

Comparative Performance of Flame Seedless Grapevines Grafted on Some Rootstocks with Respect to Productivity and Susceptibility to Root-Knot Nematodes (*Meloidogyne incognita*)

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Abstract: This investigation was conducted during two successive seasons (2017 and 2018) in a private vineyard located at Al-Alamine district, wadi El-natron El-alamina Desert road, to evaluate efficacy of some rootstocks (Freedom, Salt creek, Paulson 1103 and Richter 110) to resistance to root-knot nematodes (*Meloidogyne incognita*) and its effect on productivity and fruit quality of grafted Flame Seedless grape cultivar on them. The vines were four years old, grown in a sandy soil, supported by the Gable system, spaced at 2 X 3 meters apart, irrigated by the drip irrigation system, the double cordon system was used and spur pruned with a bud load of 60 buds/vine (30 fruiting spurs X 2 buds each). The results showed that all vines grafted on rootstocks were better than own rooted ones. Superior results were attained by vines grafted on Freedom followed by Salt creek, Paulson 1103 rootstocks and Richter 110 with respect to bud burst and fruitful buds percentage, enhancement in vegetative growth parameters and leaf content of total chlorophyll and some macro nutrients (nitrogen, phosphorus and potassium). Data of root growth parameters showed that extension of fine roots was significantly higher at 30cm depth of the soil profile; the horizontal extension of fine roots was more concentrated at a distance of 50cm from vine trunk. All considered rootstocks attained higher magnitudes of medium roots and large roots in both horizontal and vertical directions as compared with own rooted vines. The fiber fraction (acid detergent lignin, Hemicellulose and cellulose) recorded the higher percentages in roots of vines grafted on rootstocks whereas; root proline and free amino acids content were lower. Additionally, rootstocks had a positive impact on yield and its components and berry quality attributes. Richter 110 rootstock proved to be superior and recorded the highest percentage of TSS, TSS/acid ratio and anthocyanin content of berry skin and the least in acidity percentage of the berry juice. However, all rootstocks had a significant effect in reducing the total population and buildup of root-knot nematodes (*Meloidogyne incognita*) in both soil and roots. It could be concluded that Flame Seedless vines grafted on Freedom, Salt creek, Paulson 1103 and Richter 110 grape Rootstocks were more resistant to root-knot nematodes (*Meloidogyne incognita*) than own rooted Flame Seedless vines and led to a higher yield in terms of both quality and quantity. Superiority in resistance was dedicated to vines grafted on Freedom rootstock.

Key words: Flame Seedless grapevines • Rootstocks • Nematodes

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the most important and favorable fruit crops grown in Egypt. It ranks the second after Citrus with respect to both acreage and production. Flame Seedless is one of the most important cultivars grown in Egypt due to its suitability to prevailing weather conditions, high productivity and supreme

quality. Yet it suffers from infection with nematodes which is greatly evident in desert vineyards, presenting a critical problem.

Several solutions have been proposed. One of the most reliable was grafting on rootstocks which are employed in grape cultivation to overcome several biotic and abiotic stresses one of which is nematode infection in addition to their impact on vine performance in general [1].

Reynolds and Wardle [2] outlined some major criteria for rootstock choice. It was as follows in the order of their importance phylloxera and nematode resistance, adaptability to high pH soils, saline soils, wet or poorly drained soil and drought.

Grapevines are a host of a large variety of plant nematodes, the most common of which are *Meloidogyne* spp. (root-knot nematodes), *Xiphinema* spp. (dagger nematodes), *Pratylenchus* spp. (rootlesion nematodes), *Longidorus* spp. (needle nematodes), *Crictonemoides* spp. (ring nematodes) and some species of the genera *Rotylenchus* and *Helicotylenchus* (spiral nematodes) [3,4].

Meloidogyne spp. and *Xiphinema* index are the primary nematode pathogens of grapevines. These nematodes can impair the establishment of new grapevine plantations and reduce the vigor, yield and productive life span of already established vineyards as well as enhance infection and damage of their roots by other pathogens [5, 6]. *Meloidogyne arenaria*, *M. incognita* and *M. javanica* cause significant economic losses in sandy soil-grown grapevines under the mild temperature conditions that prevail in most grapevine-growing areas of California, the Mediterranean Basin and South Africa [3, 6]. Rootstocks affect growth, yield and fruit quality [7, 9].

The aim of the present investigation was to compare the relative performance of Flame Seedless grapevines grafted on four rootstocks i.e. Salt creek, Freedom, Paulson 1103 and Richter 110 or own rooted with respect to bud behavior, vegetative growth, production in terms of quality and quantity and susceptibility to root-Knot nematodes.

MATERIAL AND METHODS

This investigation was carried out on four years old Flame Seedless grapevines in a commercial vineyard that was infected with root-Knot nematode *M. Incognita* at –El Alamine district, wadi El-natron El-alamin Desert road - for two successive seasons (2017 and 2018). Vines used for this investigation were grafted on Salt creek, Freedom, Paulson 1103, Richter 110 or were own rooted.

