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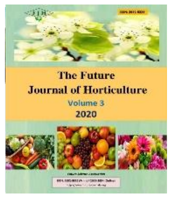
The Future Journal of Horticulture

Print ISSN: 2692-5826 Online ISSN: 2692-5834

Future Science Association



Future J. Hort., 4 (2021) **14-24**

OPEN ACCES

DOI: 10.37229/fsa.fjh.2021.11.14

ENHANCING GRAPE BERRIES QUALITY OF CV. EARLY SWEET BY A SIMULATOR OF PHOTOSYNTHESIS AND SOME GROWTH REGULATORS

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Received: 12 Oct. 2021 **; Accepted:** 14 Nov. 2021

ABSTRACT: Grape cultivar Early Sweet is seedless and early harvested in Egyptian viticulture. However, its widespread production is limited by two main problems; small berry size and formation of shot berry. Several attempts utilize safe growth regulators alone or in combinations to improve berry characteristics. The current study aims to improve the quality and quantity of the "Early Sweet" grapes by applying GA_3 and BA as well as triacontanol under Egyptian conditions. The results showed that GA_3 (10ppm) Followed by either benzyl adenine at 20ppm or triacontanol at 100ppm increased cluster weight, berry size, berry weight, TSS, total sugars, leaf area and leaf mineral content. Moreover, the above treatment decreased berry acidity, electrolyte leakage and berry carotene content. In addition, the individual treatments such as GA_3, BA and triacontanol enhanced the physical and chemical characteristics of "Early Sweet" grapes as compared with the control treatment.

Key words: Grapes, Shot berries, Benzyladenine, Photosynthesis, Triacontanol.

INTRODUCTION

Early sweet is a relatively newly introduced grape cultivar to Egyptian agriculture. It's an early season seedless variety that is ready for harvest in May and June. It also has the advantages of the sweet taste slighting and crispy berries it's limited in the production area and grown in few countries such as Morocco and Tunisia. Growing such new cultivars does not mean they have no problems or no need or potential for improvement under field conditions in Egypt. "Early Sweet" main problem is the need to increase berry size and to reduce the formation of shot berry **(Abada *et al*., 2015)**. Furthermore, berry size is the main interior used to assess the berries potential for export **(Senthilkumar *et al*., 2018).** The judicious use of safe growth regulators individually or in combinations could achieve the potential of "Early Sweet" to show greater characteristics of the berry under field conditions, which increases local marketability and export opportunity. In addition, this seedless berry should also suffer from the shortage in sink strength due to the absence of seeds and may suffer from the berry shatter for the same above reason. Thus, there must be room for utilizing plant growth regulators to overcome these problems and to improve berry quality at harvest. Previous attempts to improve fruit quality or to increase berry size without an adverse effect on the crispness and the desired sweet taste are very limited **(Farag and Attia, 2016 & Kim and Chung, 2000).** There is attractiveness of the other seedless white grapes such as "Thomson" seedless and more research attention has been given to colored grapes such as "Flame" then "Crimson" relatively late in the season. However, "Early Sweet" still has many advantages, especially for the Egyptian consumers that like to have sweet crispy and seedless grape berries early in the season.

To improve the berry size and weight of grapes, many producers and growers become aware of the effectiveness of GA_3. However, many grape growers and producers don't have sufficient knowledge about the adverse effect of the excessive use of GA_3 that inhabits floral induction in the current season as well as reducing flowering and yield in the next season. Thus, the frequency and concentration of GA_3 application to grapevine need to be under more control **(Korkutal *et al*., 2008; Attia, 2017; Attia and Farag, 2017; Kumar and Sharma, 2017; Khan *et al*., 2018; Mohsen and Ali, 2019)**. Furthermore, the judicious use of cytokinins such as benzyl adenine or CPPU needs to be utilized in a better way since it increases the sink strength of a seedless grape such as "Early Sweet" grapes (**Bound and Wilson, 2007 and Greene, 2016).** There is also a great potential to improve berry quality by enhancing the rate of photosynthesis, especially for mature grape leaves that are adjacent to the growing cluster.

