HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

The use of any trade name in this article does not imply an endorsement of the equipment, product or process named, nor any criticism of any similar products that are not mentioned.

Growth and Visual Responses of Three Southwestern Acer Taxa to High-Salt Irrigation Water[1]

Marvin D. Hatter and David L. Morgan[2]
Department of Agronomy
Horticulture and Entomology
Texas Tech University
Lubbock, TX 79409-2122

Abstract

The effects of irrigation water high in soluble salts on the establishment of three species of maple trees in a Southwestern landscape were determined. Thirty Drummond red maple, Caddo sugar maple and bigtooth maple trees were irrigated during a 15-month period with either municipal water (pH 7.9, EC = 952-1197 mg/l) or rainwater (pH 6.0, EC = 8.4 mg/l) after planting in containers of sandy clay loam soil. Trees of all species irrigated with rainwater had greater height and caliper increases, and better visual appearances than did those watered with municipal water. The Caddo and bigtooth maples were visually superior to the Drummond red maples. Frequency of irrigation had no effect on any measured plant responses, and no differences in leaf areas due to irrigation source or frequency were found.

Index words: native plants, landscaping, maple

Species used in this study: Drummond red maple (*Acer rubrum* var. *Drummondii* (Hook. and Arn. ex Nutt.) Sarg.); Caddo sugar maple (*A. saccharum*, Marsh. subsp. *saccharum*); and bigtooth maple (*A. grandidentatum* Nutt.).

Significance to the Nursery Industry

The popularity of maple trees in the landscape has created a long-standing demand for these trees throughout the country. Maple trees native to a region would be expected to adapt to urban cultivation in that location more easily than introduced species, particularly where soils and climates are similar. Survival rates under irrigation schedules with water high in soluble salts is not assured. In our study, Southwestern native Caddo (sugar) and bigtooth maples were more tolerant of salty irrigation water than were Drummond red maples. The former two species may be suitable for planting in landscapes where water is saline. Because some healthy trees were found in all treatments, we suggest that growers seek to identify and propagate salt-tolerant individual trees from among maple species.

Introduction

Maples (*Acer* spp.) are widely used as shade trees in the Eastern U.S., but are not common in landscapes of the Texas High Plains and Southwestern U.S. Low annual rainfall and alkaline soils (3) restrict the successful establishment of many Eastern tree species, including maples (6). Maples are reported to be sensitive to sodium (Na) and chloride (Cl) ions (1, 4, 7, 13, 14, 16, 17, 18) which are found in high concentrations in many municipal water sources in the Southwestern U.S. (10). The most widely planted maple in the region is the silver maple, *Acer saccharinum* L., but it ordinarily is disfigured by foliar burn and necrosis that are classical symptoms of salt toxicity. Although native maples of the Southwestern U.S. may also be affected by water quality (9, 10, 20), little research has documented their sensitivities to high salt environments (6). Similarities between soils and climates of the Texas High Plains and those where many of the native maples grow suggest broad ranges of potential adaptation (2, 6, 8, 12, 19).

In this study, we examined the effects of irrigation with a municipal water source containing high concentrations of soluble salts on height and caliper increase, average leaf area, and visual appearance of three maple species native to the Southwestern U.S.

Materials and Methods

The study was conducted in a fenced-in plot behind the horticulture greenhouses at Texas Tech University in Lubbock, Texas. The species included were: Drummond red maple, grown from seed collected at Alexander State Forest, Rapides Parish, LA; Caddo sugar maple, from the canyons of Caddo and Canadian counties of West Central Oklahoma; and bigtooth maple, native to dry canyons on the Ft. Hood military reservation, Coryell County, Texas. In their native ranges, Caddo (sugar) maples grow in calcareous soils and are reported to be cold and drought tolerant (20). In their native habitats, bigtooth maples have outstanding red and gold fall colors (2). The Drummond red maple, commonly grown in the Southeastern U.S. (21), has deep red fall coloration.

Sixty, 2-year-old container-grown seedlings of each of the three species were grown in buried containers from July 1988 through October 1989. Initial height of seedlings ranged from 30–38 cm (12–15 in). The bottomless containers were constructed of 25 cm (10 in) diameter polyvinylchloride pipe cut to 101 cm (40 in) lengths and filled with sandy clay loam soil. Elemental analysis of the soil in ppm was as follows: P, 32; K, 455; Mg, 380; Ca, 1890; Na, 87; Mn, 11; Fe, 14; Cu, 0.9; and Cl, 80. The inside of each container was lined top to bottom with a 0.005-mil poleythylene bag to prevent root contact with the container wall. Container bottom ends were left open for drainage.

