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Rootstock Effects on Yield, Fruit Quality and Nutrition Status of "Early Sweet" Grape Fertilized with Varying levels of Nitrogen and Potassium

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A TWO years study was carried out during two successive seasons (2017 and 2018) on seven years old Early Sweet grapevines budded on Freedom and Salt Creek rootstocks grown in sandy loam soil, spaced at 2 X 3 meters apart under a drip irrigation system in a private grapevines orchard located on Cairo-Alexandria desert road about 50 km from Cairo, Egypt. The main objective is to study the effect of nitrogen supported with potassium and two rootstocks salt Creek and Freedom as well as their *combinations* on yield and fruit quality properties of Early Sweet grape vine. The study was arranged in a split plot design, hence two rootstocks (Freedom and Salt creek) were occupied in the main plot, and the subplots were split by (N+K) application levels. Whereas, three levels of nitrogen (30, 40 and 50 kg /fed) as actual nitrogen were applied. Potassium levels were added at the ratio (1:1.5 and 1:2) from nitrogen level plus control treatment was (60kg N/fed+120kgK/fed). Obtained results showed that, fertilization with high rates of nitrogen reduced cluster weight, cluster length, and cluster width of "Early Sweet" Generally, Early Sweet grapevine grafted on Salt creek rootstock fertilized with 40kg N/fed plus 80kg K/fed proved to be the most efficient effect application on yield and fruit quality.

Keywords: Early sweet grape; Nitrogen; Potassium fertilization; Rootstocks.

Introduction

Grape (*Vitis vinifera* L.) has a high economic value and is considered one of the important fruit in Egypt. It ranked second among fruit crops after citrus and the total area of grapes is about 74529ha produced about 1641075 tons according to the statistics of the (FAO 2018). Early sweet grapevine cultivar is a popular cultivar and has grown successfully in Egypt. Moreover, it is an early ripening cultivar (in the last week of May) so it has a greater chance of being exported with minimum competition. Nitrogen is one of the major plant nutrients, being a part of the protein, enzymes, amino acids, polypeptides and many other biochemical compounds in the plant system (Mengel and Kirkby, 1987). Moreover, nitrogen is the most required element by plants, it effects on productivity and quality of grapes and it has effects on the vegetative development of grapevines (Conradie, (2005) and Grechi et al. (2007). Furthermore, a high rate of nitrogen fertilization induces the vigor of the grapevine and reduces the quality of grapes. On the other hand, a lack of nitrogen in vine can strongly limit vine vigor, especially from bud burst to blooming Conradie, (1991) & Grechi et al. (2007). Keller et al. (1999) reported that excessive nitrogen rates of grapes lead to delayed ripening. Increased vegetative growth, which competes with sugar translocation and pigment accumulation in the berry. Moreover, the fertilization of the "Thompson seedless" grapevine with nitrogen

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exerted a high positive effect on vegetative growth. Moreover, increasing nitrogen rates increased potassium and phosphorus concentrations in the leaf (Abou Sayed Ahmed et al., 2000). However, Hassan (2002) found that foliar spray with urea increased leaf area, total chlorophyll content, and carotenoid content and it improved leaf nitrogen and potassium content. Whereas phosphorus content increased in petiole only of Thompson seedless grapevine. Furthermore, In addition, grapevine nitrogen required ranged from 27 to 120 kg/ha for the growth shoots and fruits seasonally (Treeby & Wheatley, 2006, Schreiner et al., 2006, Pradubsuk & Davenport, 2010 and Williams, 2017). Christensen and Peacock (2000) found that nitrogen fertilization divided into split parts can improve the production either in terms of yield or quality of the grape. On the other hand, in recent studies, the efficiency of split application was not noticed in the first year, however, in the following years, grapevines showed higher sugar content and yields (Castaldi, 2011). On the other hand, Potassium is mobile within the grapevine (Mosse et al., 2013). Potassium was Involved in numerous biochemical and physiological processes, including enzyme activation in photosynthesis and respiration and the maintenance of cellular osmotic potential in plants (Salisbury and Ross, 1992). Furthermore, Potassium is the major element related to berry ripeness and its concentration in grapes is related to the must acidity (Mpelasoka et al., 2003). Potassium is involved in sugar transport (Mpelasoka et al., 2003). Moreover, it increased the total soluble solids content and decreased the total acidity of berries (Martin et al. (2004). However, High potassium fertilization has negative effect on growth and fruit quality (Mpelasoka et al., 2003). Moreover, Poni et al. (2003) revealed that the application of potassium to the soil resulted in higher K concentrations in the blades of grapevines. Furthermore, Schreiner et al. (2013) concluded that a low level of potassium fertilization resulted in reduced potassium concentration in “Pinot noir” grapevines. On the other hand, fertilization with nitrogen and potassium gave a direct significant effect on the grape’s bud production (Girgis et al., 1998). Enhanced petioles nitrogen and potassium content, vegetative growth parameters, cluster weight, cluster size, berry size, weight, and juice, however, it reduced berry firmness. However, vine fertilized with a high rate of nitrogen induced a negative effect on yield because it decreased the number of buds burst and fruitful buds. Rootstocks play very important roles in overcoming water and salinity stress in newly reclaimed areas in the north and middle of Egypt (El-Gendy, 2013). It is adaptable to high pH and wet or poorly drained soils as well as drought besides, it is protecting crops against phylloxera and nematode (Köse et al., 2014). On the other hand, rootstocks affect vine growth, yield, and fruit quality as well as nutrients absorption from soil (Bavaresco et al., 2003 & El-Gendy, 2013). Walker et al. (2000) mentioned, that grafted on rootstocks led to an increase in TSS and a decrease in total acidity. This result is very important to early harvesting and increases the total return coming in export. Moreover, Gaser (2007) found that “Superior seedless” grapevines grafted on Dog Ridge and /or Salt Creek increased yield/vine than those grafted on Freedom rootstock. That is confirmed by El-Gendy (2013) found that Flame seedless cv. grafted on Salt creek or Freedom rootstocks improved yield and fruit quality as compared with ungrafted vines. Whereas Freedom rootstock enhanced the coloring and maturity of berries and gave economic crop. On the other hand, Rühl (2000) mentioned that Freedom rootstock enhanced the leaf nutrient status of grape grafted and it gave the highest potassium concentration in the leaf of grape grafted. Furthermore. This was also confirmed by Abo EL-Wafa (2003) who found that Salt Creek and other rootstocks increased leaf nitrogen, phosphorus and potassium content of “Roumi Red” grape grafted. So this investigation was conducted to enhance yield, fruit quality, and mineral content of newly grape cultivar “Early sweet” by determining the suitable application level from each nitrogen and potassium fertilizers as well as the suitable rootstock from two rootstocks “Salt creek” and “Freedom” with the possibility to select the best combination between fertilizer application and rootstock