The plant growth regulator called triacontanol has been effective in increasing carbohydrate biosynthesis and its export to different sinks in the plant. Triacontanol has been a widely accepted growth regulator since it is naturally biosynthesized in the plant cuticle (**Sharma, 1990; Sharma *et al*., 2009; Jain and Dashora, 2010**).

Thus, the objectives of this study were to enhance the berry quality of Early Sweet grape cultivar, the judicious utilization of GA_3, BA and triacontanol to improve the quality, the yield of "Early Sweet" grapes as well as to provide grape growers and producers with a production system that could be adopted under field conditions.

MATERIALS AND METHODS

The present study was carried out during the two successive seasons of 2019 and 2020 on 7-years old of grapevines cv. Early Sweet, spacing at 2×3 m. Vines were oriented at north south direction under drip irrigation system and were applied with the same agricultural practices i.e. irrigation, fertilization, pruning, …. etc, avoiding Ethrel treatment. The bud breaking dormancy hydrogen cyanamide (5% H_2CN_2) was used immediately after pruning at the second week of January at both seasons for all studied vines. Twenty-four uniform vines, free from various physiological and visible pathological disorders were selected for investigation. The studied treatments were arranged in randomized complete block design (RCBD) with 4 replications per treatment.

Table 1. Illustration of used treatments and data of application during the two seasons 2019 and 2020

No.	Treatments	First season (2019)	Second season (2020)
1	Control		
2	GA_3 (10 ppm)	26 April	22 April
3	Benzayladenine (20 ppm)	29 April	25 April
4	Triacontanol (100 ppm)	29 April	25 April
5	GA_3 (10 ppm) followed by Benzayladenine (20 ppm)	26 April 29 April	22 April 25 April
6	GA_3 (10 ppm) followed by Triacontanol (100 ppm)	26 April 29 April	22 April 25 April

Grape clusters of different treatments were sprayed to the run-off point. At the end of each season (May), the leaves of differently treated grapevines, which close to the bunch were detached for the following measurements; leaf area, electrical leakage, photosynthetic pigments (Chlorophylls a and b) as well as some mineral contents (nitrogen, phosphorus, potassium and magnesium). Samples were taken from the mature leaves adjacent to the clusters, placed in plastic then bagged carefully transported to the laboratory for analysis. Clusters were collected at maturity (May) and immediately transferred to the laboratory to determine some physical and chemical properties.

A. Vegetative characteristics

Chlorophylls a and b were determined according to **Lichtenthaler and Wellburn (1985),** electrolytes leakage of the leaf was calculated according to the method described by **Aherens and Ingram (1988)** and leaf area was measured according to **Tsialtas *et al*. (2008).** Furthermore, leaf nutrients content was determined as follow: Leaf nitrogen content was determined according to **A.O.A.C. (1985),** phosphorous was determined according to **Murphy and Riley (1962),** the potassium content of leaves was determined according to **Brown *et al*., (1946)** and magnesium was also determined **(A.O.A.C., 1985).**

B. Fruit quality parameters

Physical properties such as cluster weight, berry weight, 100Berry size and cluster stem weight were estimated. Furthermore, chemical properties such as total soluble solids content were determined in grape berries juice using a hand refractometer, total acidity percentage was determined according to **A.O.A.C (1985)**, electrolytes leakage of cluster stems (%) was determined **(Aherens and Ingram, 1988)**. Moreover, reducing sugars (%)were determined according to Lane and Eynon colorimetric method as described by **Egan *et al*. (1981),** total sugars were determined by using the phenol sulfuric acid method **Smith (1956)** and berry **c**hlorophylls a, b as well as carotene contents were determined according to **Lichtenthaler and Wellburn (1985)**.

