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Responses of some grapevine rootstocks to long-term salinity and drought stress conditions.

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ABSTRACT

A field experiment was carried out at El-Maghara Experimental Station for Desert Research Center, North Sinai Governorate, Egypt during the three successive seasons of 2011 to 2013. The study was set up to evaluate some grapevine rootstocks as well as some grapevines varieties to salinity and drought tolerance. The rootstocks 1103 Paulsen, 110 Richter, Salt Creek, Black Balady and White Kahlili. They irrigated with effluent containing relatively high concentration (1000, 2000 and 3000 ppm) of salts water at different fractions of evapotranspiration (0.50, 0.75 and 1,00 ET). The obtained results indicated that plant hight and leaf area as well as shoot and root dry weight and potassium content of rootstocks significantly decreased linearly with increasing the salinity or drought levels. The decrement due to salinity effects higher than that due to drought ones. Contrary, proline, chloride and sodium contents took unsimilar trend. As to different studied rootstocks, Black Balady recorded the highest significant plant hight and leaf area, as well as shoot and root dry weight and contents of potassium and proline, and lowest significant chloride and sodium contents. It could be arranged the studied rootstocks for these traits as descending order, Black Balady, White Khalili, Salt Creek, 110R and 1103 P, respectively. Moreover, Black Balady had the highest or lowest values of the previous traits under the low level of salinity and drought. Contrary, 1103P and 110R had the lowest and highest values under the high level of salinity and drought. This study cleared a benefit used Black Balady or White Khalili as rootstocks in alleviating the adverse effect of salinity and drought on grape vineyards.

Key words: Vine, Rootstock, Salinity, Drought, Stress Tolerance, *Vitis* spp.

Introduction

Grapes, belong to the genus *vitis*, rank first among fruit crops in the world in terms of both production and economic importance. In Egypt, most of the extensions in vineyard plantation during the last few decades were in newly reclaimed area where salinity of soil and irrigation water as well as drought are a major problem. Salinity stress is one of the main problems facing vine growth. Salinity of irrigation water can impair the performance growth and production of grapevine. The adverse effect of salinity either soil or water on growth were confirmed in different grapevine cultivars (Hawker and Walker, 1978 and Ahmed, 2007).

Grapevines are considered as moderately sensitive to salinity (Downton *et al*., 1990) and the damage is primilarly caused by chloride ions. Symptoms of salinity start with leaf burns shoot die back, leaf fall and finally death of vine. In general, aerial numbers of roots/vine were gradually decreased as salinity concentration was increased (Walker, 1994 and Abou Sayed *et al*., 2000). Reduction in growth due to salinity is usually attributed to either ion toxicity or low external osmotic potential. Both effects may affect plant physiological and biochemical processes. Grapevine response to salinity depends on several factors, such as rootstock–scion combination, irrigation system, soil type and climate. Changing some of these factors with the same irrigation water could produce entirely different results (Greenway and Munns, 1980 & Munns and Termaat, 1986).

Certain rootstocks reduced the accumulation of chloride in scion variety, the high salt concentration in the soil or water cause growth inhibition in most plants. Also, effect of saline conditions affect plant growth in various ways (Bernstein *et al*., 1969) Moreover, salinity can cause decreasing in water uptake in the plants, accumulating ion to toxic levels and reducing nutrient availability (Flowers *et al*., 1977).

The use of salt tolerant rootstocks has been proven to be an efficient strategy to alleviate the adverse effects of salinity in grapevines (Walker *et al*., 1997).

Sensitive *Vitis vinifera* rootstocks can grow normally in soil containing 0.2 to 0.3% NaCl whereas, *Vitis riparia* and *Vitis rupestris* die above 0.4% NaCl. Salt creek and 1103 Paulsen are the most resistance rootstocks 0.8-1.5% (Walker *et al*., 2004 and Ahmed, 2007).

Recently, it is possible to observe global climatic changes. The numbers of warm years and longer periods of drought are increasing. In the course of its phylogenetic development, grapevine (*Vitis vinifera*) has developed various physiological and morphological mechanisms enabling plants to survive under conditions of water deficits (Kondouras *et al*., 2008). One of the possibilities how to adapt viticulture to climatic changes, is

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to breeding and selection rootstock with an increased tolerance to drought. A good resistance of grapevine to stress situations results from deep of root system and physiological mechanism of drought avoidance (Vandeleur *et al*. 2009, and Flexas *et al*., 2010).

Application of irrigation in crops in sub-optimal levels (regulated deficit irrigation and partial root-zone drying) is an increasingly common practice in water-limited area to improve water use efficiency (Stoll *et al*., 2002). However, there is limited information available on how deficit irrigation can affect plant performance when the water supply contained elevated levels of salts (Mittler, 2006). Sub-optimum soil water contents may limit nutrient availability to roots by affecting physical processes, including nutrient diffusion and solubility (Marschner, 1995), hence exacerbate the impacts of salinity on plant performance. Furthermore, morphological changes which occur in water stressed plants, such as the inhibition of growth and the increase in root to shoot ratio may also stimulate salt accumulation in the shoot and hence the salinity-induced injury.

Ramteke and Karibasapa (2005) evaluated 7 varieties, 11 rootstocks and 2 wild species of the genus *Vitis* spp. and classified the following rootstocks as drought-tolerant: 110 R, 1103 P, SO 4, Teleki 5A, and 1613 C.

Sommer (2009) observed very interesting differences in drought tolerance of grapevine rootstocks; so, for example the rootstocks 101-14 and Schwarzmann showed a low resistance while in Lider 116-60, Ramsey, 1103 Paulsen, 140 Ruggeri and Kober 5 BB this characteristic was better. Flexas *et al*. (2009) observed a very good drought tolerance in the rootstock Richter 110 (*V. berlandieri* x *V. rupestris*).

Decreasing the irrigation level induced the development of leaf burns causing only minor changes to leaf-Na or Cl content. There are a differences in salt uptake, accumulation and distribution due to various of rootstocks. Differences of salinity tolerance among rootstocks was only observed at the 0.50 ET irrigation level. Vines grafted on 41B were more sensitive than 1103P or 110R rootstocks (Paranychianakis and Angelakis, 2008).