Materials and Methods

This study was carried out during two successive seasons of 2017 and 2018 in a private grapevine orchard, located on the Cairo-Alexandria desert road about 50 km from Cairo, Egypt (30^0) on a seven-year-old “Early Sweet” grapevine.

The experiment was carried out on seven years old “Early Sweet” grapevines grafted on Freedom or Salt creek rootstocks grown in sandy loam soil, and spaced 2x3m apart under a drip irrigation system from a well. Physical and chemical analyses of the experimental soil were shown in

(Table 1) Moreover, the chemical analysis of the irrigation water is shown in Table (2). The vines were trained to cane pruning under the "Baron" system and pruned on 25th December with 61 buds per vine beside sprayed Dromx in the first week of January. From each season

This experiment consist of two Rootstocks (Freedom and Salt creek) and three levels of nitrogen (30, 40 and 50 kg /fed) as actual nitrogen were applied. Potassium levels were added at the ratio (1:1.5 and 1:2) from nitrogen level whereas control treatment was (60kg N/fed+120kgK/fed).

The experiment was arranged in a split-plot design, the main plots were separated for rootstocks and the subplots were split by (N+K) application levels. Thus the experiment consisted of fourteen treatments with five replicates and each replicate was represented by three trees. Nitrogen and potassium fertilizers were added as soil application under drip irrigation.

Nitrogen levels were 30, 40, 50 and 60 kg/fed, it is equivalent 89.6, 119.40, 149.25 and 179.10 kg/fed from ammonium nitrate (33.5%) as a source of nitrogen, respectively. Actual potassium applications were 45, 60, 80,75, 100 and120 kg/fed, its equivalent 93.75, 125,166.6, 156.25,208.3 and 250 kg/fed from potassium sulfate (48% K_2SO_4) as a source of potassium, respectively. Nitrogen and potassium fertilization were added three times, the firstly (25% of actual nitrogen+ potassium fertilizers were added on 15th February (after bud opening and before flowering), and the secondly (50% of actual nitrogen+ potassium fertilizers) were added on 1st April (after fruit set) and then finally (25% of actual nitrogen+ potassium fertilizers) were added at 1st June (after harvest time) in both seasons.

The following parameters were measured to evaluate the tested treatments:

Yield:

Harvesting time at the last week of May, when the TSS reached about 14% in the berries of the two studied seasons. Clusters number per vine were counted and weighed to determine the total yield per vine. and the number of shot berries as %.

Berries physical characteristics

Representative random samples of 15 clusters per replication were taken to the laboratory to determine cluster weight, cluster dimensions (length and width)

A random sample of 100 berries per replication was taken to determine: berry firmness (g/cm^2, and berry adherence strength (g/cm^2) "separating force"

Berries chemical characteristics

Total soluble solids (T.S.S.) in berry juice was determined by a Handrefract meter in (Brix), total acidity in berry juice (expressed as tartaric acid %) according to (A.O.A.C., 1985) and TSS/ Acid ratio was calculated.

TABLE 1. Analysis of experimental soil.

Soil Depth (cm)	**Particle size distribution**				
	Coarse Sand	**Fine sandy**	**Silt**	**Clay**	**Texture**
0-30	----	67	23.6	9.6	Sandy loam

Chemical analysis:

Soil Depth (cm)	**pH Soil past**	**E.Ce (dSm^{-1})**	**Organic matter %**	**Capacity (%)**	**CaCO3**	**N (%)**	**P (%)**	**K (%)**
0-60	8	1.3	0.09	25	0.8	0.64	0.53	0.45

TABLE 2. Chemical analysis of water used for irrigation.

pH	**E.C.**	**Soluble cations (meq/l)**			
	dSm^{-1}	**Ca^{++}**	**Mg^{++}**	**Na^{+}**	**K^{+}**
7.1	1.2	2.4	0.5	8.9	0.15

Leaf mineral content:

Leaves samples were taken at the verison stage from mature leaves (5-6th) leaf from the shot shoot tip). For each replicate the blades and petioles were separated and washed with tap water followed by distilled water then oven dried at 70°C until a constant weight dried petiole samples were ground by an electric mill. the ground sample was digested according to the method of (Jackson, 1958), Total nitrogen, Phosphorus, Potassium Calcium, Magnesium, Iron, Zinc, Manganese and Born were determined according to Cottenie et al. (1982)

Statistical Analysis

The obtained data in the 2017 and 2018 seasons were subjected to analysis of variance according to Clarke and Kempson (1997). Means were differentiated using the Range test at the 0.05 level (Duncan, 1955).

Results and Discussion

Effect of rootstocks and varying levels of Nitrogen and Potassium on Yield/vine, number of shot berries, Cluster number /vine and Cluster weight.

