Colorado Master Gardener[sm] Program
Colorado Gardener Certificate Training
Cooperative Extension
Colorado State University

GardenNotes #633

The Science of Planting Trees

Outline:

The Science of Planting Trees

Planting problems has become epidemic with more landscape trees dying from planting problems than all insects and diseases combined. The average life of a tree in the landscape is only eight years due to poor design and planting techniques. Trunk girdling roots (caused by planting too deep) accounts for 57% of landscape tree deaths. This publication covers the planting process. For additional details on design and selection, refer to CMG GardenNotes #631, *Tree Placement* and #632, *Tree Selection*.

Roots only grow where there is adequate levels of soil oxygen. Tree root systems are typically shallow and wide spreading. Fine feeder roots are present near the surface throughout the root system.

It is difficult to predict the root spread of any tree. Under good soil conditions, 90-95% of the roots are typically in the top 36 inches with 50% in the top 12 inches. Tree roots typically spread 2-3 times the tree height and/or canopy spread.

On compacted clayey soils, roots will be shallower with a wider spread. As a rule-of-thumb on compacted clayey soils, 90% will be in the top 12 inches or less, with the feeder roots in the top four inches. Spread may exceed five times the tree height and/or canopy spread.

Based on nursery standards, a field-grown Balled & Burlapped (B&B) or container-grown tree contains only 5-20% of the fine absorbing roots of the same size tree in the field. **The *Science of Planting Trees* is promoting rapid root growth to quickly reduce the water stress imposed by the planting process. *Post-planting stress*** (transplant shock) is the sum of all stress factors induced by the reduced root system. [Figure 1]

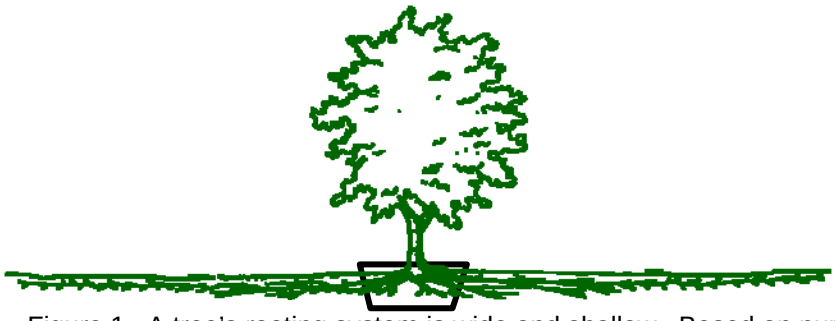


Figure 1. A tree's rooting system is wide and shallow. Based on nursery standards, the field grown B&B tree or container grown tree has only 5-20% of the fine absorbing roots found on the same size tree in an open lawn. This places the new tree under stress.

Due to low soil oxygen levels, planting too deep leads to slow root establishment and tree decline. Due to planting too deep, it is common to find trees that take years for the roots to establish and to find trees that fail to thrive and decline over time.

When planted too deep, many tree species have a strong tendency to develop trunk girdling roots. The tree may establish and put on significant growth only to decline and die some 12 to 20 years after planting. Since the girdling roots may be below the soil surface, diagnosis of the decline may be impossible without a root collar excavation.
When planted too shallow, roots may be killed by hot or cold surface soil temperatures and dry soil conditions.

Step 1. Check Depth of Tree in Root Ball

Generally, at least two structural roots should be within the top 1-3 inches of the soil surface, measured 3-4 inches from the trunk. This standard was developed by an industry-wide working group[1] to develop consensus on the issue of tree decline and death due to the excessive amounts of soil over the root system.

Noted exceptions include the following:

- In some species, roots regenerated after transplanting can grow back towards the trunk and become girdling roots. On these species, top structural roots should be within the top one inch of the root ball soil. Species with this modification include the following:
    - Crabapple
    - Green Ash
    - Hackberry
    - Littleleaf Linden
    - Poplar
    - Red Maple
    - And possible other species with aggressive root systems
- Some species may develop more strongly descending root systems. In this situation, look for structural roots nearer to the trunk.
- On landscapes with poorly drained soils (common in many soils around Colorado) there may be a need to raise structural roots slightly.
- Additional exceptions and clarifications may be identified with future research.

