ping season. Still the work could be highly seasonal, but it overcomes the major problem of too many important tasks all at once.

Could understock and budwood be stored all year and taken out for budding and callusing, then returned to storage to be then lined out all at the same time?

A lot has remained constant, until now. As long as we continue to make grafts or buds outdoors or to stick cuttings into rooting media, not much will change over the years. However, an holistic approach and a lot will change. Propagation by tissue culture is a good example. Other examples will come. We have just begun ----.

THE DEVELOPMENT OF FOAM PROPAGATING SYSTEMS

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INTRODUCTION

Propagating systems continue to evolve from the introduction of Jiffy-Pots in 1954 (1). These and other peat pots are made in round and square shapes, in a range of sizes for the propagation and growing on of individual units. Propagators familar with peat properties find few difficulties in growing plants in these biodegradable units and buyers like the concept of planting pot and all. While others less familar with peat technology, encounter difficulties in watering procedures and observe restricted root development. We see the "wicking action" problem when plants are set a bit high in the final container. Individual peat pots tend to fall over on the propagation bench. They are difficult to efficiently handle during packing and shipping processes.

The buyer of plants rooted in these pots must also deal with single units which can be difficult for him to manage. From the individual peat pot or plastic pot we see the development of Jiffy-Strips and a whole array of vacuum-formed plastic "packs". These thin walled plastic "packs" are low cost and adequately do the job for the propagator. They allow for multiple unit handling, ease of handling during propagation and packing, but getting a rooted plant to the customer in one piece can still be a shipping problem.

POLYSTYRENE FOAM TRAYS

The California Rooting Tray developed by Paul Ecke Poinsettias in the early 1970's was a further improvement in low cost, multiple unit handling, ease of handling system concept (2). This polystyrene foam tray was molded from the same commercial egg container material we see in grocery stores. Each tray was 16 in. in length, 1½ in. tall, and 1 in. wide. Cross protrusions divided the tray into nine cavities. A top closure was designed into the tray to reduce the likelihood of soil mix and plants from falling out of the tray during air or truck shipment. The primary objective of Paul Ecke Ranch is to ship high quality rooted plants to buyers and have these plants arrive in excellent condition.

Propagation benches at Paul Ecke Ranch are actually wooden framed beds of peat plus sand. These were used for the rooting of cuttings which are dug and shipped as bare-rooted plants. Beds were and still are dibbléd to hold cuttings for callused cutting production. These benches require pasteurization through steaming every 9 to 11 day cycle of callused cutting production, an energy and labor intensive sanitation measure. The California Rooting Tray propagation system reduced this need because benches were covered with new 1 mil poly film between each cycle. Furrows made into the sand plus peat beds gave added support to the California Rooting Trays which during the last week of each propagation period became unstable as plants grew in height. Rooted plants also required overhead watering and these furrows helped to support the trays.

California Rooting Trays were loaded into wire frames and mechanically filled with a soil, peat, sawdust, and perlite propagation mix. Filled trays came off the conveyor belt, were loaded on flat bed trucks, and taken to propagation houses.

In propagation the trays were spaced in the furrows. The trays were watered overhead to settle the propagation mix in the cavities and make dibbling possible. Best results occurred when cuttings were placed in dibbled holes and not watered in until callus formation had occurred.

The California Rooting Tray system of propagation and shipping yielded acceptable high quality rooted plants, but variability in plant growth and continued shipping problems were persistent. Variations in soil mix quantities within each cavity during the propagation cycle contributed to rooting and plant growth differences. Changes in peat, sawdust, and perlite physical characteristics and blending techniques made significant changes in the propagating mix characteristics. Variations in these ingredients added to the nonuniformity of mix during the year which paralleled growth differences. Plants continued to root in the lower half of each cavity. Loose soil mix did spill out during shipping. Plants could also become dislodged during transport. Printed labels and arrows to direct handlers to keep loaded shipping cartons upright help, but do not eliminate this on-going problem. A very different approach to the production of rooted poinsettia plants for shipment throughout the United States was needed.

PHENOLIC FOAM STRIPS

The Smithers Company, the leader in floral foam technology and manufacturing capability recognized this need. Researchers developed a phenolic foam product #0903 from the regular Oasis Floral Foam which is too closed cell for propagation work (4). Water is taken up, but no exchange occurs. A balance of open and closed cells govern saturation and drainage which gives proper moisture levels for rooting. To achieve this balance in #0903, some foam cell membranes were left intact. A wide range of drainage possibilities were evaluated before determining 26 to 38% drainage by weight was best. Low pH was increased to 5.5 to 6.0 by adding neutralizing salts during the foaming process. The strength of product #0903 was evaluated from a heavy-walled cell structural foam that would not receive a cutting, to a very fine structure that would not support a cutting. After drainage, pH and strength characteristics were determined for the product, numerous growth trials were performed to determine size and shape of the propagating unit.

