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DETERMINATION OF SALT TOLERANCE OF SOME AMERICAN GRAPE ROOTSTOCKS

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Abstract

To determine salt tolerance of four American grape rootstocks, 1103 P, 41 B, 140 Ru and 5 BB, characteristics measured were fresh and dry weight of root, fresh and dry weight of shoot, fresh and dry weight of plant, plant moisture, cutting moisture, shoot length, node number and leaf number. Salt tolerance of the rootstocks was determined by both tolerance rate and index values on the basis of shoot and root dry weights, and interpreted with plant viability. Results obtained indicated that 41 B was the most resistant rootstock, followed by 140 Ru and 1103 P, and the least resistant was 5 BB.

Introduction

Increase in soil salinity is becoming a world-wide problem. It was estimated that one third of the world's irrigated land (400-950 million ha) has been affected from salt (Hasegawa *et al.* 1986). The amount of salt affected lands in Turkey is around 4 million ha, composing 18% of total arable land (Sönmez 1990).

Salt influences plant metabolism (Levitt 1980) and the most important effect is halting plant growth and development. Depending on tolerance level, salt inhibits growth, develops chlorosis and necrotic spots, and decreases yield quality, leading to sudden death of affected plants (Hasegawa *et al.* 1986). Impeded plant growth due to salt could be due to physiological drought caused by low water potential in soil solution, low water potential in plant, low relative turgidity, and osmotic regulations that occurs as a result of increasing cell ionic concentration (Levitt 1980, Schwarz 1995). These changes lead to hormonal irregularities, decrease in stomatal openings and hence CO_2 uptake, loss in transpiration, chlorosis and consequently slowed down plant growth (Schwarz 1985, McKersie and Leshem 1994, Schwarz 1995).

Plants differ in their tolerance to salt. It has been reported that not only families, genera and species but also varieties of a species show differences in salt tolerance (Quamme and Stushnoff 1983, Salisbury and Ross 1992, Schwarz 1995). American grape rootstocks have also shown to have different tolerance levels to salt (Southey and Jooste 1991, 1992, Sivritepe 1995, Sivritepe and Eriş 1998, Desmukh *et al.* 2003).

In a study, two American rootstocks, 5 BB and 1613 C, were analyzed for their salt tolerance and it was found that those two differed in their effects on Na accumulation and ion balance (Sivritepe and Eriş 1998). Walker (1994) determined that Ramsey grape (*Vitis champinii*) increased the salt tolerance of Thompson seedless variety grafted on it by decreasing Cl uptake and its transport to the shoots.

Grape is grown on a 530000 ha land with a 3650000 t production in Turkey (FAO 2005). Viticulture covers 2.05% of total arable land in the country and Çanakkale has 7246 ha of total viticultural land (Anon. 1999).

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It was aimed in this study to determine the salt tolerance of four American grape rootstocks widely grown in Turkey.

Materials and Methods

One year old cuttings of four rootstocks, 1103 P, 41 B, 140 Ru and 5 BB, were collected from Umurbey Fruit Crops Production Station, Çanakkale in December of 2001 and 2002. Shoot cuttings were kept for three months at 1-4 ºC and 80-90% relative humidity, after being treated with a fungicide (Kismali 1978). Cuttings were taken out in March and kept in water for a day (Saraswat 1973).

Two budded and 7-8 mm thick cuttings were placed in 4 cm × 4 cm strong boxes filled with perlite, on March 29 in 2002 and on March 15 in 2003. Boxes were kept in an unheated plastic greenhouse. Study was carried out according to the randomized block design with 4 replicates and each replicate had 15 cuttings with standardized height and width.

In the first year, cuttings were fertilized at planting with ammonium sulphate (21%) 10 kg/da N, triple super phosphate (42 - 45%) 4 kg/da P_2O_5 and potassium sulphate (50%) 15 kg/da K_2O. Cuttings developed 2-3 leaves one month after planting and they were subjected to five different salt concentrations (0, 5000, 10000, 15000 and 20000 mg/l NaCl) for 50 days. In the second year, pure nutrient elements of N (10 kg/da), P_2O_5 (4 kg/da) and K_2O (15 kg/da) were provided to the plants by supplying them with ammonium nitrate (33%), mono ammonium phosphate (12-61-0) and potassium sulphate (50%).