C. Experimental design and statistical analysis

The obtained data was analyzed as a factorial experiment in randomized completely block design (RCBD). Data were analyzed using Costat (2008) Program. The means were compared according to the least significant difference (LSD) at 0.05 levels (**Snedecor and Cochran, 1980).**

RESULTS

Physical characteristics

The response of the "Early Sweet" grape to various applied treatments during the two seasons of 2019-2020 was reported in Table 2. Changes in cluster weight at harvest were shown in Table 2 and revealed that all treatments resulted in greater cluster weight than that of the control during the two seasons. The individual treatments of GA_3, BA, or triacontanol were all able to cause a significant increase in cluster weight that influence was further increased when combined with another treatment, for example, the combination of GA_3 plus either triacontanol or BA resulted in much greater cluster weight than that obtained with GA_3 alone. Furthermore, the highest values of cluster weight among all used treatments were found with the combination of GA_3 plus BA at 20 ppm followed by the application of GA_3 plus triacontanol, consistently during the two seasons.

The effect of used applications on berry weight was reported in Table 2and expressed the 100 berry weight. The data showed that there was a similar trend to that found with cluster weight since all used treatments resulted in greater berry weight than that obtained with the control in both seasons. However, the magnitude of such increase in berry weight valued between treatments since the combination of GA_3 followed by BA resulted in the greatest berry weight among all other treatments then the application of GA_3 followed by triacontanol in the two seasons no wonder the ability of BA to increase the sink strength in treated berries while triacontanol increases the available carbohydrates to berry in response to the increase of photosynthetic capacity of treated foliage and clusters. Thus, positive trends were obtained with the individual treatments compared with the control.

Changes in berry size in response to various applied treatments on "Early Sweet" grape clusters were reported in Table 2. The data indicated that control berries had the smallest size while the combination of GA_3 followed by BA gave the greatest or the largest berries size. Meanwhile, the role of GA_3 or BA application was also effective in causing a significant increase in berry size but lower magnitude than their combination. Such trends of results were consistent in both seasons. The second-used combination containing GA_3 followed by triacontanol also had a superior influence in berry size but less than the first combination of GA_3 plus BA. Moreover, triacontanol and BA as individual treatment had similar magnitude on increasing berry size in both seasons. Thus, it could be concluded that all used treatments had a positive influence on berry size. However, the application of GA_3 in a combination with either triacontanol or BA was the most effective in increasing berry size in both seasons.

The influence of various used treatments on the weight of cluster stems was also displayed in Table 2. The data showed that a similar trend of results to that found with the other cluster properties was also found since the greatest cluster stems weight was found with the combination of GA_3 at 10 ppm followed by BA at 20 ppm. Meanwhile, the control cluster stem weight was found to have the least value in both seasons. When GA_3 treatments were followed by triacontanol cluster stems weight was also greater than the control in both seasons. Moreover, all other treatments when used individually resulted in significantly greater cluster stems weight than the control but lower than that of the two combination treatments in a consistent manner in both seasons.

Table 2. Some physical characteristics of "Early Sweet" grapes as influenced by various applied preharvest treatments during the two seasons 2019 and 2020

Treatments	Cluster Weight (g)		100 Berry weight (g)		100Berry size (cm^3)		Cluster stems weight (g)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	318.80 E*	278.00 E	318.80 E	318.80 F	295.00 E	301.30 E	3.49 E	3.54 F
GA_3 (10ppm)	398.80 C	399.80 C	408.80 C	410.00 C	395.00 C	395.00 C	8.85 B	8.68 C
Benzyladenine (20ppm)	365.50 D	367.30 D	380.50 D	385.00 D	347.50 D	351.80 D	7.78 C	7.85 D
Triacontanol (100ppm)	363.00 D	362.30 D	366.30 D	367.50 E	357.00 CD	341.80 D	6.51 D	6.48 E
GA_3 (10 ppm) followed by Benzyladenine (20ppm)	639.30 A	641.00 A	687.50 A	687.00 A	630.00 A	626.30 A	11.02 A	11.10 A
GA_3(10ppm) followed by Triacontanol (100ppm)	544.80 B	541.30 B	557.80 B	559.80 B	515.00 B	507.50 B	9.07 B	9.18 B

***** Values, within a column, of the similar letter (s)were not significantly different according to the least significant difference (LSD) at 0.05 levels.

