ROOT HARDINESS OF GREEN ASH SEEDLINGS FROM DIFFERENT PROVENANCES

by Frank S. Santamour, Jr.

Abstract: Container-grown seedlings of green ash from different provenances were subjected to temperatures of −9°C and −15°C for 1 week. Roots of seedlings from areas where the average January temperature was above freezing were completely killed by both treatments and no shoot growth was produced. Root tips and young roots of seedlings from areas with average January temperatures between 0.1°C and 24.2°C were killed by the −9°C treatment but new roots developed and stem growth, although retarded, was resumed. The −15°C treatment killed all roots of all seedlings, but a few plants from the coldest origin initiated new roots from the root collar zone and the plants resumed shoot growth from lateral buds. It is recommended that landscape trees planted in above-ground containers in northern areas be selected from the coldest origins or, when cultivars of unknown geographic origin are so used, that they be budded or grafted on potentially cold-hardy rootstocks.

Nurserymen have become increasingly aware of the importance of cold hardiness of woody plants in recent years. Container growing of many landscape shrubs and trees in northern climates has forced the nurserymen to seek improved and inexpensive methods for overwintering containerized plants. Gouin (1976) has discussed the root hardiness aspects of containerized nursery production.

Arborists and horticulturists have seldom been concerned with root hardiness. The root systems of the plants they grow and maintain are usually insulated from temperature extremes by the soil, sod, mulch, and other natural or artificial coverings around the plants. However, the current popularity of growing shrubs and trees in large above-ground containers in urban areas has focused more attention on root hardiness. Flemer (1976) has presented an excellent perspective on the problems and possibilities of such container growing.

The two major problems associated with tree roots in containers are (1) excessive root growth of vigorous trees leading to "pot-bound" plants, and (2) the killing of young roots by low temperatures leading to death or loss of vigor of the plant. It has long been known that roots of woody plants were less cold-hardy than stems, but container growing has accentuated root problems. For instance, Wiest *et al.* (1976) showed that with fluctuating outdoor air temperatures down to −30°C in Ithaca, N.Y., the temperature 8 cm below an undisturbed soil surface reached a minimum of −6°C. The temperature in the center of the soil-medium in a 8.8-liter plastic container exposed to the same conditions reached a low of −15°C.

Research on a wide range of shrub and tree species and cultivars (Havis, 1976, Studer *et al.*, 1978) has established that killing temperatures for young roots ranged from −3°C to −11°C, while the range for mature (about 1-year-old) roots was from −8°C to slightly greater than −23°C. Studer *et al.* (1978) categorized mature roots that survived temperatures above −8°C to −10°C as "slightly hardy" and those killed by temperatures from −11°C to −15°C as "hardy." Havis (1976) exposed the entire plants (in containers) to the test temperature for 4 hours while Studer *et al.* (1978) utilized a 2-hour exposure of detached roots.

It has been assumed that root hardiness would follow the same pattern as stem hardiness, with plants originating in colder climates being more hardy. However, to my knowledge, there have been no published reports of variation in root hardiness among geographic origins within a woody-plant species. The present exploratory study on green ash provenances was undertaken to establish some parameters for testing and utilizing root hardiness.

Materials and Methods

The green ash seedlings were grown from seedlots assembled by Dr. Kim C. Steiner of Pennsylvania State University for an extensive series of provenance tests of this species. Dr. Steiner kindly donated seed of a number of seedlots to the National Arboretum in 1978 for use in our various research programs. Each seedlot consisted of seed collected from a single mother-tree at various locations throughout the range of green ash. The seed was stratified for 90 days prior to sowing in the greenhouse and the seedlings were repotted at appropriate stages up to 1-gallon (4.6 liter) plastic containers.

The seedlings, in their plastic containers, were grown outdoors on black plastic sheeting from July, 1978 through October, 1978. In October, the seedlings were mulched with wood chips that completely covered the containers.

On February 15, 1979, seedlings of selected seedlots were removed from the mulch and placed in a greenhouse where the temperature was maintained at about 36°F (2.2°C). During the six days immediately prior to moving the plants, the outdoor temperatures did not rise above freezing and the daily lows ranged between 2°F (−16.7°C) and 9°F (−12.8°C). The lowest temperature recorded in the root zone under the mulch was 28°F (−2.2°C). The root systems of seedlings from various families were examined after three days in the greenhouse, and no root damage was noted.

After one week in the greenhouse, two plants of each of 9 seedlots (Table 1), selected to represent a wide range of average January temperatures in their native locality, were placed in cold chambers at 15.8°F (−9.0°C) and 5.0°F (−15.0°C) for 7 days. Following the cold treatment, the treated plants were returned to the cool greenhouse and observations on plant performance were made on these and "control" plants at 3-day intervals.

