GRO-PLUG SYSTEMS AND THEIR PRACTICAL APPLICATION IN GROWING ORNAMENTALS

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Gro-Plugs® is the registered name we are using for our tube culture production. We have worked with a tube system for many years in our birch program. Several years ago we began experimenting with other woody seed-propagated ornamentals. Presently we have grown crops of *Abies concolor*, *Picea pungens* 'Glauca', *P. glauca* 'Densata', *P. omorika*, *Pinus mugo* (ENCI), *P. nigra*, *P. sylvestris*, *P. ponderosa*, *P. strobus*, *Tsuga canadensis* and *Thuja occidentalis*. Usually 4 months is required to produce Gro-Plugs® seedlings ready for transplanting in our own fields or for sale.

SEED

Selection. Seed selection is of paramount importance as it contains the genetic basis for each plant. In some cases we have been able to establish our own seed orchards and carefully rogue out undesirable plants. We purchase seed from many places in the United States as well as from Europe and Japan. Over the years we have carefully selected, through a process of evaluation, consistently reliable seed sources. We try to purchase from suppliers who are specialists in particular species, as they can often give us valuable information.

Testing. When seed is received from any supplier, including ourselves, we assign it a lot number and record all pertinent information. We store our seeds in a refrigerated cold storage at 35°F. Approximately two months prior to using the seed, we do a germination test on each lot number. One hundred seeds are counted out and placed on a moistened paper towel which is placed inside of a rigid clear plastic box with a tightly fitting cover. The plastic box containing up to 8 individual tests is placed in our germination chamber. Each germination chamber is equipped with 5 shelves and uses cool white fluorescent tubes as a source of light and heat. The ballasts have been removed to the outside of the box where the heat is dissipated into a workroom. The temperatures are maintained between 75 and 85°F on the surface of the towel. Germination results are recorded after 1, 2, 3, and 4 weeks. Any stratification requirements are fulfilled prior to placing the seed on the towel. From the results we then determine the amount of seed to be used per flat in order to obtain the desired seedling density.

Seeding. Seeds are sown at the proper density to obtain approximately 1,000 seedlings per standard 28 × 54 cm flat. Either fine perlite or vermiculite is used as the medium. Captan and Benlate are used as preventative fungicides. Each flat is covered with clear plastic and placed in the germination chamber under conditions previously described. Bottle thermometers which have been calibrated to a standard unit are inserted through the plastic into the medium so the temperature can be monitored.

Germination. Germination begins within a few days and at this point the plastic is immediately removed and the flats are misted several times a day. Within a week to 10 days the radicles are of sufficient length for transplanting.

PLUG TRANSPLANTING

Media. The media is formulated on a basis of 50% fluffed Canadian peat moss with a pH of 3.8 ± 0.2, 25% coarse perlite, and 25% coarse vermiculite. The pH is adjusted to the proper level for the particular species being grown by using varying amounts of calcium carbonate and dolomite limestone. The pH after equilibrium runs between 4.8 ± 0.2 for many of the conifers and 6.2 ± 0.2 for *Betula* species. We also add calcium nitrate, treble superphosphate, and potassium nitrate as standard amendments. Minor elements are added in some cases in the form of Micromax and GU-49 (iron).

Our standard batch size is 0.89 yds^3. This allows us to use the peat, perlite, and vermiculite in full bag amounts. The peat is purchased in 6 ft^3 bales and, when fluffed, makes 12 ft^3. The perlite and vermiculite are obtained in 3 ft^3 bags. By using one fluffed bale of peat, 2 bags of perlite and 2 bags of vermiculite we obtain a batch contining approximately 24 ft^3 of material which is equal to 0.89 yds^3.

Table 1 refers to a standard batch of our media. The pH has been adjusted by the full increment of calcium carbonate and dolomite limestone.

Table 1. Components contained in a standard media batch[1]

Canadian peat (fluffed)	—	12	ft^3
Perlite, coarse	—	6	ft^3
Vermiculite, coarse	—	6	ft^3
Calcium nitrate	—	102	grams
Treble superphosphate	—	306	grams
Potassium nitrate	—	204	grams
Calcium carbonate	—	1631	grams
Dolomite lime (Zone 80-89)	—	1223	grams
GU-49	—	453	grams
Micromax	—	399	grams

[1] A standard media batch equals 0.89 yds^3

Table 2. pH at equilibrium when various increments of the standard calcium carbonate and dolomite limestone are used.

Increments	*pH ± 0.2*
1.50	6.2
1.00	6.0
0.75	5.7
0.50	5.5
0.33	5.0
0.25	4.8

Each batch is adjusted to the desirable pH for specific crops by varying the amount of calcium carbonate and dolomite lime from the standard increment. Table 2 shows the pH at equilibrium when various increments of the standard calcium carbonate and dolomite limestone are used. It is important to understand that the pH at equilibrium will vary from batch to batch and we have shown this by a plus or minus 0.2 variance. A technician who has standardized her practices with our consultant in California monitors the pH using a pH meter.

