Annals of Arid Zone 35(1) : 43-48, 1996

Effect of Saline Water on Growth Parameters of Five Citrus Root-stocks

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Abstract : The pot culture experiment was carried out at the Experimental Station of Agriculture Science College at Al-Oha region to study the effect of NaCl + $CaCl_2$ (1:1 by weight) on the growth parameters of 5 citrus root-stock seedlings, viz., Volkamer lemon (*Citrus volkameriana*), Macrophylla (*Citrus macrophylla*), Sour orange (*Citrus aurantium*), Rough lemon (*Citrus jambhiri*) and Balady line (*Citrus aurantifolia*). The relative growth rate (RGR) of Volkamer lemon, Balady lime and Sour orange root-stock reduced by 52.3, 39.7 and 17.2%, respectively, where as, RGR of Macrophylla and Rough lemon increased, when irrigated with 0.6% salt solution by 10.5% and 3.8%, respectively, as compared with control. These effects were not significant. Stem dry matter and diameter of five root-stock seedlings did not respond to saline water treatments, except a significant reduction in stem diameter of Volkamer lemon and Balady lime root-stock seedlings, when irrigated with 0.4% saline water. The leaf dry matter of Rough lemon, and Macrophylla seedlings significantly increased, whereas, leaf dry matter of Volkamer lemon and Balady lime reduced significantly, when irrigated with 0.6% saline water. Root dry matter of Rough lemon and Macrophylla root-stock seedlings increased slightly, and that of Balady lime, Volkamer lemon and Sour orange, decreased with 0.6% saline water irrigation. The leaf area of Balady lime and Rough lemon root-stock seedlings did not show any significant reduction. It was observed that Rough lemon was more resistant to high salinity in irrigation water.

Key words : Salinity, citrus root-stocks, seedling, plant growth parameters.

Salinity in irrigation water is known to depress growth of many fruit trees (Swiedan, *et al.*, 1982; Nawar and Ibrahim, 1984; Kitat *et al.*, 1989; Hassan and Abou El-Azayem, 1990; Hassan,1991; Benlloch *et al.*, 1991; Al-juburi, 1992 and 1993). Increasing salinity in the irrigation water to Valencia orange and Sour orange seedlings progressively decreased the growth (El-Kholi *et al.*, 1979a, 1979b; Badawi *et al.*, 1979). Salinity treatment of "Pineapple" Sweet orange, Cleopatra mandarin and Trifoliate orange decreased hydraulic conductivity of roots, transpiration rate, leaf water potential and growth (Syvertsen and Yelenosky, 1988). The purpose of this study was to evaluate the salt tolerance among five citrus root-stocks and to investigate the effect of different concentrations of saline water on some growth parameters of citrus root-stocks.

Materials and Methods

One-year-old uniform citrus seedlings of five root-stocks, Volkamer lemon (*Citrus volkameriana* Wester), Macrophylla (*C. macrophylla*), Sour orange (*C. aurantium* L.), Rough lemon (*C. jambhiri*), and Balady lime (*C. aurantifolia*) were grown in plastic pots (40 x 25 cm) containing sand and irrigated thrice a week with nonsaline water. After one year, pots were arranged in a completely randomized blocks and irrigated with 0 (0.06 dS m^{-1}), 0.2% (3.63 dS m^{-1}), 0.4% (6.94 dS

Table 1: Effect of 0, 0.2, 0.4, 0.6% NaCl + $CaCl_2$ in irrigation water on relative growth rate percentage of citurs root- stock 212 days after treatment[zy]

Cultivar	Per cent NaCl + $CaCl_2$ in irrigation water			
	0.0	0.2	0.4	0.6
Volkamer lemon	39.13^{defg}	42.06^{defg}	26.05^{efg}	18.65^{g}
Macrophylla	52.30^{de}	57.06^{bcd}	46.86^{def}	57.78^{bcd}
Sour orange	46.43^{def}	54.13^{cd}	46.45^{def}	38.43^{defg}
Rough lemon	78.65^{abc}	87.54^{a}	49.74^{de}	81.63^{ab}
Balady lime	35.93^{defg}	40.87^{defg}	33.61^{defg}	21.68^{fg}

z : Values are mean of 20 observations. y : Means within columns of rows followed by the same letter do not differ significantly (p = 0.05) Duncon's multiple range test.

m^{-1}) and 0.6% (10.05 dS m^{-1}) of calcium chloride plus sodium chloride (1:1 by weight). Each salinity treatment, having 5 seedlings, was replicated four times. Thus, a total of 400 seedlings were used in this study (80 seedlings for each root-stock). Salinity treatments were imposed by once a week irrigating each seedling, with 1000 ml of salt solution (in addition to 1000 ml of half strength Hoagland's solution). The growth parameters (relative growth rate, stem diameter, dry matter, branch number, leaf area) were recorded as described earlier (Aljuburi *et al.*, 1990). All data were analyzed with (5 x 4) factorial analysis of variance with 5 cv. and 4 salinity levels as main effects. The data were subjected to Duncan's multiple range test and MSTAT program was used for data analysis.

