SALT TOLERANCE OF 10 DECIDUOUS SHRUB AND TREE SPECIES Richard W. Tinus

ABSTRACT: Ten species of deciduous shrubs and trees were grown in a greenhouse and irrigated with nutrient solution plus sodium sulfate, chloride, and bicarbonate to yield salt concentrations with conductivity of 1.6, 4.5, 7.2, 12.1, and 16.6 mmhos/cm. Honeysuckle, crabapple, lilac, and American plum were salt sensitive. Buffaloberry, Russian olive, and chokecherry were moderately sensitive. Green ash, juneberry, and caragana were tolerant.

INTRODUCTION

Tree nurseries in western North America frequently have salt-affected soils and salty irrigation water (Tinus 1980). Salt creates an osmotic moisture stress that reduces germination and growth, and may kill seedlings. Without careful soil and water management, the problem gradually becomes worse until the nursery is no longer able to grow certain species that it formerly grew well. In the West, because shelterbelts are commonly planted on salty soils, careful choice of species is critical.

Very little quantitative information is available on salt tolerance of shrubs and trees grown for shelterbelts (Carter 1980; 1979). Most of what is available is on crop plants (Richards 1954; Branson 1978; Maas and Hoffman 1977; Rathert and Doering 1981) and horticultural varieties of shrubs and fruit trees (Bernstein and others 1972; Dirr 1974; Francois and Clark 1978; Maas and Hoffman 1977; Townsend 1980; Pasternak and Forti 1980). The objective of this study was to provide guidelines on salt tolerance of a variety of species commonly used for shelterbelts in the northern and central Great Plains.

METHODS AND IIAIERIALS Experiment

1.--Seed Germination

Green ash seed was soaked 4 days in cold running water, caragana was used dry, and all other species were cold stratified in sand as recommended by Schopmeyer (1974).

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Seed was germinated in petri dishes containing filter paper, 100 seed per dish, five dishes per species. Each of the five dishes per species was moistened with one of the nutrient solutions plus sodium chloride, sulfate, and bicarbonate listed in table 1.

The dishes were covered, enclosed in plastic bags to retard evaporation, and placed in a germinator with a 12-hour day (fluorescent light) at 30^{0} C and a 12-hour night at 20^{0} C. Humidity ranged from 60 to 100 percent.

Germinants were counted and removed every few days, and moisture was replenished as needed with distilled water. The experiment was terminated after 45 days. Total germination and germination energy (average percent per day to 50 percent of maximum germination) were calculated. Significant differences between salt levels within species were determined by Goodman's (1964) test.

Experiment 2.--Seedling Growth

Fifty Colorado State styroblocks, each with 30 cavities with a volume of 400 ml per cavity, were filled with 1:1 peat-vermiculite plus 5 percent forest duff to inoculate with endomycorrhizal fungi. Three seeds were planted in each cavity, five blocks for each of the 10 species. The blocks were arranged on greenhouse benches in randomized groups of 10, one block of each species. Each group was watered as needed with a nutrient solution plus sodium sulfate, chloride, and bicarbonate calculated to have an electrical conductivity (EC) of 1.6, 4.5, 7.2, 12.1, and 16.6 mmhos/cm (table 1). The soil salinity of the Lincoln-Oakes Nurseries at Bismark, N.D. (table 1) corresponds approximately to solution #2. The relative proportions of sodium sulfate, chloride, and bicarbonate were selected to be the same as in the irrigation water of Lincoln-Oakes, which has EC of 1,500 mmhos (about 1,000 ppm solids) and is rated "suitable for limited irrigation." Water supplies of other nurseries vary in composition considerably, but these ions are usually the ones causing the greatest problems.

