T_9) treatments showed the highest significant values as compared to other treatments at picking date in both seasons. During cold storage, T_9 treatment showed the best berries firmness till 60 days in the first season. However, by the second one, there is no significant difference between T_8 and T_9. On the contrary, the loss firmness occurred progressively with control (T_1) during storage time in both seasons. The positive effect of Pu and SA in maintaining firmness might due to decreasing the activity of cell wall degrading enzymes as xylanase, cellulose and polygalacturonase. In addition, it had a close relation with physiological water loss from fruits during storage as showed in Table (2), since there was a highly negative relationship between firmness vs. enzyme activity of Pectin methylesterase (PME) (-0.95^{**}) and weight loss percent (-0.96^{**}). These results are supported by both Kassem *et al.,* (2011) and Ponce *et al.,* (2002) they summarized that, Pu spray delayed maturation and ripening of "Flame seedless" grape and reducing berry softening. Moreover, it was effective in decreasing respiration rate which maintaining the firmness of peach fruits during cold storage (Bal, 2013).

D. Berry shatter%

Figure (1) showed that, all treatments were effective in reducing the berry shattering percent at harvest time as well as during cold storage. The vines treated by T_6, T_7, T_8 and T_9 reached the lowest values at picking date in both seasons. During storage, the clusters harvested from vines treated with T_9 recorded the lowest berries shattering till the end of the storage period. However, control (T_1) vines showed the highest percent at picking date and during all storage period in both seasons. The positive effect of treatments reducing berry shatter percent might due to inhibition of the activity of ethylene biosynthetic enzymes which conceders as the primary product of abscission layers (Taiz and Zeiger, 2010). In this line, numerous of authors explained that, there is a positive relationship between cluster weight loss and berry shatter since, increasing water loss causes not only berry softening but also berry shattering (Zhang *et al.*, 2003 and Babalar *et al.*, 2007).

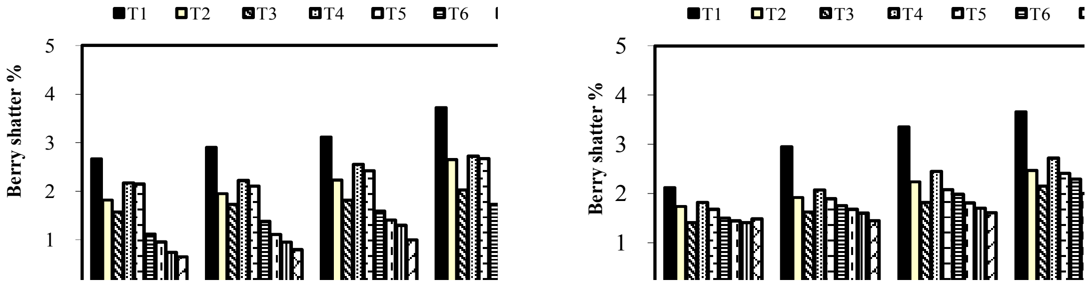

Figure 1. Effect of Putrescine and Salicylic acid sprays on berryshatter %of "Flame seedless" grapevine during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

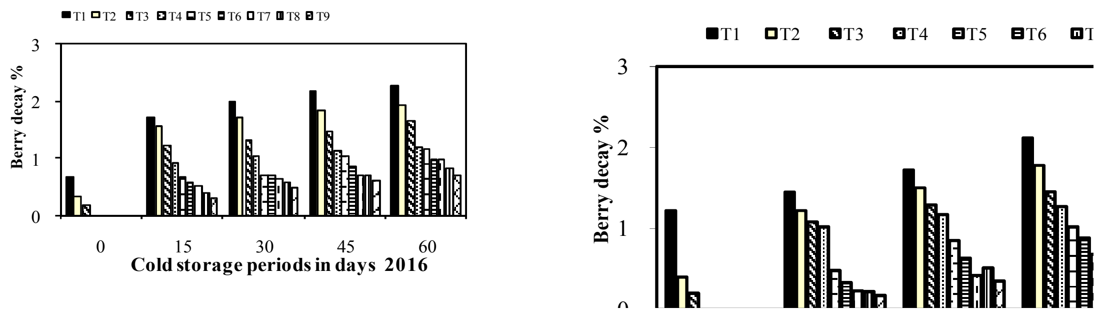

Figure 2. Effect of Putrescine and Salicylic acid sprays on berry decay % of "Flame seedless" grape during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

E. Berry decay %

Figure (2) cleared that, application of SA and Pu alone or in combinations showed an enhancement effect in reducing decays at harvesting date. Salicylic acid (T_4 and T_5) treatments and their combinations with Pu (T_6, T_7, T_8 and T_9) did not show any berry decay at picking date in both seasons. During cold storage T_9 recorded the lowest significant percent of berry decay at the end of storage however; control (T_1) showed the highest percentages in both seasons. This reduction in decay incidence may due to the known effect of Salicylic acid in increasing the accumulation of phenolic compounds, induced term of numerous defense genes and improved resistance of berries against fungal attack by increasing activities of anti-oxidant enzymes (Xu and Tian, 2008). Also, polyamines applications are thought to delaying fruit senescence through inhibiting the formation of enzymes that are necessary to ethylene synthesis (Torrigiani, 2004 and Shiri *et al.,* 2012).

4. Rachis browning index

Regarding the rachis browning index, Figure (3) showed an increase in rachis browning with the incidence of storage time from 15 till 60 days of cold storage. The clusters harvested from vines of control (T_1) tended to changes rachis color to brown faster than all treatments during storage. The lower changes of rachis color were observed with T_8 and T_9 treatments up to 60 days of cold storage in both seasons. These results are supported by correlation coefficient results presented in Table (2) that showed a highly positive relationship between shattering berries and each of berry decay (0.94^{**}) and cluster weight loss (0.92^{**}). The effect of treatments might due to inhibiting polyphenol oxidase enzymes which appear to increase during storage concurrently increasing phenolic compounds accumulation which plays an important role as antioxidants (Peng and Jiang, 2006).

These results are in agreement with those of Tareen *et al.* (2012) who reported that, Salicylic acid showed a positive effect on reducing water loss which maintaining healthy of cluster rachis of "Flame seedless" grape. Also, Putrescine applications were effective in maintaining phenolic compounds of the berries thus reduced the incidence of rachis browning in grape cv. Shahroudi during cold storage (Shiri*et al*., 2012).