Chemical characteristics

The response of total soluble solids of "Early Sweet" grape to various applied treatments was reported in Table 3. The data revealed that there was a significant increase in TSS caused by all treatments at harvest. Moreover, the highest increase was obtained with the application of the combination of GA_3 followed by BA in both seasons. The second combination of GA_3 followed by triacontanol was also effective in increasing the juice TSS but in a lower magnitude than that obtained with the first combination. Meanwhile, all used individual treatments whether GA_3, BA, or triacontanol resulted in a significant increase in TSS values as compared with the control in both seasons. However, GA_3 was superior to BA and triacontanol in increasing the TSS similarly BA resulted in greater TSS than that obtained with triacontanol.

The effect of various applied treatments on juice acidity of "Early Sweet" grapes was displayed in Table 3. The highest acidity was found in the control fruits at harvest. Meanwhile, the acidity of BA-treated fruits as well as triacontanol-treated ones was lowered consistently in both seasons. Moreover, the lowest values of juice acidity were found with the application of the combination of GA_3 followed by BA. The second combination of GA_3 plus triacontanol was still able to reduce juice acidity at harvest but in a lower magnitude than that of the GA_3 plus BA in both seasons. In addition, GA_3 alone resulted in lower juice acidity than that of the control in a significant manner in both seasons.

The data in Table 3 showed the changes in the TSS/acidity value found at harvest of "Early Sweet" grapes as a response to used treatments. It was evident again that the least TSS/ acidity value was found with the control fruits. Meanwhile, all used application was able to increase TSS/acidity at harvest with varying degrees of response for example the combined treatments of GA_3 plus BA achieved the greatest ratio. However, when GA_3 was combined with triacontanol there was also a positive increase in such ratio but at a lower magnitude than their former combination in both seasons. Moreover, the individual application of GA_3, BA and triacontanol resulted in a significant increase in

T.S.S /acidity as compared with the control in a consistent manner in both seasons. Even though, GA_3 among them was superior in its influence on TSS/ acidity ratio.

Since electrolyte leakage is an important indicator of the level of tissue integrity, more leakage means more damage. Thus, the electrical conductivity of fruitless cluster stems was determined to assess the effect of applied treatments on the viability of the tissues. It was evident that the control cluster stems had the greatest electrolyte leakage, while the combination of GA_3 plus BA had the lowest percentage of such leakage followed by BA alone as compared with the control. GA_3 alone was also able to reduce electrolyte leakage of such stems but was similar to that extent to the obtained by BA alone in both seasons. Moreover, the combination of GA_3 plus triacontanol was also effective in reducing the electrical conductivity of cluster stems but was less effective as compared with GA_3 alone.

Table 3. Some chemical characteristics of "Early Sweet" grape berries as influenced by various applied preharvest treatments during the two seasons 2019 and 2020

Treatments	TSS (%)		Acidity (%)		TSS/acidity (ratio)		Cluster stems electrolyte leakage (%)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	13.70 F*	13.88 F	0.48 A	0.50 A	28.43 E	27.82 F	55.70 A	58.50 A
GA_3 (10ppm)	17.10 B	17.40 B	0.34 D	0.33 E	51.57 B	53.06 B	24.64 D	26.25 D
Benzyladenine (20ppm)	15.13 D	15.30 D	0.39 C	0.39 C	39.27 C	39.39 D	24.58 D	24.25 D
Triacontanol (100ppm)	14.18 E	14.30 E	0.42 B	0.42 B	33.64 D	34.43 E	34.35 B	35.13 B
GA_3 (10 ppm) followed by Benzyladenine (20ppm)	18.20 A	18.30 A	0.29 E	0.31 E	63.58 A	58.99 A	14.70 E	14.25 E
GA_3 (10ppm) followed by Triacontanol (100ppm)	15.93 C	15.95 C	0.38 C	0.37 D	42.34 C	43.73 C	30.00 C	29.25 C

***** Values, within a column, of the similar letter were not significantly different according to the least significant difference (LSD) at 0.05 levels.

