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Research Article
Salinity Soil Effects on Yeild, Fruit Quality and Mineral Composition of Superior Seedless Grapevines Grafted on Some Rootstocks

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Abstract

Background and Objective: This investigation to study the evaluation of superior seedless grape cultivar grafted on Paullson 1103, Salt Creek and freedom grapevine rootstocks to soil salinity compared to own rooted superior seedless cultivar. **Methodology:** This study was conducted to estimate: Vegetative growth parameters, chemical analysis, yield and berry characteristics and antioxidant isozymes electrophoresis. The present data were statically analyzed by using new LSD method at 5% level. **Results:** The results showed that, superior grape cultivar grafted on three rootstocks gave the best results as compared to own rooted superior grape cultivar for three consecutive seasons. However, superior seedless grape cultivar grafted on Salt Creek rootstock had the highest percentage of bud burst and fruitful buds, improved the best vegetative growth parameters, increment depth of the roots and their distribution in the soil profile. Cane content of total carbohydrates, leaf content of total chlorophyll and mineral content were increased and leaf prolin content, sodium and chloride were reduced. Additionally, it had a positive impact on the yield and berry quality attributes. Vine grafted on Paullson 1103, rootstock had a moderate effect for these parameters while, superior seedless grafted on freedom rootstock came the next. As regards to isozymes (peroxidase and polyphenyl oxidase), there were differences found in banding pattern density in freedom rootstock with high density banding patterns compared with Paullson1103 and superior seedless cultivar which appeared with moderate density in banding patterns. On the other hand, polyphenyl oxidase electrophoresis analysis represent no differences in banding patterns density among all rootstocks. **Conclusion:** Superior seedless grafted on Salt Creek, Paullson 1103 and freedom grape root stocks were more tolerant to soil salinity than superior seedless cultivar on own rooted root stock, vines grafted on Salt Creek was the most tolerant one.

Key words: Salinity soil, grafted superior seedless cv., grape root stocks, fruit yield quality, mineral composition, peroxidase, polyphenyl oxidase electrophoresis

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Superior seedless grapevine cv. is a prime and popular grape cv., successfully grown under Egyptian condition. It ripens early in the first week of June. In addition, it has a great potential for export for foreign markets due to its early ripening characters and it considered an important target for pomologists and exporters. However a great acreage is located at the new reclaimed land which faces problems of the salinity in the soil which can limit successful production. Salt-affected soils represent a major limiting factor in crop production or even survival[1]. Grapes have been classified as moderately sensitive to salt, although studies have shown cultivar differences in sensitivity[2].

Vines growing normally with less than 10% production at EC 1.5-2.5 (dS m^{-1}), but at the EC 2.5-4.0 (dS m^{-1}) level the production get decreased by 10-15%, whereas severe damage occurred at EC 4.7 (dS m^{-1}) decreasing the productivity by 25-50% Ayers and Westcot[3]. Also, growth, fruit production and quality parameters today are seriously affected by soil salinity[4,5].

However, grapevine response to salinity depends on several factors, such as rootstock-scion combination, irrigation system, soil type and climate. Moreover, change in some of these factors such as grafts on some of the rootstocks produce entirely different results[6]. Grafting on selected rootstocks is generally practiced nowadays all over the world. Many rootstocks originated as hybrids between *Vitis vinifera* and *Vitis riparia* or *Vitis rupestris* have been described[7].

Most of these rootstocks are tolerant to saline or calcareous soil[8]. In this respect Salt Creek and Paullson 1103 were the most salt resistant rootstocks, as they tolerate up to 0.8-1.5% NaCl by Walker *et al.*[9]. Among these rootstocks introduced into Egypt are freedom, Salt Creek, Ramsey and Paullson 1103. In this respect, sensitive rootstocks and *Vitis vinifera* could grow normally in soils containing 0.2-0.3% NaCl Huglin[10].

Moreover, the salt tolerance may be due to genetic background[11]. However, it is reported that all varieties grafted on freedom rootstock were found more salt sensitive[12]. Isozyme markers provide a convenient method for detecting genetic changes. Moreover, they have been used in apple as biochemical markers for cultivars identification[13,14] and for the identification of clonal apple rootstocks[15].

The objective of this study was to illustrate the comparative performance of superior seedless cv. on own rooted and superior seedless cv. grafted on three root stocks (Paullson 1103, Salt Creek and freedom) under the unfavorable environmental conditions especially salinity.

MATERIALS AND METHODS

This investigation was conducted in a private vineyard located at Alamine district, wadi El-Nataron El alamine desert road for three consecutive seasons (2012, 2013 and 2014) on 4 years old vines of superior seedless cv., grafted on Paullson 1103, Salt Creek and freedom rootstocks in comparison to superior seedless on own roots acting as control. Vines were grown in a sandy soil and on supported Gable system. Distances were 2 m between vines and 3 m between rows under drip irrigation system. The vines were cane-pruned to 72 buds per vine (6 canes×12 buds/cane). The tested vines were nearly the same and subjected to the same horticultural practices. Each treatment contained 5 replicates with 6 vines/replicate. The experiment was laid out in randomized complete block designed. The treatment details are as follows:

- Superior seedless grafted on Paullson 1103
- Superior seedless grafted on Salt Creek
- Superior seedless grafted on freedom
- Superior seedless on own roots

Physical and chemical analysis of the experimental soil and chemical analysis of irrigation water were done according to the procedures of Jackson[16], Black[17] and Wilde *et al.*[18] as shown in Table 1 and 2.

