Also, by having all the material in one area, the workers did not have to travel all over the nursery to get the cuttings. There was an increase in the sticking rate. Under the old system of sticking cuttings at a central point, on person could barely do 15,000 cuttings per day. With the new system of on-site sticking, one could consistantly stick 20,000 to 25,000 cuttings per day. We feel that the better growing procedures of slowly hardening off the cuttings, and giving them priority attention during the growing process will produce a higher quality plant.

In general, we feel we have achieved all the goals we set out to do when designing this new system but there is one more measurement that is needed. The cost accounting figures need to be compared between a crop produced on the old system with one on the new system; this will be the true test as to the success of the new system.

UPDATE OF GRO-PLUG® SYSTEM

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Abstract. Most evergreen and deciduous plant material, whether seedling or cutting propagated, is being successfully integrated into our GRO-PLUG system. It has become a basic "Hub" and feeds directly into our second "Hub"—the SIX-PAC.

We reported on the practical application of GRO-PLUG systems for conifer ornamentals at the 1980 IPPS meeting (1). At the 1982 meeting, we reported on direct sticking of deciduous cuttings into the GRO-PLUG system (2). We have been asked to update our experience with GRO-PLUGS. Following are the major changes, expansions, and system philosophy that have taken place since the original two reports.

CHANGES

Conifer seedlings. We now find that all conifer seedlings we work with can be grown successfully as GRO-PLUGS. Fine tuning the system has made this possible. The system has become more and more complex—but more predictable. Complete scheduling is imperative.

Direct seeding. We have shifted from no direct seeding to almost 100% direct seeding. This required the development of our

own direct seeding machines. They had to be cheap, simple, flexible, and reasonably fast! They had to sow *Thuja occidentalis* seed as well as *Abies concolor!* Such a machine was developed just for our needs and is constantly being revised. The machines are very portable and are set up in the greenhouse being filled.

It is essential that only seed lots with high viability be used. The seeds must be clean and all debris removed. This required the development of a sophisticated system of seed cleaning, testing, and storage.

Flat filling. The GRO-PLUG system uses a 73 cell groove tube jointly developed by Evergreen Nursery Co., Inc. and Growing Systems, Inc., 2950 N. Weil St., Milwaukee, Wisconsin 53212. Direct seeding speeded production to a point where it was necessary to modify our Gleason flat filler. The changes resulted in eliminating two people from the flat filling process.

Planting. Experience has shown that GRO-PLUGS may be planted in the field or containers as soon as field soil or containers are ready in the spring. In Sturgeon Bay, we try to complete the Evergreen Seedling GRO-PLUG (ESGP) planting into the field by June 15. Deciduous Softwood GRO-PLUGS (DSWGP) are completed by August 30, in the field. ESGP and DSWGP planting into containers is usually completed by August 15.

Automation of GRO-PLUG planting into containers. Since now all container-grown material starts with a GRO-PLUG, we can no longer effectively use hand planting. In cooperation with Gleason, a machine was developed to fill and drill SIX-PACS as well as 1- to 7-gal containers for planting with GRO-PLUGS.

Softwood GRO-PLUGS. Since first reported in 1982, we have modified the system considerably.

1) Fog (Agri-Tec) has replaced the mist system. (The droplets are not fine enough to be technically a true fog.) We have a flexible control system which can easily be switched for sunny, partly sunny, or cloudy conditions.
2) We have moved the propagation area to a 100 × 100 ft gutter connected structure. The house is covered by an inner layer of clear plastic with an outside opaque layer. Several crops are put through the house each season.
3) We now use a 50% shade lathhouse as a first step acclimation. DSWPG are then moved to full sun for a minimum of one week before transplanting.
4) The rooting medium has been modified by adding 25% perlite to the regular growing medium to insure adequate drainage.
5) Because of the high rooting percentage obtained, we now only stick one cutting per cell.

EXPANSIONS

GRO-PLUGS to SIX-PACS. As our containerized system evolved, it was apparent we needed a "second step" size container. The GRO-PLUG is 4.0 cm across at the top, tapered to 2.0 cm at the base, with a depth of 7.0 cm. The volume is 49 cm^3. Each plant has 21 cm^2 of space. The SIX-PAC was developed cooperatively with Keiding, Inc., 4545 W. Woolworth Ave., Milwaukee, Wisconsin 53218. These paper mache cells are 10.9 cm across the top, tapered to 7.0 cm at the base, with a depth of 12.5 cm. The volume is 709 cm^3. Each plant has 121 cm^2 of space, or approximately 6 times as much as in the GRO-PLUG. The SIX-PAC makes an excellent "second step" container. It can be planted even in the field through September. Root binding is not a significant problem with paper mache SIX-PACS. (Table 1).

Table 1. Comparison of various type plug containers used by Evergreen Nursery Co.