The small size of the cold chambers greatly restricted the numbers of plants that could be tested in this preliminary study. Therefore, we could not afford to sacrifice plants to obtain data on root kill and root development at various time intervals following treatment. Rather, since recovery from freezing injury was judged to be of prime importance in this test, we decided to wait until shoot growth was initiated in the treated plants before "un-potting" the plants to examine the root systems.

Results and Discussion

All of the "control" seedlings, whose roots had been subjected to at least 28°F (−2.2°C), showed no root damage and resumed normal shoot growth from the terminal bud. Vegetative bud break on all "control" seedlings, regardless of provenance, had occurred by March 15, 1979, one month after being brought into the cool greenhouse.

Data on survival of seedlings 60 days after cold treatment are given in Table 1. Seedlings of KS-228 from Minnesota were the first of those treated at −9°C to break terminal buds, 3 weeks after treatment. All the other seedlings from the colder origins, except KS-207 from New York, started shoot growth within 1 month after treatment. KS-207 seedlings began top growth 38 days after treatment.

Root tips and younger portions of the 1-year-old root systems of surviving seedlings were killed by the −9°C treatment, but the extent of such damage never amounted to more than 15% of the total dry weight of the root system. New roots regenerated from older portions and the subsequent shoot growth, although retarded, was reasonably vigorous.

Only 2 seedlings, of Manitoba origin, demonstrated any shoot growth following the −15°C treatment. One began to grow 36 days after treatment and the other at 50 days. In both seedlings, the entire root system had been killed, but new roots had regenerated from the root-collar zone. The shoot growth of these plants developed from lateral buds (Fig. 1).

The conditions of this experiment were extreme and perhaps not directly comparable to conditions influencing larger plants in larger containers. The 1-year-old plants had not developed any really large roots, which, in older plants, might be more cold-hardy. Also, the 7-day exposure to a constant low temperature was not realistic for much of temperate North America.

However, the data do show that there are significant differences in root hardiness among plants of the same species from different geographic origins. If seedling trees are to be grown outdoors in above-ground containers, they should be grown from seed of the most northern seed sources obtainable. Budded or grafted cultivars, regardless of the origin of the scion, should be propagated on northern-origin rootstocks.

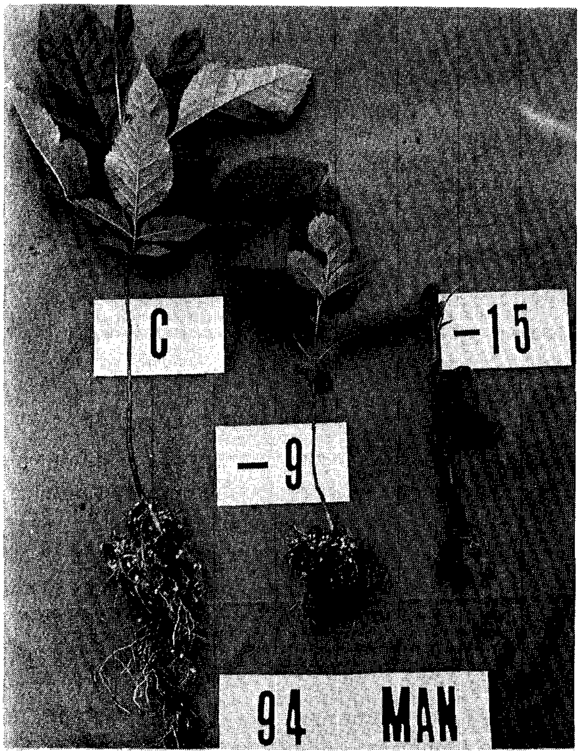

Figure 1. Root and shoot development on green ash seedlings from Manitoba 60 days after treatment at −9°C and −15°C. "C" signifies control seedling. Note small roots developing from root collar zone on plant treated at −15°C.

There are still many "unknowns" concerning the choice of material and management of trees in large containers. Container plants are usually considered as landscape "accents" and are often not expected, or desired, to attain their full growth potential in their restricted circumstances.

It is possible that rootstocks of northern origin might have a "dwarfing" effect on scion growth, and this reduced growth would increase the longevity and utility of container-grown trees. Increased longevity might also be achieved by a balance between root growth and root winter-kill. Such a balance was found, by chance, at the U.S. National Arboretum with *Oxydendrum arboreum* (L.) DC. Trees 7 feet tall in 1969 were planted in 36-inch × 18-inch concrete tubs, and by 1978 had grown to only 11 feet in height and had not suffered any severe stem dieback.

More research on container growing of trees is desperately needed, and root hardiness should be a major factor in such research.

Acknowledgment

I would like to thank Dr. M.N. Christiansen of the USDA Plant Stress Laboratory, Beltsville, Md. for permission to use the cold chambers in his laboratory.

Table 1. Survival of green ash seedlings from various provenances after exposure of root systems to low temperatures.

