SUCCESSFUL vegetative propagation of any cutting requires both a healthy, preferably vegetative cutting, and a rooting environment with the proper balance of light, temperature, water, and humidity. In addition, disease and insect pests must be controlled during the rooting process. This article will discuss the keys to successful propagation of vegetative perennial cuttings, including environmental factors and cultural procedures.

Successful propagation of cuttings demands an environment in which desiccation (drying) is prevented until roots develop sufficiently to support a growing and transpiring plant. Limiting light, maintaining high relative humidity, and limiting air flow around leaves are all essential to prevent rapid drying of cuttings. Therefore, humid still air and low light levels constitute an ideal rooting environment. Practical experience has shown that the less a cutting is misted during propagation, the fewer the problems during rooting - disease incidence is reduced, nutritional leaching is reduced, leaves are healthier, and cuttings root faster. Let’s discuss the ways cuttings can be rooted rapidly with minimal misting.

Light. Light is the primary energy source for evaporation of water in plants. Every propagator knows that mist must be applied more frequently on sunny days than cloudy days and during the day than the night. Therefore, controlling light intensity, especially during the first few days after a cutting is stuck, is critical. Light levels during the first week after sticking should be no higher than 1,500 footcandles. Higher light levels cause rapid drying, so frequent misting becomes necessary. High light

Part three of our 12-part series on herbaceous perennials examines the keys to successful vegetative propagation.

Figure 1. Example of well-designed propagation house. The double poly structure helps maintain high humidity and diffuses light, while the curtain system allows for light modulation as needed based on ambient light intensity and developmental stage of cuttings. High-pressure fog helps maintain high humidity, boom (not shown) allows misting of cuttings as needed, and lights provide photoperiodic control or supplemental lighting as needed once the crop is rooted. Also not shown is hot-water heating under benches and a fan and evaporative-pad cooling system.

Figure 2. High-quality, well-rooted, vegetative achillea ‘Moonshine’ (left) and leucanthemum ‘Snowcap’ (right) plants five weeks after sticking.
Copper Ion Generators

Automatically cleans, disinfects, removes scale and algae deposits from the plumbing and irrigation system.

Applies a positive charged copper ion. The positive charged ions have a natural attraction to plants and trees. This adhesion of copper ions insures a high residual protective coating on a product.

Kills algae, and mold on plants, plant trays, and in the greenhouses, reducing the chance of diseases spreading. This also enables the root system to absorb greater quantities of nutrients.

Copper ions are highly active. Concentrations are below two parts per million. There are no concerns regarding copper toxicity in the soil or harm to copper sensitive plants.

Flats can be dipped in a mixture of chlorine and ionized water for disinfection purposes, reducing chlorine cost.

For information package call:

Superior Aqua Enterprises, Inc.
Sarasota, FL
941-923-2221 or 1-800-225-0119 Fax: 941-925-4509
www.superioraqua.com superioraq@aol.com

56 varieties produced every week from our own tissue culture labs

WE SUPPORT ALL BROKERS!

Kwic-Klip

www.jaderloon.com

For Details Circle No. 111 on Postcard or at www.greenhousegrower.com

Temperature. Temperature is generally the most readily controlled factor in propagation. The critical temperature is that of the rooting medium because it controls the temperature of the stem tissue where roots will form. If the stem tissue is cool, cell division and differentiation will be slow, and so will rooting. The optimum medium temperature is 73° to 77°F (23° to 25°C), and bottom heat or bench heating is essential to maintain the proper medium temperature.

An air temperature of 68° to 73°F (20° to 23°C) is adequate when bottom intensity can also bleach the foliage.

Although excessive light is problematic, very low light can be deleterious to rooting. Cuttings utilize energy from light to synthesize the carbohydrates that are necessary for cell maintenance, division, and growth. Light levels should be at least 1,000 footcandles during the middle of a sunny day; cuttings are slow to root or fail to root when it is too dark.

During mid-summer when light is intense, whitewash or exterior shade fabric in combination with retractable interior shade curtains provides the optimal system for light modulation (Figure 1). Retractable interior curtains allow more light transmission on cloudy days than would be possible with a fixed shading system.

Photoperiod is often not controlled in perennial propagation. However, for some species, photoperiodic control is very important. Plants that do not require a cold treatment to flower, such as achillea and sedum, will bolt to flower under the long days of summer. As a general rule of thumb, we believe the optimum daylength for propagation is about 13 hours.

Vegetative cuttings rooted under controlled photoperiods will develop into excellent plugs (Figure 2).