Type	Material	Manu-facturer	Number grooves	Top diam. (cm)	Bottom diam. (cm)	Depth (cm)	Volume (cm^3)	Space/ plant (cm^2)
GRO-PLUGS 73 cell	Poly-styrene	Growing Systems	12	4.0	2.0	7.0	49	21
GRO-PLUGS 38 cell	Poly-styrene	Growing Systems	4	5.5	2.0	12.5	138	36
12-PAC	Paper mache	Keiding	0	7.5	5.5	9.0	299	72
SIX-PAC	Paper mache	Keiding	0	10.0	7.0	12.5	709	121

[1] available 1987

Storage. As the system progressed, it was evident we needed to develop a cheap winter storage program. The GRO-PLUGS are properly acclimated, removed from the trays, and stored at 28°F over winter. This reduced the space required by approximately 90%. The plants are kept frozen until scheduled for planting the next spring.

Deciduous seedling GRO-PLUGS. The program has been expanded to cover deciduous items grown from seed, such as *Viburnum dentatum*. Seeds are germinated in small outside beds or given proper stratification and germinated in germination chambers. They are transplanted into the GRO-PLUG.

Micropropagated cutting GRO-PLUGS. Azaleas and rhododendrons are some of the items we propagated in microculture. The cuttings are removed, rooted, and transplanted into GRO-PLUGS.

38 Cell Groove Tube. After many years of development, Growing Systems will be introducing a 38 cell groove tube. In cer-

tain cases, such as with *Larix* and *Quercus*, larger "first step" tubes are necessary. The 38 cell tubes will have approximately 5.5 cm top diameter, tapered to 2.0 cm at the base, with a depth of 12.5 cm. The volume will be 138 cm^3 and each plant will have 36 cm^2 of space (Table 1).

12-PAC. In conjunction with Keiding, we have developed a 12-PAC designed as a "second step" for slower growing evergreens. Each cell is 7.5 cm at the top, tapered to 5.5 cm at the base. The depth is 9 cm. The volume is 299 cm^3, and each plant has 72 cm^2 of space (Table 1).

Evergreen cutting GRO-PLUGS. We presently are experimenting with direct sticking of evergreen cuttings into GRO-PLUGS. This is the last major area of our propagation system to be converted to plugs. Initial tests are very encouraging.

SYSTEM PHILOSOPHY

Inputs. The type of GRO-PLUGS in our system and the approximate 1986 production are listed in Table 2.

Hubs. Our two major hubs, GRO-PLUGS and SIX-PACS allow us great flexibility and act like airline hub cities, from which we can go in many directions (Table 3 and Table 4).

Shortening crop cycles. The GRO-PLUG/SIX-PAC system of containerized liners has effectively shortened the growing cycle of all of our crops. In the past for example, an 18 in. *Pinus mugo* ENCI required 8 to 9 years to grow a quality plant from seed. Now it requires 5 to 6 years.

Consistency. This system has added greatly to the consistency of the product. In many cases 50% of the grades within the crop have been eliminated.

Losses. Transplant losses have been reduced in the field from 30%, on a 10-year average, to less than 5%.

Flexibility. The system, with its "Hubs", allows a great deal of flexibility as markets change.

SUMMARY

The GRO-PLUG and SIX-PAC "Hubs" have become an integral part of our propagation system. It is a complex system, demanding high technology under the supervision of qualified personnel. Now a reasonably priced broad spectrum of containerized liners are available to the wholesale nursery trade.

Table 2. Inputs into 73 cell GRO-PLUG system.

Code	Description	Plants produced 1986[1]
ESGP	Evergreen seedling	1,060,000
BSGP	Birch seedling	460,000
DSWGP	Deciduous softwood cutting	250,000
DSGP	Deciduous seedling	20,000
ECGP	Evergreen cutting	10,000
	Total:	1,800,000

[1]Rounded to nearest 10,000

Table 3. Dispersal of plants from GRO-PLUG hub.

Crop	To container/field	Cycle[1]	Normal cycle
Direct Sales	73 cell GRO-PLUGS	1	—
Evergreen (fast growers)	SIX-PAC	2	4
Evergreen (slow growers)	12-PAC	2	4
Evergreen	1 gallon	3	4 to 5
Evergreen, once transplant	Field	3	4
Evergreen, once transplant select	Field	4	5
Deciduous	SIX-PAC	1	2
Deciduous (fast growers)	2 gallon	1	2
Deciduous, once transplant	Field	2	3
Birch, twice transplant	Field	1	3
Birch, 3 stem	4 gallon 3 to 4 ft	1	3
Birch, 3 stem	7 gallon 6 to 8 ft	2	4

[1]Total years includes time as GRO-PLUG

Table 4. Dispersal of plants from SIX-PAC hub.

Crop	To container/field	Normal cycle[1]	cycle
Direct Sales	SIX-PAC	2	—
Evergreen	2 gallon	3 to 4	5 to 6
Evergreen, twice transplants	Field	5 to 6	8 to 9
Deciduous (slow growers)	2 gallon	3	4
Deciduous (fast growers)	4 gallon	3	4

[1]Total years (includes time as GRO-PLUG and SIX-PAC)

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