Data present in Table (3) Regarding rootstocks it could be observed that salt creek gave the highest number of clusters/vine during the two growing seasons on the other hand ,T4(40N+80K)gave the highest values of cluster number /vine during the first season and equaled by T5 (50N+75K)and T6(50N+100K)in the second season it seems that Early sweet vines grafted on salt creek rootstock fertilized with T4(40N+80K) gave the highest significant values of cluster number/vine during the two seasons and followed closely by vines treated with T5 (50N+75K),T6(50N+100K)and control grafted on salt creek freedom root stock gave the highest significant values of cluster weight during the first season only Early sweet vines fertilized with T6(50N+100K)and control treatment gave the highest values of cluster weight during the two seasons followed by the same statically stand point by T5(50N+75K)and T2, T3 in the first and second seasons respectively regarding the interaction it was difficult to determined constant direction Data present in Table (3) indicates that, rootstocks it could be observed that salt creek gave the highest yield during the two growing seasons.

On the other hand, T4 gave the highest values of yield during the first season but the second season equaled with T5, T6 and control on the other hand «Salt Creek» rootstock induced a pronounce reduction effect on the number of shot berries than «Freedom» rootstock in both seasons. In the first season, the vine fertilizes with 50N+75K kg/fed (T5) and 50N+100K kg/fed (T6) giving a similar and high reduction in the number of shot berries. But in the second season, vine fertilization with 40N+80K kg/fed (T4), 50N+75K kg/fed (T5) and 50N+100K kg/fed (T6) proved to be the superior treatment in reducing the number of shot berries. The interaction between rootstocks and nitrogen plus potassium fertilization showed that in the first season, combinations of «Freedom» rootstock fertilized with 40N+80K kg/fed (T4) and 50N+75K kg/fed (T5) and in the second season.

Effect of rootstocks and varying levels of Nitrogen and Potassium on berries physical characteristics

Data present in Table (4) indicates that there is no significant effect between rootstocks on cluster length in both seasons. In the first season, the treatment (40N+60 K kg/fed) (T3) and in the second season, the treatment (30N+60 K kg/fed) (T2) proved to be superior in this respect. The interaction between the two factors showed that in the first season, the combination of “Freedom” rootstock fertilized with 40N+60K kg/fed (T3) induced the highest positive effect than other combinations. In the second season, a combination of “Freedom” rootstock fertilized with 30N+60K kg/fed (T2) gave the highest positive effect of other combinations

In the first season, there insignificant effect between the rootstocks on cluster width but in the second season, the “Salt Creek” rootstock induced a more positive effect on cluster width than the “Freedom” rootstock. In the first season, the vine fertilizes with 40N + 80 K kg/fed (T4) and in the second season, the vine fertilizes with 30N+60 K kg/fed (T2) inducing the highest positive effect on cluster width than other treatments. The interaction between rootstocks and nitrogen plus potassium fertilization showed that in the first season, combinations of “Salt Creek” rootstock fertilized with 40N+80 K kg/fed (T4) and in the second season, “Salt Creek” rootstock fertilized with 40N+60 K kg/fed (T3) gave the highest positive effect on cluster width in this respect.

Data present in Table (4) indicated that berry firmness revealed that “Salt Creek” rootstock increased berry firmness as compared with “Freedom” rootstock in both seasons. In the first season, vine fertilizers with 40N+80 K kg/fed

TABLE 3. Effect of rootstocks and varying levels of Nitrogen and Potassium of Early Sweet grape On yield and Number of shot berries during (2017 and2018)

	Cluster number /vine			Cluster weight (g)			Yield (kg) /vine			Number of shot berries%		
	2017 season											
Actual (N + K) (kg/ feddan)	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**
T1 (30N+45K)	39.00cb	36.25ce	**37.62B**	349.20cd	359.70ad	**354.51D**	13.62ce	13.25fe	**13.43CD**	16.75ab	18.75a	**17.75A**
T2 (30N+60K)	38.75bd	36.25ce	**37.53B**	354.50bd	365.20ac	**359.87BD**	13.72ce	13.27fe	**13.51C**	15.75bc	16.75ab	**16.25A**
T3 (40N+60K)	39.25b	36.73be	**38.00B**	345.00d	362.00 ac	**353.50D**	13.60ce	13.27fe	**13.43CD**	11.25f	13.75ce	**12.50B**
T4 (40N+80K)	46.00a	38.00be	**42.00B**	344.50d	372.10 a	**358.25CD**	15.65a	14.20b-d	**1492A**	12.00ef	12.00ef	**12.00CB**
T5 (50N+75K)	39.50b	37.25be	**38.37B**	371.70a	372.00 a	**371.80A**	14.72b	13.85c-e	**14.28B**	8.75g	13.00df	**10.87C**
T6 (50N+100K)	39.25b	36.00df	**37.62B**	364.70ac	371.00 a	**367.75AC**	14.35cb	13.47de	**13.91CB**	9.00g	12.25fe	**10.62C**
Control	35.50ef	33.25f	**34.36C**	372.50a	367.20ab	**369.87AB**	13.25ef	12.50f	**12.87D**	12.00ef	14.50cd	**13.25B**
Mean	**39.60A/**	**36.25B/**		**357.٤B/**	**367.0 A/**		**14.13A/**	**13.40B/**		**12.21B/**	**14.42A/**	
	2018 season											
T1 (30N+45K)	43.88b	36.09c	**39.96 B**	383.75bf	372.50cf	**378.13BC**	16.84ab	13.65cd	**15.24A-C**	18.71a	19.50cd	**13.87CD**
T2 (30N+60K)	38.27bc	30.41d	**34.32 C**	412.00ab	400.0 ad	**406.00A**	15.77ac	12.35d	**14.06BC**	16.65ab	17.25cd	**12.00C**
T3 (40N+60K)	35.28c	31.63d	**33.45 C**	417.50 a	355.00 f	**386.25AC**	14.73ad	12.22d	**13.48C**	14.50cd	23.00ab	**17.00AB**
T4 (40N+80K)	47.35a	39.31bc	**43.33AB**	363.25ef	363.75df	**363.50C**	17.20a	14.30bd	**15.57AB**	13.00df	25.50a	**15.12A-C**
T5 (50N+75K)	44.42ab	36.62c	**40.52AB**	373.00cf	376.00bf	**374.50BC**	16.57ab	13.77cd	**15.17A-C**	12.25fe	19.25cd	**14.87A-C**
T6 (50N+100K)	44.19ab	35.41c	**39.80B**	381.00bf	403.75 ac	**392.38AB**	16.84ab	14.30bd	**15.57BA**	14.50cd	17.75cd	**1488A-C**
Control	44.42ab	43.03b	**43.72A**	377.50af	392.50ae	**385.00AC**	16.77ab	16.52ab	**16.64A**	15.75bc	20.75ac	**17.50A**
Mean	**42.54 A/**	**31.74B/**		**386.8A/**	**380.5A/**		**16.39A/**	**13.89B/**		**14.42A/**	**20.42A/**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level

