CONTAINERIZED TREES IN URBAN ENVIRONMENTS

by D.A. Rakow

Abstract. Successful management of trees in permanent landscape containers depends on a firm understanding of the conditions unique to this type of planting. Containerizing limits the extent of crown growth by restricting root development. In addition, tree roots can be killed by exposure to temporarily flooded conditions, as during periods of heavy rain. Alternatively, the small total volume of containers limits the potential reservoir of water for root uptake, which can result in extreme water stress when evaporative demand is high. Options for the management of containerized urban trees are presented, including selection of diminutive species, use of growth-restricting chemicals, modifying the growing medium, automating irrigation, and selecting group or shared planters.

An increasingly common urban landscaping practice is to plant trees in above ground containers where in-ground planting is not practical. The dimensions of the most commonly used container are 1.22 m^3 (4 ft. x 4 ft. x 4 ft.). Construction material is either concrete, wood, or fiberglass (5). Although individual tree longevity depends on container volume and dimensions, soil mix, species, and location, a widely held belief is that most containerized trees do not survive for more than 10 years after planting (16).

The practice of growing trees in containers dates back to ancient Europe and the Middle East. For example, wall paintings on Egyptian tombs dating to 1400 BC show spice trees in clay containers (6). Among the factors that have contributed to the increased popularity of containerized tree growing in urban areas over the past two decades are: the urban beautification and renewal movements that began in the 1960's (5); the desire to grow plants on raised terraces and balconies for both commercial and residential structures (6); the evolution of the suburban shopping mall parking lot (8); and the proliferation of subways, utility lines, and other obstructions to underground tree planting (6).

How Containerizing Affects Plant Parameters

To understand the severe impact of containerizing on the useful life of trees, one must examine both the physiological effects of root restriction on tree growth, as well as the environmental stresses unique to urban sites.

Tree root growth is opportunistic: it will take place wherever the environment is favorable. But when a tree is planted in a container, root growth is limited by the dimensions of the container. Since roots are essential for the uptake and translocation of water and nutrients and are the synthesis site for certain hormones, any factor that limits overall root development will limit the extent of shoot growth (14).

Containers can also damage tree root systems. Most freestanding containers are both small in total volume and shallow in depth. Even with adequate drainage holes, a container will develop a perched water table in the bottom layer of soil. This zone of completely water-filled pores will extend upward in periods of heavy precipitation. Roots growing in the saturated zone cannot tolerate the anaerobic state of the soil and can easily die (18).

The second condition common to free standing containers, that of small total volume, results in a limited reservoir of water for root uptake. In times of high evaporative demand, root loss from previously high water tables plus the limited reservoir fo water to draw upon can lead to extreme water stress in containerized trees (18).

Environmental factors favoring high rates of transpiration are characteristic in urban sites. Paved city streets - lined with multi-story buildings -typically have higher air temperatures and more cloud cover than adjacent suburban areas; and generally lower levels of radiation, humidity, and wind (4; 7; 8).

The combined effects of enhanced ambient and leaf temperatures and reduced relative humidity create wide vapor pressure gradients between air and leaf and thus increased transpiration. Transpirational losses in excess of available soil water for replenishment lead to water deficits, and if a deficit continues, a tree will suffer water stress (17).

Compounding transpirational losses during the hot summer months is the irregularity of summer rainfalls in many temperate regions (6). Supplemental irrigation could partially alleviate the extreme deficits that result. But strained municipal tree management budgets must cover a large number of cultural practices. An average of only three percent is allocated for tree irrigation (10). Given the likelihood of drought-inducing conditions in urban microclimates, free standing tree containers must be able to entrap and store adequate rain water to meet a tree's transpirational water needs if severe stress is to be avoided.

Container Size

A number of recommendations have appeared in the literature for dimensions of above ground containers (Table 1). With the exception of the size classes listed by Arnold (1), the recommended container dimensions are not related to tree size, age class, or leaf area. Moreover, explanations as to how recommended dimensions were derived are generally not provided. The one exception is Kopinga (11), who based his recommendation on the observation that potential transpiration of a street tree (leaf area index = 4) in the Netherlands is 1.2 − 2.0 times higher than known transpiration values for a forest canopy.

