

Effect of Interaction of Salt and Different Concentrations of Seaweed Extract on Balady Lime Seedlings

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Abstract : The results revealed that Balady lime seedlings (*Citrus aurantifolia*) could be irrigated with waters having moderate concentration of salt (0.2%) for 212 days without reduction in relative growth rate (RGR). Seaweed extract did not antagonize the salt effect on relative growth rate of Balady lime seedlings. Foliar application of 1% seaweed extract marginally increased the RGR. Other concentrations of salt, or seaweed extract alone, or in combination, reduced the RGR. Application of 0.6% salt significantly increased the root dry matter over the control, but seaweed extract with salt or alone had no significant effect on root dry matter. Application of 0.6% salt solution for 250 days resulted in a significant increase in stem dry matter over the control, but did not respond significantly to foliar application of different concentrations of seaweed extract. Leaf dry matter of Balady lime seedlings was significantly higher when irrigated with 0.2% salt for 250 days, whereas, application of different concentrations of salt or seaweed extract for 250 days had no significant effect on stem diameter.

Key words : Citrus, rootstocks, seaweed extract, growth parameters, salinity.

Salinity of irrigation water is a serious problem in the United Arab Emirates. Irrigation with saline water has been found to depress the growth of valencia orange, sour orange seedlings (El-Kholi *et al.*, 1979a and 1979b; Badawi *et al.*, 1979), pineapple sweet orange, Cleopatra mandarine trifoliolate orange and sour orange (El-Gazzar *et al.*, 1979; Attalla *et al.*, 1985; Syvertsan and Yelenosky, 1988).

Seaweed (*Ascophyllum nodosum*) extract contains a wide range of macro and micro elements and is a natural plant growth regulator (NAS, 1976; Abetz, 1980). Spray of seaweed extract affected the "Duncan" grape fruit and "Pineapple" orange seedlings (Aitken *et al.*, 1969). Foliar application of seaweed extract on Washington "Navel" orange increased the average yield (Haggag *et al.*, 1989) and its application to peach tree prolonged the shelf life of the treated fruits, but had no appreciable effect on pH, firmness, soluble solids or total titratable acidity of fruit (Skelton and Senn, 1969).

The present investigation was undertaken to study the interaction of foliar spray of seaweed extract and salinity in irrigation water on growth of Balady lime seedlings under Al-Ain conditions.

Material and Methods

The experiment was conducted in the nursery of Experimental Station of Agricultural Sciences College at Al-Oha region. One-year old Balady lime seedlings of uniform size were planted in pots. The pots were arranged in a completely randomized blocks and irrigated with 0.2 and 0.6% of NaCl+CaCl₂ in a mixture of 1:1 by weight. Each seedling was irrigated once a week with 1 L of saline water (0.2, 0.6%) and 1 L of seaweed extract (1, 6, 12 and 18%) was sprayed every month. Control seedlings were given 1 L of tap water. The experiment consisted of 15 treatments, each having 5 plants, in 4 replications.

Seedling growth parameters were recorded following Aljuburi *et al.* (1990). The data were subjected to Duncan's multiple range test and MSTAT program was used for statistical analysis.

Results and Discussion

Relative growth rate

Irrigation with saline water and spraying with seaweed extract for 38 days significantly influenced the RGR (Table 1). The RGR of seedlings receiving 0.2% salt + 18% seaweed extract was significantly higher than treatment numbers 2, 3, 8, 9, 11, 12, 13, but was at par with other treatments. Continuous saline water irrigation for 76 days had no significant effect on RGR. The RGR of Balady lime seedlings irrigated with 0.6% salt and 1% seaweed extract for 114 days was significantly higher than treatment numbers 8 and 10, but was at par with other treatments. The RGR of Balady lime seedlings treated with a mixture of salt and seaweed extract for 152 days was significantly lower than the control and treatment numbers 4, 8 and 11 (Table 1).