(T4) gave a high positive effect on berry firmness as compared with other treatments. In the second season, vines were fertilized with 50N+75 K kg/fed (T5), 50N+100 K kg/fed (T6) and 60N+120 K kg/fed (T7) giving a similar and high positive effect on berry firmness as compared with other treatments.

The interaction between rootstocks and nitrogen plus potassium fertilization showed that in the first season, the combination of "Salt Creek" rootstock fertilized with 40N supported with 80 K kg/fed (T4) provide to be the most efficient treatment in this respect. In the second season, the combination of "Salt Creek" rootstock fertilized with 50N+75 K kg/fed (T5) and 60N+120 K kg/fed (T7) gave a similar hence stretch high positive effect on berry firmness as compared with combinations.

Data present in Table (4 indicates that in the first season there is no significance between the two rootstocks but in the second season, the "Salt Creek" rootstock increased berry adherence strength as compared with the "Freedom" rootstock. In the first season, vine fertilizers with 50N+75 K kg/fed (T5) gave a higher significant value than control only. However, in the second season, all treatments had no significant effect on berry adherence strength in this concern. The interaction between rootstocks and nitrogen plus potassium fertilization showed that in the first season, combinations of "Salt Creek" rootstock fertilized with 40N supported with 80 K kg/fed (T4) and "Freedom" rootstock fertilized with 50N+75 K kg/fed (T5) exerted similarly and the highest values as compared with other combinations in this respect. However, in the second season, "Salt Creek" rootstock fertilized with 50N+100 K kg/fed (T6) proved to be the superior combination in this concern.

Effect of rootstocks and varying levels of Nitrogen and Potassium on fruit chemical characteristics

Data present in Table (5) demonstrates that in the first season, there was no significant effect between the two rootstocks on TSS but in the second season, the "Salt Creek" rootstock induced a positive effect on TSS than the "Freedom" rootstock. In the first season, there is no significant differential effect on TSS but in the second season, vines fertilizes with30 kg N/fed supported with 45 kg K/fed and 40 kg N/fed supported with 80 kg K/fed (T4) induced the highest positive effect on TSS. The interaction between rootstocks and

TABLE 4. Effect of rootstock and varying levels of Nitrogen and Potassium of Early Sweet grape on berries physical characteristics during (2017 and 2018)

	Cluster length (cm)			Cluster width (cm)			Berry adherence strength (g/cm²)			Berry firmness (g/cm)²		
	2017 season											
Actual N +K (kg/feddan)	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**
T1 (30N+45K)	21.25ac	19.70c	**20.47AB**	10.87ef	10.90ef	**10.88D**	1115.0b	994.0b	**1054.5AB**	763.73cd	718.75ce	**741.25CD**
T2 (30N+60K)	21.40ac	21.00ac	**21.20AB**	10.67f	11.50be	**11.08CD**	1080.0b	1032.3b	**1056.1AB**	748.75cd	698.20de	**723.51BD**
T3 (40N+60K)	21.50ac	22.00a	**21.75A**	11.50b-e	11.55ae	**11.52BC**	1053.0b	1028.8b	**1040.6AB**	819.25ab	702.00ce	**760.63AB**
T4 (40N+80K)	20.55ac	20.00bc	**20.27B**	12.27a	11.90ac	**12.87A**	1157.5a	1024.8b	**1091.1AB**	843.25a	746.20cd	**794.75A**
T5 (50N+75K)	21.07ac	21.75ab	**21.41AB**	11.67a-d	11.00df	**11.33BC**	1027.0b	2198.3a	**2112.6A**	747.00cd	700.00ce	**723.50BD**
T6 (50N+100K)	21.15ac	21.12ac	**21.13AB**	11.97a-c	11.55ae	**11.76AB**	1003.3b	992.5b	**997.9bA**	723.70ce	692.70de	**708.25CD**
Control	21.75ab	20.50ac	**21.12AB**	12.05ab	11.25cf	**11.65AB**	955.8b	885.8b	**920.8B**	699.50ce	670.20e	**684.88D**
Mean	**21.23A′**	**20.86A′**		**11.57A′**	**11.37A′**		**1055.9A′**	**1308.0A′**		**763.6A′**	**704.0B′**	
	2018 season											
T1 (30N+45K)	19.52c-f	19.50cf	**19.51CD**	11.45ce	11.25ce	**11.35B**	1086.5ac	997.5d	**1042.0A**	690.00bc	684.50c	**690.25B**
T2 (30N+60K)	21.17a-c	22.00a	**21.58A**	12.90ab	12.00bd	**12.45A**	1037.0ad	1049.2ad	**1043.1A**	843.75ac	672.50c	**758.13AB**
T3 (40N+60K)	21.45ab	20.25cf	**20.85AB**	13.27a	10.50e	**11.88AB**	1087.7ac	1000.7cd	**1044.2A**	819.25ac	737.75ac	**778.50AB**
T4 (40N+80K)	19.00ef	18.62f	**18.81D**	11.92bd	11.25ce	**11.52B**	1081.2ad	1001.7cd	**1041.5A**	842.00ac	727.00ac	**784.00AB**
T5 (50N+75K)	18.57f	19.50cf	**19.03D**	11.75cd	11.00de	**11.37B**	1102.7ab	1027.7ad	**1065.2A**	899.50a	764.25ac	**831.88A**
T6 (50N+100K)	19.25d-f	20.50ae	**19.87BD**	12.20ac	11.75cd	**11.37B**	1112.0a	997.7cd	**1054.8A**	881.75ab	784.00ac	**832.87A**
Control	20.12b-f	20.87ad	**20.50A-C**	11.37ce	11.37ce	**11.35B**	1092.5ab	1021.5bd	**1057.0A**	894.75a	796.50ac	**845.53A**
Mean	**20.17A′**	**19.87A′**		**12.12A′**	**11.28B′**		**1085.٧A′**	**1013.7B′**		**837.٦A′**	**737.٩B′**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