Salt creek rootstock recorded the highest significant shoot length, leaf area, leaf number, root length, total plant dry weight and it had a significant reduction in stomatal diffusion resistance (SDR) compared to 1103 paulsen rootstock. Whereas, 1103 paulsen had highest values of plant survival %, leaf proline content and reduction in leaf and shoot Cl and Na contents (Mehanna *et al*., 2010).

The main objectives of this study were to investigate: (a) evaluation of some grapevine rootstocks to salinity and drought tolerance (b) utilization low economic and marketable value of some grapevine varieties the optimum exploitation by use it as rootstocks.

Materials and Methods

This study was carried out during three successive seasons of 2011, 2012 and 2013 at El-Maghara Experimental Station for Desert Research Center, North Sinai Governorate, Egypt, on nurslings of five grapevine rootstocks, 1103 Paulsen (*V. berlandieri* ×*V. rupestris*), 110 Richter (*V. berlandieri* × *V. rupestris*), Salt Creek (*V. champini*), Blake Balady and White Khalili local variety (*V. vinifera*) were used in this study.

In March 2011, 270 One-year-old nurslings of five grapevine rootstocks were selected for achieving of experiment. They were planted in a sandy-loam soil in an open field and pruned to 4 eyes. The present experiment included three factors, salinity (S), drought (D) and rootstocks (R). The first factor (S) composed from three levels of salinity 1000, 2000 and 3000 ppm. The second factor (D) composed from three levels of drought 100%, 75% and 50% Etc and the third factor (R) contained five grapevine rootstocks.

The saline water levels were prepared by mix the station water well which EC were (2700 ppm) with desalination water to reaching levels 1000 and 2000 ppm, and add NaCl to reaching level 3000 ppm approximately .

Irrigation treatments included portions 0.50, 0.75 and 1.00 of the potential evapo-transpiration (ET). Potential evapotranspiration is defined in this study as the total water losses including both evaporation and transpiration losses. They were applied from 10 March to 20 September each year. Irrigation was applied to plants through a drip irrigation network. Water demand in first season (2011) was determined as follows: 15 rootstocks were irrigated until tensiometer readings approached zero or until drainage was evident, and the average water consumption was defined as the 1.00 ET level independent of rootstock and salinity level. The other two irrigation levels 0.50 and 0.75ET were proportional. Whereas, water requirement for irrigation in another two seasons was calculated as potential crop evapo-transpiration (ETc), based on climatic data obtained from the meteorological station of El-Maghara, using CROPWAT computer program. The reference evapotranspiration ETo, was calculated by Penman–Monteith equation (Allen *et al*., 1998).

The third factor contained five rootstocks as follow: White Khalili and Blacke Balady, as a local variety *V. vinifera* as well as 1103 Paulsen and 110 Richter, as rootstock hybrids and Salt Creek (*V. champini*).

Therefore, this experiment included 45 treatments (3 salinity levels, 3 drought level and 5 rootstocks). Each treatment replicated 6 times, two rootstocks were selected for each replicate. Then, the total number of transplants selected for achieving of this study were 270 transplant.

The design of this study was split split design, involving three salinity levels, as main plot and three drought levels in sub plot, whereas the five rootstocks in sub sub plot with three replication. Each replicate consisted of two plants.

Evaluation of the tested rootstocks to salinity and drought levels was carried out in respect of the following:

- Plant high (cm) at the end of each growing season.
- Leaf area (cm²) in mid of August using Digital planimeter.
- The dry weight of shoots and roots were estimated beside top/root ratio at the end of long term course (2013). The root system after separating was washed to remove the soil adhering to it. The dry matter of plant and root was oven dried at 70°C to constant dry weight and expressed in grams.

Leaf sample were taken from the sixth and seventh leaf on the shoots picked at mid of August, and mineral content was determined after washing it several times with tap water then dried to a constant weight at 70ºC and the following determinations were recorded: leaves free proline content (µg/ g fresh wt.$^{-1}$)was made using the method outlined by Bates *et al*. (1973). Chloride was estimated by titration method with silver nitrate according to Jakson (1958). Potassium and Sodium were determined by flame photometer as described by Toth *et al*. (1948).

All obtained data were tabulated and LSD method was used to compare the means of results, according to Snedecor and Cochran (1990).

Table 1: Chemical analysis of irrigation water

Irrigation water	TDS	EC ds/m	Ions concentration (mg/L)							
			Na	K	Ca	Mg	CO3	HCO3	Cl	SO4
S_1	1075	1.65	280	18.8	44	18	2.73	170	400	142
S_2	2074	3.19	490	39.5	98	48	13.6	210	890	285
S_3	3034	4.66	740	48.8	165	61	0	260	1310	450

Results:

The effect of salinity and drought levels on studied rootstocks growth have handled the main parts as follow:

Plant high and Leaf Area:

Data in Tables 2 and 3 indicated that plant hight (cm) and leaf area (cm²) were significantly affected by different salinity, drought treatments and the studied rootstocks during the three studied seasons. It is obvious from the data that the results took similar trend during the three studied seasons.

Concerning the effect of salinity and drought on these traits, the results reveal that plant high and leaf area of rootstocks were significantly decreased linearly with increasing the salinity levels from 1000 to 3000 ppm as well as increasing drought levels from 1.0 to 0.50 ET. Moreover, the decrement due to salinity effects higher than that due to drought ones.

In addition, data in Tables (2 & 3) indicated that such parameters significantly responded to interaction between the salinity and drought treatments. All combinations significantly decreased the plant height and leaf area. Moreover, the decrement of plant growth due to all combinations effective higher than that due to salinity or drought effective only. So, it concluded that salinity accompanied drought was more effective in decreasing the growth traits compared to separate effect of either salinity or drought.

As to different rootstocks, data in Tables (2 & 3) indicated that Black Balady recorded the highest significant plant height and leaf area than other rootstocks, while the lowest ones were recorded of 1103 P. It could be ascending arranged order as follow, 1103 P, 110 R, Salt Creek, White Khalili and Black Balady rootstocks, respectively.