The total soil volumes recommended in the literature vary greatly, from 733 gal. [Flemmer (6)] to 5283 gal. [Kopinga (11)], a 720% spread between values. Given the lack of transpiring leaf area data to which to relate these container volumes, the reasons for this wide variation are not clear. Interestingly, the commonly used 4' x 4' x 4' container (assuming a 6" internal lip) can hold a soil volume of only 460 gal., less than any of the recommendations of Table 1.

Research is currently being conducted in the Department of Floriculture and Ornamental Horticulture at Cornell University to determine the minimally adequate container dimensions for a wide range of ornamental species and crown sizes. It is hoped that the information derived from this research can be compiled into a easily used matrix that will benefit municipal arborists, landscape architects, and landscape contractors.

Management Options

If a tree is not to outgrow its container, certain practices must be undertaken by the plant manager. These fall into two broad categories: managing tree size and managing plant/soil water status.

Managing tree size. If it is known, on the basis of observation or of a predictive formula, that a tree has outgrown its container, then pruning to reduce crown size is one option. This process, known as heading back, has the advantage of removing actual or potential leaves, thus reducing the transpirational surface area.

A pruned plant will transpire less water than an unpruned plant if its shadow is reduced in size or density. The reduction in transpiration, however, will be less than the reduction in foliage, primarily because light interception may be increased proportionally as the crown is opened up (8).

Invigoration of individual shoots is a typical response to pruning. Thus, the initial benefits of reducing crown size are somewhat mitigated by the invigoration of the remaining shoots. At best, heading back is a temporary solution, yielding little suppression of re-growth the following growing season. To be effective, the practice must be repeated annually and becomes quite labor intensive and expensive.

Effects similar to those achieved by pruning can be realized with growth regulating chemicals. A chemical showing particular promise is ICI's paclobutrazol. A gibberellin biosynthesis inhibitor, paclobutrazol modifies both the extent and type of growth of shoots and roots (9). Specifically, paclobutrazol has been shown to reduce leaf number, leaf area, and internodal and total stem length in cherries (3) and apples (19; 20).

Application of paclobutrazol, as a soil drench, trunk injection, or foliar spray, saves considerable labor expense compared to pruning. In addition,

Table 1. Recommended dimensions for above ground containers

Source	*Diameter (in)*	*Depth (in)*	*Total Volume (gal.)*
Kopinga (11)	-----	-----	5,283
Cervelli (5)	96-120	36	1,812
Harris (8)	----	36-60	----
Arnold (1)			
Mature tree ht.			
41-70 ft.	144	48	4,309
21-40 ft.	96	42	1,675
15-20 ft.	72	36	808
Flemmer (6)	72-96	24	733

paclobutrazol has been reported by several sources to have an effective persistence of several years. Thus, it is potentially of great benefit for keeping containerized trees within their container design size limit; that is, the maximum growth for which the container can support the water needs of the tree. Although most research with paclobutrazol has been conducted on fruit species, an initial study on silver maple *(Acer saccharinum)* showed the expected effects of reduction of internodal length and sprout length (2). More research needs to be conducted on differences between ornamental species in reaction to this promising growth regulator.

There are many small to medium sized trees that tolerate wide fluctuations in soil water status, as may be found in the containers. Such species may eventually outgrow their containers, as transpirational water loss exceeds the container's storage of precipitation. But their slow rates of growth and relatively small mature sizes allow them to thrive in container culture for a greater number of years than would a species that rapidly grew to a height of 75 ft. Table 2 is a list of some smaller tree species suitable for container culture.

Water management. To improve container soil water status, it would be logical to manipulate the growing medium. An ideal container medium would strike a balance between a sand, that drains well but has poor water retention, and a clay loam, that remains saturated for extended periods of time. This can be achieved in practice by mixing enough coarse-textured amendment (sand, perlite, vermiculite, etc.) with a composite soil type to insure adequate aeration holes for drainage (18). One possible medium would be a mix of 60% (by volume) sandy loam soil, 20% horticultural grade perlite, and 20 percent milled sphagnum moss. The peat moss, representing the organic component, is relatively small to minimize shrinkage as a result of decomposition.