Trays. Over the years we have worked closely with Growing Systems, Inc., 2950 North Weil Street, Milwaukee, Wisconsin 53212, in developing the tray we are presently using. The tray is called a "Groove Tray" because the individual cells consist of twelve convex sides. The diameter of the top opening is 4 cm tapering to 2 cm at the base. The height is 6 cm. There are 73 cells in an individual tray which measures 51 × 30 cm. The trays are vaccum formed, using black PVC for our use. Through careful handling, more than one use is obtained. Each plant has 21 cm^2 of space or approximately 44 plants per ft^2.

These cells are specially designed to prevent root circling. The large opening at the base is used for air pruning. In the nursery industry it is not necessary to have the long tube which is normally used in the forest industry. Irrigation is available to us and present planting machines are easily adapted to the shorter tube.

The individual trays are filled with media through the use of a flat filler. The trays are then placed in a specially designed pallet. The pallet holds 12 trays or 876 plants. The pallets are so designed that the bottom of each cell is exposed to air for the root pruning process.

Transplanting. The pallets containing the trays filled with media are then transported by dolly to the work area where individual trays are removed and placed at optimum working level for the individual transplanter. Compaction and moisture content of the media must be proper to prevent the media from falling out of the large hole at the base and to provide an optimum moisture level for the tiny new radicle. This comes only with experience.

During transplanting all crooked, weak, and otherwise undesirable plants are discarded. The radicle of the newly germinated seedling is carefully dibbled into the medium. Care must be taken not to bend, twist, or in any way deform the radicle during this cruical operation. The medium is then firmed to a point where the radicle will not push out of the medium as it begins to grow nor to a point where the structure of the medium is destroyed. Ther performance and quality is constantly monitored through our system of reasonable expectancies. The trays are then replaced in pallets and the pallets moved to the greenhouse. Two people can easily handle one pallet.

Culture. The individual pallets are set on cement blocks which form the bench. The edge pallets are skirted with microfoam and black plastic.

Media temperature is maintained between 55-60°F, while the air temperature varies from 35° to 80°F. Bottom heat is provided by hot water heat under the pallets.

Water and a constant fertility program is provided through the use of a variable speed boom and T-jet nozzles. The pH of the water is adjusted to 6.0 ± 0.2 through injection of concentrated sulphuric acid into the water. The fertilizer water, as it is applied, contains between 150-300 ppm of N, 28-88 ppm of P and 100-130 ppm of K. Minor elements are either added through amendments such as Micromax to the medium or in the fertilizer water. Each crop varys in its fertility requirements. The pH and salinity levels are monitored each week on major crops during the growing season. If any problems arise, our technician supplies our consultant with pertinent information so that he can advise us as to the best course of action. If the salinity level rises too high we simply switch to an 80% concentrate level or occasionally to clear water for a week. We are much more concerned about trends rather than the absolute numbers.

Photoperiod is controlled through the use of incandescent lights mounted on a boom. It's on-off cycle is controlled by a photoelectric cell. A timer may be installed in the circuit if so desired. A trip counter monitors the boom travel during the night and is checked each day to see that the correct number of trips have been made. Each plant receives a minimum of 30 foot candles of incandescent light for approximately 4% of the night hours, with a minimum of one lighting period each 30 minutes.

A preventative fungicide program is used. Presently Captan and Benlate are the main ingredients. The houses are baited for mice and other pests are monitored and sprayed or dusted accordingly. We employ an integrated pest management concept. Good housekeeping techniques and sanitation are an integral part of our entire Gro-Plug® system.

The greenhouses are covered with two layers of clear polyethylene and air inflated. A third layer of clear plastic is used inside to drain condensation to the edge of the greenhouse. During the summer months the plastic is removed and the houses are covered with shade cloth giving approximately 35% shade. A fan-jet is employed to ensure good air movement and acts to circulate the hot air heat supplied from an LP heater. The thermostat on this heater is set at 35°F and only supplements the air temperature during very cold nights when the bottom heat may not prevent the tops from freezing. It also acts as a back up system to the hot water heat. The standard exhaust fans and motorized louvers are used to cool the greenhouses during the time the plastic is on.

The plants remain in the greenhouses for four to six months after which they are ready to transplant to the field or sell. A given greenhouse may be used for two or three crops per year depending upon th amount of energy one may wish to consume. We start our first crop approximately February 15th and it can be moved outside in mid-May after the danger of frost is over to finish its growth. It is ready for transplanting or selling between June 15th and July 1st. In mid-May the second crop is started in the greenhouse under plastic. After approximately one month the plastic is removed and the shade cloth put in place. The crop is finished by September 15th, or four months, since the temperatures are warmer at this time of year. We field transplant this crop ourselves or hold some of it over the winter for sale the following spring. We do not usually sell Gro-Plugs® in the fall unless the customers are far enough south so that root generation can occur and proper winter conditioning take place. A third crop may be started in the greenhouse on September 15th and run thru February 15th; however, this crop is expensive as it consumes considerably more fuel.