Each strong box was weighed and made up to 1 kg in the second year. Until the start of salt applications, boxes were weighed in every two days and lacking amount was replenished with water. Because sprouting of 2-3 leaves was delayed for two months due to prevailing cold temperature, salt applications were postponed till then. Every box was weighed and irrigated with water containing salt solutions until they reached 1 kg. Cuttings were dug out and measurements of various parameters were done when plants treated with highest salt concentrations started to show severe symptoms. Shoot length (mm), node number and leaf number were recorded. Shoots and roots were separated and fresh weights were noted. Dry weigths were obtained after drying at 70ºC for 24 h. Percentage of viable plants left after the treatments were considered as plant viability. The scale developed by Martinez-Barraso and Alvarez (1997) for strawberry plants were modified and used for determination of damages on the materials. Plants with no necrotic tissues was graded as 0; light dryness and necrosis on the tip of the leaves as 1; necrosis on more than 50% area of the leaves and necrosis on the stem as 2 and necrosis leading to the death of the plant as 3.

Tolerance Index (TI) developed by LaRosa *et al.* (1989) was used for comparing tolerance of the rootstocks and formulated as below by using shoot and root dry weights.

$$TI = 100 + \sum^{n} [x\,(T_x / T_o)100]$$

where n, number of treatments; x = 0.0, 0.5, 1.0, 1.5, 2.0 NaCl %; T_x = shoot/root weight of NaCl treated cutting (g); T_o = shoot/root weight of untreated cutting (g).

Tolerance rate (TR) of Chandler *et al.* (1986) was used for determining rootstock resistance to the different concentrations of NaCl. It is calculated, as shown below, for every rootstock and salt concentration separately using shoot and root dry weights.

$$TR = T_x / T_o$$

where, T_x = shoot/root weight of NaCl treated cutting (g); T_o = shoot/root weight of untreated cutting (g).

Data for 41 B and 140 Ru were obtained for one year. The other two rootstocks were evaluated for two years. All data were evaluated with MINITAB statistical software package program. Differences between the mean values were evaluated with LSD test.

Results and Discussion

Rootstocks differed in their response to salt treatments. 1103 P was affected with increasing salt concentrations. Salt treatments had their most prominent effects on leaf number of 41 B. Other characteristics were less influenced. 140 Ru had most of the characteristics affected by the salt treatments; however, they were not sharp and too fast influence. 5 BB was affected more or less similarly by 0 and 5000 mg/l. Increasing salt concentrations resulted in adverse effects in all parameters. Evaluation of the Table 1 as a whole showed that for plant viability 41 B was the most resistant rootstock, followed by 140 Ru and 1103 P. The most susceptible rootstock was 5 BB.

Table 1. Effects of different concentration of salinity on 1103 P, 41 B, 140 Ru and 5 BB American grape rootstocks.

NaCl (mg/l)	Root fresh wt. (g)				Root dry wt. (g)			
	1103 P	41 B	140 Ru	5 BB	1103 P	41 B	140 Ru	5 BB
0	1.023 A	0.573	0.378 A	1.460 A	0.050 A	0.038	0.028 A	0.075 A
5000	0.813 AB	0.393	0.390 A	1.245 A	0.038 AB	0.023	0.023 AB	0.060 AB
10000	0.530 BC	0.408	0.155 B	0.410 B	0.028 BC	0.025	0.008 B	0.020 BC
15000	0.345 C	0.305	0.198 AB	0.363 B	0.015 C	0.020	0.013 AB	0.018 C
20000	0.315 C	0.190	0.118 B	0.445 B	0.015 C	0.013	0.010 B	0.019 C
LSD (%)	1	NS	5	5	1	NS	5	5
	Plant fresh wt. (g)				Plant dry wt. (g)			
0	1.850 A	1.443	0.847 A	2.835 A	0.228A	0.235	0.138 AB	0.358 A
5000	1.523 AB	1.120	0.900 A	2.485 A	0.200 AB	0.193	0.148 A	0.310 AB
10000	0.993 BC	1.068	0.465 B	0.992 B	0.160 BC	0.188	0.095 BC	0.188 BC
15000	0.673 C	0.838	0.445 B	0.795 B	0.130 C	0.180	0.080 C	0.163 C
20000	0.610 C	0.593	0.313 B	0.823 B	0.135 BC	0.133	0.078 C	0.158 C
LSD (%)	1	NS	1	5	5	NS	5	5
	Shoot length (mm)				Node number			
0	51.9	39.1	27.4	53.2 A	4.33	3.05	3.00	3.94 A
5000	48.4	33.1	29.3	43.1 AB	4.52	2.65	2.80	3.67 AB
10000	41.8	31.5	30.3	36.1 B	3.69	2.80	3.15	3.11 BC

