Influence of Some Rootstocks on the Performance of Red Globe Grape Cultivar

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Abstract: This investigation was conducted for three successive seasons (2008, 2009 and 2010) in a private vineyard located at El-Khatatba, Menoufiya governorate; to study the growth, yield and fruit quality of Red Globe grape cultivar grafted onto some rootstocks; Dogridge, Salt creek, Freedom, Harmony, and Paulsen 1103 in addition to own-rooted vines. The chosen vines were five-year-old, grown in a sandy loam soil, spaced at 2 X 3 meters apart, irrigated by the drip irrigation system, cane-pruned and trellised by the Spanish Parron system. The results showed that all rootstocks especially Dogridge, Salt creek and Freedom were effective in increasing the yield and its components, ensuring the best physical properties of bunches, improving the physical and chemical characteristics of berries, achieving the best vegetative growth parameters (i.e. average shoot diameter, average shoot length, average number of leaves/ shoot, average leaf area, total leaf area/vine, coefficient of wood ripening and weight of prunings) and increasing leaf content of total chlorophyll and percentages of total nitrogen, phosphorus and potassium as well as cane content of total carbohydrates in comparison with the non grafted vines. The economical study indicated that Red Globe grapevines grafted on Dogridge, Salt creek, Freedom, Harmony, and Paulsen 1103 rootstocks gave the maximum net profit compared with the own-rooted vines.

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1. Introduction

Rootstocks have recently gained great importance in the only consistently effective and successful strategy in major viticultural countries worldwide (Troncoso, *et al*, 1999 and Omer, *et al*, 1999). The importance of rootstocks in viticulture is well documented, they are used 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 the vine (McCarthy *et al*., 1997; Walker *et al*., 2000 and Keller 2001). However, the choice of a certain rootstock is becoming increasingly difficult as a result of the availability of numerous new rootstocks (Loreti and Massai, 2006). In addition, Reynolds and Wordle (2001) 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 soils, wet or poorly drained soils and drought. These effects take place in a more or less indirect manner and are consequences of the interactions between environmental factors and the physiology of the scion and rootstock cultivars employed.

Many investigations proved that rootstocks affect vine growth, yield, fruit quality through the interactions between the environmental factors and the physiology of scions and rootstock cultivars employed. In this respect, Hedberg (1980) found that yields of all grafted cultivars were much higher than those of own-rooted vines, especially those grafted on Ramsey and Dogridge rootstocks. Fardossi *et al* (1995) found that shoot growth of "Gruner veltline" was slower on "5C" and "Fercal" but more rapid on "P1103", "725P" and "125AA". Ripening of grapes occurred earlier on "1103P", "G1" and Riparia Sirbu" than on other rootstocks. Bunch quality, bunch weight, berry size and soluble solids content were affected by rootstocks (Zhiyuan 2003). The level of mineral uptake differed according to the rootstocks (Grant & Matthews 1996, Ruhl 2000 and Kocsis & Lehoczky 2002).

Red Globe grapevines are characterized by having a considerably low vine vigour, which is not proportional to the yield (Gasser, 2006). The good production of yield of this cultivar faces some challenges; depression of vegetative growth, increasing the possibility of berry exposure to sunburn damage and irregular colouration of the berry, these defects are undoubtedly reflected on reducing bunch quality.

The main goal of this investigation was to study the influence of some grape rootstocks; Dogridge, Salt creek, Freedom, Harmony, and Paulsen 1103 on growth, yield and fruit quality of Red Globe grapevines.

2. Material and Methods

This investigation was conducted for three successive seasons (2008, 2009 and 2010) in a private vineyard located at El-Khatatba, Menoufiya governorate; to study some parameters of growth, yield and fruit quality of Red Globe grapevines grafted on some rootstocks; Dogridge, Salt creek, Freedom, Harmony, and Paulsen 1103 in addition to own-rooted vines. These rootstocks were characterized according to (Schmid *et al*., 1998; Sule, 1999; Walker *et al*., 2002 and Ozden *et al*., 2010) as follows:

- Dogridge (V. champini): very high vigor with good resistance to nematodes, moderate resistant to phylloxera and moderate drought tolerant.
- Salt creek (V. champini): very high vigor with quite resistance to nematodes, moderate resistant to phylloxera and moderate drought tolerant.
- Freedom (1613C x V. champini): moderate to high vigor, highly resistant to nematodes and phylloxera and moderate drought tolerant.
- Harmony (1613C x V. champini): moderate vigor, highly resistant to nematodes, moderate resistant to phylloxera and moderate drought tolerant.
- Paulsen 1103 (V. berlandieri x V. rupestris): moderate vigor, moderately resistant to nematodes, highly resistant to phylloxera and highly drought tolerant.