5. Cluster weight loss%

The results illustrated as Figure (4) cleared that, foliar sprays with Pu as well as SA were effective in reducing cluster weight loss as compared to control during both seasons. Generally, the loss in cluster weight percent was increased with prolonged storage time. This loss of cluster weight was less severe with all treatments as compared to control (T_1). The application of T_8 and T_9 were more effective in reducing the physiological cluster weight loss during all storage period. At the end of the storage period (60 days), vines treated with T_9 showed the lowest values in both seasons. This result is in harmony with that of Lu *et al.* (2011) and Tareen *et al.* (2012) they concluded that, Salicylic acid applications reduced the weight loss of different vegetable and fruit products during storage and maintaining fruit quality. Moreover, Putrescine applications were effective in decreasing cluster weight loss of "Flame seedless" grape (Champa *et al.*, 2014).

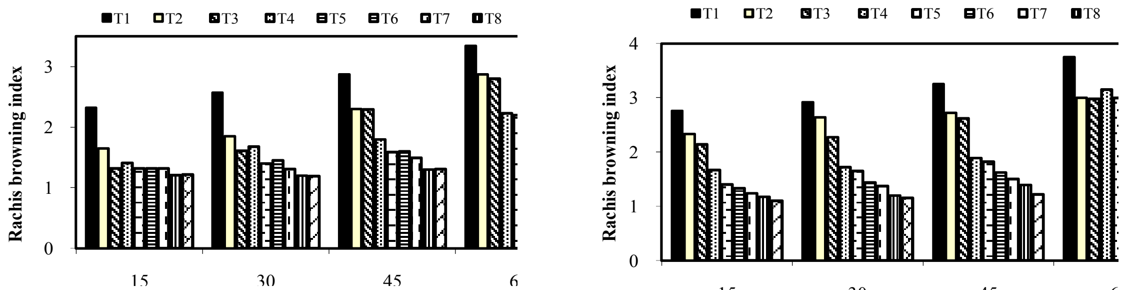

Figure3. Effect of Putrescine(Pu) and Salicylic acid (SA) sprays on rachis browning index of "Flame seedless" grapevine during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons

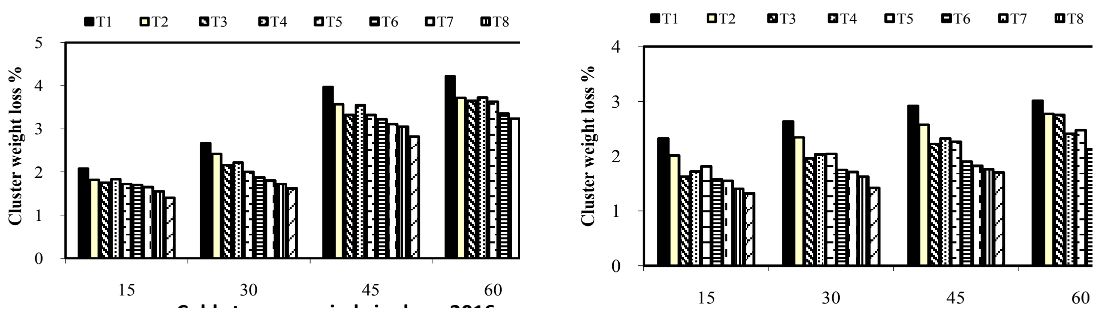

Figure4. Effect of Putrescine and Salicylic acid sprays on cluster weight loss, of "Flame seedless" grapevine during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

6. Berries chemical characters

A. Berries anthocyanin

Berries anthocyanin content was clearly reduced with the use of Pu and SA as well as interaction treatments as showed in Figure (5). However, control (T_1) showed the higher values at picking date in both seasons. During cold storage, all treatments including control showed a slight increase of anthocyanin up to 30 days.The control (T_1) treatment showed a rapid reduction in berries anthocyanin after 45 days of storage.On the contrary, other treatments (T_2 to T_9) showed an increase in these pigments until the end of storage time. By the end of storage (60 days) control treatment showed the lowest significant values concurrently T_6 and T_7 reached the highest values. This trend was true during both seasons. The effect of treatments in maintaining berries anthocyanin may due to known role of Pu and SA in retarding the degradation of chlorophyll that reduction skin color changes throughout the storage and retarding senescence rate in table grapes (Champa *et al.*, 2015). Similar results were recorded by Ullah and Jawandha, (2013) concluded that, application of Pu showed a slow rate of conversion from green to yellow and chlorophyll degradation in peach fruits.

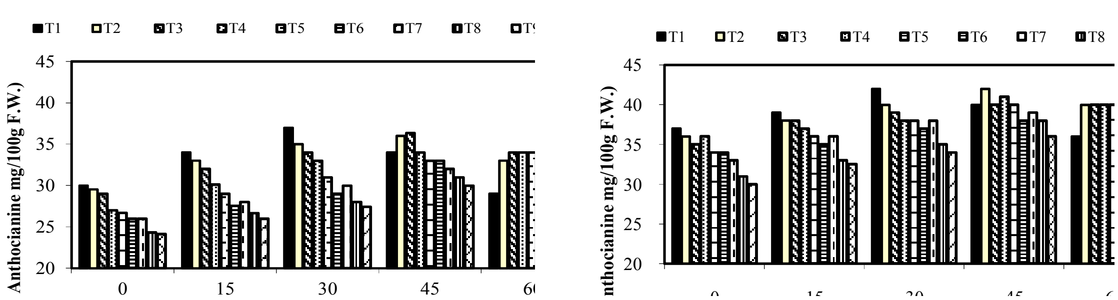

Figure 5. Effect of Putrescine and Salicylic acid sprays on berries anthocyanine content of "Flame seedless" grape during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

B. Pectin methylesterase activity (PME)

The activity PME was severely affected treatments versus control as showed in Figure (6). The vines received T_7, T_8 and T_9 treatments recorded the lowest activity values (unit/h). On the contrary, control (T_1) showed the highest values at picking date in both seasons. During cold storage, the activity of this enzyme showed a severe increasing with control but it was increased slightly with the others. The combination (T_7, T_8 and T_9) treatments cleared the lowest level of PME activity starting 15 up to 60 days of cold storage. Moreover, data in Table (2) cleared anegative relationship between PME activity vs. berry firmness (-0.96^{**}) and removal force (-0.76). On the contrary, it showed positive relationships with berry shatter (0.89^{*}), berry decay (0.95^{**}) and cluster weight loss (0.92^{**}). These results are in harmony with that of Champa *et al.* (2014) reported that Pu application at 1.0 mM maintained the quality and extended the shelf life of grape cv. "Flame seedless" up to 60 days in cold storage (3-4 ^{o}C and 90-95% RH) and it was effective in reducing the rate of berry softening and suppressed Pectin methylesterase activity.

