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IMPROVING QUALITY AND COLOR OF FLAME SEEDLESS GRAPES BY SPRAYING (ABSCISIC, ASCORBIC AND SALICYLIC) ACIDS AND ETHREL (ETHEPHON)

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ABSTRACT: This investigation carried out throughout two successive seasons 2016 and 2017, on six years-old Flame seedless grapevines in a private vineyard located at Km 93, Cairo, Alexandria desert road. Vines grown in sandy soil under drip irrigation system are trellised with Spanish (Paron) system and trained with quadrilateral cordon. The experiment included 10 treatments as follow:T1-Control (sprayed with water only), T2-Ethrel (ethephon) at 300 ppm, T3-Ascorbic acid (AA) at 500 ppm, T4 - Salicylic acid (SA) at 100 ppm, T5- ABA (Protone10% abscisic acid) at 400 ppm, T6-AA at 500 ppm + Ethrel (Eth) at 300 ppm, T7- SA at 100 ppm+ Eth at 300 ppm, T8-Eth at 300 ppm + ABA at 400 ppm, T9-AA at 500 ppm+ ABA at 400 ppm and T10-SA at 100 ppm+ ABA at 400 ppm. The foliar spray was used two times in the treatments from T2 to T5 but used once for every substance in the treatments from T6 to T10. The results cleared significantly effect of all treatments on yield, bunch, berry physical and chemical characteristics. Spraying with ascorbic acid (AA) or salicylic acid (SA) recorded highest values of 100-berry weight (g), berry firmness, attachment, berry length and width (cm) without significant differences with ABA in both seasons. The treatments of Ethrel (Eth), ABA and Eth+ ABA had maximum TSS (%), while Ethrel or Eth+ ABA had highest TSS/acid ratio and anthocyanin (%) in berries and also these treatments had least values of total acidity (%) in the two seasons. Spraying with ascorbic acid (AA) or salicylic acid (SA) or AA+ ABA or SA+ ABA recorded uppermost yield (kg/ vine) and bunch weight (g), followed by spraying Ethrel (Eth) or (Eth+ ABA).

Key words: Flame seedless grapes, Ethrel (ethephon), ABA (protone10% ABA), ascorbic acid, salicylic acid, berry quality, anthocyanin.

INTRODUCTION

The grape (*Vitis vinifera* L.) was considered one of the most popular and common fruit crops in the world and Egypt. The fruiting area reached 133811 feddans producing about 1183968 tons with an average of 8.85 ton/fed. (**Arab Agricultural Statistics Yearbook, 2020**). Flame seedless' is a popular table grape cultivar that recently introduced in Egypt and consider as a promising variety because of its good qualities for local market and export **(Hegazi and Sallam, 2003).** The market value of grape 'Flame seedless is dependent upon its desirable appearance (homogeneity of the red color, berry and cluster size and shape). Grapes are highly perishable non-climacteric fruits and, their fruit quality (size and color) are influenced by many factors such as, temperature. Therefore, many efforts that could be done to maintain berries with high quality characteristics in berry size, firmness, color intensity and cluster uniformity after harvest and during marketing, which would be very important for the Flame seedless producers in order to obtain better marketing quality. Color is an important aspect of grape quality, especially for red, blue or black grapes. Coloration in grape berries is due to anthocyanin accumulation in

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the skin berries at veraison stage **(Korkutal *et al*., 2008).** Poor berry color development in red varieties, such as Flame Seedless, Red Globe and Crimson Seedless, causing serious economic losses **(Dokoozlian *et al*., 1995).** Table grapes are generally grown in warm-climate regions where high temperatures inhibit anthocyanin accumulation, which preventing adequate color development of some red and black **(Peppi *et al*. 2006).** As such, this pigment is negatively affected by air temperature, and differences between day and night **(Downey *et al*., 2006).**

Ethrel is considered a promoting compound responsible for enhancing colouration and ripening of some fruits. For several decades, table grape growers have relied on ethephon applied at veraison, 10-20% berry color, to improve berry color. Moreover, late or excessive applications of ethephon can result in soft berries with a poor shelf life **(Greyling, 2007).**

Abscisic acid (ABA) is a plant hormone which increases in grape berry skin at the onset of maturation and is involved in the regulation of anthocyanin accumulation. Various studies have suggested that the exogenous application of abscisic acid (ABA) increases the anthocyanin content of the skins of table grape cultivars, without changing berry maturation and without causing excessive softening **(Lee *et al*., 1997; Cantín *et al*., 2007; Peppi *et al*., 2006, 2007a&b; Peppi and Fidelibus, 2008).**

Attia (2018) recommended that using the ABA (Protone) plus methionine and oleic acid at veraison stage as an alternative to Ethrel (ethephon) treatment to overcome some adverse effects of Ethrel such as increased berry shattering and berry weight loss, which reflects on berry appearance.