The following parameters were measured to evaluate the tolerance of superior seedless cv., grafted on Paullson 1103, Salt Creek and freedom rootstocks compared to own rooted superior seedless cv. to soil salinity.

Table 1: Physical and chemical analysis of the experimental soil

Physical properties						Chemical properties							
						Soluble anions (meq L^{-1})			Soluble cations (meq L^{-1})				
Sand (%)	Clay (%)	Silt (%)	Texture	EC (dS m^{-1})	pH	HCO_3	Cl	SO_4	Na	Mg	Ca	K	SAR
80.9	7.86	11.24	Sandy	3.4	7.78	2.7	19	12.2	23	4.1	13	2	7.80

Table 2: Chemical analysis of water irrigation

		Anions (meq L^{-1})				Cations (meq L^{-1})			
PH	EC (dS m^{-1}) 0.85	CO_3^-	HCO_3^-	Cl^-	SO_4^-	Ca^{++}	Mg^{++}	Na^+	K^+
7.15	544 ppm	0.1	2.55	0.86	1.22	1.82	0.71	2.3	0.18

Bud behavior measurements: Bud burst percentage was calculated according to the following equation:

$$\text{Bud burst (\%)} = \frac{\text{Calculated by dividing number of bursted buds}}{\text{Numbers of buds load per vine}} \times 100$$

$$\text{Fruitful buds (\%)} = \frac{\text{Number of fruitful buds per vine}}{\text{Number of bursted buds per vine}} \times 100$$

Vegetative growth parameters: Main shoot length (cm) and total surface of the leaves/vine were determined as follows: Leaf surface area was multiplied by the average number of leaves/shoot and then by number of shoots/vine using leaf area meter model CI 203, USA.

Root distribution: Soil samples were collected using an auger from 4 directions at 50 and 100 cm from the vine trunk and from depths of 0-30 and 30-60 cm. Root were classified into fine roots (less than 2 mm) in diameter, medium roots (2-6 mm) and large roots (more than 6 mm). Length was recorded for each sample[19]. Moreover, soil temperature through the 30 cm below the soil surface (where most of the root system is located) was recorded daily by using 25 cm long sensor thermometer.

Chemical studies:

- Leaf total chlorophyll content (SPAD) was measured by using nondestructive Minolta chlorophyll meter SPAD 502[20]
- Leaf proline content (mg g^{-1}) was colorimetrically estimated on fresh weight basis according to the method of Bates *et al.*[21]
- Cane total carbohydrate content % DuBois *et al.*[22]
- Leaf mineral content: N % Pregl[23], P % Snell and Snell[24] and K (%) Jackson[16], Mg (%), Ca (%), Cl (%) and Na (%) were estimated according to the methods of Wilde *et al.*[18]

Yield and berry characteristics:

- Number of clusters per vine, yield per vine (kg) and average cluster weight (g)
- Average berry weight (g) berry size (cm^3)
- Berry juice measurements
- Total Soluble Solids (TSS) percentage using a hand refractometer
- Titratable acidity percentage according to AOAC[25]
- Total soluble solids/acid ratio (TSS/acid)

Antioxidant isozymes electrophoresis: Extraction of isozymes was adopted as described by Jonathan and Weeden[26]. Native-polyacrylamide gel electrophoresis (Native-PAGE) was performed on 12% (w/v) slab gels[27]. Then, gels were stained according to Tanksley and Rick[28] for peroxidase (Px) isozyme and polyphenyl oxidase (PPO). The stained gels were incubated at 37°C in dark conditions for complete staining after adding the appropriate substrates and staining solutions.

Statistical analysis: The statistical analysis of the present data was carried out according to Snedecor and Cochran[29]. Averages were compared using the new LSD method at 5% level.

RESULTS AND DISCUSSION

Effect of grafting superior seedless cv. on some rootstocks under soil salinity condition

Bud behaviour: Table 3 shows the percentage of bud burst and fruitful buds of grafted superior seedless grapevine on some rootstocks show tolerance to soil salinity compared to the ungrafted vines. Data revealed that, bud burst percentage gained the highest values in the three seasons, for grafted superior cv. on Salt Creek, whereas, vines grafted on Paullson 1103 rootstock ranked second followed by grafted superior cv. on freedom rootstock. On the other hand, ungrafted superior cv., resulted in remarkable reduction in bud burst. The results, as a general trend are in harmony with the conclusion given by Prakash and Reddy[30] who reported that the effect of rootstocks on bud break in the cultivar Anab-e-shahi, gave a significant effect of rootstocks on bud burst. It is interesting to notice that, grafting superior cv. on Salt Creek rootstock gave the highest percentage of fruitful buds through the three studied seasons compared with ungrafted grapevines which resulted in the lowest percentage of fruitful buds.