Thirty trees of each species were irrigated with Lubbock,

[1]Received for publication October 9, 1991; in revised form March 30, 1992. Texas Tech College of Agricultural Sciences Journal Article No. T-4-329. We gratefully appreciate the statistical assistance of David Wester.

[2]Former graduate student and Associate Professor, resp. Senior author's current address: Lone Star Growers, Inc., Rt. 9, Box 220, San Antonio, TX 78227.

TX, municipal water (pH 7.9, electrical conductivity (EC) of 1.36–1.71 dSm (952–1197 mg/l)) (Table 1), and 30 with rainwater (EC 0.012 dSm (8.4 mg/l), pH 6.0) collected as runoff from a greenhouse roof. Chloride and Na were not detected in the rainwater.

Two irrigation frequencies were evaluated. Within each water source treatment, half the trees (15) received 2 liters (0.5 gal) of water in a single application. Fifteen trees received 2 l (0.5 gal) of water in equal but split applications with the second liter applied when the soil surface was dry. Intervals between irrigations varied according to rainfall but were generally 7 days during the summer months and 14 days during the dormant season. A total of 34.1 cm (13.4 in) of precipitation was recorded during the 15 month period.

The experimental design was a completely randomized split plot with species as the main plot treatment. The subplot was a factorial combination of water source and irrigation frequency. The treatments were replicated 15 times, and individual trees were treatment units.

In September 1989, the trees were visually rated using a 1–5 qualitative scale similar to those used by Dirr (5) and Reider (11) in which mortality and foliar damage were rated with 5 = deep green color with no evidence of physiological stress, and 1 = dead plants. In October 1989, average leaf area per tree was determined in five randomly selected replicates of each treatment. Height and caliper measurements were recorded for all trees at the beginning and termination of the study. Caliper was measured 5 cm (2 in) above the soil line. All data were subjected to analysis of variance using the SAS general linear model (GLM) procedures (15). The three species were compared visually, but because of inherent differences among maple species, growth parameters among species were not compared.

Results and Discussion

Water source affected height and caliper increases of maple seedling. Trees irrigated with rainwater had significantly ($P<0.05$) greater height and caliper increase (by 41% and 22%, respectively), than those irrigated with city water (Table 2). No significant differences in leaf area among treatments were found (Table 2).

Appearance ratings also were significantly higher ($P<0.01$) in trees irrigated with rainwater. A comparison among the three species (Table 3) revealed a significantly higher rating regardless of treatment among the Caddo and bigtooth maples than in the red maples. Frequency of irrigation had no effect on any of the parameters measured, probably because insufficient water was applied to provide leaching of salts through the root zone.

Table 1. Chemical analysis of city of Lubbock water supply from May, 1988 through September, 1989.[z]

Parameter	Low	High	Average
Conductivity	952	1197	1057
Ca	46	59	53
Mg	25	34	29
Na	244	334	293
K	7	15	9
Cl	349	412	372

[z]Monthly water analyses by the City of Lubbock Water Treatment Laboratory units in mg/l.

Table 2. Effects of water source and irrigation frequency on height increase, caliper increase, and average area per leaf across all 3 maple species.

Type of Water	Mean cumulative increase[z] Height (cm)	Caliper (mm)	Ave. area per leaf (cm^2)
City	36.5[y]	6.1	12.8[x]
Rain	47.7	7.6	12.6
Significance			
Frequency (F)	NS[w]	NS	NS
Water Source (W)	**	**	NS
F × W	NS	NS	NS

[z]Mean cumulative increase in height or caliper = height or caliper measurement at harvest minus measurement at planting.

[y]Each number representing height and caliper is a mean of 90 replicates.

[x]Each number representing leaf area is a mean of 30 replicates leaves per tree/area per tree

[w]Nonsignificant (NS) or significant at 5% (**).

Visually, the red maple may be the least acceptable among the three species on the High Plains. The bigtooth maple had a slightly healthier appearance than did the Caddo maple in all treatments, and because the bigtooth maple is native to somewhat drier canyons than the Caddo maple it might adapt better to a semi-arid landscape. All three species were adversely affected by irrigation with the municipal water. However, several individual trees within each species appeared unaffected by the salty water. Selection of individuals for salt tolerance among tree species has been suggested (4) and might be appropriate for maple trees.

