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Transplant Shock: Disease or Cultural Problem?

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Introduction

When trees and shrubs are moved from one growing site to another (e.g. from nursery to landscape), they endure stress. If care is taken to minimize stress through proper transplanting techniques and maintenance, plants are likely to recover rapidly and become well-established in their new sites.

Unfortunately, the opposite usually occurs. Trees and shrubs suffer "transplant shock" (Figure 1) from improper transplanting or maintenance, and recovery is hindered. Under stressful conditions, plants are unable to recover, continue to decline, and eventually die. Although plant diseases may be responsible, transplant stresses are most often the culprit of death or decline of newly planted trees and shrubs.

Woody plants may take as long as 3 to 5 years to establish in their new locations and to recover from transplant stresses. Visible leaf and shoot emergence are not indicators of plant establishment. Transplants are not considered established until primary roots expand into native surrounding soil, branch out, and produce sufficient feeder roots on their tips.

If trees fail to regenerate new, healthy roots or fail to establish root systems in new planting sites, transplant shock often results. Such root-related problems may be traced to one or more factors: stresses which occurred when plants were removed from original sites, injury during transit, improper planting techniques, and/or poor cultural practices.

Figure 1. Dieback due to transplant shock often begins with death of scattered limbs. (Photo: Jason Sharman, Vitalitree, Bugwood.org)

Figure 2. Leaf scorch is caused by inadequate water availability, which is common in poorly-maintained trees. (Photo: Nicole Ward Gauthier, UK)

Figure 3. Premature fall coloration and early leaf drop can result from stresses of transplant shock. (Photo: Ohio Nursery & Landscape Association, Bugwood.org)

Figure 4. Trees stressed from transplant shock are more susceptible to diseases, such as Thyronectria canker. (William Jacobi, Colorado State University, Bugwood.org)

Transplant Shock

Symptoms of Transplant Shock

Symptoms of transplant shock can resemble disease and other stresses.

- Decline
- Canopy thinning
- Dieback (Figure 1)
- Leaf scorch (Figure 2), tip burn
- Reduced winter hardiness
- Poor leaf color
- Premature fall color (Figure 3)
- Limited stem growth, stunting
- Limited flowering
- Premature defoliation/leaf drop
- Delayed leaf emergence in spring
- Secondary disease problems (Figure 4)
- Secondary insect problems
- Excessive seed or cone production

Causes of Transplant Shock

Causes of transplant shock and related stresses can range from pre-plant care to post-plant maintenance:

Poor plant material

- Species/cultivar not suited to Kentucky climate.
- Plant not healthy and vigorous due to previous stress, insects, or disease damage.
- Root ball too small for amount of top growth.
- Plant roots dried out between digging and transplanting, resulting in root damage and/or death.
- Leaves and twigs of plant not protected from wind during transport from nursery to landscape.

Undesirable growing site

- Soils poorly drained – including both surface drainage and internal drainage (e.g. subsoil or other high clay content soils).
- "Wet feet" resulting from locations near gutter downspouts or other low-lying areas. See *Wet Feet in the Landscape* (PPFS-OR-W-04)
- Compacted soil, resulting in reduced root growth, lack of oxygen and air exchange, and reduced water penetration. See *Trees and Compacted Soil* (HO 93)
- Shade loving tree or shrub planted in full sun, or vice versa.

Poor transplant techniques

- Root ball allowed to dry-out before planting.
- Root ball allowed to freeze prior to planting.

Figure 5. Wire from tags and guides can girdle branches and trunks if not removed at time of planting. (Photo: John Hartman, UK)

Figure 6. Burlap does not readily degrade in planting holes and should be removed from plants before installation. This synthetic "burlap" material prevented roots from expanding beyond the original rootball. (Photo: Cheryl Kaiser, UK)

- Mechanical injury during digging, moving, or transplanting.
- Planting hole too small, crowding roots.
- Sides of hole "glazed," preventing root expansion.
- Twine or wire from nursery tags and guides left intact; girdling roots, trunk, or limb (Figure 5)
- Burlap or synthetic (non-biodegradable) "burlap" (Figure 6) or twine left around root ball.
- Container-grown plant is root-bound, and roots continue to grow around or spiral (Figure 7), rather than growing outward.
- Planted at the wrong depth, either too deep or too shallow.
- Failure to protect young tender bark from exposure to temperature fluctuations in winter, leading to sunscald and frost crack injury (Figure 8).
- Tree wrap left on trunk more than one season.
- Excessive use of fertilizer at planting time, resulting in root "burn."
- Mower or string trimmer damage (Figure 9).