The chosen vines were five-year-old, grown in a sandy loam soil, spaced at 2 X 3 meters apart, irrigated by the drip irrigation system, cane-pruned and trellised by Spanish Parron system. The vines were pruned during the third week of January with bud load of (72 buds/vine). Each five vines acted as a replicate and each three replicates were used for each rootstock under study.

*The following parameters were determined to evaluate the performance of different rootstocks:-

Representative random samples of six bunches/vine were harvested at maturity when TSS reached about 16-17% according to Tourky *et al.*, (1995). The following characteristics were measured:

1. Yield and physical characteristics of bunches:

Yield/vine (kg) was determined as number of bunches/vine X average bunch weight (g). Also, average bunch weight (g), bunch length and width (cm) were determined.

2. Physical characteristics of berries:

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

3. Chemical characteristics of berries:

Total soluble solids in berry juice (T.S.S.) (%) were determined using a hand refractometer and total titratable acidity was expressed as tartaric acid (%) according to (A.O.A.C., 1985). Hence TSS /acid ratio and total anthocyanin of the berry skin (mg/100g fresh weight) according to Husia *et al.*, (1965) were calculated.

4. Some characteristics of vegetative growth

At growth cessation, the following morphological and chemical determinations were carried out on 4 shoots / the considered vine:

1- Average shoot diameter (cm).
2- Average shoot length (cm).
3- Average number of leaves/shoot.
4- Average leaf area (cm^2) of the apical 5th and 6th leaves using a CI-203- Laser Area-meter made by CID, Inc., Vancouver, USA.
5-Total leaf area/vine (m^2) was determined by multiplying average number of leaves/shoot by average leaf area then by the number of shoots per vine.
6- Coefficient of wood ripening was calculated by dividing length of the ripened part of the shoot by the total length of the shoot according to Bouard (1966).
7- Weight of prunings (Kg) at the dormancy period (winter pruning) was determined.

5. Chemical characteristics of vegetative growth

1- Leaf total chlorophyll content: it was measured by using nondestructive Minolta chlorophyll meter SPAD 502 (Wood *et al.,* 1992).
2- Leaf mineral content: Percentage of nitrogen was determined using the modified micro-Kjeldahl method according to Pregl (1945). Percentage of phosphorus was determined calorimetrically estimated according to Snell and Snell (1967). Percentage of potassium was determined photometrically estimated according to Jackson (1967).
3- Cane total carbohydrates content (%): it was determined according to Smith *et al*., (1956).

Statistical analysis:

The complete randomized blocks design was adopted for the experiment. The statistical analysis of the present data was carried out according to the methods described by Snedecor & Cochran (1980). Averages were compared using the new LSD method at 5% level.

3. Results and Discussion

1. Yield and physical characteristics of bunches:

Data shown in Table (1) revealed that yield and its components varied significantly among all rootstocks. It can be observed that Red Globe grafted onto Dog Ridge, Salt creek and Freedom rootstocks were found to produce the highest yield, followed in a descending order by those grafted onto Harmony and Paulsen 1103 rootstocks which produced an intermediate yield, while own-rooted vines gave the lowest yield in the three seasons under study.

The highest number of bunches per vine was recorded on vine grafted onto Freedom rootstock followed in a descending order by own-rooted vines. On the contrary, the fewest number of bunches per vine was recoded on Dog Ridge and Salt creek rootstocks in the three seasons.

Average bunch weight differed significantly among the rootstocks. The greatest bunch weight was given by Dog Ridge, Salt creek and Freedom rootstocks, while the smallest bunch weight was recorded on own-rooted vines. The bunch weight was intermediate in Harmony and Paulsen 1103 rootstocks.