Antioxidants have many functions in plants, as it was responsible for enhancing photosynthesis, plant pigments, amino acids and provide good control for diseases and pests. Spray Banaty and Flame seedless grapevines with ascorbic acid (25-200 ppm) once or more improved number and weight of clusters and the yield /vine. Moreover, it increased total soluble solids and total sugars while reduced the total acidity. In addition, ascorbic acid plays an important role in improving growth and productivity of fruits **(Farag *et al*., 1996).**

Salicylic acid is one of the phenolic compound groups, that are proven to be important in secondary metabolites in grape berries and play an essential role in determining grape berry quality **(Chamkha *et. al*., 2003**).

The aim of this study is to investigate the effect of preharvest foliar applications of ascorbic acid, salicylic acid and ABA (Protone10% ABA) on the yield, bunch and fruit physico-chemical characteristics of Flame seedless grapevine under new reclaimed sandy soil in Egypt.

MATERIALS AND METHODS

This study was carried out throughout two successive seasons of 2016 and 2017 seasons on six years - old of Flame seedless cv. grapevines in a private vineyard located at Km 93, Cairo – Alexandria desert road. The experimental vines selected to be healthy nearly similar in its vigor and uniformly, received the normal horticulture practices, similar to those in commercial vineyards except for the tested treatments. The vines planted at 2 m between the vines in the row and 3 m apart between rows. The vines grown in sandy soil under drip irrigation system are trellised with Spanish (Paron) system and trained with quadrilateral cordon. Flame seedless vines pruned at winter according to short pruning (fruit spurs) of each season leaving 80 buds/ vine (i.e. 16 fruit spurs x 5 buds/spur). This investigation was conducted on 60 vines, 10 treatments x 6 vine (3 replicates x 2 vine/ replicate). The experiment included 10 treatments as follow:

T1- Control (water only).

T2- Ethrel (Eth) at 300 ppm.

T3- Ascorbic acid (AA) at 500 ppm.

T4- Salicylic acid (SA) at 100 ppm.

T5- Abscisic acid (Protone 10% ABA) at 400 ppm.

T6- Ascorbic acid (AA) at 500 ppm+Ethrel (Eth) at 300 ppm.

T7- Salicylic acid (SA) at 100 ppm+Ethrel (Eth) at 300 ppm.

T8- Ethrel (Eth) at 300 ppm + Protone (10% ABA) at 400 ppm.

T9- Ascorbic acid (AA) at 500 ppm+ Protone (10% ABA) at 400 ppm.

T10- Salicylic acid (SA) at 100 ppm+ Protone (10% ABA) at 400 ppm.

All chemicals were sprayed as fallow:

Ascorbic acid and salicylic acid treatments sprayed two times during berry development, the first at pea stage (5-7 mm fruitlet width) and the second at veraison stage (when approximately 10 % of the berries on 50% of the clusters had softened and red color).

Ethrel and ABA (Protone 10% ABA) sprayed two times during berry development, the first at veraison stage and the second one week later.

Ethrel sprayed one time at veraison stage and ABA (Protone) was sprayed one time at one week later in the treatments 6, 7, 8, 9 and 10 .

The surfactant BB5 at the rate of 40 cm/100 L water added to all sprayed solutions to obtain best penetration results. The chemicals were applied directly to the bunches with a handheld sprayer until runoff. The solutions were sprayed once in the early morning.

At harvest day, Yield/vine (kg) was determined as number of bunches/vine x average bunch weight (g). Also, a sample of 6 bunches for each replicate was randomly collected in both seasons to calculat bunch weight (g), number of berries per bunch, number of red and green berries per bunch and its percentages (%).

Berries qualities were studied as follow:

1. Average of 100 berries weight (g).
2. Berry length and width (cm).
3. Berry shape index (berry length/berry width).
4. Berry firmness (g/cm) and berry adherence strength (separation force) were recorded by using a texture analyzer instrument (Fruit Hardness Tester, No. 510-1) as a small cylinder (3 mm in width) penetrates into a distance of 3 mm inside the berry with a speed of 0.2 mm/second.
5. The percentage of total soluble solids (TSS) in the juice measured by using a hand Refractometer (A.S.T., Japan).
6. Total acidity in the juice as tartaric acid (%) determined by titration with 0.1 N NaOH solution in presence of phenolphthalein as indicator **AOAC (2012)**.
7. Maturity index was defined as the TSS/acidity ratio estimated in fresh weight.

9. Anthocyanin content in 1 g fruit peel tissue was determined according to **Fuleki and Francis (1968).**

Statistical Analysis

The obtained data were subjected to one-way analysis of variances (ANOVA) technique according to **Snedecor and Cochran (1982)**. The treatments arranged in randomized complete block design with three replications. The individual comparisons between the obtained values were carried out using **Duncan (1955)** at 5% level.

RESULTS

Vine Yield and Bunch Characteristics

Data in Tables 1, 2, 3 and 4 show the significant effect of single and combined foliar application treatments on vine yield(kg), number of bunches/vine and bunch characteristics (bunch weight (g), number of berries/bunch and number of red and green berries/bunch and their percentages at harvest date.