Foam strips 16 in. in length were cut with varying widths (¾ in., 1 in., 1½ in.) and heights (1 in., 1¼ in., 1½ in., 2 in.). Initially holes on 1¾ in. centers were made by punching the foam units with a sharpened pencil or dowel before settling upon ⅜ in. holes, punched to within ½ in. of the bottom of the strip, the lower ½ in. of each hole tapered to nothing. To facilitate breaking apart each plant, scores were made between units approximately ½ in. into the surface of the strip.

Growth trials were performed to determine callus initiation, root development, watering requirements, holding time on bench, shipping weight, and transplanting success before deciding upon a strip 16 in. long, 1 in. wide and 1½ in. high. Handling of these strips after plants had rooted proved difficult because the water heavy foam broke apart too easily. Therefore a 0.080″ thick liner was designed from the egg carton polystyrene foam to act as a sleeve for the strip. The liner was secured around the strip by a brass staple. Growing tests with or without the sleeve/liner showed that cuttings in strips with liners rooted ahead of those without.

These trials also indicated a need to leach or flush the neutralizing salts from the foam prior to sticking cuttings, otherwise basal stem injury occurred. Fungicide drenches were tested and were found to cause basal injury at the recommended rates. Additional tests at The Ohio State University indicated that poinsettia cuttings stuck in Rootcubes® will root faster and better when no fungicide is applied. Applications of all fungicides caused an inhibition of rooting. The extent of rooting inhibition varied among the four fungicide treatments examined (3).

During the development of the phenolic foam growing medium, many of the earlier practices associated with the use of California Rooting Trays were incorporated to improve plant handling. Since foam strips were placed in the plastic lined furrows and the benches were sloped, a furrow irrigation system for watering the rooted plants was developed. Fertilizer solution trickled into the beginning of each furrow could flow along the furrow and through the foam. This eliminated individual strip overhead hand watering. Packing frames were designed so workers could efficiently load entire groups of rooted plants in an upside down manner. This facilitated placing the carton over the plants without breaking the plants. Alternative packing methods have since been devised where workers gather up strips of plants in the plastic liners of each shipping carton. The entire group of plants is gently dropped into the shipping carton.

In 1976 Paul Ecke Poinsettias adopted Oasis® Rootcubes® Growing Medium for the propagation of all rooted plants for shipping to customers as well as in-house stock plantings. The Strip and Liner system allows for the efficient annual production of several million plants at the Paul Ecke Ranch. Besides meeting the objective of getting a rooted poinsettia plant to the customer in one piece, the use of Oasis® Rootcubes® Growing Medium reduces the need for stockpiling soil mix ingredients, preparing soil mixes, pasteurizing mix and beds, and drenching with fungicides. It speeds clean-up operations after each propagation cycle.

Since the commercial introduction of Oasis® Rootcubes® Growing Medium in 1976 by The Smithers Company, propagators of poinsettias throughout the United States have adapted this growing medium system to their greenhouse propagation needs. Continued development of phenolic foam into other shapes and sizes has occurred to meet the needs of other propagators, propagators of chrysanthemums, geraniums, foliage plants, and woody ornamentals who require consistent uniform results.

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FUEL ECONOMY IN THE PROPAGATION BENCH

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Efford Experimental Horticulture Station (EHS) is part of the Ministry of Agriculture Fisheries and Food's Agricultural Advisory and Development Service and has responsibility for work with propagation and container production of hardy nursery stock. Work on propagation has been in progress for 4 years and has considered aspects of fuel economy, improving speed of rooting, and maintenance of cutting quality. The scope of this paper reviews the work aimed at reducing electricity fuel costs for heat-assisted winter propagation. Economy measures investigated can be categorised under four headings:

1. Efficient heat control.
2. Efficient heat transfer to rooting medium.
3. Reduction of heat loss.
4. Plant requirements.

EFFICIENT HEAT CONTROL

Most nursery stock is propagated in trays stood on the heated base; the important temperature to consider is that at the base of the cutting within the rooting medium. The advent of electronic controllers with probes which can be inserted into the rooting medium has provided a more accurate means of control than rod thermostats which can only control from a fixed point in the sand base. Optional temperature read-out scales linked into the electronic system provides an important, easily monitored, temperature check. Where rod thermostats are used compost temperatures need checking by thermometers inserted into the tray, and the thermostat must always be covered by a tray, otherwise temperatures will be very different from those desired.

EFFICIENT HEAT TRANSFER

Usually there is no problem in achieving the required temperature in the rooting medium, but efficiency of heat