Table (1): Influence of some rootstocks on yield/vine and physical characteristics of bunches in Red Globe grapevines in 2008, 2009 and 2010 seasons

Characteristics / Rootstocks	Yield/vine (kg)			Average number of bunches			Average bunch weight (g)			Average bunch length (cm)			Average bunch width (cm)		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Dogridge	16.67	18.11	21.35	20.1	21.6	25.4	829.4	838.3	840.7	20.9	21.3	21.6	12.7	12.9	13.2
Salt creek	16.40	17.85	21.02	20.3	21.9	25.6	808.1	814.9	821.1	20.7	21.2	21.4	12.6	12.7	13.1
Freedom	16.31	17.84	20.73	21.5	23.5	26.8	758.8	759.1	773.4	20.6	20.9	21.3	12.4	12.5	12.9
Harmony	15.92	17.43	20.27	21.3	23.2	26.6	747.6	751.5	762.1	20.4	20.8	21.1	12.3	12.3	12.8
Paulsen 1103	15.45	16.91	19.69	21.0	22.8	26.3	735.8	741.7	748.7	20.3	20.8	20.9	12.1	12.2	12.6
Own-rooted vines	14.66	16.05	18.73	20.6	22.3	25.9	711.5	719.8	723.1	19.9	20.3	20.5	11.8	11.9	12.1
new L.S.D. at 0.05 =	**0.71**	**0.64**	**0.93**	**0.2**	**0.3**	**0.2**	**78.3**	**81.4**	**75.8**	**0.4**	**0.5**	**0.4**	**0.3**	**0.5**	**0.4**

As regards bunch dimensions, it is clear that bunch length and bunch width were found to vary significantly among all rootstocks, Red Globe grafted onto Dog Ridge, Salt creek and Freedom rootstocks recorded the highest values, followed in a descending order by those grafted onto Harmony and Paulsen 1103 rootstocks which recorded the intermediate values, while own-rooted vines gave the lowest values in all seasons of the investigation.

As previously mentioned the smallest numbers of bunches per vine given by vines grafted on Dog Ridge and Salt creek rootstocks as compared to own-rooted vines, agree with the findings of Sommer *et al.* (1993) who showed that Ramsey and Dog Ridge (Vitis champinii) rootstocks conveyed high shoot length and vine vigour to the scions grafted onto them, with a tendency to develop dense canopies. They consequently observed the lesser penetration of sunlight into the leaf canopy and even negligible penetration of sunlight to the location of auxiliary buds in the vines grafted onto vigorous rootstocks in comparison with own-rooted vines and those grafted onto less vigorous rootstocks. This explains the reduced fruit bud differentiation in more vigorous and denser canopies compared to vines with reduced shoot length and less vigour, which allow more sunlight to reach the fruiting buds during the period of fruit bud differentiation, resulting in higher fruitfulness.

The effect of rootstock on scion yield has been well documented; most results showed that rootstock significantly affects scion yield. In this respect, Hedberg *et al.* (1986) recorded higher yields on all grafted cultivars than on own-rooted vines, especially on Ramsey and Dog Ridge rootstocks. Similarly, Ferree *et al.* (1996) reported an increased yield from grafted Cabernet Franc and White Riesling than from own-rooted vines. Also, Wunderer *et al.* (1999) mentioned that ‘Gruner Veltliner’ grape had a higher wood productivity when grafted on the three rootstocks tested (‘SO4’, ‘K5BB’ and ‘5C’) than that of the own-rooted vines. In addition, Sommer *et al.* (2001) found that grafted sultana vines were always more fruitful than own-rooted vines.

2. 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. Red Globe vines grafted onto Dog Ridge, Salt creek and Freedom rootstocks recorded the highest values, followed in a descending order by those grafted onto Harmony and Paulsen 1103 rootstocks which recorded intermediate values. On the contrary, own-rooted vines gave the lowest values in the three seasons.

The obtained results referring to the positive effect of rootstocks on the physical characteristics of berries are in agreement with those reported by Gaser (2007) and Satisha *et al*., (2010) who found that bigger and heavier berries, as indicated by higher berry diameter and berry weight, were recorded on vines grafted onto Dog Ridge rootstocks as compared to own-rooted vines.

3. 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 3).

Red Globe grafted onto Freedom, Harmony and Paulsen 1103 rootstocks were 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 own-rooted vines which recorded intermediate values, while Red Globe grafted onto Dog Ridge and Salt creek gave the lowest values of TSS, TSS/acid ratio and anthocyanin content of berry skin and the highest values of acidity in the three seasons under study.