The effect of preharvest applications of various treatments on the content of reducing sugar of "Early Sweet" grapes was reported in Table 4. The data revealed that all treatments were able to cause a significant increase in the reducing sugars when compared with the control. However, the magnitude of such increase is valued among used treatments. The greatest value of reducing sugars was obtained with the combination of GA_3 plus BA followed by the second used formulation that contained GA_3 spray plus triacontanol. Meanwhile, BA alone was able to cause a significant increase of reducing sugars that were even higher than that found with GA_3 alone, especially in the second season. The least increase in reducing sugars was found with the application of triacontanol alone. Thus, it was beneficial to apply GA_3 Followed by BA to get the maximum increase in reducing sugars in "Early Sweet" grapes.

Changes in total sugars of "Early Sweet" grapes berries were shown in Table 4. It was evident that there was a significant increase caused by some treatments over the two seasons. However, the greatest increase in total sugars was obtained again with the application of GA_3 that was followed by BA treatment. Such increase value was not as great as the second used combination that included GA_3 plus triacontanol when comparing the obtained value. However, the magnitude of the increase in total surges caused by either GA_3 alone or BA alone was not that great even though, it resulted in a significant increase in total sugars as compared with the control in both seasons. It was surprising to find that the individual application of triacontanol was not able to cause a significant increase in total sugars despite the expected role of triacontanol in increasing leaf photosynthetic.

Table 4. Reducing sugars and total sugars of "Early Sweet" grape berries as influenced by various applied preharvest treatments during the two seasons 2019 and 2020

Treatments	Reducing sugars (%)		Total sugars (%)	
	2019	2020	2019	2020
Control	3.01 E*	3.02 F	9.37 D	9.37 C
GA_3 (10 ppm)	3.49 BC	3.45 D	10.75 B	10.38 B
Benzyladenine (20 ppm)	3.45 C	3.47C	10.13 C	10.13B
Triacontanol (100 ppm)	3.28 D	3.26 E	9.62 D	9.62 C
GA_3 (10 ppm) followed by Benzyladenine (20 ppm)	3.60 A	3.62 A	11.75 A	11.88 A
GA_3 (10 ppm) followed by Triacontanol (100 ppm)	3.53 B	3.53 B	10.25 C	10.13 B

***** Values, within a column, of the similar letter (s) were not significantly different according to the least significant difference (LSD) at 0.05 levels.

The influence of various used treatments on grape barriers content of chlorophyll a during the two seasons were shown in Table 5. The data revealed that the control berries at harvest had the highest chlorophyll a. All treatments had a significant increase in chlorophyll as compared with the control in both seasons. It was found that the combination of GA_3 followed by BA, resulted in the highest content of chlorophyll among all treatments. Furthermore, the combination of GA_3 plus triacontanol followed in other the former combination in turns of the magnitude of the increase of chlorophyll content in "Early Sweet" grapes barriers each component in that combination, namely GA_3 alone or triacontanol or BA resulted in greater chlorophyll in the berries at harvest. Meanwhile, both BA and triacontanol were equally effective in their influence on chlorophyll content while GA_3 alone resulted in greater chlorophyll a than that obtained with BA or triacontanol individually.