These rootstocks were characterized according to Schmid *et al.* [10]; Sule [11]; Walker *et al.* [12] and Ozden *et al.* [13] as follows: Salt creek (*V. champini*): very high vigor with high 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.

Paulsen 1103 (*V. berlandieri* x *V. rupestris*): moderate vigor, moderately resistant to nematodes, highly resistant to phylloxera and highly drought tolerant.

Richter 110 (*V. berlandieri* x *V. rupestris*): moderate vigor and resistant to nematodes and phylloxera.

Selected vines were uniform as much as possible, grown in sandy soil and supported with a Gable system. Vines were planted at 2X3m apart and double cordon trained, spur pruned with a buds load of 60 buds/vine (30 fruiting spur of 2 buds each). Pruning was carried out on the first week of January and same horticultural practices recommended by Ministry of Agriculture were applied. Eighteen vines of each considered rootstock and own rooted vines were selected. Each six vines acted as a replicate and the completely randomized design was adopted. The following parameters were measured to assess the performance:

Bud Behavior: Bud burst percentage was calculated according to the following equation:

Bud burst (%) = Number of burst buds / Number of bud load per vine x 100

Fruitful buds (%) = Number of fruitful buds per vine / Number of burst buds per vine x 100 [14].

Vegetative Growth Parameters: At growth cessation, Main shoot length (cm), cane thickness (cm), leaf area using leaf area meter model C/203, USA, the total surface area of the leaves/vine (m²) using the following equations: leaf surface area x average number of leaves/shoot x number of shoots/vine and Coefficient of wood ripening using the following equation: length of ripened part / the total length of cane [15].

Chemical Analysis: Leaf chlorophyll content (mg/g fresh weight) were measured in the mature leaves of the sixth and seven position from the apex by using nondestructive Minolta chlorophyll meter SPAD 502 (SPAD is an acronym for soil plant analysis development) [16].

The leaves opposite the clusters were taken at full bloom and percentages of N, P and K contents were determined in the petioles according to Wilde *et al.* [17].

Root Distribution: Soil samples were collected using an auger (auger volume = 1153.8cm³) from four direction at 50cm and 100 cm from the vine trunk and at depths of 30cm and 30-60cm). Roots were classified into fine roots (less than 2mm diameter) medium roots (2-6 mm diameter) and large roots more than (6mm diameter), lengths of each category were recorded for each sample [18].

Chemical Constituents of Roots

Fiber Fraction: Cell wall constituents were analyzed according to Goering and Van Soest [19] to determine neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL), hemicellulose and cellulose were mathematically determined.

Prolin: Was estimated by using the method of Batels *et al.* [20].

Free Amino Acid: Method of Rosein [21] was used after modification carried out by Selim *et al.* [22] for determination of free amino acids. The concentration of amino acids was calculated from standard curve of glutamic acid.

Yield and its: Harvest was carried out for all treatments when TSS percentage of fruit juice reached 16-17% [23]. Yield/vine (kg) was determined as number of clusters/vine multiplied by the average cluster weight (g). Representing samples of 12 clusters/vine were harvested at random to estimate average cluster weight (g).

Physical and Chemical Characteristics of Berries:

Average berry weight (g), average berry size (cm³) were determined. Total soluble solids in berry juice (TSS %) was determined using hand refractometer and total titratable juice acidity expressed as tartaric acid (%) according to A.O.A.C. [24]. The TSS /acid ratio was calculated and total anthocyanin of the berry skin (mg/100g fresh weight) according to Yildiz and Dikman [25] was determined.

Nematode Parameters: This experiment was lasted for four months, every month nematode populations in both soil and root including number of secondary stage juveniles/ 250g. Soil, developmental stages, females, eggs and eggs/egg-mass were determined from the bud burst stage to the harvest stage. The nematode population in an aliquot of 250 g. soil was extracted by sieving and

decanting technique [26]. Roots were stained by acid fuchsin in acetic acid according to Byrd *et al.* [27] and examined for counting number of developmental stages and females/g. root. Egg masses, eggs /egg-mass of *M. incognita* were extracted by using sodium hypochloride (NaOCl) method as described by Hussey and Barker [28]. In addition, the final nematode population (PF) and rate of build-up of *Meloidogyne incognita* (PF/PI) were calculated according to Oostenbrink [29] as follows:

Final nematode population (PF) = (No. of egg-masses x No. of eggs/egg-masses) + No. of females + No. Of developmental stages + No. of juveniles in soil).

$$\text{Rate of buildup of nematodes (PF/ PI)} = \frac{\text{Final nematode population PF}}{\text{Initial nematode population PI}}$$

Statistical Analysis: Data were subjected to analysis of variance according to Gomez and Gomez [30] and means were compared by using the new LSD at 5% level of significance according to Snedecor and Cochran [31].