After germination, the seedlings were thinned to one per cavity, leaving the largest. The remaining seedlings were allowed to grow 14 weeks. After this time, some of them were as large as they could be in the container without appreciable growth restriction, and differences between seedlings watered with different salt concentrations were clearly evident. The blocks of seedlings

Table 1.--Composition of nutrient and salt solutions in parts per million

Component	Solution number 1	2	3	4	5
EC (mmhos/cm)	1.6	4.5	7.2	12.1	16.6
N as NO_3^-	229	224	220	211	202
N as NH_4^+	67	66	64	62	59
P as $H_2PO_4^-$	27	27	26	25	24
K^+	155	152	149	143	136
S as $SO_4^=$	142	139	136	131	125
Ca^{++}	212	208	204	195	187
Mg^{++}	48	47	46	44	42
Fe^{+++}	4	4	4	4	4
B as H_3BO_3	0.5	0.5	0.5	0.5	0.5
Mn^{++}	0.5	0.5	0.5	0.5	0.5
ZN^{++}	0.05	0.05	0.05	0.05	0.05
CU^{++}	0.02	0.02	0.02	0.02	0.02
Mo as $MoO_4^=$	0.01	0.01	0.01	0.01	0.01
Na^+	0	786	1,572	3,144	4,716
Cl^-	4	105	210	420	630
$SO_4^=$	0	922	1,844	3,688	5,532
HCO_3^-	0	732	1,464	2,928	4,392
TOTAL	889	3,416	5,943	10,998	16,052

were photographed and survivors were counted. Stem height and the length of two fully mature leaves were measured on each seedling.

For each species and measurement, a regression equation was calculated with height, leaf length, or survival as a function of salt concentration (measured by EC). Eight equation forms were tried using the Hewlett-Packard 9825A family regression program (General Statistics Vol. I, [2] tape 0982515004). The one with the highest r was used to calculate the salt concentration at which growth or survival was reduced by 25 percent compared to growth or survival with nutrient solution only.

RESULTS AND DISCUSSION Experiment

1.--Seed Germination

Russian olive and caragana germinated well at all salt concentrations, and neither total germination nor germination energy declined noticeably at high salt concentrations (table 2). Germination energy of buffaloberry declined steadily with increasing salt concentration, but total germination remained high through 12.1 mmhos/cm. Total germination of green ash and honeysuckle declined somewhat, and germination energy was greatly reduced by high salt concentration. Total germination and

Table 2.--Total germination and germination energy of seven species in nutrient solution with increasing concentrations of sodium chloride, sulfate, and bicarbonate. Within species values followed by the same letter are not different at the 5 percent level by Goodman's test.

Species	Total germination					Germination energy				
	Solution conductivity (mmhos/cm)					Solution conductivity (mmhos/cm)				
	1.6	4.5	7.2	12.1	16.6	1.6	4.5	7.2	12.1	16.6
	percent					percent/day				
Lilac (*Syringa vulgaris* L.)	73 a	54 b	40 c	19 d	1 e	1.63	1.13	0.82	0.33	0.02
Crabapple (*Malus baccata* (L.) Borkh.)	40 a	24 b	12 c	4 d	3 d	1.23	0.56	0.32	0.09	0.06
Honeysuckle (*Lonicera tatarica* L.)	33 a	30 ab	22 b	6 c	5 c	0.79	0.94	0.76	0.24	0.22
Green ash (*Fraxinus pennsylvanica* Marsh.)	88 a	71 c	80 b	61 d	58 d	4.2	2.7	2.9	2.0	1.4
Caragana (*Caragana arborescens* Lam.)	87 b	96 a	85 bc	75 c	89 ab	5.4	4.8	7.1	3.5	3.5
Russian olive (*Eleagnus angustifolia* L.)	84 c	94 b	100 a	62 d	82 c	10.4	7.4	8.1	4.7	6.5
Buffaloberry (*Shepherdia argentea* (Pursh) Nutt.)	90 a	91 a	78 b	86 a	66 c	11.3	9.7	8.4	6.5	2.6

Table 3.--Salt concentration (measured by conductivity) causing a 25 percent reduction in growth or survival, compared to nutrient solution with EC of 1.6 mmhos/cm

