GROWING INTERIOR SPRUCE (Sx) SOMATIC SEEDLINGS IN THE NURSERY[1]

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INTRODUCTION

Since the late 1980s in British Columbia, there has been a growing interest in the idea of replicating conifers through embryogenesis. Theoretically this procedure allows the production of unlimited numbers of trees with the same genetic make up (i.e. for insect resistance, better growth, desirable wood quality). In practice and with due diligence with respect to testing and biodiversity issues, this technique could be used to produce custom clonal lots tailored to specific site needs in the field. While this technique may not be acceptable in some situations, it could offer advantages in areas where timber production is the primary land use.

The actual production of the somatic propagules takes place in the laboratory and is beyond the scope of this paper. Suffice to say that seed embryos from superior provenances are dissected out of the seed and passed through a variety of processes to develop an undifferentiated callus-like material. Portions of the callus can then be differentiated into many small somatic propagules resembling germinating seedlings. Those propagules can then be raised in a nursery using normal cultural practices. At various times, the common name for this kind of tree has been either somatic seedling or embling.

At the suggestion of Drew Brazier, Director of Nursery and Seed Operations Branch, our Extension Services (ES) nursery started growing interior spruce (Sx) somatic seedlings in 1994. This was part of a larger program that would grow and test various clones in the nursery and out in the field. To-date, with the cooperation of Kendal Thomas (Woodmere Nursery, Fairview, Alberta), Chris Hawkins (UNBC, Prince George, B.C.) and a number of other ministry and industry partners, there are in the order of 30 demonstration sites and 33 research sites planted in the Prince George and Cariboo Forest Regions. The field goals of this project are to test and demonstrate the performance of the various clones produced over the range of biogeoclimatic zones they may be planted in. There have been a number of other nurseries involved from time to time, but we will only report on what we have found at Extension Services.

SCALING UP

Table 1 illustrates the gradual increase in numbers of somatic seedlings grown in our nursery between 1994 and 1997. For comparison, in 1998, Green Timbers Nursery began an operational crop of 190,000.

Table 1—Production of somatic seedlings at Extension Services 1994-1997

Year	Age	# Lines (cones)	# Arriving	# Lifted	Percent[a]
1994	1+0	10	4,704	2,881	61.2
	2+0	4	1,792	1,200	67.0
1995	1+0	21	22,396	13,688	61.1
1996	1+0	34	23,987	19,487	81.2
1997	1+0	38	93,502	64,450	68.9
	1+0	776	41,587	35,369	85.0

[a] Culls often include entire clones, testing should reduce this in time.

In 1997, we had 38 lines or clones that were destined for clonal block demonstration sites and 776 lines destined for research trials. To put this in perspective, each clone has the specific genetic traits of one seed. In essence, the individuals in each block of the same clone or each pallet of the same clone exhibit very similar growing characteristics. To put this in perspective further, the natural variation you might find within a seedlot is now separated into batches within the greenhouse. In 1994, there were some styroblocks that held 2 or 3 clones each and as you can imagine, that affected crop management. In 1997, production was scaled up for part of this work and we were able to produce 2 or more pallets of each of the 38 clones above. That significantly improved our ability to manage the crop. Some of the issues this raises will be discussed later.

THE GROWING REGIME

Somatic seedlings arrive in the nursery as young plantlets (1.5 - 5 cm long including radicle) in their laboratory media containers and bearing varying amounts of root and shoot. In general (as you would expect) we found that more roots on young plantlets improves survival and early growth.

Tender somatic seedlings are removed by hand and individually placed in watered 415B styroblock containers with our regular seedling mix (3:1 Peat/vermiculite; lime and micromax) (table 2). Planting dates ranged from March/April in 1994 to mid-February in 1997. During planting the blocks are misted to keep the media moist, much like with germinating seed. This is critical with somatic seedlings because they initially have a radicle protruding into the media right at the start. They lose some of their turgor quickly after transplanting and are subject to desiccation at this point. We generally use 3 to 5 scheduled mistings a

[1]Summers, D.; Calam, C. 1999. Growing interior spruce (Sx) somatic seedlings in the nursery. In: Landis, T.D.; Barnett, J.P., tech. coords. National proceedings: forest and conservation nursery associations—1998. Gen. Tech. Rep. SRS-25. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 119-121.