Results and Discussion

Relative growth rate

The RGR of Rough lemon root-stock seedlings was markedly higher at all growth stages. Both Sour orange and Macrophylla root-stock seedlings maintained a comparable RGR. In Balady lime and Volkamer lemon the RGR was markedly less. The RGR of five root-stock seedlings recorded after 212 days of treatment is presented in Table 1. The RGR was highest in seedlings receiving irrigation water containing 0.2% salts, except in Macrophylla where it was at 0.6% salt. RGR of Rough lemon was significantly higher when irrigated with 0.6% salt concentration for 212 days as compared with Volkamer lemon, Sour orange and Balady lime root-stocks, but did not show significant difference with Macrophylla root-stock. The results are in conformity with those of El-Kholi *et al.* (1979a, 1979b) and Badawi *et al.*, (1979) who found that the increasing salinity in the irrigation water progressively decreased the growth of Valencia orange and Sour orange seedlings.

Stem diameter

Irrigation with different concentrations of salt significantly influenced the stem diameter of citrus root-stock seedlings (Table 2). Stem diameter of Volkamer lemon was significantly more than that of Sour orange in control. Continuous irrigation with 0.2% saline water for 250 days significantly reduced the stem diameter of Sour orange and Balady root-stock seedlings as compared to the others. Stem diameter of Sour orange root-stock was significantly reduced, when irrigated with 0.4%, and 0.6% NaCl + $CaCl_2$ except in Volkamer lemon at 0.4% salt solution.

Stem dry matter

Irrigation of seedlings with saline water for 250 days significantly influenced the stem dry matter in Balady lime and it was sig-

Table 2. Effect of 0, 0.2, 0.4, 0.6% NaCl + $CaCl_2$ in irrigation water on growth parameters of five citrus root stocks at 250 days after treatment[zy]

Variety	Per cent NaCl + $CaCl_2$ in irrigation water			
	0.0	0.2	0.4	0.6
Trunk dia. (cm)				
Volkamer	10.05^{a}	9.55^{abc}	8.02^{cdef}	8.88^{abcde}
Macrophylla	8.65^{abcde}	9.05^{abcd}	8.48^{bcde}	8.40^{bcde}
Sour orange	7.42^{efg}	6.94^{ab}	6.60^{fg}	6.21^{g}
Rough lemon	9.32^{abcd}	9.62^{ab}	9.32^{abcd}	8.70^{abcde}
Balady lime	9.16^{abcd}	7.89^{deb}	8.84^{abcde}	8.96^{abcd}
Stem dry matter (%)				
Volkamer	45.24^{bcde}	45.62^{bcde}	43.55^{def}	44.1^{cdef}
Macrophylla	46.32^{bcd}	46.60^{bcd}	46.92^{bcd}	48.21^{abc}
Sour orange	43.81^{cdef}	45.84^{bcde}	42.94^{def}	40.96^{f}
Rough lemon	45.31^{bcde}	48.99^{ab}	41.93^{ef}	45.97^{bcde}
Balady lime	51.90^{a}	51.60^{a}	49.00^{ab}	47.26bcd
Leaf dry matter (%)				
Volkamer	32.25^{efg}	31.60^{fgh}	27.24^{i}	27.90^{i}
Macrophylla	31.49^{fgh}	33.95^{def}	34.72^{cdef}	35.18^{cde}
Sour orange	30.38^{ghi}	30.05^{ghi}	28.39^{hi}	27.52^{i}
Rough lemon	31.54^{fgh}	37.56^{bc}	37.01^{bcd}	36.02^{bcd}
Balady lime	42.93^{a}	35.56^{bcde}	35.16^{cde}	38.83^{b}
Root dry matter (%)				
Volkamer	$36.42^{bcdefgh}$	37.43^{bcdef}	38.54^{bcde}	33.83^{cdefgh}
Macrophylla	38.86^{bcd}	34.13^{cdefgh}	39.25^{bc}	37.92^{bcdef}
Sour orange	33.00^{defgh}	35.27^{cdefgh}	32.15^{fgh}	31.51^{gh}
Rough lemon	32.76^{efgh}	31.85^{gh}	31.26^{h}	34.88^{cdefgh}
Balady lime	46.18^{a}	41.37^{ab}	34.12^{cdefgh}	41.55^{ab}

z : Values are mean of 20 observations. y : Means within columns of rows followed by the same letter do not differ significantly (p = 0.05) Duncon's multiple range test.