Many municipalities maintain healthy trees in

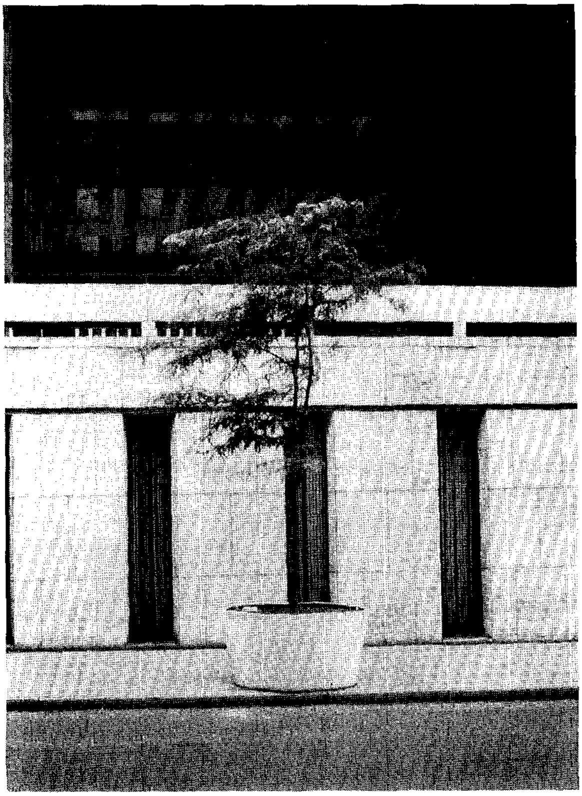

Fig. 1. Trees are often placed in above ground containers when utility or sewer lines make in-ground planting impossible.

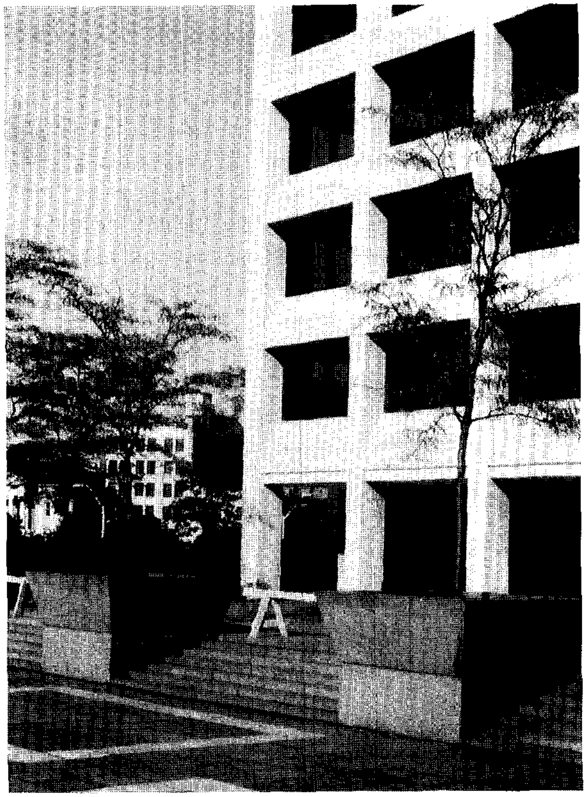

Fig. 2. In situations in which trees are to be planted in urban malls, above ground planters are the only practical alternative.

Table 2. Tree species for container culture

Name	*Height (ft)*
Acer campestre, hedge maple	25-35
A. ginnala, amur maple	15-18
A. tataricum, tatarian maple	15-20
Amelanchier spp., serviceberry	20-25
Cornus mas L., Cornelian cherry	20
Crataegus phaenopyrum, Washington thorn	20-30
C. viridis	
cv. 'Winter King', Winter King thorn	20-35
Magnolia stellata, star magnolia	15-20
Malus sargentii, Sargent crabapple	8-10
Prunus 'Accolade', 'Accolade' cherry	20
Syringa reticulata, Japanese tree lilac	25-35

containers for several years under a regular irrigation regime. By combining irrigation with annual or biennial crown pruning and perhaps root pruning, trees can be maintained in a bonzai-like state. Such practices are, of course, quite costly and often the labor necessary for them simply does not exist.