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Table 2—Growing regime for spruce at Extension Services

Lights	21h through July/August
Soil mix	Peat/vermiculite (3:1) plus lime and micromax
Blocks	PSB 415B
Misting	3-5 times/day; changing to ad lib once germinated
Day/night temps	21 through germination changing to 24/17 during growth. Ambient once outside in July/ August
Lift	December after storability testing

day, depending on weather and may apply one or two manual passes as needed on hot days. Misting occasionally includes a foliar application of fertilizer (at 25 ppm N). Misting continues for up to a month, depending on the condition of the somatic seedlings and how long it takes them to begin regain their turgor.

Our measure for how long to mist has been to watch the foliage. When the turgor increases (i.e. the young tops begin to straighten up just a little), we reduce misting (other than for heat protection) and begin the fertilizer regime (table 2) and wet/dry cycles. Greenhouse temperatures are set about the same as for germinating seeds (24h at 21C) during the misting period. Day/night temps (24/18 C) are instituted once the misting is terminated. A day length of 21h was used for acclimating somatic seedlings in most years. An outline of our culture is provided in table 2.

During the growing season, visual differences in growth appear between clones. Due to a slow transplanting process and different delivery times from the lab, some clones are planted earlier. Some others may recover quicker after transplanting and some seem to grow faster. We have found that sorting the material into 2 or more groups can be beneficial when this occurs. In fact, with some clones this can occur early on and grouping may be beneficial when misting is reduced. We seldom had more than 3 groups of clones for any length of time and it did not result in too much extra management, once we were use to it.

Stock is moved outside as it begins to reach minimum height specifications (13 cm = cull: BCMOF Stock Specifications, 1997, unpublished). Early grouping according to height facilitates this. In general, the bulk of the material was ready to go out within a window of about a month.

Crop management remained much the same outside the greenhouse as in, however there was no supplemental lighting. Irrigation and fertilization were done according to wet/dry cycles of the crop. Reduced rates of fertilizer began at about the end of July or early August and became periodic about the middle of September with the onset of fall rains. Lifting took place after storability testing in December.

Table 3—Example lift data for interior spruce seedlots (SL) and somatic seedlings

Seedlot or somatic line	Height (std. dev.)	Caliper (std. dev.)
SL 29163 (wild seed)	183.63 (21.64)	3.42 (0.48)
SL 6863 (orchard seed)	213.65 (27.17)	3.82 (0.44)
119-2558	154.91 (12.61)	3.70 (0.32)
107-1917	203.71 (18.02)	3.85 (0.41)
1-1446	181.43 (17.01)	3.37 (0.42)
7-2833	300.64 (33.61)	4.10 (0.56)

In the final crop the clonal effects are quite apparent. Individual clones have identifiable height, color, needle shape and tree form. Other than some variation (table 3) due to position in the blocks and location of the blocks on each pallet (i.e. within each clone), the individual clones generally appear quite uniform.

Discussion

Probably the most important thing to note is that only minor modifications to early seedling culture and some bio/spatial issues due to clone are required to grow somatic spruce seedlings.

Somatic seedlings arrive in the nursery as a lab culture with varying degrees of tops and roots. Some resemble young germinants just after the seed coat has fallen off - although they are much smaller and less robust. Others more resemble very small cuttings - all top, a bit of stem and almost no root. As they are planted, there is obviously damage being done to any root hairs and perhaps the root tips. This compounds the existing low root to shoot ratio and their inability to support high transpirational demands.

In essence what you are starting with is an upside-down version of a seedling. With a seedling, the radicle emerges first and becomes established as the shoot and leaves begin to expand. Seedlings draw on the endosperm and gradually shed the seed coat as the roots develop, take hold and begin to supply nutrients and water. With somatic seedlings, you have the reverse: a significant top and due to transplanting, very little root support until the root gets acclimated to it's new medium.

This is probably the most critical stage of production. The difference is that with somatic seedlings at this stage, you have a high rate of evapo-transpiration from the foliage and an impaired root system. Humidity and irrigation patterns are critical to ensure the tops don't dry up and the roots are able to get established. For the most part however, we found that misting and irrigation was much like with regular germination. The key is to keep the humidity around the plants high and avoid prolonged periods with saturated blocks which could induce additional stress and disease. Bottom heat may help in reducing evapo-transpirative stress as compared to the unit heaters, fans and overhead tubes used to heat many greenhouses. It may also help with moisture management in the media.