nificantly higher in non-saline treatment as compared with others. Dry matter of stem of Balady lime root-stock seedlings was higher when irrigated with 0.2% or 0.4% salt solution as compared with most citrus root-stocks except for Rough lemon or Macrophylla root-stock seedlings, respectively. Irrigation with high salt concentration (0.6%) significantly reduced the stem dry matter of Sour orange except with Volkamer lemon. Dry matter of stem of Balady lime root-stock seedlings reduced significantly, when irrigated for long term with 0.6% salt concentration as compared with control.

Leaf dry matter

Irrigation with different levels of salinity in water significantly affected leaf dry matter among root-stock seedlings. The leaf dry matter of Balady lime was significantly higher as compared to others, when irrigated with non saline water. When irrigated with 0.2% saline water for 250 days leaf dry matter of Rough lemon was significantly higher as compared to the Sour orange, Macropylla and Volkamer lemon, but did not show a significant difference with Balady lime root-stock seedlings. Leaf dry matter of Volkamer lemon

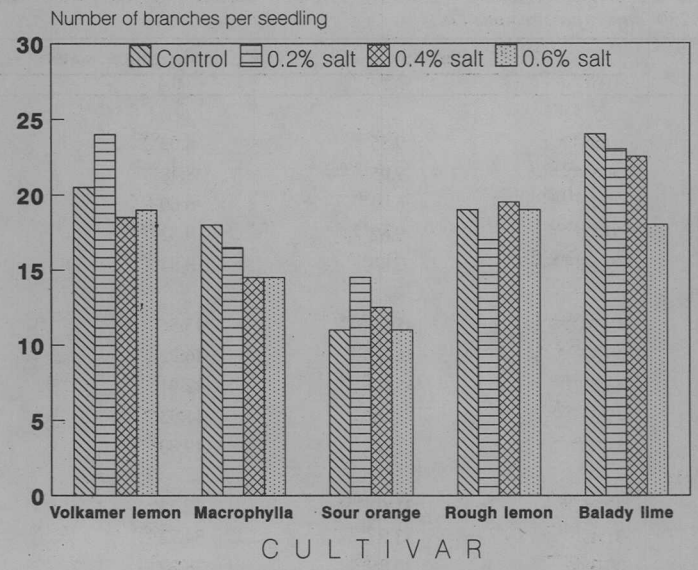

Fig. 1. Effect of saline water irrigation on number of branches per seedling in five citrus root-stocks at 212 days after treatment.

and Balady lime root-stock seedlings showed a significant reduction when irrigated for 250 days with 0.6% saline water, whereas, leaf dry matter of Sour orange root-stock seedlings was not affected. Rough lemon and Macrophylla root-stock seedlings showed sig-

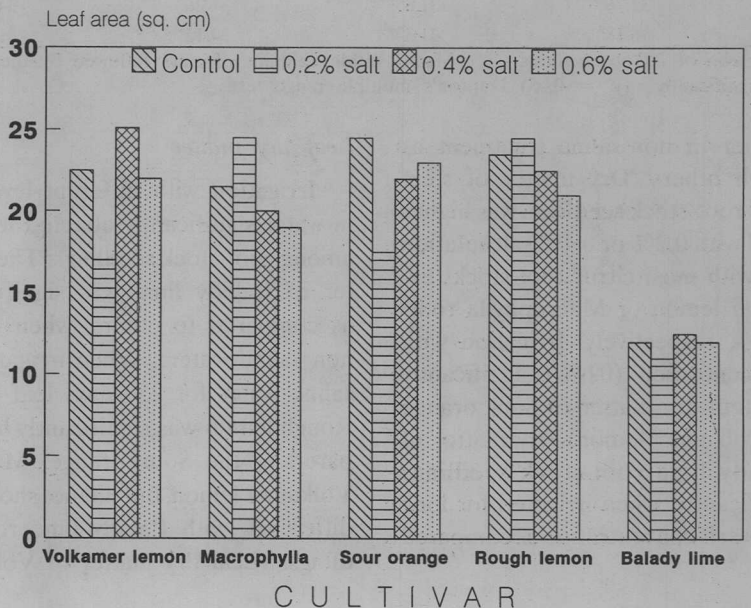

Fig. 2. Effect of salt treatments on leaf area of five citrus root-sotck seedlings.

nificant increase in leaf dry matter, when irrigated with 0.6% saline water as compared to control.