nitrogen plus potassium fertilization showed that in the first season, combinations of “Salt Creek” rootstock fertilized with 60N + 120 K kg/fed (T7) and in the second season, “Salt Creek” rootstock fertilized with 30N + 45 K kg/fed (T1) proved to be the superior combinations in this concern.

Data present in Table (5) indicates that in the first season, “Salt Creek” rootstock induced a reduction effect on acidity than “Freedom” rootstock. In the second season, there was no significant difference effect between the two rootstocks. In the first season, the treatment 40N + 80 K kg/fed (T4) induced the highest reduction effect on acidity but in the second season, there was no significant differential effect on acidity. The interaction between rootstocks and nitrogen plus potassium fertilization showed that in the first season, combinations of “Salt Creek” rootstock fertilized with 40N+80k kg/fed (T4) and in the second season, combinations of “Salt Creek” rootstock fertilized with 40N+80K kg/fed (T4) gave high positive reduction effect

Data present in Table (5) results proved that in the first season, there was no significant effect between two rootstocks on TSS/acid ratio but in the second season, “Salt Creek” rootstock induced a positive effect on TSS/acid ratio than “Freedom” rootstock. In the first season, vine fertilizers with 40N+80K kg/fed (T4) induced the highest positive effect on TSS/acid ratio but in the second season, there was no significant differential effect on TSS/acid ratio. The interaction between the two factors showed that in the first season, combinations of “Salt Creek” rootstock fertilized with 40N + 80K kg/fed (T4) and in the second season, “ Salt Creek “ rootstock fertilized with 40N+80K kg/fed (T4) and 50N+75 K kg/fed (T5) induced the highest values than other combinations.

TABLE 5. Effect of rootstock and varying levels of Nitrogen and Potassium of Early Sweet grape on fruit chemical characteristics during (2017 and2018)

	TSS (%)			Acidity (%)			TSS/acid ratio		
	2017 season								
Actual N + K (kg/feddan)	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**
T1 (30N+45K)	13.83b	13.88b	**13.85a**	0.387cb	0.380cb	**0.383b**	35.70bd	36.57bc	**36.13b**
T2 (30N+60K)	14.18b	13.63b	**13.90a**	0.370cb	0.395b	**0.382bc**	38.32ac	34.50bd	**36.41ab**
T3 (40N+60K)	14.13b	14.13b	**14.08a**	0.377cb	0.375cb	**0.376bd**	37.40ac	37.55ac	**37.47ab**
T4 (40N+80K)	14.58b	14.15b	**14.37a**	0.340d	0.375cb	**0.357d**	42.85a	37.45ac	**40.15a**
T5 (50N+75K)	14.30b	14.20b	**14.25a**	0.360cd	0.365cd	**0.362cd**	39.90ab	38.95ab	**39.42ab**
T6 (50N+100K)	14.18b	14.00b	**14.12a**	0.370cb	0.365cd	**0.367bd**	38.27ac	38.67ac	**38.47ab**
Control	15.38a	13.73b	**14.20a**	0.380cb	0.430a	**0.405a**	30.75d	33.37dc	**32.06c**
Mean	**18.07A/**	**13.95A/**		**0.369B/**	**0.383A/**		**37.6A/**	**36.7A/**	
	2018 season								
T1 (30N+45K)	14.60a	13.87cd	**14.23ab**	0.378b	0.335b	**0.356a**	38.75b	40.55b	**39.65a**
T2 (30N+60K)	24.20ac	13.67d	**13.93ac**	0.350b	0.328b	**0.339a**	40.82b	38.42b	**39.62a**
T3 (40N+60K)	14.15ad	13.72cd	**13.93ac**	0.350b	0.345b	**0.348a**	41.45b	39.25b	**40.35a**
T4 (40N+80K)	14.57ab	13.97cd	**14.23ab**	0.300b	1.26a	**0.437a**	48.70a	38.57b	**43.63a**
T5 (50N+75K)	13.67d	14.07bd	**13.87c**	0.318b	0.360b	**0.339a**	43.0ba	38.97b	**40.98a**
T6 (50N+100K)	13.58cd	13.92cd	**13.88bc**	0.335b	0.367b	**0.351a**	42.32b	37.57b	**39.95a**
Control	13.65d	13.80cd	**13.72c**	0.363b	0.330b	**0.346a**	38.22b	41.20b	**39.65a**
Mean	**14.10A/**	**13.86B/**		**0.342A/**	**1.61A/**		**41.89A/**	**39.22B/**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

The obtained results of nitrogen supported with potassium fertilization regarding their positive effect on yield and fruit quality are in harmony with the findings of Christensen and Peacock (2000) they found that nitrogen fertilization divided into split parts can improve the production either in terms of yield and quality of the grape. Moreover, Grechi et al. (2007) mentioned that grapevine fertilized with nitrogen had a positive effect on yield and quality. Furthermore, a high rate of nitrogen fertilization induces the vigor of the grapevine and reduces the quality of grapes. In addition, grapevine required ranged nitrogen from 27 to 120 kg/ha for the growth shoots and fruits seasonally (Treeby and Wheatley, 2006; Schreiner et al., 2006; Pradubsuk and Davenport, 2010 and Williams, 2017).

