Basic Principles of Vegetative Plant Propagation

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Plant propagation refers to the process of increasing or reproducing the number of new plants from a single parent plant. Plants can be propagated from seed (called sexual propagation) or from vegetative cuttings (called asexual propagation). With the exception of annual bedding plants grown in flats, most of the important greenhouse crops are propagated via vegetative means. Examples of crops that are propagated from some type of vegetative cutting or division include poinsettias, mums, orchids, carnations, roses, florist hydrangea and azaleas, flowering bulb crops such as lilies, zonal geraniums, most new guinea impatiens, many herbaceous perennials, and many of the species used for spring flowering baskets.

It is generally more costly to produce plants through vegetative propagation than from seed. Consequently, vegetative propagation is most often used on high-value crops or on crops that are difficult to reproduce true to type from seed. With vegetative propagation from cuttings or division, the new plants are identical to the parent plant. Another advantage of vegetative propagation is the reduction in the time to flower. This is especially true with plants that may have a long juvenile stage such as orchids, bulbs or many woody perennials.

There are several methods of vegetative propagation that can be used for greenhouse crops. These include semihardwood cuttings (azalea), herbaceous cuttings (geranium, poinsettia, mums, coleus, new guinea impatiens), leaf cuttings (rex begonia, african violets), leaf-bud cuttings (hydrangea), root cuttings (poppy, phlox), propagation by runner (chlorophytum or spider plant), separation (bulbs and corms), and division of rhizomes (iris), tuberous roots (dahlia) and crowns (phlox).

Propagating plants by division or from runners involves a relatively simple procedure and no special facility. The new division contains complete plants with functional shoots and roots. Producing a viable plant from a shoot cutting is more complicated than from division and requires special controlled environment facilities. These cuttings must be protected until a new root system is formed. By comparison, leaf cuttings are even more challenging to propagate than shoot cuttings because they must form both roots and shoots before the propagation process is complete.

The Anatomical and Physiological Basis of Rooting

Using a shoot tip cutting as an example, the rooting process involves the following steps. Once the cutting is removed from the stock plant, the cells on the wound surface die and form a necrotic plate. This plate helps protect the living cells from infection from pathogens. The water conducting tissue in the stem (the xylem) becomes plugged with gum. As a result cuttings do not readily take up water and nutrients. In a few days, the cells behind the plate begin to divide and the formation of root initials begins. Finally, primordial roots begin to grow and emerge through the stem tissue and into the rooting medium. In some plant species, dormant adventitious roots may already be present in the stem at the time the cutting is taken.

Hormones control the root development process. Auxin is the hormone that triggers the metabolic processes that leads to root formation. This process may not be completed even when adequate auxin is present if certain chemical cofactors are missing. These chemical cofactors work by increasing auxin activity or by preventing the enzymatic breakdown of auxin within the plant tissue. Synthetic auxins such as IBA and NAA are sometimes applied to cuttings to stimulate root formation. Most propagators are familiar with the commercial synthetic auxin products Dip 'N Grow, Rootone and Hormodin.

Cytokinins are a separate class of hormone that generally inhibit rooting but stimulate shoot forma-tion. Cytokinins are produced naturally by plant roots, while auxins are produced naturally by shoot tips.

Plant response to externally applied hormones varies with each species. Some plant species do not require auxin treatments to root, while some species root much more readily when auxin is applied, and still other species are difficult to propagate vegetatively regardless of hormone treatments. Species that root easily without auxin treatments naturally produce the auxins and co-factors required for the rooting process to occur. Species that respond favorably to auxin treatments possess the necessary metabolic cofactors but do not produce adequate levels of natural auxin. Species that fail to root, even when auxin is applied, may or may not produce adequate amounts of natural auxin. These species lack the co-factors needed to either enhance auxin activity or to protect auxin from being destroyed within the plant tissues.

The fundamental basis of root formation in cuttings is still not completely understood. From a practical standpoint, most of the plant species used by the greenhouse industry root relatively easily. However, if this is not the case, propagators are advised to refer to the reference book *Plant Propagation* by Hartmann, Kester, and Davies (Prentice Hall, 1990) to find the specific propagation practice recommended for each plant type.

In addition to the cultivar and specific differences that affect rooting, environmental conditions during rooting, the physiological status of the cutting, the condition of the stock plant prior to cutting removal, the type of plant tissue used for propagation and the seasonal timing of cutting removal may all influence propagation.

Selecting Cuttings from Stock Plants

Clean stock is a top priority. Cuttings removed from plants infected with viral, bacterial or fungal organisms represent the foundation of a failed crop. Stock plants must be free of all insect and disease organisms. (See article "Preventing Pest Problems during Propagation" in this issue.)

Only select cuttings from turgid stock plants. Cuttings taken from water stressed stock plants root less vigorously than cuttings from turgid plants. A buildup of stress hormones in cuttings removed from water-stressed plants may play a role in reducing rooting vigor. The air temperature that the stock plant is grown at will not affect the rooting of cuttings, as long as extreme temperatures are avoided.