Data presented in Table 1 showed that maximum total yield per vine (kg/ vine) was recorded by spraying Ethrel (T2) (21.70 and 17.930 kg/vine), ascorbic acid (T3) (23.10 and 19.99 kg/vine), (T4) salicylic acid (21.18 and 20.000 kg/vine), AA+ ABA (T9) (23.48 and 19.50 kg/ vine) and (T10) SA+ ABA (Protone) (22.94 and19.80 kg/ vine) in the first and second season respectively, likewise, ABA or Eth+ ABA in the second season with non-significant differences between them. The lowest total yield per vine (kg/vine) recorded from treatments control (20.00 and17.200 kg/vine), AA + Ethrel (l20.00 and 17.25 kg/vine) and SA + Ethrel (20.20 and17.550 kg/vine) in both seasons, respectively, as well as treatments ABA (Protone) and Eth + ABA (Protone) in the first season had moderate values

Table 1. Effect of some foliar applications on yield and bunch weight of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	Yield (kg/ vine)			Bunch weight (g)		
	First season	Second season	Total average	First season	Second season	Total average
T1	20.00 c	17.20 c	**18.60 c**	670.00c	573.33 c	**621.66 c**
T2**	21.70 abc	17.93 abc	**19.81 bc**	700.00 abc	578.33 bc	**639.16 c**
T3**	23.10 ab	19.99 a	**21.54 a**	770.00 a	660.00 a	**71500 a**
T4**	21.18abc	20.00 a	**20.59 abc**	673.33 c	666.67 a	**670.00 abc**
T5**	20.78 bc	18.60 abc	**19.69 c**	716.67 abc	600.00 abc	**658.33 bc**
T6*	20.00 c	17.25 c	**18.62 c**	666.67 c	575.00 c	**620.83 c**
T7*	20.20 c	17.55 bc	**18.87 c**	683.33 bc	585.00 bc	**634.17 c**
T8*	20.77 bc	19.60 ab	**20.18 abc**	670.00 c	613.33 abc	**641.665 c**
T9*	23.48 a	19.50 ab	**21.49 a**	757.67 ab	650.00 ab	**703.83 ab**
T10*	22.94 ab	19.80 a	**21.37 ab**	740.00 abc	660.00 a	**700.00 ab**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
* = one foliar spray
** = two foliar sprays

Table 2. Effect of some foliar applications on total no of bunches/vine and total berries no/bunch of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	Total no. of bunches /vine			Total berries no. / bunch		
	First season	Second season	Total average	First Season	Second season	Total average
T1	30.00 b	31.00 bc	**30.50 bc**	149.67 bc	165.00 abc	**157.33 a**
T2**	31.00 ab	30.00 c	**30.50 bc**	148.00 bcd	160.00 a-d	**154.00 a**
T3**	33.00 ab	33.00 ab	**33.00 a**	163.33 a	150.00 cd	**156.66 a**
T4**	30.00 b	34.00 a	**32.00 ab**	138.00 cd	174.33 a	**165.16 a**
T5**	33.00 ab	31.00 bc	**32.00 ab**	140.00 cd	168.00 ab	**154.00 a**
T6*	31.00 ab	30.00 c	**30.50 bc**	143.00 bcd	152.67 bcd	**147.83 ab**
T7*	30.00 b	30.00 c	**30.00 c**	136.00d	146.33d	**141.16 b**
T8*	34.00 a	33.00 ab	**33.50 a**	154.67 ab	163.3 a- d	**159.00 a**
T9*	33.00 ab	31.00 bc	**32.00 ab**	150.00 bc	160.00a-d	**155.00 a**
T10*	31.00 ab	33.00 ab	**32.00 ab**	148.67bcd	155.67bcd	**152.17 ab**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
* = one foliar spray
= **two foliar sprays

Table 3. Effect of some foliar applications on red and green No. berries/bunch of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	Red berries no. / bunch			Green berries no. / bunch		
	First season	Second season	Total average	First Season	Second season	Total average
T1	16.00 f	25.00 f	**20.50 e**	133.67 a	140.0 a	**136.84 a**
T2**	147.00 a	160.00 a	**153.50 a**	1.00 h	0.00 e	**0.50 g**
T3**	113.33d	98.67 e	**106.00 d**	50.00 b	51.33 b	**50.67 b**
T4**	100.00 e	126.33cd	**113.17 cd**	38.00 c	48.00 b	**43.00 c**
T5**	115.00d	145.00abc	**130.00 b**	25.00 d	23.00 c	**24.00 e**
T6*	120.00d	135.33bc	**127.67 b**	23.00 de	17.33 cd	**20.17 e**
T7*	124.00Cd	133.67bc	**128.84 b**	12.00 fg	12.67 d	**12.34 f**
T8*	146.00a	152.00ab	**149.00 a**	8.67 g	11.33d	**10.00 f**
T9*	132.00be	113.00de	**122.50 bc**	18.00 ef	47.00 b	**32.50 d**
T10*	135.00b	130.67cd	**132.84 b**	13.67 fg	25.00 c	**19.34 e**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
*= one foliar spray
** = two foliar sprays

Table 4. Effect of some foliar applications on red and green berries/bunch percentages of "Flame Seedless" grapes during 2016 and 2017 seasons.