Table 3: Effect of grafting superior seedless cv. on some rootstocks under saline condition on bud behavior during (2012, 2013 and 2014 seasons)

	Bud burst (%)			Bud fertility (%)		
Rootstocks	2012	2013	2014	2012	2013	2014
Paullson 1103	69.52	71.62	73.14	61.80	64.30	65.76
Salt Creek	72.80	76.25	78.81	65.35	67.45	68.90
Freedom	65.35	67.11	68.10	59.96	60.78	62.00
Superior seedless	62.45	64.35	64.90	55.62	58.16	59.12
New LSD 5%	2.73	2.55	2.97	2.81	2.32	2.65

Table 4: Effect of grafting superior seedless cv. on some rootstocks under saline condition on vegetative growth during (2012, 2013 and 2014) seasons

	Leaf Surface area L/vine (cm^2)			Shoot length (cm)		
Rootstocks	2012	2013	2014	2012	2013	2014
Paullson 1103	17.01	18.16	19.85	248.48	255.18	262.35
Salt Creek	20.63	21.58	23.00	259.79	267.15	270.12
Freedom	15.60	15.95	16.50	235.75	241.65	248.81
Superior seedless	12.89	13.00	13.97	211.50	218.43	221.51
New LSD 5%	2.41	2.57	2.39	9.95	10.87	6.76

Generally, it is clear that grafting superior seedless on some rootstocks (Salt Creek, Paullson 1103 and freedom) gave the best result for fruitful buds than superior seedless on own rooted. Maximum fruitful buds were recorded on vines grafted on rootstocks. The analysis of nutrient elements in the leaves, Table 3 showed a significant variation in phosphorus concentration in superior seedless grafted on different rootstocks and it was positively correlated with percentage of fruitful bud, while a negative correlation was observed between sodium and chloride concentration and percentage of fruitful buds.

Zhongyan[31] 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.*[32], Jogaiah *et al.*[33] and El-Gendy[34] they reported that ungrafted vines resulted in the lowest percentage of bud burst and fruitful bud compared with vines grafted on rootstock.

Vegetative growth parameters

Total leaf surface area per vine and shoot length: Table 4 represents the effect of the tested treatments on total leaf surface area per vine and shoot length of superior seedless cv. grafted on Paullson 1103, Salt Creek and freedom rootstocks to tolerance of saline soil. The data revealed better shoot length and leaf surface area per grafted vine in contrast to ungrafted vines. The reduction in these parameters may be attributed with osmotic effect of salt on root and toxic effect of accumulated ions in the plant tissues, Similarly Urdanoz and Aragues[35] reported that the decrease in growth with increase in salinity were attributed to the osmotic effect rather than to specific ion toxicities. Also, Munns[36] found that, the plants exposed to salinity stress reduced cell elongation and cell division result in slower leaf appearance and inhibition of shoot growth. Whereas, grafting on Salt Creek rootstock enhanced significant increment in these parameters dring the three seasons of this investigation. Moderate leaf surface area and shoot length were recorded in vines grafted on Paullsen 1103, rootstock while, in the present study superior seedless grafted on freedom rootstock came the next.

The ameliorative effect of the grafting on leaf area and shoot length could be attributed to the high efficiency of the root system of Salt Creek rootstock in absorbing and transporting water and minerals via the grafted union to the shoots of superior scion and to the favorable reciprocal relationship between scion and stock.

Parallel results were obtained by Grant and Matthews[37] who found that the grape cv., krakhuna had the largest leaf surface area per vine when it was grafted on chasseras×berlandieri rootstock. In addition Jogaiah *et al.*[33] who found that, thompson seedless grapevine grafted on dog ridge rootstock, recorded increasing in shoot length compared to graft on St-George and own its roots.

Root distribution parameters

Fine roots (root less than 2 mm in diameter): The effect of grafting superior seedless cv. on some rootstocks (Paullson 1103, Salt Creek and freedom) under saline soil on the average length of fine roots (<2 mm) assessed at two distance from the vine trunk (50 and 100 cm) are presented in Fig. 1 and 2. The maximum increase on the fine roots length was obtained when superior seedless cv. on grafted the 3 rootstocks. It was also observed that the length of fine roots,