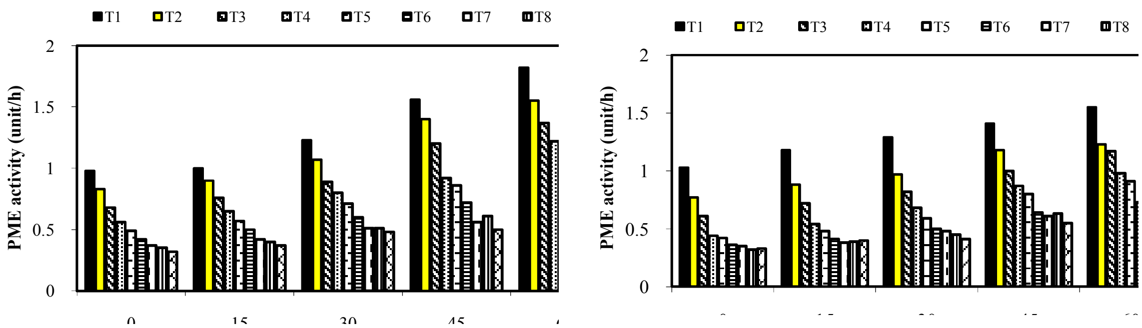

Figure 6. Effect of Putrescine and Salicylic acid sprays on Pectin methylesterase activity of "Flame seedless" grape berries during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.
T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

C. *JuiceSSC%*

Data presented in Table (6) cleared that, application of Pu and SA alone or in combinations reduced the accumulation of SSC% in berries of "Flame seedless" grape versus control. The vines treated with T_7, T_8 and T_9 recorded the lowest significant percent at picking time in the first season as well as that treated with T_8 andT_9 in the second one. However, the highest percentages were recorded with control (T_1) in both seasons. Regarding storage period, foliar application of Pu and SA especially at T_6, T_7, T_8 and T_9 were more effective maintaining and retarding degradation of SSC% during cold storage. However, control (T_1) showed the highest declination degree after 45 days of storage during both seasons. These results are in line with that of Lo'ay, (2017) who showed that, application of SA at 4mM maintained total solid content (SSC%) during shelf life and effective for delaying cluster ripening of 'Superior seedless' grapes. Also, Champa *et al.* (2014) reported that, "Flame Seedless" grape berries treated with Pu showed the lowest SSC% as compared to control during 60 days of cold storage. Moreover, the SSC% showed a declination in untreated berries by 1.4% and treated berries by only 0.4% decreasing.

D. *Titratable acidity*

The titratable acidity of berry juice was affected all foliar treatments versus control at picking date and during cold storage as showing in Table (6). The vines received T_6, T_7 and T_9 recorded the highest significant percentages however, the lowest values were observed with control (T_1) at picking date. In addition, all spray treatments maintained the acidity of berries at higher levels till 60 days of storage as compared to control (T_1) in the first season. In the second one, nearly trend was noticed especially with combination treatments. These findings are accordance with that of Champa *et al.* (2015) who summarized that, Salicylic acid applications were effective suppressing degradation of SSC% and acidity during cold storage of "Flame Seedless" fruits. In addition, Abdel-Salam (2016) reported that SA applications reduced SSC% and acidity of berry juice of "Bez El-Naka" grape cultivar.

E. *SSC/acid ratio*

Data illustrated in Table (7) cleared that, the spray treatments under study reduced SSC/acid ratio as compared to control (T_1) during both harvesting date and cold storage in both seasons. The combination treatments (T_7, T_8 and T_9) showed the lowest significant ratio compared with others at picking date in the two seasons. During cold storage, applications of T_8 and T_9 were more effective in reducing this character in both seasons. Our results are in agreement with those of Babalar *et al.* (2007) on strawberry and Ezzat *et al.* (2017) on apricot, they concluded that, polyamines applications were effective delaying maturity and fruits ripening.

F. Total sugars (%)

Data of Table (7) cleared that, total sugars of "Flame seedless" grape berries were affected Putrescine and Salicylic acid sprays. The highest significant values were recorded with control berries at harvesting time in both seasons. However, the lowest values were obtained with T_8 and T_9 in the first season and T_9 in the second one. All treatments including control tended to increase total sugars percent during cold storage. Control (T_1), T_2 and T_3 treatments showed a reduction in this parameter with the extending of storage to 60 days of storage. On the other hand, the combination treatments (T_6, T_7, T_8 and T_9) showed a slight increase during all storage period in the first season. In the second one, nearly trend was noticed. These results could be ascribed to the effect of Pu delaying senescence process through enhancing protein synthesis, retarding cell degradation and reduced respiration rate (Mahajan *et al.*, 2010 and Razzaq *et al.*, 2014). Also, Lo'ay (2017) concluded that, Salicylic acid was effective for delaying fruit ripening and maintain cluster quality of 'Superior seedless' grapes.

Table 6. Effect of Putrescine and Salicylic acid sprays on berries SSC% and titratable acidity (%)of "Flame seedless" grape during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

