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Evaluation of Flame Seedless Grapevines Grafted on Some Rootstocks

Rafaat S.S. El-Gendy

Department of Vitic. Hort. Res. Instit. Agric. Res. Center, Giza, Egypt

Abstract: The current investigation was conducted during the two successive seasons of 2011 and 2012 on six years old vines in a private vineyard at Cairo - Alexandria Desert Rood where soil was sandy. Vines of Flame Seedless cv. grafted on either Salt Creek or Freedom rootstocks, in addition to own-rooted vine to evaluate their effects on growth, fruit quality, yield and growth rate of roots. The vines were almost in similar vigor and supported by Gable system, spaced at 2 x 3 meters apart, were irrigated and fertilized through the fertigation system. The double cordon system was used where bud load was 70 / vine (35 fruiting spurs x 2 buds each). The tested vines were nearly the same and subjected to the normal horticultural practices. The results showed that rootstocks had a positive impact on the yield and its components, ensuring the best physical properties of clusters, improving the physical and chemical characteristics of berries,. Freedom rootstock proved to be superior and recorded the highest percentage of TSS, TSS / acid ratio and anthocyanin content of berry skin and the lowest percentage of acidity in the berry juice. The best vegetative growth parameters were achieved by grafting (i.e. average shoot diameter, average shoot length, total leaf area / vine and coefficient of wood ripening). It was also increased leaf content of total chlorophyll as well as cane content of total carbohydrates. Concerning leaf mineral content of flame seedless, Salt Creek rootstock had enhanced nitrogen and phosphorous uptake, but had an intermediate performance potassium uptake. Whereas, Freedom rootstock ranked among the highest efficient stocks in potassium uptake.As for root growth parameters, grafting gave the highest values of white and fibrous roots (brown roots), whereas, Flame Seedless vines on their own roots gave the least values. Similarly to the mentioned results clearly show that stomata density and dimension had a positive response to grafting especially grafting Flame Seedless cv. onto Freedom rootstock induced larger stomata than either those grafting onto Salt Creek, while ungrafted vines markedly reduced number and size of stomata. Finally, Flame Seedless cv. Grafted on either Salt Creek or Freedom rootstocks achieved the best yield and fruit quality comparing to un-grafted vines, whilst, Freedom rootstock enhanced the coloring and maturity of berries to give economic crop.

Key words: Flame seedless · Grapes · Vines · Rootstock · Grafting · Salt Creek · Freedom

INTRODUCTION

Grape is an old deciduous temperate fruit crop, widespread and highly valuable horticultural vine among the most important crops in the world. Flame Seedless as a promising grapevine cultivar that grown successfully under Egypt environmental condition and has progressively developed in the last few years. Vast acreage of Flame Seedless grapevine is being cultivated in the newly reclaimed areas along the desert roads in North and Middle Egypt. Flame Seedless grapevines may be suffering under new reclaimed semi arid areas from water stress that may prevail in such environment throughout the season or from high salinity or spread of nematodes. Therefore, grafting on some rootstocks is a good solution to overcome such problems.

Rootstocks have recently gained great importance in the only consistently effective and successful strategy in major viticulture countries worldwide [1]. The importance of using rootstocks are not only as an effective means of controlling important biological pests such as phylloxera and nematodes, but they can also be used effectively to regulate nutrient exclusion, uptake of water in vines [2, 3]. However, the choice of a certain rootstock is becoming

Corresponding Author: Rafaat S.S. El-Gendy, Department of Vitic. Hort. Res. Instit. Agric. Res. Center, Giza, Egypt.

increasingly difficult as a result of the availability of numerous new rootstocks [4]. In addition, Reynolds and Wordle [5] outlined seven major criteria for rootstocks choice in the order of their importance as phylloxera resistance, nematode resistance adaptability to high pH soils, saline soils, low pH soil, wet or poorly drained soil and drought. The effects take place in a more or less indirect manner and consequences of the interactions between environmental factors and the physiology of the scion and rootstock cultivars employed. In this respect, Freedom (1613cxv.Champini) is highly resistant to phylloxera and nematodes, it renders scions more vigorous but less than Dog Ridge, it is highly resistant to drought, well adapted to acidic soils and moderate resistant to salinity. Salt Creek "Ramsey" rootstock imports great vigor to its scions. It is quite resistant to nematodes and moderately resistant to phylloxera, it is performed well in light sandy soils of low fertility, has good tolerance to salt, perform well in slightly acid and calcareous soils.