WE SUPPORT ALL BROKERS!
Heat is available to maintain medium temperature. If bottom heat is not available, air temperature will need to be 77° to 80°F (25° to 27°C) to maintain adequate medium temperature. Maintaining air temperature lower than medium temperature is desirable because it reduces shoot growth while roots form and reduces the requirement for misting. Proper temperature control of the air and medium encourages rapid rooting and thereby reduces the risk of attack by pathogens.

Humidity. Evaporation from a wet leaf is driven by vapor pressure deficit (VPD), the difference between the water vapor pressure of the bulk greenhouse air and water vapor pressure in the air immediately surrounding the leaf. When plant and air temperature are the same and the humidity is 100%, VPD is zero and no evaporation occurs. Therefore, no misting is necessary. This situation seldom occurs, especially during the day because, even if the air were saturated, energy from the sun warms leaves. The warmer leaf will have a higher vapor pressure, resulting in a VPD between the leaf and the air.

However, we can limit VPD and hence water loss by increasing the water content of the air (i.e., increasing air humidity). Humidity in a propagation house will generally be higher if the number of air exchanges is limited. If humidity is low, as is common in glass greenhouses when the outside air temperature is cold, water vapor should be added to the air. In our research propagation house, we increase humidity by adding steam to the air to maintain a VPD no higher than 0.7 kPa (at least 75% relative humidity). When steam is not available, humidity can be increased with fog delivered by either high pressure (Figure 1) or a fan-driven water atomizer (Figure 3).

High humidity in a propagation house is easier to maintain during the winter in double poly houses than in single poly plastic or glass-glazed houses because less water condenses on the glazing.

Low air velocity is also essential in a propagation house. As air velocity increases, evaporation increases. In addition, evaporation cools the leaf and soil, creating a situation in which medium temperature is lower than desired, and additional energy must be invested to heat the soil. Use of hori-
zontal airflow (HAF) fans is not recom-
mended during the early rooting stage in propagation because they dry the cuttings. Once cuttings have root-
ed, HAF fans can be useful for the same reason.

Misting. If the environment is ideal (i.e. humid still air and low light lev-
te, humidity, and natural light lev-
els).

Highest quality cuttings will devel-
op in humid propagation houses where the environment limits evapo-
ration, and misting can be infrequent. In a humid propagation house, night-
time misting should not be needed after the first few days a cutting is stuck. Infrequent low-volume misting is important because misting that is heavy, frequent, and lengthy leads to leaching of nutrients from the soil and plant leaves. Leaching of plant foliage nutrients leads to chlorosis, necrosis, and disease. Leaching of the medium means micro- and macro-nutrients must be recharged as cuttings root and are weaned from the mist. An alterna-
tive to mist propagation, especially effective under moderate temperature and light conditions (i.e. during the winter), is to tent benches until cut-
tings root (Figure 4).

Water. Water quality is also impor-
tant during propagation. Water low in salts, bicarbonates, sodium, and boron is especially important. If quality water is unavailable, rainwater collect-
ed off the greenhouse is an alternative, as is the use of reverse osmosis. If water quality is otherwise good but has high bicarbonate levels, neutralize the bicarbonates to 60 to 80 ppm to im-
prove rooting of many plants. The best
acid for neutralization is nitric acid because the reaction products yield a nutrient solution equivalent to that made from calcium nitrate and magnesium nitrate. Such water does not leave residue on the foliage. The drawback of nitric acid is that it is dangerous to work with; proper equipment and training are essential.

Sulfuric and phosphoric acids reduce bicarbonate in water, but the reaction products are insoluble and leave a residue on the cutting foliage. For sulfuric acid, the reaction product is calcium sulfate or gypsum, the same component as in drywall sheets. For phosphoric acid, the reaction product is calcium phosphate, a major component of superphosphate.

Medium. Aeration of the propagation medium is important because oxygen is necessary for cell division and root formation. A saturated medium with low oxygen levels causes slow rooting and, under high temperatures, can lead to erwinia infections that can kill the cuttings. We have found that some hard-to-root species such as campanula 'Birch Hybrid' readily root when propagated in medium composed of 65% perlite and 35% peat moss.

Rooting hormone. Auxins delivered as rooting hormones accelerate rooting of many cuttings. Most cuttings benefit from IBA at 1,500 to 2,500 ppm. For slow-rooting species, dipping cuttings in a high concentration (for some species, up to 10,000 ppm) of rooting hormone may accelerate the rooting process. Both powder and liquid forms of IBA are available. We prefer the liquid formulation because application is more uniform between cuttings. With powder, some cuttings may get a heavy dose if the cutting is wet, while a dry cutting may get almost no rooting hormone. Care must be taken, however, to maintain the liquid level in the dipping container when using the liquid formulation (Figure 5).

