OPPORTUNITIES FOR IMPROVEMENT IN CONTAINERIZED REFORESTATION--AN INDEPENDENT VIEW

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Abstract.--The basic container system is examined with reference to areas relatively untouched by research. Profitable areas for research, where economies and/or productivity improvements could be realized, are suggested.

Résumé.--On examine l'essentiel du système de semis en récipients par rapport à des domaines qui sont demeurés relativement à l'écart d'une recherche approfondie. On propose des domaines fructueux de recherche qui permettraient certaines économies ou une amélioration de la productivité.

INTRODUCTION

Pathways to change are always strewn with obstacles. To establish a container installation quickly one must often push ahead and get the work done, without considering side effects. There is always opportunity for improvement, but at some stage one has to stop improving and start producing. Nevertheless, it is essential to consider the longer term, especially when one is dealing with forests that may not be harvested in one's own lifetime. "Never leave well enough alone" is a motto for the innovator. Perhaps it is time to evaluate our progress and see what opportunities there are for the future.

The main advantages offered by containers include:

- individual control over seedling growth
- possible mechanization of operations
- absence of planting shock
- extended season for outplanting
- greater control in tree improvement programs.

However, there are a number of concerns related to container planting, viz:

- economics of container operations vary with size
- investment in one system discourages change to a better system
- progress in mechanization of container handling has been slow
- not all extended season plantings are successful
- even experts disagree on genetic requirements for "tree improvement".

ECONOMICS

When designing a new containerized seedling production facility, it is important to consider the size of the operation, both now and in the near future. Budgets for staff and greenhouses can vary from $10,000 to $10 million. A surplus of labor in remote areas may eliminate the need for automation. The availability of materials, hardware, machine shops, and innovative or mechanically inclined staff should all be kept in mind.

Some of the main economic considerations for anyone planning a containerized seedling production operation are:

- budget
- target cost per seedling
- greenhouse location

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- materials--growing media, water, fertilizers, energy sources
- management preferences and standards
- staff--labor, management, technical (and availability of experienced nursery staff in local area).

A typical goal is to grow one million seedlings annually, with a $100,000 budget for a greenhouse, and to produce those seedlings for less than $75.00 per thousand. This gives an operating budget of $75,000.

A typical cost breakdown would be as follows:

"Rootrainer" containers		$10,950
Growing medium		2,100
Depreciation 10%/annum		10,000
Energy (Alberta figures)		2,100
Water		850
Seed, misc. supplies		2,050
Subtotal, expenses		$28,050
Labor		
supervisor	$20,000	
technician	14,000	
casual	11,900	45,900
		$73,950

("Rootrainers" may be used three times; hence, $3,650 annually should be budgeted for container replacement after the first year.)

Economics of scale can apply if two crops a year are grown in the facility. The costs of growing medium, energy, water, seed, and miscellaneous supplies will likely double, but depreciation and possibly labor will remain at the same level. An important thing to note is that labor costs cannot be reduced much below $34,000 (i.e., the salaries of the supervisor and technician). This means that, with an allowance of $75 per thousand seedlings, the break-even point is about 750,000 seedlings in this greenhouse. It should be remembered that a labor cost of $45,900 is unrealistic unless the greenhouse is well automated.

Research is needed to standardize methods of cost analysis so that comparison between greenhouses can be made fairly. This is especially true when Forest Management Agreements are signed and private companies begin to raise their own seedlings. Factors sometimes forgotten are labor benefits and holidays, extra transport, borrowed money, and productivity for species type. Perhaps only 85% of the seedlings sown will be of sufficiently high quality to plant. Effective planning requires such information.

GERMINATION

Perhaps 85% of the seedlings that germinate will be plantable. Such information is essential for effective planning.

A number of nurseries find it most economical to obtain as high a quality of seed as possible and to sow one seed only in each container. Other nurseries sow as many as five seeds in each container, and accept the need for thinning. Although thinning is labor-intensive, it may be that the job can be done by workers who are not fully occupied elsewhere. In some cases, government departments will employ casual labor. Thinning, however, requires care, and it is best, if thinning is planned, to hire skilled people, even if only for a few weeks.

One or two companies have begun selling equipment to pregerminate seeds and then sow them. The advantage of this technique, if it works, is that it eliminates extra seed and/or thinning costs. More research and development are needed to improve the speed and efficiency of this technique.

As noted above, the germination rate has a tremendous influence on the economics of container seedling production. If, through research, we can obtain 98-100% germination while maintaining adequate seedling quality, and can guarantee one seedling per cavity, then thinning, selection, standardization and consolidation will cost a great deal less. In addition, greenhouse utilization will be more efficient, and mechanization will begin to make more sense.

SYSTEM RESEARCH

The container system may be illustrated by means of a flow diagram (Fig. 1). The forester can use this diagram as an aid in analyzing his costs, by adding or subtracting those elements of the system that he will or will not require.

TREE IMPROVEMENT

Tree improvement presents a basic dilemma. The criteria of the past may not apply to the future. Consider structural timber, for example. In recent years, construction grade lumber has contained many knots and checks because trees are being harvested at a younger age than formerly. "Clear fir" is seldom available. Selection of seed from trees that have few branches may mean slow growth, since there will be less photosynthetic activity. The large trees have all been harvested.