Treatments	Red berries % / bunch			Green berries % / bunch		
	First season	Second season	Total average	First Season	Second season	Total average
T1	10.69 f	15.16 f	**12.93 h**	89.31 a	84.84 a	**87.08 a**
T2**	97.12 a	100.0 a	**98.56 a**	0.64 f	0.00 f	**0.32 g**
T3**	69.30 e	65.76 e	**67.53 g**	30.69 b	34.24 b	**32.47 b**
T4**	72.54 e	72.40 d	**72.47 f**	27.46 b	29.52 b	**28.49 b**
T5**	82.12 d	86.29 c	**84.21 d**	17.88 c	13.69 cd	**15.79 d**
T6*	84.00 cd	88.71 bc	**86.36 d**	16.00 c	11.28 cde	**13.64 d**
T7*	91.16 b	92.05 b	**91.61 bc**	8.84 de	9.34 de	**9.09 ef**
T8*	91.08 b	93.06 b	**92.07 b**	5.59 e	6.94 e	**6.27 f**
T9*	87.98 bc	70.66 de	**79.32 e**	12.02 d	29.34 b	**20.68 c**
T10*	90.91 b	84.15 c	**87.53 cd**	9.09 de	16.12 c	**12.61 de**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
= *one foliar spray
= **two foliar sprays

A significant increase in bunch weight was obtained in both seasons (Table 1) by sprayed substances of ascorbic acid (T3) (770.00 and 660.00 g), salicylic acid (T4) (716.67 and 666.67 g), AA+ ABA (T9) (757.67 and 650.00g) and SA+ ABA (T10) (740.00 and 660.00 g) respectively compared to the control, as well as Ethrel (T2) (700.00g) in the first season and Eth+ ABA (T8) (613.33 g) in the second one only. Furthermore, the differences between treatments of Ethrel and ABA were non-significant in the two seasons.

Generally, the highest cumulative total average from first and second seasons of yield (21.54 kg/vine) were recorded by T3 ascorbic acid (500 ppm), which were statistically at par with those treated by T4, T8, T9 and T10. The highest total average of two seasons for bunch weight (715.00 g) were recorded by T3 ascorbic acid (500 ppm), which were statistically at par with those treated by T4, T9 and T10. Whereas the lowest cumulative total average yield (18.60 kg/vine) and bunch weight (621.66 g) were recorded by the control without significant differences with those treated by T2, T5, T6, T7.

Data of Table 2 showed that treatments control, salicylic acid at 100 ppm (T4) and SA (500 ppm) + Eth at 300 ppm (T7) had the lowest number bunches/vine, but other treatments recorded highest values with non- significant differences between them in the first season only. While, in the second season the treatments ascorbic acid at 500 ppm (T3), salicylic acid at 100 ppm (T4), Eth+ ABA (T8) and SA+ ABA (T10) gave the highest number bunches/vine, but other treatments recorded the lowest non-significant values. Thus, total number of bunches per vine did not have specific trend in both seasons.

In general, the highest total average of two seasons for bunches number / vine was recorded by T3 and T8 which was statistically at par with those treated by T4, 5, 9 and 10. Whereas the lowest total average number of bunches/vines, was recorded by T7 without significant differences with those treated by T1and 2.

Spraying with ascorbic acid (T3) or Eth+ ABA (T8) gave the highest total number of berries per bunch (163.33 and 154.67) in the first season. While in the second season the treatments salicylic acid (T4), ABA(T5), Eth+ ABA (T8) recorded the highest total number of berries per bunch (174.33 and 168.00) and without significant differences between them and with treatments Eth (T2), Eth+ ABA (T8), AA+ ABA (T9) and Control. The least total berries number of berries per bunch was from treatment T7 (SA+Eth) (136.00 and 146.33) in the two seasons, respectively. The other treatments had intermediate values of total number of berries per bunch in both seasons.

On the whole, the highest total average of two seasons for number berries/bunch was recorded by T4 without significant differences with all tested treatments except, those treated by T7 which valued 141.16 number of berries / bunch.

Data of Tables 3 and 4 showed that Eth at 300 ppm (T2) and Eth + ABA (T8) had a highest significant increase number of red berries in both seasons as well as ABA at 400 ppm (T5) treatment in the second season only. While, treatment of control recorded highest number of green berries and its percentage in the two seasons. The uppermost percentage of red berries per bunch was from Ethrel treatment in the two seasons. The other treatments had values in between in both seasons.

Mostly, the highest total average of two seasons for number red berries (153.50) and lowest green berries (0.50) were recorded for Ethrel at 300 ppm (T2) whereas, the lowest number of red berries (20.50) and highest number of green berries (136.84) were recorded by the control (T1). The other tested treatments came in between. The same trend was observed by the effect of the tested treatments on the percentages of red and green berries.

Berry Physical Characteristics

Data in Tables 5, 6 and 7 showed significant effect of abscisic, ascorbic and salicylic acids or Ethrel and its combinations on some berry physical characteristics (berry firmness, berry attachment, berry dimension, berry shape index and100 berries weight) of "Flame Seedless" grapes.