Rootstocks affect vine growth, yield and fruit quality through the interactions between the environmental factors and the physiology of scions and rootstock cultivars employed. In this respect, Hedberg *et al*. [6] found that yields of all grafted cultivars were much higher than those of own-rooted vines. Moreover, Wunderer *et al.* [7] mentioned that Gruner Veltliner grape had higher wood productivity when grafted on the three rootstocks tested (SO4, K5BB and 5C) than that of the own-rooted vines. Morano and Kliewer [8] stated that root frequencies significantly varied according to rootstock. Concerning cluster weight, berry size and soluble solids content were affected by rootstocks [9]. The level of mineral uptake differed according to rootstocks [10, 11].

The objective of this study was to evaluate the effects of grafting Flame Seedless grapevines on two rootstocks (Freedom or Salt Creek) on vegetative growth, growth rate of roots, yield and fruit quality.

MATERIALS AND METHODS

The present study was performed during 2011 and 2012 seasons on six years old Flame Seedless cv. grafted either on Freedom or Salt Creek rootstocks in comparison to Flame Seedless on own roots, acting as control, in a private vineyard at the 89th Kilometer from Cairo on Cairo - Alexandria Desert Road where soil was sandy. The vines were of almost similar vigour, supported by Gable system. Distances were 2m between vines and 3m between rows, were irrigated and fertilized through the fertigation system. The double cordon system was used where bud load was 70/vine (35 fruiting spurs x 2 buds each). The number of clusters was adjusted to 35 clusters/vine. The tested vines were nearly the same and subjected to the normal horticultural practices. Each six vines acted as a replicate and each three replicates were used for each rootstock under study. The experimental design was randomized complete block design.

The following parameters were determined to evaluate the performance of different rootstocks. Representative random samples of six cluster / vine were harvested at maturity when TSS reached about 16-17% according to Tourky *et al.* [12]. The following characteristics were measured.

The Vegetative Growth: Five current season shoot per vine (fruiting shoot) were labeled shortly after growth commencement to be measured at monthly intervals for determining growth rate (SGR) as well as the total surface area of the leaves per vines (m^2/vine) which was determined as follows:

The mean leaf area multiplied by the number of leaves/shoot by number of shoots per vine using leaf area meter, Model cl 203, USA as well as cane thickness (cm) and average shoot length (cm). Coefficient of wood ripening was calculated by dividing length of ripened part by the total length of cane [13].

Yield and Fruit Quality:

- Yield per vine (kg) was estimated after adjusting the number cluster to 35/vine.
- Average cluster weight (g).

Berry Characteristics: Average berry weight (g), average berry size (cm^3) and average berry dimensions (length and diameter) (cm) were determined.

Chemical Characteristics of Berries: Total soluble solids in berry juice (TSS) percentage were determined using hand refractometer and total titratable acidity was expressed as tartaric acid (%) according to A.O.A.C. [14]. Hence TSS / acid ratio and total anthocyanin of the berry skin (mg/100 g fresh weight) according to Husia *et al.* [15] were calculated.

Chemical Characteristics of Vegetative Growth:

- Leaf total chlorophyll content was measured by using nondestructive Minolta chlorophyll meter SPAD 502 [16].
- Leaf mineral content:

Percentage of nitrogen was determined using the modified micro-Kjeldahl method according to Pregl [17]. Percentage of Phosphorus was estimated calorimetrically according to Snell and Snell [18]. Also, percentage of Potassium was estimated photometrically according to Jackson [19].

- Cane total carbohydrates content (%):

It was determined according to Smith *et al.* [20].

Root Growth: Root growth system was studied using Minirhizotrons technique [21]. Root length measurements were estimated monthly through counting number of roots crossing grid using the equation mentioned by Tennant [22].

Root length = 0.786 x number of intercepts x grid units.

The means representing of the effect of the tested treatments were compared using New LSD method at 0.05 levels according to Senedecor and Cochran [23].

Physiological Studies

Stomata Impressions: The Xantopren method for studying plant tissue previously described by Stino *et al.* [24] was used. A negative impression of the medium portion of the lower epidermis of each leaf was taken at 10 AM while still attached to the plant. Positive impressions of the previously prepared negatives were made at the laboratory with cellidam dissolved in acetone. The transparent impressions were fixed on glass slides and examined by the use of lanameter projector microscope. The fields were examined to each slides and the number of stomata counted. The leaves which used were the mature basal 7^{th} and 8^{th} leaves.

