THE USE OF GREENHOUSES IN PLANTING STOCK PRODUCTION

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In keeping with the theme of this meeting, my purpose is to examine the potential value of greenhousing as a tool for manipulating and optimizing seedling growth in the nursery. I hope to show that greenhouses, rather than being restricted in application to the production of containerized planting stock, can be a valuable addition to the bare root nursery also.

I do not intend to deal with factors governing greenhouse design or the selection of equipment, nor shall I say very much about greenhouse operation per se. While these are important areas for those involved with greenhouse management, at present or in the future, I shall confine my remarks mainly to a discussion of the biological gains which can be achieved through greenhousing.

INTRODUCTION

Although there is a recognized need to expand planting programs substantially in Ontario, we are all familiar with the pressures that demands for increased planting targets exert upon the nursery system. Not only is a great strain placed upon a nursery's production capacity and resources but, almost inevitably, nursery costs escalate as a result of the need to undertake nursery expansion or acquire additional equipment and staff in order to meet these demands.

To a large degree labour costs and availability are at the heart of the nurseryman's problem. We usually recognize two basic approaches in attempting to reduce labour costs--the first, and most obvious, is through increased mechanization; the second through the development of more efficient cultural techniques and new types of product. Although there has been a considerable advancement in both areas over the past twenty years, there is obviously still considerable scope for improvement and innovation.

We must recognize, however, that the challenge posed by increased production targets is not simply a matter of reducing costs. The nurseryman can no longer consider his job finished when planting stock leaves the nursery gate, alive and healthy, at least cost.

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Because of the complexity of regeneration needs, field performance must be amongst the criteria used in assessing the success of the nursery system, despite all that may happen to nursery stock between the time it leaves the nursery and field planting. While we recognize that field practices are outside the nurseryman's control, it is clearly essential that he relate more directly to the field performance of his products in order to match them to the wide range of site conditions which now have to be planted.

It is this diversity of site conditions which poses problems for nursery production. In simplest terms, the nurseryman's objective may be defined as "the production of planting stock of maximum survival and growth potential, with a high probability of establishment success". However, it is clear that in addition to efforts aimed at improving planting stock quality, he must increasingly strive to develop techniques for producing an array of products that are more closely matched to specific site requirements and, in total, are suitable for planting throughout the planting season. This not only assumes close collaboration between planter and nurseryman, particularly in the drawing up of planting stock specifications, but also implies a high level of technological competence in the nursery and more advanced facilities for manipulating plant growth than exist at present.

The traditional bare root nursery system is, of course, an attempt to manipulate and control the natural processes of regeneration, with the aim of increasing the probability and reducing the time required for stand re-establishment. Thus, within the limits permitted by local climate, we attempt to optimize and manipulate seedling growth by the application of fertilizers, controlled irrigation, root pruning and, in some cases, transplanting. However, manipulation of crop development can be costly, a fact that must be borne in mind when we think of a wider range of nursery products. In addition, bare root systems are highly vulnerable to seasonal weather fluctuations, so that anything that can be done to reduce the effects of uncontrolled climate increases reliability and the probability of achieving production goals at reasonable cost. For this reason, I believe that some of the more significant changes in nursery practice for the future are likely to come about through the increased use of greenhouses, not only for specific products such as containerized stock, but also as an integral component of the overall nursery system.

GREENHOUSING IN THE NURSERY SYSTEM

As an aid to the controlled growth of tree seedlings, greenhouse techniques are no more than an extension of the principles govern-