Irrigation with different concentrations of salts and foliar application of seaweed extract showed significant differences in RGR. The RGR of Balady lime seedlings irrigated with 0.2% salt for 212 days was significantly higher than those in treatment numbers 3, 5, 10, 12, 13, 14 and

15, but was at par with other treatments. High concentration of seaweed extract or salt in combination or alone, reduced RGR of Balady lime seedlings when irrigated for long time (212 days). Application of 6% seaweed extract or 0.2% salt + 12% seaweed extract or 0.2% salt + 18% seaweed extract significantly reduced the RGR by 72.7%, 79.85% and 74.2%, respectively, over the control. The RGR of Balady lime seedlings was observed in all the treatments except with 0.2% salt and 1% seaweed extract which caused slight increase (1.2% and 4.6%, respectively), but these effects were not significant over the control. The results revealed that Balady lime seedlings could be irrigated with waters of moderate salt concentration (0.2%) for 212 days without influencing RGR. Seaweed extract did not reverse the salt effect on Balady lime seedlings. Foliar application of 1% seaweed extract increased RGR slightly but not significantly. Other concentrations of salt or seaweed extract, either alone or in combination, reduced the RGR.

Root dry matter

Irrigation of Balady lime seedlings for 250 days with saline water and seaweed extract sig-

Table 1. Effect of interaction of different concentrations of salt and seaweed extract on per cent relative growth rate of Balady lime seedlings

No.	Treatments	Days after treatment				
		38	76	114	152	212
1	Control	31.48 ^{ab}	40.74 ^a	16.83 ^{ab}	36.37 ^a	39.80 ^{abc}
2	0.2% salt	19.14 ^{cd}	44.31 ^a	16.09 ^{ab}	15.23 ^b	44.24 ^a
3	0.6% salt	21.82 ^{bcd}	39.45 ^a	18.08 ^{ab}	24.20 ^{ab}	14.70 ^{cd}
4	1% seaweed extract	31.37 ^{ab}	43.43 ^a	18.85 ^{ab}	33.54 ^a	41.62 ^{ab}
5	6% seaweed extract	26.77 ^{abcd}	30.94 ^a	24.67 ^{ab}	26.37 ^{ab}	10.88 ^d
6	12% seaweed extract	31.97 ^{ab}	31.09 ^a	19.22 ^{ab}	21.88 ^{ab}	18.88 ^{abcd}
7	18% seaweed extract	28.79 ^{abc}	39.37 ^a	16.25 ^{ab}	26.95 ^{ab}	19.41 ^{abcd}
8	0.2% salt + 1% seaweed extract	21.67 ^{bcd}	41.56 ^a	9.53 ^b	34.20 ^a	25.54 ^{abcd}
9	0.6% salt + 1% seaweed extract	17.27 ^d	40.19 ^a	34.92 ^a	29.71 ^{ab}	23.89 ^{abcd}
10	0.2% salt + 6% seaweed extract	26.21 ^{abcd}	41.87 ^a	9.06 ^b	28.69 ^{ab}	16.03 ^{bcd}
11	0.6% salt + 6% seaweed extract	18.14 ^d	30.08 ^a	19.34 ^{ab}	34.00 ^a	22.57 ^{abcd}
12	0.2% salt + 12% seaweed extract	22.27 ^{bcd}	34.37 ^a	14.84 ^{ab}	30.21 ^{ab}	8.02 ^d
13	0.6% salt + 12% seaweed extract	20.98 ^{cd}	42.54 ^a	16.68 ^{ab}	26.81 ^{ab}	17.94 ^{bcd}
14	0.2% salt + 18% seaweed extract	34.24 ^a	44.22 ^a	15.00 ^{ab}	22.68 ^{ab}	10.25 ^d
15	0.6% salt + 18% seaweed extract	24.09 ^{abcd}	28.31 ^a	13.75 ^{ab}	23.61 ^{ab}	14.11 ^{cd}

- Values are mean of 20 observations.

- Mean within columns or rows followed by the same letter do not differ significantly.