Poor follow-up cultural practices

- Improper watering—little or no watering, excessive watering (especially problematic in heavy clay soils) or frequent light sprinkling.
- Application of high levels of nitrogen, resulting in excessive top growth compared to root growth (root-to-shoot ratio).

Recommendations for Reversing Transplant Shock

Prevention is the key to minimizing transplant shock. Only healthy, hardy landscape material should be purchased and installed into landscapes. The following steps are important for reducing transplant stress and may reverse transplant shock symptoms:

Figure 7a. Encircling roots often continue this growth habit after installation. (Photo: Ambrose Labs)

Figure 7b. After years of encircling, roots can girdle structural roots or trunks. (Photo: John Hartman, UK)

Figure 8. Sunscald damage occurs during early spring on thin-barked trees.

Figure 9. Mower damage causes wounds that girdle trunks. (Photos: Nicole Ward Gauthier, UK)

- Relocate plants to more appropriate sites (during dormant season).
- Prune or remove dead and dying branches.
- Water thoroughly during dry periods with the equivalent of 1 to 1½ inches rain per week.
- Fertilize according to soil test results (not recommended during year-1, see Fertilization, below).
- Mulch. See *Mulch Myths* (HO-106).

Proper Transplant Procedures

Improper tree planting is one of the leading causes of tree decline and death. Proper planting methods for nursery stock will vary slightly based on growing technique and type of nursery stock.

Types of Nursery Stock Available

Woody plants are commonly produced and sold in three different forms: container-grown, balled-and-burlapped, and bare root (Figure 10). Container-grown trees and shrubs are grown, established, and sold in containers or pots. Balled-and-burlapped (B&B) plants, on the other hand, are grown in field beds and then dug prior to sale. Root balls with surrounding soil are wrapped in burlap for transport to planting sites. Bare root plants are also grown in fields or prepared beds. However, they are dug during dormancy, and soil around roots is removed. Plants are kept in cold storage (40°F) until they are sold.

Refer to Table 1 for a comparison of the three forms of nursery stock available.

Handling Plant Material

Trees and shrubs should be installed as soon as possible after delivery, regardless of whether they are container-grown or field-dug. Plant material should be protected from physical damage, freezing

Figure 10. Planting material is available as (a) container grown, (b) balled-and-burlapped or (c) bareroot. (Photo: Cheryl Kaiser, UK)

TABLE 1. A COMPARISON OF THE CHARACTERISTICS OF THE TYPES OF NURSERY STOCK AVAILABLE.

Container grown	Balled-and-Burlapped	Bare root
Grown in containers	Grown in field; must be dug	Grown in field; must be dug
Root system completely intact	Root system cut and reduced when dug	Root system cut and reduced when dug
Plants can be kept for extended periods before planting	Plants can only be held for short periods of time after digging	Plants need to be planted promptly while they are dormant
Soil and containers provide protection for roots	Soil around roots provides limited protection from drying	Absence of soil around roots increases risk of drying
Can be planted throughout the growing or dormant seasons	Plant during dormancy in fall or in early spring before active growth begins.	Plant during dormancy before active growth begins
Easy to transport and handle during moving; soilless media is lighter than field soil	Heavy due to weight of field soil; usually not shipped long distances	Can be shipped at lower costs due to absence soils
If pot-bound, roots may spiral, causing girdling	Roots are severed at edges of rootball	Need to spread roots out in planting hole
Difficult to inspect entire root system	Difficult to inspect entire root system	Can inspect and prune root system

temperatures, heat and drought, or other adverse conditions. Dampened sawdust, loose compost, or potting mix is packed around plants during shipping and should be kept moist at all times.