RESULTS AND DISCUSSION

Bud Behavior: Data in (Table, 1) show the percentages of bud burst and fruitful buds of considered grapevines. Data revealed that highest bud burst percentage was that of vines grafted on Freedom rootstock in both seasons followed by those grafted on salt creek, on Paulson 1103 and then others grafted on Richter 110. On the other hand, own rooted vines attained the lowest percentage.

The results, in general are in agreement with the findings by Parakash and Reddy [32] who reported that rootstocks resulted in a significant effect on bud break in the cultivar Anab-e-shahi. It was also interesting to notice that; grafting Flame Seedless cv. on Freedom rootstock attained the highest significant percentage of fruitful buds through the studied seasons compared with own rooted Flame Seedless vines which showed the lowest percentage of fruitful buds.

Zhongyan [33] mentioned that flower promoting rootstocks decrease the level of floral abortion by encouraging the buds of scions to use a greater proportion of the reserve carbohydrates for flower development in Kiwi fruit. Similar result were obtained by El-Morsi *et al.* [34] and Jogaiah *et al.* [35] as they reported that ungrafted vines resulted in the lowest percentage of bud burst and fruitful bud compared with vines grafted on rootstocks.

Table 1: Impact of used rootstock on bud behavior of scions during seasons 2017 and 2018

Rootstocks	Bud burst (%)		Bud fruitful (%)	
	2017	2018	2017	2018
Freedom	76.62	78.75	64.87	68.48
Salt Creek	71.82	73.58	62.75	65.81
Paulson 1103	68.40	70.55	59.72	61.83
Richter 110	65.28	68.32	56.91	58.71
Own rooted (control)	60.76	61.97	51.83	50.95
New LSD at 5%	2.93	3.08	2.09	2.35

Table 2: Impact of used rootstock on vegetative growth parameters during seasons 2017 and 2018

Rootstocks	Average ultimate shoot length (cm)		Cane thickness (cm)		Average leaf surface area/vine (m ²)		Coefficient of wood ripening	
	2017	2018	2017	2018	2017	2018	2017	2018
Freedom	288	297	1.10	1.15	20.63	22.70	0.87	0.89
Salt Creek	283	292	1.00	1.11	18.16	21.50	0.85	0.86
Paulson 1103	276	280	0.97	1.08	15.11	18.27	0.81	0.83
Richter 110	273	278	0.94	0.96	13.57	15.43	0.80	0.81
Own rooted (control)	235	229	0.89	0.87	10.95	11.18	0.65	0.63
New LSD at 5%	3.0	4.0	0.02	0.03	1.52	1.78	0.01	0.02

Table 3: Impact of used rootstock on chemical characteristics of vegetative growth during seasons 2017 and 2018

Rootstocks	Total chlorophyll (mg/g F.W.)		Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	2017	2018	2017	2018	2017	2018	2017	2018
Freedom	47.85	50.22	2.20	2.23	0.43	0.47	1.13	1.17
Salt Creek	45.19	47.59	1.96	1.98	0.40	0.43	1.08	1.12
Paulson 1103	43.85	45.27	1.70	1.73	0.36	0.38	1.04	1.06
Richter 110	40.67	43.85	1.65	1.66	0.32	0.33	1.16	1.19
Own rooted (control)	30.91	28.31	1.12	1.10	0.29	0.27	0.84	0.81
New LSD at 5%	1.15	1.37	0.03	0.04	0.02	0.03	0.03	0.04

Vegetative Growth Parameters: As shown in (Table, 2) it is evident that rootstocks induced significant increases in shoot length, cane thickness, total leaf surface area per vine and wood ripening coefficient. The data revealed better vegetative growth parameters per grafted vine in contrast to ungrafted vines. Flame Seedless vines grafted on Freedom rootstock showed the highest increments of these parameters in both seasons. Followed by vines on Salt Creek rootstock which came next followed by Paulson 1103 and then those grafted on Richter 110. Meanwhile, own rooted vines attained the least values of these parameters. The ameliorative effect of grafting on vegetative growth parameters in comparison with own rooted vines might be due to the high efficiency of the root system of Freedom in absorbing and transporting water and minerals via the grafted union to the shoots of Flame scion and to the favorable reciprocal relationship between scion and stock. However, the vigorous growth of the grafted Flame Seedless Cv. on the rootstocks could be due to their resistance against parasitic nematode which decreases the roots capability of absorption. The

present results are in agreement with Sasanelli *et al.* [36] who found that shoot length was longer for Paulson 1103 than cv. Italia when infested with root-knot nematode *Meloidogyne sp.* Also, Gutierrez *et al.* [37] stated that shoot and main stem diameters appeared to be the most sensitive variables of damage caused by infection by *Meloidogyne spp.* with reduction rates from 36%-53% in 161-490 and 57-66% in 140 Ruggeri.