RESULTS AND DISCUSSION

Effect of Grafting Flame Seedless Cv. On Two Rootstocks on Vegetative Growth

Total Leaf Surface Area per Vine, Cane Thickness and Average Shoot Length: Table 1 represents the effect of the tested treatments on total leaf surface area per vine of Flame Seedless cv. grafted on Freedom or Salt Creek rootstocks. The data revealed better leaf surface area per vine in contrast to ungrafted vines. Whereas, grafting on Salt Creek rootstock caused or enhanced increments in this parameter in both seasons. While own - rooted vines had the lowest values in this respect. However, grafted Flame Seedless cv. on Freedom ranked in-between. The ameliorative effect of the grafting on leaf area could be attributed to the high efficiency of the root system of rootstocks in absorbing and transporting the water and minerals via the grafted union to the shoots of Flame scion and to the favorable reciprocal relationship between scion and stock. Parallel results were obtained by Grant and Matthews [25] who found that the grape cv. Krakhuna had the largest leaf surface area per vine when it was grafted on Chasselas x Berlandieri rootstock. In addition, Colldecarrera *et al.* [26] reported that rootstocks 110 R, SO4 and 140 Ruggeri had the most vigorous scions while 110 R and 140 Ruggeri had the most productive scions. Also, Ezzahouam and Larry [27] found that the scion cultivar Italia was most vigorous on rootstocks 101 - 14 and Rupestris duLot.

Concerning shoot length, data in Table 1 disclosed that grafted Flame Seedless grapevine on Freedom or Salt Creek rootstocks are superior in this respect and enhanced of shoot length during the two studied seasons. Also, data revealed that grafted on Salt Creek, gained the highest values, whereas vines grafted on Freedom rootstock ranked second in this parameter. Meanwhile, ungrafted vines which exhibited an inhibitory effect the final gained growth.

It may be concluded that, grafting on to Salt Creek or Freedom rootstocks was beneficial at early shoot growth and attributed their effects on average total leaf surface area per vine which were mentioned before. Williams and Smith [28] observed more vegetative growth of Caberner Sauvighon, expressed in high values of bio mass on vines grafted on Arawan Rupestris Gargin rootstock with the lowest vegetative growth on st. Georg.

The same observation was also noticed by Fardossi *et al.* [29]. They found that shoot length of (Gruner Veltliner) was slower on 5 C and Fercal tout more rapid on (1103 P), 725 P and 125 AA ripening occurred earlier on1103 P, Gl and Riparia Sirbu than on the other rootstocks. It can be deduced from Table 1 that Flame vines grafted on Salt Creek or Freedom rootstocks possessed somewhat thicker canes but with no significant differences between them and ungrafted vines.

Table 1: Effect of two rootstocks on total leaf surface area per vine (m^2), cane thickness (cm) and average shoot length (cm) during 2011 and 2012 seasons

	1st season				2nd season			
Rootstocks	Leaf Surface area / vine (cm^2)	Cane thickness (cm)	Average shoot length (cm)	Coefficient of wood ripening	Leaf Surface area / vine (cm^2)	Cane thickness (cm)	Average shoot length (cm)	Coefficient of wood ripening
Salt Creek	22.85	1.2	255.77	0.92	24.26	1.3	263.51	0.96
Freedom	19.70	1.0	246.96	0.89	21.61	1.1	250.25	0.92
Flame on own roots	15.55	0.96	238.53	0.80	17.89	0.98	241.60	0.84
New LSD at 5%	3.10	0.26	7.81	0.02	2.33	0.39	10.89	0.03

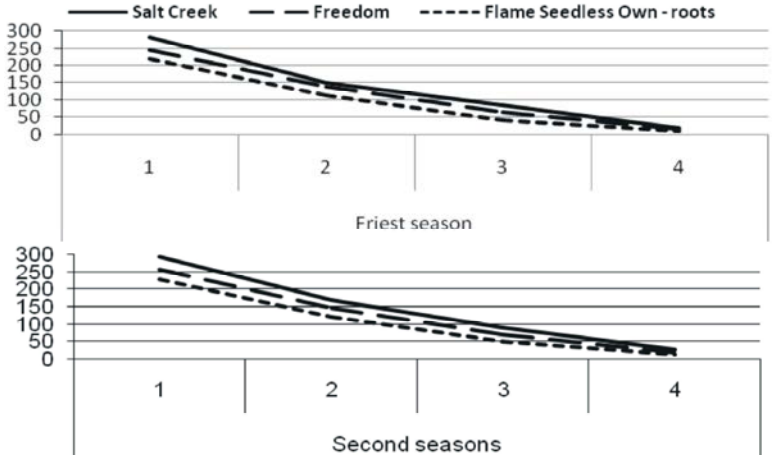

Fig. 1: Effect of grafting flame seedless cv. On to roorstock on shoot growth rate (%) (SGR) during 2011 and 2012 season. Date 1 (10/3-10/4), Date 2 (10/4-10/5), Date 3 (10/5-10/6) and Date 4 (10/6-10/7).

