



Plant Propagation

Plant propagation is defined as the science and art of plant multiplication. New plants are created from a variety of sources, such as seeds, cuttings, bulbs and other plant parts. The act of propagation results in increased numbers of plants within a particular species or cultivar. The intricacies of plant propagation require knowledge of botany, horticulture, plant pathology, entomology and genetics as well as skills to grow, sell and distribute the resulting plant product.

The plant propagation industry is large and complex involving not only the group that multiplies plants for sale and distribution, but also those who provide services, sell the product or regulate distribution. The key person within this business is the **plant propagator** who possesses the knowledge and skills either to perform or supervise the essential propagation tasks for specific plants.

Very often, employees who mix soils, irrigate and fertilize, prune, or apply chemicals have little idea of how their actions affect the performance of propagation materials. Likewise, those who actually make the cuttings or otherwise start new plants may not be aware of the many factors that impact the final results of propagation, and how attention to

small details can spell the success or failure of the crop. All nursery employees, whether or not they deal with the practice of propagation, need to be trained in the mutually reciprocal importance of stock plant management, cutting or seedling selection and handling, cutting or seedling propagation techniques, and subsequent production methods. These integrative processes maximize the results of propagation efforts in the nursery setting.

Environmental Considerations

An environment that limits stress on the developing **propagule** (cutting, seedling, etc.) is essential for successful propagation. The propagation environment must also be kept clean to reduce any stress from insects or pathogens. High or low temperatures, excessive water loss, and light levels out of the desired range can limit the rate of development and result in death of the propagule. The propagator may modify the propagation medium, relative humidity at the leaf surface, air and soil temperature, as well as light intensity and daylength to optimize development and growth of **liners** (plants that have been propagated and are mature enough to move into the production phase).

Media

The **ideal medium** for outdoor propagation contains approximately 25% to 35% air space at **container capacity** (water remaining after irrigation and drainage). It is possible to produce quality liners in media with less air space when a covered greenhouse is used, and when irrigation and misting are precisely managed. However, a more porous medium is an excellent buffer during times of excessive rainfall or irrigation.

In addition to water and aeration properties, soil particle size in relation to seed size should be considered in media selection. There must be sufficient surface contact between the particles and the seed to maintain proper seed moisture. A small seed in a medium with large particles will not have adequate contact with the medium and will probably dry too much between irrigations. Media particle size is less critical for larger seeds.

Cost should also be a consideration, but an inferior media selection just because the purchase price is lower should be avoided. A quality medium is a wise investment and will pay for itself in healthier plants, fewer **culls** (inferior plants), and fewer pest problems.



Figure 1. Greenhouse benches used for propagation and growing. Bottom heat is provided by warm water circulating through black plastic tubing beneath the crop.

Temperature

Optimum temperature differs with plant species. Generally, air temperature of 70° to 85°F and soil temperature of 70° to 75°F have proven optimum for many plants commonly grown in temperate climates. Yet, the optimum temperature range for roots is narrow in comparison to that for shoots. To maintain ideal conditions, air temperature in enclosed structures must be controlled. Ventilation should be provided in the summer and on winter days with high light intensity.

Heat must be added during cold periods to provide optimum temperatures or to minimize cold injury. The strategies for cold protection differ greatly with the specific crop and climate in which plants are grown, but cost and return ratio is the primary consideration. It may be economically feasible to provide near optimum temperatures in a warmer climate, whereas in colder regions it may only be feasible to keep temperatures above those causing injury.

Heat can be added to the total air volume of the structure or may be strategically placed in relation to the crop. One efficient means is to heat the soil and allow the heat to rise into the crop canopy. Air temperatures two feet above the crop may be lower than desired, while the temperature around the plants is in the desired range. Heat can be provided to the root zone several ways, including below the bench heating and in the bench heating with heating cables or warm (100° to 115°F) water circulating through a series of polybutylene tubing or PVC pipe. An overhead plastic shield in a greenhouse, often called a thermal blanket or heat retention blanket, placed at or below eave height can also be used to reduce heat loss from the crop zone.

Light

The proper **light intensity** also differs with plant species. Some plants are quite efficient at lower light levels, while others may require almost full sun for optimum photosynthesis. Inadequate light intensity will result in leggy plants with weak stems that are sparsely foliated. Excessive light will stress the plant, resulting in a short, stubby, weakened plant with light green or yellowish foliage.

Since the products of photosynthesis are used for growth and development, it is important to maximize photosynthesis during propagation. Depending upon the air temperatures and ventilation capabilities in the propagation area, light level may have to be compromised between optimum light for photosynthesis and reduction of heat load on the structure.

Humidity

Relative humidity, the amount of moisture in the air, affects the degree of water stress in plants. This is especially critical for cuttings since they have no roots for water uptake to replenish the water lost through transpiration. The higher the water content of air adjacent to the leaves, the lower the amount of water loss. Intermittent mist and fog systems are the



Figure 2. Mist application raises humidity and provides gentle watering to developing seedlings or cuttings.

primary ways to maintain moisture content on leaf surfaces, by creating a nearly 100% relative humidity environment during the day when potential evapotranspiration is highest.

