PROPAGATION FACILITIES — PAST AND PRESENT

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During the last few decades the ingenuity and innovation of both the nursery propagator and research worker has resulted in the improvement of the traditional facilities and the development of entirely new propagation concepts. The objective of this paper is to briefly review these developments in propagation facilities.

During the early days of nursery production the open ground was normally the only facility available. Raising plants by seed, layering, grafting, and hardwood cuttings were the dominant methods used. Today, open-ground methods are still very important and they have been made much more efficient through mechanization, herbicides, and knowledge of correct timing for carrying out each operation. Examples which illustrate this include techniques to overcome seed dormancy, development of specialized machinery for mounding up stool beds of apple rootstocks, and the use of herbicides to reduce labour costs and improve crop quality of species raised from hardwood cuttings.

Many of the greatest advances have been realized in protected propagation facilities. Bell-jars were one of the first facilities used by the nursery propagator. They were made of glass and were round at the base varying in height up to approximately 60 to 70 cm (1 to 2½ ft.). They could be handled by one person and were placed over individual small quantities of cuttings or grafts. Ventilation was provided by placing a small block of wood to tilt the bell-jar. During spring and summer the jars were shaded except on the north side. These bell-jars essentially provided a miniature greenhouse environment where there was some control over light, temperature, and humidity. One traditional facility which is still successfully used today was evolved by the Canadian nursery propagator, Leslie Hancock of Woodland Nurseries, Mississagua, Ontario, in the 1920's following a visit he made to China. It was referred to as the "burlap-cloud" — whereby softwood cuttings were stuck in raised beds filled with sifted soil. A humid and cool environment was provided around the cuttings by regular handwatering over the burlap to keep it moist.

Cold frames are a traditional facility which, although labour-intensive, still provide low cost-effective methods for plant propagation. The traditional cold frame is a wooden or brick rectangular framework around and over an unheated soil base. Uses for cold frames include:

- (i) Breaking seed dormancy by cold-moist stratification.
- (ii) Germinating seeds of broadleaf trees, shrubs, and conifers, for rootstocks or ornamentals.
- (iii) Rooting softwood, semi-ripewood, evergreen hardwood, and deciduous hardwood cuttings.
- (iv) Hardening-off flats of cuttings and bench grafts, bedding out rooted cuttings for liner production, and providing space for pot-grown liners and rootstocks.

Modifications in the design of cold frames have taken place. They include the implementation of the smaller Dutch light, making it easier for the lights to be handled by one person. Also, the provision of basal heat through hot water pipes or electric wiring in order to raise the soil temperature. In order to give greater control over temperature and humidity, an inner layer of glass was placed between the cuttings and the outer light. These modified cold frames were referred to as double-glass frames. The improved control over the environment, providing there was sufficient extra shading, meant that besides winter hardwood cuttings, both semi-ripewood and softwood cuttings could be successfully rooted. Today, instead of the inner glass light, polyethylene is sometimes substituted.

The development of the greenhouse provided the nursery propagator with a facility which provided the opportunity to control the environment far more effectively. Innovations in greenhouse design, cladding (covering) materials, equipment, heating systems, and energy saving methods, now provide the propagator with many alternatives from which to choose for the small and large scale nursery. The last decade has demonstrated how consideration to effective bench and floor area layout for the integration of materials handling systems has been an important contributory factor to increased financial nursery profits — particularly for operators who undertake direct sticking procedures.

Research in both Europe and North America has shown many ingenious and effective ways for saving energy. These include the use of a fan for blowing air between two layers of polyethylene used for cladding a greenhouse, thermal screens and thermal covers, installation of electronic equipment for controlling the air and base temperature, the provision of basal heat by day or night only, and insulating the benches or beds with 2.5 cm (1 in.) or 5.0 cm (2 in.) sheets of expanded polystyrene (Styrofoam®).

Today the propagator has a number of different propagation systems from which to choose. The choice will be dependent upon locality, available capital, size of nursery, and the types and quantities of species to be grown. These systems can conveniently be grouped as follows:

CLOSED CASE

The traditional closed case (utilizing polyethylene) is a brick or wooden cold frame structure located within a greenhouse. Basal heat is provided through hot water pipes or electric cables. Besides being very effective for rooting cuttings, they provide an excellent environment for callusing bench grafts, hence the alternative name — grafting cases — is sometimes referred to. To provide more flexibility in use one, or occasionally two, layers of polyethylene are now normally used instead of glass.

Polyethylene film allows some movement of gases, such as oxygen and carbon dioxide, but inhibits the movement of water vapor, so encouraging an increase of humidity to keep the cuttings turgid. For closed case propagation to be successful, the propagator must appreciate that it is necessary to create a correct balance between air temperature, leaf temperature of the cutting, humidity levels, and shade. Up to 80% shade is necessary during the summer months to avoid stress to the cuttings or grafts.

Until recently there has been little fundamental research related to the environment of cuttings being rooted under polyethylene. Research by K. Loach at the Glasshouse Crops Research Institute, Littlehampton, Sussex, England, has now provided the propagator with a greater appreciation of the physiology involved — particularly in comparison with mist propagation.

The nursery industry in Holland has been effectively using polyethylene over cuttings and grafts for many years and this experience was no doubt a major factor for its implementation in many other countries. For rooting conifers and broad-leaved evergreens during the winter months some nurserymen in temperate climates have been experiencing problems with mist propagation. The advantages in rooting cuttings under polyethylene include:

(i) Minimal leaching of nutrients and subsequent leaf drop induced by frequent overhead misting.

(ii) Less stress from excess water being retained in the rooting medium — particularly where a high peat ratio mix is used for broad-leaved evergreens.