Shoot Growth Rate (SGR): As shown in Fig. 1, data revealed a reduction is shoot growth rate (SGR) of the ungrafted Flame Seedless grapevines. While, grafting Flame Seedless cv. on Freedom or Salt Creek rootstock was more effective at the advanced stage of growth rate. Grafting on to Salt Creek was beneficial at early shoot growth and recorded the highest values, followed in a descending order by those grafted on to Freedom which had intermediate values, while own - rooted vines were found to recorded the lowest values in the two seasons of the study.

Also, it is obvious that growth rate of current shoot was raised and improved through the first period of growth during the two studied seasons. This rapid increase of shoot growth may be attributed to be reserved carbohydrates stored in dormant. Meanwhile a sharp decrease occurred during the second period and continued till it reached least value at the last period. It is noticeable that, the sharp decrease in this parameter was observed during the second period was coincided with the approach of blooming time and during the last period may be ascribed to the lessening of competition between shoot growth and cluster growth in favor of the later. Similar results were obtained by prior studies [30, 31].

Wood Ripening: Data dealing with dynamics of wood ripening are presented in Table 1. Generally, the data showed that ungrafted Flame cv. resulted in remarkable reduction in wood ripening for both seasons. On the other hand, it can be observed that Salt Creek rootstock was more effective in this respect and induced earlier or faster wood ripening followed by Freedom rootstock. The present results are in agreement with those obtained by Wunderer *et al.* [7] who mentioned that Gruner Veltliner grape had a higher wood productivity when grafted on three rootstocks tested (So_4, K_5 BB and 5C) than of the own - rooted vines.

Effect of Grafting Flame Seedless Cv. On Two Rootstocks on Growth Rate of Roots: Fig. 2 illustrates root growth rate (cm / tube / month) of newly developed roots (white root) during observation dates (Jan. - Dec.) effect grafted Flame Seedless grapevine on different rootstocks (Salt Creek or Freedom) and ungrafted vines. Generally, root development of both rootstocks disclosed two growth cycles during both seasons of study, a smaller one occurring after growth beginning in spring and lasted for 2 months during March and April with a remarkable peak in April. Grafting Flame Seedless cv. on to Salt Creek

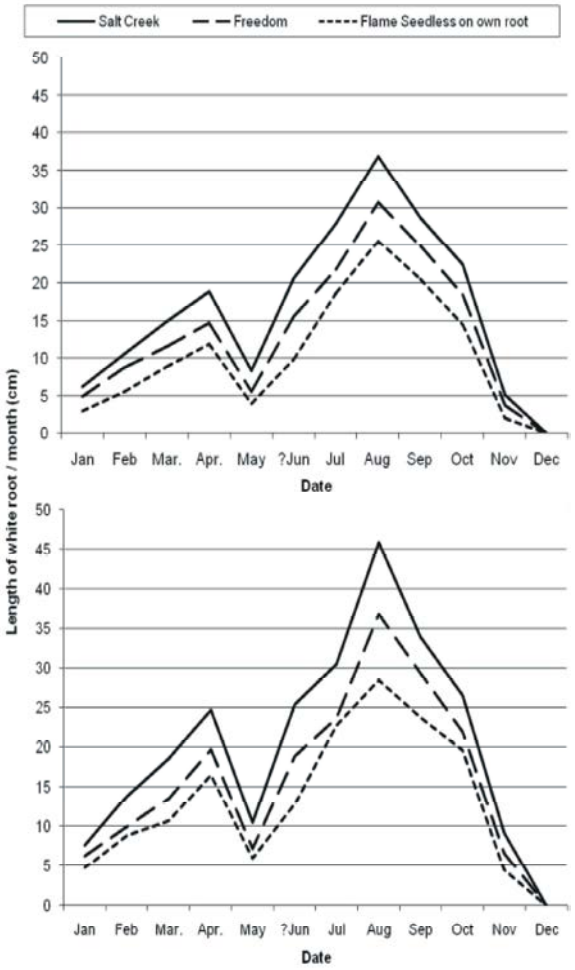

Fig. 2: Effect of two roorstock on white roots (cm/tube/month) of Flame seedless scion cultivar during 2011 and 2012 season.

