CONTAINER SEEDLING PRODUCTION AT MT. SOPRIS NURSERY

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INTRODUCTION

Containerized seedlings are a relatively new phase of nursery production all over the United States. Our greenhouse facilities at Mt. Sopris Nursery are only 1½ years old although the nursery has operated over 15 years. We are therefore still learning the culture of container stock but I feel that our facility is representative of many western greenhouse operations.

Our greenhouse was built in response to the current effort to eliminate the "reforestation backlog" in the Western States. The Central Rocky Mountain Region has over 325,000 acres of national Forest land to be aforested or reforested based on a recent inventory. This translates to over 130 million seedlings using planting density of 400 trees per acre. We have been given 10 years to alleviate this backlog ending in 1984. Considering that our bareroot seedling production requires from 2-3 years and that our annual production at Mt. Sopris Nursery was around 4 million trees, you can appreciate our dilemma. So the decision was made to build a greenhouse to supplement the bareroot program and provide a rapid means of producing stock for the reforestation backlog.

MT. SOPRIS GREENHOUSE FACILITY

We use two different size containers or cells in our greenhouse, one of 10 cu. in. capacity and another of 6 cu. in. Both types of containers are produced by Ray Leach and are made of soft plastic and bullet-shaped and are interchangeable in a hard plastic rack. The 1 ft. x 2 ft. rack holds 98 10 cu. in. cells or 200 of the 6 cu. in. size. We prefer this type of container because they are reuseable and the removeable cells allow culling and consolidation eliminating wasted bench space.

Our greenhouse is a metal frame fiberglass-covered structure containing 9,264 sq. ft. of useable table space out of a total 11,500 sq. ft. or 81% space efficiency. This converts to 926,000 seedlings of the 6 cu. in. size or 454,000 of the larger 10 cu. in. size. The seedling trays rest on 4 ft. high tables permitting good air circulation beneath the containers. These raised tables promote air pruning of seedling roots and heating from below provides warm soil temperatures.

We produce two crops of container seedlings each year, one in the spring and one in the fall (Figure 1). The early crop is sown around the first of March and remains in the greenhouse until the end of July. By this date, the seedlings should complete the desired top growth and are transferred to the shadehouse. The second crop is sown in July and remains in the greenhouse through the winter. These seedlings finish their "hardening-off" in the greenhouse are transferred to the greenhouse late in the winter. Container seedlings are usually planted in the spring although late-summer and fall plantings are becoming common.

Because the majority of the reforestation backlog is Engelmann spruce (Picea engelmannii Parry), we are emphasizing that species in our greenhouse. Engelmann spruce requires three years in the field so our 6-month container seedlings represent a considerable savings in time alone. We have produced a small quantity cf lodgepole pine (Pinus contorta var. latifolia Engelm.), ponderosa pine (P. ponderosa var. scopulorum Engelm.) and Douglas-fir (Pseudotsuga menziesii var. glauca (Beissn.) Granco.

LOADING THE GREENHOUSE

A typical rotation begins with the preparation of the potting mix which consists of 50% acid peat moss and 50% coarse vermiculite. These ingredients are mixed together in a large rotary mixer along with a small amount of water. The resultant potting mix is coarse textured for good aeration and leaching, has excellent water retention, a slightly acid reaction of 5.0 - 5.5 and is essentially sterile. This potting mix is moved by conveyor to the loading table where the containers are filled.

Our homemade loader contains a motor-driven cam which shakes the containers while they are being filled; this eliminates air pockets within the containers. The filled containers are then tamped to compress the potting soil and provide space for the seed. The seeding operation utilizes a commercially-made shutter box which contains a number of holes corresponding to the container tray and a moveable shutter with offset holes. The prescribed number of seeds fall into the holes on the shutter and the seed drops into the containers when the shutter is moved over the lower holes. This system is reasonably precise and three seeders can keep up with the rest of the process. We usually seed from 2-6 seeds per cell to minimize empty containers. The seed is covered with a thin layer of white perlite which serves to keep the seed moist and reflects excess heat while providing easy penetration for the emerging seedlings. Completed trays are carried to the greenhouse by a Cushman scooter where they are loaded onto the conveyor which takes them to the tables.

GREENHOUSE GROWTH PERIOD

The growth period begins with the first irrigation of the fully loaded greenhouse. The germinating seedlings require frequent irrigation and emergence is usually complete in 3-4 weeks. The seedlings are thinned to one per cell and all empty cells are removed from the trays and replaced with containers with seedlings. This operation is time-consuming but assures a full greenhouse.

If the number of empty trays exceeds 5%, they are resowed after removing the perlite and ungerminated seed with a shop vacuum.

After the germination period is complete, the seedlings enter the exponential growth phase, so named because of the rapid height growth which occurs. Seedlings are forced to their maximum potential growth during this period by supplying all their biological requirements. The object is to minimize all ecological limiting factors through environmental modification. Day and night temperatures are kept within 2^{o} F of the optimum for the species. Plant moisture stress is minimized through frequent fertigation, a termed we coined to describe simultaneous irrigation and fertilization. Carbon dioxide is generated during early morning hours to stimulate photosynthetic production. Vegetative growth is promoted through intermittent bursts of red light throughout the night.

Our fertilization formulas were developed by Dr. Tinus of the Rocky Mountain Forest and Range Experiment Station and are scientifically calibrated to provide exactly what rapidly growing conifers require (Figure 2). All 13 chemical elements are supplied to the natural irrigation water which is simultaneously buffered to ph. 5.5. While seedlings are in the exponential growth phase they receive a high nitrogen macronutrient solution (S.S. #1) and micronutrient solution (S.S. #2) which promotes vegetative top growth. After they have been moved to the shadehouse, they are switched to a low nitrogen-high phosphorus formula (S.S. #3), along with micronutrients.