Water

The quality of the water applied during propagation is important. Higher concentration of calcium and/or iron in the water applied through a mist system results in deposits on the leaves. These deposits may not be obvious while the leaves are wet, but a white calcium or reddish iron deposit can reduce the attractiveness of the finished liner. These deposits probably do not reduce growth or vigor, unless they are extremely thick, but might reduce salability. Calcium and iron can be removed from irrigation water by filtration, though the cost of filtration may be prohibitory when large volumes of water are used.

Nutrients

Controlled-release fertilizers can be used in the propagation medium, but the rate of nutrient release and the period of release must be carefully considered because of the sensitivity of newly developing roots. A controlled-release fertilizer must be predictable over the range of temperatures and moisture conditions possible in a particular propagation system.

Soluble fertilizers applied at moderate rates give more control of nutrient levels in the medium but require more intense management; even so, soluble fertilizer should not be incorporated in the propagation media. Controlled-release fertilizers may be incorporated in the medium during mixing or applied to the surface after cuttings have been stuck or seedlings have been transplanted. Whatever fertilization program is chosen, routine monitoring of soluble salts and pH is essential. The propagator should be cautious when selecting and managing a fertilization system, and should fertilize with moderation during propagation.

Propagation Methods for Some Common Florida Landscape Plants

| Botanical Name Common Name | Seed | Layering | Division | Cuttings |
|--|--|------------|----------|---|
| <i>*Most common means of propagation</i> | | | | |
| <i>Abelia grandiflora</i> glossy abelia | --- | tip | --- | *semihardwood, tip, early summer |
| <i>Acca sellowiana</i> pineapple guava | collect fruit when they soften; remove fleshy pulp; germination in 2 or 3 weeks | --- | --- | --- |
| <i>Acer rubrum</i> red maple | *collect seed when mature in late spring; sow seed in outdoor bed or greenhouse flats in spring | --- | --- | softwood, tip, early spring |
| <i>Agave americana</i> century plant | --- | --- | clump | --- |
| <i>Aspidistra elatior</i> cast iron plant | --- | --- | clump | --- |
| <i>Aucuba japonica</i> Japanese aucuba | sow when ripe | --- | --- | *semihardwood, early summer |
| <i>Bougainvillea</i> spp. bougainvillea | --- | tip | --- | *semihardwood or hardwood, tip or stem |
| <i>Bursera simaruba</i> gumbo limbo | sow when mature | --- | --- | *hardwood; larger branches root readily |
| <i>Butia odorata</i> pindo palm | collect seed when mature before they fall; remove pulp; germinate immediately at 80° to 90°F for best results | --- | --- | --- |
| <i>Buxus</i> spp. boxwood | --- | --- | --- | semihardwood, tip, early summer |
| <i>Camellia</i> spp. camellia | scarification of seed coat necessary | air | --- | *semihardwood, tip, early summer grafting and budding |
| <i>Chionanthus virginicus</i> fringe tree | *cold-warm-cold stratification; takes over 2 years to germinate | air | --- | softwood (difficult), grafting, budding |
| <i>Chrysobalanus icaco</i> cocoplum | sow when mature; do not allow to dry out | --- | --- | *semihardwood |
| <i>Coccoloba uvifera</i> sea grape | collect and clean seed when ripe; germinate immediately at 75° to 85°F | --- | --- | *softwood, tip, summer |
| <i>Codiaeum variegatum</i> croton | germinate easily when fresh; much variability | air, mound | --- | *softwood, tip, or leaf bud |
| <i>Cycas</i> spp. sago palm | *remove fleshy coat when ripe; high humidity germination | --- | clump | --- |
| <i>Cyrtomium falcatum</i> holly fern | spores | --- | *clump | --- |
| <i>Dracaena</i> spp. dracaena | --- | air | --- | *softwood or semi- hardwood, tip or stem |
| <i>Duranta erecta</i> golden dewdrop | sow in spring | --- | --- | *softwood |

