are then placed into boxes until they can be tied into bundles of approximately 100 sticks. The tops of bundles are painted with spray paint to indicate the color of the flowers and which way is up.

The bundles are then placed in fumigated cypress sawdust and covered with approximately 10 cm (4-in.) of saw dust. The bundles are kept warm and moist through winter until 1 April. The cuttings are then stuck in raised fumigated ground beds. As a reference, our last frost is usually 15 April. The cuttings are rooted and grown in the raised beds until the first winter when they are dug. The plants will be multi-trunked and range in size from 30 to 120 cm (1 to 4 ft.). At this stage they are ready to either sell as a bare-rooted plant or be potted on to grow to a larger size.

Propagating Herbaceous Perennial Liners and Plugs

David J. Beattie
Department of Horticulture, The Pennsylvania State University, University Park, Pennsylvania, U.S.A. 16802

INTRODUCTION

Herbaceous perennials or most often just called perennials are frequently planted in private and public gardens, and in the promotional gardens of landscape designers or growers. Perennials provide a unifying design influence between woody plants and annuals. They are even being used to beautify highway rest stops; I recently saw thousands of *Hemerocallis* 'Stella de Oro', the most popular daylily in the U.S.A., planted at a truck stop in Virginia.

In the past, perennials were often field-grown, dug, and sold directly to the consumer. Although field production of perennials continues to expand, container production has increased dramatically. Containerized plants are more marketable. In addition, this production method allows considerable mechanization, facilitates shipping, and circumvents several transplanting problems. Containerization has also resulted in a marked increase in the propagation of smaller plant sizes—liners and plugs—which can be easily produced by specialty propagators and shipped great distances.

Larger perennial nurseries in the U.S.A. routinely propagate and grow more taxa than woody nurseries or bedding plant growers. For example, there are nearly 40,000 registered cultivars of *Hemerocallis*. Some nurseries may carry several hundred cultivars and large specialty growers may grow several thousand.

The method used to propagate a particular perennial depends on the species, the propagation equipment available, and the time-of-the-year. For instance, tissue culture has been a particularly effective method to control disease and to quickly introduce new cultivars, but requires sterile lab facilities and special techniques. Although laboratory propagation can be done any time of the year, not all perennials can be propagated by this technique. In another example, the only effective time to propagate *Paeonia* is by division during the late summer and early fall. Finally, the use of mechanized methods and controlled germination environments has been most frequently used for seed propagation, but not all perennial cultivars taxa can be seed propagated. What this means for the perennial propagator is that they must

be aware of many propagation methods and how they apply to a plethora of taxa.

PROPAGATION METHODS

Seed Propagation. Several perennials can be directly sown in the field, a method that is simple and requires little equipment. However, most perennials require the protected environment of germination rooms and greenhouses to achieve maximum plant numbers in the shortest time. Using modern seeders and seed pre-treatment methods are the same procedures used by bedding plant growers; however, the lack of consistently high quality seed, or seed that germinates uniformly without pre-treatment continues to be a problem for the perennial propagator. For instance, *Adonis* and *Gentian* seed are both short lived; legumes like *Lupinus* and *Baptisia* require scarification; *Cimicifuga* and *Acteae* require warm pre-treatment followed by stratification, but still germinate erratically; and *Helleborus* seed must be fresh-sown for speedy germination. Seeds like the annual impatiens that are routinely pregerminated or coated for seeder efficiency are mostly unavailable to perennial growers.

While seed may be the easiest, or even the only way to propagate, it is sometimes misused. For example, *Astilbe chinensis* 'Pumila' can be readily propagated by seed. However, the resulting plants are very heterozygous and mostly unlike the cultivar. Unfortunately, some nurserymen purchase on the basis of price and seed propagated *Astilbe chinensis* 'Pumila' are usually substantially cheaper. If you wish to have the uniformly short cultivar, then you must purchase asexually propagated plants. Another seed-propagated perennial is the lovely, bronze-leafed *Heuchera* 'Palace Purple.' Given cultivar designation, this *Heuchera* was originally asexually propagated. However, growers found that it readily propagated by seed, and it is less expensive to do so. However, the leaf color of seedlings varies from bright green to deep, shiny bronze, requiring that large numbers of seedlings should be discarded. Recently though, I have seen some very uniform seedling populations, indicating that, with care, seed propagation is possible. Further, from seedling populations of 'Palace Purple' several excellent new cultivars have been introduced, including 'Molly Bush' and 'Bressingham Bronze.' However, to maintain their cultivar identity these cultivars must now be asexually propagated. Harlan Hamerick presented an informative paper on how to treat stock plants with GA_3 in order to increase *Heuchera* cutting production. This paper will appear in volume 45 of the Combined Proceedings.

Cutting Propagation. Industry-wide, the majority of perennials are propagated asexually. Compared to woody plants, cuttings are generally easier to root and require little hormone treatment. Many propagators prefer to use polytents or to cover newly stuck cuttings with light weight fabrics rather than use intermittent mist. Fog generation, long used in Europe, is also becoming popular.

One of the most important considerations to propagating perennials is timing the harvesting of cuttings in relation to flowering. Often the rapid spring growth and flowering leaves little time to harvest cuttings before flowering slows rooting. The window of cutting opportunity can be extended for plants like *Coreopsis* and *Veronica* by shearing stock plants after the first cuttings are harvested to produce a new flush of growth. Several plants like *Artemisia* and *Perovskia* root poorly when greenhouse temperatures rise in the late spring. If greenhouse space is available,

bringing stock plants in and placing them under HID light with an extended day length will produce numerous cuttings. Several growers root *Scabiosa* 'Butterfly Blue' for more than six months each year by using this technique. New cuttings are harvested at 10-day to 2-week intervals and direct stock in 72- or 48-cell plug trays.