Locating Structural Roots in the Root Ball

Don't assume that the tree was planted at the proper depth at the nursery. With mechanization of the industry, planting depth became an issue. Take the time to check.

The presence of the root flare is an indication of good planting depth. However, small trees may have minimal root flare development making it difficult to determine. Be careful not to mistake swelling of the trunk below the graft as the root flare.

[1] Members of the working group included experts from Morton Arboretum, American Nursery and Landscape Association (ANLA), American Society of Consulting Arborists (ASCA), American Society of Landscape Architects (ASLA), Associated Landscape Contractors of America (ALCA), International Society of Arboriculture (ISA) and Tree Care Industry Association (TCIA).

A good way to evaluate planting depth in the root ball is with a surveyor's chaining pin or similar tool such as a knitting needle, a barbeque skewer, or even a slender screwdriver. Gently probe the root ball 3-4 inches out from the trunk to locate structural roots and determine depth. Generally, at least 2 structural roots should be located within the top 1-3" of soil. [Figure 2]

Figure 2. Gently probe the root ball with a slender screwdriver. Generally, at least 2 structural roots should be found in the top 1-3 inches of soil, 3-4 inches out from the trunk. Noted exception for trees prone to developing girdling roots, where the top structural roots should be in the top one inch of soil.

Remediation for Trees Planted Too Deep in the Root Ball

Two options exist in dealing with trees planted too deep in the root ball, 1) don't purchase the tree or 2) correct it in transplanting.

Don't purchase – It takes time to correct the planting depth, so in a contract installation (where labor cost is paramount) the best options may be to reject the tree. National standards (ANSI Z60.1, 2004) state that for B&B trees the "soil above the root flare… shall not be included in the ball depth measured and should be removed." With the extra soil in the upper portion of the root ball and roots only in the lower portion, it also raises the question: is the root ball adequately sized for the tree? [Figure 3]

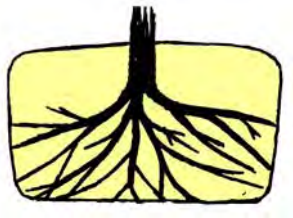


Figure 3. Another issue with soil levels above the root flare is root ball size. With roots only in a portion of the root ball area, the root ball may be too small for the tree to thrive following planting.

Correct it in planting – Another option would be to correct the planting depth in the root ball during transplanting. The first step in transplanting would be to gently probe the root ball (as described above) to determine adjustments needed in the planting hole depth. To avoid cracking the root ball, leave wrappings in place until the tree is stabilized in the planting hole. Extra soil may be removed during the backfill process or over time after planting. [Figure 4]

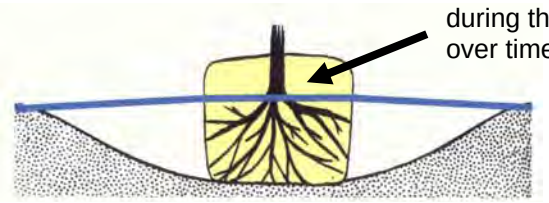


Figure 4. Adjust the depth of the planting hole to bring the root flare to the correct depth.

Step 2. Dig Saucer-Shaped Planting Hole Three-Times Root Ball Diameter

Saucer-Shaped Planting Hole

To support rapid root regeneration, research suggests a wide saucer-shaped planting hole. If the roots have difficulty penetrating compacted site soil, sloped sides direct roots to continue to grow towards the higher oxygen soil near the surface rather than being trapped in the planting hole. Roots that do penetrate the site soil will grow more slowly. [Figure 5]

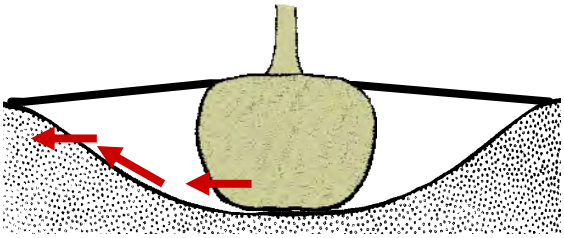


Figure 5. When roots can't penetrate the site soil (due to low oxygen levels) the saucer-shaped planting hole directs the root upwards where oxygen levels are higher.