With a germinating seedlot, individuals may germinate at different rates. The same holds true for somatic seedling establishment, but with an added twist - clones differ as well. Depending on the quality of the material planted, you are presented with the same issue as with seedlings and/or an extra consideration - pallets of different clones that are generally growing faster or slower. In many ways, it's much like having a number of different seedlots in the same house.

One of the biggest challenges is getting all the material planted so that the future crop is uniform. This requires a lot of organization and well trained manpower. Currently, the process is not automated, although companies are working hard to accomplish this through various means.

The organizational skills that are needed are much the same as with any job that requires a crew of people on an assembly line. Materiel must be supplied at the rate and in the order needed. Crew movement should be limited and tasks should be focused.

When planting somatic seedlings, we found 2 things that can speed up a crew's production: pre-gritting the cavities (top dressing with forestry sand) and dibbling planting holes in the media. With pre-gritting, we use somewhat less grit than normal (about 0.5 cm), but still enough to slow down evaporation and inhibit algae and mosses. If this is not done beforehand, gritting must be done afterwards by hand and this can damage the young plants. Dibbling is done after gritting with a home-made dibbler. It consists of a piece of wood about the same dimensions as a styroblock with a handle attached to one of the flat sides. Nails are driven through the wood such that they match up with the cavity layout in the styroblocks. The wood is placed over the block and pressed down to create planting holes. This process seems to reduce the amount of damage done to roots during planting. Blocks are watered after planting to settle the media around the new roots.

Once the material is planted, we mist under lights for a week or two until the crop shows signs of perking up. This is largely a subjective assessment much like estimating when most of the seedcoats have been shed in a seedling crop. In this case, we wait until stems and foliage stand taller and start to elongate a bit. There has been some suggestion that misting or charging the media or mist with phosphorus may promote faster root establishment (Dan Polenenko, Silvagen Inc., personal comm.). We tried this one year, but did not see a difference.

With somatic seedlings you have individual clones representing the range of diversity of a regular seedlot in terms of growth. Seedlots have slow and fast growing seedlings mixed up and they are all treated the same. However, with clonal material, each clone seems to exhibit the same general patterns - some individual clones seem generally fast growing (or more responsive to nursery culture) and some seem slow. As the season progresses, this requires a bit more management of the crop. The fast growers may have to be separated out and treated differently than the slow ones. Typically we have 2 - 3 groups.. For example, we keep the slow ones inside the greenhouse under full fertilization and lights for up to 4 weeks after the faster growers have been moved outside.

If the crop is managed properly, grading also presents a unique experience - for the most part, a clone is either a cull or not. However, even with the obvious visual clonal similarity, there is still variation for individuals within a clone due to such things as lab culture, planting technique or position in the block or on a pallet (table 2). With careful management, some of those differences can be minimized.

In summary, other than a few minor management differences, growing Sx somatic seedlings is much like growing regular seedlings. Misting continues until the plants appear to be established. Once that is accomplished the culture changes over to a regular fertilizer regime and wet dry cycles. Normal culture is used through to the final lift. There is more opportunity to manage diversity within the crop with somatic material and to a certain extent the cull factor can be reduced.

Somatic seedling quality at time of planting is as important as having a good seedlot and it seems that within certain bounds, larger plantlets are better than small, some root is better than none and sturdy is better than lanky due to the tendency to 'wilt' a bit on transplanting.

Planting dates (environment) can be significant. In our case it seems that planting in February provides more assurance of success than planting in March due to the rapid, frequent changes in weather and insolation that occur in the early spring in the Vancouver area. In sunnier climes this may point out the need for stricter control of media moisture, temperature and humidity for the establishment phase.

Knowing something about past nursery performance can help in organizing the crop to minimize the amount of labour expended in moving stock around. In the early stages of testing this is critical so that important genetic gains are not screened out at the nursery stage. This has to be managed carefully until more testing is done. It may be that clonal forestry will demand some custom cultural techniques to ensure that the very best material gets planted out in the field. After all, genetic gain is what the customer if after.

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