Moreover, the interaction of rootstocks, salinity and drought levels showed significant effect. Significantly highest shoot length (153.3, 140 and 127.7 cm) and leaf area (110.35, 100.7 and 80.49 cm) were noticed in Black Balady, White Khalili and Salt Creek rootstocks at the salinity level S_1 and drought level D_1 respectively in the third studies seasons. Significantly least shoot length (75.7 and 90.7 cm) and leaf area (23.81and 23.77 cm²) were recorded in 1103P and 110R rootstocks respectively due to the salinity level (S_3: 3000 ppm) and drought level (D_3, 0.50 ET) in the third studied season, respectively.

Such results indicated that the Black Balady and White Khalili can be used as a suitable rootstocks for tolerance of salinity and drought stress.

Table 2: Effect of salinity and drought treatments on plant high (cm) of some grapevine rootstocks during 2011, 2012 and 2013seasons.

Treat.	2011					Mean	2012					Mean	2013					Mean
	R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5	
S_1	120.5	133.6	96.2	87.8	87.7	105.1	124.6	135.2	108.6	94.8	95.0	111.6	135.0	149.4	125.3	118.6	107.2	127.1
S_2	101.7	113.4	82.8	74.0	77.3	89.8	115.1	126	89.3	85.2	80.3	99.2	120.1	135.8	116.0	112.0	90.9	115.0
S_3	82.1	98.0	61.7	52.9	52.7	69.5	104.9	115.6	70.8	61.7	55.3	81.6	106.8	121.7	101.0	95.9	82.1	101.5
D_1	110.6	125	86.2	75.7	79.3	95.3	119.8	129.8	96.7	85.2	82.1	102.7	126.2	140.3	116.0	110.7	95.9	117.8
D_2	98.2	112.3	81.9	72.8	72.6	87.6	115.3	125.8	88.9	79.2	76.7	97.2	120.4	135.9	118.1	111.6	97.3	116.7
D_3	95.5	107.7	72.5	66.3	65.8	81.5	109.4	121.2	83.1	77.2	71.9	92.6	115.2	130.7	108.2	104.2	87.0	109.1
S_1D_1	128.2	141.2	100.8	92.2	91.2	110.7	129.3	139.3	114.7	100.3	100.3	116.8	140.0	153.3	127.7	119.7	111.0	130.3
S_1D_2	119.4	131.2	95.6	88.2	88.8	104.6	124.7	135.7	110.3	93.3	95.0	111.8	135.0	150.0	128.3	120.0	110.3	128.7
S_1D_3	113.8	128.4	92.2	83.0	83	100.1	119.7	130.7	100.7	90.7	89.7	106.3	130.0	145.0	120.0	116.0	100.3	122.3
S_2D_1	118.2	129.0	86.0	77.0	84	98.8	120.3	130.3	95.0	90.0	85.7	104.3	125.0	138.3	119.3	115.0	92.0	117.9
S_2D_2	95.4	105.8	85.2	73.0	75.2	86.9	115.3	125.0	89.0	85.3	79.7	98.9	120.3	137.7	119.0	115.0	95.7	117.5
S_2D_3	91.4	105.4	77.2	72.0	72.8	83.8	109.7	122.7	84.0	80.3	75.7	94.5	115.0	131.3	109.7	106.0	85.0	117.5
S_3D_1	85.4	104.8	71.8	57.8	62.6	76.5	109.7	119.7	80.3	65.3	60.3	87.1	113.7	129.3	101.0	97.3	84.7	105.2
S_3D_2	79.8	100.0	65.0	57.2	53.8	71.2	106	116.7	67.3	59.0	55.3	80.9	106.0	120.0	107.0	99.7	86.0	103.7
S_3D_3	81.2	89.2	48.2	43.8	41.6	60.8	99	110.3	64.7	60.7	50.3	77.0	100.7	115.7	95.0	90.7	75.7	95.5
Mean	101.4	115.0	80.2	71.6	72.6		114.9	125.6	89.6	80.6	76.9		120.6	135.6	114.1	108.8	93.4	

LSD.05 2011						LSD.05 2012						LSD.05 2013					
S	1.9	SD	1.28	SDR	2.52	S	4.06	SD	2.44	SDR	5.77	S	0.97	SD	1.84	SDR	4.22
D	1.15	DR	1.58			D	2.18	DR	3.62			D	1.65	DR	2.65		
R	1.10	SR	1.58			R	2.52	SR	3.62			R	1.84	SR	2.65		

S1 Salinity 1000 ppm D1 Drought 100% ETc R1 White Khalili R4 110R (Richter)
S2 Salinity 2000 ppm D2 Drought 75% ETc R2 Black Balady R5 1103 P (Paulsen)
S3 Salinity 3000 ppm D3 Drought 50% ETc R3 Salt Creek (Ramsey)

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Table 3: Effect of salinity and drought treatments on leaf area (cm^2) of some grapevine rootstocks during 2011, 2012 and 2013 seasons.

Treat.	2011					Mean	2012					Mean	2013					Mean
	R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5	
S_1	93.73	95.09	78.27	57.48	58.46	76.61	102.98	105.25	76.32	61.68	65.44	82.34	92.91	102.2	74.25	58.65	59.79	77.56
S_2	83.17	85.59	67.91	47.45	47.64	66.35	96.47	99.36	61.77	52.99	55.55	73.23	87.28	96.03	56.10	50.54	47.18	67.42
S_3	73.00	75.42	57.02	37.06	37.90	56.08	90.73	95.78	49.21	40.10	35.21	62.21	78.97	89.10	43.57	32.62	32.60	55.37
D_1	88.53	89.23	71.46	51.97	50.91	70.42	102.24	105.50	66.64	55.51	57.45	77.47	91.63	102.4	62.92	54.68	52.48	72.82
D_2	82.52	85.01	69.08	47.72	49.66	66.80	96.75	98.86	62.00	52.00	51.60	72.24	88.27	95.17	59.87	50.59	49.00	68.58
D_3	78.85	81.88	62.67	42.3	43.44	61.83	91.20	96.03	58.67	47.27	47.15	68.06	79.26	89.76	51.13	36.54	38.09	58.96
S_1D_1	99.30	98.10	84.20	61.86	59.80	80.65	108.74	110.00	80.24	65.18	71.06	87.05	100.70	110.35	80.49	70.33	65.11	85.40
S_1D_2	92.63	95.85	79.57	58.19	62.24	77.70	102.70	103.37	75.36	59.69	64.60	81.14	93.78	99.65	76.00	65.20	61.79	79.28
S_1D_3	89.26	91.33	71.04	52.39	53.35	71.47	97.51	102.38	73.37	60.16	60.66	78.82	84.25	96.61	66.26	40.43	52.46	68.00
S_2D_1	89.48	90.84	70.62	50.89	50.50	70.47	102.34	105.46	64.98	56.24	60.76	77.96	91.23	101.38	56.76	54.94	53.23	71.51
S_2D_2	82.48	84.46	69.49	47.51	48.33	66.45	95.45	97.81	61.68	55.56	54.86	73.07	89.38	94.37	60.04	51.23	50.31	69.07
S_2D_3	77.56	81.49	63.62	43.94	44.09	62.14	91.61	94.79	58.65	47.18	51.02	68.65	81.23	92.33	51.50	45.44	37.99	61.70
S_3D_1	76.81	78.74	59.54	43.16	42.41	60.13	95.62	101.04	54.71	45.10	40.51	67.40	82.97	95.48	51.51	38.77	39.11	61.57
S_3D_2	72.46	74.71	58.18	37.46	38.40	56.24	92.11	95.39	48.95	40.74	35.34	62.51	81.64	91.49	43.56	35.33	34.89	57.38
S_3D_3	69.72	72.81	53.35	30.56	32.90	51.87	84.47	90.92	43.98	34.47	29.77	56.72	72.30	80.33	35.63	23.77	23.81	47.17
Mean	83.30	85.37	67.73	47.33	48.00		96.73	100.13	62.44	51.59	52.06		86.39	95.78	57.97	47.27	46.52	