| Plant Name | Seed | Layering | Division | Cuttings |
|---|---|-----------------|----------|--|
| <i>Epipremnum aureum</i> pothos | --- | tip | --- | *leaf bud or stem, anytime |
| <i>Fatsia japonica</i> fatsia | germinate at 70° to 75°F | --- | --- | *softwood |
| <i>Ficus</i> spp. | --- | air | --- | *semihardwood, tip, or stem, summer |
| <i>Ficus pumila</i> creeping fig | --- | air, trench | --- | *semihardwood |
| <i>Gardenia jasminoides</i> gardenia | --- | --- | --- | *semihardwood, tip, early summer; grafting |
| <i>Gelsemium sempervirens</i> Carolina jasmine | --- | tip | clump | *hardwood, fall |
| <i>Gordonia lasianthus</i> loblolly bay | stratification required | air | --- | *softwood, early spring |
| <i>Hibiscus rosa-sinensis</i> Hibiscus | --- | air | --- | *semihardwood, tip; grafting & budding |
| <i>Heemerocallis</i> spp. daylily | sow when ripe | *clump | --- | --- |
| <i>Ilex</i> spp. holly | sow in fall or spring; cover seed with 1/8" to 1/2" of soil; complete germination requires 2 to 3 years | air | air | *semihardwood, tip, early summer |
| <i>Illicium</i> spp. anise | --- | tip | --- | *softwood, tip or 2" stem, early summer |
| <i>Ixora coccinea</i> ixora | --- | --- | --- | softwood or semihardwood |
| <i>Jacaranda mimosifolia</i> jacaranda | seed capsule black when mature; remove seed from capsule and germinate immediately | --- | --- | *softwood, grafting |
| <i>Juniperus</i> spp. juniper | germinate readily when available | --- | --- | *semihardwood, hardwood, tip, late fall; some are difficult |
| <i>Lagerstroemia</i> spp. crape myrtle | sow when ripe; germination in 10 to 14 days | root suckers | --- | *semihardwood, nonflowering tip, early summer; hardwood in winter; root |
| <i>Liriope muscari</i> lilyturf | collected in fall; remove pulp using food blender 3/4 full of water with rubber covered blades; germinate immediately at 70°F | --- | *clump | --- |
| <i>Magnolia grandiflora</i> southern magnolia | *collect when cones turn brown in fall; remove red fleshy part; stratify for 120 to 150 days at 50°F | air, tip | --- | semihardwood, tip, summer |
| <i>Magnolia soulangiana</i> Japanese magnolia | do not allow seed to dry; stratify for 120 to 150 days at 40°F | mound | --- | softwood |

| Plant Name | Seed | Layering | Division | Cuttings |
|--|--|-----------------|------------------|--|
| <i>Myrica cerifera</i> wax myrtle | *sow in late fall or spring to avoid germination and seeding mortality during winter; cover with 1/4" of soil; for spring sowing, seed should first be stratified at 34° to 40°F for 90 days | --- | --- | semihardwood, tip, early summer |
| <i>Nerium oleander</i> oleander | --- | tip, air | --- | *semihardwood, tip, early summer |
| <i>Ophiopogon japonicus</i> mondo grass | clean and stratify for 4 to 6 months at 40°F | --- | *clump | --- |
| <i>Plumbago auriculata</i> plumbago | sow when ripe | --- | clump | *softwood, tip, in spring; semihardwood, tip, in late summer |
| <i>Pittosporum tobira</i> pittosporum | --- | tip, trench | --- | *semihardwood, tip, summer |
| <i>Podocarpus</i> spp. podocarpus | sow when ripe | --- | --- | *semihardwood, tip, early summer |
| <i>Quercus</i> spp. oaks | do not let dry out; sow in fall or stratify at 40°F for 3 months | --- | --- | --- |
| <i>Rhapis excelsa</i> lady palm | --- | --- | clump | --- |
| <i>Rhododendron</i> spp. azalea | sow as soon as ripe; dry storage in airtight container at 40°F tolerated for 1 year; difficult due to small seed size | tip, air | --- | *semihardwood, early summer |
| <i>Rosa</i> spp. roses | --- | tip | --- | *softwood; hardwood in winter; grafting and budding |
| <i>Sabal palmetto</i> cabbage palm | same as pindo palm | --- | --- | --- |
| <i>Swietenia</i> spp. mahogany | collect before pods open; fast growing from seed | --- | --- | --- |
| <i>Tibouchina urvilleana</i> princess flower | --- | mound | --- | *softwood |
| <i>Trachelospermum</i> spp. confederate jasmine | --- | tip | *clump | softwood, early summer |
| <i>Viburnum</i> spp. viburnum | --- | --- | --- | *tip, early summer |
| <i>Washingtonia robusta</i> Washingtonia palm | same as pindo palm | --- | --- | --- |
| <i>Yucca</i> spp. | sow when ripe | --- | *clump, offshoot | root, fall and winter |
| <i>Zamia floridana</i> Florida coontie | *collect when ripe after cone falls apart; remove fleshy coat; scarify; high humidity | --- | clump | --- |

Source: Adapted from *Plant Propagation Techniques for the Florida Gardener (#CIR579)* by Sydney Park Brown, University of Florida, IFAS Extension. The asterisk (*) indicates the most common means of propagation.

Figure 44. Reference chart for propagation of common woody ornamental plants.

Micropropagation

The **in vitro** procedures (taking place in a laboratory vessel) used for establishment, growth and maintenance of plant cells, tissues and organs under controlled conditions of light and temperature are known collectively as **tissue culture**, micropropagation and, more recently, biotechnology. This method of asexual propagation requires a sterile environment, an artificial nutrient medium, specialized laboratory equipment, artificial growing conditions and highly skilled technicians. These requirements make the process rather expensive and limit the commercial applications of tissue culture to plants that generate high unit prices. However, one of the bigger advantages to the use of tissue culture methods is the resulting faster propagation of larger quantities, which ultimately saves greenhouse space and lowers disease potential.