Water-logging concerns – In the wide saucer-shaped planting hole three-times the root ball diameter, the upper half contains 85% of the back fill soil and the upper 1/4 contains 75% of the back fill soil. Water could saturate the lower 3/4 of the backfill soil and only affect 25% of the root system! The saucer-shaped planting hole actually gives the tree a larger margin for error in over-watering.

When the planting hole is dug with an auger, break down the sides with a shovel to help eliminate the glazing and create the preferred sloping sides. An alternative is to rototill a 12-24" inch ring of soil around the planting hole after planting. [Figure 6]

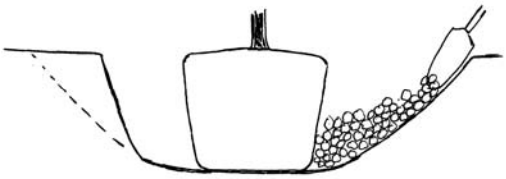


Figure 6. When dug with an auger, cut down the sides into the saucer shape during the backfill process.

Planting Hole Depth

For optimum soil oxygen levels conducive to root growth, top of the root ball should rise 1-2 inches above the original soil grade. This prevents water from settling and puddling over the root ball, reducing soil oxygen levels. [Figure 7]

Backfill soil should NOT cover the top of the root ball. Backfill soil covers the "knees" gradually tapering downward to the original grade. The root ball should sit on undisturbed firm soil to prevent sinking and reduce rocking in wind.

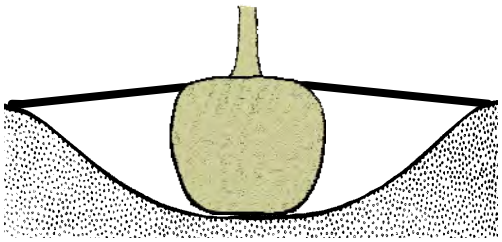


Figure 7. Top of root ball rises 1-2 inches above soil grade. No soil is placed over the root ball. Backfill soil covers the "knees" tapering downward to the original soil grade.

Root ball sits on undisturbed soil to prevent sinking.

The planting hole depth should be 1-2 inches less than the height of the root ball (adjusting for proper planting depth in the root ball as described above). If the hole is dug too deep, backfill and pack the bottom to the proper depth.

Low soil oxygen levels are the primary factor limiting root growth. If the root ball is below grade, water can puddle over the root ball reducing soil oxygen. If backfill soil is placed over the root ball, the change in soil texture (actually the change in pore space) between the backfill soil and the root ball creates a soil texture interface that impedes movement of water and air across the interface line. To minimize interface issues, the root ball soil must come to the surface, with no backfill soil on top of the root ball. [Figure 8]

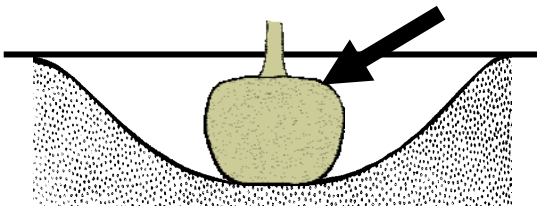


Figure 8. When backfill soil is placed over the root ball it creates a soil texture interface that impedes water and air movement into the root ball.

Planting Hole Width

Planting hole width is the key to promoting rapid root growth reducing *post-planting stress*. Depending on the soil's tilth, root growth slows when roots reach the undisturbed site soil beyond the backfill area. This is due to lower soil oxygen levels in the undisturbed soil.

25% wider – A planting hole with vertical sides that is only 25% wider than the root ball hinders root re-generation. If the soil is compacted and difficult to penetrate, the roots may circle inside the hole just as if the root system was in a container. The size of the regenerated root system (before growth is slowed by the lower oxygen levels of the site soil) is insufficient to reduce *post-planting stress*.

