Transplanting Seedlings

Seedlings should be transplanted before becoming rootbound because this condition may permanently alter growth habit. Seedlings produced in flats at a high density must obviously be transplanted earlier than seedlings produced in larger containers at a low density.

The ideal time to transplant young seedlings is when they are small and there is little danger of setback. This is usually about the time the first true leaves appear above the ***cotyledons*** (the seed leaves or first leaves the seedling produces).

Lift seedlings by the rootball, using a plant label or ***dibble*** for support. Gently ease seedlings apart into small groups, thus making it easier to separate individual plants. Avoid tearing roots in the process. Never hold the seedling by its stem, as doing so may crush it, or harm the growing tip. Instead, gently hold the plant by a leaf. A seedling that has lost a leaf can grow another, but a seedling that has lost its growing point or suffered damage to the vascular system cannot survive.

Make a hole in the growing medium deep enough for the seedling to be placed at the same depth it was growing in the seed flat; some seedlings, such as tomatoes, may be buried up to their cotyledons. After planting, lightly firm the soil and water gently. Keep newly transplanted seedlings in lower light for a few days, and keep them away from direct heat sources. Continue watering and fertilizing as done in the seed flats.

Figure 9. Always hold a seedling by the leaf, never the stem.

After a period of protected growth, seedlings must be hardened before transplanting to outdoor growing conditions. If not gradually acclimatized to the outdoor environment, leaves may be scorched by sun or wind; wilting and death could even occur. During the ***hardening off*** process, irrigation and fertilization frequency are reduced and the light level may be increased. Proper hardening will ensure seedlings are more successful in the landscape.

Asexual Propagation Techniques

A group of plants originating from a single plant and reproduced by vegetative means is called a ***clone***. Most plants in the landscape plant industry are selected because of certain characteristics such as size, form, color and/or growth habit. Asexual propagation techniques usually ensure that plants being propagated will maintain the same characteristics as the parent plant.

In some species, asexual propagation may be the only way to perpetuate certain cultivars. These methods also bypass a plant's juvenile characteristics, which may have less desirable leaf and growth habits. Asexual propagation is the only practical way to multiply plants that do not produce viable seed or that have difficult to germinate seeds. *Ilex vomitoria* 'Schellings' and several junipers are examples of plants that do not normally produce seed. *Ilex* species (holly) are likewise ***dioecious***, which means male and female flowers are borne on different plants. Therefore, even with *Ilex* species that do produce seed, the plant desired for propagation may be a male plant that does not bear seed.

A plant produced by asexual propagation can become larger than a plant produced by sexual propagation in a similar amount of time. Although the advantages of clonal (asexual or

vegetative) propagation are numerous, one disadvantage is the lack of genetic variability. In a ***monoculture*** (production of a single crop with limited genetic variability), there is more threat of rapid spread of disease and insect infestations.

The most common method for asexual propagation is from cuttings. A cutting is any detached plant part which, under favorable conditions for regeneration of missing parts, will produce a new plant identical to the parent plant. Cuttings should be taken from healthy plants with desirable characteristics, and placed in a warm, humid environment to hasten root development and prevent drying.

Root production begins as soon as a cutting is severed from its parent. ***Root initiation*** and early root development occur inside the stem, leaf or root before new roots are visible on the outside. ***Callus*** tissue develops around wounded plant tissues to initiate healing when cuttings are removed from the plant. Callus formation appears as a somewhat hardened mass of newly formed cells, and usually precedes or coincides with root development in cuttings. New roots do not arise from the callus, but from the cambium beneath it; thus, excessive callus formation can actually slow the emergence of developing roots.

Figure 10. Callused base and newly rooted stem cutting.

Cuttings are taken from stems, leaves, roots, or combinations of plant parts such as stems with leaves. Many plants can be propagated with good results by several cutting types. The type selected depends upon the propagator's circumstances, the time of year, and the plant to be propagated.

Stem Cuttings

Stem cuttings can be taken from the stem tip containing the terminal bud or from secondary sections further down the stem. Many plants can be propagated from either, but plants usually root best from tip cuttings. Stem cutting wood is usually characterized as softwood, semi-hardwood or hardwood.

Softwood

Softwood cuttings are taken from woody plants when growth is still relatively soft and succulent before tissues have ***lignified*** (become woody); this physiological age is usually three to four weeks after a new flush of growth. Tissue of softwood cuttings will usually collapse when bent and not snap or spring back when released. Extremely fast growing, soft and tender shoots are not desirable, because they often will deteriorate before rooting.