LSD.05 2011						LSD.05 2012						LSD.05 2013					
S	1.17	SD	1.61	SDR	2.51	S	0.93	SD	2.04	SDR	3.27	S	3.18	SD	5.39	SDR	8.22
D	1.44	DR	1.58			D	1.82	DR	2.05			D	4.82	DR	5.16		
R	1.10	SR	1.58			R	1.43	SR	2.05			R	3.59	SR	5.16		

Shoot and root dry weight (g) and top/root ratio:

Tabulated results in Table (4) illustrate that shoot and root dry weight as well as top/root ratio were significantly affected by different salinity and drought treatments and the studied rootstocks**.** Regardling, salinity or drought treatments, data decleared that shoot and root dry weight significantly decreased linearly with increase in salinity or drought levels. The decrement due to increase the saline levels was higher than that due to drought ones. On other hand, top/root ratio was significantly increased linearly with increase in salinity or drought levels.

As interaction between salinity and drought, Table (4) showed that all combinations of them significantly decreased the shoot and root dry weight, whereas, top/root ratio was significantly increased. There more, the decrement of shoot dry weight due to all combinations effective higher than that due to salinity or drought effective only. The reduction of root dry weight higher than reduction of shoot dry weight, hence, the top/root ratio was increased.

Also, Black Balady rootstock recorded the highest shoot and root dry weight as well as least values of top/root ratio than other rootstocks. On other hand, the lowest shoot and root dry weight, as well as the highest top/root ratio were recorded by 1103P and 110R.

The interaction of rootstocks, salinity and drought levels showed significant effect. Significantly highest shoot and root dry weights (370, 328 and 270.3 for shoot d.w. & 139.3, 120.0 and 92.0 for root d.w.)**,** as well as, significantly least top/root ratio (2.66, 2.69 & 2.80) were noticed in Black Balady, White Khalili and Salt Creek respectively at the salinity level of S_1 and the drought level D_1. Least significant shoot and root dry weights values (119.7 and 130.7 for shoot d.w & 35 and 39.7 for root d.w.), as well as significantly highest top/root ratio (3.21 and 3.47) were recorded in 1103P and 110R in the salinity level S_3 and drought level D_3, respectively.

Table 4: Effect of salinity and drought treatments on Shoot dry weight (g), root dry weight (g) and Top/root ratio of some grapevine rootstocks in 2013 seasons.

Treat.	Shoot dry weight (g)					Mean	Root dry weight (g)					Mean	Top/root ratio					Mean
	R1	R2	R3	R4	R5		R1	R2	R3	R4	R5		R1	R2	R3	R4	R5	
S_1	319.7	360.2	260.2	199.7	190.2	266.0	114.8	134.8	86.4	62.8	59.9	91.7	2.76	2.68	2.93	3.20	3.23	2.96
S_2	290.0	329.9	230.4	171.1	160.2	236.3	100.3	119.8	76.3	54.6	50.6	80.3	2.89	2.77	2.99	3.15	3.27	3.01
S_3	260.0	299.8	200.2	140.4	130.4	206.2	90.3	105.0	66.4	44.2	39.9	69.2	2.91	2.87	3.09	3.12	3.37	3.07
D_1	299.3	339.8	240.3	179.8	170.6	246.0	106.7	124.9	81.6	57.3	54.6	85.0	2.80	2.75	2.88	3.14	3.21	2.96
D_2	290.0	329.7	230.0	170.3	160.6	236.1	101.3	119.7	76.0	54.7	50.4	80.4	2.87	2.77	3.01	3.12	3.28	3.01
D_3	280.3	320.4	220.6	161.1	149.8	226.4	97.4	115.0	71.7	49.6	45.3	75.8	2.89	2.80	3.07	2.26	3.37	3.08
S_1D_1	328.0	370.0	270.3	210.3	201.0	275.9	120.0	139.3	92.0	64.0	64.3	95.9	2.69	2.66	2.80	3.30	3.17	2.92
S_1D_2	320.7	360.0	260.3	199.3	190.7	266.2	114.3	134.7	86.0	64.7	60.3	92.0	2.78	2.68	2.94	3.14	3.22	2.95
S_1D_3	310.3	350.7	250.0	189.3	179.0	255.9	110.0	130.3	81.3	59.7	55.0	87.3	2.80	2.70	3.06	3.17	3.30	3.01
S_2D_1	300.0	339.7	240.7	179.3	169.7	245.9	105.0	124.3	81.3	59.3	55.0	85.0	2.85	2.77	2.89	3.06	3.16	2.95
S_2D_2	289.3	329.7	230.0	170.7	160.3	236.0	99.7	119.7	76.0	55.0	50.7	80.2	2.91	2.76	3.00	3.11	3.29	3.01
S_2D_3	280.7	320.3	220.7	163.3	150.7	227.1	96.3	115.3	71.7	49.3	46.0	75.7	2.92	2.78	3.09	3.27	3.35	3.08
S_3D_1	270.0	309.7	210.0	149.7	141.0	216.1	95.0	111.0	71.3	48.7	44.3	74.1	2.86	2.81	2.96	3.05	3.30	3.00
S_3D_2	260.0	299.3	199.7	141.0	130.7	206.1	90.0	104.7	66.0	44.3	40.3	69.1	2.92	2.88	3.10	3.10	3.34	3.07
S_3D_3	250.0	290.3	191.0	130.7	119.7	196.3	86.0	99.3	62.0	39.7	35.0	64.4	2.95	2.93	3.21	3.21	3.47	3.15
Mean	289.9	330.0	230.3	170.4	160.3		101.8	119.9	76.4	53.9	50.1		2.85	2.77	3.01	3.16	3.29	