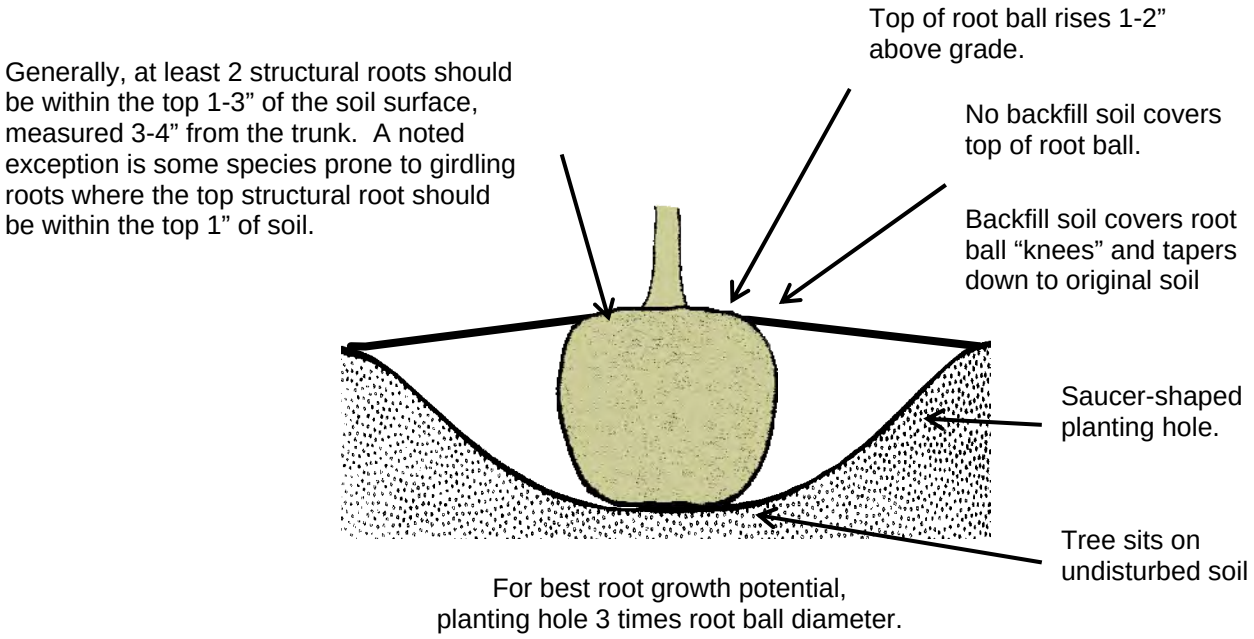
Two times root ball – A planting hole twice the diameter of the root ball with sloping sides will allow the root system to grow rapidly to 150% of the root ball size before growth is slowed by the lower oxygen levels of the site soil. This is not enough to avoid *post-planting stress* under normal conditions.

Three times root ball – A planting hole three times the diameter of the root ball with sloping sides will allow the root system to grow rapidly to 400% of the root ball size before being slowed by the lower oxygen levels of the site soil. **This is enough to avoid *post-planting stress* under normal conditions**. A two inch diameter tree, with a 24 inch root ball, needs a 6 foot wide, planting hole. The hole is shallow and saucer shaped.

The shallow wide planting hole is a primary technique encouraging rapid root growth, the objective in the *science of tree planting*. However, it is readily recognized that it requires significantly more labor to 1) dig the wider hole and 2) return to the site after watering for final grade. If tree growth is the objective, invest extra effort for a wide planting hole!

Summary: Planting Hole Specifications

Figure 9. Planting hole criteria to promote rapid root establishment, reducing post-planting stress.



Modification for Wet Soils

On wet soils, placing the root ball so that 1/3 is above grade may be helpful to adapt to wet soil conditions. Cover root ball "knees" with soil, gradually tapering down. Do not use mulch to cover knees as roots will readily grow in moist mulch, but will be killed when the mulch dries out. [Figure 10]

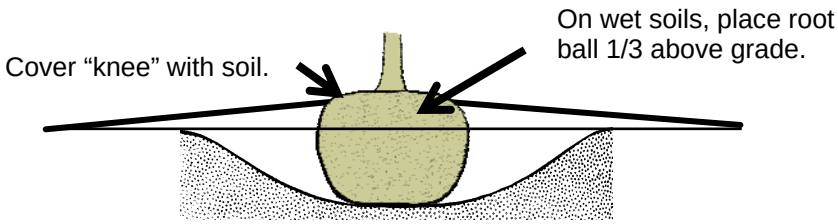


Figure 10. On wet soils, place root ball 1/3 above grade covering knees with soil tapering off.