- (P=0.05) Duncan's multiple range test.

nificantly affected the root dry matter among treatments. The root dry matter of seedlings irrigated with 0.6% salt was significantly higher than those in treatment numbers 10, 11, 12, 13 and 15, but was at par with the values observed in other treatments (Table 2). Application of

numbers 10, 11, 12, 13, and 15, but was at par with control and treatment numbers 2, 4, 5, 6, 7, 8 and 9 (Table 2). The application of 0.6% salt solution, for 250 days significantly increased stem dry matter, over the control, but salt, in combination with 6% seaweed extract, significant-

Table 2. Effect of different concentrations of salts and seaweed extract on growth of Balady lime rootstock seedlings at 250 days after treatment

No.	Treatments	Root matter %	Stem dry matter %	Leaf dry matter %	Stem diameter (cm)
1	Control	34.41 ^{abcd}	50.36 ^{bc}	33.22 ^{bc}	8.43 ^a
2	0.2% salt	35.61 ^{abcd}	52.13 ^{ab}	39.60 ^a	6.98 ^a
3	0.6% salt	38.41 ^a	54.03 ^a	34.34 ^{bc}	7.13 ^a
4	1% seaweed extract	37.78 ^{ab}	49.60 ^{bcd}	33.89 ^{bc}	8.48 ^a
5	6% seaweed extract	37.25 ^{abc}	48.94 ^{bcd}	34.51 ^{bc}	7.08 ^a
6	12% seaweed extract	35.31 ^{abcde}	49.41 ^{bcd}	33.21 ^{bc}	8.23 ^a
7	18% seaweed extract	35.85 ^{abcd}	49.42 ^{bcd}	32.71 ^{bc}	7.97 ^a
8	0.2% salt + 1% seaweed extract	33.33 ^{abcde}	48.43 ^{bcd}	32.15 ^{bc}	8.10 ^a
9	0.6% salt + 1% seaweed extract	33.05 ^{abcde}	48.84 ^{bcd}	36.31 ^{ab}	6.71 ^a
10	0.2% salt + 6% seaweed extract	32.45 ^{bcde}	48.94 ^{bcd}	31.28 ^c	7.65 ^a
11	0.6% salt + 6% seaweed extract	30.10 ^e	46.52 ^d	34.33 ^{bc}	6.94 ^a
12	0.2% salt + 12% seaweed extract	31.05 ^{de}	47.53 ^{cd}	31.69 ^c	7.25 ^a
13	0.6% salt + 12% seaweed extract	30.39 ^{de}	47.03 ^{cd}	32.02 ^{bc}	7.45 ^a
14	0.2% salt + 18% seaweed extract	33.24 ^{abcde}	47.41 ^{cd}	32.35 ^{bc}	8.07 ^a
15	0.6% salt + 18% seaweed extract	31.95 ^{cde}	47.97 ^{cd}	32.89 ^{bc}	7.22 ^a

- Values are mean of 20 observations.

- Mean within columns or rows followed by the same letter do not differ significantly.

- (P=0.05) Duncan's multiple range test.

salt and seaweed extract significantly reduced root dry matter of treatment numbers 1, 12, 13 and 15 over the control.

The results revealed that the application of 0.6% salt significantly increased the root dry matter of Balady lime seedlings over the control. Application of different concentrations of seaweed extract, in combination or alone had no significant effect on root dry matter over the control.

Stem dry matter

Irrigation of Balady lime seedlings with salt solutions or seaweed extract, in combination or alone, significantly influenced the stem dry matter, and the same was significantly higher at 250 days, when irrigated with 0.6% salt over treatment

ly reduced the stem dry matter. Application of different concentrations of seaweed did not significantly influence the stem dry matter.

Leaf dry matter

Irrigation of Balady lime seedlings for 250 days, with saline water or seaweed extract alone, or in combination, showed significant difference in leaf dry matter among treatments. The leaf dry matter of Balady lime seedlings, irrigated with 0.2% salt, was significantly higher than the control and other treatments, except that with treatment number 9.

Number of branches

Irrigation of Balady lime seedlings for 38 days, with saline water and foliar application of seaweed extract, showed significant difference in number of branches per seedling, among the treatments.

The number of branches per seedling of Balady lime was significantly higher, when irrigated with 1% seaweed extract or 0.6% salt + 1% seaweed extract, as compared to 0.2% salt + 18% seaweed extract, but was at par with the control and other treatments (Table 3).

Continuous irrigation with 0.2% salt + 18% seaweed extract, for 76 days significantly reduced the number of branches per seedling, over treatment number 10 only. Irrigation with 0.2% saline + 18% seaweed extract, for 114 days, reduced significantly the number of branches/seedling of Balady lime, over the control and treatment num-

seedling. Application of 0.2% salt + 18% seaweed extract, for 250 days, caused a significant reduction in number of branches/seedling as compared to treatment with 0.6% salt.