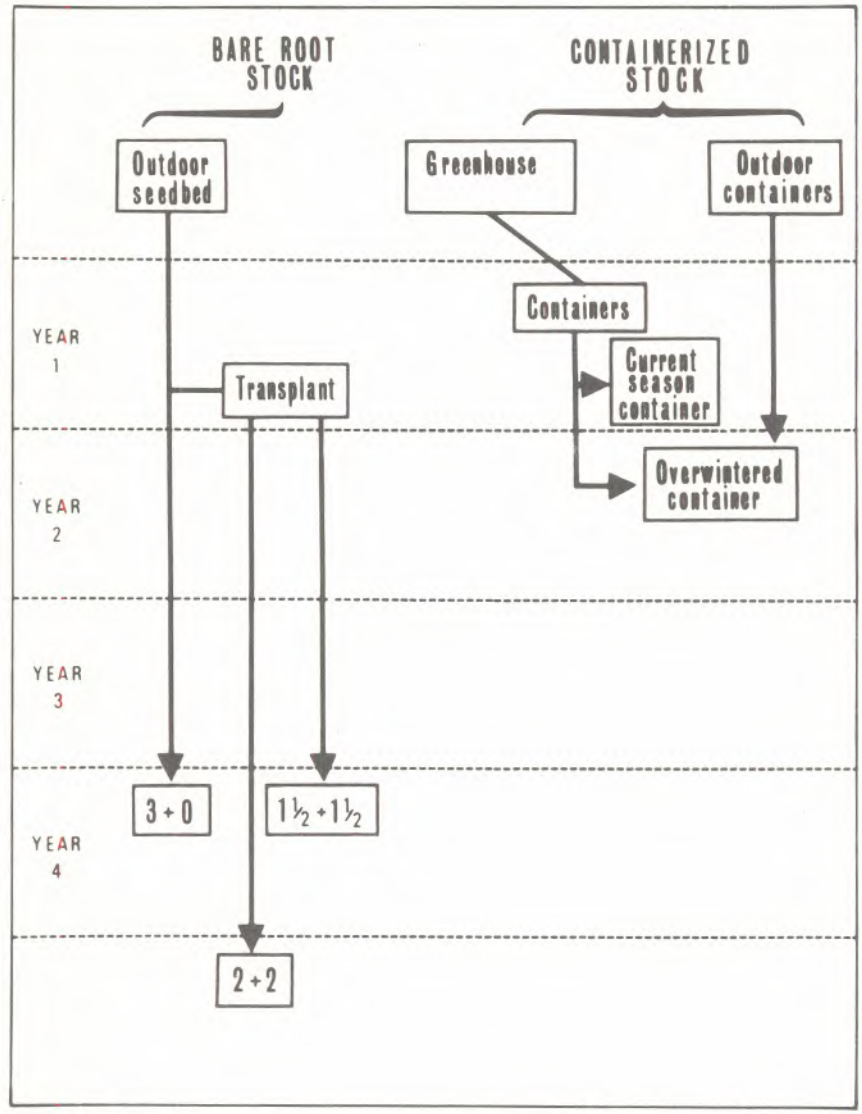

Figure 1. Diagrammatic representation of current production options for spruce planting stock in Ontario.

Correction: Transplanting of bare root stock will normally be carried out in Year 2.

ing conventional production methods. More factors are under the nurseryman's direct control, and his capacity for manipulating germination and growth is therefore considerably enhanced. Greenhousing offers no magic solutions, however, although it can, through more intensive growing techniques, optimize the advantages while reducing or eliminating the disadvantages of traditional bare root culture. As a result, we might anticipate both greater control over planting stock quality and potential savings in time or cost, with the added possibility of greater efficiency for the planting system as a whole. This is not to imply that such methods might replace traditional growing techniques, but rather that they might supplement existing methods, enabling us to achieve greater versatility in production capability.

Although greenhousing was originally introduced into Ontario for the production of containerized seedlings, new applications of greenhouse techniques promise to eliminate the almost traditional division that now exists between bare root and container stock production. There are many benefits that can be foreseen from a melding of the two technologies, not least of which is the fact that they would become complementary components of a single production system rather than the competing technologies we see in the present nursery system (Fig. 1). Furthermore, a fully integrated nursery system incorporating greenhouses can undoubtedly open the way to a much wider range of cultural options than has hitherto been available. In the following examples I hope to demonstrate some areas in which biological gains may be achieved.