By automating the irrigation process, the City of Milwaukee, WI has greatly increased tree survival while minimizing labor costs. The container they use consists of an inner pot in which the tree is actually planted, housed within an outer pot that contains a gravel zone at its base. The gravel zone is filled with water via an inlet hose in the outer container. Water moves from this zone to the soil mass by capillary action along a wick which has its base in the water reservoir. Approximately once every 7 - 10 days, the reservoir is re-filled. Beside labor savings, the great advantage of this approach is that water moves into the soil directly in response to decreasing soil water potentials, thus protecting against both saturated and drought conditions (15).

Other planting options. Although some urban locations will always be unsuited to the planting of trees in the ground, the group or shared planter provides an alternative to single tree containers. Shade trees, understory shrubs, and groundcovers can be set in long, uninterrupted planters.

Shared planters allow for greater root development per plant, as well as mutual shading between the plants. The former increases the soil volume that can be explored for water, while the latter lowers leaf temperatures and wind speeds, and thus reduces transpiration. Together, these benefits improve water balances and reduce plant water stress (12, 13).

In addition, group planters allow for more varied and naturalistic plantings than is possible in either single tree containers or tree pits. Multi-stemmed trees, whose growth habits cannot otherwise be accommodated, are well suited to group planters.

Many types of plantings will continue to be used in urban settings. If the needs of trees in each of these situations can be clearly understood, then cost-effective procedures that extend the useful lives of trees can be realized.

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ABSTRACTS

COOK, ALAN D. 1987. **Trees and lawsuits: know the responsibilities.** Am. Nurseryman 165(4): 104, 106.

Lawsuits have become a way of life. And more and more cases involve trees. The following lists were aggregated by a layman to alert other laymen. They include some ways that problems with trees may result in lawsuits and ways to avoid such suits. The following damages to trees may result in lawsuits: tree pruning or felling by trespass, chemical damage, water damage, lowered water table, physical damage from soil compaction by vehicles and equipment, vandals, fire, mud slides, animals and so on. The following damages caused by trees may result in lawsuits: falling trees or tree parts that cause damage to people, property or both, invasion of and damage to property by overhanging limbs, leaning and expanding trunks, and roots, damage to vehicles or pedestrains by thorns, limbs, leaning trunks, roots and so on, accidents caused by obstructed views of oncoming traffic, hazards, signs or signals.

BONESS, KENNETH R. 1986. **Avoiding kickback.** Am. Forests 92(11&12): 12-15, 40.

Lack of saw control is the major reason kickbacks occur. A saw cannot kick up and back unless it has something from which to push off. Kickback is governed by a law of physics that states: "For every action, there is an equal, opposite reaction." The saw chain by itself does not contain enough mass to push the saw around. The engine exerts a force against the chain so when the chain isn't touching anything, it moves while the saw remains relatively stationary. If the saw chain is designed to cut wood, why doesn't it cut through the wood instead of bouncing off? The raker portion of a saw chain's cutter link is designed to limit the cutting depth so that the tooth will work at peak efficiency. However, if the raker probes into the wood, the cutter is allowed to dig in beyond its effective cutting depth. Unable to chip out the bite it has taken; the tooth comes to an abrupt halt. When it does, motion is transferred from the chain to the chainsaw. Since the chain had been going forward, the saw is now moving to the rear -- where the operator is located.

SHURTLEFF, MALCOLM C. 1986. **Root diseases of trees.** Grounds Maintenance 21(9): 22, 26, 28, 30.

Symptoms of root diseases are not immediately obvious and give no indication of severity. You should suspect root problems when a tree l) declines in vigor for 1 or more years, 2) shoot growth is reduced (as measured by rings of terminal bud scales on the twigs), 3) the foliage over much of the tree is off-color or dwarfed, usually beginning in the upper branches, and 4) the top of the tree or crown wilts and dies back. An unusually heavy crop of fruit (berries, cones, acorns) sometimes precedes death. These symptoms commonly overlap those of twig, branch and trunk diseases. Root problems are generally much more severe to a tree's health than those that affect the foliage and most of those that affect the stems.