In this respect, Potassium is the major element related to berry ripeness and its concentration in grapes is related to the must acidity and potassium involved in sugar transport. It also increased the total soluble solids content and decreased the total acidity of berries (Esteban et al., 1999; Mpelasoka et al., 2003 and Martin et al., 2004). However, Mpelasoka et al. (2003) mentioned that high potassium fertilization has a negative effect on fruit quality. In addition, "Crimson Seedless" grape fertilization with three nitrogen rates (24, 36, 48 kg/ha.) combined with three potassium levels (240, 285, 330 kg/ha). Fertilization with nitrogen combined with potassium enhanced vegetative growth parameters, cluster weight, cluster size, berry size, weight, and juice, however, it reduced berry firmness. However, vine fertilized with a high rate of nitrogen induced a negative effect on yield because it decreased the number of buds burst and fruitfulness. In addition, the vine fertilized with potassium increased total TSS and reduced acidity (Abd El-Razek et al., 2011).

The obtained results of rootstocks regarding their positive effect on yield and fruit quality are in harmony with the findings of Walker et al. (2000) they indicated that grape grafted on rootstocks led to an increase in TSS and a decrease in total acidity. This result is very important to early harvesting and increases the total return coming in export. Furthermore, Colapietra (2003) demonstrated that the "Superior" grape grafted on Freedom rootstock or Salt Creek rootstock gave the highest values of weight and size of the berry fruit. Moreover, In this respect, Gaser (2007) found that "Superior seedless" grapevines grafted on Dog Ridge and /or Salt Creek increased yield/vine than those grafted on Freedom rootstock. That is confirmed by El-Gendy (2013) found that Flame seedless cv. grafted on Salt creek or Freedom rootstocks improved yield and fruit quality as compared with engrafted vines. Whereas Freedom rootstock enhanced the coloring and maturity of berries and it gave economic crop.

Effect of rootstocks and varying levels of Nitrogen and Potassium on macronutrients contents:

Data present in Table (6) indicates that in the first season, there was no significant effect between the two rootstocks on nitrogen concentration but in the second season, the "Freedom" rootstock induced a positive effect on nitrogen concentration of petiole than "Salt Creek" rootstock. In the first season, vine fertilizers with 60N+100k kg/fed (T7) induced the highest positive effect on nitrogen concentration. In the second season, vine fertilizers with 50N+100K kg/fed (T6) and 60N+120k kg/fed (T7) gave the highest values of nitrogen concentration as compared with other treatments. The interaction between the two factors showed that in the first season, combinations of both "Salt Creek" rootstock or "Freedom" rootstock fertilized with 60N + 120 K kg/fed (T7) and in the second season, "Freedom" rootstock fertilized with 60N + 120 K kg/fed (T7) induced the highest values than other combinations.

Data present in Table (6) indicates there is no significant effect between rootstocks on phosphorus concentration in both seasons. In the first season, vine fertilization with 50N+100K kg/fed (T6) induced the highest positive effect on phosphorus concentration of petiole but in the second season, vine fertilization with 40N+60K kg/fed (T3) gave the highest values of phosphorus concentration of petiole. The interaction between the two factors showed that in the first season, combinations of both "Salt Creek" rootstock and "Freedom" rootstock fertilized with 50N+100K kg/fed (T6) and in the second season, "Salt Creek" rootstock fertilized with 40N + 60K kg/fed (T3) gave a pronounced effect on leaf petiole phosphorus concentration than other combinations in this concern

Data present in Table (6) reveals that "Freedom" rootstock induced a positive effect on potassium concentration than "Salt Creek" rootstock in both seasons. The treatment 60N+120k kg/fed (T7) proved to be the superior treatment in this concern in increased potassium concentration in both seasons. The interaction between the two factors showed that in the first season, combinations of both "Salt Creek" rootstock and "Freedom" rootstock fertilized with 60N + 120 K kg/fed (T7) and in the second season, "Freedom" rootstock fertilized with 60N + 120 K kg/fed (T7) exerted the highest positive effect on potassium concentration of petiole than other combinations in this concern. Data present in Table (6) indicates that there is no significant effect between rootstocks on the calcium concentration of leaf petiole in both seasons. In the first seasons, the treatments fertilizes with 40N+80K kg/fed (T4), 50N+75 K kg/fed (T5) and 60N+120k kg/fed (T7) gave a similar high positive effect on calcium concentration as compared with other treatments. And in the second season, the treatments fertilizes with 40N+80K kg/fed (T4) and 50N+75 K kg/fed (T5) gave similarly and the highest values in this respect.

The interaction between two factors showed that in the first season, combinations of both "Freedom" rootstock fertilized with 60N + 120K kg/fed (T7) proved to be a superior combination in this concern. However, in the second season, "Freedom" rootstock fertilized with 40N+60K kg/fed (T3), 40N+80K kg/fed (T4) as well as "Salt Creek" rootstock fertilized with 50N+75 K kg/fed (T5) gave similarly and the highly significant effect on calcium concentration of petiole than other combinations in this concern.