1. Containerized Seedlings

Since production techniques are largely determined by the product required, let us briefly review the current status of container planting within the overall regeneration system as it applies to Ontario. In general containers are still regarded as a supplement, rather than an alternative, to bare root planting, primarily as a vehicle for extending the planting season into the summer months. Consequently, present standards for field performance of planting stock make no distinction between container grown and bare root material (Table 1). Irrespective of stock type we are looking for comparable survival and growth impact after three growing seasons. These standards are based on the assumption that the benefits of scarification will last an average of 3 years, and are related to the need for a tree to keep ahead of weed competition. With present stock specifications this effectively includes the use of containerized spruce on our more difficult, fertile sites.

Table 1. Field performance standards (shoot height) for planting stock at end of second and third field season

	End of second field season	End of third field season
WHITE SPRUCE	30 cm (12 in.)	51 cm (20 in.)
BLACK SPRUCE	36 cm (14 in.)	64 cm (25 in.)
JACK PINE	36 cm (14 in.)	76 cm (30 in.)

Even though, on the basis of current production technology, it is evident that the spectrum of sites suitable for container planting is considerably narrower than that for bare root stock, it will be appreciated that failure to attain these arbitrary performance levels seriously reduces the chances for plantation success. Consequently, present growing prescriptions for containerized seedlings (Table 2) rely heavily upon intensive greenhouse culture in order to produce planting stock capable of meeting performance standards. Through greenhousing, of course, we can expect substantially shorter production rotations than with bare root stock, with all the advantages that this offers in terms of production flexibility, both biological and operational.

Table 2. Size specifications and suggested production rotations for containerized planting stock in Ontario

	Planting Stock Grade	
	Medium	Small
SIZE SPECIFICATIONS		
Total dry weight (mg)	700	350
Shoot height (cm)	15.0	7.5
Stem diameter (mm)	1.5	1.0
PRODUCTION ROTATIONS		
White spruce	26-30 weeks (overwinter)	14-16 weeks (current) [1]
Black spruce	30-32 weeks (overwinter)	16-18 weeks (current)
Jack pine	15-20 weeks (current)	8-10 weeks (current)

[1] Current = planted in same year as produced.

Although the seedling specifications, and the greenhouse rotations required to achieve them, may appear overly demanding, there is ample evidence to show that seedling size has a profound influence upon the field performance of container stock. Much of the stock produced in the past was far too small, and we are only now beginning to see the potential benefits to be gained from greenhouse culture as larger, better quality material is made available to the planter.

That containerized seedlings approaching the size specifications outlined in Table 1 can match the height growth of bare root stock on suitable sites is indicated by preliminary results of planting trials with paperpot seedlings. Although less than one tenth the dry weight of bare root stock at time of planting, these seedlings achieved considerably greater height increment during their first full season in the field (Fig. 2). If similar early growth responses can be reliably duplicated in operational situations then the future of container planting in Ontario can be viewed with optimism, irrespective of the type of container adopted. Clearly, much depends _Ton the ability and willingness of growers to meet more stringent product specifications--an obligation that will undoubtedly necessitate a more critical approach to intensive greenhouse culture than we have seen in the past.