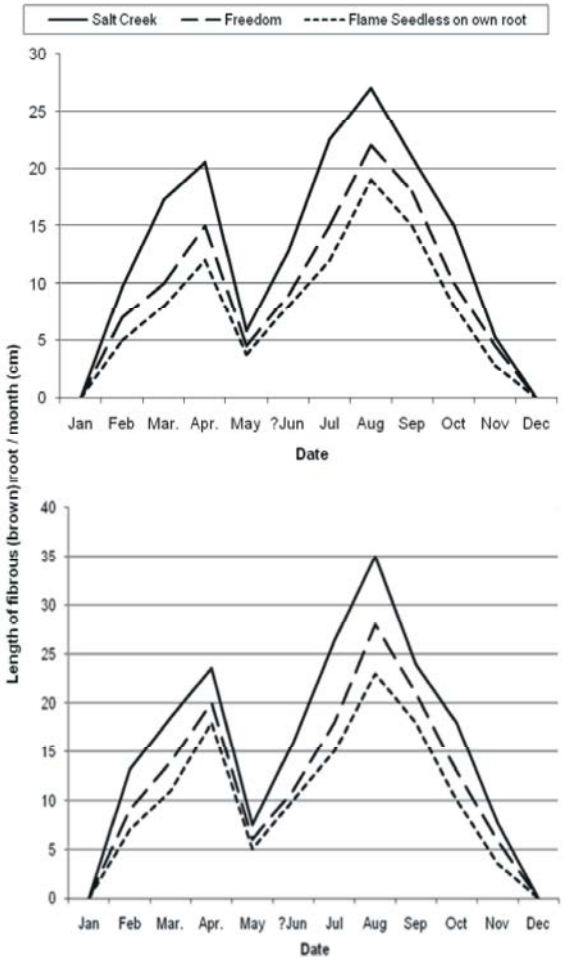

Fig. 3: Effect of two roorstock on fibrous (Brown) root (cm/tube/month) of Flame seedless scion cultivar during 2011 and 2012 season.

rootstock gave the highest values followed by grafting the cv. on Freedom rootstock. On reverse, ungrafted Flame Seedless vines gave the least values in this respect. The second major cycle occurred during summer and extended for a longer period from July up to October with the peak of growth occurring in August - September. However, root growth declined in November and lasted in a gradual decreasing manner up to the end of December. Moreover, it was observed that the rate of root growth was sharply decreased during May when it reached its lowest average in both seasons. This reduction occurring during this month may be due to the beginning of cluster ripening which requires the translocation of more nutrients and water towards clusters thus causing root growth cessation.

Data shown in Fig. 3 show the growth rate of fibrous roots during the period of study in both seasons. A similar trend to that of white root growth rates was also observed. These results are in accordance with those of Morano and Kliewer [8] as well as Southey and Fouche [32] who stated that root frequencies significantly varied according to rootstock.

Effect of Grafting Flame Seedless Cv. On Two Rootstocks on Yield / Vine and Cluster Weight: It is obvious from Fig. 4 that yield / vine and cluster weight were more pronounced when Flame Seedless cv. grafted on Freedom or Salt Creek rootstocks than compared with Flame Seedless own roots. It is worthwhile, to mention that Salt Creek rootstocks superiority and was given an increase in the yield / vine as well as the weight of a heavy cluster

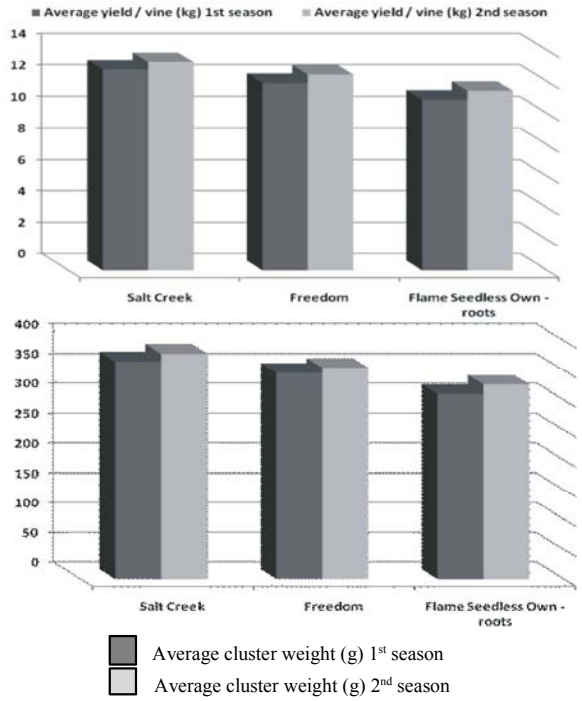

Fig. 4: Effect of grafting flame Seedless cv. On two rootstock on yield/vine (kg) and cluster weigth (g) during 2011 and 2012 season.

compared with control which marked decrease in the former data. It could be noticed that Freedom produced an intermediate effect in those after mentioned parameter in the two seasons under study. Since the number of cluster was adjusted to 35 per vine, it is supported that any increase in cluster weight should be parallel with the increase in yield by weight.