Another way to increase cutting production is to combine techniques. For instance, the Perennial Plant Association has chosen *Salvia* 'Mainacht' ('May Night') as the 1997 Perennial Plant of the Year. Past experience has suggested that demand for this plant will increase by 50% to 100%, so many propagators are concerned about availability. A 60 : 1 or greater plant increase can likely be achieved by purchasing field-grown transplants and removing and rooting the shortened shoots, sometimes called basal cuttings. These will root readily, then tip cuttings can be harvested from each rooted basal cutting. I recently did this and separated 30 to 40 cuttings from each field grown plant. Conceivably, successive cutting harvests will increase propagule numbers many times.

Root Cuttings. Root cuttings are an important propagation method for several plants, especially members of Acanthaceae, Boraginaceae, for several composites, and *Papaver orientale*. Fleshy root segments, 2 to 3-cm-long, are prepared in mid-to-late fall and placed in trays in the basipetal position. They can be placed in groups of 10- to 20-root pieces in clean cell trays. These trays are maintain at a high humidity by covering with polyethylene or by placing in a grafting case and keep at a temperature at 18 to 20C. Under these conditions adventitious shoots emerge, usually at the top of the root piece. When the shoots are 5 to 10 mm in length, they are removed and planted either in small pots or in cell trays. Planting depth is important and the base of the shoot must be below the medium surface to encourage new adventitious roots.

Division. One of the easiest ways to propagate perennials is by division. Usually no protected environments or special equipment is needed. This is how we propagate *Astilbe* and *Epimedium* at our nursery. Although we purchase some field grown divisions from Europe, we ensure cultivar correctness by dividing our own plants, producing large liners in 7.5-cm pots. Although both genera can be divided at almost any time from early spring to late summer, early spring division is usually best. The medium is shaken from the root system and the crown is pulled apart so that at least 1 bud is visible for each division. Increase rates vary depending on the particular taxon. *Astilbe* may produce 5 to 15 propagules while *Epimedium* usually produce fewer. To even out production, we continue to divide into late summer, but prefer not to continue past 1 Sept. unless propagules are placed in a heated greenhouse. Propagating before this date allows sufficient time for root re-establishment. A well-established root system is required so that under the decreasing temperature and day length conditions of the fall that plants will rapidly increase crown size and bud number for rapid growth the following spring.

Other popular perennials that are propagated mostly by division are *Iris*, *Hemerocallis*, and *Hosta*. The size of bearded *Iris* divisions usually preclude establishing liners in pots smaller than 10 cm. *Iris* can be divided in the early spring before shoots are more than 2 to 3 cm long, but most commercial propagation is done in mid-summer after they have bloomed. *Hemerocallis* is also done mostly in mid-summer. However, some fans, especially tetraploids, are so large that the only practical way to re-establish them is either in the field or in 15-cm containers. *Hosta* crown size

varies from miniature size plants like 'Ginko Craig' and 'Golden Tiara' that can easily be established in 7.5-cm pots, to very large eyed plants like 'Frances Williams' that is best replanted in pots larger than 10 cm. However, we have found that some cultivars seem to increase eye production when their root systems are restricted in smaller pots. *Hosta* is one of the easiest perennials to divide at almost any time during the growing season. Again, when divided after leaves are fully expanded, reduce leaf area, and shade.

Tricyrtis, an increasingly popular shade-tolerant perennial, has an interesting way of propagating itself in our climate. The crown of potted plants will usually winter kill leaving uninjured roots. Shoots will then form on these roots and begin growth. Separating new shoots from the medium in the spring may yield 50 or more new plants from a 10-cm pot.

Tissue Culture. Some propagators chose tissue culture to rapidly increase new varieties or to reduce disease incidence. Although *Hemerocallis* and *Hosta* have been widely propagated from tissue culture, some caution must be exercised. Some cultivars are very uniform, but others may be very variable. Many types of *Hemerocallis* 'Stella de Oro' are now in the trade because they have originated from tissue culture. Variegated hostas are even more of a problem. *Hosta* 'Patriot' is a relatively new and popular sport of 'Francee' that was introduced by John Machem, a long-time I.P.P.S. member. Some less reliable tissue-culture labs have shipped many 'Patriot' propagules that have not been rogued properly to unsuspecting U.S.A. nurseries. The best way to avoid this problem is to purchase propagules from reputable labs and to know what the cultivar should look like.

Although sales of perennials are booming, knowledge about propagation methods is just beginning to become general knowledge. This is due, in part, to the large number of taxa involved, but also to some proprietary knowledge which is now being shared. As methods and knowledge about perennial propagation become more available, even more of these popular plants will become available to the general public rather than residing in botanical gardens or in the gardens of the gardening elite.

Cultivar Integrity in Australian Tree Production

James Will
Faculty of Agriculture, Forestry and Horticulture, The University of Melbourne - Burnley College, Yarra Boulevard, Richmond, IC 3121

In Australian tree production, many of the issues concerned with producing high-quality trees have been addressed. Root system research has lead to the production of trees that successfully establish post-transplanting. Also, tree cultivars of non-Australian origin are quickly imported by the major propagating companies, and are made available to the market for testing and sales, once quarantine requirements are met. This leaves three areas of deficiency in Australian tree production:

1) Formative pruning and the development of tree canopies to best suit the end use.

2) Trialing of taxa to ascertain their suitability for differing Australian landscape situations.