The influence of rootstock on fruit composition has been studied by several workers; Cirami *et al*. (1984) recorded higher juice pH in Shiraz grafted onto Ramsey, Dog Ridge, Harmony, Schwarzmann and 1613C than in own-rooted vines. Fruits had greater colour density and more anthocyanins. In addition, Ruhl *et al*. (1988) showed that own-rooted ‘Riesling’, ‘Ruby Cabernet’ and ‘Shiraz’ had low to medium juice pH while the own-rooted ‘Chardonnay’ had higher juice pH; rootstocks ‘Harmony’, ‘Dog Ridge’, ‘Freedom’ and ‘Rupestris du Lot’ generally caused a high juice pH, whereas ‘140R’, ‘1202’, ‘5A’, ‘SO4’ and ‘101-14’ had low pH. Kubota *et al*. (1993) grafted Fujimori grapes onto seven different rootstocks and found that the highest level of skin anthocyanin was observed in berries from vines grafted onto 3306 C. Similarly, grafted Shiraz recorded higher colour hue than own-rooted vines (Walker *et al*., 2000).

Table (2): Influence of some rootstocks on physical characteristics of berries in Red Globe grapevines in 2008, 2009 and 2010 seasons

Characteristics / Rootstocks	Average berry weight (g)			Average berry size (cm^3)			Average berry length (cm)			Average berry diameter (cm)		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Dogridge	9.16	9.35	9.51	8.93	9.09	9.23	2.93	2.97	2.98	2.79	2.81	2.84
Salt creek	8.92	9.08	9.29	8.67	8.81	8.99	2.90	2.93	2.95	2.78	2.80	2.83
Freedom	8.35	8.44	8.74	8.09	8.15	8.43	2.88	2.90	2.94	2.75	2.79	2.81
Harmony	8.22	8.35	8.61	7.95	8.04	8.28	2.85	2.88	2.90	2.73	2.74	2.78
Paulsen 1103	8.09	8.24	8.46	7.82	7.92	8.13	2.84	2.85	2.88	2.70	2.74	2.75
Own-rooted vines	7.81	7.98	8.14	7.53	7.64	7.80	2.76	2.78	2.81	2.62	2.64	2.67
new L.S.D. at 0.05 =	**0.91**	**0.97**	**0.86**	**0.95**	**0.98**	**0.91**	**0.06**	**0.08**	**0.07**	**0.05**	**0.06**	**0.05**

Table (3): Influence of some rootstocks on chemical characteristics of berries in Red Globe grapevines in 2008, 2009 and 2010 seasons

Characteristics / Rootstocks	TSS (%)			Acidity (%)			TSS/acid ratio			Total anthocyanin (mg/100g F.W.)		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Dogridge	15.6	15.9	15.8	0.57	0.55	0.54	27.4	28.9	29.3	23.7	25.1	25.5
Salt creek	15.7	15.9	16.0	0.55	0.54	0.52	28.5	29.4	30.8	24.7	25.7	26.9
Freedom	16.4	16.7	16.7	0.52	0.49	0.46	31.5	34.1	36.3	27.8	30.2	32.5
Harmony	16.3	16.5	16.7	0.53	0.49	0.47	30.8	33.7	35.5	26.9	30.0	31.6
Paulsen 1103	16.3	16.4	16.6	0.53	0.50	0.48	30.8	32.8	34.6	27.1	29.0	30.9
Own-rooted vines	16.1	16.3	16.4	0.54	0.52	0.51	29.8	31.3	32.2	26.0	27.4	28.5
new L.S.D. at 0.05 =	0.2	0.3	0.2	0.01	0.02	0.04	1.2	1.7	1.3	1.1	1.5	1.2

Table (4): Influence of some rootstocks on morphological characteristics of vegetative growth in Red Globe grapevines in 2008, 2009 and 2010 seasons