LSD.05	2013 Root fresh weight					LSD.05	2013 Root dry weight					LSD.05	Tap/root ratio 2013				
S	6.19	SD	5.27	SDR	7.98	S	4.06	SD	6.21	SDR	10.45	S	0.14	SD	0.28	SDR	0.52
D	4.72	DR	5.01			D	5.56	DR	6.56			D	0.25	DR	0.33		
R	3.49	SR	5.01			R	4.56	SR	6.56			R	0.23	SR	0.33		

Free proline and potassium contents:

Data in Tables (5 & 6) indicated that free proline and potassium content**s** were significantly affected by different salinity and drought treatments and the studied rootstocks during the three seasons. The free proline content linearly increased with the increased either salinity or drought levels. Contrary, potassium content linearly decreased with the increased either salinity or drought levels. But, effect of salinity levels on free proline and potassium content were higher than its by drought levels.

In addition, data in Tables (5 & 6) decleared that free proline and potassium contents significantly responded to interaction of the salinity and drought effects. All combinations significantly increased the free proline. Moreover, the increment of free proline due to all combinations effective higher than that due to salinity or drought effective only. On other hand, all combinations significantly decreased the potassium content and the decrement due to all combinations effective higher than that due to salinity or drought effective only. Hence, it concluded that salinity accompanied drought was more effective in increasing free proline and reduce the potassium contents compared to effect of either salinity or drought singly.

As rootstock effects, data in prementioned tables showed that significantly higher free proline and potassium contents (44.52, 44.77 & 47.33 µg g fresh wt.$^{-1}$) and (0.68, 0.66 & 0.62 %) was recorded in Black Balady in 2011, 2012 and 2013 seasons, respectively. On other hand, significantly the lowest free proline and potassium contents were (30.22, 31.15 & 32.29 µg/ g fresh wt.$^{-1}$) and (0.60, 0.55 & 0.53%) was recorded in 1103P in 2011, 2012 and 2013 seasons, respectively.

Table 5: Effect of salinity and drought treatments on proline content (µg/ g fresh wt.$^{-1}$) of some grapevine rootstocks during 2011, 2012 and 2013 seasons.

Treat.	2011					Mean	2012					Mean	2013					Mean
	R1	R2	R3	R4	R5		R1	R2	R3	R4	R5		R1	R2	R3	R4	R5	
S_1	27.61	29.06	25.63	20.00	18.60	24.18	28.62	29.45	26.79	23.64	19.88	25.68	29.68	31.20	27.83	23.62	19.98	26.46
S_2	41.52	45.22	38.61	32.64	30.52	37.70	43.74	45.26	39.72	34.88	31.67	39.05	45.36	48.12	41.25	36.97	32.57	40.85
S_3	55.51	59.29	53.23	43.68	41.54	50.65	58.27	59.60	54.07	43.40	41.89	51.45	59.23	62.66	56.38	47.60	44.32	54.04
D_1	36.92	39.63	34.66	28.60	26.52	33.27	38.53	39.68	35.73	30.05	27.23	34.24	39.71	42.64	36.87	31.10	28.65	35.80
D_2	41.55	43.98	39.26	31.70	30.20	37.34	43.84	44.69	40.08	34.21	31.28	38.82	44.49	47.08	41.39	36.84	31.93	40.35
D_3	46.17	49.95	43.54	36.02	33.94	41.92	48.25	49.94	44.77	37.65	34.93	43.11	50.06	52.27	47.20	40.26	36.28	45.22
S_1D_1	22.67	23.87	21.83	16.59	14.62	19.92	23.70	24.62	22.75	17.75	15.69	20.90	23.75	26.55	23.75	17.60	16.55	21.64
S_1D_2	27.65	28.80	25.49	19.77	18.44	24.03	28.54	28.94	26.80	24.56	19.46	25.66	29.55	30.67	27.65	24.19	19.75	26.36
S_1D_3	32.52	34.50	29.57	23.64	22.73	28.59	33.61	34.78	30.81	28.61	24.49	30.46	35.72	36.39	32.11	29.07	23.62	31.38
S_2D_1	36.59	39.54	34.49	28.49	26.57	33.13	38.47	39.66	35.78	31.68	27.60	34.64	40.71	42.71	37.15	31.95	28.76	36.26
S_2D_2	41.54	44.51	38.77	32.66	30.62	37.62	43.38	45.62	39.74	35.58	31.71	39.21	44.64	47.87	40.81	37.58	32.46	40.67
S_2D_3	46.43	51.60	42.56	36.75	34.38	42.35	49.38	50.51	43.65	37.36	35.70	43.32	50.73	53.78	45.79	41.37	36.49	45.63
S_3D_1	51.51	55.49	47.66	40.71	38.39	46.75	53.42	54.77	48.66	40.74	38.39	47.20	54.67	58.65	49.72	43.75	40.65	49.49
S_3D_2	55.47	58.63	53.52	42.66	41.54	50.36	59.62	59.52	53.71	42.48	42.66	51.60	59.28	62.69	55.72	48.73	43.58	54.00
S_3D_3	59.56	63.75	58.49	47.67	44.70	54.83	61.76	64.52	59.86	46.97	44.60	55.54	63.74	66.64	63.71	50.33	48.74	58.63
Mean	41.55	44.52	39.15	32.10	30.22		43.54	44.77	40.19	33.97	31.15		44.76	47.33	41.82	36.07	32.29	