These results revealed that the application of 1% seaweed extract, for 38 and 114 days, increased the number of branches per plant, whereas, the number of branches after 152 days were highest when irrigated with 0.2% salt + 1% seaweed extract. Application of 0.2% salt + 18% seaweed extract, for 38, 76, 114, 152 and 250 days, caused a significant lowering in number of branches/plant of Balady lime.

Table 3. Effect of interaction of different concentrations of salts and seaweed extract in irrigation water on number of branches/seedling of Balady lime rootstocks

No.	Treatments	Days after treatment					
		38	76	114	152	212	250
1	Control	9.71 ^{ab}	12.95 ^{ab}	16.67 ^{ab}	18.20 ^{abcd}	19.60 ^a	19.60 ^{ab}
2	0.2% salt	9.94 ^{ab}	13.43 ^{ab}	14.15 ^{abc}	15.48 ^{bcd}	18.94 ^a	19.16 ^{ab}
3	0.6% salt	10.31 ^{ab}	13.95 ^{ab}	16.38 ^{abc}	18.23 ^{abcd}	23.33 ^a	22.63 ^a
4	1% seaweed extract	10.80 ^a	13.90 ^{ab}	17.85 ^a	18.80 ^{ab}	21.15 ^a	21.15 ^{ab}
5	6% seaweed extract	10.30 ^{ab}	12.40 ^{ab}	14.60 ^{abc}	15.45 ^{bcd}	19.05 ^a	19.05 ^{ab}
6	12% seaweed extract	8.14 ^{ab}	11.40 ^{ab}	14.15 ^{abc}	16.25 ^{abcd}	21.00 ^a	21.00 ^{ab}
7	18% seaweed extract	8.20 ^{ab}	10.05 ^{ab}	13.40 ^{bc}	15.50 ^{bcd}	18.50 ^a	18.50 ^{ab}
8	0.2% salt + 1% seaweed extract	9.65 ^{ab}	14.40 ^{ab}	17.75 ^a	19.35 ^a	21.10 ^a	21.10 ^{ab}
9	0.6% salt + 1% seaweed extract	10.71 ^a	13.45 ^{ab}	16.38 ^{abc}	17.56 ^{abcd}	19.55 ^a	19.55 ^{ab}
10	0.2% salt + 6% seaweed extract	10.15 ^{ab}	14.80 ^a	16.95 ^{ab}	18.50 ^{abc}	21.00 ^a	21.00 ^{ab}
11	0.6% salt + 6% seaweed extract	8.66 ^{ab}	11.63 ^{ab}	13.77 ^{abc}	14.96 ^{cd}	18.83 ^a	18.83 ^{ab}
12	0.2% salt + 12% seaweed extract	7.70 ^{ab}	10.70 ^{ab}	14.65 ^{abc}	16.45 ^{abcd}	18.35 ^a	18.35 ^{ab}
13	0.6% salt + 12% seaweed extract	8.38 ^{ab}	11.63 ^{ab}	15.34 ^{abc}	17.06 ^{abcd}	20.10 ^a	21.19 ^{ab}
14	0.2% salt + 18% seaweed extract	6.65 ^b	9.25 ^b	12.45 ^c	14.60 ^d	17.60 ^a	17.60 ^b
15	0.6% salt + 18% seaweed extract	7.75 ^{ab}	11.60 ^{ab}	15.05 ^{abc}	16.15 ^{abcd}	18.50 ^a	18.20 ^{ab}

- Values are mean of 20 observations.

- Mean within columns or rows followed by the same letter do not differ significantly.

- (P=0.05) Duncan's multiple range test.

bers 4, 7 and 10 only. Application of 1% seaweed extract or 0.2% salt and 1% seaweed extract significantly increased the number of branches per seedling of Balady lime, compared with treatment numbers 7 and 14 only (Table 3). Irrigation of Balady lime seedling for 152 days, with 0.2% salt + 1% seaweed extract, had significantly higher number of branches per seedling than treatment numbers 2, 5, 7, 11 and 14. Continuous irrigation with saline water and different concentrations of seaweed extract, for 212 days, had no significant effect on number of branches per

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