Concerning the changes in chlorophyll b in "Early Sweet" grapes in response to various applications, the data in Table 5showed that the combinations treatment had the greatest chlorophyll b in their berries. Since, when GA_3 was followed by either triacontanol or BA achieved the highest values as compared with the control or with other applied treatments. Moreover, both combinations were equally effective in their influence on chlorophyll b except in the first season with the combination of GA_3 plus triacontanol. Moreover, the individual treatments of GA_3, triacontanol and BA had a similar influence on chlorophyll b except for GA_3 in the second season. Thus the response of chlorophyll b varied from that obtained with chlorophyll a in both seasons.

The data in Table 5 showed that the control treatment had the greatest carotene content. The combination of GA_3 plus BA had the lowest percentage of berry carotene content followed by GA_3 alone as compared with the control. Benzyladenine alone was also able to reduce berry carotene content but similar to that obtained by GA_3alone in both seasons. Moreover, the combination of GA_3 plus triacontanol was also effective in reducing berry carotene content as compared with control.

The effect of various used treatments on grape leaves the content of chlorophyll a during the two seasons was shown in Table 6. The data indicated that all preharvest applied treatments increased leaf chlorophyll contents as compared with the control treatment. The highest increase was obtained with the application of the combination of GA_3 at 10ppm followed by Benzyl adenine at 20ppm. The second combination of GA_3 at 10ppm followed by triacontanol at 100ppm was also effective in increasing the chlorophyll leaves but less than obtained by the first combination. Meanwhile, all used individual treatments resulted in a significant increase in chlorophyll values as compared with the control in both seasons.

Table 5. Berry chlorophylls and carotene contents of "Early Sweet" grape berries as influenced by various applied preharvest treatments during the two seasons 2019 and 2020

Treatments	Chlorophyll a(mg/100g)		Chlorophyll b (mg/100g)		Carotene (mg/100g)	
	2019	2020	2019	2020	2019	2020
Control	1.80 E*	1.80 E	3.44 D	3.51 D	3.110 A	3.108 A
GA_3 (10 ppm)	2.60 C	2.59 C	4.92 C	4.68 B	1.860 D	1.860 D
Benzyladenine (20 ppm)	2.47 D	2.46 D	4.75 C	4.52 C	2.100 C	2.072 B
Triacontanol (100 ppm)	2.48 D	2.48 D	4.78 C	4.40 C	2.270 B	2.270 B
GA_3 (10 ppm) followed by Benzyladenine (20 ppm)	3.98 A	3.99 A	7.90 A	5.22 A	1.580 E	1.570 E
GA_3 (10ppm) followed by Triacontanol (100 ppm)	2.81 B	2.83 B	5.40 B	5.17 A	1.890 D	1.890 D

***** Values, within a column, of the similar letter were not significantly different according to the least significant difference (LSD) at 0.05 levels.

The influence of various used treatments on grape leaves the content of chlorophyll b during the two seasons was displayed in Table 6. The data revealed that the combination treatment consisting of GA_3 followed by BA had the greatest chlorophyll b contents in grape leaves. It was found that GA_3 treatment alone or followed by BA achieved the highest values when compared with the control or with other applied treatments. Moreover, the individual treatments BA and triacontanol, as well as the combination of GA_3 followed by triacontanol, were equally on their influence on chlorophyll b.

The changes in electrolyte leakage percentage (EC) of "Early Sweet" grapes leaves were reported in Table 6. It was evident that the control treatment had the greatest electrolyte leakage while the combination of GA_3 plus BA had the lowest percentage of such leakage followed by the combination of GA_3 followed by triacontanol. Moreover, the individual treatments that included GA_3, BA and triacontanol were also effective in reducing the electrical conductivity of leaves as compared with the control treatment.

Changes in leaf area of "Early Sweet" grape leaves were found in Table 6. It was evident that treatments had a significant increase in leaf area as compared with the control in both seasons. Moreover, it was found that the combination of GA_3 followed by BA resulted in the highest leaf area among all treatments. Furthermore, the combination of GA_3 followed by triacontanol was the second highest leaf area. Meanwhile, all used individual treatments whether GA_3, BA, or triacontanol resulted in a significant increase in leaf area values as compared with control in both seasons. However, BA was lower than GA_3 or triacontanol in decreasing leaf area.