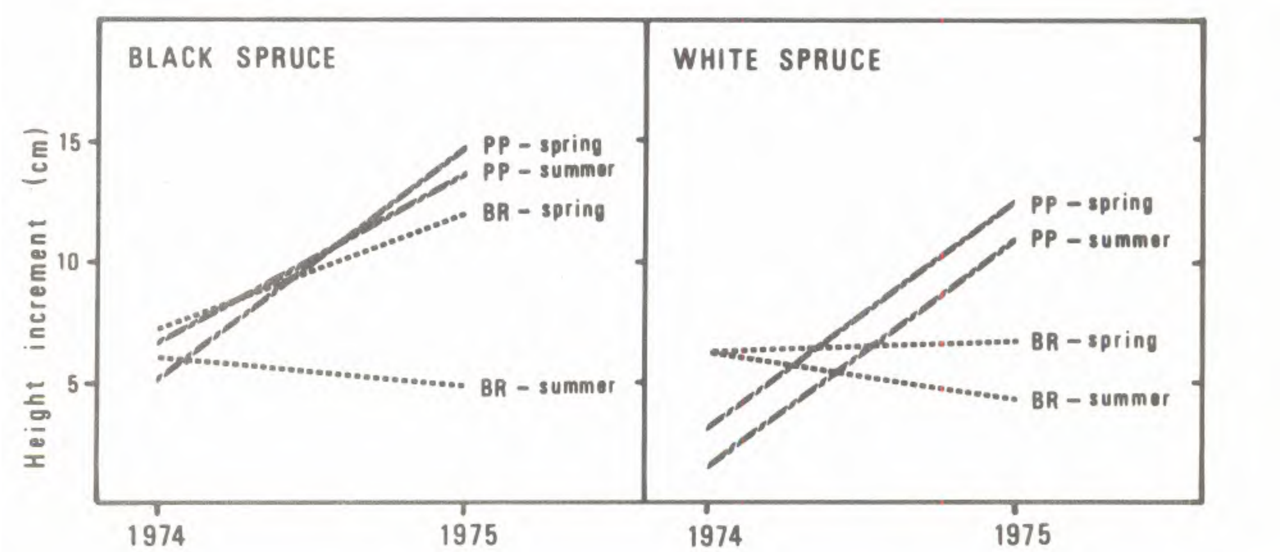

Figure 2. Annual height increment of bare root (BR) and paperpot (PP) seedlings for two planting dates (spring = May; summer = July). Thunder Bay district (n = 50).

Although greenhousing is accepted as an integral part of containerized seedling production technology, we might ask how many growers derive optimum gains from greenhouse culture. For many operational situations it is probably true to say that greenhouses are a seriously under-utilized, but expensive, capital asset, which are rarely used to maximum biological advantage. Thus, there appears to be considerable scope for improvement in production efficiency and capability through the better utilization of greenhouse facilities and techniques, as well as excellent opportunities for product diversification. At present, the latter is of secondary importance, for the growers' immediate concern must obviously be to develop the expertise necessary for meeting upgraded seedling specifications as efficiently as possible. However, we should not exclude the possibility that, in the long term, a variety of product specifications might extend the application of container planting to a wider range of site conditions, even to the extent of providing an alternative to bare root stock on some of our more difficult spruce sites.

2. Accelerated Production of Bare Root Stock

So far as bare root production is concerned, greenhousing offers the prospect of increased reliability during the most critical phase in the production cycle--i.e., the seedbed stage. Because greenhouses allow greater control over germination and early growth, the potential benefits to be derived by transferring the traditional seedbed to an enclosed, greenhouse environment are extremely attractive, viz.: shorter seedbed rotations; improved quantity and quality of seedling stock available for planting or transplanting; greater plant uniformity; more efficient attainment of product specifications; perhaps lower seedbed costs to offset transplanting costs.

In light of the increased demand for spruce transplants and rapidly escalating production costs, trials are now being conducted at the Swastika nursery in northern Ontario to evaluate the feasibility of utilizing greenhouses for the accelerated production of seedling material. The test unit is a Vary ® greenhouse, a simple plastic-covered structure of the type sometimes referred to as a "Finnhouse". The house covers a bed of peat approximately 15 cm (6 in.) in depth and, with the exception of early season start-up, is essentially unheated; the plastic is removed as required to harden-off the seedlings. All nutrients are applied in the irrigation water. Early results have been quite encouraging, and demonstrate substantial gains in seedling growth under greenhouse culture compared with traditional seedbeds (Fig. 3). There are still many unanswered questions, but it does appear that the technique may hold considerable potential for the intensive production of seedling stock for transplanting, particularly black spruce (Picea mariana (Mill.) B.S.P.). In addition, preliminary tests suggest that it may be possible to produce 1+0 jack pine (Pinus banksiana Lamb.) suitable for outplanting using this method.