Characteristics / Rootstocks	Average shoot diameter (cm)			Average shoot length (cm)			No. of leaves/shoot			Average leaf area (cm^2)			Total leaf area/vine (m^2)			Coefficient of wood ripening			Weight of prunings (Kg)		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Dogridge	1.13	1.17	1.21	169.9	176.0	182.2	28.5	29.4	30.4	155.5	161.2	167.1	23.8	25.4	27.2	0.91	0.93	0.94	4.64	4.72	4.87
Salt creek	1.09	1.14	1.17	164.1	171.7	176.5	27.5	28.7	29.4	150.1	157.2	161.6	22.2	24.2	25.5	0.87	0.90	0.91	4.33	4.49	4.56
Freedom	1.05	1.11	1.13	158.4	167.4	170.7	26.6	28.0	28.5	144.7	153.1	156.2	20.7	23.0	23.9	0.85	0.86	0.89	4.04	4.27	4.43
Harmony	1.03	1.08	1.12	155.5	163.0	169.2	26.1	27.3	28.2	142.0	149.1	154.9	20.0	21.9	23.5	0.82	0.84	0.85	3.89	4.06	4.19
Paulsen 1103	1.02	1.05	1.10	154.1	158.7	166.4	25.9	26.6	27.8	140.7	145.0	152.2	19.6	20.7	22.7	0.80	0.81	0.83	3.82	3.85	4.06
Own-rooted vines	0.97	0.99	1.02	146.9	150.1	154.8	24.7	25.2	25.9	133.9	136.9	141.3	17.8	18.6	19.7	0.77	0.79	0.80	3.48	3.53	3.59
new L.S.D. at 0.05	**0.09**	**0.08**	**0.09**	**12.3**	**12.7**	**12.4**	**2.1**	**1.6**	**2.0**	**12.1**	**11.5**	**11.9**	**3.7**	**3.5**	**3.6**	**0.07**	**0.09**	**0.06**	**0.62**	**0.58**	**0.65**

4. Some characteristics of vegetative growth

Data presented in (Table 4) show that most of vegetative growth parameters (shoot diameter, shoot length, number of leaves per shoot, leaf area, total leaf area/vine, coefficient of wood ripening and weight of prunings) responded positively to all rootstocks. Red Globe grafted onto Dog Ridge and Salt creek rootstocks recorded the highest values, followed in a descending order by those grafted onto Freedom, Harmony and Paulsen 1103 rootstocks which gave intermediate values, while own-rooted vines had the lowest values in this respect.

The maximum values of shoot length, total leaf area/vine and pruning weights and the highest number of leaves were given by vines grafted on Dog Ridge and Salt creek rootstocks as compared to own-rooted vines could be attributed to the total biomass produced in Dogridge and Salt creek rootstocks which provided the frame work for total leaf area which by its turn was reflected on the amount of old wood retained on the grapevine which may have positively affected the yield and bunch quality.

The results in this respect are in line with those of Williams and Smith (1991) who observed more vegetative growth of Cabernet Sauvignon, expressed in high values of biomass on vines grafted on Arawan Rupestris Gargin rootstock, with the lowest vegetative growth on St. George. Also, Fardossi *et al*. (1995) found that shoot growth of 'Gruner Veltliner' was slower on '5C' and 'Fercal', but more rapid on '1103P', '725P' and '125AA'; ripening occurred earlier on '1103P', 'G1' and '*Riparia* Sirbu' than on the other rootstocks. In addition, Colldecarrera *et al*. (1997) 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, Ezzahouani & Larry (1997) found that the scion cultivar 'Italia' was most vigorous on rootstocks '101-14' and '*Rupestris* du Lot'.

5. Chemical characteristics of vegetative growth

Nutritional status of leaves, leaf content of total chlorophyll and percentages of total nitrogen, phosphorus and potassium and cane content of total carbohydrates were positively affected by all rootstocks (Table, 5).

As regards leaf total chlorophyll content, it was found that Red Globe grafted onto Dog Ridge, Salt creek and Freedom rootstocks recorded the highest values, followed in a descending order by those grafted onto Harmony and Paulsen 1103 rootstocks which had intermediate values, while own-rooted vines were found to record the lowest values in the three seasons of the study.

This result was supported by several studies on the effect of rootstocks on physio-biochemical processes in scion leaves. In this respect, During (1994) 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 cases, grafting increased the rate of photosynthesis more than could be attributed to changes in stomatal conductance. In addition, Bica *et al*. (2000) found that the effect of rootstock was significantly higher on chlorophyll content, stomatal conductance and quantum yield. Chardonnay vines grafted onto SO4 showed lower photosynthesis, quantum yield, stomatal conductance and chlorophyll content than those grafted onto 1103 P.