Treatments	2016						2017					
	Cold storage periods in days						Cold storage periods in days					
	0	15	30	45	60	Mean	0	15	30	45	60	Mean
SSC%												
T_1	17.4^{a}	17.5^{a}	17.9^{a}	17.6^{a}	17.4^{a}	17.6^{A}	18.0^{a}	18.3^{a}	18.4^{a}	18.3^{a}	18.0^{a}	18.2^{A}
T_2	16.5^{ab}	16.9^{ab}	17.0^{ab}	17.1^{ab}	17.3^{ab}	17.0^{AB}	16.5^{b}	16.7^{b}	16.9^{b}	16.9^{b}	17.0^{b}	16.8^{B}
T_3	16.3^{ab}	16.4^{b}	16.7^{ab}	16.7^{ab}	16.4^{ab}	16.5^{B}	16.3^{bc}	16.4^{bc}	16.5^{bc}	16.8^{b}	16.9^{bc}	16.6^{BC}
T_4	16.4^{ab}	16.7^{ab}	16.8^{ab}	16.9^{ab}	16.9^{ab}	16.8^{AB}	16.3^{bc}	16.3^{bc}	16.4^{bc}	16.7^{bc}	16.9^{bc}	16.5^{BC}
T_5	16.3^{ab}	16.4^{b}	16.5^{b}	16.7^{ab}	16.9^{ab}	16.6^{B}	16.1^{bc}	16.4^{bc}	16.5^{bc}	16.6^{bc}	16.7^{bc}	16.5^{BC}
T_6	16.1^{ab}	16.3^{b}	16.5^{b}	16.8^{ab}	16.8^{ab}	16.5^{B}	16.0^{bc}	16.3^{bc}	16.5^{bc}	16.9^{b}	16.9^{bc}	16.5^{BC}
T_7	15.9^{b}	16.1^{b}	16.4^{b}	16.8^{ab}	16.9^{ab}	16.5^{B}	15.7^{bc}	15.9^{bcd}	15.9^{c}	16.1^{bc}	16.4^{bc}	16.0^{BC}
T_8	15.8^{b}	16.0^{b}	16.3^{b}	16.4^{b}	16.5^{ab}	16.2^{B}	15.4^{c}	15.5^{cd}	15.7^{c}	15.8^{c}	16.0^{c}	15.7^{C}
T_9	15.6^{b}	15.9^{b}	15.9^{b}	16.0^{b}	16.3^{b}	16.0^{B}	15.3^{c}	15.4^{d}	15.7^{c}	15.9^{c}	16.0^{c}	15.6^{C}
Mean	16.3^{A}	16.5^{A}	16.7^{A}	16.8^{A}	16.8^{A}		16.2^{A}	16.3^{A}	16.5^{A}	16.7^{A}	16.7^{A}	
Total titratable acidity (%)												
T_1	0.68^{b}	0.57^{b}	0.54^{b}	0.51^{c}	0.48^{c}	0.56^{B}	0.54^{b}	0.49^{b}	0.45^{b}	0.41^{b}	0.38^{b}	0.45^{B}
T_2	0.72^{ab}	0.67^{a}	0.64^{a}	0.58^{b}	0.55^{b}	0.63^{A}	0.67^{a}	0.62^{ab}	0.58^{ab}	0.53^{ab}	0.51^{ab}	0.58^{AB}
T_3	0.74^{ab}	0.70^{a}	0.66^{a}	0.60^{ab}	0.58^{ab}	0.66^{A}	0.70^{a}	0.65^{a}	0.61^{ab}	0.57^{a}	0.55^{a}	0.62^{A}
T_4	0.70^{ab}	0.67^{a}	0.64^{a}	0.60^{ab}	0.56^{b}	0.63^{A}	0.66^{ab}	0.61^{ab}	0.57^{ab}	0.53^{ab}	0.50^{ab}	0.57^{AB}
T_5	0.72^{ab}	0.68^{a}	0.64^{a}	0.61^{ab}	0.57^{ab}	0.64^{A}	0.69^{a}	0.62^{ab}	0.58^{ab}	0.54^{ab}	0.50^{ab}	0.59^{AB}
T_6	0.77^{a}	0.71^{a}	0.68^{a}	0.66^{a}	0.63^{a}	0.69^{A}	0.73^{a}	0.69^{a}	0.63^{ab}	0.57^{a}	0.53^{ab}	0.63^{A}
T_7	0.78^{a}	0.70^{a}	0.66^{a}	0.62^{ab}	0.60^{ab}	0.67^{A}	0.77^{a}	0.72^{a}	0.67^{a}	0.60^{a}	0.56^{a}	0.66^{A}
T_8	0.76^{ab}	0.72^{a}	0.68^{a}	0.65^{a}	0.62^{a}	0.69^{A}	0.79^{a}	0.73^{a}	0.70^{a}	0.67^{a}	0.62^{a}	0.70^{A}
T_9	0.78^{a}	0.72^{a}	0.68^{a}	0.65^{a}	0.63^{a}	0.69^{A}	0.78^{a}	0.72^{a}	0.69^{a}	0.66^{a}	0.60^{a}	0.69^{A}
Mean	0.74^{A}	0.68^{AB}	0.65^{B}	0.61^{C}	0.58^{D}		0.70^{A}	0.65^{AB}	0.61^{B}	0.56^{C}	0.53^{C}	

In a column under each character, means followed by the same letter are not significantly different at the 5% level by DMRT.
T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1),
T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

Table 7. Effect of Putrescine and Salicylic acid sprays on berries SSC/Acid ratioand total sugars of "Flame seedless" grape during cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