Effect of rootstocks and varying levels of Nitrogen and Potassium on micronutrients contents:

Data present in Table (7) the first season, there was no significant effect between the two rootstocks on iron concentration but in the second season, the "Freedom" rootstock gave a significant effect on iron concentration than the "Salt Creek" rootstock. In the first seasons, the treatments 40N+80K kg/fed (T4) and 60N+120k kg/fed (T7)

TABLE 6. Effect of rootstock and varying levels of Nitrogen and Potassium of Early Sweet grape on macronutrients contents during (2017 and2018)

	Nitrogen (%)			Phosphorus (%)			Potassium (%)			Calcium (%)		
	2017 season											
Actual N + K (kg/feddan)	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**
T1 (30N+45K)	0.76e	0.75e	**0.75E**	0.21ce	0.20e	**0.20C**	0.78e	0.79e	**0.78E**	1.33ef	1.16f	**1.24C**
T2 (30N+60K)	0.83de	0.84de	**0.83E**	0.19e	0.19e	**0.19C**	0.85e	0.88e	**0.86DE**	1.50cf	1.30f	**1.41CB**
T3 (40N+60K)	0.93cd	0.95cd	**0.94D**	0.21ce	0.20de	**0.20C**	0.90e	0.93e	**0.93DE**	1.73ad	1.50cf	**1.61AB**
T4 (40N+80K)	0.99bc	0.99bc	**0.99CD**	0.24be	0.26ac	**0.25B**	1.43d	1.70cd	**1.56C**	1.76ad	1.90ac	**1.83A**
T5 (50N+75K)	1.06a-c	1.06ac	**1.06BC**	0.27ab	0.25a-d	**0.26AB**	0.95e	1.06e	**1.01D**	1.56cf	1.90ac	**1.73A**
T6 (50N+100K)	1.10ab	1.09ab	**1.09AB**	0.29a	0.29a	**0.29A**	1.66bc	1.90bc	**1.78B**	1.46df	1.94ab	**1.70AB**
Control	1.16a	1.16a	**1.16A**	0.26ac	0.26ab	**0.26AB**	2.03a	2.26a	**2.15A**	1.56cf	2.10a	**1.83A**
Mean	**0.97A/**	**0.98A/**		**0.24A/**	**0.23A/**		**1.23B/**	**1.36A/**		**1.56A/**	**1.68A/**	
	2018 season											
T1 (30N+45K)	0.60g	0.68d-f	**0.63E**	0.27b	0.28b	**0.27B**	0.63f	0.69ef	**0.66D**	1.16c	1.46a-c	**1.31B**
T2 (30N+60K)	0.61g	0.65f	**0.64E**	0.25b	0.23b	**0.24B**	0.63f	0.70ef	**0.67D**	1.50ac	1.46a-c	**1.48AB**
T3 (40N+60K)	0.67ef	0.67ef	**0.67D**	0.64a	0.29b	**0.46A**	0.71ef	0.71ef	**0.71D**	1.33bc	1.76a	**1.55AB**
T4 (40N+80K)	0.71c	0.70cd	**0.71C**	0.31b	0.29b	**0.30AB**	0.86de	0.85df	**0.85C**	1.63ab	1.76a	**1.70A**
T5 (50N+75K)	0.77ab	0.76b	**0.77B**	0.31b	0.30b	**0.30AB**	0.87de	0.86df	**0.87C**	1.73a	1.66ab	**1.70A**
T6 (50N+100K)	0.79ab	0.79ab	**0.79A**	0.29b	0.28b	**0.28B**	0.99cd	1.26b	**1.13B**	1.50ac	1.53a-c	**1.51AB**
Control	0.79ab	0.79a	**0.79A**	0.30b	0.28b	**0.29AB**	1.16bc	1.63a	**1.40A**	1.46ac	1.46a-c	**1.46AB**
Mean	**0.70B**	**0.72A/**		**0.34A/**	**0.28A/**		**0.84B/**	**0.96A/**		**1.47A/**	**1.59A/**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

gave a similar and high positive effect on iron concentration to other treatments. However, in the second season, the treatment 40N+80K kg/fed (T4) proved to be the superior treatment in this concern. Data present in Table (7) the first season, there was no significant effect between the two rootstocks on zinc concentration of petiole but in the second season, the "Freedom" rootstock gave a significant effect on zinc concentration than the "Salt Creek" rootstock. In the first seasons, 60N+120k kg/fed (T7) gave the lowest values in this concern. However, in the second season, there was no significant differential effect on zinc concentration. However, in the second season, all combinations induced a high positive effect on zinc concentration except the combination of "Salt Creek" rootstock fertilized 40N+60K kg/fed (T3) gave the lowest values in this concern.

Data present in Table (7) indicates that in the first season, "Freedom" rootstock induced a positive effect on manganese concentration of petiole than "Salt Creek" rootstock but in the second season, there was no significant effect between to rootstocks. In the first season, Vine fertilizes with 30N+60 K kg/fed (T2) gave the highest manganese concentration of petiole and in the second season, 40N+80K kg/fed (T4) and 50N+100K kg/fed (T6) gave similar and high positive effect on manganese concentration of petiole than other treatments. These results are in harmony with those found by Rühl (2000) mentioned that Freedom rootstock enhanced the leaf nutrient status of grape grafted and it gave the highest potassium concentration in the leaf of grape grafted. Furthermore. This was also confirmed by Abo EL-Wafa (2003) who found that Salt Creek and other rootstocks increased leaf nitrogen, phosphorus and potassium content of "Roumi Red" grape grafted. So this investigation was conducted to enhance yield, fruit quality and mineral content of newly grape cultivar "Early sweet" by determining the suitable application level from each nitrogen and potassium fertilizer as well as the suitable rootstock from two rootstocks "Salt creek" and "Freedom" with the possibility to select the best combination between fertilizer application and rootstock.