Figure 45. In vitro plant production (tissue culture).

Commercial Methods of Micropropagation

Plants normally grow from division of meristematic cells found in the apical meristems at shoot or root tips or in buds at nodes. After division, these cells differentiate to form mature tissues of the plant body. Because of the highly organized cellular structure, apical meristems tend to be genetically stable and are most useful in micropropagation. Stem nodes are another area where meristematic tissue is present. This is the location where buds or branches and adventitious roots tend to form in conventional propagation. Tissue culture techniques attempt to manipulate normal responses in these areas by reducing internodes and increasing nodal tissue to enhance proliferation of meristematic cells used in micropropagation.

Shoot culture from axillary shoots has proven a reliable method and is the most frequently used micropropagation method for commercial production. This method relies on repeated in vitro stimulation of lateral shoots following the disruption of apical dominance. The process uses shoot tip or lateral bud **explants** cultured in a medium supplied with growth regulators, typically a cytokinin. The axillary shoots produced are either subdivided into shoot tips and nodal segments that serve as secondary explants for further proliferation, or are treated as microcuttings for rooting. The method provides better levels of genetic stability and is successful in a larger number of plant species.

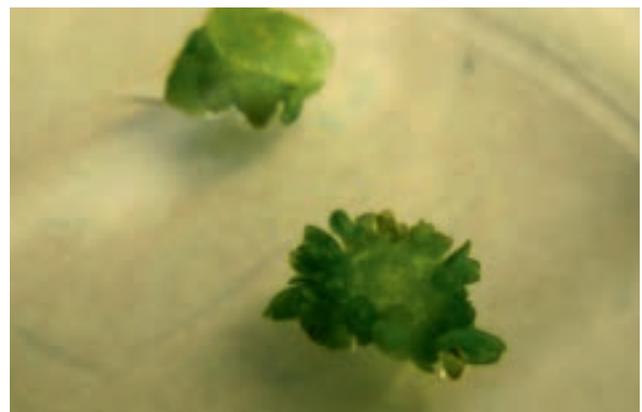


Figure 46. Shoot explants on tissue culture medium.

Micropropagation Facilities

Micropropagation facilities should include a preparation area, transfer area and culture or growing area. The facility should be separated from the regular nursery and greenhouse production area with restricted entry to avoid introduction of contaminants into the culture room. Floors, benches and table tops should be rigorously cleaned and technicians should wear clean lab coats, foot coverings and hairnets.

The **preparation area** serves to clean glassware, prepare and sterilize culture media, and stock supplies. At minimum, this area should have a refrigerator to store chemicals, scales to measure media components, an autoclave capable of reaching 250°F to sterilize media, a pH meter to calibrate media to the desired pH range (about 5.2 to 6), and water purifying equipment.

The **transfer area** is where explants are inserted into culture media, and where transfers of subcultures to fresh media take place. Transfer is done under a laminar airflow hood where air is prefiltered to remove dust and microbial spores. Ultraviolet (UV) germicidal lamps may also be used to sterilize the interior of the transfer chamber. Scalpels and forceps are inserted into instrument sterilizers capable of heating to 1,500°F and then cooled prior to division of explants. Microscopes with 20X to 40X power magnification may also be desirable for dissection of explant tissue.

The **culture or growing area** should have lights where both daylength and irradiance levels can be controlled and specific temperature regimes can be provided. Various types of rolling drum culture devices or shakers are sometimes used to provide aeration in liquid culture systems.

Culture Media

Tissue culture media usually include a semisolid support (agar), mineral salts (major and minor nutrient elements), an energy source (primarily sucrose), vitamins,



Figure 47. Glassware ready for sterilization in autoclave using high pressures and temperatures in the lab preparation area.



Figure 48. Explants and subcultures being placed into culture media using sterile instruments under a laminar hood in the lab transfer area.



Figure 49. Microcultures developing in the controlled environment of the lab growing area.

supplemented with growth regulators, and activated charcoal in very low concentration (0.3%) as a detoxifying agent. There is no one universal culture medium for establishment of all species, but most cultures require plant growth regulators at particular ratios and/or amounts for establishment and maintenance.

Various growth regulators are used in tissue culture media to control plant development. In particular, synthetic versions of auxins (NAA, IBA) and cytokinins (BA, 2iP) are most common. The type of **morphogenesis** (differentiation and growth) that occurs in a plant tissue culture largely depends upon the ratio and concentration of auxins and cytokinins present in the medium. Root initiation of plantlets, embryogenesis, and callus initiation all generally occur when the ratio of auxin to cytokinin is high, whereas adventitious and axillary shoot proliferation occur when the ratio is low. The concentrations of auxins and cytokinins are equally as important as their ratio.



Figure 50. Plants established in tissue culture media mixture.

| Auxin : Cytokinin Ratios | | |
|---------------------------------|--------------|------------------|
| Tissue Reaction | Auxin | Cytokinin |
| Callus | High | Low |
| Axillary shoots | Low to none | Very high |
| Adventitious shoots | Equal | Equal |
| Rooting | High | Low |
| Embryogenesis | High | Low |

Figure 51. Sample hormone ratios for culture media mixtures.