Chemical Characteristics of Vegetative Growth

Total Chlorophyll: It is clear from the results demonstrated in Table (3) that total chlorophyll content in the leaves was positively affected significant by the grafting Flame Seedless cv. onto Freedom, Salt Creek rootstock, Paulson 1103 or Richter 110 rootstocks compared to own rooted vines. Vines on both Freedom and salt creek rootstocks in the first season and in the second one attained significantly the highest leaf total chlorophyll. Whereas, leaves of own rooted vines attained significantly the least total chlorophyll in both seasons. In this respect, it could be said that Richter 110

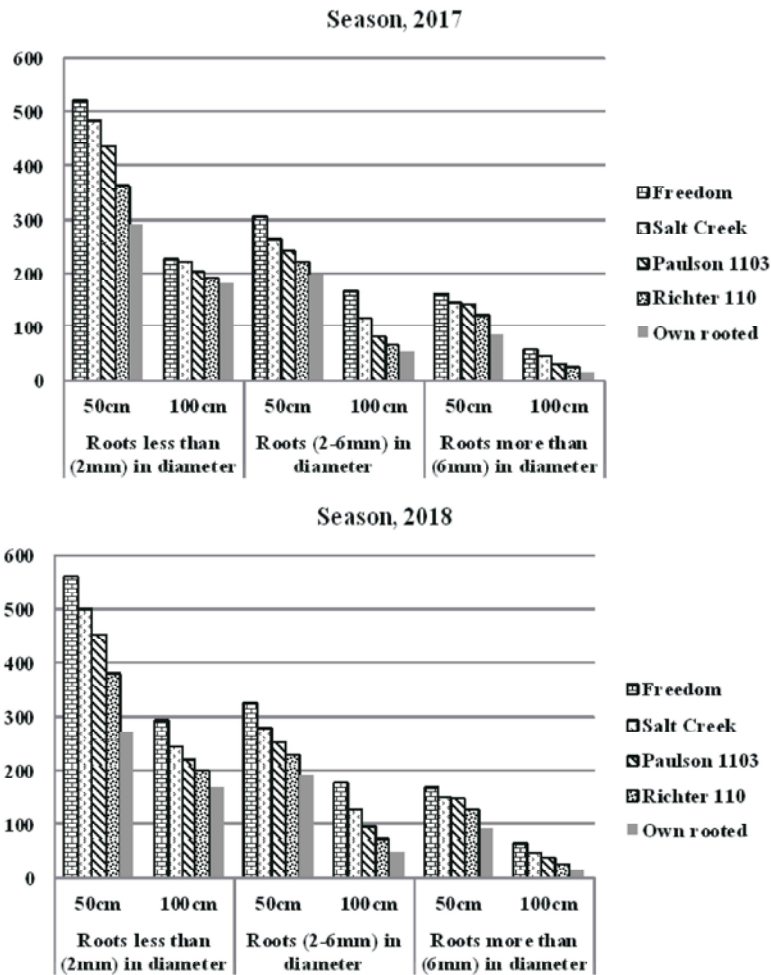


Fig. 1: Impact of used rootstock on root distribution within the distance during seasons 2017 and 2018

was more sensitive to nematodes than Freedom and Salt Creek rootstocks have more ability to highest resistant to nematode. Similarly, Keller *et al.* [38] reported that chlorophyll content was the highest in vines grafted on K5BB and the lowest for 330ac. Furthermore, Sourial *et al.* [39] found that nematode depressed pigments contents of Thompson Seedless grapevines, while it was high in the vines grafted on Dog ridge. The effect of *M. incognita* on leaf photosynthetic pigments might be due to the lower ability of injured roots to absorb enough quantities of such elements as nitrogen, zinc, iron and magnesium which increases the pigments synthesis [40]. Bavaresco and Lovisolo [41] confirmed that the chlorosis could be attributed to the different hydraulic conductivities between the rootstocks and the scions for iron.

Leaf Macro Nutrients Content: Results dealing with the impact of rootstocks on leaves content of macro nutrients (N, P and K) are presented in (Table 3). Data attained

show that the least percentages of the leaf nutrients were those of own rooted vines. On the other hand, the highest significant percentage of nitrogen and phosphorus were attained by leaves of vines grafted on Freedom rootstock. With respect to the effect of rootstock used on leaf potassium content, data show significant differences between rootstocks and own rooted vines and Richter 110 recorded the highest significant potassium content. From the previous results, it could be noticed that the differences in leaf nutrient 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 Brancadoro and Valenti [42] who 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. Also, Grant and Matthews [43] declared that different rootstocks might