(iii) Less energy is required to heat the rooting medium because there is no overhead mist removing heat.

There are essentially three methods for rooting cuttings under polyethylene film:

1. **Contact.** A continuous layer of polyethylene film is layed directly on the cuttings, and then tucked in around the edges of the bed or bench to ensure it is in direct contact with the upper leaf surfaces. Condensation droplets will quickly form on the underside of the polyethylene ensuring a humid environment is maintained.

2. **Supported.** Here the polyethylene is supported by a wooden or metal framework to leave an air space between the cuttings and layer of film. Some propagators prefer this system as it is easier to inspect the cuttings as it provides greater air circulation which, in turn, may help to reduce disease incidence. However, with lower humidity levels occurring, greater care must be given to correct shading values.

Supported polyethylene to provide a series of tunnels provides an excellent system for rooting broadleaved evergreens in the winter, and then for the summer months, a mist line can be easily installed within the tunnels for softwood propagation.

3. **Drape.** Polyethylene drapes are used to increase the air space around the cuttings by securing it down the inside of the greenhouse roof and allowing it to hang down along the side of the propagative bench or floor bed. In wider span greenhouses a false ceiling can be created by supporting the film on tight wires and allowing it to drape down on all four sides to create a tent. Mist lines or foggers can be installed if required.

MIST PROPAGATION

Since the Tennessee nurseryman, H. Templeton, in 1953 devised and implemented the concept of intermittent mist (controlled bursts of mist), mist propagation has developed worldwide as a standard and effective system for rooting cuttings. (The physiology, equipment, and various adaptions have been well-documented in the IPPS Proceedings and in plant propagation textbooks). The overhead application of small water droplets keeps the cuttings turgid by reducing transpiration and respiration while the cell tissues are kept cool by the evaporation of the film of water which had formed on the upper surfaces of the leaves. Today mist propagation facilities are sited outdoors (in warm climates), and in cold frames, tunnels, shade houses, and greenhouses.

Engineering technology has improved the effectiveness of mist propagation, particularly in relation to nozzle design and control equipment for regulating misting frequency and retaining accurate control of basal heat. Traditionally, in a greenhouse a mist propagation system was sited on a bench, but the need for reducing costs and implementing effective materials handling has meant that today most systems are constructed at floor level.

Management of mist propagation systems can be a problem with some propagators — particularly in temperate climates. Sometimes this is due to ineffective maintenance and disease control procedures. Experience has shown problems can be due to cutting stress caused by excess water application from the nozzles. Mist propagation should not be considered as a system which is "problem-free", because it is not. This is one reason why propagators today are installing fogging and closed case facilities with polyethylene film covers as an alternative.

LOW POLYETHYLENE TUNNELS (SUN TUNNELS)

Low polyethylene tunnels are essentially an extension of mist propagation but have been classified in this paper as a separate system as they provide the propagators with a temporary or permanent low cost facility. They are constructed to provide a continuous tunnel 1.0 m (3¼ ft.) high and 0.9 to 1.2m (3 to 4 ft.) wide supported by a metal or wooden framework. Following sticking of the cuttings and fungicidal drench the tunnels are covered with milky (opaque) polyethylene. The tunnels as originally designed in Denmark do not contain an internal misting line while those in North America and many other European countries do. Providing that the incoming light intensity is reduced by at least 50%, high temperature and high humidity are allowed to develop without causing undue stress to the cuttings.

Low polyethylene tunnels are particularly useful for softwood cuttings in that they save utilizing valuable greenhouse space for large quantities of easy-to-root cuttings. Also they are a useful facility for a new nursery business where capital expenditure is limited.

FOGGING

The concept of fogging is not new but during the last five years the nursery propagator has found that in certain situations it has many advantages over other systems. For example, significantly less water is required than a mist system resulting in reduced waterlogging of the rooting medium and less stress to the cuttings. Larger cuttings may be successfully rooted — particularly those with large, soft leaf laminas. Fogging systems are particularly useful for establishing new plants from the micropropagation laboratories to wean them to a more normal regime.

With fogging there is a distribution of very small water droplets to create a constant high humidity level. These airborne droplets, down to 10 microns or less, increase the humidity level of the atmosphere until there is an excess of water droplets suspended in the air. True fogging essentially gives the propagator an environment similar to a sea mist. Mist propagation creates droplets with a considerable size range, most of which are larger than 50 microns, so they quickly fall and are unable to create the suspension effect.

During the 1950's and 1960's the main fogging equipment for propagation was the Swiss manufactured Defensor® units. Today we have a considerable wider selection of more sophisticated equipment some of which was initially developed for industrial use. Essentially equipment now available can be placed in three categories:

1. High pressure fogging whereby a series of atomizing nozzles are embedded in 1.3 cm (½ in.) pipes with the filtered water particles distributed upwards as a "symmetrical cone"; e.g. Mee Industires Fog System®.

2. Ultrasonic humidifier nozzle (siphon nozzle) whereby very fine droplets are produced by water being accelerated by compressed air; e.g. Sonicore® system.

3. Ventilated high humidity whereby self-contained units are sited within the greenhouse to generate fine water particles that are then, in turn, forced by a fan and mixed into a stream of cool air for distribution within the greenhouse; e.g., Agritech® system.

In conclusion, the choice of the propagation facility will largely be determined by available financial capital, the crops to be grown, and the geographical location of the nursery. It is important that today's facility is designed so that it can be easily modified to future market demands and innovations. Before making the final choice it is very important to seek advice from fellow nursery propagators, extension officers and, where applicable, specialist private consultants.