Artificial Light

Plants make their own food by capturing energy from the sun and fixing carbon dioxide from the atmosphere to produce sugar, energy and oxygen. Sugar is then used to produce carbohydrates, proteins and other needed compounds. Minerals from the soil (fertilizers, salts, etc.) are also used by the plant to manufacture needed compounds for growth and development. But plants in tissue culture do not receive enough energy from the artificial lights to use photosynthesis as their energy source, plus minerals from the soil are not present. Therefore, a culture medium is used to provide all minerals needed plus sugar. Plant cells can then convert the sugar into all of the compounds needed to grow into a plant.

Plants will still need light in culture rooms to regulate normal plant development. Light is needed to signal cells to develop chloroplasts and other components. Light wavelengths may influence tissue development. For example, blue wavelengths are better for shoot formation and red wavelengths are better for root formation. Without supplemental light, plants do not develop properly and typically will become yellowed and abnormally shaped.

Developmental Stages

In order to carefully manage each aspect of the regeneration and development process, micropropagation procedures are separated into distinct stages. Each stage of the sequence is manipulated through selection of explants and control of the culture environment. The system is based on the maintenance and multiplication of microshoots in culture to produce microcuttings.

Stage 0: Donor Plant Selection and Preparation

Careful attention must be given to the selection and maintenance of stock plants used as the source of explants. Stock plants used for micropropagation must be maintained in clean, controlled conditions to minimize the risks of contamination. During this phase,

practices such as trimming or plant growth regulator pretreatments are implemented to modify the physiological status of the stock plant and increase explant responsiveness in vitro.

Stage I: Explant Establishment Stage

The primary objective of this stage is the elimination of microbial contaminants on explants prior to placing them into the in vitro environment. Surface disinfection of tissues is usually accomplished using dilute alcohol or sodium hypochlorite (bleach). Disinfection agents must be thoroughly rinsed from the explant tissue with sterile deionized water. Explants are then placed on a sterile medium in culture vessels. This procedure is carried out using sterilized scalpels and forceps in the laboratory transfer area under a laminar airflow hood.

The explant initially grows by elongation of the main terminal shoot, with limited

proliferation of axillary shoots. A mass of microshoots is produced within a few weeks. The culture mass is subdivided after two to four weeks and subcultured on fresh medium. Division and subculturing are repeated at intervals.

Stage II: Multiplication Stage

The purpose of this stage is to maintain the microculture in a stabilized state and multiply microshoots to the number required for rooting. This is accomplished in a culture medium supplemented with a higher cytokinin level to disrupt apical dominance of the shoot tip and enhance repeated formation of axillary shoots.

Stage II cultures (transfers) are routinely subdivided into smaller clusters, individual shoot tips, or nodal segments that serve as propagules (plant pieces used in propagation) for further proliferation. Axillary shoot clusters may be harvested as individual unrooted