Primary sites of root regeneration are severed root ends of field-dug plants (balled-and-burlapped and bare root plants). Therefore, soil around these reduced-size root balls should remain moist. Plants should not be left standing in tubs of water; a thorough soaking with a hose is usually sufficient. If bare root or balled-and-burlapped plants cannot be installed immediately after purchase, they may be "heeled" into a bed of damp sawdust or loose compost that completely covers root balls. Before planting, soak roots in water for up to 30 minutes to rehydrate.

Site Selection

Growing sites should be carefully selected. Consider not only aesthetics, but also sites where plants will adapt and thrive. Trees and shrubs should be able to reach full maturity without growing into overhead wires, buildings, fences, other plants, driveway areas, etc. Sun and wind exposure should also be taken into account before planting. Choose a site with fertile, loose, well-drained soil that lacks a hardpan or compacted layer (deep soil). Refer to *Trees and Compacted Soils* (HO-93).

Time of Planting

Ideal planting times include: dormancy, after leaf drop in autumn, and before budbreak in early spring. These dormant plant phases optimize survival rates by providing opportunities for early root development while soil moisture is high. Autumn plantings provide more time for new root systems to become established, since roots continue to grow throughout fall and winter months (as long as ground is not frozen). Resulting extended root systems increase water uptake during hot, dry summer conditions. In contrast to autumn installations, early spring plantings may be preferred during extremely cold winters or during winters with numerous freeze-thaw cycles. Early spring installations are also recommended for broadleaf evergreens such as hollies, boxwoods, and rhododendrons. Because these plants do not drop leaves in winter, they may lose large quantities of water through leaves. Drying winds cause desiccation and drying of leaves and other plant tissues.

Planting Hole

Before digging, consider locations of underground utilities; contact utility location services by dialing 8-1-1 (electric, cable, water, and other providers).

Hole Size

Planting holes should be dug twice as wide as the

diameter of root balls, but at the same depth as root balls (FIGURE 11). Planting holes should always be large enough to accommodate roots without twisting and breaking root tips. Plants should be no deeper than their original depth, with root flares visible or first roots located just underneath soil. Excessive planting depth is a major cause of transplant shock and plant death, as roots suffer from low oxygen, excess water, and often root rot. Refer to the section below on Planting Depth for information on determining original planting depth.

Digging Equipment

Hand digging is the preferred planting method. Mechanical equipment such as augers or posthole diggers, particularly in soils with high clay content, result in "glazing" of sides of planting holes. In these cases, roots are unable to penetrate slick or glazed surfaces and, thus, unable to expand into surrounding soil. Alternatively, a spade or other tool may be used to roughen sides of planting holes to loosen soil along the sides. Regardless of digging method, never work in wet soils, especially in wet clay or clay loam. Any digging tool, including manual shovels, can leave sides of holes slick and nearby soil compacted.

Remove Packing and Binding Materials

All nursery tags and string, twine, or wire used to attach them should be removed from plants to prevent future girdling and death of branches and trunks. Containers and root coverings should also be removed as described below.

Container-grown

Containers must be removed from plants prior to setting into holes. Tamp plastic containers on bottoms and sides to loosen soil balls. It may be necessary to cut sides of plastic containers if roots are dense or crowded.

Balled-and-burlapped

Wire baskets from balled-and-burlapped trees should always be removed. Wire does not disintegrate quickly and can girdle structural roots. Use wire cutters to remove baskets after trees are set into planting holes (FIGURE 11). In addition, remove all burlap from root balls. Most balled-and-burlapped plants are prepared using synthetic or plastic burlap. Synthetic burlap often looks like natural burlap, but does not decay. Natural burlap is also slow to decay. In both cases, roots are unable to break through wrapping material, and they take on a "pot-bound" growth habit. Scissors and wire cutters may be necessary to prevent root disturbance. Always remove wrapping and packaging materials; never leave them in bottoms of planting holes.

Root Ball

Prune damaged roots

As soon as plants are set into bottoms of holes and packaging materials removed, examine roots carefully. Use sharp pruners to remove broken or damaged roots. Similarly, diseased roots and dead root tips should be pruned beyond point of damage. Damaged root tissues are ideal entry sites for root rotting fungi. In addition, root-pruning encourages branching and subsequent growth.