As shown in Table 5, application of abscisic, ascorbic and salicylic acids or Ethrel and its combinations significantly enhanced on berry

Table 5. Effect of some foliar applications on berry attachment and firmness of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	Berry attachment (g/cm)			Berry firmness (g/cm)		
	First season	Second season	Average	First Season	Second season	Average
T1	348.33 abc	401.33 a	**374.83 ab**	310.00 abc	367.00 ab	**338.50abc**
T2**	281.00 e	318.33 cd	**299.67 c**	262.67 d	256.33 d	**259.50 e**
T3**	388.33 a	391.33 ab	**389.83 a**	318.67 abc	358.33 ab	**338.50abc**
T4**	370.67 ab	356.67 abc	**363.67 ab**	333.33 a	375.67 a	**354.50 a**
T5**	360.00 abc	367.33 abc	**363.67 ab**	317.67 abc	367.67 ab	**342.67 ab**
T6*	352.00 abc	341.67 bcd	**346.83 b**	287.67 cd	368.00 ab	**327.83abc**
T7*	325.33 cd	354.00 abc	**339.67 b**	292.33 bcd	336.33 bc	**314.33 cd**
T8*	306.67 de	298.33 d	**302.50 c**	274.67 d	305.00 c	**289.84 d**
T9*	350.67 abc	382.00 ab	**366.34 ab**	317.67 abc	336.33abc	**327.00abc**
T10*	353.67 abc	367.33 abc	**360.50 ab**	325.00 ab	303.33 c	**314.17 cd**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
* = one foliar spray
** = two foliar sprays

Table 6. Effect of some foliar applications on berry length and width of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	Berry length (cm)			Berry width (cm)		
	First Season	Second season	Average	First Season	Second season	Average
T1	1.70 e	1.71 b	**1.71 e**	1.73 b	1.70 c	**1.72 b**
T2**	1.74 cde	1.78 a	**1.76 b-e**	1.76 b	1.75 abc	**1.76 ab**
T3**	1.82 ab	1.77 a	**1.80 ab**	1.78 ab	1.74 abc	**1.76 ab**
T4**	1.78 a-d	1.77 a	**1.78 a-d**	1.78 ab	1.76 abc	**1.77 a**
T5**	1.73 de	1.77 a	**1.75 cde**	1.77 ab	1.78 ab	**1.77 a**
T6*	1.73 de	1.74 ab	**1.74 cde**	1.75 b	1.79 a	**1.77 a**
T7*	1.70 e	1.76 ab	**1.73 de**	1.73 b	1.80 a	**1.76 ab**
T8*	1.80 abc	1.77 a	**1.79 abc**	1.79 ab	1.78 ab	**1.79 a**
T9*	1.77 bcd	1.77 a	**1.77 a-e**	1.77 ab	1.71 c	**1.74 ab**
T10*	1.84 a	1.79 a	**1. 82 a**	1.84 a	1.72 bc	**1.78 a**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
= *one foliar spray
** = two foliar sprays

Table 7. Effect of some foliar applications on 100-berry weight and berry shape index of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	100-berry weight (g)			Berry shape index		
	First season	Second season	Average	First Season	Second season	Average
T1	331.67 cd	316.67 ab	**324.17 a**	1.020 ab	1.007 bc	**1.013 a**
T2**	320.00 d	341.67 ab	**330.83 a**	0.983 bc	1.017 abc	**1.000 ab**
T3**	370.00 a	256.67 b	**313.33 a**	1.023 a	1.013 abc	**1.018 a**
T4**	365.83 ab	368.33 a	**367.08 a**	1.000 abc	0.997 cd	**0.998 abc**
T5**	355.00 ab	345.00 ab	**350.00 a**	0.980 c	0.997 cd	**0.988 bc**
T6*	331.67 c	340.00 ab	**335.84 a**	0.983 bc	0.970 d	**0.977 c**
T7*	336.67 c	341.67 ab	**339.17 a**	0.983bc	0.977 d	**0.980 bc**
T8*	333.33 cd	340.00 ab	**336.67 a**	1.007 abc	0.990 cd	**0.998 abc**
T9*	365.00 ab	355.00 ab	**360.00 a**	0.997 abc	1.027 ab	**1.012 a**
T10*	353.33 b	360.00 ab	**356.67 a**	0.990 abc	1.037 a	**1.015 a**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
* = one foliar spray
** = two foliar sprays

firmness and attachment. The tested treatments ascorbic acid, salicylic acid, ABA (Protone), ascorbic acid + ABA (Protone) and salicylic acid + ABA (Protone) had higher effects on berry firmness and attachment as well as control treatment without significant differences between them in both seasons. In addition, the treatment salicylic acid + Ethrel gave high berry attachment in the two seasons.

Generally, the highest total average of two seasons for berry firmness (354.50) was recorded by T4 salicylic acid (100 ppm) which was statistically at par with those treated by T3, T5, T6, and T9. While the lowest berry firmness (259.50) was recorded by T2 Ethrel (300 ppm). The other tested treatments came in between. Moreover, the tested treatments affected significantly berry attachment as the highest value (389.83) was recorded by T3 ascorbic acid (500 ppm) which was statistically at par with those treated by T1, T4, T5, T9, and T10. While the lowest value of berry attachment (299.67) was recorded by T2 Ethrel (300 ppm) without significant differences with those treated by T8. The other tested treatments recorded intermediate values.