Species	Height	Leaf length	Percent survival	Regression quality (r^2) Height	Leaf length	Percent survival
	- - - - mmhos/cm - - - -					
Honeysuckle (Lonicera tatarica L.)	2.2	3.3	3.3	.55	.32	.71
Crabapple (Malus baccata (L.) Borkh.)	2.6	6.0	--[1]	.54	.67	NS
Lilac (Syringa vulgaris L.)	3.6	4.1	15.7	.70	.71	.92
American plum (Prunus americana Marsh.)	6.3	7.1	5.0	.35	.78	.69
Buffaloberry (Shepherdia argentea (Pursh) Nutt.)	7.6	8.2	>16.6	.33	.29	.33
Russian olive (Eleagnus angustifolia L.)	8.3	>16.6	>16.6	.30	.18	NS
Chokecherry (Prunus virginiana L.)	8.7	9.6	>16.6	.30	.60	NS
Green ash (Fraxinus pennsylvanica Marsh.)	11.7	8.6	>16.6	.42	.30	NS
Juneberry (Amelanchier alnifolia (Nutt) Nutt.)	11.8	14.5	>16.6	.51	.36	NS
Caragana (Caragana arborescens Lam.)	>16.6	5.1	>16.6	.07	.23	NS

[1]Regression equation not meaningful.

germination energy of crabapple and lilac declined precipitously with the first increment of salt, and germination was almost nil at 16.6 mmhos/cm.

Experiment 2.--Seedling Growth

Table 3 lists the 10 species tested in order of increasing salt tolerance as measured by height growth. As expected, leaf length was reduced by about the same degree as stem height (Sepaskhah and Boersma 1979), except that leaf length response of Russian olive was more nearly in keeping with field observation than height response. Russian olive has a reputation for being highly salt tolerant. Bernstein and others (1972) report that the salt tolerance of a related species, silverberry (Eleagnus pungens), is also high; the threshhold for reduction of growth in silverberry is 9.4 mmhos/cm. Caragana also showed high salt tolerance when measured by height reduction, but not when measured by leaf length. It is possible that reduced leaf length is part of the species' adaptive reaction to moisture stress. This agrees with field observations because caragana flowers and grows vigorously in early summer, when moisture is normally adequate, but yellows and begins dropping its leaves in August, when moisture stress is frequently high.

As with germination, height growth and leaf length of honeysuckle, crabapple, and lilac decreased rapidly with increasing salt. Maas and Hoffman (1977) also report that apple (Malus sylvestris L. Mill) is salt sensitive. American plum was sensitive, as expected, in comparison with Prunus domestica (Richards 1954; Maas and Hoffman 1977), but chokecherry (Prunus virginiana L.) was surprisingly tolerant, especially with respect to survival.

Once established, most species survived well at much higher salt concentrations than were required to suppress growth. Exceptions were honeysuckle and American plum. Survival information is thus useful to tree planters for site selection, but