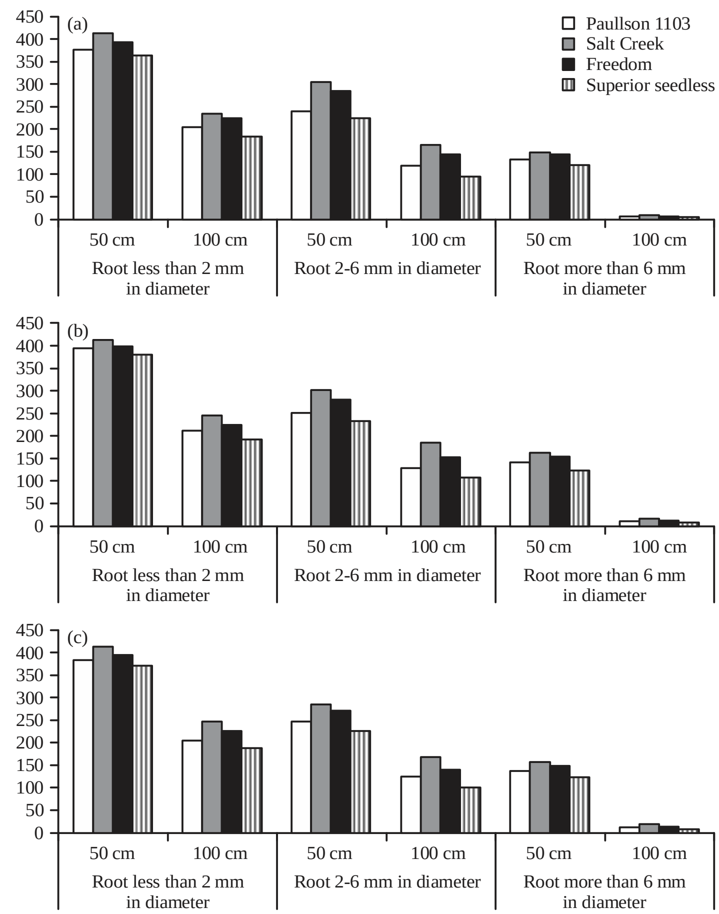

Fig. 1(a-c): Effect of grafting superior seedless cv. on some rootstocks, under saline condition on average roots length (cm) at different distances of vine trunk during (a) 2012, (b) 2013 and (c) 2014 seasons

(<2 mm in diameter) was higher for superior seedless cv. grafted on Salt Creek rootstock. In contrast superior seedless cultivar grafted on freedom rootstock recorded the shorter length than own rooted superior seedless cv., which grafted on Paullson 1103, came intermediate in this respect. Concerning the ungrafted vines it gave the least values of fine root length. In addition, the obtained data disclosed that fine root extension through the vertical direction was also affected by grafting superior seedless on some rootstocks to tolerance saline soil. Superior seedless grafted on these rootstocks caused increased density of roots expressed at the length of fine roots at 0-30 cm depth than that found 30-60 cm depth. On the contrary, the least value in the growth of fine root length was observed in the ungrafted superior seedless vines, these results obtained during the three experimental seasons.

The results in this connection are in harmony with those obtained by Deshmukh and Patil[38] they found a significant effect on the reduction in root growth under salinity stress.

Medium roots (root 2-6 mm in diameter): Figure 1 and 2 showed the lowest values obtained from ungrafted vines (superior seedless own rooted) while grafted superior seedless cv. on Salt Creek gave the highest value of medium root diameter followed by grafting superior seedless on Paullson 1103, rootstock. However, grafting on freedom rootstock, ranked in between. It can also be observed that, an obvious increase in medium roots took place either at 50 cm distance from the trunk or at 0-30 cm soil depth while the growth of medium roots was reduced by increasing the distance more than 50 cm from vine trunk or at depth more than 30 cm from soil surface. This may be due to salt distribution in the same row, that the lowest salinity level was found at 0-30 cm in depth and 50 cm distance from trunk. Meanwhile, the highest salinity level was found at 30-60 cm depth and 100 cm from the trunk. Similar results were recorded by Buck *et al.*[39], Ali *et al.*[40] on grapevine they found that the highest salinity values were located at 30-60 cm depth.

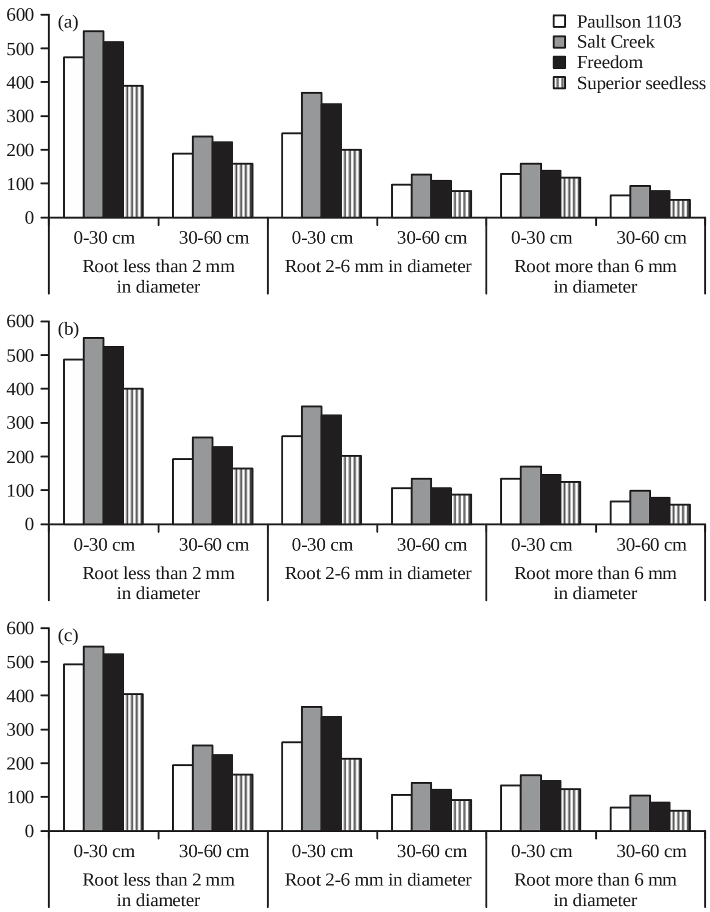

Fig. 2(a-c): Effect of grafting superior seedless cv. on some rootstocks, under saline condition on average roots length (cm) at different depth during (a) 2012, (b) 2013 and (c) 2014) seasons

Table 5: Effect of grafting superior seedless cv. on some rootstocks under saline condition on total chlorophyll, total carbohydrate of shoot and proline in leaf % during (2012, 2013 and 2014) seasons