Concerning the effect of type of rootstock on leaf mineral content, it is apparent noticed that Dog Ridge and Salt creek rootstocks were 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 in all seasons of the study.

Many reports dealt with mineral uptake and distribution of minerals in grapevines; 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 results are in agreement with those obtained by Tangolar & Ergenoglu (1989) who grafted 'Gruner Veltliner' onto 10 rootstocks and concluded that leaf N levels were similar for scions on all rootstocks. The leaf K+ was found to be the highest in 'Rupestris du Lot' and '110 R', and leaf P was the highest in '110 R'. Fardossi *et al*. (1995) used the same scion and rootstocks and confirmed that leaf mineral concentrations could be influenced by the rootstock, but the changes were in the normal range. They also tested 'Neuburger' grape on 12 different rootstocks to determine the micro- and macronutrients in leaf blades and found that vines on the Euro-American hybrid rootstocks '26G' and '333 EM' showed the lowest K+ concentrations. Brancadoro & Valenti (1995) 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*. (1991) pointed out that rootstocks with lime resistance have a 'strategy' to overcome chlorosis with high root iron uptake. Also, Grant & Matthews (1996) thought that different rootstocks might have different ability to absorb phosphorus. In addition, Ruhl (2000) also found a high K+ absorbing mechanism in some rootstocks, which would affect pH of fruit and wines. Second, translocation and distribution of nutrients may differ among rootstocks. In this respect, Giorgessi *et al*. (1997) found differences in number and size of the xylem vessels between rootstocks and own-rooted vines. Also, Bavaresco & Lovisolo (2000) 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 & Antcliff (1972) found 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*. (2001) discovered that over 85% of nitrogen was assimilated by way of vine root metabolism.

Table (5): Influence of some rootstocks on chemical characteristics of vegetative growth in Red Globe grapevines in 2008, 2009 and 2010 seasons

Characteristics / Rootstocks	Leaf total chlorophyll content			Leaf nitrogen content (%)			Leaf phosphorus content (%)			Leaf potassium content (%)			Cane total carbohydrates content (%)		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Dogridge	37.3	38.6	39.8	0.66	0.69	0.72	0.33	0.35	0.37	0.38	0.40	0.42	0.29	0.30	0.32
Salt creek	36.1	37.6	38.6	0.63	0.67	0.69	0.32	0.33	0.36	0.36	0.39	0.40	0.27	0.29	0.30
Freedom	34.8	36.7	37.3	0.60	0.65	0.66	0.30	0.32	0.33	0.40	0.43	0.44	0.26	0.28	0.29
Harmony	34.2	35.8	36.9	0.59	0.62	0.65	0.29	0.31	0.33	0.35	0.38	0.40	0.25	0.27	0.27
Paulsen 1103	33.9	34.8	36.4	0.58	0.60	0.64	0.29	0.29	0.32	0.34	0.36	0.39	0.23	0.25	0.26
Own-rooted vines	32.3	33.0	33.9	0.54	0.55	0.58	0.26	0.28	0.29	0.31	0.34	0.36	0.20	0.21	0.23
new L.S.D. at 0.05 =	**2.9**	**2.4**	**2.7**	**0.07**	**0.06**	**0.07**	**0.04**	**0.03**	**0.04**	**0.02**	**0.03**	**0.02**	**0.04**	**0.03**	**0.05**

As for the percentages of total carbohydrates of the cane, it was found that Red Globe grafted onto Dogridge, 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 three seasons of the study.

The results in this respect are in line with those of Richards, (1983) 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*. (2008) observed that the maximum carbohydrate content was recorded in St. George, with the least carbohydrate measured in the 110R rootstock.

Data illustrated in Figures (1 & 2) indicated the presence of a positive correlation, between the total leaf area per vine (m^2) and yield per vine (kg) and between the weight of prunings (kg) and yield (kg) in the three seasons of the study.

6. Economical justification of the contribution of some rootstocks in raising vine productivity compared with own-rooted vines:

It can be shown from the data presented in (Table 6) that Dogridge, Salt creek and Freedom rootstocks (as the best rootstocks) gave the maximum net profit compared with the own-rooted vines in the three seasons. In spite of the high costs of grafted plants compared with ungrafted ones. Hence, it can be anticipated that the added cost of establishment will be offset by an increase in vine productivity.