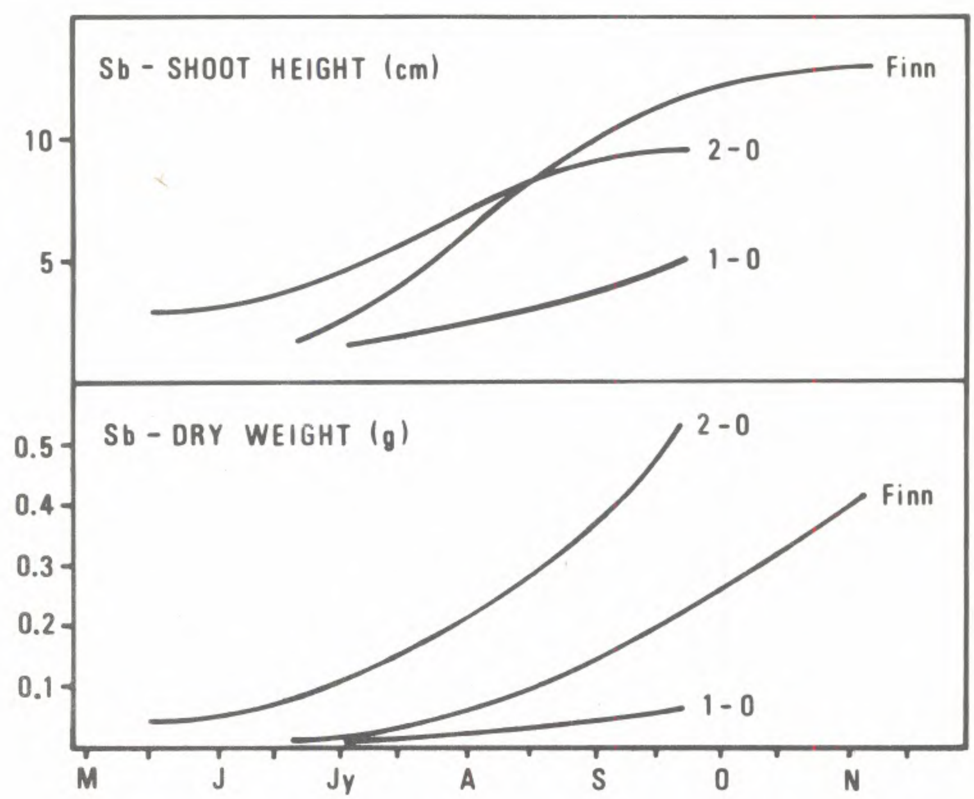

Figure 3. Growth of black spruce seedlings in "Finn" style greenhouse, grown on 15-cm (6 in.) bed of compacted peaty muck, compared with 1+0 and 2+0 seedbeds. Swastika nursery.

Seedlings grown in greenhouse seedbeds must, of course, be transplanted bare root if transplants are required. This has a number of obvious disadvantages when transplanting under unfavourable weather conditions. An alternative approach to the accelerated production of transplant stock is through the transplanting of containerized seedlings. Although probably more costly in terms of stock for transplanting, this method could provide a more effective means for producing large transplants rapidly because of the advantages conferred by the "packaged" and undisturbed root system.