Softwood cuttings usually root easier and faster than other types of stem cuttings (generally four to six weeks). Many ornamental plants can be started by softwood cuttings. Among them are crape myrtle, magnolia, oleander, azalea, jasmine and boxwood.

Figure 11. Prepared softwood cuttings of rosemary.

Semi-hardwood

A semi-hardwood cutting differs from a softwood cutting only in maturity of the wood. This type cutting is collected later in the growing season when the lower portion of the cutting has become lignified. Semi-hardwood cuttings are usually taken from new shoots six to nine weeks after a flush of growth when the wood is partially matured. Semi-hardwood is characterized by a snap when bent; the tissue is firm enough to stay intact, but not woody enough to spring back after bending. The snap or turgidity test is a quick way to determine if the material possesses proper maturity for successful rooting. However, the break must be clean, and not merely a bending of the stem. Many ornamental plants, such as camellia, pittosporum, junipers and some hollies and are commonly propagated by this type of cutting.

Hardwood

Hardwood cuttings are from the previous season's growth; the cuttings are taken just before or during the dormant period. This type cutting is commonly used to propagate narrow-leaved evergreens and deciduous species. For ***narrow-leaved cuttings***, mature terminal shoots of the current season's growth are usually used. Easier rooting has also been associated with cuttings taken from the lower halves of mature plants. In some instances, older and heavier wood can also be used, resulting in a larger plant when it is rooted. Not all narrow-leaved evergreens root at the same rate, nor do all propagate readily from cuttings. In general, low-growing *Juniperus* species roots easily, while upright junipers are more difficult to root. Narrow-leaved evergreen cuttings can be taken successfully throughout much of the year, but are best taken between late summer and late winter.

Deciduous hardwood cuttings are taken in the dormant season when tissues are fully matured or lignified through their entire length and when leaves have dropped. Common ornamental shrubs started by hardwood cuttings are crape myrtle and fruit tree species. In Florida, these cuttings can be planted in the propagating medium immediately after harvesting. Cuttings of some plants can be taken during the dormant period and stored at 40^{0}F until spring, during which time callusing occurs.

photo by neil bell, oregon state university

Figure 12. Examples of semihardwood cuttings in a propagation tray using peat and perlite media.

Figure 13. Deciduous hardwood cuttings of mulberry leafing out after rooting.

Leaf Cuttings

Leaf cuttings may be comprised of only the leaf blade or the leaf blade and petiole (leaf stalk). Leaf cuttings of some plants, such as the Rex begonia, are wounded by cutting the underside of the main veins before placing the leaf surface flat and in firm contact with the propagation medium. Leaf cuttings of many plants can be stuck upright in the propagation medium with the basal end of the leaf inserted into the propagation medium. Roots and new shoots will start at the base of the leaf or at points where the veins were cut. Begonias and peperomias are commonly propagated by leaf cuttings.

photo by irrec, uf/ifas

Figure 14. Examples of leaf cuttings stuck upright and placed flat in the medium.

Leaf-bud Cuttings

Leaf-bud cuttings are particularly valuable when source material is scarce because it produces at least twice as many new plants from the same amount of stock material as can be started by stem cuttings. Actually, each node can be used as a cutting. This cutting, which should be taken in the spring from partially matured shoots, consists of a leaf blade plus a short piece of the stem with the attached axillary bud. The stem section should be cut about 1/2 to 1 inch above and below the point of leaf attachment. The bud is then placed vertically in the rooting medium and lightly covered so only the leaf blade can be seen. This method of propagation has been successful with certain varieties of bougainvilleas, crotons and hibiscus.

photo by irrec, uf/ifas

Figure 15. Emerging shoots from wounded leaf veins.