In conclusion, it can be said that Dogridge, Salt creek and Freedom rootstocks, achieved the best yield and its components as well as the best physical properties of bunches, improved the physical characteristics of berries, ensured the best vegetative growth parameters, improved the uptake efficiency of nutrients and increased total chlorophyll of leaves and total carbohydrates of canes in comparison with the ungrafted vines. Hence, it is recommended to graft Red Globe vines onto these rootstocks.

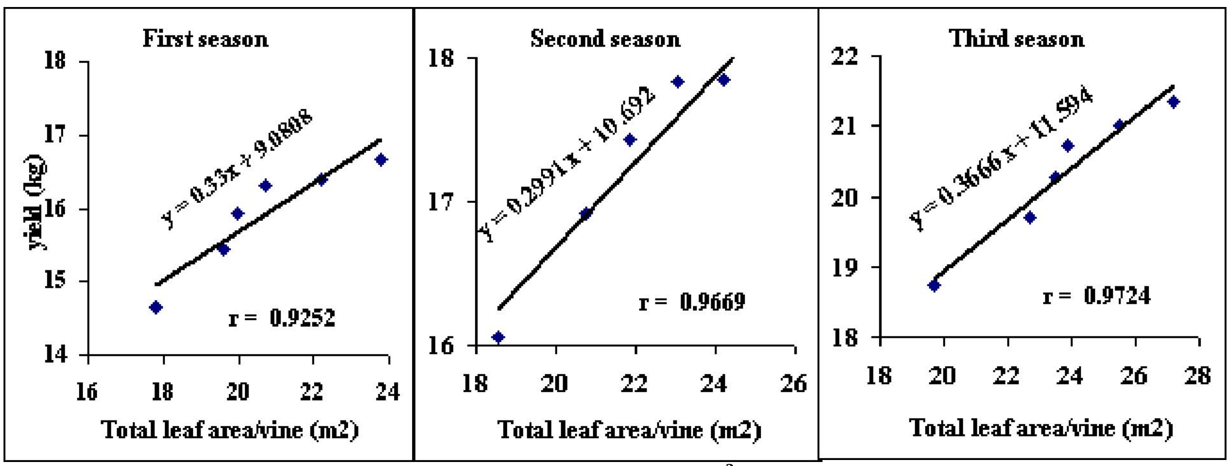

Fig (1): The relationship between the total leaf area (m^2) and yield (kg) in the three seasons

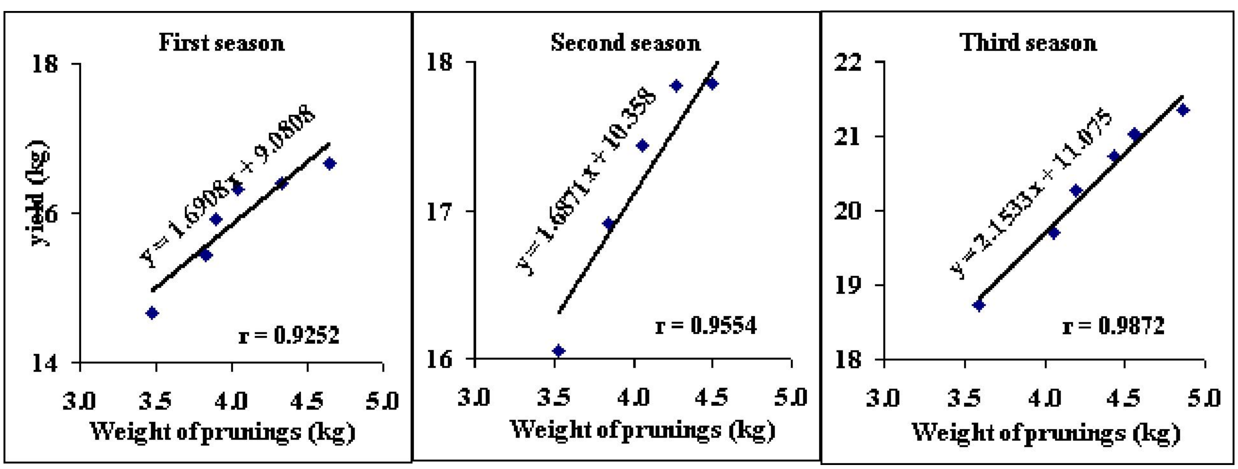

Fig (2): The relationship between the weight of prunings (kg) and yield (kg) in the three seasons