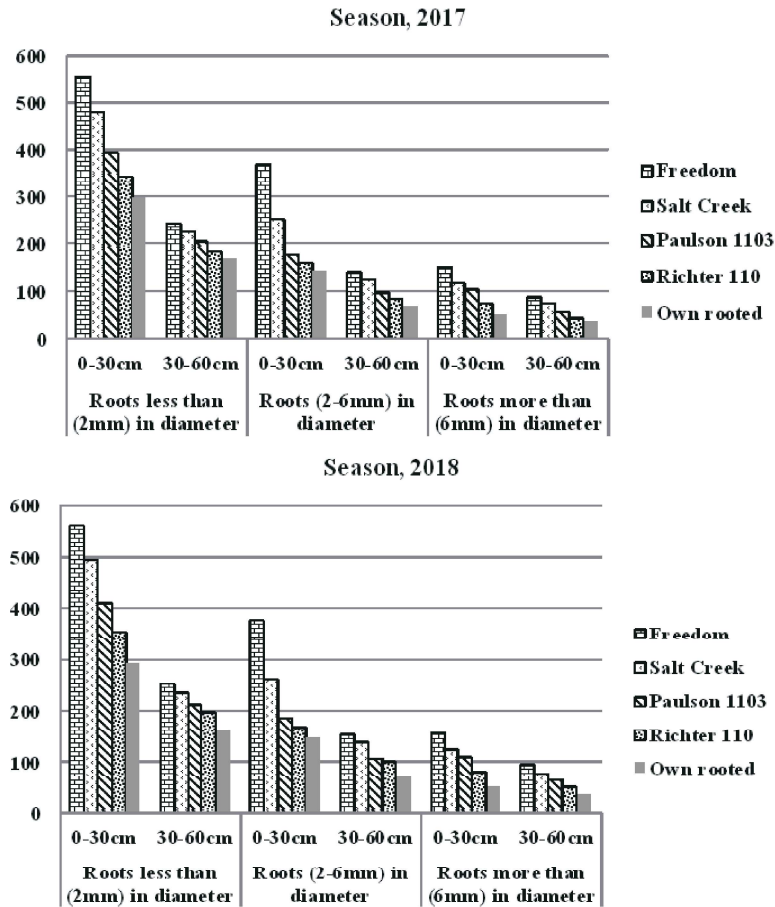


Fig. 2: Impact of used rootstock on root distribution with the depth during seasons 2017 and 2018

have different abilities to absorb phosphorus. Moreover, some nutrients might be assimilated mostly by roots, thus reducing the amount translocated to the shoots. In this respect, Keller *et al.* [38] found that over 85% of nitrogen was assimilated by way of vine root metabolism.

Root Distribution: Depth of the roots and their distribution in soil profile are important criteria for the nematodes population in the root zone. Figures (1 & 2) show distribution of roots at depths of (0-30 and 30-60cm) and at (50 and 100cm) for the grapevine on different rootstocks different treatments.

Fine Roots (Root Less Than 2mm in Diameter): Figures (1 & 2) show that vines on rootstocks throughout the two successive season's attained longer roots. Also, the bulk of the roots are usually concentrated in the upper soil layer. Vines grafted on rootstocks significantly recorded the highest values of roots being almost in the horizontal, as well in the vertical direction. In this concern, the greatest amount of roots was observed within the

distance 50 cm from the vine trunk 50cm when compared to roots located at 100 cm. Also roots concentrated at 0-30 cm depth rather than 30-60 cm. the positive effect of rootstocks on the fine roots extension through the vertical and horizontal directions could be ranked in the following descending order, Freedom, Salt creek, Paulson 1103 and Richter 110 rootstocks. Moreover, Freedom and Salt creek were superior in producing higher values of fine root density. However, the minimum values of fine roots extension were observed in the ungrafted Flame Seedless grapevines.

Medium Roots (Root 2-6mm in Diameter): Results revealed that medium roots were significantly affected by different rootstocks, the highest values resulted from Freedom rootstock and the lowest ones obtained from Flame Seedless own-rooted, while Salt creek, Paulson 1103 rootstocks and Richter 110 ranked in-between. Data presented in Figures (1 & 2) show an obvious concentration of medium roots at 50cm from the vine trunk and at 30cm soil depth.

Large Roots (Roots More than 6mm in Diameter):

Figures (1 & 2) reveal that the highest magnitudes were attained by vines on rootstocks. Generally speaking, results show that the horizontal and vertical extension of large had a trend similar as those of fine and medium roots. The positive effect of rootstocks on root length may be due to translocation and distribution of nutrients which may differ among rootstocks. In this respect, Giorgessi *et al.* [44] found differences in number and size of the xylem vessels between rootstocks and own rooted vines. The least value root length was observed in the ungrafted Flame Seedless vines. The results in this respect are in harmony with those obtained by El-Gendy and Shawky [45] and Mervat *et al.* [46] they found a significant effect on the reduction in root growth as a result of infected vineyards with *M. incognita*.