Spread roots evenly throughout planting hole

Roots of bare root plants should be spread evenly in planting holes. Packing roots into small holes will turn roots and encourage encircling. This often results in girdling roots as plants establish (Figure 7b).

Prevent encircling roots

If container-grown plant materials are rootbound (roots already circling within pots) at transplanting, roots may continue to spiral within planting holes. To prevent encircling, cut or disturb roots by pulling them apart. Alternatively, use a sharp knife to make vertical cuts one inch deep at 4 to 6 different locations around root balls. If plants are not root bound, it is not necessary to disturb roots.

Planting Depth

Roots must be set at the same depth in which they were previously grown. Look for trunk flares or swellings at collars where trunks meet roots. Often, there is an abrupt change in color near bases of trunks that signifies previous soil lines and proper planting depth. Expect that soil and rootball will settle after planting, so a slight allowance for settling is acceptable for loamy soils. If holes are dug too deeply, soil should be added to bottoms and packed well to reduce risk for settling.

It may be difficult to determine original plant depth. If original soil line is not clear, carefully rub off any excess soil from tops of root balls until root flare and/or the first roots are visible. Next set plant so that upper roots are covered by 1 to 2 inches of soil.

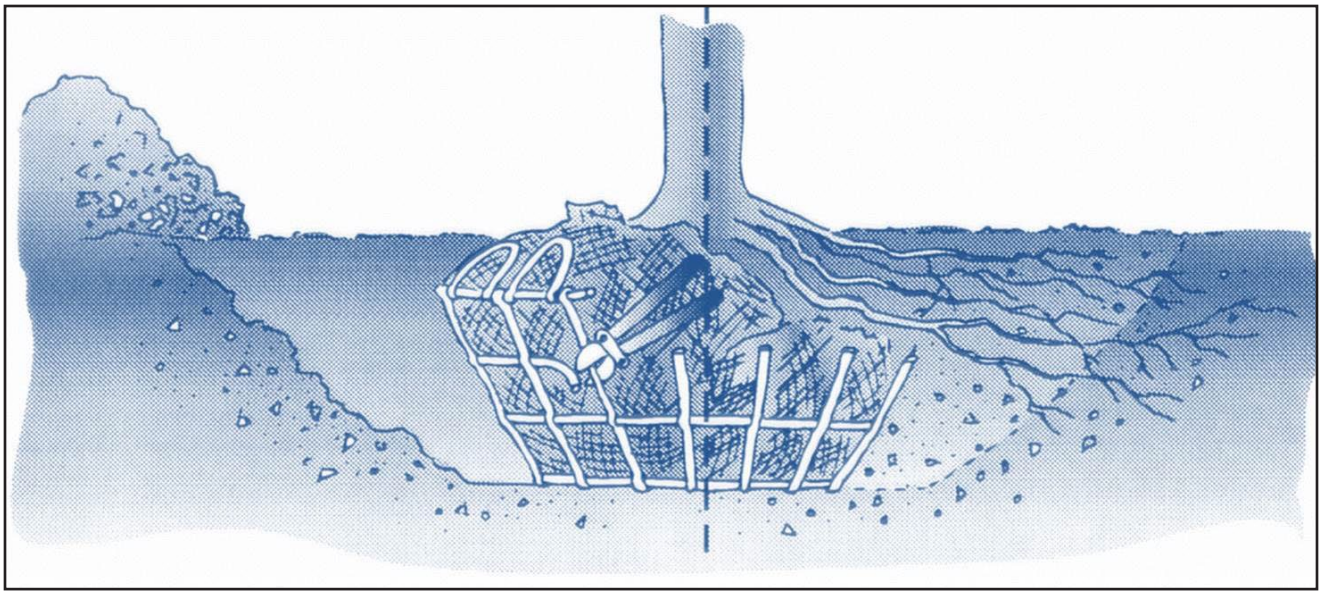

Figure 11. Proper installation (right side of image) includes wide planting hole, exposed root flare, evenly distributed roots, natural backfill, and removal of basket and burlap. (Photo: International Society of Arboriculture, Bugwood.org)

Root flare should be exposed after planting. The root flare is described as the point at bases of tree trunks where trunks expand outward and flow into upper roots.