The data in Table 7 provided evidence that there was a significant increase in nitrogen content in the leaves of "Early Sweet" grapes as a result of preharvest applying treatments as compared with the control treatment. The highest values were obtained with the application of the combination of GA_3 followed by either 6-BA or triacontanol in both seasons. Furthermore, all individual treatments whether GA_3, BA triacontanol resulted in a significant increase in nitrogen percentage values compared with control treatment in both seasons.

The effect of various applied treatments on the leaf phosphorus content of "Early Sweet" grapes was reported in Table 7. The data illustrated that the highest value of phosphorus percentage was obtained with the application of a combination of GA_3 at 10ppm followed by BA at 20ppm in both seasons. The second combination of GA_3 followed by triacontanol was also effective in increasing p% leaf content but lower than the first combination and similar to GA_3 treatment. On the other hand, the data also indicated that the individual treatment of 100ppm triacontanol and the control had a similar influence on P% leaf content, especially in the second season.

Table 6. Chlorophyll a and b contents, electrolyte leakage (EC) and leaf area of "Early Sweet" grape berries as influenced by various applied preharvest treatments during the two seasons 2019 and 2020

Treatments	Leaf chlorophyll a (mg/100g)		Leaf chlorophyll b (mg/100g)		Leaf electrolyte leakage (%)		Leaf area (cm^3)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	19.19 E*	19.05 D	9.87 E	9.86 D	58.60 A	59.50A	76.81 D	62.97 E
GA_3(10ppm)	21.11 C	21.13 BC	15.23 B	15.22 B	36.4 B	37.25 B	144.80 C	141.20 C
Benzyladenine (20ppm)	20.71 D	21.92 B	14.67 C	14.07 C	35.5 BC	37.45 B	120.00 C	119.50 D
Triacontanol(100ppm)	20.52 D	20.55 C	14.32 D	14.34 C	37.92 B	37.25 B	120.40 C	127.90 CD
GA_3 (10 ppm followed by Benzyladenine (20ppm)	24.12 A	24.14 A	17.14 A	17.13 A	20.42 D	20.30 D	289.10 A	362.10 A
GA_3(10ppm) followed by Triacontanol (100ppm)	23.27 B	23.3 A	14.45 CD	14.40 C	31.65 C	31.50 C	236.40 B	235.70 B

***** Values, within a column, of the similar letter (s) were not significantly different according to the least significant difference (LSD) at 0.05 levels.

Concerning the changes in leaf potassium percentage content of "Early Sweet" grapes during the two seasons in response to various applications, the data in Table 7 revealed that the combination of GA_3 at 10ppm followed by 6-BA at 20ppm obtained the highest leaf K contents as compared with control treatment. Furthermore, the combination of GA_3 at 10ppm was the second-highest leaf P content. Meanwhile, all used individual treatments whether GA_3 at 10ppm, BA at 20ppm, or triacontanol at 100ppm resulted in a significant increase in leaf K content as compared with the control in both seasons.

Changes in magnesium content of "Early Sweet" leaves were shown in Table 7. The data indicated that the combination of GA_3 at 10 ppm followed by BA at 20ppm obtained the highest leaf Mg % content as compared with the control treatment. Furthermore, the combination of GA_3 at 10ppm was the second-highest leaf Mg% contents treatment. Meanwhile, all used individual treatments whether GA_3 at 10ppm, BA at 20ppm, or triacontanol at 100ppm resulted in a significant increase in leaf Mg content as compared with the control during the two seasons of study.