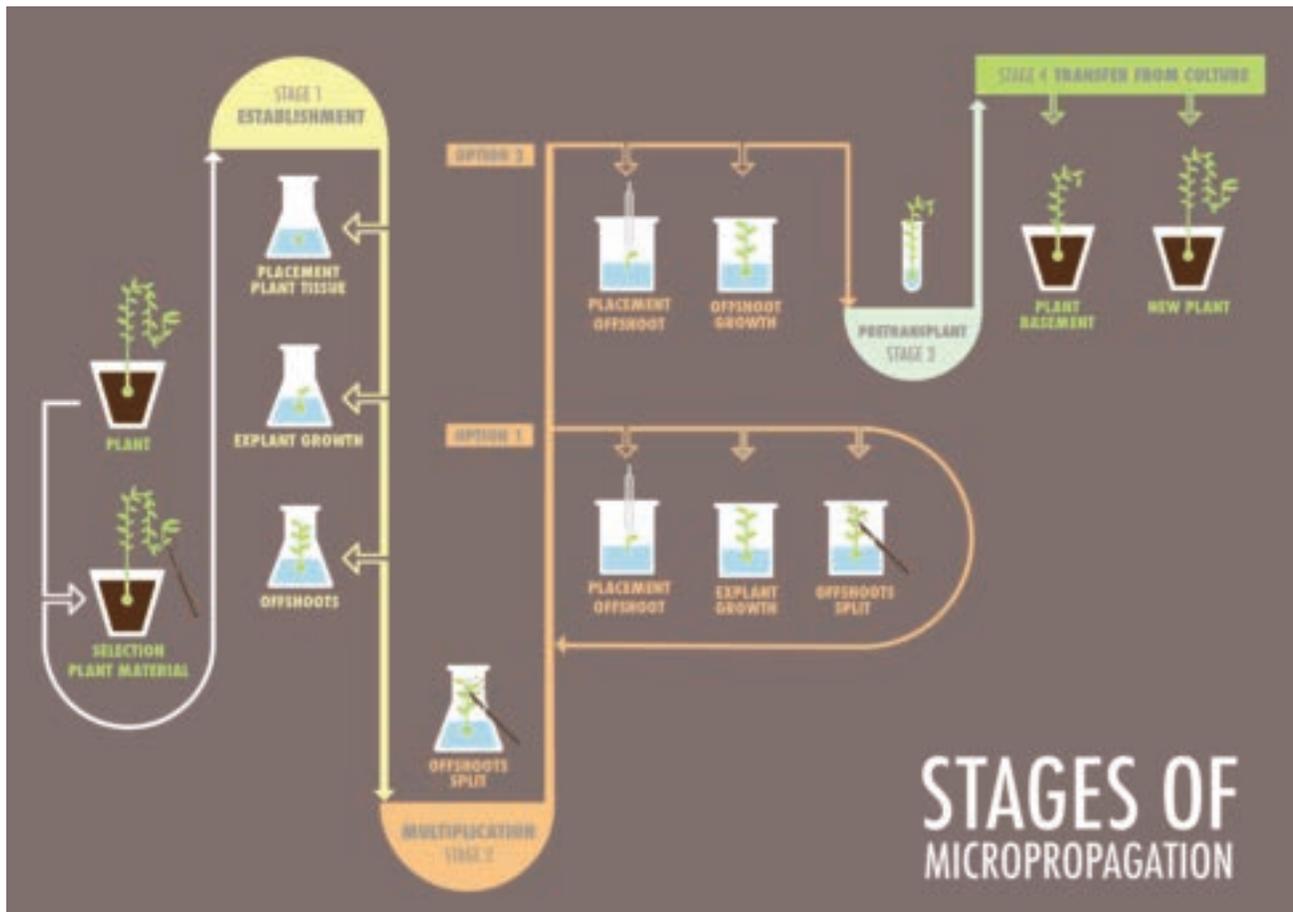


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Figure 52. Illustration of the developmental sequences of micropropagation.



Figure 53. Example of Stage II cultures ready for division.

microcuttings for ex vitro (outside tissue culture in potting media) rooting and acclimatization.

Stage III: Pretransplant (Rooting) Stage

This stage is often characterized by preparation of shoots or shoot clusters for successful transfer into soil. Stage III culture is used solely to elongate Stage II microcuttings (shoots) prior to separation and inducement of root formation. Since many plants readily develop roots in Stage II, this stage is often skipped in commercial tissue culture because ex vitro microcuttings tend to form roots that are more normal with a more well-formed vascular system. In some species, adventitious rooting and ex vitro plant performance is enhanced by the addition of an auxin (IBA or NAA) in the culture medium.



Figure 54. Hardening off tissue cultured plantlets in a greenhouse with lower light and higher humidity until sufficiently rooted.

Stage IV: Transplant (Acclimatization) Stage

This stage involves acclimatizing or hardening off plantlets to conditions of significantly lower relative humidity and higher light intensity. Tissue cultured plants have physiological and anatomical differences that often make them difficult to transplant. For example, micropropagated plants have a reduced capacity for photosynthesis and limited capacity to regulate water loss. To overcome these limitations, plantlets are transplanted into a well-drained “sterile” growing medium and maintained initially at high relative humidity and reduced light levels. Transplants are acclimatized by gradually lowering the relative humidity over a one to four week period. Plants are gradually moved to higher light intensities and exposed to more change in day/night temperatures to promote vigorous growth. During this stage, container size and growing medium have a profound effect on the quality of the plants produced.

Pest Management

External contaminants are present literally everywhere. Lab air, solid surfaces, improperly prepared media, improperly disinfected explants, improper aseptic procedures, and lab technicians are all sources of contamination in tissue culture. Explants, tools and the working area must be disinfested to remove surface contaminants. All work must be done in special transfer areas where contaminants have been eliminated and precautions taken to prevent recontamination.

Potential microbial contaminants in the lab include bacteria, fungi, mycoplasma (small bacteria), and viruses. These microbes can enter cultures as a result of human contact, improper aseptic techniques, dirty lab surfaces, or through explants taken from plants that were not properly maintained.

Contamination of cultures during micropropagation is often the result of fungal infections introduced by mites, tiny arthropods that are difficult to see with the unaided eye. While mites and other small insects such as thrips cause minimal damage to plant material, they may travel between culture vessels and tubs, acting as vectors carrying fungal spores and bacteria in and on their bodies into the tissue culture.

The best strategy to control tissue culture contamination is to establish aseptic (clean) cultures and to maintain good laboratory practice, including routine testing for contamination by microorganisms and microarthropods (mites).

Propagation Structures

Sophisticated structures are not always essential to successfully propagate most ornamental plants using the more common reproduction techniques. When propagating plants by cuttings, the main objective is to prevent wilting until roots are produced. A misting system inside or even outside a growing structure can provide the humid atmosphere required to avoid wilting and maintain plants in a turgid state.