	Total chlorophyll			Shoot total carbohydrates content (%)			Proline (%)		
Rootstocks	2012	2013	2014	2012	2013	2014	2012	2013	2014
Paullson 1103	37.15	39.11	40.97	18.52	19.87	20.95	0.31	0.30	0.28
Salt Creek	41.77	42.85	44.03	21.83	23.89	24.44	0.24	0.22	0.19
Freedom	34.49	36.19	37.94	17.78	18.80	19.92	0.33	0.32	0.30
Superior seedless	28.89	31.79	32.84	15.86	16.43	16.96	0.36	0.35	0.35
New LSD 5%	3.62	2.88	2.97	0.70	1.05	0.98	0.02	0.02	0.04

Total carbohydrate content in the canes

Large roots (roots more than 6 mm in diameter): The horizontal and vertical extensions of large roots are presented in Fig. 1 and 2. Generally results of this estimate revealed a trend similar to that of the previously mentioned with fine and medium roots. The positive effect on root length may be due to translocation and distribution of nutrients which may differ among rootstocks. In this respect, Giorgessi *et al*.[41] found difference in number and size of the xylem vessels between rootstocks and own rooted vines.

Leaf chlorophyll content: Generally, the data in Table 5 showed that, superior cv., grafted on Salt Creek rootstock gave the highest significant leaf chlorophyll content under this study followed in descending order by superior seedless grapevine grafted on Paullsen 1103, then on freedom rootstocks while on own rooted superior seedless gave the lowest leaf chlorophyll content. In this respect it can be said that, freedom rootstock more sensitive to saline soil conditions than Salt Creek rootstock which inhibited more ability to contain higher amount of pigment and it is considered the highest tolerant to saline soil. Similarly, Charbaji and Ayyoubi[42] indicated that chlorophyll content of ashlamesh, helwani and kassafee was significantly decreased by increasing salinity. Furthermore, Sourial *et al.*[43] found that increasing salinity level depressed pigments contents of dog ridge and thompson seedless grapevines.

Chemical characteristics

Proline content in the leaves: Data illustrated in Table 5 clear reveal the effect of soil salinity on the proline leaf content of superior seedless on own roots or grafted on three grape rootstocks Paullson 1103, Salt Creek and freedom during the three studied seasons of this investigation. Leaves of own rooted superior seedless cv., recorded the highest proline percentage during three seasons, followed by superior seedless grafted on freedom rootstock, while superior seedless grafted on Salt Creek rootstock recorded the lowest proline percentage. However, intermediate values were noted for superior seedless grafted on Paullsen 1103, rootstock in this respect. Accordingly, the relationship between the leaf proline content under salt condition and tolerant of grape rootstocks to salinity was cleared by Ahmed[44] who indicated that the capacity of the grape rootstocks to accumulate proline was found to be positively correlated with the salt.

Moreover, Ahmed[44], Mehanna *et al.*[45] are in harmony with our data which found that the leaves of Salt Creek and Paullsen 1103, rootstocks recorded the lowest proline percentage comparing with freedom which recorded the highest proline percentage.

Also, Fan *et al.*[46] showed that proline and soluble sugars were very important osmotic adjustable organic substances to grape under salt stress.

Data concerning total carbohydrates content are presented in Table 5. It can observed that this parameter was at the lowest level in own rooted superior seedless cv. As for the response of different rootstocks, it is obvious that, Salt Creek, Paullsen1103 and freedom rootstocks had the highest values of this estimate followed in descending order by Paullsen 1103 than freedom rootstock. This result came in line with the finding of Kilany *et al.*[47] who found that salinity in the soil effectively depressed the synthesis of carbohydrates.

Mineral content in the leaves: Results dealing with the effect of soil salinity on leaf mineral content (N, P, K, Ca, Mg, Na and Cl) of own rooted Superior Seedless cv. or grafted on three rootstocks (Paullson 1103, Salt Creek and freedom) are presented in Table 6 data indicated that, total mineral content (N, P and K) levels below the minimal level were registered in the leaves of superior seedless on own rooted (ungrafted). The reduction occurs in N, P and K content in the leaves of superior seedless growing under soil salinity, might be attributed to the increase in the osmotic pressure, thereby reducing the water uptake by the vines. On the other hand, the highest percentage of N, P and K were obtained in the leaves when grafted superior seedless cv. On Salt Creek rootstock. While, superior seedless on freedom rootstocks recorded the lowest values of N, P and K percentages through the three studied seasons. However, it can be observed that, superior seedless on Paullson 1103 rootstocks came in between in this respect.

Table 6: Effect of grafting superior seedless cv. on some rootstocks under saline condition on minerals content during (2012, 2013 and 2014) seasons

Rootstocks	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cl (%)	Na (%)
2012 season							
Paullson 1103	2.73	0.30	1.84	2.58	0.71	1.26	0.44
Salt Creek	2.85	0.36	1.94	2.68	0.78	1.18	0.37
Freedom	2.64	0.23	1.78	2.48	0.65	1.22	0.42
Superior seedless	2.60	0.17	1.68	2.39	0.56	1.32	0.48
New LSD 5%	0.03	0.06	0.09	0.08	0.05	0.05	0.03
2013 season							
Paullson 1103	2.75	0.31	1.87	2.61	0.72	1.23	0.43
Salt Creek	2.90	0.38	1.96	2.71	0.81	0.99	0.36
Freedom	2.69	0.25	1.79	2.50	0.67	1.02	0.40
Superior seedless	2.63	0.18	1.70	2.42	0.58	1.30	0.46
New LSD 5%	0.05	0.07	0.08	0.06	0.04	0.02	0.02
2014 season							
Paullson 1103	2.81	0.33	1.90	2.63	0.75	1.21	0.41
Salt Creek	3.01	0.40	1.98	2.75	0.83	0.94	0.33
Freedom	2.71	0.28	1.81	2.53	0.68	0.97	0.38
Superior seedless	2.65	0.20	1.73	2.44	0.61	1.28	0.45
New LSD 5%	0.06	0.06	0.08	0.08	0.05	0.01	0.04