Chemical Constituents of Roots: Effect the natural infestation with *M. incognita* on the chemical constituents of roots Flame Seedless grapevines cv. grafted on some rootstocks or own rooted. Data given in Table (4) revealed that grapevine rootstocks and own rooted ones varied significantly in their root chemical constituents. The fraction (ADL, Hemicellulose and cellulose) recorded the highest percentage in Flame Seedless cv. grafted on Freedom followed by Salt creek, then Paulson 1103 then Richter 110 comparing with the own rooted ones. In contrast the concentration of proline and free amino acids were extremely higher in the own rooted Flame Seedless grapevines Cv. than rootstocks one. However, the highest values of proline and free amino acids in roots was obtained from rootstock Richter 110 followed by Paulson 1103 while rootstock Salt creek ranked the third position. On the other hand, rootstock Freedom had significant decreased in both seasons. It could be observed that roots of nematode resistant rootstocks contain higher percentage from fiber fraction than the own rooted cultivar, whereas the later contain higher concentration from proline and free amino acids. Nevertheless increasing the percentage of the fiber fraction in the roots of nematode resistant rootstocks than the own rooted ones could be due to the differences in the anatomical structure of their cell walls, whereas increasing the concentration of the proline and free amino acids in the susceptible own rooted ones could be due to the induced resistance against nematode infection. Thus could be explain the decreasing total numbers of root knot *M. incognita* of rootstocks Freedom, Salt creek, Paulson 1103 and Richter 110 and increasing nematode numbers in own rooted cultivars.

The obtained results are confirmed by the finding of Duncan *et al.* [47] as they found that numbers of citrus nematode were related positively to root content of reducing sugars, starch and total nonstructural carbohydrates, whereas related inversely root lignin content. James *et al.* [48] studied the effect of endophyta (*Neotyphodium Spp*) on the concentration of acid detergent fiber (ADF), neutral-detergent fiber (NDF) in three tall fescue (*Ledum arundinaceum*), they found that E⁺ plants had higher concentration of ADF and NDF. The endophyta increased or decreased fiber content of tall fescue depending upon plant genotype. Also, El-Hady [49] showed that the fiber fraction (ADL, Hemicellulose and cellulose) recorded the highest percentage in cultivars grafted on Freedom and Salt Creek rootstocks comparing with own-rooted ones.

Concerning to amino acids levels, El-Hady [49] found that a significant increases in concentration of proline and free some amino acids in the fibrous root of own rooted cultivars infected with root knot nematode *M. incognita* compared with grapevine cultivars grafted on rootstocks, in addition, there is a positive relationship between proline concentration and numbers of nematodes *M. incognita* developed on grapevines.

Yield and its Components: Data in Table (5) reveal that yield and its components were influenced significantly due to the rootstock rafted on in the two seasons of this study., Flame Seedless vines grafted on Freedom significantly attained the highest yield in the two experimental seasons, followed in descending order by Flame Cv. on Salt creek, on Paulson 1103 rootstocks then on Richter 110, Whereas the own rooted ones showed lowest yield. Concerning the cluster weight and number of clusters/vine, the results show a similar trend. Increasing grape yield, cluster weight and number of clusters/vine for grafted Flame Seedless on rootstocks could be due to the resistance of these rootstocks to nematode infestation, in addition to enhancing their growth characteristics. On the other hand, our results demonstrated that infected vines own rooted had the lowest yield. This may be due to the negative effect of nematodes on reducing the feeder roots, inducing inability to withstand stress and reduction in uptake of N, P and K.

The results attained are in agreement with Luvisi *et al.* [50] who mentioned that productivity of marketable grapes was highest on rootstocks Freedom and 1103-P, followed by 039-16 and the self-rooted plants.

Table 4: Impact of used rootstock on chemical constituents of roots during seasons 2017 and 2018

Rootstocks	Fiber fraction									
	ADL (%)		Hemicellulose (%)		Cellulose (%)		Proline (%)		Free amino acids (mg/g F.W.)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Freedom	27.39	28.45	41.64	42.75	29.85	30.12	0.33	0.32	55.64	54.92
Salt Creek	24.81	25.78	37.76	38.89	27.13	28.15	0.36	0.35	58.47	59.83
Paulson 1103	22.61	24.31	33.46	35.07	25.89	26.43	0.40	0.40	63.81	65.24
Richter 110	21.30	22.53	31.09	33.12	22.18	22.78	0.42	0.43	67.93	69.11
Own rooted (control)	16.89	16.53	20.30	20.75	14.34	14.23	0.51	0.56	74.48	77.63
New LSD at 5%	0.95	1.02	1.95	2.12	1.65	1.72	0.03	0.02	2.11	2.09

Table 5: Impact of used rootstock on yield and its components during seasons 2017 and 2018

Rootstocks	Number of clusters/vine		Cluster weight (g)		Yield/vine (Kg)	
	2017	2018	2017	2018	2017	2018
Freedom	27.75	28.81	531.11	553.12	14.74	15.94
Salt Creek	26.59	26.73	460.31	490.32	12.24	13.32
Paulson 1103	24.27	25.13	356.37	372.15	8.65	9.50
Richter 110	23.18	24.41	339.81	361.58	7.88	8.83
Own rooted (control)	19.57	20.11	318.00	297.00	6.28	5.97
New LSD at 5%	0.98	0.45	12.55	14.31	0.50	0.30

Also, El-Hady [49] reported that vines on Freedom and Salt creek rootstocks had higher average annual yields than own rooted vines which infected with root-knot nematode *Meloidogyne* sp.