Misting Systems

Intermittent mist systems (meaning the mist is on and off for specified periods) are widely used and have given propagators great flexibility in rooting cuttings. Such sprays provide a film of water over the cuttings and media.

The most important function of the film of water on leaf surfaces is to intercept the irradiation of light so that water is evaporated

from the surface, rather than losing internal water from leaf tissues. Intermittent mist systems control water loss from cuttings by reducing both leaf and surrounding air temperature through evaporative cooling, and by raising relative humidity. To counteract the lower media temperatures caused by mist, bottom heat is frequently used in outdoor and indoor rooting structures during the cooler months. Intermittent mist can also reduce leaching of nutrients and help prevent excessive water in the medium.

Intermittent mist systems may be used in greenhouse benches or in outside beds under shade. Raised beds are preferred to ground beds due to the ease of use and better drainage. Because ten minutes without water on a hot, sunny day can desiccate cuttings, mist systems used outside must be protected to eliminate wind drift and ensure complete mist coverage; otherwise, cuttings will become dry. In areas where freezing temperatures occur during winter months, check valves should be installed on the end of each line for drainage after each misting cycle.

Intermittent mist systems are dependent on the interaction of solenoid valves, mist nozzles and controllers to regulate water flow, distribute mist evenly, and control the timing of mist application.



Figure 55. Mist applied to rooting cuttings.

Solenoid Valves

Solenoid valves control water flow through the mist system in response to electrical signals sent from controllers. The valves are available in two types. The **normally open** solenoid valve is constructed to remain open and allow water to pass through if electric power becomes disconnected. Flow of electric current closes the valve and shuts off the water. If an accidental power failure occurs on the solenoid line or any failure in the time clocks takes place, the mist remains on continuously with no permanent damage to the cuttings.

A **normally closed** valve requires electric current to open and allow the flow of water. The normally closed solenoid valve is more readily available, has a cheaper initial investment, and will operate as efficiently as the normally open valve, but has the disadvantage of remaining closed causing the mist to stop when the electricity is off. To eliminate this problem, a bypass can be built into the system so the mist can be manually operated when power fails. However, if water pumps also operate

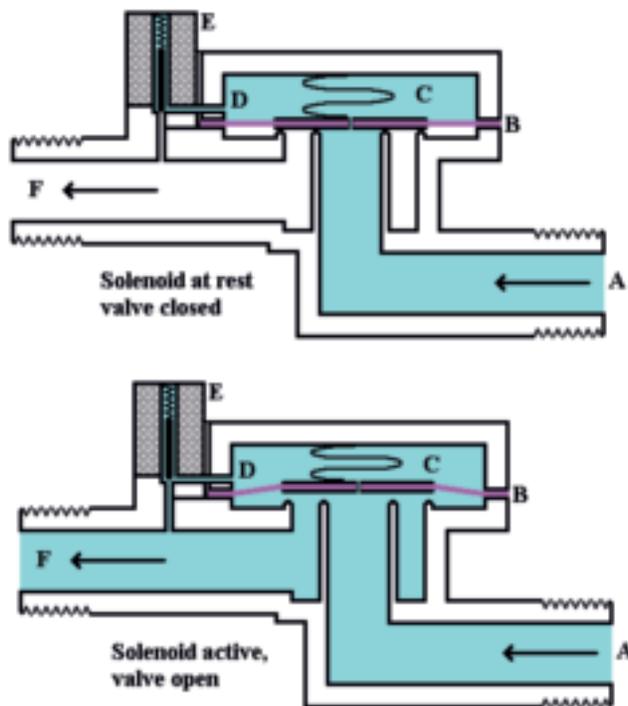


Figure 56. Water flows through pipelines from input A to output F. The solenoid E opens drain passage D in response to electrical current from the controller, thus allowing water movement around rubber gasket B.

from electric current, the bypass would be inoperative in a power failure. This could result in severe damage or loss of cuttings due to desiccation.

Mist Nozzles

Mist nozzles break water droplets into very fine, foglike particles so that droplets fill the area around cuttings, wetting both sides of the leaves. The primary function of mist is to produce 100% humidity and a continuous film of water over the entire leaf surface. The choice of mist nozzles is based on cost, maintenance, convenience in operation, availability from suppliers, size of mist droplet, amount of water used and mist pattern.

Most commercial propagators in Florida use **deflection type nozzles**. The deflection nozzle develops a mist when pressurized water passes through the orifice and strikes a flat surface or anvil. The larger aperture used in this type produces a rather coarse spray and greatly reduces clogging, but it uses larger volumes of water (4 to 20 gph). The height of the misting nozzles should be no less than 12 to 15 inches from the top of the propagating bed and not more than three feet above it.

Mist nozzles should be spaced effectively to cover the propagating bed. They should produce a spray with an umbrella pattern of 360 degrees. Different brands of nozzles deliver different mist patterns. Therefore, individual nurseries must select the type that fits the operation.



Figure 57. Example of a deflection mist nozzle.

