Egypt. J. Hort. **Vol. 48**, No.1. pp. 1-8 (2021)

Egyptian Journal of Horticulture
https://ejoh.journals.ekb.eg/

جمعية فلاحة البساتين المصرية
THE EGYPTIAN HORTICULTURE SOCIETY

Effect of Some Rootstocks on the Performance of Flame Seedless Grapevines

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THE present investigation was carried out for two successive seasons (2018 and 2019) in a private vineyard at El-Sharkia, Governorate, Egypt. Vines were grafted on some rootstocks, Salt creek, Richter and Freedom, in addition own-rooted vines as a control treatment. Vines were 8 years old, grown in a sandy soil, under drip irrigation system and planted at 2x3 m. apart, cane-pruned and trellised by the Spanish Parron system. All rootstocks incrased bunch weight, bunch width, weight of 100 berries and berry characteristics (berry length, berry diameter, berry shape index). Also, the tested rootstocks increased separation force and berry firmness in comparison with own rooted vines. Grafting Flame Seedless improved chemical characteristics (TSS%, acidity, TSS/acid ratio and berry anthocyanine content) and vegetative growth (i.e. shoot length at full bloom and cane diameter).Generally, All rootstocks improved the packable number of bunches at first harvest and its percentage especially Richter rootstock which ranked first among the tested rootsocks. It is clear that grafting Flame Seedless vines on Richter rootstock achieve the maximum color expressed as anthocyanine content, Packable yield at first harvest compared with the own-rooted vines.

Keywords: Rootstocks, Flame Seedless, Quality, Yield and Anthocyanine.

Introduction

Grape (*Vitis vinifera* L.) is considered one of the most important and popular fruit crops in the world, especially in temperate, tropical, and subtropical regions. In Egypt, grapes are one of the most widely grown fruit crops. Egypt's grape cultivation is spread geographically from the north to Aswan to the south, which, combined with the production of early and late-ripening grapes varieties, enables to prolonged availability of fresh table grapes to local consumption and exportation from May to November every year. The production of grapes in Egypt increased as a result of introducing several new varieties, rootstocks, and improved cultural practices, post-harvest treatments of storage as well as new marketing methods and exportation. Egypt ranks fourth worldwide in the global production volume of table grapes and has shown impressive growth in the past 5 to 10 years. In 2016, production of grapes in Egypt amounted to 1 691 194 tones on 184 254 feddan of cultivated land (Nakai, 2018).

Flame Seedless is considered the main early ripening seedless table grape in Egypt. It is a vigorous heavy bearing table grape cultivar that keeps well in storage. It is a hybrid of several Vitis vinifera cultivars (Cardinal x Sultanina) x [(Red Malaga x Tifafihi Ahmer) x (Muscat of Alexandria x Sultanina)]. Vines of Flame Seedless was bred in 1973 at the U.S. Department of Agriculture station in Fresno, California. It has set the standard for table grape quality all over the world. This fast early growing cultivar is suitable for hot, sunny areas and provides an early-season harvest of sweet and large berries (Brooks and Olmo, 1997). Flame Seedless grapes have superior eating characteristics. Since, berry texture is crispy and firm, excellent flavor and high TSS percentage

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(*Received* 20/10/2020, *accepted* 21/01/2021)
DOI: 10.21608/ejoh.2020.47060.1145

at harvest time. It takes special concern in Egypt because it`s characteristics are favorable for local consumption and exportation also, it is suitable to reach the early market window to the European Union when prices are high. Using rootstocks in grape cultivation has become a common practice among grape growers all over the world, mainly because rootstocks provide means for cultivation under unsuitable soil conditions, presence of pests and nematodes, high level of salinity (Köse et al., 2014, Meggio et al., 2014 and Walker et al., 2004).

Moreover, rootstocks affect vegetative growth, yield, and clusters, berries quality through the interaction effect between the physiology of scions and rootstock cultivars (El-Gendy, 2013) and regulate and control nutrient exclusion (Lo’ay & El-Khateeb, 2017 and Walker et al., 2000).A wide range of rootstocks are now commercially available, allowing grape producers to select those that are more suitable for their conditions to achieve high yield and superior quality for clusters and berries (Dry, 2007). Available information on rootstock effects over yield components and with the volume of vigor conferred to the scion by the rootstock (Dry and Loveys, 1998), which in turns affect productivity and fruitfulness (Satisha et al., 2010). It is important to consider that these effects are highly correlative to the soil fertility level (Lambert et al., 2008). In this experiment, we evaluate one cultivar (Flame Seedless) as a scion using three rootstocks (Freedom, Richter 110, Salt Creek, and flame own rooted). The main aim of this experiment was to study the effect of using three grape rootstocks named Freedom, Salt Creek, and Richter in addition to those own-rooted vines on shoot growth, yield and fruit quality parameters of Flame Seedless grapevines under Egyptian condition.