Backfill

Always backfill with soil that came from the original hole (Figure 12). Do not add gravel or foreign materials to bottoms of planting holes. Soil amendments (such as peat moss, pine bark, etc.) are not recommended. Amended soils are loose, fertile, and are "preferred" by new plants. Roots do not readily move out of this ideal environment, and reduced root systems result. Additionally, these amended planting sites can also create a "soup bowl" effect and water may accumulate in bottoms of holes. This loose, loamy backfill drains rapidly, but when water reaches finer native soil, penetration stops or slows. Roots contained within these soup bowls suffer from wet feet and/or root rot diseases.

Backfill until the hole is half full. Tamp lightly and water thoroughly. After water has filtered down and settled soil, continue adding more soil a few inches at a time, settle with more water, then fill the remainder of the hole with topsoil and water again. Bare root plants require extra care to fill between roots. It is not necessary to fertilize trees at planting time or during the first year of growth in the new location.
In large plantings, beds may be created by roto-tilling and amending heavy soils with organic materials. This provides improved aeration and water movement, thereby improving root growth. Soil amendments may also be necessary when introducing plants with specific requirements (example, low pH in rhododendron and azalea beds). Begin with a soil test and amend soils according to test results. Often raised beds are built using large amounts of peat moss or compost.

Mulch Entire Root Zones

Mulch is an important part of planting and caring for landscape trees and shrubs. Add a layer of organic mulch (bark, wood chips, pine straw) 2 to 3 inches deep over entire root zone (Figure 13). Mulch helps:

Figure 12. Backfill should consist of naturally occurring soil, not amendments or artificial media. (Photo: John Hartman, UK)

Figure 13. Mulch is spread across entire root zone and pulled away from trunk. (Photo: Nicole Ward Gauthier, UK)

Figure 14. "Volcano" mulch is characterized by high narrow piles around trunks.(Photo: William Fountatain, UK)

- Control weeds
- Conserve soil moisture
- Moderate soil temperatures
- Protect plants from mower and string trimmer damage.

Avoid "volcano mulching," (Figure 14) since piling mulch against trunks leads to bark decay, as well as damage from voles and field mice. Never let mulch touch trunks of trees; keep it back 2 to 3 inches.

Black plastic should not be used as mulch. Roots underneath plastic may become deprived of oxygen, thereby declining prematurely when insufficient oxygen is available. Roots may also grow at soil surfaces right underneath plastic where temperature fluctuations are prevalent. Some of the new fiber mulch cloths may offer improved air exchange, but these are still not sufficient for root growth. Additionally, plastic mulches make it difficult to replant and renovate beds after fabric is laid.

Staking Is Not Necessary

Staking is often not necessary. Trunk diameter and overall strength increases when plants are allowed to move with the breeze. As a result, roots develop more deeply and more rapidly. Plants should be staked only when there is danger that they will be blown over by high winds. Top-heavy trees may also require staking.

If staking is necessary, follow these steps: Two or three opposing stakes should be placed outside of planting holes where ground is firm. Use wide, flexible, strap-like material (not wire, string, or rope) to support trees from both directions. Ties should be placed on the lower half of trees and should be loose enough to allow some trunk movement. Single stakes are not recommended since rubbing can cause trunk injury. Straps should be loosened periodically to prevent girdling. Remove stakes after one year, and remove all ties from branches and trunks.

Sunscald Protection

While most trees are not prone to sunscald/winter injury, thin-barked plantings are extremely susceptible to fluctuations in winter day/night temperatures. Newly transplanted trees, such as thin-barked maple, honey locust, and apple, should be protected during the first one to three winter seasons. White paper tree wrap should be applied in late fall before freezing temperatures begin and then removed in spring after risk for freezing has passed. White tree wrap reflects sunlight from tender trunks and helps insulate dormant tissue from freeze-thaw cycles. Loosely wrapped window screen is another option. Protect trunks from the ground up to the first branches. Never use black plastic drain pipe or plastic tree guards because they encourage higher surface temperatures during winter and during dormant periods.