Root Cuttings

Root cuttings are used infrequently in the nursery industry because of the labor required in taking the cuttings and, unlike stem and leaf cuttings, plants produced from root cuttings may not reproduce true to type or may have characteristics different from the parent plant. Plumbago, bayberry, some rose species, oak-leaf hydrangea and yucca are among the plants that can be propagated from root cuttings. Best results from root cuttings are likely if cuttings are taken in late winter or

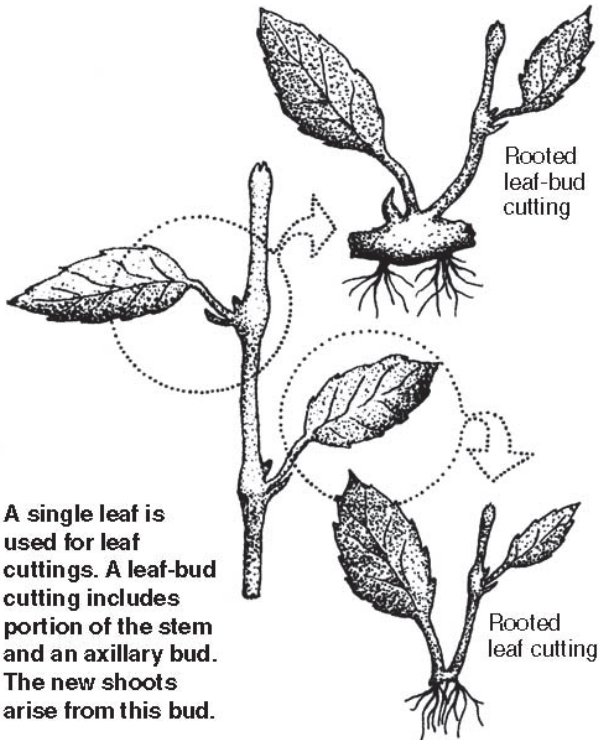


photo by us forest service

Figure 16. Example of leaf and leaf-bud cuttings.

early spring from two to three year old stock plants. The period in the spring when plants are actively growing should be avoided. Root cuttings can be treated similarly to deciduous hardwood cuttings. Cuttings can be taken in the fall and stored at 41^{0}F until spring or they can be planted immediately.

Stock Plants

Cuttings can be taken from production plants, from plants being maintained as a cutting source, or from plants in a landscape planting. The health and vigor of stock plants is extremely important because problems brought into the propagation area are usually magnified. Cuttings taken from stock plants growing under good management conditions are capable of more rapid root production than cuttings from poorly maintained stock plants.

Stock plants should be monitored for systemic diseases and insect infestations. These pests can be transmitted easily from the parent plant to the cutting, even though the symptoms may not be evident on cuttings. Care and nutrition of stock plants affects the success of rooting as well as the initial growth of liners. Periodic pruning or tipping of stock plants can result in improved cutting material in some species. Heading or cutting back the main shoots will usually force out numerous lateral branches from which cuttings can be made.

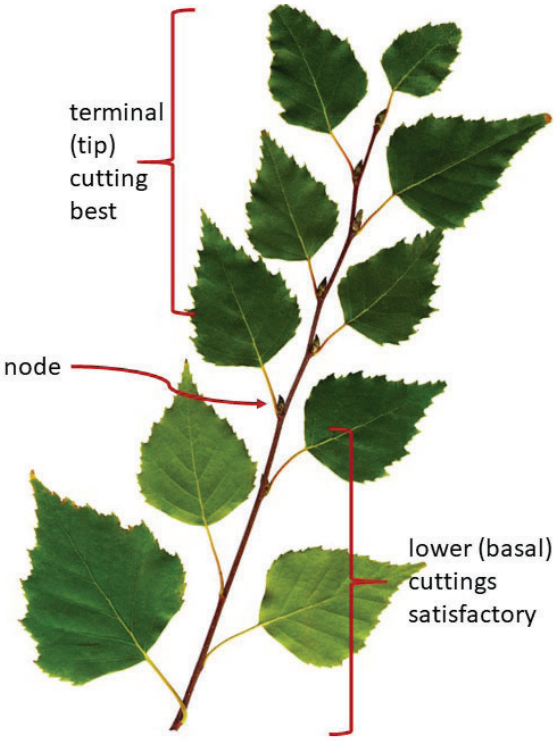
Figure 17. Stock plants pruned and maintained in production.

Taking and Preparing Cuttings

Cuttings with the desired characteristics and of the proper age should be selected from stock plants. Cuttings from portions of the plant canopy receiving higher light levels seem to root best. Do not select wood from extremely vigorous growth with abnormally long internodes or from small, weak growing interior branches. In most cases, cuttings taken from outside branches of relatively young plants root more readily than those taken from older plants of the same species. The position of the cutting on the plant can also affect growth after rooting.