15000	37.6	34.6	25.7	33.1 B	3.58	2.97	2.52	3.04 C
20000	40.6	25.5	23.6	35.8 B	3.60	2.33	2.25	3.03 C
LSD (%)	NS	NS	NS	5	NS	NS	NS	5

(Contd.)

(Contd.)

	Shoot fresh wt. (g)				Shoot dry wt. (g)			
0	0.825 A	0.873	0.473 AB	1.373 A	0.175	0.198	0.108	0.283 A
5000	0.713 A	0.725	0.510 A	1.237 A	0.163	0.170	0.123	0.255 AB
10000	0.463 B	0.663	0.313 BC	0.583 B	0.135	0.160	0.088	0.165 BC
15000	0.325 B	0.535	0.248 C	0.430 B	0.115	0.158	0.070	0.143 BC
20000	0.293 B	0.405	0.195 C	0.373 B	0.120	0.120	0.068	0.140 C
LSD (%)	1	NS	5	1	NS	NS	NS	5
	Plant moisture (%)				Cutting moisture (%)			
0	86.9 A	83.3	82.7 AB	86.2 A	57.2	57.9	55.8	58.9
5000	86.3 A	81.8	84.1 A	84.4 AB	58.5	56.7	55.4	57.9
10000	83.8AB	81.1	79.2 BC	79.4 B	57.1	57.3	55.5	57.5
15000	79. 5B	77.8	81.2 AB	78.6 B	56.8	57.7	55.4	59.8
20000	74.7 C	77.6	75.7 C	71.1 C	56.1	57.2	55.3	57.5
LSD (%)	1	NS	5	1	NS	NS	NS	NS
	Leaf number				Plant viability (%)			
0	4.17 A	2.98 A	3.02 A	3.73 A	97.2 A	100.0	100.0 A	98.3 A
5000	3.88 A	2.57 AB	2.59 AB	3.17 A	89.3 AB	100.0	98.1 A	90.5 AB
10000	2.83 B	2.50 AB	2.50 AB	2.30 B	78.4 C	98.1	100.0 A	73.1 BC
15000	2.49 B	2.27 BC	2.03 BC	2.21 B	70.2 C	94.2	93.8 AB	64.8 C
20000	2.62 B	1.73 C	1.62 C	2.17 B	39.4 D	95.2	80.2 B	54.1 C
LSD (%)	1	5	5	1	1	NS	5	1

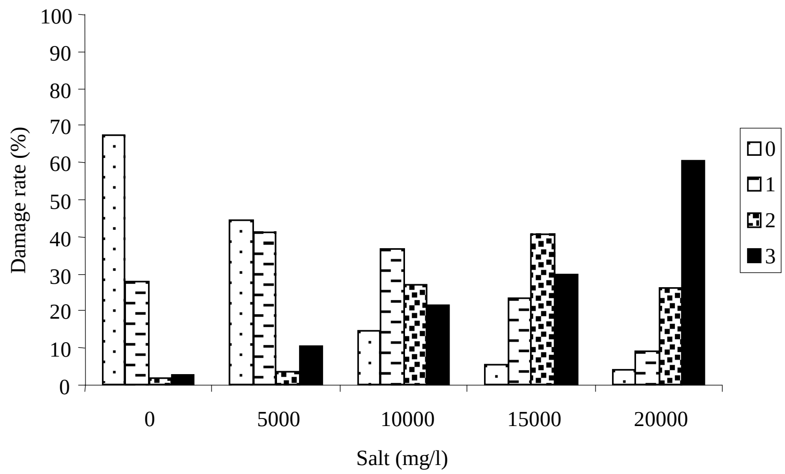

Fig. 1. Damaging level for 1103 P rootstock of grape.