This result was confirmed by Ferree *et al.* [33] who reported an increase yield from grafted Cabernet Franc and white Riesing than from own - rooted vine. Also, Sommer *et al.* [34] found that grafted Sultana vines were always more fruitful than own - rooted vines.

Effect of Grafting Flame Seedless cv. On Two Rootstocks on Physical Characteristics of Berries: As shown in Table 2, it is obvious that all berry physical components i.e. berry weight, size, length and diameter were significantly affected by the kind of rootstock. Flame Seedless vine grafted onto Salt Creek rootstocks recorded the highest values followed in a descending order by those grafted on to Freedom rootstock. On the contrary, Flame Seedless owns rooted vines gave the lowest values in this concern.

The obtained results referring to a positive effect of rootstocks on the physical characteristics of berries are in agreement with those reported by Satisha *et al.* [35] who found that bigger and heavier berries, as indicated by higher berry diameter and berry weight, were recorded on vines grafted on to Doy Ridge rootstocks as compared to own - rooted vines.

According to the previously mentioned results, it could be found that leaf surface area and root growth rose at grafted of Flame Seedless cv. on both rootstocks especially Salt Creek rootstock therefore can be interpreted increased cluster weight and physical characteristics of berries, due to the efficiency of root system to transport nutrients from the soil to the leaves, which is the process of photosynthesis and transmitted elements and carbohydrates in the direction and have positively affected the clusters and berries characteristics.

Effect of Grafting Flame Seedless Cv. On Two Rootstocks on Chemical Characteristics of Berries: It is interesting to note, that all berry chemical parameters, including total soluble solids, titratable acidity, TSS / acid ratio and anthocyanin content of berry skin were significantly affected by rootstocks (Table 2). Accordingly, Flame Seedless grafted onto Freedom rootstock was found to record the highest percentages of TSS, TSS / acid ratio and anthocyanin content of berry skin and the lowest percentages of acidity of the berry juice, followed in a descending order by grafted onto Salt Creek rootstock which recorded intermediate values, while Flame Seedless on own - rooted gave the lowest values of TSS, TSS / acid ratio and anthocyanin content of berry skin and the highest values of acidity in the both seasons under study.

There is a strong relation between sugar content and the content of anthocyanin in the skin berries Yokotsuka *et al.* [36] who reported that, in the period from berry coloration to ripening sugar content of the berry rose, TSS and the content of anthocyanines per berry increased as ripening proceeded and that amounts were maximal at 18-20^{o} Brix. It is worth mentioning that, the proportion of potassium rose in Flame Seedless leaves when grafted onto Freedom rootstocks. This fact may reflect the positive effect of potassium in increasing the accumulation of sugar in the berries. Subsequently, there is a direct correlation between potassium uptake and sugar content (TSS) and hence anthocyanin synthesis in the skin of berries.

Table 2: Effect of grafting Flame Seedless cv. on two rootstocks on physical and chemical characteristics of berries in Flame Seedless grapevine in2011 and 2012 seasons

Rootstocks	Berry (g)	Berry length (cm)	Berry diameter (cm)	Berry size (cm^3)	TSS %	Acidity %	TSS/acid ratio	Total anthocyanin (mg/100g f.w.)
				1st season				
Salt Creek	2.38	1.85	1.81	2.29	17.8	0.60	29.67	24.6
Freedom	2.35	1.79	1.72	2.26	18.2	0.57	31.93	27.5
Flame Seedless on own roots	2.28	1.70	1.68	2.18	17.2	0.65	26.46	22.1
New L.S.D	0.02	0.04	0.03	0.02	0.20	0.02	1.30	1.60
				2nd season				
Salt Creek	2.41	1.89	1.84	2.36	18.0	0.58	30.00	26.3
Freedom	2.39	1.82	1.79	2.30	18.5	0.55	33.64	30.2
Flame Seedless on own roots	2.31	1.73	1.71	2.26	17.5	0.63	27.78	23.8
New L.S.D	0.01	0.06	0.04	0.03	0.40	0.03	1.50	1.80