Modification for Compacted Soils

On extremely compacted soils, roto-tilling a ring around the backfill area to a width of 4-5+ times the root ball diameter may be helpful. This should be done after planting is completed so the soil is not re-compacted by foot traffic in the planting process. [Figure 11]

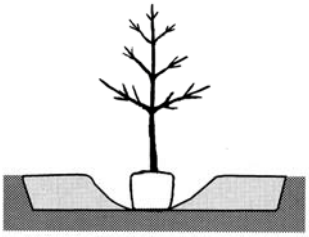


Figure 11. Roto-tilling a ring around the planting hole may help roots spread into compacted soil.

Planting Bare-Root Trees

For bare-root trees, spread roots over a mound of packed soil, as illustrated in Figure 12.

Generally, at least 2 structural roots should be within the top 1-3" of the soil surface, measured 3-4" from the trunk. A noted exception is some species prone to girdling roots where the top structural root should be within the top 1" of soil.

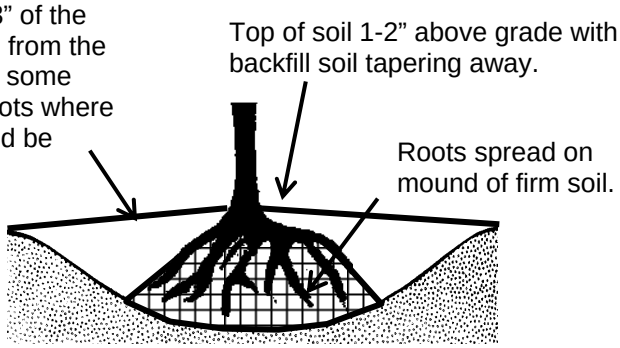
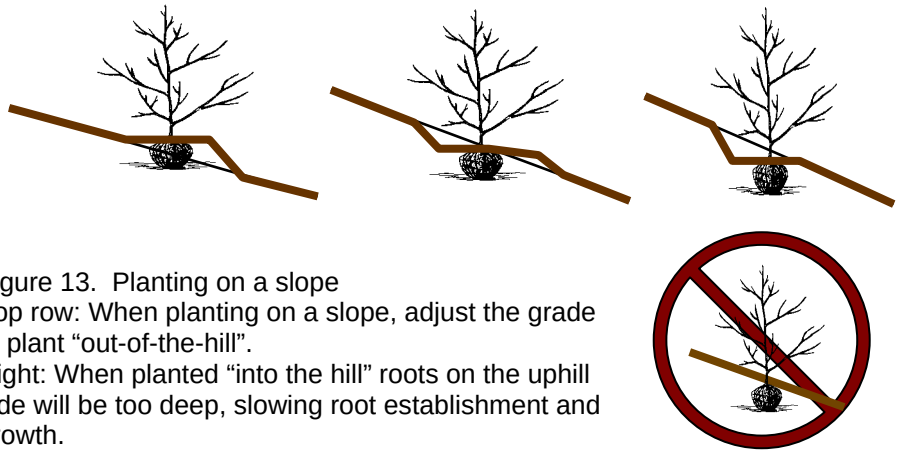


Figure 12. Bare-root tree planting

Planting on a Slope

When planting on a slope, plant "out-of-the-ill" by adjusting the grade around the planting hole as illustrated in Figure 13.



. Figure 13. Planting on a slope
Top row: When planting on a slope, adjust the grade to plant "out-of-the-hill".
Right: When planted "into the hill" roots on the uphill side will be too deep, slowing root establishment and growth.