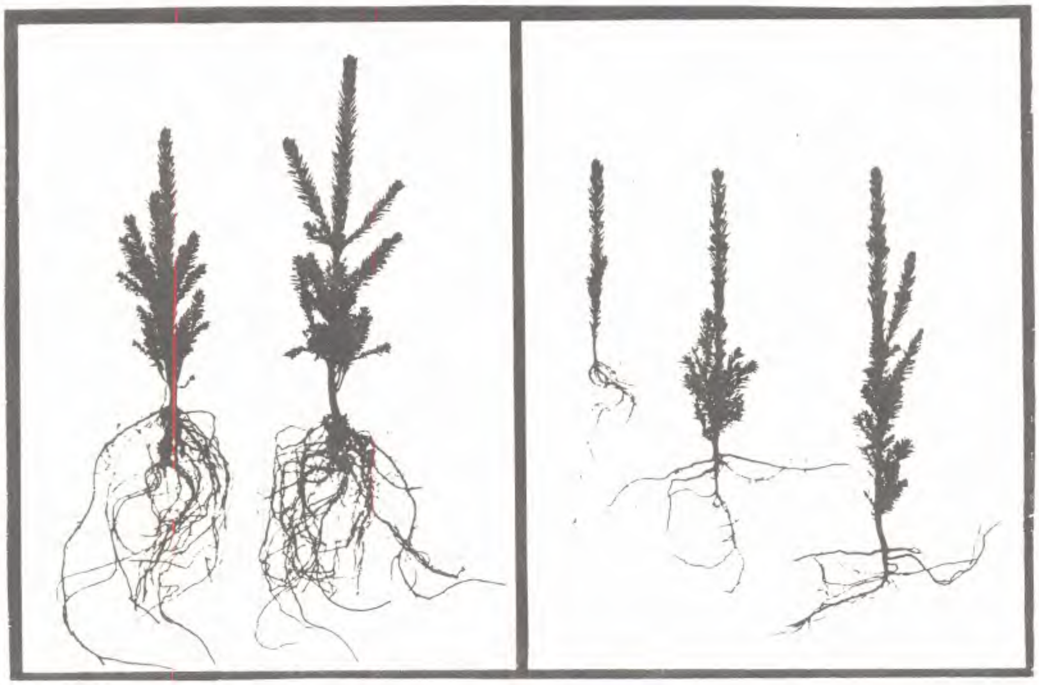

Figure 4. Comparative morphology of 3+0 seedling stock (right) and ½+2 paperpot transplants (left) at time of lifting for planting. The paperpot and residual growing medium have been removed from the transplant roots to show root development. Interval between horizontal lines is 5 cm.

Preliminary studies in which 16-week-old white spruce (Picea glauca (Moench) Voss) paperpot seedlings were transplanted under typical nursery conditions have demonstrated large growth responses compared with adjacent and contemporary bare root seedling stock. After two growing seasons (i.e., as ½+1 stock) the container transplants were clearly superior to conventional 3+0 stock, while after three seasons (i.e., as ½+2) they were well within the medium to heavy grade specification limits set for 2+2 stock (Table 3). While the transplanted container stock was significantly superior in all characteristics--offering more balanced, sturdier planting material (Fig. 4)--data for dry matter production, root area indices and shoot/root ratios are particularly worthy of note. Since the initial container stock was grown under a relatively conservative nutrient regime, it may be concluded that production of satisfactory ½+1 spruce transplant stock is entirely feasible using this technique.