Table 3: Effect of grafting Flame Seedless cv. on two rootstocks on leaf mineral content, total chlorophyll and cane carbohydrates during 2011 and 2012 seasons

Rootstocks	Leaf total Chlorophyll content	Leaf Nitrogen content (%)	Leaf Phosphorus content (%)	Leaf Potassium content (%)	Cane total Carbohy drates content (%)
			1st season		
Salt Creek	35.8	2.69	1.67	2.39	45.67
Freedom	34.5	2.64	1.61	2.42	43.15
Own - rooted vines	31.9	2.56	1.59	2.34	39.76
			2nd season		
Salt Creek	38.6	2.72	1.72	2.41	47.73
Freedom	36.7	2.69	1.66	2.44	46.23
Own - rooted vines	33.4	2.58	1.63	2.36	41.82
New $LSD_{at\ 5\%}$	1.6	0.02	0.02	0.03	1.38

As previously mentioned, grafting led to an increase in TSS percentage, anthocyanin content of berry skin and a decrease in acidity. This result is very important to harvesting and increasing the total return coming from sales of yield early.

The influence of rootstock on berry composition has been studied by several workers, Cirami *et al.* [37] recorded higher juice pH and fruits had greater color density and more anthocyanines in Shiraz grafted onto Ramisey, Dog Ridge, Harmony, Schwartzman and 1613 C than in own - rooted vines. In addition, Kubota *et al.* [38] grafted Fujimori grapes onto seven different rootstocks and found that the highest level of skin anthocyanin was observed in berries from vines grafted onto 3306C. Similarly, grafted Shiraz recorded higher color hue than own - rooted vines [2].

Effect of grafting Flame Seedless cv. on Two Rootstocks on Leaf Mineral Content, Total Chlorophyll and Cane Content of Total Carbohydrates

It can be shown from the data in Table 3 that leaf total chlorophyll content was positively affected by grafting Flame Seedless cv. onto Salt Creek or Freedom rootstock, compared to ungrafted vines (Flame Seedless on own - rooted). Grafting onto Salt Creek rootstock in the ascending order was favorable for increasing total chlorophyll, whereas vines grafted on Freedom rootstock ranked second in this respect in both seasons. On the other hand, the lowest values of leaf total chlorophyll content were recorded by ungrafted vines. This result was supported by Bica *et al.* [39] who found that the effect of rootstock was significantly higher on chlorophyll content. Also, Keller *et al.* [40] reported that chlorophyll content was the highest for vines grafted on K5BB and the lowest for 330ac.

Concerning the effect of the type of rootstock on leaf mineral content data in Table 3, it is apparent that Salt Creek rootstock was the most efficient in nitrogen and phosphorous uptake but had an intermediate performance for the uptake of potassium. While Freedom rootstock ranked among the highest efficient stocks in potassium uptake as compared to own - rooted vines which had lower efficiency than grafted vines in assimilating the mineral in two seasons of this study. From the previous results, it was noticed that the differences in nutrient uptake and distribution could be attributed to the genotype of rootstock which gives different absorption capability or tendency for some specific minerals. The obtained result are in agreement with those obtained by Tangolar and Ergenoglu [41] who grafted Gruner Veltliner onto 10 rootstocks and concluded that leaf N levels were similar for scions on all rootstocks. While the leaf K^+ was

found to be the highest in Rupestris du Lot and 110R and leaf P was the highest in 110 R. In addition, Brancadoro and Valenti [42] grafted Croatina onto 20 different rootstocks and found that K^+ content of must and leaves was significantly affected by rootstocks. They suggested that K^+ deficiency should be improved by choosing an appropriate rootstock.

The differences in nutrient uptake and distribution of the nutrients can also be interpreted in different ways. First, rootstocks may have different absorption capability or tendency for some specific minerals. In this connection, Bavaresco *et al.* [43] pointed out that rootstock, with lime resistance have a (strategy) to overcome chlorosis with high root iron uptake. Also, Grant and Mathews [25] thought that different rootstocks might have different ability to absorb phosphorus. In addition, Ruhl *et al.* [44] also found a high K^+ absorbing mechanism in some rootstocks, which would affect pH of fruit. Second, translocation and distribution of nutrient may differ among rootstocks. In this respect, Giorgessi *et al.* [45] found differences in number and size of the xylem vessels between rootstocks and own rooted vines. Also, Bavaresco and Lovisolo [46] confirmed that the chlorosis should be attributed to the different hydraulic conductivities between the rootstocks and the own - rooted vines for iron. Third, hormone synthesis of rootstock roots and their translocation may be different. In this connection, Skene and Antcliff [47] found that different levels of cytokinins in the bleeding sap of rootstocks. For instance, rootstock 1613 contained less cytokinins in the sap, both on a concentration basis and in terms of the total amount passing to the shoot each day. Fourth, some nutrients might be assimilated mostly by roots, thus reducing the amount translocated to the shoots. In this respect, Keller *et al.* [40] discovered that over 85 % of nitrogen was assimilated by way of vine root metabolism.