Materials and Methods

Experimental design

The present investigation was carried out during the two successive seasons of 2018 and 2019 on 8 year old Flame Seedless grapevines grown in a private vineyard at Sharkia, (30.7327° N, 31.7195° E) Egypt. The experimental vines were selected to be healthy and nearly similar in growth vigor and uniformly received normal cultural practices (nutrition, irrigation, fertilization, and pest management). The selected vines were planted at 2 x 3 m apart in sandy soil under a drip irrigation system and trellised on the Spanish Baron system. Vines were trained according to the cane pruning system and pruned to leave around 50 buds/vine, i.e., 10 fruit canes/vine x 5 buds/cane) in winter of each season. All experimental vines were adjusted to 30 clusters/vine and all clusters were tipped to approximately 16 cm length directly after the fruit set. Three different rootstocks in addition control treatment (own rooted grapevines) were examined using Flame Seedless grapevines, as shown in (Table 1).

Vines were harvested when the total soluble solids reached the market minimum requirement around 16° Brix in most of bunches and berries of bunches became red color (more than 90% of berries/bunch) at control treatment. Bunches which achieved the minimum requirement in TSS% and color were harvested in relation to total number of bunches /vine (30 bunches), then the packable yield and its percentage were calculated. So, the harvestable bunches were collected two times during harvesting time and days between them were recorded. Bunches of each vine (replicate) were picked and the yield/ vine (kg) was recorded. Five bunches per replicate were randomly chosen to determine bunch characteristics and the following parameters were measured: bunch weight (g), number of berries/ bunch, and 100 berry weight (g) as well as berry polar diameter and length (cm) using Vernier caliper and then berry shape index, i.e., length/width was calculated. Berry firmness was measured by using a fruit Push-Pull Effegi penetrometer device (Model FD 101) supplemented with a plunger penetrator. Berry separation force was measured by using a hook instead of the plunger. Berry firmness and berry separationl force were expressed in Newton (N). Cane diameter (cm) were measured by using Vernier caliper at middle of the cane at pruning time. Shoot length (cm) were measured at bloom flowering.

TABLE 1. The pedigree and origin of the studied rootstocks (Walker et al., 2004).

Rootstock	Pedigree	Origin
Freedom	Couderc 1613 × *V. champinii*	USA
Richter	*V. berlandieri* × *V. rupestris*	France
Salt Creek	*V. champinii*	USA

Moreover, the berry chemical constituents were determined in berry juice after being extracted from 100 berries representing each replicate. The average total soluble solids percentage (TSS %) using a hand refractometer. The titratable acidity percentage was estimated by titration against sodium hydroxide (0.1 N) in the presence of phenolphthalein as an indicator. The total juice acidity was expressed as g tartaric acid per 100 ml of juice. The TSS/ acid ratio of each juice sample was then calculated (Horwitz and Albert, 2006). Samples of berries were lyophilized until a constant weight was obtained. The anthocyanin content was colorimetrically determined at (OD 535 nm) according to the method described by (Caleb et al., 2013).

Statistical analysis method

This experiment was set in a completely randomized block design with 4 treatments, each treatment was applied on five vines (five replicates). The obtained data were subjected to analysis of variance (ANOVA) according to (Snedecor and Cochran, (1980) using the Costas program. The individual comparisons among the obtained values were carried out using LSD at 5% level.

Results

Yield

Data presented in Table 2, cleared that yield for Flame Seedless vine was increased insignificantly, with the exception of grafted vines on Freedom rootstock in the first season only. The findings obtained are in line with (Jones et al., 2009). An increase in nitrogen concentration in the aerial portions of vines when grown using Salt Creek, an effect that has been positively correlated to plant growth vigor and yield, (Ibacache G. and Sierra B., 2009). By changing many plant traits, rootstocks have the potential to increase yield. For instance, water and nutrient uptake have been identified as two key processes that differ between own-rooted and grafted plants (Serra et al., 2014). Moreover, the capacity the o synthesize and transport cytokinins in the roots has been shown to strongly correlate with nitrogen levels in the xylem sap, which suggests that rootstock effects on plant yield are a combination of increased nutrient uptake capacity and cytokinin synthesis (Aloni et al., 2010, Sorce et al., 2002).