It has been demonstrated that the uptake of N and K differs among rootstocks. This in turn will affect the N, P and K status of the grafted vines. These variations could be caused by difference in the absorption capacity of the roots and /or differences in the incorporation of K ions into the xylem and their translocation from the roots to shoots[48].

Concerning variations in P uptake have been reported by Nikolaou *et al.*[49] and Fisarakis *et al.*[50] who suggested that the different rootstocks absorb unlike levels of P with concomitant effects on the growth of shoots and leaves.

Finally, the diverse effect of soil salinity on the uptake of N, P and K in the leaves were confirmed by the results of Ahmed[44] who mentioned that leaf N and P content was decreased with salinity. In addition, Wasim[51] reported that, flame seedless on ramsey rootstock recorded the highest significant leaf N, P and K percentage, while flame seedless on freedom rootstock and on own rooted recorded the lowest values in these parameters, respectively.

In the same (Table 6) data indicated that salinity soil clearly inhibited the percentage of Ca and Mg in the leaves, superior seedless cultivar (ungrafted) gave the least values in this respect during the three seasons. Similar results were reported by Hooda *et al.*[52] who indicated that the leaf Ca content decreased with an increase in soil salinity. Regardless grafting superior seedless on Salt Creek rootstock followed by superior seedless on Paullsen 1103, rootstocks recorded the highest significant leaf Ca and Mg percentage under these studies. While, superior seedless on freedom rootstock recorded the lowest leaf Ca and Mg percentage. The present results are in agreement with those obtained by Wasim[51].

On the other hand, it is clear from the data presented in Table 6 that salinity was associated with considerable and significant increase in the percentage of Na and Cl percentage in the grapevine. The lowest Na accumulation in leaf tissue due to soil salinity was attained in vine of superior seedless grafted on Salt Creek followed by superior seedless on Paulson 1103 rootstock, then superior seedless grafted on freedom rootstock. While, superior seedless on own rooted (ungrafted) have the highest values of Na in the 3 experimental seasons. This can mean that superior seedless cultivar (ungrafted) is more sensitive to Na comparing to other grapevine in this investigation, while the reverse is true with respect to grafted on rootstocks especially when grafted superior seedless on Salt Creek rootstock. Recently, Fisarakis *et al.*[6] reported a strong correlation between leaf Na concentration and salt toxicity symptoms in own-rooted and grafted sultana vines. Furthermore, the effect of rootstock on the Na accumulation in leaves of salt treated plant varied depending on the shoot genotype. Consequently, rootstock genotype caused differences in the accumulation of Na ions in the leaves of muskule vine after exposure to salinity[53]. Also, Paranychianakis and Angelakis[54] reported that, grafted or 418 and 110 R accumulated lower amounts in all organs compared to vines grafted on Paullsen1103. As for the chloride (Cl) content, the results are in agreement with those of Sykes[55] who concluded that the ability to exclude Cl^- by the *V. champinii* species (Ramsey rootstock) is probably due to action of many genes. Moreover, Bravdo *et al.*[56] found in his study on cabernet sauvignon vines grafted on 140 Ruggeri or Salt Creek irrigated with saline water. They found that chloride accumulation in leaves was significantly lower in vines grafted on 140 ruggeri than on Salt Creek, Wasim[51] mentioned that grafted flame seedless on freedom rootstock recorded the highest values of leaf Na and Cl content. Also, ramsey rootstock recorded the lowest values of leaf Na and Cl content.

Yield and its components

Yield, cluster weight and number of cluster/vine: Table 7 showed that the highest yield/vine was affected by superior seedless vine grafted on salt tolerance rootstock. In this respect superior seedless vine grafted on Salt Creek significantly increased the yield during the 3 experimental seasons, followed in descending order by grafting superior cv. on Paullsen 1103, rootstock then grafting superior cv. on freedom rootstock. Superior seedless grapevines grown on their own roots gave the lowest yield/vine during the three seasons. Concerning cluster weight and number of cluster/vine the results showed a similar trend.