Treatments	2016						2017					
	Cold storage periods in days						Cold storage periods in days					
	0	15	30	45	60	Mean	0	15	30	45	60	Mean
SSC/Acid ratio												
T_1	25.6^{a}	30.8^{a}	33.1^{a}	34.6^{a}	36.3^{a}	32.1^{A}	33.3^{a}	37.3^{a}	40.9^{a}	44.6^{a}	47.4^{a}	40.7^{A}
T_2	23.0^{bc}	25.3^{b}	26.6^{b}	29.5^{b}	31.4^{b}	27.1^{B}	24.7^{b}	26.9^{b}	29.1^{b}	31.9^{b}	33.3^{b}	29.2^{B}
T_3	22.0^{cd}	23.4^{cd}	25.3^{cd}	27.8^{c}	28.3^{d}	25.4^{DE}	23.2^{c}	25.2^{c}	27.1^{c}	29.6^{d}	30.7^{d}	27.2^{C}
T_4	23.4^{b}	24.9^{b}	26.4^{b}	28.2^{c}	30.2^{c}	26.6^{BC}	24.7^{b}	26.7^{b}	28.8^{b}	31.5^{bc}	33.7^{b}	29.1^{B}
T_5	22.6^{bc}	24.1^{bc}	25.8^{bc}	27.3^{c}	29.7^{c}	25.9^{CD}	23.4^{c}	26.5^{b}	28.5^{b}	30.9^{c}	33.3^{b}	28.5^{B}
T_6	21.0^{de}	22.9^{cd}	24.3^{ef}	25.6^{d}	26.8^{e}	24.1^{FG}	21.9^{d}	23.6^{d}	26.2^{c}	29.6^{d}	31.8^{c}	26.6^{C}
T_7	20.4^{e}	23.0^{cd}	24.9^{de}	27.2^{c}	28.2^{d}	24.8^{EF}	20.4^{e}	22.0^{e}	23.8^{d}	26.9^{e}	29.3^{e}	24.5^{D}
T_8	20.3^{e}	22.2^{d}	23.9^{fg}	25.2^{d}	26.7^{e}	23.8^{FG}	19.5^{e}	21.3^{e}	22.4^{e}	23.7^{f}	25.8^{f}	22.5^{E}
T_9	20.1^{e}	22.0^{d}	23.4^{g}	24.6^{d}	25.8^{e}	23.2^{G}	19.6^{e}	21.4^{e}	22.7^{e}	24.1^{f}	26.7^{f}	22.9^{E}
Mean	22.1^{E}	24.3^{D}	26.0^{C}	27.8^{B}	29.3^{A}		23.4^{D}	25.7^{C}	27.7^{B}	30.3^{AB}	32.5^{A}	
Total sugars (%)												
T_1	17.8^{a}	17.9^{a}	17.8^{a}	17.3^{ab}	17.1^{ab}	17.7^{A}	16.6^{a}	16.9^{a}	16.9^{a}	16.8^{a}	16.8^{a}	16.8^{A}
T_2	17.6^{ab}	17.7^{a}	17.8^{a}	17.8^{ab}	17.7^{ab}	17.7^{A}	15.8^{ab}	15.8^{ab}	16.1^{ab}	16.1^{ab}	16.0^{ab}	15.9^{AB}
T_3	17.4^{ab}	17.5^{ab}	17.7^{a}	17.7^{ab}	17.7^{ab}	17.6^{A}	15.4^{ab}	15.7^{ab}	15.8^{b}	15.9^{ab}	15.8^{b}	15.7^{AB}
T_4	17.7^{ab}	17.7^{a}	17.8^{a}	17.9^{a}	17.8^{a}	17.8^{A}	15.4^{ab}	15.5^{ab}	15.7^{b}	15.8^{ab}	15.7^{b}	15.6^{AB}
T_5	17.3^{ab}	17.4^{ab}	17.7^{a}	17.8^{ab}	17.8^{a}	17.5^{A}	15.4^{ab}	15.5^{ab}	15.6^{b}	15.7^{ab}	15.7^{b}	15.6^{AB}
T_6	16.8^{ab}	17.2^{ab}	17.2^{ab}	17.5^{ab}	17.8^{a}	17.2^{AB}	15.4^{ab}	15.4^{b}	15.6^{b}	15.6^{b}	15.7^{b}	15.5^{B}
T_7	16.1^{ab}	16.5^{bc}	16.7^{ab}	16.9^{ab}	17.2^{ab}	16.6^{B}	15.3^{ab}	15.4^{b}	15.5^{b}	15.6^{b}	15.7^{b}	15.5^{B}
T_8	16.2^{b}	16.5^{bc}	16.7^{ab}	16.8^{ab}	17.0^{ab}	16.6^{B}	15.3^{ab}	15.5^{b}	15.5^{b}	15.7^{b}	15.7^{b}	15.5^{B}
T_9	16.2^{b}	16.3^{c}	16.5^{b}	16.7^{b}	16.9^{b}	16.4^{B}	15.2^{b}	15.4^{b}	15.4^{b}	15.5^{b}	15.6^{b}	15.4^{B}
Mean	17.0^{A}	17.2^{A}	17.3^{A}	17.4^{A}	17.4^{A}		15.5^{A}	15.7^{A}	15.8^{A}	15.9^{A}	15.9^{A}	

In a column under each character, means followed by the same letter are not significantly different at the 5% level by DMRT.
T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1),
T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

7. Cluster shelf life

Shelf life in days at room temperature experiment was started directly after picking date and after each storage period (15, 30, 45 and days of cold storage). It was terminated when about 50% of pedicles turned to brown color completely. Data of Table (8) showed the enhancement effect of different Pu and SA treatments on extending shelf life of "Flame seedless" grape cluster over control. Vines treated with T_9 showed the highest extending the shelf life in days at picking date during both seasons. The interaction (T_6, T_7, T_8 and T_9) treatments were more effective in this respect as compared to control, especially T_8 and T_9 treatment after each cold storage period in both seasons. This enhancement effect on shelf life period might due to the role of Pu reducing physiological weight loss of clusters, the activity of oxidative enzymes and retarding fruit softening. Also, SA increased phenolic compounds and enhancing resistant system as previously shown in this study. These results are in line with those of Perez-Vicente *et al.* (2002) who reported that, exogenous polyamines applications delayed color changes, reduced mechanical damage, chilling injury susceptibility and increase shelf life in both climacteric and non-climacteric fruits.

Table 8. Effect of Putrescine and Salicylic acid sprays on shelf life in days over control of "Flame seedless" grape after cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

Treatments	Shelf life in days over control											
	2016						2017					
	0	15	30	45	60	Mean	0	15	30	45	60	Mean
T_1	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{c}	0.00^{C}	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{d}	0.00^{e}	0.00^{C}
T_2	3.00^{b}	1.75^{b}	2.00^{ab}	2.00^{b}	1.75^{b}	2.20^{AB}	2.25^{b}	2.00^{b}	1.75^{c}	1.75^{c}	1.50^{d}	1.85^{B}
T_3	3.00^{b}	2.25^{ab}	2.25^{ab}	3.00^{a}	1.75^{b}	2.45^{AB}	3.50^{ab}	2.00^{b}	2.00^{b}	1.75^{c}	1.75^{c}	2.20^{AB}
T_4	3.00^{b}	1.75^{b}	1.75^{b}	1.25^{c}	2.00^{ab}	1.95^{B}	2.25^{b}	2.25^{ab}	1.25^{c}	1.25^{c}	1.75^{c}	1.75^{B}
T_5	3.25^{ab}	2.00^{ab}	2.00^{ab}	1.25^{c}	1.75^{b}	2.05^{B}	2.50^{b}	2.50^{ab}	1.50^{c}	1.75^{c}	2.00^{c}	2.05^{AB}
T_6	3.50^{ab}	2.00^{ab}	2.25^{ab}	2.75^{ab}	2.00^{ab}	2.50^{AB}	3.25^{ab}	2.50^{ab}	2.25^{ab}	1.75^{c}	2.25^{bc}	2.40^{AB}
T_7	3.75^{ab}	2.25^{ab}	2.25^{ab}	3.00^{a}	2.00^{ab}	2.65^{AB}	3.75^{ab}	2.75^{ab}	2.75^{ab}	2.25^{b}	2.00^{c}	2.70^{AB}
T_8	4.25^{ab}	2.50^{ab}	2.75^{ab}	3.50^{a}	2.25^{ab}	3.05^{A}	4.25^{a}	2.75^{ab}	3.25^{a}	2.75^{b}	2.50^{b}	3.10^{A}
T_9	4.50^{a}	3.00^{a}	3.00^{a}	3.50^{a}	3.00^{a}	3.40^{A}	4.50^{a}	3.75^{a}	3.50^{a}	3.00^{a}	3.00^{a}	3.55^{A}
Mean	3.19^{A}	1.94^{C}	2.03^{AB}	2.25^{AB}	1.83^{C}		2.92^{A}	2.28^{AB}	2.03^{AB}	1.81^{B}	1.86^{B}	