Water Regularly

Supplemental watering is the single most important method for preventing transplant shock. Newly transplanted trees and shrubs require at least 1 to 2 inches of rainfall per week, while water-loving trees and those installed in sandy soils may require more. Supplementary watering may be required until plants are fully established (approximately 3 to 5 years).

Supply enough water to soak soil around roots at each watering, and then allow soil surfaces to dry between watering. A good practice is to thoroughly soak entire root zones every 7 to 10 days during dry periods. Avoid frequent light waterings since they encourage root growth near the soil surface, and may result in shallow root systems that are more susceptible to drought damage.

Field-dug trees (balled-and-burlapped and bare root trees) are installed with reduced root systems. The effect of extensive root loss must be considered with irrigation frequency. When a substantial portion of root area is lost, plants' abilities to take up water are also significantly reduced. As a result, transplanted trees and shrubs can experience considerable water stress. The other extreme is giving plants too much "TLC." Daily watering or excessive applications of fertilizer or mulch are known as "killing the plant with kindness."

Needled evergreens (e.g. pine, spruce) and broad-leaf evergreens (e.g. holly, rhododendron) retain leaves during winter. Because evergreens continue to lose water through needles and leaves during this time, evergreens should be watered during dry periods in winter (as long as the ground is not frozen). Deciduous plants (e.g. maple, oak) do not hold leaves in winter and generally do not require watering during these months. However, winter watering for recently-planted deciduous plants may be necessary during winters with little rain or snow.

Root-to-shoot Balance

It is usually not necessary to reduce canopy size at planting. Leaves produce vital sugars that provide energy for root formation, so they should be preserved when possible. Avoid "balancing" growth unless plants exhibit significant imbalance.

There are instances when newly planted trees should be pruned. Dead, damaged, and diseased limbs should be removed. Misshapen branches or double leaders may create structural problems as trees mature, so selective pruning is also recommended. Do not remove the central stem. Proper pruning practices are critical, so refer to *Pruning Landscape Trees* (HO-45) and *Pruning Landscape Shrubs* (HO-59) for further information.

Fertilization

Allow plants to establish for at least 1 year before fertilization. The goal during the first year is re-establishment of root systems, not promotion of canopy growth. Fertilization results in production of more leaves than limited root systems can support. Plants often establish better if allowed to recover from the initial shock of transplanting before fertilization. Most soils are fertile enough to support plant growth over a period of years without supplemental nutrients.

One to 2 years after transplanting, fertilizer may be applied according to soil test results. Applications should be made during late fall or early spring. If surrounding lawns are fertilized, there should already be sufficient amounts of fertilizer available to tree roots.

Additional Resources

Web Sites

- Plant Pathology Extension Publications
http://www2.ca.uky.edu/agcollege/plantpathology/extension/pubs.html
- Entomology Extension Publications (ENTFacts)
http://www2.ca.uky.edu/entomology/dept/entfacts.asp
- Horticulture Extension Publications for Home-owners
http://www.uky.edu/hort/home-horticulture

Publications

- How Dry Seasons Affect Landscape Plants (ID-89)
http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/ID-89.pdf
- Leaf Scorch and Winter Drying of Woody Plants (PPFS-W-OR-17)
http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-OR-W-17.pdf
- Mulch Myths (HO-106)
http://www2.ca.uky.edu/agc/pubs/ho/ho106/ho106.pdf
- Planting Balled and Burlapped Trees and Shrubs in Your Landscape (HO-91)
http://www2.ca.uky.edu/agc/pubs/ho/ho91/ho91.pdf
- Principles of Home Landscape Fertilization (ID-72)
http://www2.ca.uky.edu/agc/pubs/id/id72/id72.pdf

- Pruning Landscape Shrubs (HO-59)
http://www2.ca.uky.edu/agc/pubs/ho/ho59/ho59.pdf
- Pruning Landscape Trees (HO-45)
http://www2.ca.uky.edu/agc/pubs/ho/ho45/ho45.pdf
- Trees and Compacted Soils (HO-93)
http://www2.ca.uky.edu/agc/pubs/ho/ho93/ho93.pdf
- Wet Feet in the Landscape (PPFS-OR-W-04)
http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-OR-W-4.pdf

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