Table 7: Effect of grafting superior seedless cv. on some rootstocks under saline condition on yield and berry characteristics during (2012, 2013 and 2014) seasons

	Average cluster weight (kg)			Average yield/vine (kg)			No. of clusters			Berry weight (g)			Berry size (cm^3)		
Rootstocks	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
Paullson 1103	525.60	563.22	593.82	7.78	8.73	9.98	14.80	15.50	16.80	4.38	4.52	4.68	4.20	4.35	4.48
Salt Creek	586.52	607.81	622.90	9.33	10.15	10.90	15.90	16.70	17.50	4.45	4.68	4.90	4.27	4.46	4.62
Freedom	510.30	538.65	554.60	7.00	7.65	8.21	13.70	14.20	14.80	3.95	4.06	4.20	3.62	3.85	3.98
Superior seedless	468.80	475.53	490.71	6.19	6.56	6.92	13.20	13.80	14.10	3.58	3.66	3.83	3.36	3.42	3.68
New LSD 5%	14.22	13.89	12.95	0.71	0.98	1.02	0.43	0.39	0.64	0.31	0.14	0.18	0.06	0.09	0.12

Table 8: Effect of grafting superior seedless cv. on some rootstocks under saline condition on berry characteristics during (2012, 2013 and 2014) seasons

	TSS (%)			Acidity (%)			TSS/acid ratio		
Rootstocks	2012	2013	2014	2012	2013	2014	2012	2013	2014
Paullson 1103	16.19	17.00	17.20	0.72	0.71	0.69	23.47	23.94	24.93
Salt Creek	17.30	17.50	17.80	0.68	0.66	0.64	25.44	26.52	27.81
Freedom	16.50	16.70	16.80	0.75	0.73	0.72	22.00	22.88	23.33
Superior seedless	16.20	16.30	16.40	0.79	0.77	0.76	20.51	21.17	21.58
New LSD 5%	0.20	0.30	0.30	0.03	0.03	0.02	1.38	1.02	1.84

Table 9: Distribution of peroxidase isozyme banding patterns groups, density and relative mobility of root for the three rootstocks of grape (Paullson1103, Salt Creek, freedom and on own rooted superior seedless cv. under soil salinity)

Peroxidase groups	Relative mobilty	P	S	F	Ss
P×1	0.1	1^{+}	1^{-}	1^{++}	1^{+}
P×2	0.2	1^{+}	1^{-}	1^{++}	1^{+}
P×3	0.7	1^{++}	1^{++}	1^{++}	1^{++}
P×4	0.8	1^{++}	1^{++}	1^{++}	1^{++}
P×5	0.9	1^{+}	1^{-}	1^{+}	1^{+}

$^{++}$High Density of band, $^{+}$Moderate density of band, $^{-}$Low density of band

The improving effect of the rootstocks on yield, cluster weight and number of clusters may be due to Na and Cl ions reduction and raising of NPK levels in the vine (Table 6) consequently it increased total surface area and vegetative growth (Table 4). Dealing with effects of salt tolerance rootstocks on yield and its components, Ferrara and Pagano[57], Sommer *et al.*[58] who found an increase in yield and cluster weight of sultana vines grafted on cabernet france and white riesling than from own-rooted vines.

As for the response of grapevine to salinity[59] found that there was a reduction in the rate of CO_2 assimilation, correlated with increases in Cl^- concentrations in the leaf blades and reduction of bunches number and yield.

Berry characteristics: It is evident from Table 7 that, using of salt tolerance rootstocks under saline soil significantly improved physical characters of the berries in terms of increasing berry weight and size. Varying the kind of rootstock had a pronouncing influence on berry weight and size, since superior seedless grapevines grafted on Salt Creek gave the highest significant values followed in a descending order by those grafted on Paullsen 1103 and freedom rootstocks, unfavorable effects were observed in the ungrafted vines. These results were true during 2012, 2013 and 2014 seasons. The obtained results referring to appositive effect of rootstocks on the physical characteristics of berries are in agreement with those reported by Satisha *et al.*[60] who found that bigger and heavier berries as indicated by higher berry diameter and berry weight were recorded on vines grafted on dog ridge rootstocks as compared to own-rooted vines.

Juice characteristics: It is clear from the data in Table 8 that application of the salt tolerant rootstocks under saline soil namely Paullson 1103, Salt Creek and freedom significantly were very effective in stimulating TSS% and TSS/acid ratio and reducing total acidity rather than ungrafted ones. It is worthy to note that superior seedless grapevine grafted on Salt Creek were grown under saline soil resulted in the highest values of TSS and TSS/acid ratio followed in a descending order by those grafted on Paullsen 1103 and freedom rootstock in the three experimental seasons. Ungrafted superior seedless grapevines gave the lowest values in this concern.

This result was supported by Walker[59] who found that, higher concentration of Na^+ and Cl^-, reduced fruit sugar content of grapevine grown under salinity conditions. El-Morsi *et al.*[32], El-Gendy[34] found that superior seedless grafted on freedom and Salt Creek led to an increase in TSS% and decrease in the acidity compared with ungrafted vines.

Peroxidase banding patterns: Figure 3 and 4 and Table 9 represent peroxidase electrophoresis banding patterns among the examined fresh root of the three rootstocks (Paullson 1103, Salt Creek and freedom) and own rooted superior seedless cv., under soil salinity.