Damaging level for all the rootstocks were determined. The lowest salt concentration (5000 mg/l) showed 2nd and 3rd degree damages on 1103 P. Controls and degree 1 plants were approximately the same in 5000 mg/l. Increasing salt concentrations (10000, 15000 and 20000 mg/l) caused increased loss of plant viability (Fig. 1). 41 B had the same amount of no damage and degree 1 plants even at 20000 mg/l and showed very low level of degree 3 damages (Fig. 2).

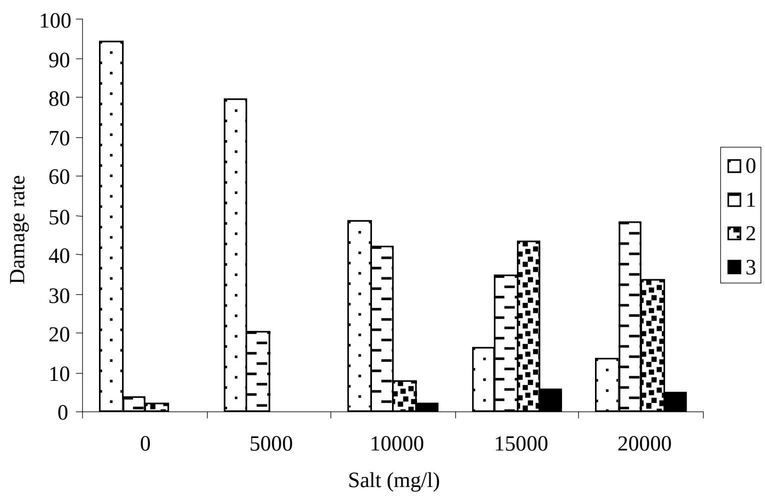

Fig. 2. Damaging level for 41 B rootstock of grape

140 Ru had increasing number of damaged plants and decreasing number of live plants as the concentrations went up (Fig. 3). The lowest salt treatment resulted in 2 and 3 degree damages on 5 BB, with elevated damage rates on increasing concentrations, causing a prominent loss of viability (Fig. 4). Considering the figures, the highest number of live plants was obtained from 41 B, followed by 140 Ru, 5 BB and 1103 P.

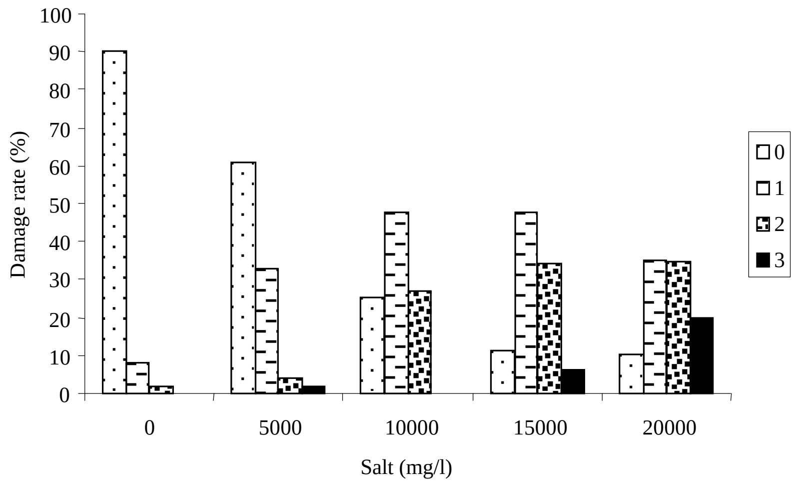

Fig. 3. Damaging level for 140 Ru rootstock of grape.

