Root growth and water use in transplanted woody ornamentals

Jack L. Paul
David Barnett

Maintenance of extensive woody plant collections typical of botanical gardens and arboreta requires new plantings yearly to start new collections, to expand existing collections, or simply to replace dead or dying plant specimens. Many of the plants used in such cases are container-grown. When transplanted, these container-grown plants sometimes grow poorly and fail to become established. Water stress is considered to be the most important single cause of such transplant failure.

Limitations of containers

A typical container plant is well fertilized and irrigated in the nursery and has a large, vigorously growing top. At the same time, the root system is confined within a relatively small soil volume in the container. The commonly used 1-gallon container holds about 3 liters (L) of soil with approximately 800 mL (1.7 pints) of available water. A plant in full leaf in such a container often uses 500 mL (1 pint) or more of water per day. Under nursery conditions, a 1-gallon container plant must be irrigated every day to avoid water stress. After transplanting, the already limited water supply in the rootball is further reduced by drainage, since the rootball is then in direct contact with the field soil. Unfortunately, new transplants are usually watered much less frequently than the daily irrigations typically applied to container plants in the nursery, and under these conditions water stress is inevitable.

The key to the establishment and subsequent survival of a newly transplanted container-grown plant is the rapid development of its root system into the surrounding field soil. Extension of roots into new regions of soil greatly increases the volume of water available to the plant. Although this may seem obvious, very little information has been available about the actual rates of root extension and the early root distribution patterns that occur around newly transplanted woody landscape plants.

To determine irrigation and management practices most favorable for optimum root growth and plant establishment, this study in 1984 examined early root growth patterns around transplanted container-grown plants. In April, 24 Lodense privet (*Ligustrum vulgare* 'Lodense') plants were transplanted from 1-gallon cans into a deep, well-drained Yolo loam soil in Davis, California. Berms were formed around each plant to create a basin 1.2 meters (4 feet) in diameter, to which a measured volume of water could be applied. During the first month, all the plants were irrigated equally every one or two days as needed to avoid water stress. Then for the next six

Apparently healthy container-grown plants often do poorly when transplanted. Tests with privet at UC Davis showed that, for best establishment and plant growth, frequent irrigation is vital to achieve maximum root development of a newly transplanted plant. The pipe-like devices are tensiometers, which measure soil drying patterns.

weeks, half the plants were watered every tenth day. The intervals between irrigations were then increased to six and twelve days, respectively, for the rest of the summer. No significant rainfall occurred during the experiment period.

At various times during the season, we estimated plant top size by measuring height and width and calculating total volume. Plants receiving frequent irrigation grew significantly more than those irrigated infrequently. Average plant volumes at the end of the season were 4.9 cubic feet for the frequently irrigated shrubs and only 1 cubic foot for the infrequently irrigated plants. The plants irrigated every 12 days were more sparsely foliated and generally appeared stressed.

For an estimate of root growth following transplanting, soil core samples were collected at several depths and distances from the plant crown 4, 7, 9, 11, 16, and 21 weeks after planting. Roots first reached the 10-cm radius from the plant crown in the 15- to 30-cm soil depth 9 weeks after transplanting. Roots were not found in the 30- to 45-cm depth until the 21st week.

The distance that roots extended from the rootball of the infrequently irrigated plants during the 21-week experiment was less than it was for the plants irrigated more frequently. By 21 weeks, roots had extended an average of 45 cm (18 inches) from the plant crown of the frequently irrigated plants; the shrubs irrigated less frequently had extended roots only 30 cm (12 inches). Using calculations based on the loam soil water-holding capacity and the amount of water applied to the plants, we estimated that lateral root extension had made 14.3 liters of water available to the frequently irrigated shrubs compared with only 6.4 liters for those less frequently watered. The larger reservoir of available soil water due to the relatively greater root extension by the frequently irrigated plants would have enabled these plants to withstand a much longer dry period without being stressed.

Root density most important

Although measurements of lateral root extension give an indication of the increasing volume of soil being tapped, they provide no measure of the root proliferation within that soil volume. In studying water uptake by a plant's root system it is important to consider the length of root per unit volume of soil (root length density). This density determines the rate at which a plant can extract water from a given soil volume; the higher the density, the greater the rate of water absorption.

The soil cores used in measuring root extension were also used for for calculations of root length density at various locations within the root system. A consistent finding throughout the growing season was that density decreased rapidly with increasing distance from the plant crown. Roots branched most profusely just outside the original rootball; relatively few roots extended to outer regions of the root system.

Tensiometers were installed at various depths and distances around the plants for observation of soil drying patterns between irrigations. The rates of soil drying were monitored by daily measurement of soil water matric potential (tension). Throughout the summer, substantial differences in soil drying rates were observed at different distances from the plants. The soil closest to the rootball consistently dried out (increased in tension) more rapidly than soil farther from the plant. Since root length density is highest near the plant rootball, most rapid soil moisture depletion takes place in this area.

Our results showed that, for maximum establishment and plant growth, frequent irrigation is necessary for a newly transplanted container-grown plant. If water stress is avoided, the root system will expand rapidly, and intervals between irrigations can be lengthened as the season progresses. Horticulturists should give serious consideration to the special water requirements of new transplants as they plan for maintenance of existing collections and for future plantings.

Jack L. Paul is Professor, Environmental Horticulture, University of California, Davis; and David Barnett is Assistant Director, Planting Fields Arboretum, Oyster Bay, New York.