Physical Characteristics of Berries: Physical characteristics of berries i.e. berry weight and size are important as parameters for quality. It is clear from Table (6) that grafting on nematode resistance rootstocks significantly improved physical characteristics of berries in terms of increasing berry weight and size. Different rootstock had a pronounced influence on berry weight and size, since Flame Seedless grapevines grafted on Freedom resulted in the highest significant magnitudes followed in a descending order by those grafted on Salt creek, Paulson 1103 and Richter 110 rootstocks, while least magnitudes were those attained by own rooted vines.

The obtained results referring to positive effects of rootstocks on physical characteristics of berries are in agreement with those reported by Satisha *et al.* [51] who found that bigger and heavier berries, in terms of larger berry diameter and berry weight, recorded on vines grafted onto Dog Ridge rootstocks as compared to own-rooted vines.

Chemical Characteristics of Berries: Data presented in Table (7) indicate that all berry chemical characteristics i.e.

total soluble solids, acidity, total soluble solids/acid ratio and anthocyanin content of berry skin were significantly affected by nematode resistance rootstocks. Flame Seedless grapevines grafted onto Richter 110 were found to record the highest percentages of TSS %, TSS/acid ratio and anthocyanin content of berry skin and the lowest percentage of juice acidity in the berry juice. These results were supported by Mervat *et al.* [46] who found that natural infestation with *Meloidogyne incognita* decreased fruit sugar content of Thompson Seedless grapevines. There was a relation between potassium and the content of anthocyanins. It is worth mentioning that, the proportion of potassium rose in Flame Seedless leaves when grafted onto Richter 110 rootstock. This fact may reflect the positive effect of potassium in increasing the accumulation of sugars in berries. Subsequently, there is a direct correlation between potassium uptake and sugar content and hence anthocyanin synthesis in the skin of berries. The effect of rootstock on berry composition has been studied by several workers, Kubota *et al.* [52] 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 CV recorded higher color hue than own-rooted vines [12]. Also, El-Gendy [9] reported that Flame Seedless CV grafted on Freedom and Salt Creek and showed an increase in TSS% and decrease in the acidity compared with ungrafted vines.

Table 6: Impact of used rootstock on physical characteristics of berries during seasons 2017 and 2018

Rootstocks	Berry weight (g)		Berry size (cm ³)	
	2017	2018	2017	2018
Freedom	2.85	2.96	2.67	2.71
Salt Creek	2.79	2.85	2.59	2.65
Paulson 1103	2.73	2.80	2.55	2.60
Richter 110	2.61	2.69	2.48	2.54
Own rooted (control)	2.35	2.31	2.22	2.18
New LSD at 5%	0.06	0.08	0.05	0.04

Table 7: Impact of used rootstock on chemical characteristics of berries during seasons 2017 and 2018

Rootstocks	TSS (%)		Acidity (%)		TSS/acid ratio		Anthocyanin (Mg/100g F.W.)	
	2017	2018	2017	2018	2017	2018	2017	2018
Freedom	17.4	17.8	0.61	0.56	28.52	31.79	48.62	49.85
Salt Creek	17.2	17.5	0.63	0.60	27.30	29.17	45.71	47.31
Paulson 1103	16.8	17.1	0.65	0.62	25.85	27.58	42.57	43.22
Richter 110	17.8	18.0	0.55	0.52	32.36	34.62	50.78	52.43
Own rooted (control)	14.4	14.2	0.70	0.71	20.57	20.00	31.23	29.81
New LSD at 5%	0.1	0.2	0.02	0.02	1.15	1.35	2.11	2.33

Table 8: Comparative susceptibility of various vines roots to nematode, *Meloidogyne incognita* under field conditions in 2017 season

Grape rootstocks	Initial	After one month		After two months		After three months		After four months	
	Total population in soil/ 250 g	Total population in soil/ 250g.+ in root/g	PF/PI	Total population in soil/ 250g.+ in root/ g	PF/PI	Total population in soil/250g + in root/g	PF/PI	Total population in soil/250g + in root/ g	PF/PI
Freedom	640	680	1.06	720	1.13	800	1.25	760	1.19
Salt creek	980	1080	1.10	1160	1.18	1320	1.35	1240	1.27
Paulson 1103	1260	1480	1.17	1560	1.24	1780	1.41	1720	1.37
Richter 110	1550	1880	1.21	2140	1.38	2340	1.51	2340	1.51
Own rooted	1800	2760	1.53	2880	1.60	2990	1.66	2920	1.62
New L.S.D.	29.6	36.8	0.03	55.1	0.05	63.3	0.07	61.5	0.06

at 0.05% level

Table 9: Comparative susceptibility of various vines roots to nematode, *Meloidogyne incognita* under field conditions in 2018 season