Result in Table 6 revealed that treatments AA (T3), SA(T4), ABA(T5), Ethrel + ABA(T8) and SA + ABA (T10) recorded the highest values of berry length (cm), berry width (cm) in both seasons, as well as T2, 6 and 7 in the second season with non-significant differences between them. Also, T9 recorded high values of berry length in the second and berry width in the first season only. In the second season only, all treatments except control (T1) recorded higher values of berry length without significant differences between them.

As a rule, the highest total average of two seasons for berry length (1.82 cm) was recorded by T10 without significant differences with those treated by T3, T4, T8 and T9. However, the lowest berry length (1.71cm) was recorded by T1 (control) which was statistically similar with those treated by T2, T5, T6, and T7. As for, berry width, data in Table 6 also clear that the highest total average of berry width was recorded by T8 (1.79 cm) without significant differences with all tested treatments except the control which recorded the lowest value.

Data presented in Table 7 cleared that the highest berry shape index was from treatments ascorbic acid at 500 ppm (T3), AA+ABA (T9) and SA+ABA (T10), also, T2 in the second season and T1,4,8 in the first season only without significant differences between them.

Usually, the highest total average of two seasons for berry shape index (1.018) was recorded by T3 ascorbic acid (500 ppm) which was statistically at par with those treated byT1, T2, T9 and T10 which had more elongated berries, whereas the lowest berry shape index was recorded by T6 (0.977) without significant differences with T5, T7 and T8 which had more round berries.

The data in Table 7 indicated that spraying with any acids (abscisic, ascorbic and salicylic) and its combinations significantly improved the weight (g) of 100 berries. The obtained highest values of 100 berries weight (g) were recorded from treatments ascorbic acid (T3) (370.00g), salicylic acid (T4) (365.83g), ABA (T5) (355.00 g) and ascorbic acid + ABA (T9) (365.00 g) without significant differences between them in comparison to the control and other treatments in the first season only. While, in the second season all treatments gave higher values of 100 berries weight (g) compared with T3. The least weight of100 berries was from T2 (320.00 g) in the first season and from T3 (256.67g) in the second season.

Generally, the data cleared that the tested treatments had no significant effect on total average of two seasons for 100-berry weight.

Berry Chemical Constituents

Data presented in Tables 8 and 9 cleared significantly the effect of abscisic, ascorbic and salicylic acids or Ethrel and its combinations on some berry chemical characteristics of "Flame Seedless" grapes.

The treatments of Ethrel at 300 ppm (T2) (16.20 and 17.00%), ABA at 400 ppm (T5) (15.97 and 16.50%), AA+Eth (T6) (15.63 and 16.93%) and Eth+ ABA (T8) (16.08 and17.30%) recorded maximum significant percentages of TSS in both seasons, respectively, likewise AA+ ABA (T9) and SA+ABA (T10) in the first season. The least TSS% (14.00 and 14.67%) was recorded from control in both seasons, respectively. The other tested treatments recorded intermediate percentages of TSS.

Data in Table 8 illustrated that all tested treatments decreased the total acidity compared with control in both seasons. The highest percentage of acidity was from control (0.307 and0.267%) in the two seasons, respectively. The lowest Total acidity was from treatments Ethrel at 300 ppm (T2) (0.119 and 0.110%) or Eth+ ABA (T8) (0.122 and 0.105%) in the first and second season, respectively.

Mostly, the highest total average of two seasons for TSS% value (16.69%) was recorded for T8, which was statistically similar with those treated by T2, T5, and T6. whereas the lowest TSS% was recorded by T4 (14.83%) without significant differences with T1, T3. T7, T9 and T10. The highest value of total acidity % (0.287) was recorded for the control (T1) whereas the lowest value (0.115) was recorded for T2 without significant differences with T8. The other tested treatments recorded intermediate values.

As shown in Table 9, spraying of Ethrel at 300 ppm (T2) or Eth+ ABA (T8) recorded highest TSS/ acid ratio in both seasons compared with control and other treatments in the two seasons. The control treatment had lowest value of TSS/ acid ratio (46.87 and 55.33%), as well as treatments ascorbic acid (T3) (50.90 and77.90) or salicylic acid (T4) (54.57 and 63.87) had the least values in the first and second season, respectively. The other tested treatments recorded intermediate values of TSS/ acid ratio.

Spraying with Ethrel (T2) (89.48 and 92.96%) or Eth+ ABA (80.25 and 84.76%) gave highest significant percentage anthocyanin of berries in both seasons, respectively compared with the control and other treatments. The lowest percentage anthocyanin of berries was in the control (20.84 and 22.97%). The other treatments recorded moderate values of berries anthocyanin content in both seasons (Table 9).

Generally, the highest total average of two seasons for TSS/acid ratio (146.03) was recorded by T2 without significant differences with T8. While the lowest TSS/acid ratio (51.10) was recorded by the control without significant differences with T3 and T4. The other tested treatments came in-between. As for the anthocyanin content, the highest value (91.22%) was recorded for T2 whereas the lowest value (21.91%) was recorded for the control. The other tested treatments came in-between.