Root dry matter

Root dry matter of citrus root-stock seedlings decreased by 2.4% to 10.0% with 0.6% salinity in irrigation water, except for Rough lemon root-stock seedlings that increased by 6.4%. The diferences were, however, not significant. The data in Table 2 show that the root weight of Balady lime were significantly higher compared with other root-stock seedlings. Irrigation with different concentrations of saline water showed significant differences in root dry matter among seedlings. The root dry matter of Balady lime was significantly high as compared with Rough lemon, Sour orange and Macrophylla seedlings, when irrigated for 250 days with 0.2% salt concentration, but did not show significant difference with Volkamer lemon seedlings. Irrigation with 0.4% salt water increased significantly root dry matter of Macrophylla root-stock seedlings as compared with Rough lemon and Sour orange root-stock seedlings, but there were no differences with Balady lime and Volkamer lemon root-stock seedlings. Irrigation with 0.6% salt concentration significantly increased the root dry matter of Balady lime as compared with Rough lemon, Sour orange and Volkamer lemon.

Branch number

When irrigated for 38 days with 0.0%, 0.2% and 0.4% of saline solutions the number of branches per seedling in Balady lime was significantly more as compared to others. When irrigated with 0.6% saline water, Balady lime root-stock seedlings were significantly high in number of branches per seedling as compared to Sour orange and Volkamer lemon Macrophylla root-stock seedlings, but not with Rough lemon and Macrophylla root-stock seedlings. Irrigation of Balady lime, Sour orange and Volkamer lemon seedlings with high salt concentration (0.6%) for 38 days reduced the number of branches per seedling by 24.8%, 21.1% and 18.0%, respectively, as compared to control seedlings, but differences were not significant. Number of branches per seedling of Balady lime root-stock was significantly high as compared with others on day 114 at all salinity levels. The branch numbers reduced for Volkamer lemon, Macrophylla, and Balady lime, by 11.4%, 12.7% and 10.9%, respectively, whereas, the number of branches per seedling marginally increased for Rough lemon, and Sour orange when irrigated with 0.6% salt solution for 114 days. The branch numbers of Balady lime root-stock was significantly more, when irrigated for 212 days with 0.0%, 0.4% salt concentrations as compaed with other citrus root-stocks, whereas, at 0.2% salt concentration, number of branches per seedling of Balady lime was significantly high as compared to Rough lemon, Sour orange, and Macrophylla, but did not show a significant difference with Volkamer lemon root-stock seedlings. The branch number of Sour orange and Macrophylla root-stock seedlings was less as compared with other citrus root-stocks, when irrigated with 0.6% salt solution (Fig. 1). The results are in agreement with those of Attalla *et al.* (1985), who found that the short term treatment of Sour orange with moderately salinized irrigation water reduced dry weight and growth.

Leaf area

Leaf area of Volkamer lemon root-stock seedlings was significantly high when irrigated for 250 days with 0.4% salt compared with control and other treatments. Continuous irrigation of Macrophylla and Rough lemon root-stock seedlings with 0.2% salt for 250 days increased leaf area as compared with control, while it decreased marginally when irrigated with 0.4% and 0.6% salt. A significant reduction in leaf area of Sour orange occurred

when seedlings were irrigated with 0.2% salt, whereas, slight reduction occurred at 0.4% and 0.6% salt relative to control (Fig. 2). Similar results were reported by a number of workers (Swiedan *et al.*, 1982; Nawar and Ibrahim, 1984; Kitat *et al.*, 1989; Benlloch *et al.*, 1991; Aljuburi, (1992, 1993) who found that the salinity in irrigation water depressed growth parameters of many fruit trees.

The study indicates that among different cultivars of citrus root-stocks, Rough lemon was more resistant to high salinity in irrigation water as concerned with RGR, dry matter, number of branches and leaf area. It is concluded from this study that Rough lemon root-stock is more adapted to high saline water irrigation under Al-Ain conditions.

Acknowledgements

The author wishes to express his thanks to Mr. H. Al-Masry, Mr. R. Al-Kasab, Mr. A. Azab and Mr. Shukry, for providing the necessary facilities, help and encouragement.

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