Packable number of bunches at first harvest, its percentage and days for the second harvest

Data shown in Table 2, revealed that Flame Seedless vines grafted on Richter rootstock significantly produced the highest number of the packable number of bunches at first harvest with a percentage of 15.6 &16.8 % in the two seasons respectively. It means the Richter Rootstock advance the ripening process more than the other rootstocks. Concerning days for the second harvest, vines grafted on Freedom rootstock and own- rooted vines recorded the highest value while Richter rootstock recorded the lowest value. This result is due to the highest packable bunches in the first harvest for Richter rootstock and lowest packable bunches in the first harvest for Freedom rootstock and own- rooted vines.

Cane diameter and Shoot length at bloom flowering

Data shown in Table 2, clear that shoot length increased significantly by using different

TABLE 2. Effect of some rootstocks on yield/vine, packable number of bunches and its percentage, days for second harvest, cane diameter and shoot length of Flame Seedless grapevines in 2018 and 2019 seasons.

Treatments	Yield/vine (kg)		Packable number of bunches at first harvest		Packable number of bunches at first harvest (%)		Days for the second harvest		Cane diameter (cm) at pruning		Shoot length at bloom flowering (cm)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Own roots (Control)	9.378	9.602	2.12	2.46	7.07	8.20	3.84	3.62	0.68	0.72	110.9	117.5
Salt Creek	9.507	9.977	2.46	2.81	8.20	9.36	3.28	3.51	0.93	0.97	160.5	165.6
Richter	9.972	10.721	4.68	5.03	15.6	16.8	2.43	2.13	0.73	0.76	129.0	122.4
Freedom	11.363	11.252	2.35	2.74	7.38	9.13	3.51	3.31	0.81	0.84	141.3	137.8
LSD at 0.05	0.79	2.03	0.35	0.58	1.17	1.93	0.36	0.57	0.12	0.19	20.08	19.09

rootstocks. Generally, there was a significant difference in shoot growth among the used rootstocks compared with the Own-rooted ones in both seasons. The highest shoot length was recorded with Salt Creek rootstock. While the lowermost shoot length was recorded by Own-rooted vines in both seasons. Results presented in Table 4, show that there is a significant enhancement of cane diameter by using different rootstocks. Where vines grafted on Salt Creek and Freedom rootstocks recorded the highest cane diameter in both seasons. While Own rooted vines gained the lowermost cane diameter in both seasons without significant differences between them. In this concern, *Vitis champinii* rootstocks (Salt Creek and Freedom) may had greater relative water content and water use efficiency, which resulted in more vigorous plants than other tested vines (Satisha et al., 2010). (Jones et al., 2009) observed that Salt Creek produced more vigorous productive vines with larger berry size than the average trial, a trend that has been associated with a higher capacity to supply water to the aerial portions of the plant (Marguerit et al., 2012). (Serra et al., 2014) mentioned that rootstocks enhance vigor growth by modifying the nutrient and water uptake in comparison with own rooted vines.

Bunch characteristics

Data in Table 3, clear that, bunch characteristics (bunch weight, bunch width, and bunch shape index) significantly affected by the type of used rootstock, in both seasons. Flame seedless grafted on Freedom rootstock recorded the highest bunch weight, while own-rooted vines recorded the lowermost value. This effect is in agreement to results reported by (Satisha et al., (2010). Bunches produced by vines grafted on Salt Creek and Richter came in-between values, without significant differences between them in both seasons. Flame seedless vines grafted on Freedom rootstock recorded the highest bunch width in both seasons and take the same trend. As mentioned above, bunch shape index is in the same line of bunch width. Vines grafted on Freedom rootstock get the lowermost value because of its high value of bunch width. It means Freedom rootstock produces a large bunch in size compared with other rootstocks. The obtained results are in line with (Sommer et al., 2001).

Berry characteristics

Total number of berries

The results indicated in Table 3 clear that all rootstocks type affect the number of berries /bunches significantly in both seasons. The obtained results cleared the negative effect of rootstocks on the number of berries /bunches. Own-rooted vines gained the highest number of berries/ bunches. While, Salt Creek rootstock, recorded the lower the greatest number of berries/ bunches.