In a column, means followed by the same letter are not significantly different at the 5% level by DMRT.
T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0 mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

8. Marketable clusters (%)

The results in Table (9) showed that, vines treated with the combination between Pu and SA (T_6, T_7, T_8 and T_9) recorded the highest marketable clusters percentages followed by that received Pu at higher concentration (T_3) however, control (T_1) vines showed the lowest percentages. This trend was true at picking date and overall storage periods with regarding that the marketable clusters percent was reduced with prolonged of cold storage period. The present results were supported by El-Sayed (2013) who reported that, Pu applications gave the lowest values of both shattering and unmarketable berries percentages. Also, Lo'ay, (2017) reported that, SA is effective for delaying fruit ripening and maintain cluster quality of 'Superior seedless' grapes.

Table 9. Effect of Putrescine and Salicylic acid sprays on marketable clusters of "Flame seedless" grape after cold storage at 0-2ºC and RH 90-95% in 2016 and 2017 seasons.

Treatments	Marketable clusters (%)					
	At picking date			After 60 days of cold storage		
	2016	2017	Mean	2016	2017	Mean
T_1	96.5^{b}	97.3^{b}`	96.9^{B}	87.1^{c}	85.5^{b}	86.3^{C}
T_2	97.3^{ab}	97.6^{ab}	97.5^{AB}	94.5^{b}	95.2^{ab}	94.9^{B}
T_3	97.7^{ab}	97.9^{ab}	97.8^{AB}	96.9^{ab}	96.7^{ab}	96.8^{A}
T_4	97.4^{ab}	97.5^{ab}	97.5^{AB}	96.8^{ab}	95.8^{ab}	96.3^{AB}
T_5	97.3^{ab}	97.5^{ab}	97.4^{AB}	96.8^{ab}	96.5^{ab}	96.7^{AB}
T_6	98.3^{a}	98.8^{a}	98.6^{A}	97.2^{a}	97.1^{a}	97.2^{A}
T_7	98.4^{a}	98.7^{a}	98.6^{A}	97.5^{a}	97.3^{a}	97.4^{A}
T_8	98.5^{a}	98.7^{a}	98.6^{A}	97.5^{a}	97.3^{a}	97.4^{A}
T_9	98.8^{a}	98.8^{a}	98.8^{A}	97.6^{a}	97.5^{a}	97.6^{A}
Mean	98.0	98.3		95.6	95.3	

In a column, means followed by the same letter are not significantly different at the 5% level by DMRT.

T1= Control, T2=Putrescine at 1.0mM (Pu_1), T3= Putrescine at 2.0mM (Pu_2), T4=Salicylic acid at 2.0mM (SA_1), T5=Salicylic acid at 4.0mM (SA_2), T6= (Pu_1) + (SA_1), T7= (Pu_1) + (SA_2), T8= (Pu_2) + (SA_1) and T9= (Pu_2) + (SA_2).

CONCLUSION

The exogenous applications of Putrescine at 2mM plus Salicylic acid at 4mM two times; when berry reached about 4-6 mm in diameter and retreated at veraison stage were effective in increasing yield and enhancing cluster and berry quality characters of "Flame seedless" grape at picking date. Moreover, it reduced cluster weight loss, maintained berry firmness, stabilized berries anthocyanine, reduced juice acidity, berry softening, berries decay and rachis browning during cold storage at 0-2 º C and 90-95 % RH. It suppressed other ripening related changes as Pectin methylesterase activity. Thus, this treatment can be used commercially to enhancing yield maintaining quality during cold storage and extend the shelf life of "Flame seedless" grape with acceptable fruit quality.

REFERENCES

A.O.A.C., (1995). Official Methods of Analysis 16th Edition. Association of Official Analytical Chemists Washington D.C., USA.

Abdel-Salam, M. (2016). Effect of Foliar Applications of Salicylic Acid and Micronutrients on the Berries Quality of "Bez El Naka" Local Grape Cultivar. Middle East Journal of Applied Sciences, 06 (1):178-188.

Ali, I.; N. A. Abbasi and I.A. Hafiz (2014). Physiological response and quality attributes of peach fruit cv. Florida king as affected by different treatments of calcium chloride, Putrescine and Salicylic acid. Pak. J. Agri. Sci., 51(1): 33-39.

Al-Obeed, R.S. (2011). Enhancing the shelf life and storageability of "Flame seedless" grapevine by agrochemicals preharvest foliar applications. Middle-East Journal of Scientific Research, 8(2): 319-327.

Anthon, G. E. and D. M. Barrett (2006). Characterization of the Temperature Activation of Pectin Methylesterase in Green Beans and Tomatoes. J. Agric. Food Chem. 2006, 54: 204-211

Applewhite, P. B.; R. Kaur-Sawhney and A. W. Galston (2000).A role for spermidine in the bolting and flowering of *Arabidopsis.Physiol. Plant.*, 108, 314-320.

Babalar, M.; M. Asghari, A. Talaei and A. Khosroshahi (2007). Effect of pre- and postharvest Salicylic acid treatment on ethylene production, fungal decay and overall quality of selva strawberry fruit. Food Chem., 105: 449-453.

Bal, E. (2012). Effect of postharvest Putrescine and Salicylic acid treatments on cold storage duration and quality of sweet cherries. Suleyman Demirel University Journal of the Faculty of Agriculture 7:23-31.

Bal, E. (2013). Effects of exogenous polyamine and ultrasound treatment to improve peach storability. Chilean Journal of Agricultural Research 73(4): 435-440.