Seedlot No.	*Origin* State or province	*Origin* Ave. Jan. temp.[1] °F (°C)	*Seedling survival after treatment at:* −9°C	*Seedling survival after treatment at:* −15°C
KS 147	Tennessee	40.3 (4.6)	0/2	0/2
KS 190	Kentucky	36.6 (2.5)	0/2	0/2
KS 188	Tennessee	35.2 (1.8)	0/2	0/2
KS 253	Michigan	24.2 (−4.3)	2/2	0/2
KS 207	New York	23.4 (−4.8)	2/2	0/2
KS 410	Nebraska	20.3 (−6.5)	2/2	0/2
KS 228	Minnesota	3.3 (−15.9)	2/2	0/2
KS 93	Manitoba	0.1 (−17.7)	2/2	1/2
KS 94	Manitoba	0.1 (−17.7)	2/2	1/2

[1]Temperature data for United States locations from U.S. Dept. Agr. Yearbook (Climate and Man) 1941 and for Canadian location from Wernstedt, Frederick L. 1972. World Climatic Data, Climatic Data Press.

Literature Cited

Flemer, William III. 1976. Container trees for use in landscaping. *In* F.S. Santamour, Jr., *et al.*, Eds. Better Trees for Metropolitan Landscapes, USDA Forest Serv. Gen. Tech. Rpt. NE-22, p. 185-193.

Gouin, Francis R. 1976. Winter injury to container-grown plants. *In* F.S. Santamour, Jr., *et al.*, Eds. Better Trees for Metropolitan Landscapes. USDA Forest Serv. Gen. Tech. Rpt. NE-22. p. 179-184.

Havis, John R. 1976. *Root hardiness of woody ornamentals.* HortScience 11: 385-386.

Studer, Elaine J., Peter L. Steponkus, George L. Good, and Steven C. Weist. 1978. *Root hardiness of container-grown ornamentals.* HortScience 13:172-174.

Wiest, Steven C., George L. Good, and Peter L. Steponkus. 1976. *Analysis of thermal environments in polyethylene overwintering structures.* J. Amer. Soc. Hort. Sci. 101: 687-692.

MBC-P INJECTION OF ELMS AT COLORADO STATE UNIVERSITY

by Lawrence B. Helburg

During 1977 and 1978, 187 elms, most of them apparently healthy, were treated on the Colorado State University campus with a 424 ppm solution of MBC-P fungicide (Lignasan BLP® or Correx®), using the Canadian dosage recommendation. All injections were made at or below the root collar. The species complement consisted of 153 American elms, *Ulmus americana,* averageing 68 cm (27 inches) diameter at breast height (dbh); and 34 rock elms, *Ulmus thomasi,* averaging 66 cm (26 inches) dbh. Chemical uptake under 143-426 gms per cm^2 (2-6 pounds per square inch) pressure varied from 1.3 to 86 liters per hour (0.35-22.7 gallons per hour) in American elms and averaged 20 liters per hour (5.3 gallons per hour). Rock elms took the chemical much more slowly, averaging 2.5 liters per hour (0.66 gallons per hour) and ranging from 0.5 to 18 liters per hour (0.13-4.8 gallons per hour). The only variable that noticeably affected uptake within a given species was soil moisture. If the lawn sprinklers had been operating within 24 hours before injection was attempted, uptake was noticeably slower. Windspeed, cloud cover or temperature did not have an appreciable affect on uptake.

The type of injector head also did not seem to affect uptake. Two types of heads were utilized: wooden dowel injectors (Kondo, 1975) and Lamb plastic "T" injectors supplied with the injection apparatus purchased from PicArbor of Sault Ste. Marie, Canada. The wooden injectors were easier and faster to use and did not leak as badly as the Lamb injectors, although they had to be reworked or replaced periodically. Three sets of wooden injectors were used in rotation, with two sets drying while the third was in use.

Ten to 14 days after treatment branch samples were taken from four sides of each tree crown to determine if the chemical was present in a high enough concentration to prevent *Ceratocystis ulmi* from becoming established. Care was taken during the process to select a terminal sample from each of the major branch systems. The samples were surface sterilized, peeled and cut into discs which were aseptically transferred to *C. ulmi* seeded plates. The fungus was allowed to grow for 3 or 4 days before the culture was analyzed. Inhibition of the fungus (little or no mycelial growth) on the discs or culture medium was noted. A tree was classified as having "good" distribution when 75-100% of the discs showed inhibition. A classification of "fair" was awarded trees with 50-75% inhibition zones, and "poor" with less than 50% inhibition.

1977 Results

Seventy-seven American elms were treated in 1977, 32 of which were bioassayed. Nine trees showed "good" distribution, 14 "fair," and 9 "poor." Fourteen of the "fair" or "good" trees were resampled in April, 1978 and only four had retained enough chemical to maintain a "fair" distribution status. The other ten had lost the abili-