Weight of 100 berries

Data in Table 3 clear that vines grafted on Salt Creek and Freedom rootstocks recorded the highest weight of 100 berries in both seasons, without significant difference between them. While own-rooted vines gained the lowermost values. It means, that rootstocks generally improved berry weight compared with own-rooted vines. The above-mentioned results are in agreement with (Gaser & Aisha, 2007, Satisha et al., 2010, and Sommer et al., 2001).

TABLE 3. Effect of some rootstocks on bunch weight, bunch width, Bunch shape index, total number of berries/ bunch, weight of 100 berry, separation force and berry firmness of Flame Seedless grapevines in 2018 and 2019 seasons.

Treatments	Bunch weight (g)		Bunch width (cm)		Bunch shape index		Total number of berries/ bunches		Weight of 100 berry (g)		Separation force (N)		Berry firmness (N)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Own roots (Control)	309.2	316.8	11.8	12.1	1.37	1.32	167.2	172.4	183.1	180.7	6.39	6.21	5.17	5.23
Salt Creek	313.4	329.2	15.1	15.7	1.07	1.02	111.6	118.1	275.2	273.0	8.12	7.92	6.81	6.68
Richter	329.2	354.1	17.9	18.5	0.90	0.87	122.5	130.7	264.3	268.1	8.00	7.61	6.73	6.59
Freedom	375.8	371.9	20.9	22.3	0.77	0.72	134.3	139.0	276.4	272.5	7.91	7.36	6.4	6.21
LSD at 0.05	32.56	36.97	3.02	2.06	0.25	0.10	7.49	6.22	7.95	6.50	0.80	1.25	0.84	0.55

Separation force and berry firmness

It is clear that from Table 3, the attachment force of Flame Seedless grape berries was increased with all rootstocks, without significant differences among them in both seasons. The berry firmness was recorded the highest value with Salt Creek rootstock. Vines grafted on Salt Creek rootstock recorded the highest firm and attachment force in both seasons. Own-rooted vines gained the lowermost value of berry attachment force and berry firmness, in both seasons. it could be pointed out for higher attachment force that due to brush and pedicel of berries have more stable un-soluble pectin content (Bassetto et al., 2005). Change in berry attachment force and firmness are closely related to weight and water losses factors (Kader, 2002).

Physical characteristics of berries

Results in Table 4 clear that, rootstock type affects berry length significantly. Flame Seedless grafted on Richter rootstock recorded the highest berry length while own rooted vines recorded lowermost values. Flame Seedless grafted on Salt Creek and Freedom rootstocks recorded intermediate values without significant differences between them, this result is in line with (Sommer et al., (2001). Regarding berry diameter, vines grafted on Salt Creek and Richter recorded the highest berry diameter without significant differences between them in the two seasons. Generally, grafting Flame seedless vines with all rootstocks, improved berry diameter in compare with own-rooted vines. This result is in line with (Satisha et al., (2010). (Jones et al., (2009) found that, larger grape berries from grafted vines on Salt Creek rootstock is due to its ability to absorb more water for the vegetative parts.

Chemical characteristics of berries

Data shown in Table 5 clear that all chemical characteristics (total soluble solids, titratable acidity, and TSS/acid ratio) were significantly affected by rootstocks type compared to own-rooted vines. It was found that Flame Seedless grafted on Richter rootstock recorded the highest TSS percentage, TSS/ acid ratio and the lowest titratable acidity in the two studied seasons. The indicated results are in the same trend as (Rizk-Alla et al., 2011). The increases at harvest time as to TSS% might be suggested that the more activation of carbohydrates metabolism accumulation during berry development (El-Gendy, 2013). Type of rootstock on leaf mineral content, it is apparent noticed that Salt creek rootstocks 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 minerals (Rizk-Alla et al., 2011). With regard to anthocyanine content, significant differences were found among the tested treatments in both seasons, Table 5. It could be noticed that Richter and Freedom rootstocks presented significantly the highest anthocyanine content compared with control treatment and Salt Creek rootstock. This result is in line with (Rizk-Alla et al.,(2011) and Hifny et al., (2016). This means degree or level of anthocyanine in grape berry skin of flame seedless grapes depend on the used rootstock (rootstock genotype).

Conclusion

It is recommended to graft Flame Seedless vines on Richter rootstock to improved fruit quality and also to enhance berry color. It might be concluded that the used rootstocks effects on cluster behave. Richter rootstock had a positive

TABLE 4. Effect of some rootstocks on berry length, berry diameter, berry shape index of Flame Seedless grapevines in 2018 and 2019 seasons.