Labor Saving Techniques

- A small tiller or "garden weeder" makes for quick digging. Simply place the tiller where the hole will be and walk around in a circle. Stop periodically to remove the loosened soil from the hole and continue walking and tilling in a circle. [Figure 14]

Figure 14. Digging the hole with a small tiller or "garden weeder"

- Another time-saving technique is to dig the hole twice the root ball width with more vertical sides. Place the tree in the hole, pack base, remove wrappings, and check for girdling roots. Then with a shovel cut the sides of the planting hole to form the saucer-shape planting hole three times the root ball diameter. With this technique part of the backfill soil does not have to be removed and shoveled back, but simply allowed to fall into the hole. Soil "peds" (dirt clods) up to the size of a small fist are acceptable. With this technique it is not practical to mix in soil amendments, as amendments must be thoroughly mixed thought the backfill soil. [Figure 15]

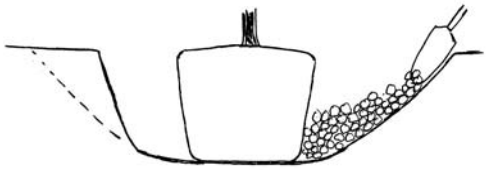


Figure 15. Planting hole widened into saucer-shape during back fill process.

Step 3. Set Tree in Place

In setting the tree in the planting hole, if the tree has a "dogleg" (a slight curve in the trunk just above the graft) the inside curve must go to the north to avoid winter bark injury. [Figure 17].

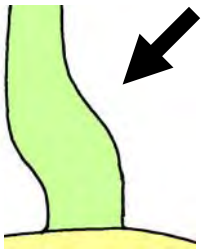


Figure 17. The inside curve of the graft crook or "dogleg" must go to the north to avoid winter bark injury.

Vertically align the tree with the top centered above the root ball. Due to curves along the trunk, the trunk may not necessarily look straight. It will appear straighter with growth.

A lot of variations occur in how to handle root ball wrappings depending on the root ball and the type of wrapping or container. The important aspect here is that wrappings which hold the root ball together are NOT removed until after the tree is situated in the planting hole.

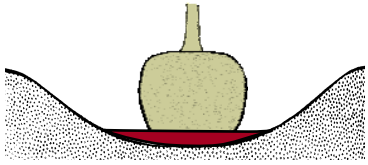
For field grown B&B-type tree, do not remove the wrapping that hold the root ball together (typically the burlap and wire basket) until Step 6. To facilitate handling of the tree, additional coverings (like shrink wrap or placing the tree in a container) are sometimes placed on the root ball. These additional coverings may be removed as long as it does not exposure the root ball to potential breakage. With a tapered wire basket, some arborists like to cut off the bottom of the wire basket before placing the tree in the planting hole. This makes it easy to remove the basket in Step 6.

Some container grown trees have a tightly knit root ball and can be slipped out of the container without concerns of cracking the root ball. Depending on the root ball and the container, it may be a better alternative to cut off the bottom of the container before placing the tree in the hole and removing the side of the container in Step 6. For situations like a fabric grow bag, remove fabric after the tree is situated in the planting hole in Step 6.

Step 4. Firm Base

Once the tree is situated, the wide planting hole allows an extra step to stabilize the tree from rocking in the wind. Firm a small ring of backfill soil around the base. [Figure 16]

Figure 16. Stabilize the tree by firming a small ring of backfill soil around the base of the root ball.



Step 5. Remove Root Ball Wrapping

An advantage of the wider planting hole is that it gives room for the planter to remove root ball wrappings AFTER the tree is placed in the hole.

Based on research, standard procedures are to remove root ball wrapping materials (burlap, fabric, grow bags, twine, ties, wire basket, etc.) from the upper 12 inches or 2/3 of the root ball, whichever is greater AFTER the tree is set in place. Materials under the root ball are not a concern since roots grow outward, not downward.

These recommendations are based on the following concerns:

- The decomposition rate of burlap may be slow enough to interfere with root spread.
- Burlap left above the soil surface wicks moisture from the root ball.
- Synthetic burlap, fabric grow-bags, and nylon twine never decompose in the soil.
- Trees are often girdled from twine left around the trunk.
- Wire baskets last 30 plus years. Long term research shows that wire baskets may cause rooting problem over time.

Step 6. Check for Circling Roots

With the root ball now exposed, check for roots circling the root ball. Cut all circling roots. If the root ball has a lot of circling roots, it is standard procedure to simply run a knife down the edge of the root ball on all four sides, cutting the circling roots. Any roots that have been sticking outside of the wrapping materials are desiccated and should be cut off.

Step 7. Backfill

In backfilling the planting hole, the best method is to simply return the soil and let water settle it. Avoid compacting the soil by walking or stamping on it. In the backfill process, the planting hole can be widened into the desired sauce shape. Underground stabilization is generally installed prior to backfilling the planting hole.