The light environment that the stock plant is grown under will affect cutting performance. Light quantity, day length and light quality are all important. In general, light conditions that promote vegetative growth over flowering promote the rooting of cuttings. For crops that flower under short-day conditions (i.e. mums and poinsettia), stock plants should be maintained under long-day conditions so that flowering does not occur. Light conditions that stimulate dormancy will also inhibit the rooting performance of cuttings. Some plant species root most vigorously when stock plants are shaded prior to cutting removal (jade plant, schefflera, rhododendron), while the complete exclusion of light from a portion of the stem (a process called etiolation) stimulates rooting in other species (clematis, hibiscus).

Carbohydrate levels in the stock plant greatly affect rooting of cuttings. A stock plant produced under optimal light will produce cuttings that have a good store of carbohydrate reserves. Once the cutting is removed, these reserves will help fuel the development of new roots. The nutritional status of the stock plant is also important. Any nutrient deficiency will adversely affect rooting. Nitrogen is the exception. Excessive nitrogen fertilization during stock plant development reduces cutting quality and subsequent rooting performance. Low nitrogen status actually enhances rooting in some species.

The Rooting Environment

Do not allow cuttings to wilt. Mist cuttings and stick in the propagation bench immediately or mist and store cuttings at a cool temperature (40° to 45°F) until planting. Once on the propagation bench, maintain cutting water status by balancing water uptake with water loss. For cuttings, this is achieved by preventing water loss from leaves using mist, fog or plastic enclosures (cuttings lack the ability to rapidly take up water through the stem). Mist works well to prevent wilting, but it also tends to leach nutrients out of cuttings. Mist can also oversaturate the rooting medium and evaporation off the soil surface cools the root zone to undesirably low temperatures. Enclosures are cheap and easy to use, but they trap heat and prevent air circulation. Fog systems present the least problems for rooting (since water does not accumulate on surfaces, overwetting, nutrient leaching and overcooling do not occur), but these systems are expensive.

In terms of effectiveness and costs, misting is usually the best alternative. Use intermittent misting to prevent oversaturating the soil and to reduce nutrient leaching. Short mist intervals (3 to 15 seconds) should be used. The off cycle duration will depend on how quickly the mist evaporates. **Note:** The longer a plant takes to root, the more nutrients will be leached by misting. It is important to start with cuttings from stock plants that have a good nutrient status. A low level of liquid fertilizer or slow release fertilizer can be applied to the rooting medium so that some nutrients will be available to the cutting as soon as viable roots develop.

Root zone heating should be used with misting. For most species, a temperature of 65° to 77°F in the root zone is best for rapid rooting to occur. Optimum air temperature depends on the species. Generally, a daytime air temperature in the range of 70° to 80°F and a 60°F night temperature is desirable.

Light levels must be high enough to support adequate photosynthetic activity without overheating the plant. Light levels as low as 500 footcandles or as high as one-third full sun are good for herbaceous plants like poinsettias, mums and geraniums.

Environmental Control

Since the propagation environment is key to successful propagation, propagators need to incorporate some type of environmental control into their system. A typical mist control system involves a controller that triggers a magnetic (solenoid) valve. The controller can be as simple as a time clock or as sophisticated as a computer. With time clocks, a 24-hour timer is used in series with a short-interval timer. The 24-hour timer energizes the interval timer during daytime hours only, and the interval timer runs on a regular on/off cycle during this period.

Timers are not responsive to fluctuations in light caused by variable weather conditions. Overmisting or undermisting can result. Electronic leaves and screen balance controllers measure water evaporation to estimate the environmental conditions on the propagation bench. These types of sensors are sometimes subject to fouling from poor quality water or algae growth. Photoelectric cells sense light directly and use a counter to determine when to mist. A computer can integrate the signals from a number of sensors to control conditions in a number of different environments simultaneously. Computer control is expensive and may not be practical for small scale or strictly seasonal propagation .

Mist distribution must be uniform over the propagation area. Water may have to be filtered if it contains sand, silt or debris that will clog nozzles. Dissolved nutrients such as sodium can also be a problem if levels are high.

Temperature must also be controlled. Temperature can be controlled with a thermostat or from a computer. It is important to sense the temperature in the plant environ-ment. Locate a sensor directly in the root-zone to control the rooting medium temperature. Use an aspirated ther-mostat or thermocouple to sense air temperature. (See "Designing a Root Zone Heating System" in this issue).

Acclimating the Rooted Cuttings

During rooting, the aim is to minimize stress. Once cuttings are rooted, they must be slowly acclimated to a more stressful environment. The hardening-off or wean-ing process begins as soon as functional roots develop. Start by removing the plants from mist and provide a low level of nutrients (50 ppm N from a complete fertilizer formulation will do). Allow plants to stay under low light until they can remain turgid without mist, but be ready to syringe by hand if they do wilt. Gradually increase light exposure until the cuttings can tolerate normal green-house light conditions. The entire acclimation period should take about seven to 10 days.