Table (6): Economical justification of the contribution of some rootstocks in raising vine productivity compared with own-rooted vines

Per Feddan	First season					
	Dogridge	**Salt creek**	**Freedom**	**Harmony**	**Paulsen 1103**	**Own-rooted**
Price of the rootings (L.E.)	3500	3500	3500	3500	3500	700
Cost of cultural practices (L.E.)	2700	2700	2700	2700	2700	2700
Total cost (L.E.)	6200	6200	6200	6200	6200	3400
The increase in Cost of cultural practices over control (L.E.)	2800	2800	2800	2800	2800	---
Yield in (Kg)	11669.7	11483.1	11419.9	11146.7	10816.3	10259.8
Increase of the yield over control (Kg)	1409.8	1223.3	1160.1	886.9	556.4	---
Kg (L.E.)	2.00	2.00	2.00	2.00	2.00	1.90
Price of the increase in Kg over control (L.E.)	0.10	0.10	0.10	0.10	0.10	---
Yield (L.E.)	23339.3	22966.2	22839.9	22293.4	21632.5	19493.7
Price of the increase in yield over control (L.E.)	3845.64	3472.53	3346.20	2799.76	2138.84	---
The net profit (L.E.)	17139.3	20266.2	20139.9	19593.4	18932.5	16793.7
The net profit (L.E.) over control (L.E.)	345.6	3472.5	3346.2	2799.8	2138.8	---
Per Feddan	**Second season**					
	Dog ridge	**Salt creek**	**Freedum**	**Harmony**	**Paullsen 1103**	**Own-rooted**
Price of the rootings (L.E.)	3500	3500	3500	3500	3500	700
Cost of cultural practices (L.E.)	2800	2800	2800	2800	2800	2800
Total cost (L.E.)	6300	6300	6300	6300	6300	3500
The increase in Cost of cultural practices over control (L.E.)	2800	2800	2800	2800	2800	---
Yield in (Kg)	12675.1	12492.4	12487.2	12204.4	11837.5	11236.1
Increase of the yield over control (Kg)	1439.0	1256.3	1251.1	968.3	601.5	---
Kg (L.E.)	2.25	2.25	2.25	2.25	2.25	2.15
Price of the increase in Kg over control (L.E.)	0.10	0.10	0.10	0.10	0.10	---
Yield (L.E.)	28519.0	28107.9	28096.2	27459.8	26634.4	24157.6
Price of the increase in yield over control (L.E.)	4361.40	3950.37	3938.62	3302.24	2476.88	---
The net profit (L.E.)	22219.0	25307.9	25296.2	24659.8	23834.4	21357.6
The net profit (L.E.) over control (L.E.)	861.4	3950.4	3938.6	3302.2	2476.9	---
Per Feddan	**Third season**					
	Dog ridge	**Salt creek**	**Freedum**	**Harmony**	**Paullsen 1103**	**Own-rooted**
Price of the rootings (L.E.)	3500	3500	3500	3500	3500	700
Cost of cultural practices (L.E.)	2900	2900	2900	2900	2900	2900
Total cost (L.E.)	6400	6400	6400	6400	6400	3600
The increase in Cost of cultural practices over control (L.E.)	2800	2800	2800	2800	2800	---
Yield in (Kg)	14947.6	14714.1	14509.0	14190.3	13783.6	13109.8
Increase of the yield over control (Kg)	1837.8	1604.3	1399.2	1080.5	673.8	---
Kg (L.E.)	2.50	2.50	2.50	2.50	2.50	2.40
Price of the increase in Kg over control (L.E.)	0.10	0.10	0.10	0.10	0.10	---
Yield (L.E.)	37369.1	36785.3	36272.5	35475.8	34458.9	31463.5
Price of the increase in yield over control (L.E.)	5905.59	5321.75	4808.93	4012.23	2995.39	---
The net profit (L.E.)	30969.1	33885.3	33372.5	32575.8	31558.9	28563.5
The net profit (L.E.) over control (L.E.)	2405.6	5321.8	4808.9	4012.2	2995.4	---

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