LSD.05 2011						LSD.05 2012						LSD.05 2013					
S	0.14	SD	0.16	SDR	0.27	S	0.12	SD	0.22	SDR	0.33	S	0.38	SD	0.20	SDR	0.48
D	0.15	DR	0.17			D	0.20	DR	0.21			D	0.18	DR	0.30		
R	0.12	SR	0.17			R	0.14	SR	0.21			R	0.21	SR	0.30		

The interaction of rootstocks, salinity and drought levels showed significant effect. Significantly maximum free proline content (73.75, 64.52 & 66.64 µg/ g fresh wt.$^{-1}$) was noticed in Black Balady rootstock grown under salinity level S_3 and drought level D_3 during the three seasons, respectively. Significantly the least free proline content (14.62, 15.69 & 16.55 µg/ g fresh wt.$^{-1}$) was recorded in 1103P grown under salinity level S_1 and drought level D_1 during the three studied seasons, respectively. On other hand, the highest potassium contents

(0.97, 0.91& 0.82 %) was recorded in Black Balady grown under salinity level (S_1) and drought level (D_1) during the three studied seasons, respectively. Whereas, the least values (0.43, 0.38 & 0.35 %) was detected in 110R grown under salinity (S_3) and drought (D_3) during the three studied seasons, respectively.

Table 6: Effect of salinity and drought treatments on Potassium content (%) of some grapevine rootstocks during 2011, 2012 and 2013 seasons.

Treat.	2011					Mean	2012					Mean	2013					Mean
	R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5	
S_1	0.88	0.8	0.8	0.81	0.72	0.8	0.75	0.85	0.75	0.72	0.69	0.75	0.72	0.77	0.68	0.70	0.66	0.71
S_2	0.62	0.66	0.64	0.62	0.59	0.63	0.59	0.65	0.58	0.55	0.54	0.58	0.59	0.61	0.55	0.53	0.52	0.56
S_3	0.49	0.53	0.51	0.47	0.48	0.5	0.45	0.47	0.43	0.42	0.43	0.44	0.44	0.46	0.43	0.40	0.41	0.43
D_1	0.72	0.71	0.7	0.69	0.64	0.69	0.65	0.71	0.65	0.61	0.60	0.64	0.63	0.66	0.60	0.59	0.58	0.61
D_2	0.67	0.66	0.64	0.64	0.59	0.64	0.61	0.66	0.58	0.56	0.55	0.59	0.59	0.62	0.55	0.54	0.53	0.56
D_3	0.59	0.61	0.61	0.57	0.56	0.59	0.54	0.60	0.54	0.52	0.51	0.54	0.53	0.57	0.51	0.49	0.49	0.52
S_1D_1	0.87	0.97	0.86	0.88	0.78	0.87	0.82	0.91	0.81	0.77	0.76	0.81	0.77	0.82	0.73	0.75	0.72	0.76
S_1D_2	0.79	0.88	0.79	0.82	0.72	0.8	0.76	0.85	0.75	0.72	0.68	0.75	0.72	0.78	0.67	0.71	0.65	0.70
S_1D_3	0.73	0.78	0.74	0.73	0.67	0.73	0.68	0.80	0.70	0.67	0.63	0.70	0.67	0.72	0.63	0.64	0.62	0.65
S_2D_1	0.67	0.69	0.7	0.69	0.63	0.67	0.63	0.72	0.64	0.60	0.58	0.63	0.63	0.67	0.59	0.58	0.58	0.61
S_2D_2	0.63	0.67	0.64	0.62	0.58	0.63	0.59	0.66	0.58	0.54	0.54	0.58	0.60	0.60	0.55	0.53	0.52	0.56
S_2D_3	0.57	0.62	0.59	0.55	0.54	0.58	0.54	0.58	0.53	0.51	0.49	0.53	0.53	0.57	0.50	0.48	0.47	0.51
S_3D_1	0.53	0.58	0.56	0.49	0.5	0.54	0.49	0.50	0.48	0.46	0.47	0.48	0.48	0.50	0.47	0.45	0.44	0.47
S_3D_2	0.49	0.53	0.49	0.48	0.48	0.49	0.47	0.47	0.43	0.42	0.43	0.44	0.44	0.47	0.42	0.39	0.41	0.43
S_3D_3	0.43	0.49	0.51	0.43	0.46	0.46	0.39	0.43	0.38	0.38	0.39	0.40	0.40	0.42	0.40	0.35	0.37	0.39
Mean	0.65	0.68	0.65	0.63	0.6		0.60	0.66	0.59	0.56	0.55		0.58	0.62	0.55	0.54	0.53	

LSD.05 2011						LSD.05 2012						LSD.05 2013					
S	0.02	SD	0.04	SDR	0.07	S	0.04	SD	0.05	SDR	0.07	S	0.05	SD	0.04	SDR	0.08
D	0.03	DR	0.04			D	0.05	DR	0.04			D	0.04	DR	0.05		
R	0.03	SR	0.04			R	0.03	SR	0.04			R	0.04	SR	0.05		

Chloride and sodium contents:

Data in Tables (7 and 8) showed that chloride and sodium leaf contents significantly affected due to different salinity and drought treatments and the studied rootstocks during the three studied seasons.

Concerning the salinity and drought effects, the data indicated that the chloride and sodium leaf contents were significantly increased linearly with increase the salinity levels from 1000 to 3000 ppm, as well as increase the drought levels from 1.0 to 50 ET. Moreover, the increment due to salinity effects higher than that due to drought ones.

In addition, data in previously tables decleared that chloride and sodium leaf contents significantly increased to interaction between the salinity and drought treatments. There more, the increment of chloride and sodium leaf contents due to all combinations effective higher than that due to salinity or drought effective only. Then, it concluded that salinity accompanied drought was more effective in decreasing these traits compared to effect of either salinity or drought only.

Regarding to the rootstocks, data showed that 1103 paulsen rootstock recorded highest chloride and sodium leaf contents compared to other studied rootstocks. On other hand, the lowest values were detected of Black Balady. It could be descending arranged order as follows 1103P, 110R, Salt Creek, White Khalili and Black Balady, respectively.