TABLE 7. Effect of rootstock and varying levels of Nitrogen and Potassium of Early Sweet grape on micronutrients contents during (2017 and2018)

	Zinc (ppm)			Iron (ppm)			Manganese (ppm)		
2017 season									
Actual N +K (kg/feddan)	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**	**Salt Creek**	**Freedom**	**Mean**
T1 (30N+45K)	40.66a	42.66a	**41.66AB**	51.66e	53.33de	**52.50C**	72.33de	75.66bc	**74.00A-C**
T2 (30N+60K)	41.66a	44.38a	**43.00A**	53.33de	54.33ce	**53.83bC**	73.33ce	80.00a	**76.66A**
T3 (40N+60K)	42.33a	42.00a	**42.16bA**	56.66ae	51.66e	**54.16bC**	72.00de	77.60ab	**74.83AB**
T4 (40N+80K)	42.66a	44.50a	**43.66A**	62.66a	58.33ae	**60.50A**	74.66bd	77.33ac	**76.00AB**
T5 (50N+75K)	42.45a	28.66b	**43.33A**	55.00be	61.66ab	**58.33AB**	70.66e	77.30ac	**74.00A-C**
T6 (50N+100K)	42.40a	44.00a	**40.33AB**	61.00ac	55.00be	**58.00AB**	71.66de	71.66de	**71.66C**
Control	40.00a	40.00a	**35.50B**	60.00ad	61.00ac	**60.50a**	73.33c-e	73.33ce	**73.50CB**
Mean	**41.85A/**	**40.90A/**		**57.19A/**	**56.47A/**		**72.57B/**	**76.19A/**	
2018 season									
T1 (30N+45K)	42.66a	48.00a	**45.33A**	61.66c	65.00bc	**63.33AB**	77.33a-c	74.33b-d	**75.83AB**
T2 (30N+60K)	41.66a	46.00a	**43.83A**	61.33c	69.00ab	**65.16AB**	71.00d	45.00a-d	**73.00B**
T3 (40N+60K)	29.66b	49.66a	**39.66A**	61.30c	63.66c	**62.50B**	76.00a-c	71.00d	**73.50B**
T4 (40N+80K)	45.33a	44.33a	**44.83A**	62.66c	70.60a	**66.50A**	79.66a	76.00ac	**77.83A**
T5 (50N+75K)	44.33a	43.00a	**43.66A**	61.66c	64.33bc	**63.00B**	75.00ad	70.33d	**72.66B**
T6 (50N+100K)	45.00a	46.66a	**45.83A**	63.00c	64.32bc	**62.83B**	79.00ab	77.66a-c	**78.33A**
Control	45.00a	48.33a	**46.66A**	62.00c	64.33bc	**63.00B**	73.33cd	78.33ab	**75.83AB**
Mean	**41.95B/**	**46.57A/**		**61.85B/**	**65.66A/**		**75.90A/**	**74.66A/**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

Conclusion

Shortly, the results showed that “Salt Creek” rootstock induced a significant effect on cluster number/vine, yield, berries firmness, cluster width, TSS, acidity, and TSS/acid ratio, compared with “Freedom” rootstock.

Furthermore, “Freedom” rootstock gave a positive effect on Cluster weight, and leaf petiole potassium, iron, zinc and manganese content as compared with “Salt Creek” rootstock. In this respect, increasing nitrogen supported with potassium led to enhanced yield and fruit quality. Moreover, high rates of fertilization reduced yield and decreased fruit quality of the Early Sweet grape. Finally, 40N+80K kg/fed (T4) improved yield, berries firmness, cluster width, and TSS/acid ratio it also increased leaf petiole calcium, magnesium and iron content. it could be recommended that “Salt Creek” rootstock fertilized with 40N+80K kg/fed (T4) improved yield/vine, and fruit quality i.e. berries firmness and berry adherence strength, number of shot berries, acidity, TSS and TSS/acid ratio. Finally, it could by safely recommended by, Early Sweet grapevines grafted on Salt creek rootstock fertilized with 40kg N/fed plus 80kg K/fed proved to be most efficient effect application on yield and fruit quality.

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Conflicts of interest

There were no conflicts of interest during this work

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تأثيرات أصول الجذر على المحصول ونوعية الثمار والحالة التغذوية للعنب "الحلو المبكر" المخصب بمستويات متفاوتة من النيتروجين والبوتاسيوم

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أجريت هذه الدراسة خلال موسمي ٢٠١٧ و ٢٠١٨ على كرمات عنب صنف ايرلى سويت مطعوم على اصليين سولت كريك وفريدم فى تربة رملية طميية على مسافات زراعة ٢×٣ تحت نظام الري بالتنقيط فى مزرعة خاصة بطريق مصر اسكندرية الصحراوى الكيلو ٥٠ حيث كان الهدف من التجربة هو دراسة تاثير مستويات من النتروجين والبوتاسيوم مع اصليين سولت كريك وفريدم وتأثيرهما على المحتوى المعدنى للأوراق والمحصول وجوده الثمار فى العنب صنف أيرلي سويت. وصممت هذه التجربة فى قطع منشقة بحيث كانت الأصول فى القطع الرئيسية وكانت السبعة معاملات من النتروجين والبوتاسيوم.

٣٠كجم نتروجين + ٤٥ كجم بوتاسيوم

٣٠ كجم نتروجين + ٦٠ كجم بوتاسيوم

٤٠ كجم نتروجين + ٦٠ كجم بوتاسيوم

٤٠ كجم نتروجين + ٨٠ كجم بوتاسيوم

٥٠ كجم نتروجين + ٧٥ كجم بوتاسيوم

٥٠ كجم نتروجين + ١٠٠ كجم بوتاسيوم

المقارنة (٦٠ كجم نتروجين + ١٢٠ كجم بوتاسيوم)

فى القطع تحت فرعية، وقد أظهرت النتائج أن المستويات المرتفعة من الأسمدة النيتروجينية أدت الى قلة في مواصفات الجودة والمحصول وكان العنب الإيرلى سويت المطعوم على الاصل سويت كريك أفضل من حيث مواصفات الجودة والمحصول وكانت المعاملة الرابعة (٤٠ وحدة نتروجين + ٨٠ وحدة بوتاسيوم) هى أفضل المعاملات من حيث مواصفات الجودة والمحصول ومحتوى العناصر.