140 Ru had the highest TR on the basis of shoot dry weight, followed by 41 B and 1103 P and 5 BB. TR on the basis of root dry weight was the lowest for 5 BB, following 1103 P, 140 Ru and the highest for 41 B (Table 2). Table 3 presents the result of TI for all the rootstocks in 5 salt treatments. The highest TI on the basis of root dry weight was obtained from 41 B, while shoot dry weight based TI was highest in 140 Ru.

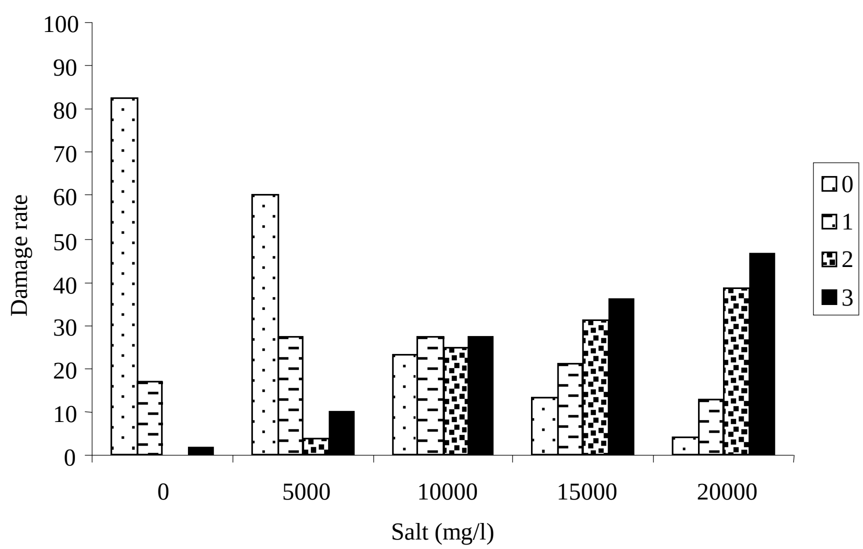

Fig. 4. Damaging level for 5 BB rootstock of grape.

Table 2. Tolerance rate on the basis of shoot and root dry weight.

Root	Salt concentration (mg/l)

stocks	5000		10000		15000		20000	
	Shoot dry wt.	Root dry wt.	Shoot dry wt.	Root dry wt.	Shoot dry wt.	Root dry wt.	Shoot dry wt.	Root dry wt.
1103 P	0.938	0.793	0.778	0.600	0.668	0.343	0.700	0.318
41 B	0.860	0.605	0.855	0.793	0.810	0.645	0.618	0.460
140 Ru	1.190	1.068	0.958	0.258	0.670	0.468	0.615	0.508
5 BB	0.928	0.768	0.603	0.300	0.525	0.275	0.498	0.243
LSD	ns	ns	ns	ns	ns	ns	ns	ns

Table 3. Tolerance index on the basis of root and root dry weight.

Root stocks	Salt concentration (mg/l)	
	Root dry wt.	Shoot dry wt.
1103 P	2235.8	4186.8
41 B	3078.5	3836.0
140 Ru	2604.8	4315.0
5 BB	1679.1	2956.9
LSD	ns	ns

Four rootstocks had different responses to increasing salt concentrations. The findings are consistent with the previous studies that reported decreased vegetative development, leaf burns resulting plant death (Khanouja *et al.* 1980, Sivritepe and Eriş 1998, Desmukh *et al.* 2003 and Walker *et al.* 2003). 41 B was the most resistant rootstock which was not affected by the elevated salt levels and had the highest number of plants with the least damage.

TR showed that 41 B and 140 Ru had the highest tolerance while 5 BB had the least tolerance level on the root dry weight basis. TI data indicated that the most tolerable rootstocks were 41 B on the root dry weight basis and 140 Ru on the shoot dry weight basis.

Overall results showed that 41 B is the most salt resistant rootstock, followed by 140 Ru and 1103 P. The least resistance was 5 BB. It is believed that similar studies should be performed with other rootstocks prevalently used in the rest of the grape growing areas in Turkey.

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