Moreover, the data due to interaction of rootstocks, salinity and drought levels showed significant effects. The significantly highest chloride leaf contents (3.32, 3.41 & 3.50%) and sodium (52.20, 56.45 & 59.6 ppm) were recorded of 1103P rootstocks grown under salinity level (S_3) and drought level (D_3) during the three studied season, respectively. Contrarly, the significantly least chloride leaf contents (0.52, 0.59 & 0.64%) and sodium content (16.34, 17.64 & 21.19 ppm) were recorded of Black Balady grown under the lowest level of salinity and drought ($S_1 D_1$) during the three studied seasons, respectively.

On the light of the previous results, it could be concluded that Black Balady cultivar can be used as a suitable rootstocks for salinity and drought tolerance.

Table 7: Effect of salinity and drought treatments on chloride content (%) of some grapevine rootstocks during 2011, 2012 and 2013 seasons.

Treat.	2011					Mean	2012					Mean	2013					Mean
	R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5	
S_1	1.16	0.64	1.27	1.63	2.2	1.38	1.25	0.71	1.28	1.71	2.19	1.43	1.33	0.74	1.42	1.81	2.24	1.51
S_2	1.66	1.72	1.72	2.13	2.81	1.84	1.67	0.98	1.74	2.2	2.88	1.89	1.77	1.06	1.88	2.29	2.98	2
S_3	2.05	1.13	2.07	2.68	3.22	2.23	2.15	1.18	2.11	2.79	3.29	2.31	2.18	1.3	2.26	2.88	3.42	2.41
D_1	1.48	0.8	1.55	1.97	2.56	1.67	1.52	0.87	1.56	2.06	2.62	1.73	1.62	0.94	1.72	2.17	2.71	1.83
D_2	1.61	0.89	1.69	2.16	2.76	1.82	1.69	0.96	1.73	2.22	2.78	1.88	1.77	1.04	1.86	2.32	2.9	1.98
D_3	1.77	0.98	1.82	2.32	2.91	1.96	1.85	1.04	1.84	2.41	2.97	2.02	1.89	1.13	1.99	2.48	3.04	2.11
S_1D_1	1.02	0.52	1.13	1.41	1.92	1.2	1.12	0.59	1.15	1.52	1.95	1.27	1.21	0.64	1.25	1.65	2.01	1.35
S_1D_2	1.14	0.64	1.26	1.62	2.24	1.38	1.23	0.72	1.28	1.69	2.14	1.41	1.32	0.72	1.4	1.81	2.24	1.5
S_1D_3	1.31	0.75	1.41	1.85	2.44	1.55	1.39	0.82	1.42	1.92	2.48	1.61	1.45	0.85	1.62	1.97	2.47	1.67
S_2D_1	1.48	0.83	1.53	1.96	2.63	1.69	1.46	0.91	1.51	2.03	2.72	1.73	1.57	0.97	1.77	2.14	2.81	1.85
S_2D_2	1.67	0.9	1.75	2.14	2.83	1.86	1.69	0.99	1.79	2.19	2.91	1.91	1.81	1.07	1.89	2.27	2.99	2.01
S_2D_3	1.82	0.98	1.88	2.29	2.97	1.99	1.85	1.04	1.91	2.37	3.02	2.04	1.92	1.15	1.99	2.45	3.15	2.13
S_3D_1	1.94	1.04	1.98	2.53	3.13	2.12	1.99	1.1	2.02	2.62	3.19	2.18	2.08	1.21	2.13	2.72	3.3	2.29
S_3D_2	2.02	1.12	2.04	2.71	3.22	2.22	2.16	1.18	2.12	2.79	3.28	2.31	2.19	1.32	2.29	2.89	3.47	2.43
S_3D_3	2.17	1.21	2.18	2.81	3.32	2.22	2.31	1.27	2.2	2.95	3.41	2.43	2.29	1.37	2.37	3.02	3.5	2.51
Mean	1.62	0.89	1.69	2.15	2.74		1.69	0.96	1.71	2.23	2.79		1.76	1.03	1.86	2.32	2.88	

LSD.05 2011						LSD.05 2012						LSD.05 2013					
S	0.0222	SD	0.0008	SDR	0.0013	S	0.0009	SD	0.0010	SDR	0.0017	S	0.0287	SD	0.0010	SDR	0.0547
D	0.0007	DR	0.0008			D	0.0009	DR	0.0011			D	0.0009	DR	0.0344		
R	0.0006	SR	0.0008			R	0.0008	SR	0.0011			R	0.0239	SR	0.0344		

Table 8: Effect of salinity and drought treatments on Sodium content ((ppm) of some grapevine rootstocks during 2011, 2012 and 2013 seasons.

Treat.	2011					Mean	2012					Mean	2013					Mean
	R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5		R_1	R_2	R_3	R_4	R_5	
S_1	22.73	22.73	20.96	22.00	24.80	22.71	26.15	23.02	24.57	24.14	25.06	24.59	26.72	24.54	25.79	29.14	27.86	26.81
S_2	35.15	33.20	35.84	35.84	37.04	35.28	38.65	37.62	38.34	39.92	39.19	38.74	37.71	37.53	38.86	39.85	39.61	38.71
S_3	45.70	45.81	49.22	48.42	49.11	47.65	48.02	47.39	50.54	51.68	52.02	49.93	51.73	49.56	53.19	49.84	54.43	51.75
D_1	30.87	29.77	31.42	30.88	32.44	31.08	33.90	31.81	33.36	34.22	34.58	33.57	34.58	33.70	35.07	36.46	36.00	35.17
D_2	34.33	34.10	35.48	35.32	37.53	35.35	38.11	36.34	37.76	38.29	38.67	37.83	38.85	36.76	39.35	39.68	41.04	39.14
D_3	38.73	37.86	39.12	39.37	40.98	39.21	40.82	39.89	42.33	43.22	43.02	41.86	42.72	41.16	43.41	42.69	44.87	42.97
S_1D_1	17.54	16.34	17.27	17.45	17.54	17.65	22.92	17.64	20.57	19.79	20.76	20.34	22.18	21.19	21.99	25.19	23.14	22.74
S_1D_2	23.29	24.43	20.36	22.21	25.42	23.14	26.16	23.44	24.28	23.99	25.28	24.63	27.46	24.28	26.16	29.57	28.99	27.29
S_1D_3	28.40	27.41	25.24	26.33	29.33	27.34	29.38	27.99	28.86	28.64	29.14	28.80	30.53	28.14	29.21	32.67	31.46	30.40