Costs depend greatly on survival percentage. Currently at 85% survival, the cost per plug is approximately 35¢. This includes all fixed and variable costs at a production level of 900,000 units per year. All amortizations are included except research in prior years.

SELLING/FIELD TRANSPLANTING

Selling. Because the 73 cell trays are relatively inexpensive, they can be used as a shipping container. Currently the PVC costs approximately 90¢ and the polystyrene 55¢ per tray. We have designed a shipping box for UPS, or the trays may be delivered in our own truck. It is important to educate the customer as to the proper handling of Gro-Plus®. It is critical that the plug is transplanted when the roots are active and at a time

when they will develop sufficient root systems prior to winter. They must be subjected to the normal fall photoperiod and temperature conditioning at their new locaiton prior to winter.

Field Transplanting. In our own operation we do not harden off the plants prior to transplanting as we want a large number of white active roots on the surface of the plug. We transplant all of our plugs with a modified mechancial transplanter at spacings varying from 8½" to 28" on the square. We design our production schedules in the greenhouse so that we are actually planting from May 1st through August 15th. Root regeneration and movement out into the surrounding medium occurs within 24 to 72 hours if the roots are active. During the cirtical first few days we use a mist blower several times a day depending on weather conditions to reduce the stress on tops of the plants. We are careful not to overwater new plants so as to inhibit root regeneration. Sample plants are dug every few days to monitor moisture and root development. The herbicide program varys during the course of the season and the physiological condition of the plant at the time of transplanting. Pests are monitored through an integrated pest management program.

Survivability was between 95-99% this past season. By the end of the summer the conifer plants are the same size and of better quality than our standard 3-year transplants (2-1) of the same species. The Gro-Plugs® are 4 to 7 months while the 2-1 are 3 years old. Furthermore, the quality of the Gro-Plug® is much more consistant, and its performance the following year excels that of the standard 2-1.

Deciduous plants such as *Betula* respond very well. A seed planted in late March and run through the Gro-Plug® system, being transplanted into the field in early June, reaches an average height of 2 to 3' by fall with excellent caliper and branching habit.

SUMMARY

Over the past 10 years we have developed a Gro-Plug® System which has become an integral part of our propagation methods for seedling-grown conifers and birch. The advantages for us appear to greatly outweigh the disadvantages. The major disadvantage is lack of technical knowledge and skilled people to perform the intricate tasks involved in producing a quality crop on a consistent basis at a reasonable price. Gradually this disadvantage has been overcome as we have learned by experience, and the percentage survival in the greenhouse has steadily climbed.

Some of the major advantages to us are that we are able to more quickly respond to market needs as our growing time is

greatly reduced. We make more efficient use of seed which is in short supply, such as our strain of *Pinus mugo* (ENCI). Crops which are not hardy in our area can be grown and sold in markets further south. Plants with low pH requirements can now be grown. Our transplanting work-load has been spread over the entire summer rather than concentrated in the busy spring months. Survivability is consistently excellent and predictable. Quality is improved through grading standards at the time of the initial transplanting and carries on into the field production. Finally, the Gro-Plus® system is replacing a considerable amount of our seed bed production and bare-root transplanting.

RALPH SHUGERT: Can you put *Taxus cuspidata* through this system?

THOMAS PINNEY: Yes. The key is getting good seed.

GREENHOUSES HEATED FROM POWER STATIONS[1]

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In the early 1970's, Northern States Power Company (NSP) began to explore methods of utilizing for beneficial purposes the large amounts of heat rejected by the condensers of electric generating plants. At that time all of NSP's plants had cooling systems which were designed for "once-through" cooling, that is, water was taken into the plant from a river, used to condense steam, and then was returned to the river. Minimum temperatures of condenser discharge water at plants designed for this type of cooling range from 50°F to 60°F.

Since it would be extremely costly to remove significant amounts of heat from water of this temperature, it was not until a "closed cycle" cooling system, such as the one designed for the Sherburne County plant (SherCo), came into the picture that the Company could seriously consider developing beneficial uses of power plant cooling water. Minimum temperature of SherCo's condenser discharge water is 85.F. Sometimes the temperature during the heating season can be as high as 95° to 100°F. In a closed cycle system, cooling water is circulated from the power plant condenser through cooling towers, where the heat is removed by evaporative cooling. The cooled water is returned to the condenser where the cycle is repeated.

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[1] Editor's Note: the paper by Russell Stansfield was presented by Dr. Harold Pellett, University of Minnesota, St. Paul, Minnesota.