Table 8. Effect of some foliar applications on TSS and total acidity of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	(%)TSS			Total acidity (%)		
	First season	Second season	Total average	First Season	Second season	Total average
T1	14.32 bc	14.67 c	**14.49 e**	0.307 a	0.267 a	**0.287 a**
T2**	16.20 a	17.00 a	**16.60 a**	0.119 g	0.110 e	**0.115 e**
T3**	14.22 bc	16.00 b	**15.11 def**	0.280 b	0.208 bc	**0.244 b**
T4**	14.00 c	15.67 b	**14.83 ef**	0.258 c	0.247 ab	**0.253 b**
T5**	15.97a	16.50 ab	**16.23 abc**	0.161 ef	0.173 cd	**0.167 cd**
T6*	15.63 a	16.93 a	**16.28 ab**	0.200 d	0.140 de	**0.170 cd**
T7*	14.38 bc	16.00 b	**15.19 def**	0.193 d	0.167 d	**0.180 c**
T8*	16.08 a	17.30 a	**16.69 a**	0.142 f	0.105 e	**0.124 e**
T9*	15.67 a	16.00 b	**15.83 bcd**	0.170 e	0.142 de	**0.156 d**
T10*	15.33 ab	15.67 b	**15.50 cde**	0.157 ef	0.167d	**0.162 cd**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, T6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA) .
* = one foliar spray
** = two foliar sprays

Table 9. Effect of some foliar applications on berry TSS/ acid ratio and anthocyanin of "Flame Seedless" grapes during 2016 and 2017 seasons

Treatments	TSS/ acid ratio			Anthocyanin (%)		
	First season	Second season	Total average	First Season	Second season	Total average
T1	46.87 f	55.33 e	**51.10 c**	20.84 g	22.97 f	**21.91 h**
T2**	135.77 a	156.30a	**146.03 a**	89.48 a	92.96 a	**91.22 a**
T3**	50.90 ef	77.90 de	**64.40 c**	38.21 f	40.43 e	**39.32 f**
T4**	55.50 ef	63.87 e	**59.69 c**	32.52 f	35.98 e	**34.25 g**
T5**	99.40 b	95.90 cd	**97.65 b**	78.22 b	81.30 b	**79.76 b**
T6*	78.47 cd	122.43b	**100.45 b**	63.30 c	67.28 c	**65.29 c**
T7*	74.80 d	96.83 cd	**85.82 b**	55.82 de	58.78 cd	**57.30 de**
T88	113.83 b	165.93 a	**139.88 a**	80.25 b	84.76 ab	**82.51 b**
T9*	70.10 de	115.20 bc	**92.65 b**	58.46 cd	62.29 cd	**60.38 cd**
T10*	97.70 bc	94.87 cd	**96.285 b**	50.81 e	55.18 d	**53.00 e**

T1 = Control (sprayed with water only), T2** = Ethrel (ethephon) at 300 ppm, T3** = Ascorbic acid (AA) at 500 ppm, T4** = Salicylic acid (SA) at 100 ppm, T5** = (ABA) (Protone10% abscisic acid) at 400 ppm, **T**6* =(AA+Eth), T7* = (SA+Eth), T8* = (Eth+ABA), T9* = (AA+ABA), and T10* = (SA+ABA**).**
* = one foliar spray
** = two foliar sprays

DISCUSSION

All treatments of ascorbic acid (AA), salicylic acid (SA), ABA (Protone) or combinations between them under this study significantly improved yield and cluster weight as well as both physical and chemical characteristics in both seasons compared with the control. These results are in agreement with those reported by **Ahmed *et al*. (2011), Kassem *et al*. (2011), Marzouk and Kassem (2011). Gad El-Kareem and Abd El-Rahman (2013), Champa *et al*. (2015), Roustakhiz and Saboki (2017),** they found that spraying salicylic acid (SA) improved yield, bunch weight, bunch number per vine, berry number/bunch and berry quality and larger berries. **Abdelaal *et al*. (2014)** concluded that application of AA four times on Thompson seedless grapes was very effective in enhancing berry quality (berry weight, berry equatorial, berry longitudinal, TSS%, TSS/acid and total sugars%) and decreased total acidity% in relative to the check treatment.

Yield per vine, cluster physical characteristics and berry quality characters were improved by sprayed ascorbic acid (**Ahmed *et al*., 2011; Marzouk and Kassem, 2011; Abdelaal *et al.*, 2014; Kumar *et al*., 2017; Allahveran *et al.*, 2018).**

Cantin *et al*. (2007), Amiri *et al*. (2010) and Sourial and Ibrahim (2014), mentioned that application of abscisic acid (ABA) was more effective than ethephon for enhancing the color and maintaining quality of fruits.

All studied treatments of abscisic acid (ABA) application significantly improved peel colour of berries of Flame seedless cv. grapevines. These results are in line with those reported by **Kitamura *et al*.(2007); Venburg *et al*. (2008); Quiroga *et al*., (2009); Owen *et al.*(2009); Koyama *et al*.(2010); Peppi and Retamales (2010); Ferrara *et al*. (2013); Roberto *et al*.(2013); Katayama-Ikegami *et al*. (2016); Zhu *et al*. (2016); Neto *et al*.(2017); Olivares *et al*. (2017); Jia *et al*. (2018); Koyama *et al*. (2018); Mekawy and Ahmed (2018); El-Sayed *et al.* (2019).** In the other hand, **Lurie *et al*. (2009)** they noticed that ripeness parameters of Crimson Seedless' grape cultivar were not affected by ABA treatment. Anthocyanin accumulation in berries treated with 400 mg l^{-1} ABA was almost double that of the control berries.