Irrigation with water high in soluble salts may affect plants in ways not easily recognized by the grower. In the absence of foliar damage or diminished leaf size, the subtle effects of salt toxicity may go unnoticed, as trees stunted in height and caliper may otherwise appear healthy. Results from this study suggest that many growth characteristics should be

Table 3. Effects of water source and irrigation frequency (1 = one application, 2 = split application) on the visual appearance (1 = dead,. . .5 = healthy) of 3 maple species.

Species	Water Source	Visual Rating
Caddo	City Water	3.6[z]
	Rainwater	3.9
	Mean	3.8
Bigtooth	City Water	3.6
	Rainwater	4.4
	Mean	4.0
Red	City Water	3.1
	Rainwater	3.4
	Mean	3.2
	LSD = 0.357	
Significance		
Species (S)		*[y]
Frequency (F)		NS
Water Source (W)		*
S × W		NS
S × F		NS
W × F		NS
S × W × F		NS

[z]Each number in the column is a mean of 30 replicates.

[y]Nonsignificant (NS) or significant at 1% (*).

considered to determine the effects of irrigation with water high in soluble salts. In our study, appearance was the singular measure in which differences were manifested among the species, and on that basis it would appear that High Plains landscapes would be more greatly enhanced by the planting of bigtooth and Caddo maples than of the red maples and the commonly grown silver maples. These conclusions are supported by our observations of several bigtooth and Caddo trees of various sizes that have apparently adapted well to our plantings in home landscapes in Lubbock since 1988. No freeze damage has been observed among any of the species tested in our experiment or in landscapes.

Literature Cited

1. Baker, J. H. 1965. Relationship between salt concentration in leaves and sap and the decline of sugar maples along roadsides. Mass. Agr. Expt. Sta. Bul. 553.

2. Barker, P. A. 1974. The spectacular canyon maple. Utah Sci. 35(1):7–10.

3. Blackstock, D. A. 1979. Soil Survey of Lubbock County, Texas, USDA Soil Cons. Serv. and Tex. Agr. Expt. Sta.

4. Dirr, M. A. 1976. Selection of trees for tolerance to salt injury. J. Arboriculture 2:209–216.

5. Dirr, M. A. 1978. Tolerance of seven woody ornamentals to soil-applied sodium chloride. J. Arboriculture 4:162–165.

6. Hatter, M. D. and D. L. Morgan. 1989. New, tougher plants needed for High Plains landscapes. The Texas Nurseryman 20(7):13.

7. Holmes, F. W. and J. H. Baker. 1966. Salt injury to trees. II. Sodium and chloride in roadside sugar maples in Massachusetts. Phytopathology 56:633–636.

8. Little, E. L., Jr. 1939. The vegetation of the Caddo County canyons, Oklahoma. Ecology 20:1–10.

9. Morgan, D. L. 1991. Trees for the South Texas Plains. The Texas Nurseryman 22(6):13–14, 16, 18.

10. Morgan, D. L. and M. D. Hatter, 1989. Hard water: why plant introductions are limited in West Texas. The Texas Nurseryman 20(5):15, 84.

11. Reider, L. M. 1987. Evaluation of two watering regimes on three species of containerized native Texas woody ornamental plants. M. S. Thesis, Texas Tech Univ., Lubbock.

12. Rice, E. L. 1960. The microclimate of a relict-stand of sugar maples in Devils Canyon in Canadian County, Oklahoma. Ecology 41:445–453.

13. Rich, A. E. 1972. Effects of salt on eastern highway trees. Amer. Nurseryman 135:36–39.

14. Rubens, J. M. 1978. Soil desalination to counteract maple decline. J. Arboriculture 4:33–42.

15. SAS Institute. 1989. SAS user's guide: statistics, version 6.06.01. SAS Institute, Cary, N.C.

16. Shortle, W. C. and A. E. Rich. 1970. Relative sodium chloride tolerance of common roadside trees in southeastern New Hampshire. Plant Dis. Rept. 54:360–362.

17. Smith, E. M. and S. Treaster. 1982. Sodium chloride phytotoxicity to sugar maple. Ohio Agr. Res. Dev. Ctr. 268:7–8.

18. Sucoff, E. 1975. Effects of de-icing salts on woody vegetation along Minnesota roads. Minn. Agr. Expt. Sta. Tech. Bul. 303.

19. Tankersley, B. E., III. 1981. Growth and propagation of *Acer grandidentatum* Nutt. M.S. Thesis. Texas A&M Univ., College Station.

20. Wasowski, S. and A. Wasowski. 1988. Native Texas plants: Landscaping Region by Region. Tex. Month. Press, Austin. 406p.

21. Whitcomb, C. E. 1985. Know It and Grow It, II. Lacebark Publications, Stillwater, OK. 740p.