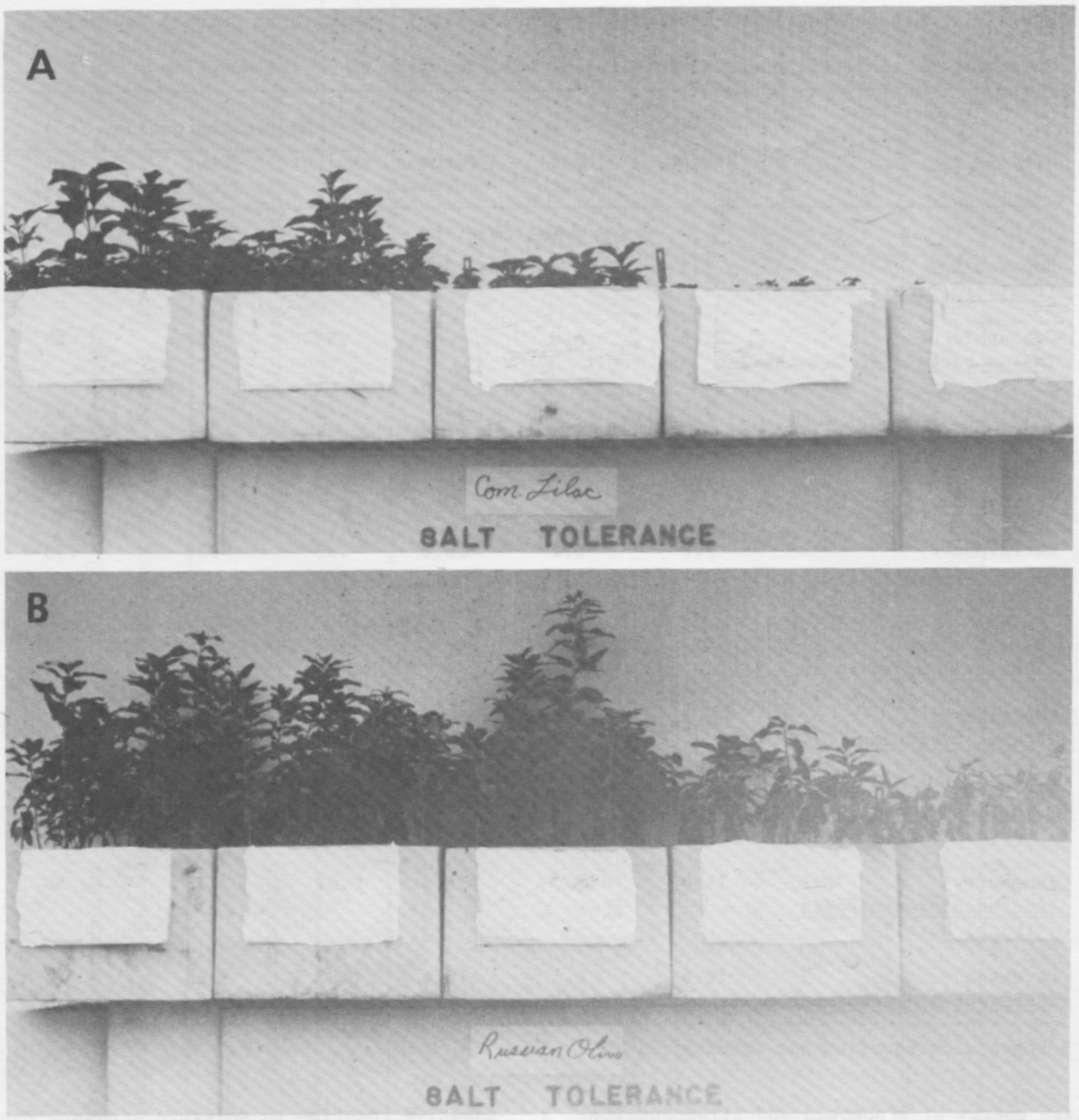

Figure 1.--Decreasing growth with increasing salt concentration (measured by EC) of (A) lilac, a salt sensitive species and (B) Russian olive, a salt tolerant species.

not to nurserymen, whose product must reach a certain size within one or two growing seasons.

Because of the need to keep this experiment small and simple, only one germinating dish of 100 seed and only one block of 30 seedlings per species per treatment was used. For statistical purposes, the individual seed or seedling was treated as the unit of replication. Strictly speaking, however, there was no replication. Furthermore, variability was great, and the regression equations used yielded confidence limits so great that only the broadest comparisons between species can be made. Thus, although the results were quite obvious even without measurement (fig. 1), they should be considered indicative and not definitive.

CONCLUSIONS AND RECOMMENDATIONS

1. Crabapple, lilac, American plum, and honeysuckle are sensitive to salt. They should not be grown at a nursery with salty irrigation water or soil nor outplanted into salty soils.

2. Buffaloberry, Russian olive, chokecherry, green ash, juneberry, and caragana are salt tolerant. Their growth should not be limited at most western nurseries because of salt problems, and they should be able to tolerate the saltiness of most western soils where shelterbelts are planted.

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