S_2D_1	31.62	29.45	30.27	31.66	32.19	31.04	33.63	32.85	33.14	34.44	35.56	33.93	33.62	33.42	34.62	37.47	35.64	34.95
S_2D_2	34.46	32.53	36.71	34.39	37.54	35.12	39.66	37.71	38.28	39.71	38.55	38.78	37.38	36.35	38.45	39.88	39.66	38.35
S_2D_3	39.38	37.64	40.55	39.43	41.40	39.68	42.66	42.31	43.59	45.6	43.46	43.52	42.14	42.80	43.5	42.2	43.54	42.84
S_3D_1	43.44	43.54	46.72	43.54	45.50	44.55	45.14	44.94	46.36	48.43	47.43	46.46	47.95	46.50	48.6	46.73	49.23	47.80
S_3D_2	45.23	45.35	49.38	49.37	49.62	47.79	48.51	47.86	50.71	51.18	52.18	50.09	51.73	49.64	53.45	49.59	54.46	51.77
S_3D_3	48.41	48.54	51.56	52.36	52.20	50.61	50.41	49.37	54.55	55.43	56.45	53.24	55.50	52.55	57.51	53.20	59.60	55.67
Mean	34.64	33.91	35.34	35.19	36.98		37.61	36.01	37.82	38.57	38.76		38.72	37.21	39.28	39.61	40.64	

LSD.05 2011						LSD.05 2012						LSD.05 2013					
S	0.200	SD	0.221	SDR	0.328	S	0.152	SD	0.266	SDR	0.31	S	0.197	SD	0.147	SDR	0.3
D	0.197	DR	0.206			D	0.238	DR	0.195			D	0.131	DR	0.188		
R	0.143	SR	0.206			R	0.135	SR	0.195			R	0.131	SR	0.188		

Discussion:

Salinity is one of the most severe abiotic factor, whereas, drought is the major biotic factors that limiting agricultural production worldwide. The detrimental impact of salinity on grape production will worsen as a consequence of the adverse effects of climate change on the availability of the existing water resources and their quality.

In recent years with the increasing problems of soil salinity, growing of commercial grape varieties on suitable rootstocks has become inevitable. Further, different rootstocks and cultivars of grape absorb chloride and sodium at different rates, so tolerance can vary considerably between species and varieties within a species. Rootstocks that differ in their ability to absorb and transport salts posses different salt tolerance capacities (Downton, 1985 and Shannon, 1997). The development of salt-tolerant crops or desalination of soil by leaching excessive salts, though successful, is not economical for sustainability. In this respect, biological processes such as use of moderately salt-tolerant rootstocks could be better options (Hartmond *et al*., 1987 and Dixon *et al*., 1993).

Plant high and leaf area in Tables (2 & 3) was significantly reduced with the increase in salinity or drought stress. Reduction in plant high and leaf area is attributed to the decrease in root cytokinins under stress (salinity or moisture) as cytokinins are known to be produced in the roots and translocated to the shoots where they have physiological effect. The secondary cause for shoot length and leaf area reduction is loss of turgidity and elongation of the cells in the plants under moisture stress (Hasio *et al*., 1970 and Walker *et al*., 2004).

In the present salinity or drought stress significantly reduced shoot length of different grape rootstocks varieties. Many workers reported reduction in shoot length due to salinity stress in grapevines (Hawker and Walker, 1978; Alsaidi *et al*., 1985; Alsaidi *et al*., 1988 and Fisarakis *et al*., 2001). These authors are of the opinion that reduction might be due to the physiological scarcity of water caused by high concentration of salts because of i) osmotic effect on plant ii) the toxic effect of accumulated ions in plant tissue iii) specific effect of constituent ions or iv) combination of all these.

The dry weight of both shoot and root (Table 4) of the different rootstocks grape decreased with the increase either salinity or drought levels. Increased salinity, as well as drought have an inverse relationship with stomatal conductance and net photosynthetic rate, leading to reduced photo-assimilation and dry matter production (Rozeff, 1995).

A good resistance of grapevines to stress situations results from deep of root system and physiological mechanism of drought avoidance (Chaves *et al*., 2010). Monitoring of changes in the growth of annual shoots is a very sensitive indicator of the lack of water and can help to reveal the water stress even before it is possible to detect changes in the water potential of leaves (Grimplet *et al*., 2007).

Free proline accumulation in the leaves of grape rootstocks, progressively increased with the increase in salt concentration in soil solution. The data indicated that the free proline accumulation was more positively correlated with Na^+ and Cl^- showing its possible synthesis due to ion-toxicity. Salt tolerance has been mainly associated with ability of different cultivars, rootstocks or their combinations to restrict Cl entry into shoot. Results of the present investigation are in agreement with those of Paranychianakis and Angelakis (2008) which free proline content as well as Cl^- and Na^+ increased in response to increased salinity levels. Salt tolerant plants adjust osmotically by the synthesis of highly water soluble compatible osmotica (e.g. glycinebetaine, free proline, and low molecular weight sugars) and maintain turgor. Among these, free proline ameliorates salt-induced oxidative damage to membranes (Jain *et al*., 2001).

Irrigation level had effect on leaf salt content. A rootstock specific effect of irrigation level on leaf salt content may be due to a physiological response or to changes in salt availability in the rhizosphere. The severe water deficit for vines irrigated at 0.50 ET irrigation level may have stimulated the uptake of Cl. The decrease of leaf-Na of Black Balady at the lower irrigation level may be due to a decreased its availability as has been found for K (Paranychianakis *et al*., 2006 and Paranychianakis and Angelakis, 2008) and possibly to the lower ability of Black Balady rootstock to discriminate Na over K. The later is confirmed by the increase in Na/K ratio with increasing irrigation level.

Conclusion:

The obtained results indicated that Black Balady and White Khalili grape cultivars had good growth and nutrient status, as well as had higher free proline accumulation and potassium contents. Contrary, they had lowest contents of chloride and sodium compared to other studied rootstocks. These advantages will eventually to conclude that Black Balady and White Khalili can be used as a suitable rootstocks for tolerance of salinity and drought stress.

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