After selecting the appropriate wood, section the shoot into cuttings of suitable lengths. The optimum size of a cutting differs with the species and the time of year. Cuttings can be divided into two types: terminal or tip cuttings and subterminal or basal cuttings. Tip cuttings will generally root faster and produce more uniform root systems.

Tip cuttings are made by taking the terminal five to six inches of the shoot with three or more nodes. The cut should be made just below a node. ***Basal cuttings*** are made



graphic by gale allbritton

Figure 18. Stem cutting locations.

by taking four to six inch sections of the stem below the terminal portion. Some propagators obtain satisfactory rooting responses using smaller cuttings only three to four inches in length. This may be necessary when cutting material is limited, but is not the recommended practice for most plants because the reduced leaf area could decrease rooting rate and percentage. Cuttings should be as uniform as possible so that all material will be equally exposed in the propagating container and for development of a uniform crop of liners.

Rapid handling of cuttings after removal from stock plants is important. To reduce water stress, cuttings should be taken in the early morning when stems are turgid and kept in clean, moist conditions out of the sun at all times until stuck (placed in the propagation medium).

The cuttings can be prepared for sticking at the time they are taken or they can be transported to a preparation and sticking area. If preparation of the cuttings is delayed, store them in the mist area, in a shady, cool spot, or in a refrigerated cooler. The proper storage temperature will differ with plants, but a temperature of 45^0 to 50^0F is suitable for most woody plants. Ice might be added to the container if refrigeration is not possible.

Before sticking, leaves are usually stripped from the lower third of the cutting. This practice reduces leaf contact with the propagation medium (thus reducing foliar disease potential), and exposes nodes for soil contact to encourage root development. If the upper leaves of cutting materials are extremely large (as on southern magnolia, some crotons and hibiscus), the size can be reduced by about one-third to allow closer spacing in the propagating tray. This practice allows better mist coverage, more light penetration and may reduce diseases because of increased air circulation. As a general rule, maximum leaf area should still be retained to produce a stronger root system in a shorter period. All flower buds should be removed because they use energy that can hinder rooting of many species.

To encourage branching some growers also remove the tip of terminal cuttings. This is a specialized practice rather than a rule. Plants may also require pruning while in the propagation area to develop the desired and/or uniform growth habit. The number of times pruning occurs depends on the plant and the length of time between rooting and potting into production containers.

Procedures for taking ***hardwood cuttings*** (deciduous species) differ from those for other

Figure 19. Cuttings harvested from healthy stock plants should be kept in clean, moist and cool conditions at all times.

Figure 20. Preparing stem cuttings for placement in rooting trays by stripping lower leaves.

types of stem cuttings. These cuttings can vary in length from four to 20 inches with at least two nodes included in the cutting. The basal cut is usually just below a node and the top cut 1/2 to 1-inch above a node. The diameter of cuttings may range from 1/4 to 1-inch depending upon the species. Where it is difficult to distinguish between the top and base of the cuttings, it is advisable to make all basal cuts at a 45^0 angle and the top cuts at right angles. It may also be beneficial to wound the basal area of some cuttings (such as juniper, maple, magnolia, some holly species and cuttings from older wood) to expose more cambium tissue for greater rooting potential. This can be accomplished with additional cutting or scraping of the bark.

There are several methods commonly used for handling hardwood cuttings before planting. In Florida, cuttings taken in the dormant season should be bundled and allowed to callus in storage boxes of moist sand or peat moss in either an unheated building or out-of-doors. After cuttings have callused and dormancy is satisfied, they may be potted. These cuttings can also be planted in the propagating medium immediately after harvesting.

photo by peter kulakow, iita

Figure 21. Hardwood cuttings with callus formation beginning at basal end.

Rooting Hormones

The purpose of treating cuttings with ***hormones*** is to increase successful rooting percentage, to hasten root initiation, to increase the number of roots per cutting, and to increase the uniformity of roots produced. The two most commonly used rooting hormones are the synthetic ***auxins*** indolebutyric acid (IBA) and naphthalenacetic acid (NAA). NAA is usually used in combination with IBA because NAA by itself is not extremely useful.

Rooting hormones come in various formulations and contain different ingredients. Auxin-based rooting hormones are available in dry (mixed with talc powder) or liquid forms (mixed with a carrier such as alcohol or water). Rooting products may contain from 500 ppm to 10,000 ppm hormone concentration, selected based on the ease or difficulty of rooting. Care should be taken when using rooting hormones because overapplication of some formulations can cause damage to the cutting base. Talc-based products have the advantage of being less toxic; formulations dissolved in alcohol are more prone to cause burn or dehydrate plant tissue.