Table 7. Leaf mineral contents of "Early Sweet" grape berries as influenced by various applied preharvest treatments during the two seasons 2019 and 2020

Treatments	N (%)		P (%)		K (%)		Mg (%)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	1.872 F*	1.870 D	0.210 E	0.225 D	1.225 F	1.325 F	0.377 F	0.380 F
GA_3 (10ppm)	2.142 C	2.070 B	0.300 B	0.320 B	1.725 C	1.77 C	1.500 A	0.520 C
Benzyladenine (20 ppm)	2.045 D	2.030 B	0.280 C	0.277 C	1.625 D	1.675 D	0.480 D	0.480 D
Triacontanol (100 ppm)	1.940 E	1.928 C	0.260 D	0.260 D	1.400 E	1.450 E	0.440 E	0.430 E
GA_3 (10 ppm) followed by Benzyladenine (20 ppm)	2.283 A	2.280 A	0.340 A	0.335 A	2.000 A	2.100 A	0.620 B	0.630 A
GA_3 (10ppm) followed by Triacontanol (100 ppm)	2.230 B	2.230 A	0.320 B	0.330 B	1.875 B	1.870 B	0.540 C	0.560 B

***** Values, within a column, of the similar letter (s) were not significantly different according to the least significant difference (LSD) at 0.05 levels.

DISCUSSION

The present study provided evidence about the possibility of improving the berry quality of "Early Sweet" grapes by the judicious use of plant growth regulators. It has been reported that "Early Sweet" berries size is not large enough for commercial use as other table grapes and cultural practices must provide solutions to improve its size several folds since berry size is the main quality factor in the international market **(Abada *et al*., 2015).** The routine use of GA_3 has limits since the excessive use could lead to thin skin that does not tolerate many stresses or infection with some fungal diseases and the exclusive GA_3 concentration result in inhibiting the flower induction for the next season crop **(Srinivasan and Mullins, 1981).** Thus, it was decided here to use a new approach to improve berry quality of "Early Sweet" grapes that depended on the role application of GA_3 at 10ppm instead of the frequent application or overuse of GA_3 that may reach in some farms to 6-7 spray per one season. Our GA_3 spray was at a diameter of berry between 4- 6mm followed three days later by the application of either triacontanol at 100ppm or by the application of BA at 20 ppm. These applications resulted in the greatest values of cluster weight, 100 berry weight and berry size consistently in both seasons. The natural compound triacontanol is part of the fruit cuticle called the Epicuticle (surface waxes) that has been recently produced on a commercial scale and has been approved worldwide to protect the plant against many biotic and abiotic stress **(Ries *et al*., 1977; Naeem *et al*., 2012 and Islam *et al*., 2020).**

In this study, the control cluster stem weight was found to have the least value in both seasons. However, when GA_3 treatment was followed by triacontanol, cluster stems weight was greater than the control. The ability of triacontanol to stimulate the photosynthetic capacity of mature leaves is reflected in the number of carbohydrates allocated to various sinks in the grapevine such as the buds, the stems, branches, roots and berries **(Barua, 1990; Sharma, 1990 and Naeem *et al*., 2012)**. Furthermore, the role of BA in increasing the leaf vigor and delaying senescence means higher carbohydrates content which demonstrated the reason behind the greatest TSS found with the application of GA_3 followed by BA. Meanwhile, the magnitude of such an increase in TSS was found with GA_3 followed by the application of triacontanol. No wonder the same above two combinations of either GA_3followed by BA or GA_3followed by triacontanol resulted in the greatest ratio of TSS to acidity among all other treatments, respectively. Furthermore, it was very important to assess the electrolyte leakage of fruit-less stems since more the tissues damage, means more the leakage that as to why the control cluster stems had the greatest electrolyte leakage. While the combination of GA_3 plus BA had the lowest percentage of such leakage followed by BA alone when compared with the control. The increase in chlorophyll a and b provided further support for the role of triacontanol and BA in enhancing the vine vigor and viability, while there was no significant difference between the individual treatment of either triacontanol or BA in chlorophylls a and b. Thus, these studies provided much evidence about the possibility of utilizing a growth regulator a relatively new combination to improve the quality of white grapes such as "Early Sweet" under field conditions.

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