Ethephon application did not significantly affect the yield as compared to non-treated control, but fruit maturation (color) and berry size significantly increased **(Amiri and Parseh, 2011; Abdel Aal, 2013; González *et al*., 2018).**

Ethrel (Eth) or Eth+ ABA had highest TSS/ acid ratio and anthocyanin (%) in berries. The effect of abscisic acid (ABA) on the color of 'Crimson Seedless' grapes was linked to expression of the key anthocyanin pathway gene UDP-glucose: flavonoid 3-O-glucosyltransferase (UFGT). In the skins of ABA treated fruits, the level of mRNA UFGT increased markedly within one week and then returned to levels that were similar to those of non-treated fruits after three weeks. The mRNA UFGT levels from untreated fruits were similar from veraison to nine weeks later. The color of ABA treated fruit also changed quickly **(Peppi *et al*., 2008). Jeong *et al*. (2004)** provided a physiological basis for ABA activity by showing that the hormone stimulated the accumulation of mRNA of several genes involved in anthocyanin biosynthesis including that coding for the UDP-glucose: flavonoid 3-O-glucosyltransferase (UFGT) enzyme that catalyzes a critical step in anthocyanin biosynthesis in grape. Increased UFGT mRNA levels were noted two to four weeks after application of ABA.

Conclusions

This study recommended using the formulation containing abscisic acid (Protone) plus ascorbic acid (AA) or salicylic acid (SA) as an alternative to Ethrel (ethephon) treatment for improved yield and cluster weight as well as enhancing berry coloration, berry quality and overcome some adverse effects of Ethrel (Eth).

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تحســـين جـودة ولـون حبـــات وعنـاقيـد عنـــب الفـليـم ســـيدلـس بـــرش أحـمـاض (الابسيسيك، الاسـكوربيـك والسـلسـيليـك) والايثرل (الاثيفـون)

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تم إجراء هذا البحث على مدارموسمين متتاليين 2016 و 2017 على عنب صنف الفليم سيدلس Flame seedless cv. عمر ست سنوات في مزرعة عنب خاصة تقع عند الكيلو 93 طريق مصر اسكندريه الصحراوي. الكروم نامية في تربة رملية تحت نظام الري بالتنقيط وتم تربيتها بالنظام الإسباني (بارون) والكردون الرباعي. تضمنت التجربة 10 معاملات على النحو التالى: T1- الكنترول (الماء فقط) ، T2- ايثيريل بمعدل 300 جزء في المليون ،T3- حمض الأسكوربيك (AA) بمعدل 500 جزء في المليون، T4 - حمض الساليسيليك (SA) بمعدل 100 جزء في المليون ، T5 - حمض الأبسيسك ABA 10% (بروتون) بمعدل 400 جزء في المليون، T6- حمض الأسكوربيك (AA) بمعدل 500 جزء في المليون + إيثريل بمعدل 300 جزء في المليون، T7 - حمض الساليسيليك (SA) بمعدل 100 جزء في المليون + إيثريل بمعدل 300 جزء في المليون، T8- إيثريل عند 300 جزء في المليون+ ABA 10% (بروتون) بمعدل 400 جزء في المليون، T9 - حمض الأسكوربيك (AA) بمعدل 500 جزء في المليون+ (ABA 10% بروتون) بمعدل 400 جزء في المليون و - T10 حمض الساليسيليك (SA) عند 100 جزء في المليون+ ABA (بروتون) بمعدل 400 جزء في المليون. تم الرش الورقى مرتين في المعاملات من 2 الى 5 ولكن تم الرش مرة واحدة لكل مادة في المعاملات من رقم 6 إلى 10. أوضحت النتائج التأثير المعنوي لجميع المعاملات على الخواص الفيزيائية والكيميائية للمحصول والعناقيد والحبات. سجل الرش بحمض الأسكوربيك (AA) أو حمض الساليسيليك (SA) اعلى قيم لوزن 100 حبة (جم)، وصلابة الحبات، وقوة شد وتعلق الحبة ، وطول وعرض الحبة (سم) دون فروق معنوية مع ABA (بروتون) في كلا الموسمين. أعطت معاملات Ethrel (Eth) وABA (Protone) و Eth + ABA أقصى نسبة TSS%، بينما اعطت معاملات الايثريل (Eth) أو+ Eth حمضABA أعلى نسبة TSS/ للحموضة والأنثوسيانين (%) في الحبات وأيضًا كان لهذه المعاملات أقل القيم من الحموضة الكلية (%) في الموسمين. سجل الرش بحمض الأسكوربيك(AA) أو حمض الساليسيليك (SA) أو AA + ABA أو SA + ABA أعلى إنتاجية (كجم/كرمة) ووزن للعنقود (جم)، يليه الرش بالايثريل (Eth) أو Eth + ABA .

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