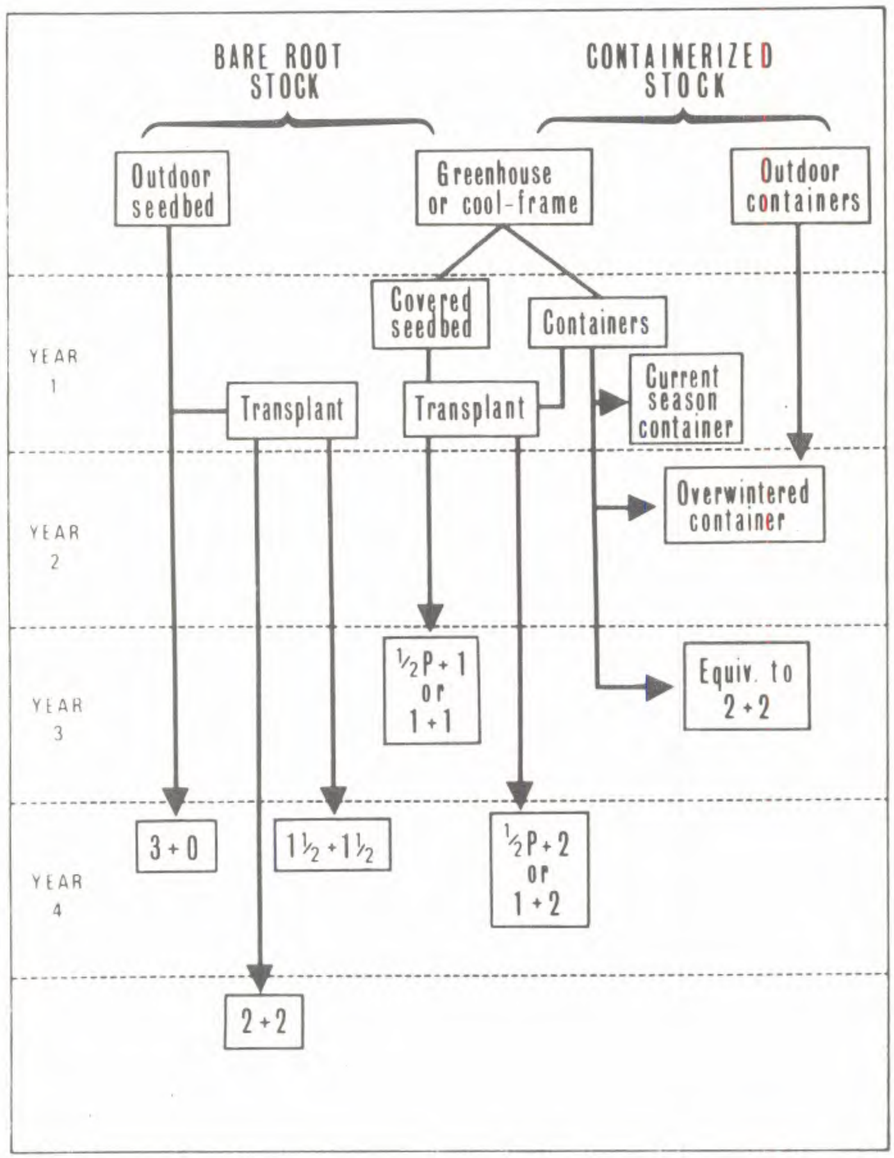

Figure 5. Diagrammatic representation of potential production pathways for spruce planting stock in an integrated bare root/container nursery with greenhouses.

Correction: Transplanting of bare root stock will normally be carried out in Year 2.

Table 3. Comparative size of 2+0 and 3+0 white spruce seedlings and transplanted paperpot seedlings, Kirkwood nursery. n = 200

		Seedbed stock		Paperpot transplants	
	Size at:	2+0	3+0	½	½ +2
Shoot height	(cm)	12.5	27.5	14.4	27.4
Root collar diam.	(mm)	1.8	3.5	3.3	6.1
Total dry weight	(g)	0.738	3.620	3.089	10.378
Root area index	(cm^2)	6.7	15.2	41.4	83.5
Shoot/root ratio		4.3	5.4	2.1	2.5

CONCLUSION

The examples cited illustrate the large biological gains that can be achieved through the application of greenhouse techniques to planting stock production. Far from being confined to the culture of containerized stock, greenhousing obviously holds considerable potential for bare root production also, and we would be negligent if we closed our minds to the possible benefits to be gained from integration of greenhouses into the traditional nursery system. Although the techniques described here are unlikely to displace traditional methods, they do open the way to additional production options by which the nurseryman can improve production efficiency and diversify his range of products. This is illustrated in Figure 5, which indicates some of the alternative pathways for spruce production made possible by the availability of greenhouses (compare with Fig. 1).

While the likely trend is to replace more bare root production with greenhouse products, lack of capital funds for greenhouse development will probably restrain any major expansion in this area in the near future. However, it should be borne in mind that highly sophisticated greenhouse facilities are by no means essential in order to achieve large biological gains. We have already witnessed, in the development of container systems, an unwarranted emphasis upon technological sophistication in many greenhouse operations, and it needs to be stressed that, in the hands of competent and knowledgeable growers, excellent stock can be raised in relatively simple facilities. By way of example we need only look at Scandinavia, where large numbers of seedlings, both bare root and containerized, are raised annually in simple, low-cost cool-frames. In Ontario, preliminary trials have demonstrated that jack pine can be grown just as efficiently, in biological terms, in such cool-frames or "hoop-houses" as in conventional