As for the percentage of total carbohydrates of the cane, it was found that Flame Seedless cv. grafted onto Salt Creek and Freedom rootstocks resulted in the highest significant increase as compared to own - rooted vines which resulted in the lowest values in the two seasons of the study.

The results in this respect are in the line with those of Richards [48] who observed that the major functions of the grapevine root system are vine water relations, the uptake and translocation of nutrients, the synthesis and metabolism of plant growth substances and the storage of carbohydrates. Also, Satisha *et al.* [49] observed that the maximum carbohydrate content was recorded in st. George, with the least carbohydrate measured in the rootstock 110 R.

Effect of Grafting Flame Seedless cv. On Two Rootstocks on Stomata Impressions: Data presented in Table 4 and Photo 1 clearly show that stomata density (number of stomata per mm) of grafting Flame Seedless cv. on Salt Creek or Freedom rootstocks (during second season). The highest density was associated with grafting Flame Seedless on Freedom rootstock followed by Salt Creek rootstock, while ungrafted vine decreased number of stomata to the least average.

Similarly to the above mentioned results, data recorded on stomata dimensions expressed as length and width clearly show that, stomata size had positive response to grafting Flame Seedless cv. on to Freedom rootstock induced larger stomata than either those grafting on to Salt Creek, while ungrafting vines markedly reduced stomata size.

The obtained results referring to the positive effect of rootstocks on stomata impressions are in agreement with those reported by During [50] who studied the influence of rootstock on scion photosynthesis and concluded that the effect of rootstock on gas exchange parameters is as scion specific. In some case, grafting increased the rate of photosynthesis more than could be attributed to changes in stomata conductance. In addition, Bica *et al.* [39] reported that the effect of rootstock was significantly higher on stomata conductance when Chardonnay vine grafted on to So_4 showed lower stomata conductance than those grafted on to 1103 P.

From the forgoing results, it can concluded that, Flame Seedless cv. grafted either on Salt Creek or Freedom rootstocks, achieved the best yield, fruit quality and ensured the best vegetative growth parameter, improved the uptake efficiency of nutrients and increased growth rate of white and brown roots in comparison with the

Table 4: Effect of grafting Flame Seedless on two rootstocks on stomata impressions during 2012 season

	Stomata density number (mm^2)	Stomata length (micron)	Dimension width (micron)
Salt Creek	118	25	8
Freedom	125	30	10
Own - rooted vines	110	23	7
New LSD $_{at\ 5\%}$	6	4	2

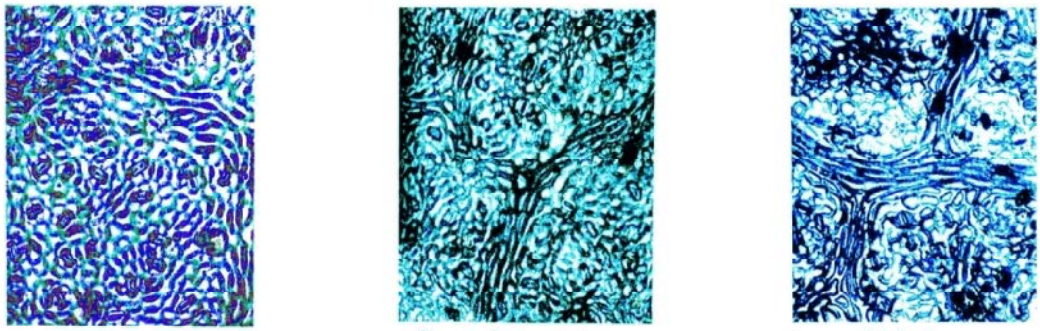

Photo 1: Effect of grafting Flame Seedless cv. on two rootstocks on stomata impressions during 2012

ungrafted vine. Hence, it is recommended to graft Flame Seedless vines onto these rootstocks especially Freedom rootstock to improved color berries and maturity is reflected to give economic crop.

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