Figure 3 and 4 and Table 9 explain that, the total of 5 peroxidase bands were characterized for the three rootstocks and superior seedless on own rooted cv. with relative mobilities 0.1, 0.2, 0.7, 0.8 and 0.9, respectively which were present in all of them. The differences were found in banding pattern density which has high density in each of P×3 and P×4 in the three rootstocks and superior seedless cv. on own rooted also there were differences in band density in freedom rootstock with high density banding patterns at each of P×1 and P×2 in compared with Paullson1103 and superior seedless cv. on own rooted which appeared with moderate density in banding patterns. While, Salt Creek rootstock represent low banding pattern density. On the other hand, there were moderate density in banding patterns at 0.9 relative mobility in each of Paulson 1103,

Fig. 3: Peroxidase isozyme banding patterns of root for the three rootstocks of grape (Paullson 1103, Salt Creek, freedom and on own rooted superior seedless cv., under soil salinity

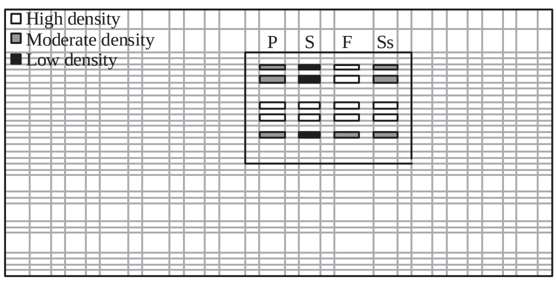

Fig. 4: Edeogram analysis for peroxidase isozyme banding patterns root for the three rootstocks of grape (Paullson 1103, Salt Creek, freedom and on own rooted superior seedless cv., under salinity soil

Table 10: Distribution of polyphenyl oxidase isozyme banding patterns groups, density and relative mobility of root for the three rootstocks of grape (Paullson1103, Salt Creek, freedom and on own rooted superior seedless cv., under soil salinity

Polyphenyl oxidase groups	Relative mobilty	P	S	F	Ss
P×1	0.7	1^{++}	1^{++}	1^{++}	1^{++}
P×2	0.8	1^{++}	1^{++}	1^{++}	1^{++}
P×3	0.9	1^{-}	1^{-}	1^{-}	1-

$^{++}$High density of band, $^{+}$Moderate density of band and $^{-}$Low density of band

freedom and superior cv. on own patterns and these data reflect increasing in gene expression under soil salinity between the three rootstocks and superior seedless cv. on own rooted under study.

Poly phenyl oxidase banding pattern: Figure 5 and 6 and Table 10 represent polyphenyl oxidase electrophoresis banding patterns among examined fresh root of the three rootstocks (Paullson 1103, Salt Creek and freedom) and superior seedless cv. on own rooted under soil salinity.

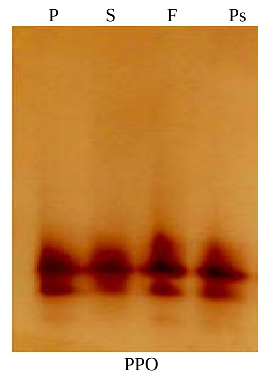

Fig. 5: Polyphenyl oxidase isozyme banding patterns of root for the three rootstocks of grape (Paullson 1103, Salt Creek, freedom and on own rooted superior seedless cv., under soil salinity

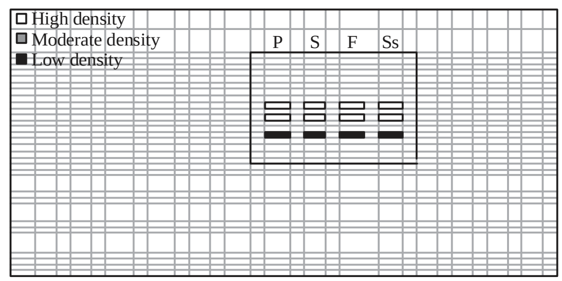

Fig. 6: Edeogram analysis for polyphenyl oxidase isozyme banding patterns of root for the three rootstocks of grape (Paullson 1103, Salt Creek, freedom and on own rooted superior seedless cv. under soil salinity

Figure 5 and 6 and Table 10 showed that the total of three bands were characterized for the three rootstocks and superior seedless cv. on own rooted studied with relative mobilities 0.7, 0.8 and 0.9, respectively which were present in the three rootstocks and superior seedless cv. on own rooted. There were no differences found in banding pattern density in the three rootstocks and superior seedless cv. on own rooted under study.

The results obtained herein are in harmony with Rayan *et al.*[61], Abo Rekab *et al.*[62], who established that peroxidase and polyphenyl oxidase banding patterns represent differences in density of bands with increase or decrease and absent of bands in treatments in comparison with control in plum and date palm cultivars.

CONCLUSION

- Superior seedless grape cultivar grafted on Salt Creek rootstock had the highest percentage of bud burst and fruitful buds

- It improved the best vegetative growth parameters, increment depth of the roots and their distribution in the soil profile
- Cane content of total carbohydrates, leaf content of total chlorophyll and mineral content were increased and leaf content of prolin, sodium and chloride were reduced
- Finally, superior seedless grafted on Salt Creek, Paullson 1103 and freedom rootstocks grape were found more tolerant to salinity than own rooted superior seedless cv., vines grafted on Salt Creek was the most tolerant one

SIGNIFICANCE STATEMENT

- This study revealed superior seedless grape cultivar grafted on Salt Creek rootstock had the highest percentage of bud burst and fruitful buds
- It improve the best vegetative growth parameters, increment depth of the roots and their distribution in the soil profile, cane content of total carbohydrates, leaf content of total chlorophyll and mineral content were increased and leaf prolin content, sodium and chloride were reduce
- Superior seedless grafted on Salt Creek, Paullson 1103 and freedom rootstocks grape were more tolerant to soil salinity than superior seedless cv. on own rooted
- Vines grafted on Salt Creek was the most tolerant one
- Therefore, vines grafted on Salt Creek must be recommended to spread in saline soils

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