Also, some species are especially sensitive to the alcohol in some IBA liquid formulations. If cuttings are dipped too deeply in the IBA, or if cuttings are turned upside down so the solution runs on the growing point, leaf twisting may occur (Figure 6).

Table 1. Action Plan For Herbaceous Perennial Propagation

<table>
<thead>
<tr>
<th>Time</th>
<th>Stage of Development (Desired Light Levels)</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Stick to callus (about 1,250 footcandles)</td>
<td>Stick cuttings</td>
<td>Stick cuttings</td>
<td>Stick cuttings</td>
<td>Apply broad spectrum fungicide drench plus fungic, gran insecticide</td>
<td>Apply fungicide as spray for foliar diseases</td>
</tr>
<tr>
<td>Week 2</td>
<td>Callus to rooting (1,250 to 2,000 footcandles)</td>
<td>Apply 200 ppm nitrogen from complete fertilizer such as 20-10-20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 3</td>
<td>Weaning and hardening (2,500 to 3,500 footcandles)</td>
<td>Apply 200 to 400 ppm nitrogen from complete fertilizer such as 20-10-20</td>
<td></td>
<td></td>
<td></td>
<td>Apply systemic insecticide at exit</td>
</tr>
</tbody>
</table>

Pathogens. The incidence of disease during propagation depends heavily on plant species, the condition of the cutting when stuck, the propagation room environment, and the duration a cutting is under mist. Species like achillea are susceptible to foliar decay when rooting, while clean cuttings of plants like pachysandra may not show any disease symptoms for a month or more during propagation. Cuttings infected with pathogens quickly rot, while clean cuttings of the same species remain healthy. Rogue dead, dying, and diseased foliage at least weekly to avoid disease spread.

Excessively high temperatures (generally above 86°F/30°C) in the propagation room can lead to bacterial infections, especially if cuttings are frequently...
misted and the medium becomes saturated. The longer it takes a cutting to root, the more susceptible it becomes to infection. Rapid rooting is one of the best ways to avoid disease problems in propagation.

Fungal diseases can be controlled by using a broad-spectrum fungicide drench within five days of sticking and using weekly fungicidal sprays to help control foliar diseases. Fungicides, however, generally will not control bacteria, although some copper-based products reportedly have some efficacy. Avoiding high temperatures and excess water are the keys to bacterial control.

Fungus gnats. One should always assume that fungus gnats are already in the medium or will infect it during propagation. Fungus gnat larvae will feed on the cuttings' stems, inhibiting rooting in many species. We believe an insecticide should be applied as a drench within the first five days after a cutting is stuck to control any fungus gnat larvae that may be present.

Nutrition. Cuttings do not require nutrition from the soil during the first few days after sticking. However, as the cutting starts to root, it benefits from a balanced but low charge of nutrients in the soil. Mist propagation generally leaches the soil of all nutrients, including nitrogen, potassium, phosphorous, and all the minor nutrients.

There are no universal recommendations for fertilization as cuttings root, other than the application of a complete fertilizer with minors. Many cuttings benefit from applications of at least 400 ppm N and K as they start to root, especially if misting has leached the soil. Other cuttings such as New Guinea impatiens will not tolerate such high fertility rates and elongate rapidly when fertilized with more than 100 ppm N and K. Chlorosis generally means the cutting is nutrient deficient and fertilization is required immediately to maintain quality as roots form.

Weaning. As the cuttings develop callus and start to form roots, mist should be reduced to gradually harden them off. If a computer mist program is not available to reduce mist every day, one should gradually weaken cuttings off mist in steps according to the stages of rooting. We use three stages: Stage 1 is from sticking to callus, Stage 2 is from callus to roots about one inch long, and Stage 3 is from one-inch roots to production growth. In most cases, it is beneficial to increase light levels from one stage to the next to acclimate the rooted cutting to its final growing conditions.

Summary. Propagation requires the proper light, temperature, and aerial environment. Insect and pathogen control is also important. Table 1 shows the general chemical action plan we use in our research propagation houses. This program has been highly successful for us, with high rooting percentages and few plant losses.

About the authors: David Joeright and Dan Tschirhart are technicians, and Royal Heins, Arthur Cameron, and Will Carlson are professors, Department of Horticulture, Michigan State University, East Lansing, MI 48824.