Grape rootstocks	Initial	After one month		After two months		After three months		After four months	
	Total population in soil/ 250 g	Total population in soil/ 250g.+ in root/g	PF/PI	Total population in soil/ 250g.+ in root/ g	PF/PI	Total population in soil/ 250g.+ in root/g	PF/PI	Total population in soil/250g + in root/ g	PF/PI
Freedom	740	780	1.05	800	1.08	880	1.19	820	1.11
Salt creek	1060	1140	1.08	1240	1.17	1400	1.32	1320	1.25
Paulson 1103	1340	1560	1.16	1640	1.22	1880	1.40	1800	1.48
Richter 110	1620	1940	1.20	2220	1.37	2420	1.49	2400	1.51
Own rooted	1880	2840	1.51	2960	1.57	3080	1.64	3020	1.61
New L.S.D.	29.6	42.5	0.02	58.7	0.07	67.5	0.09	65.3	0.08

at 0.05% level

The Effect on Nematode Populations: The nematode populations were counted throughout the experimental period and documented in Table (8 and 9). Total nematode population in both soil and root samples revealed different degrees of susceptibility to root-knot nematodes; *Meloidogyne incognita* for rootstocks used. In general, the nematode counts increased gradually in

both soil and root of the considered vine. All grape rootstocks performed rates of buildup of nematodes (PF/PI) ranging between 1.06-1.53 after one month. Then, remarkable increases in nematode counts were attained after two months or more expect at the fourth month where the total nematode population in both soil and root samples decreased. At the end of experiment all

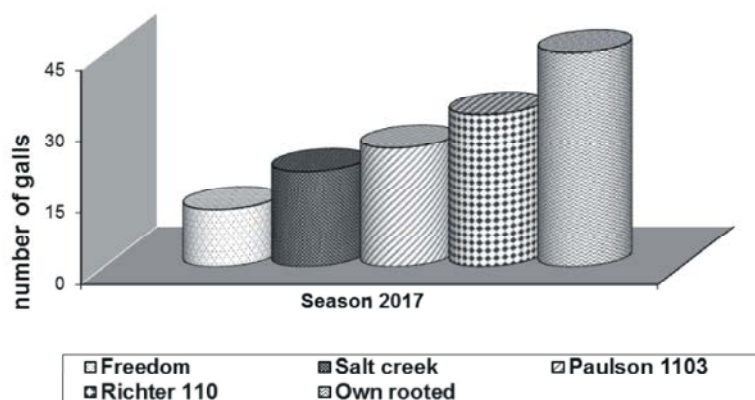


Fig. 3: Comparative susceptibility of various vines on number galls of roots to nematode, *Meloidogyne incognita* under field conditions in 2017 season

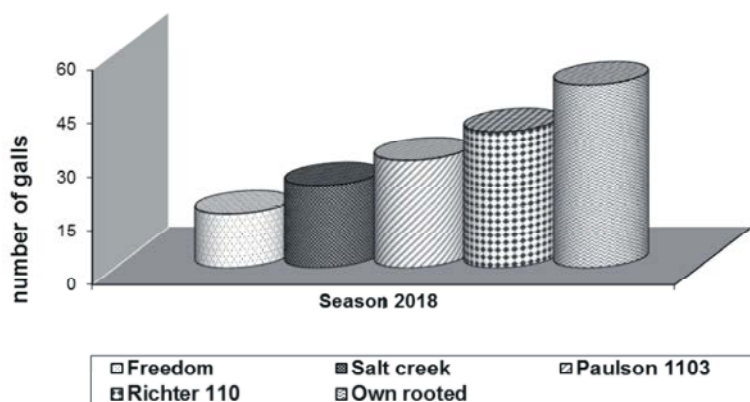


Fig. 4: Comparative susceptibility of various vines on number galls of roots to nematode, *Meloidogyne incognita* under field conditions in 2018 season

grapevines showed satisfactory reductions in the nematode counts and build-up of nematode, the rootstocks freedom was highly resistance followed by salt creek, Poulson 1103 and Richter 110 than the flame seedless cultivar was highly susceptible to the infestation. The same trend was observed in the second also.

Fig. (3 & 4) shows the number of root galls per vine in 2017 and 2018 seasons. Freedom rootstock attained lowest number of galls in comparison with the other grape rootstocks and own rooted vines at harvest. Flame Seedless roots showed the highest number in both seasons of the investigation.

The obtained results are highly supported with the findings of Mc-kenry *et al.* [53] who tested 18 rootstocks in addition *vitis vinifera* cv. Thompson Seedless against five *Meloidogyne spp* they found that grape rootstocks 1613 C, Dog Ridge, Freedom, Harmony, Telki 5C, K51-32 and Ramsey were resistant to 4

Meloidogyne spp except *M. arenaria*. Also, Aman [reported that grape rootstocks Freedom, Salt creek and Harmony were highly resistant to Root -knot nematode *Meloidogyne spp* than the grapevine Cvs. Superior Seedless, Flame and Crimson cultivars under field conditions.

CONCLUSION

In conclusion data revealed that all studied parameters were enhanced by grafting on rootstocks. These results support our suggested hypothesis that rootstocks resistant to nematode could play important role in management of root knot nematodes in Flame Seedless vineyards. The net impact of rootstocks was enhancement on vegetative growth, crop productivity and fruit quality of Flame Seedless grapevines and induction of a remarkable reduction in nematodes population the same subject.

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