Backfill soil covers the root ball “knees” tapering down to the original soil grade. No backfill soil goes on top of the root ball. [Figure 17]

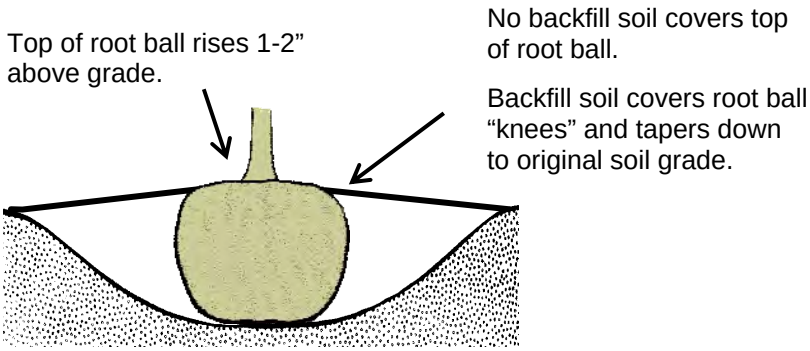


Figure 17. Backfill soil covers the "knees" tapering down to original soil grade. It is imperative that no soil cover the top of the root ball.

In preparing any garden for planting, it is standard gardening procedure to ***modify*** the soil structure (i.e., loosen the soil) by cultivating. It is also routine to ***amend*** the soil by adding organic matter to improve water-holding capacity of sandy soils or to increase large pore space in clayey soils. Modifying and amending, while related, are not the same process and serve different purposes in improving the soil tilth for plant growth. A soil may be modified without amending.

Ideally, soils in a tree's entire potential rooting area would be modified and amended. However, this is generally not practical. In most tree plantings we are primarily concerned with backfill soil in the planting hole.

Modifying the Backfill

When planting trees, soil in the planting hole is modified (loosened-up) by digging the hole. The issue around "modifying the soil" is planting hole width, as discussed above. Due to lower levels of soil oxygen in the site soil, root growth slows as roots reach the undisturbed site soil beyond the backfill. A saucer-shaped planting hole three-times the diameter of the root ball supports rapid root growth, reducing post-planting stress. Amending backfill soil in a narrow planting hole will not substitute for modifying soil in the early rooting area of the wider planting hole!

For backfill, soil "peds" (dirt clods) up to the size of a small fist are acceptable. The soil does not need to be totally pulverized. In clayey soils, totally pulverizing the soil will destroy all structure and may lead to excessive re-compaction with minimal large pore space.

Amending the Backfill

Amending the soil just <u>in the planting hole</u> is a very complex issue. Amended backfill soil <u>may</u> be more supportive to root growth in the planting hole during the first two years. However, the amended soil in the hole <u>may</u> also hinder root spread beyond the planting hole.

In tree planting, it is a common procedure to amend backfill soil with organic matter. It is a good marketing technique for the nursery to recommend soil amendments with the sale of a tree.

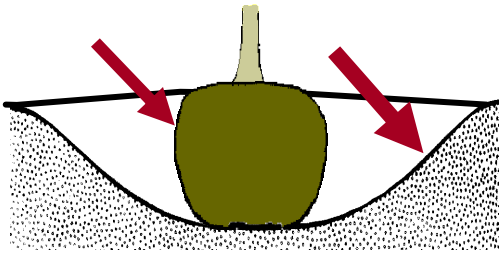
Arborists are divided on the benefits and needs of amending the backfill soil. Too many soil-related variables play into this amended planting pit for a simple directive. B&B trees, being field grown, will typically have soils lower in organic matter. Soil texture will depend on the site where the trees were grown; and may be somewhat like the site soil. Container-grown trees are typically in a coarse textured soil (for drainage) with higher organic content (to hold water and nutrients). Some arborists believe that there is a greater benefit to amend backfill soils when planting container-grown trees than with B&B trees.

In amending the soil, the organic matter needs to be thoroughly mixed with the backfill soil. Never backfill with organic matter in layers or clumps as this creates additional texture interface lines. Amendments should be well aged. Never use unfinished compost or fresh manure as it may burn tender roots.