Champa, W. H.; M. S. Gill, B. C. Mahajan and N. K. Arora (2015). Preharvest Salicylic acid treatments to improve quality and postharvest life of table grapes (*Vitisvinifera*L.) cv. Flame Seedless. J. Food Sci. Technol., 52(6):3607-3616

Champa, W. H.;M. S. Gill, B. C. Mahajan and N.K. Arora (2014). Postharvest treatment of polyamines maintains quality and extends shelf-life of table grapes (*Vitis vinifera* L.) cv. Flame Seedless. Postharvest Biology and Technology, 91:57–63

Crisosto, C. H.; D. Garner and G. Crisosto (2002). Carbon dioxide-enriched atmospheres during cold storage limits losses from Botrytis but accelerate rachis browning of Red Globe table grapes. Postharvest Biol. Tec., 26:181-189.

Dubois, M.;K. A. Gilles, J. K. Hamilton, P. A. Reberes and F. Smith (1956). Colorimetric method for determination of sugars and related substance. Anal. Chem., 28(3): 350-356.

Duncan, D. B. (1955). Multiple ranges and multiple F Test. Biometrics, 11:1-42.

El-Abbasy, U. K.;S. M. Al-Morsi, F. E. Ibrahim and M. H. Abd El-Aziez (2015). Effect of Gibberellic Acid, Cytofex and Calcium Chloride as Pre-Harvest Applications on Storability of "Thompson Seedless" Grapes *Egypt. J. Hort*., 42(1): 427- 440.

El-Sayed, M.E.A. (2013). Improving Fruit Quality and Marketing of "Crimson Seedless" Grape Using Some Preharvest Treatments. Journal of Horticultural Science and Ornamental Plants, 5 (3): 218-226.

El-Tohamy, W. A.;H.M. El-Abagy and N.H.M. El-Greadly (2008). Studies on the effect of Putrescine, yeast and vitamin C on growth, yield and physiological responses of eggplant (*Solanum melongena* L.) under sandy soil conditions. Australian Journal of Basic and Applied Sciences, 2(2):296-300.

Ennab, H.A. and S.A. El-Sayed (2016). Treatments to alleviate adverse effect of saline soil on growth and productivity of Balady mandarin trees (*Citrus reticulata*). Alex. J. Agric. Sci., 61(5):419-503.

Ezzat, A.;A. Ammar, Z. Szabó and I. J. Holb (2017). Salicylic acid treatment saves quality and enhances antioxidant properties of apricot fruit. Hort. Sci. 44 (2): 73-81.

Hayat, Q.;S. Hayat, M. Irtan and A.A. Ahmed (2010). Effect of exogenous Salicylic acid under changing environment: A review. Environmental and Experimental Botany, 68:14-25.

Kassem, H.A.;R.S. Al-Obeed and S.S. Soliman (2011). Improving Yield, Quality and Profitability of Flame Seedless Grapevine Grown Under Aird Environmental by Growth Regulators Preharvest Applications. Middle-East Journal of Scientific Research, 8(1):165-172.

Khan, A.S.; Z. Singh, N. A. Abbasi and E.E. Swinny (2008). Pre or post-harvest applications of Putrescine and low temperature storage affect fruit ripening and quality of 'Angelino' plum. Journal of the Science of Food and Agriculture 88:1686-1695.

Khosroshahi, M.R.Z. and E.M. Ashari (2008). Effect of Putrescine application on post-harvest life and physiology of strawberry, apricot, peach and sweet cherry fruits. Journal of Science and Technology of Agriculture and Natural Resources 45:219-230.

Khosroshahi, M.R.Z.;M. Esna-Ashari and A. Ershadi (2007). Effect of exogenous Putrescine on postharvest life of strawberry (*Fragaria ananassa* Duch.) fruit, cultivar Selva. Scientia Horticulturae, 114:27-32.

Koukourikou, M.; E. Zioziou1, A. Pantazaki2, N. Nikolaou1 and D. Kyriakidis (2015). Effects of Gibberellic Acid and Putrescine on 'Thompson Seedless' Grapes. American International Journal of Biology, 3(2)19:29

Lo'ay, A. A. (2017). Preharvest Salicylic acid and delay ripening of 'superior seedless' grapes. Egyptian Journal of Basic and Applied Sciences, 4:227-230.

Lu, X.; D. Sun, Y. Li, W. Shi and G. Sun (2011). Pre and post-harvest Salicylic acid treatments alleviate internal browning and maintain quality of winter pineapple fruit. *Scientia Horticulturae*, 130, 97-101.

Mahajan, B.V.C.;N. K. Arora, M .I. S. Gill and B. S. Ghuman (2010). Studies on extending storage life of Flame Seedless grapes. J. Hortic. Sci. Ornamen. Plants 2, 88–92.

Malik, A. U. and Z. Singh (2004). Endogenous free polyamines of mangos in relation to development and ripening. *J. Am. Soc. Hort. Sci.*, 129, 280-286.

Manaa, A.;E.Gharbi, M.H.Wasti, S.Aschi-Smiti, and H. Ben-Ahmed (2014). Simultaneous application of Salicylic acid and calcium improves salt tolerance in two contrasting tomato (Solanum lycopersicum) cultivars. S. Afr. J. Bot., 95, 32-39.

Martínez-Romero, D.;M. Serrano, A. Carbonell, O.L. Burgos, F. Riquelme and D. Valero (2002). Effect of postharvest Putrescine treatment on extending shelf life and reducing mechanical damage in apricot. Journal of the Science of Food and Agriculture, 67:1706-1712.

Marzouk, H.A. and H.A. Kassem (2011). Improving yield, quality, and self life of Thompson seedless grapevine by preharvest foliar applications. Scientia Horticulturae, 130, 425-430.

Peng, L. and Y. Jiang, (2006). Exogenous Salicylic acid inhibits browning of fresh-cut Chinese water chestnut. Food Chem., 94: 535-540.

Perez-Vicente, A.;D. Martinez-Romero, A. Carbonell, M. Serrano, F. Riquelme and F. Guillen (2002). Role of polyamines in extending shelf life and the reduction of mechanical damage during plum (Prunus salicina Lindl.) storage.Postharvest Biol. Technol. 25:25-32.

Ponce, M. T.;M. Guiñazú, and R. Tizio (2002). Effect of Putrescine on embryo development in the stenospermocarpic grape cvs Emperatriz and Fantasy. *Vitis*, 41:53–54.