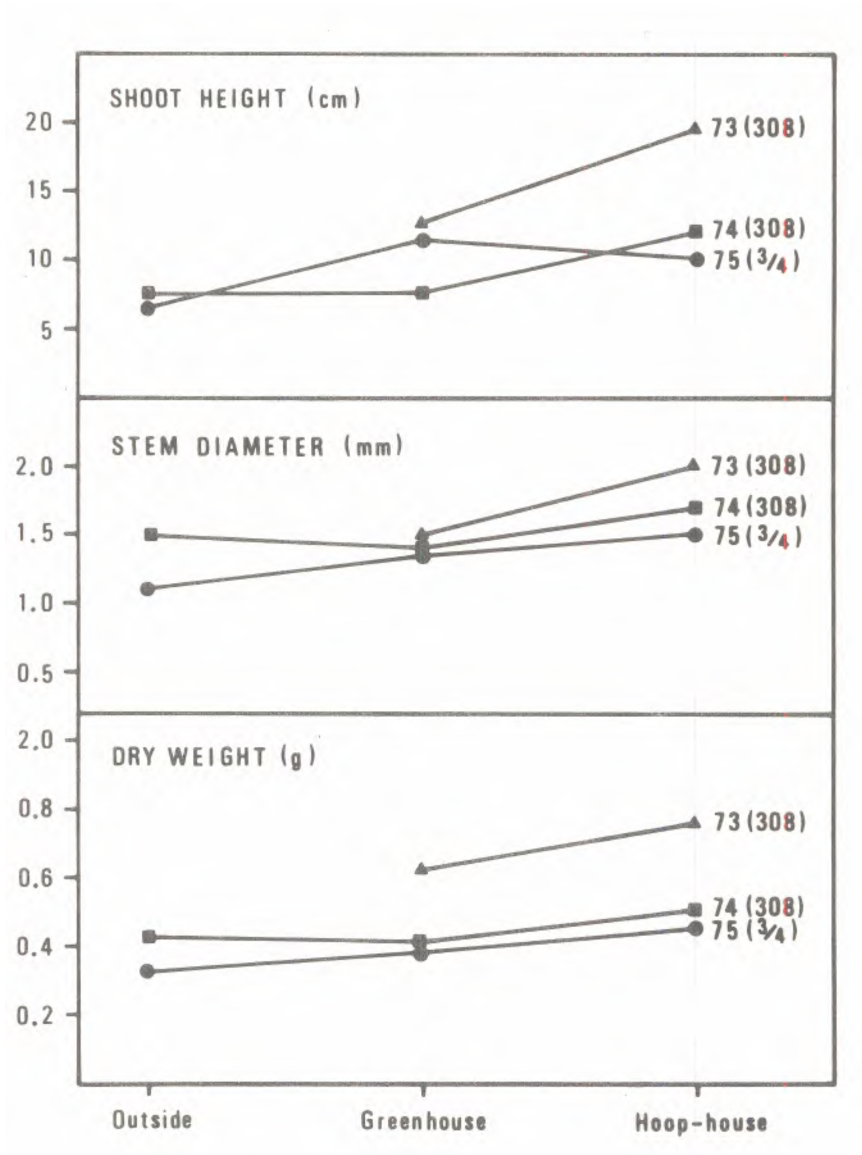

Figure 6. Comparative size of jack pine seedlings for three production locations - (1) grown outdoors, (2) grown in conventional greenhouse environment, (3) grown in plastic-covered cool-frame or "hoop-house" - using the same fertilizer regimes. Seedlings started about June 1; production periods the same for all locations within a given year (1973, 1974, 1974), but slight differences in growing period between years. 308 = FH 308 paperpot; 3/4 = 3/4 in diameter plastic tube.

greenhouses (Fig. 6), but at far lower capital cost. Although the same may not be true for all species, the point is that we should not assume that greenhousing necessarily denotes elaborate facilities or large capital expenditures. Scale of production and operating constraints will obviously have a major influence upon the type of facility adopted, but the grower should keep in mind that, from a biological viewpoint, major benefits can be derived in many cases even from low-cost structures.

To close, a warning. Although greenhousing can bring many benefits to the nursery system it is not devoid of hazards. Intensive cultural methods provide us with a greater opportunity for manipulating seedling growth, but at the same time demand a high degree of grower competence. In the traditional nursery system production periods are relatively long, and few problems of major proportions are encountered. With intensive greenhouse culture, however, problems can arise rapidly and without warning, and minor errors in technique or diagnosis can be disastrous for the crop. This is no place for amateurs, and we would do well to recognize now the need for developing the necessary technical expertise before embarking upon an expanded program of greenhouse culture.

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