Texture Interface

Changes in soil texture (actually changes in soil pore space) create a texture interface that impedes water and air movement across the texture change. There will always be a texture interface issue between the root ball soil and backfill soil and to a lesser degree between the backfill soil and undisturbed site soil. Amending the backfill soil to "match" the organic content of the root ball will not diminish the interface issue.

To deal with the interface issue make sure that the root ball soil comes to the surface (that is no backfill soil covers the top of the root ball). If backfill soil covers the root ball soil, the interface between the root ball and backfill soil will impede water and air movement into the root ball.



Changes in soil texture (actually soil pore space) create a texture interface that impedes water and air movement.

There will always be a texture interface difference between the root ball and backfill soils, and the backfill soil and the undisturbed site soil.

Figure 18. To minimize texture interface issues, the root ball must come to the soil surface, with no backfill over top of the root ball.

Summary on Modifying and Amending

Contrary to popular belief, amending the backfill soil with organic matter will not compensate for poor planting techniques. While amending the backfill is routine, attention to planting hole width and depth is far more important in promoting rapid root regeneration.

The key to rapid root regeneration is to use a wide planting hole where soil is modified by the digging process. Attention to correct planting depth (generally at least two structural roots in the top 1-3 inches in the root ball, with the root ball 1-2 inches above grade and no backfill soil over the top of the root ball) is more important.

Step 8. Staking or Underground Stabilization (if needed)

Staking became a routine procedure when trees were planted in deep holes and the trees sunk and tilted as the soil settled. In the *Science of Planting Trees*, where trees are set on undisturbed soil and a ring of soil is firmed around the base before backfilling, staking is not needed in many landscape settings.

In areas with extreme winds, "anchor staking" may be needed for improved wind resilience. In some landscapes new trees may need "protection staking" to protect trees from people activities (like the football game on the lawn). For additional information on staking refer to CMG GardenNotes #634, *Tree Staking and Underground Stabilization.*

Step 9. Watering to Settle Soil

Watering is done after staking so the gardener doesn't compact the wet soil installing the stakes. Watering is a tool to settle the soil without overly packing it.

Step 10. Final Grade

In the wide shallow planting hole, the backfill soil may settle in watering. Final grading may be needed after watering.

Step 11. Mulching

A mulch ring of bark/wood chips is suggested around all trees to help protect the trunks from lawnmower damage. On newly planted trees, organic mulch can increase fine root development by 400% compared to grass competition. This results in 20% faster top growth.

Site-specific water needs should be considered regarding placement of mulch directly over the root ball. Mulch over the rooting area helps conserve moisture and moderate soil temperatures. However, on wet sites the mulch may help hold too much moisture leading to root/crown rots and

may be undesirable. Wood/bark chips may blow in the wind and therefore are not suitable for windy areas.

Standard mulch depth over the root ball is 1 to 2 inches. Never place mulch up against the trunk. Over the backfill area and beyond, 3-4 inches of mulch will give better weed control and prevents additional soil compaction from foot traffic. [Figure 19]

Figure 19. Do not make mulch "volcanoes". Mulch piled up against the tree trunk may lead to bark decay and reduced trunk taper. Excessive mulch can reduce soil oxygen levels.

Additional Information

CMG GardenNotes on Tree Selection and Planting

#631 Tree Placement: Right Plant, Right Place
#632 Tree Selection: Right Plant, Right Place
#633 The Science of Planting Trees
#634 Tree Staking and Underground Stabilization
#636 Care of Newly Planted Trees
#636 Tree Planting Steps

- Books: Watson, Gary W. and Himelick, E.B. *Principles and Practices of Planting Trees and Shrubs*. International Society of Arboriculture. 1997. ISBN: 1-881956-18-0
- Web: Dr. Ed Gilman's tree planting information at http://hort/ifas.ufl.edu/woody/planting

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- Colorado Master Gardener *GardenNotes* are available on-line at www.cmg.colostate.edu.
- Colorado Master Gardener training is made possible, in part, by a grant from the *Colorado Garden Show, Inc.*
- Colorado State University, U.S. Department of Agriculture and Colorado counties cooperating.
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Revised December 2006