Figure 22. Preparing stem cuttings with talc rooting hormone.

Rooting hormones are best applied just prior to sticking cuttings into the propagation medium. When using powder, care should be taken to avoid knocking the hormone off the cutting base when inserting it into the medium. Place only the amount of rooting hormone needed in a smaller container and dip the bottom 1/2 to 3/4 inch of the cutting stem into the powder or liquid hormone concentration. Never dip cuttings into the stock formulation. Remove a small quantity to satisfy immediate needs and discard any left after treatment. Do not contaminate the powder preparation or the stock solution by pouring used portions back into the original container.

Concentrated liquid solutions can be stored for relatively long periods of time if kept in a refrigerator at 40^0 to 45^0F and not exposed to light. Amber bottles or clear bottles wrapped completely with aluminum foil are suitable containers. Solutions should be brought to room temperature before use. This is necessary because the auxins may not be completely dissolved at lower temperatures and the solution would be less effective.

Sticking the Cutting

Because root initiation and growth require adequate oxygen, cuttings must be inserted into the medium at the proper depth. The cuttings should be stuck into the medium only deep enough to support the cuttings and hold them upright (approximately 1/2 to 1-inch), even in somewhat windy conditions. The base end of the cutting should always be inserted down into the propagation medium. While this is obvious with stem tip cuttings, it may not be so obvious with secondary stem or leaf cuttings. Root cuttings are generally pressed into the surface of the propagation medium and covered lightly.

Figure 23. Sticking stem cuttings in a propagation tray.

The length of time rooted cuttings can be left in a container or flat depends upon the rate of root and shoot growth and the density of sticking. Generally, liners that are harvested bare root are moved into production containers or the field without delay during the cooler, dormant season. Liners that are produced in containers can be transplanted during hotter and dryer conditions than those required for bare root liners. Containerized roots are undisturbed and the propagation medium remains intact to provide protection, water, air and nutrients to the liner during transport and establishment. Production of liners in containers is recommended if they are to be sold and transported to other nurseries.

photo by uf/ifas environmental horticulture

Figure 24. Oak liner rooted in a 2 1/4 inch container ready for transplant.

Figure 25. Newly potted liners being acclimatized in a shadehouse production area.

Post-Rooting Care

Fertilization must begin in the propagation phase as soon as roots emerge. The propagator can choose from many fertilizer methods, including liquid, soluble inorganic and several slow-release materials. Use caution because overfertilization can increase soluble salts to a point where newly developing roots would be burned.

Liners must be hardened before they are transplanted into larger containers and moved to the field. Hardening liners involves gradually altering the environment to become more like the environment where the plant will be transplanted. Conditions in the field are typically more stressful, with more intense light, higher temperatures and less moisture. Therefore, conditions must be changed gradually from the relatively cool, moist environment of the propagation area to those similar to field conditions.

To facilitate this acclimatization, the mist interval is gradually lengthened, and mist may be scheduled for fewer hours during the day. Light conditions should also be gradually changed to approach field conditions. Proper hardening of liners will minimize transplanting shock and help decrease the time required for liner establishment in the production container. Plants that have been adequately hardened are more likely to survive when transplanted into larger containers or the landscape.

Other Asexual Propagation Techniques

Effective but commercially less common methods of vegetative propagation include layering, division, grafting and budding. These methods require less manipulation of environmental conditions than cutting propagation. Furthermore, these methods may be the only viable way to propagate some species, especially if cuttings are difficult or impossible to root.

Layering

Layering is a relatively easy method of propagation; new plants are formed while attached to the parent plant. The new plant receives nutrients and water from the parent plant until roots develop. This method of asexual propagation yields a large plant in a relatively short time, and is an excellent way to propagate plants that are difficult to reproduce using other methods. Layering outdoors is best performed during spring and summer months, although it can be done during any season of the year. Spring and summer layers are usually rooted and ready for transplanting in the fall or winter.

Healthy, maturing branches that are growing vigorously and have been exposed to adequate light should be chosen for layering since these usually have more food reserve (carbohydrates) and therefore root faster. Branches from pencil size to about 3/4 inch in diameter are best for layering. While there are other methods, air and tip layering are the most popular for this form of propagation.