The fertilizer solutions are mixed in 200 l. plastic tanks and then injected into the water system using a mechanical injector. The seedlings are fertigated often enough to maintain the plant moisture stress below 13 bars of tension; a pressure chamber helps to monitor plant moisture stress. We always fertigate long enough to adequately leach through the containers to prevent harmful chemical buildup. The fertigation "catch" solution is regularly tested for ph and salt concentration to assure that the fertilizer injectors are working properly.

The exponential growth period usually lasts for about 3 months at which time the seedlings have reached their prescribed height. They are graded to certain height standrads and moved to the shadehouse via conveyors.

SHADEHOUSE GROWTH PERIOD

The shadehouse growth period is designed to harden-off the seedling foliage and induce bud set. Fertigation and partial shading are the only environmental conditions we can alter during this period. The fertilizer recipe is changed to the low nitrogen-high phosphorus solution to promote root and caliper growth. The cool night temperatures at our elevation also promote dormancy.

Most seedlings are ready for outplanting after 4-6 weeks in the shadehouse even though they are not completely dormant. If they are not going to be planted immediately they will be held over in the shadehouse to the following spring. Container seedlings are usually shipped in refrigerated trucks to reduce stress during transport.

PROBLEMS IN CONTAINER SEEDLING PRODUCTION

The accelerated growth of container seedlings leads to some interesting problems. A greenhouse is a very fine-tuned instrument and the elaborate monitoring equipment is far from trouble-free. Rapidly growing greenhouse seedlings are quite succulent and susceptible to injury. In a greenhouse problems happen quickly and tender seedlings can be damaged in a very short time.

Disease organisms thrive under warm moist greenhouse conditions. Even though precautions are taken to exclude diseases, it is impossible to do so completely. In our greenhouse we have had no serious problems yet. Two fungi has caused some damage, however, *Botrytis cineria* causes a foliage blight and will eventually lead to a stem-girdling canker. *Fusarium* spp. causes a cortical root rot which kills seedlings during the cotyledon stage. If these diseases are controlled by rapid detection, roguing, fungicide application and environmental modification they do not lead to serious losses.

Equipment failure is possible at any time although most critical during the winter. A backup diesel generator protects against power failure and an alarm system will alert personnel of radical changes in environmental conditions. Our most serious problem to date involved our cooling vent which stuck about 4" inches open one night. That night the temperature dropped to around 0^{o} F and the row of seedlings nearest the vent suffered foliage burn. Luckily, the buds were not killed and most of the seedlings recovered.

Sometimes we are our own worst enemies. In May of this year our greenhouse crop of Engelmann spruce was in the cotyledon state and we noticed that our field crop of spruce had broken bud and started top growth. We reasoned, therefore, that daylengths were long enough so that we could save some energy and shut off the supplemental night lights in the greenhouse. A few weeks later we noticed that some of the seedlings had set terminal buds. Realizing our mistake, we turned the lights back on and those seedlings eventually began to grow again but we had lost about a months growth in the meantime. The moral is do not tamper with a well-running system.

COMPARING CONTAINER AND BAREROOT SEEDLINGS

At our nursery all our bareroot stock is 2-0 or 3-0 in age whereas we can produce comparable container seedlings in 6 months. This quick growth is the most obvious benefit of a greenhouse system because it is more sensitive to changing reforestation priorities. Biologically, container seedlings suffer less transplant shock during outplanting because the roots never lose contact with the potting soil. Tubelings can be planted almost all year long except during spring shoot expansion when the succelent tops can be easily damaged. Storage on the planting site does not usually require refrigeration if the seedlings are kept moist. An additional benefit is that it is almost impossible to misplant a tubeling although it has been done.

Container seedlings are not without disadvantages. At our present prices, they cost twice as much as bareroot seedlings. The most serious problem is the increased handling and greater space required during transport and at the planting site. Shipping requires 5 times as much space and the heavy bulky trays are difficult for planters to handle. At the present time, we are having a hard time getting the containers returned promptly from the field. Tray breakage and loss always occurs to some degree.

The determining factor in the container vs. bareroot seedling comparison will be in the outplanting success. We currently have studies underway and have plans for several others. Initial results show comparable survival between the 2 types of stock but increased shoot growth for container seedlings. Outplanting trials must encompass the entire range of site conditions as one type of seedling may outperform the other in certain situations. I personally feel that container seedlings are simply another reforestation tool and will add a much needed flexibility to most western planting programs.

CONTAINER SEEDLINGS
TWO-CROP ROTATION

		SPRING CROP		FALL CROP	
YEAR	MONTH	GREENHOUSE	SHADEHOUSE	GREENHOUSE	SHADEHOUSE
	JAN				
	FED				
	MAR	0 GERMINATION			
	APR	EXPONENTIAL GROWTH			
	MAY				
	JUNE				
1978	JUL		CALIPER &	0 GERMINATION	
	AUG		ROOT GROWTH	EXPONENTIAL	
	SEP		OUTPLANTING	GROWTH	
	OCT				
	NOV		or	ROOT & CALIPER GROWTH	
	DEC		DORMANCY		
	JAN			DORMANCY	
	FEB				
	MAR				DORMANCY
	APR		OUTPLANTING		OUTPLANTING
	MAY		0		0
	JUN				
1979	JUL				
	AUG				
	SEP				
	OCT				
	NOV				
	DEC				