Treatments	Berry length (cm)		Berry diameter (cm)		Berry shape index	
	2018	2019	2018	2019	2018	2019
Own roots (Control)	1.50	1.52	1.53	1.56	0.98	0.98
Salt Creek	1.63	1.66	1.79	1.80	0.91	0.92
Richter	1.77	1.80	1.77	1.75	1.02	1.03
Freedom	1.69	1.71	1.70	1.68	1.03	1.02
LSD at 0.05	0.06	0.10	0.16	0.09	0.06	0.07

TABLE 5. Effect of some rootstocks on TSS%, acidity%, TSS/acid ratio and anthocyanine content of Flame Seedless grapevines in 2018 and 2019 seasons.

Treatments	TSS (%)		Acidity (%)		TSS/acid ratio		Anthocyanine (mg/kg)	
	2018	2019	2018	2019	2018	2019	2018	2019
Own roots (Control)	16.2	16.0	0.71	0.73	22.8	22.0	33.0	34.7
Salt Creek	16.5	16.8	0.64	0.62	25.8	27.1	40.7	42.0
Richter	18.6	19.0	0.55	0.57	33.9	33.4	47.0	46.3
Freedom	16.3	16.5	0.68	0.67	24.0	24. 7	45.3	45.0
LSD at 0.05	1.29	0.70	0.04	0.06	2.60	3.14	4.95	3.98

impact on improving the physical and chemical quality attributes of clusters. Increases the amount of the packable number of bunches at first harvest, anthocyanine content at harvest, and minimizes acidity. It is recommended to graft Flame Seedless vines on Richter rootstock to improved fruit quality and also to enhance grapes marketing. This study concludes that Richter rootstock results in the best performance across all three cultivars evaluated, showing the uppermost results in terms of fruit and yield. Observations from this study clear that Richter rootstock is recommended for red color varieties such as Flame Seedless , which it enhance anthocyanin content followed by Freedom rootstock.

Acknowledgment

The author wish to thank members of Horticulture Department, Faculty of Agriculture, Zagazig University for their help and support in preparing the manuscript.

Funding statements

Author didn't receive any funding for this research.

Conflict of interest

There is no conflict of interest during this experiment.

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تأثير استخدام بعض الاصول على اداء العنب صنف فليم سيدلس

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أجريت هذه الدراسة خلال موسمي ٢٠١٨ ، ٢٠١٩ لتقييم تأثير ثلاث أصول مختلفة على النمو والانتاج وجودة ثمار العنب صنف فليم سيدلس .تم تقييم شجيرات العنب صنف فليم سيدلس والمطعومة علي ثلاث اصول تجارية هي سولت كريك و ريختر و فريدم بالاضافة الي معاملة المقارنة (شجيرات فليم سيدلس غير مطعومة) . تم اختيار شجيرات عمرها ٨ سنوات نامية في تربة رملية تحت نظام الرى بالتنقيط ومزروعة على مسافة ٣x٢ وتم تقليمها تقليم قصبى تحت نظام التكاعيب للاسبانية في محافظة الشرقية بمصر.

أظهرت جميع الأصول تأثير ايجابى لزيادة وزن العنقود وعرضة و وزن ال١٠٠ حبة كذلك الى زيادة خصائص الحبات (طول الحبه وعرضها ودليل شكل الحبه). أدى أيضا استخدام الأصول الى زيادة قوة التصاق الحبة وصلابتها مقارنة مع معاملة المقارنة.

أدى أيضا تطعيم الفليم سيدلس بصفة عامة الى تحسين الصفات الكيماوية للحبات وهى (النسبة المئوية للمواد الصلبة الذائبة والنسبة المئوية للحموضة ونسبة المواد الصلبة الذائبة الى الحموضة والمحتوى من صبغة الانثوسيانين) وكذلك تحسين النمو الخضرى للشجيرات من خلال تحسين طول الفرخ الخضرى عند قمة التزهير وكذلك قطر الطراح الثمرى).

بصفة عامة أدى استخدام الأصول الى تحسين وزيادة النسبة المئوية لعدد العناقيد القابلة للجمع عند اول جمع وقد اعطى التطعيم على اصل الريختر اعلى قيمة لها. ويمكن ان نستنتج ان تطعيم شجيرات العنب على اصل الريختر يعطى اعلى درجة لون للحبات معبرا عنها بصبغة الانثوسيانين وكذلك اعلى نسبة عناقيد قابلة للجمع عند اول جمع مقارنة مع الأصول الأخرى ومعاملة المقارنة.