Ideally, nozzles should be nonclogging and nondripping, easy to clean, low in cost, fit standard plumbing fittings and be easy to install and maintain. Most nozzles can be obtained with plastic, stainless steel, or brass orifice types. Those with a stainless steel orifice usually cost twice as much as those with brass, but they have a life expectancy five times greater than the brass orifice. All styles are available for installation directly to the line with adjustable fittings or with steel and poly (PVC) pipe or copper tubing.

Mist Controllers

Management of intermittent mist propagation systems can be accomplished using various types of controllers, either preset to specific operational times or with overrides influenced by environmental conditions.

The **preset mist system** requires two time clock controls. The day-night or 24-hour timer turns the system on and off at predetermined times. In addition, a cycle timer wired to the solenoid valve regulates mist cycles when the timer is on. The cycle timer is controlled by the 24-hour timer. The 24-hour clock turns the cycle timer on at a specified time in the morning and shuts it off at a specified time in the evening,

usually 2 hours after sunrise and 1 hour before sunset. Cycle timers are set to control the on-off mist intervals.

Environmental conditions have no influence on misting frequency when time clocks are used; therefore, close personal observation is needed and daily adjustment may be required.

Preset systems with environmental overrides use a thermostat controlled system to supersede the cycle of time clocks. When temperatures reach a certain level, the thermostat overrides the time clock controls and applies continuous mist until the temperature is reduced. A sensing element for the thermostat is placed just above the cuttings.

This system can also utilize a photocell to override the preset time clock. A short period of mist is applied after a predetermined amount of light has been received by the photocell. When using light to override the time clock system, the amount of misting does not vary; only the intervals between applications will vary. Therefore, the higher the light intensity, the more often the mist will turn on. This system is effective only in greenhouses where high humidity can be maintained.



Figure 58. A preset intermittent mist system is controlled with a 24-hour time (left) and a timer cycler (right) working together.

Variable environmental cycle systems have no time clocks; however, systems related to light, evaporation, or weight of water control the mist cycle. For example, an *electronic leaf system* maintains a uniform level of humidity at the leaf surface. The electronic leaf is activated as water evaporates from the surface of the leaflike extension and cuts off as water covers the surface. The function of this system can vary with placement of the “leaf” in the propagating bench; it is also difficult to use outdoors because wind influences the amount of water applied. In areas where water has a high salt content, salts tend to accumulate on the surface of the extension and prevent the “leaf” from turning the water on and off properly.

Multizone misting controllers work well with preset mist systems. They are designed to offer the highest degree of flexibility for growers who require a variety of misting intervals in different propagation zones. Plants in one zone may require a short burst of mist whereas plants in another may respond well to much longer periods of mist application at more widely spaced intervals. The ease of accomplishing independent misting programs is one of the best features of multiple zone misting controllers.



photo by phytotronics, inc.

Figure 59. Variable environmental system using an electronic leaf to activate intermittent mist.

The system that is best for one propagator may not be best for another. Systems, cycles, and the amount of water applied must be adjusted to fit the cultural and environmental conditions at individual nurseries. Absolute requirements in propagation structures dictate that the rooting media remain moist, but not wet, and that a film of water be constantly present over the cutting surface. Likewise, cuttings must be misted until well rooted. However, misting frequency should be reduced as cuttings begin to root in order to avoid soft and weak growth. Any system used must be capable of maintaining these conditions.

Summary

The art of plant propagation depends on both skill and insight. Achieving expertise is much easier with an understanding of the science behind the art. Although the optimum procedures for propagating ornamental plants differ with plant species and cultivars within species, the basic principles are similar. The procedures are more critical for some plants than others, but proper propagation practices will result in healthy, vigorous liners and quality plants growing in the landscape.

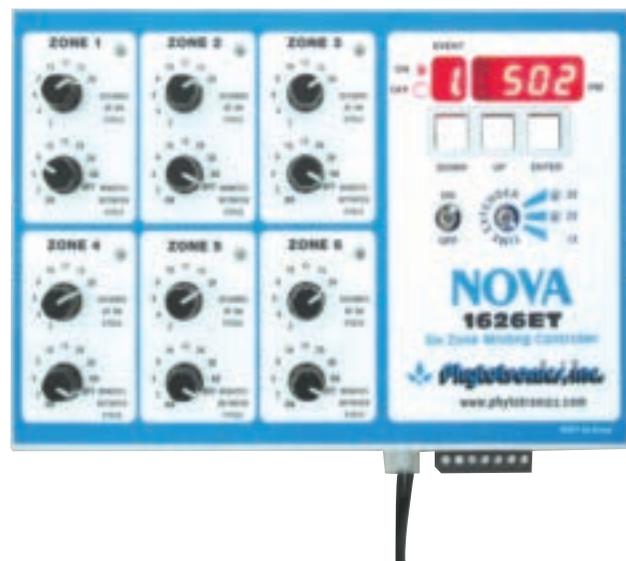


photo by phytotronics, inc.

Figure 60. Preset system with multiple zones to control seconds of mist and minute intervals between cycles.