Ranganna, S. (1986). Hand book of Analysis and Quality Control of Fruit and Vegetable Products. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Razzaq, k.;A.S. Khan, A.U. Malik, M. Shahid, S. Ullah (2014). Role of Putrescine in regulating fruit softening and antioxidative enzyme systems in 'Samar Bahisht Chaunsa' mango. Postharvest Biol. Technol., 96: 23- 32.

Renault, A. S.;A. Deloire and J. Bierne (1996). Pathogenesis-related proteins in grapevines induced by Salicylic acid and *Botrytis cinerea.*Vitis, 35: 49-52.

Serrano, M.;D. Martinez-Romero, F. Guillén and D. Valero (2003). Effects of exogenous Putrescine on improving shelf life of four plum cultivars. Postharvest Biology and Technology 30:259-271.

Shafiee, M.;T. S. Taghavi and M. Babalar (2010). Addition of Salicylic acid to nutrient solution combined with postharvest treatments (hot water, Salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. SciHortic., 124:40–5.

Shiri, M. A.;M. Ghasemnezhad, D. Bakhshi and H. Sarikhani (2012). Effect of postharvest Putrescine application and chitosan coating on maintaining quality of table grape cv. Shahroudi during longterm storage. Journal of Food Processing and Preservation 37(5):999-1007

Snedecor, G.W. and W.G. Cochran (1980). Statistical Methods 6th ed. The Iowa state, Univ. Press, Amer, Iowa, U.S.A.

Taiz, L. and E. Zeiger (2010). Plant Physiology, 3rd Edition, Sinauer Associates, p. 306, ISBN 0878938230.

Talaat, N.B. (2003). Physiological studies on the effect of salinity, ascorbic acid and Putrescine of sweet pepper plant. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt.

Tareen, M.J.;N.A. Abbasi and I.A. Hafiz (2012). Postharvest application of Salicylic acid enhanced antioxidant enzyme activity and maintained quality of peach cv. 'Florda king' fruit during storage. SciHortic 142:221–228.

Torrigiani, P. (2004) Pre-harvest polyamine and amino ethoxyvinyl glycine (AVG) applications modulate fruit ripening in Stark Red Gold nectarines (*Prunus persica* L. Batsch). *Postharvest Biol. Technol.*, 33: 293–308.

Tourkey, M.N.; S.S. El-Shahat and M.H. Rizk (1995). Effect of Dormex on fruit set, quality and storage life of "Thompson seedless" grapes (Banati grapes). J. Agric., Mansoura Univ., 20(12):5139-5151.

Ullah, S. and S.K. Jawandha (2013). Effect of post-harvest treatments of polyamines on colour of stored peach fruits. The Asian Journal of Horticulture, 8 (2):785-787.

Valero, D.;D. Martinez-Romero and M. Serrano (2002). The role of polyamines in the improvement of the shelf life of fruit. Trends Food Sci. Technol. 13, 228–234.

Wang, C.Y.; W.S. Conway, J.A. Abbott and G.F. Kramer (1993). Postharvest infiltration of polyamines and calcium influences ethylene production and texture changes in Golden Delicious apples. J. Am. Soc. Hortic. Sci. 118: 801–806.

Xu, X. and S. Tian (2008). Salicylic acid alleviated pathogen-induced oxidative stress in harvested sweet cherry fruit, Postharvest Biol. Technol., 49: 379-385.

Zhang, Y.;C. Kunsong, S. Zhang, I. Ferguson (2003). The role of Salicylic acid in postharvest ripening of kiwi fruit. Postharvest Biol. Tec., 28(1): 67-74.

تأثيرالرش بالبيوترسين و حمض السلسليك على المحصول وجودة الثمار والقدرة التخزينية لعنب الفلايم سيدلس

صابرسعد بسيونى[1] ، مها حسيب عبد العزيز[2] و هيام مصطفى فهمي[2]
[1]قسم بحوث العنب - معهد بحوث البساتين – مركزالبحوث الزراعية - الجيزة - مصر
[2] قسم بحوث تداول الفاكهة-معهد بحوث البساتين - مركزالبحوث الزراعية - الجيزة – مصر

أجريت هذه الدراسة خلال موسمى 2016 و2017 فى مزرعة خاصة بمركز بدرمحافظة البحيرة جمهورية مصر العربية وذلك لاختبار الرش بالبيوترسين بتركيزات 1 و2 ملليمول وحمض السلسليك بتركيزات 2 و4 ملليمول و كذلك الجمع بينها بالاضافة الى معاملة المقارنة (الكنترول) وتأثير ذلك على المحصول وصفات الجودةوالقدرة التخزينية لثمارعنب الفليم عديم البذور. تم رش المعاملات مرتين الاولى عند وصول الحبات الى قطر 4-6 مل والثانية عند بداية مرحلة طراوة الحبات وبداية التلوين (veraison). اوضحت النتائج تأثر كل من المحصول وصفات الجودة لعنب الفليم عديم البذور بالرش بكل من البتروسين و حمض السلسيلك وكان الجمع بينهما الاكثر فاعلية فى زيادة المحصول وجودة الثمارفى مقابل معاملة مقارنة. اظهرت معاملة الرش بكلا المركبين بالتركيزالاعلى (بتروسين 2 + حمض السلسيلك 4 ملليمول) المحصول الاعلى معنويا وكذا التحسن فى صفات العناقيد (الوزن والطول والعرض) والحبات (القطر والطول ووزن والصلابة وحجم ال 100 حبة) مقارنة بمعاملة المقارنة . كما كانت هذة المعاملة الاكثر تاثيرا فى الحفاظ على صفات الجودة اثناء التخزين البارد على درجة حرارة من 0 الى 2 مئوى ورطوبة نسبية من 90 الى 95 % حيث اظهرت القيم الاقل معنويا فى نسبة الفقد فى وزن العنقود وانفراط الحبات ونسبة الاعفان وتلون محورالعنقود وكذلك نسبة العناقيد غير الصالحة للتسويق . كما ادت الى خفض نشاط انزيم تحلل البكتين فى حين اظهرت القيم الاعلى لصلابة الحبات وكذا القوة اللازمة لنزعها مع الحفاظ على محتوى الثمار من نسبة المواد الصلبة الكلية الذائبة والحموضة ونسبة المواد الصلبة الى الحموضة وصبغة الانثوسيانين و ذلك حتى 60 يوم من التخزين البارد. كما ان كل معاملات الجمع ادت الى زيادة معنوية فى نسبة العناقيد الصالحة للتسويق وكذالك فترة العرض مقارنة بالكترل.