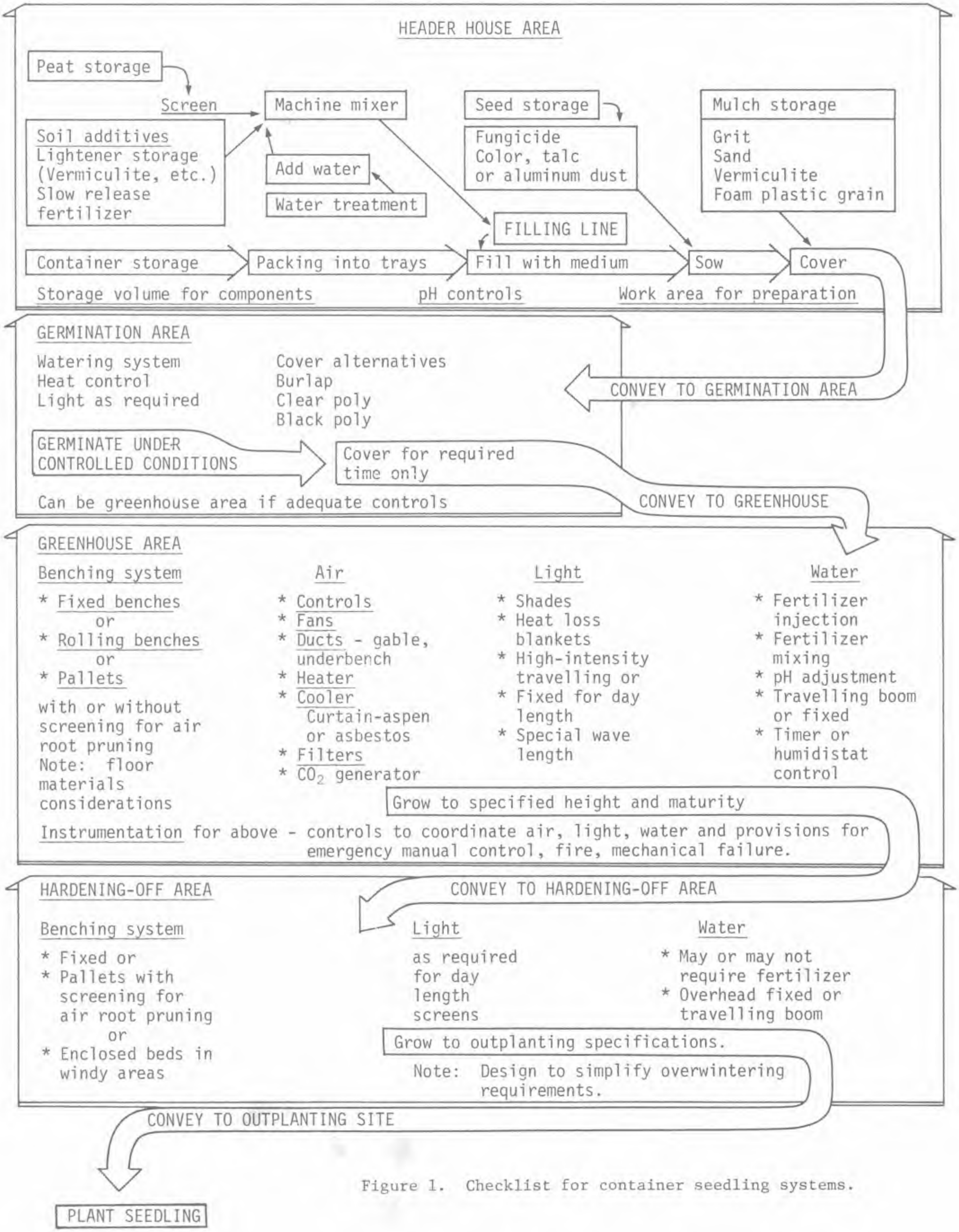

Figure 1. Checklist for container seedling systems.

A researcher may, in the future, find a way of removing the lignin and bonding materials from trees, of separating out long strands of fibre, and of reconstituting the wood into an extruded structural member of standard density and size, with a smooth finish, the way aluminum is extruded or steel is rolled. Harvests might then take place in 20 years instead of 60 or 80 years, and tree spacing in a new forest could be very close.

For now, we need to determine the genetic makeup of trees that provide easy germination, fast growth, strength, suitability for paper fibre, and perhaps in the near future as oil becomes more expensive, good cellulose quality for making cellulosic plastics.

CONTAINER DESIGN

A great deal of work has been done in the container field over the past 10 years or so. Even 20 years ago, the Walters bullet was proven successful. Still earlier, degradable tubes of various kinds made from materials at hand, and compacted plugs made like native bricks, sections of polyethelene pipe, and canvas, jute and perforated plastic bags were developed in tropical countries. The use of such methods recognized the need for individual seedlings to be grown and outplanted safely and reasonably cheaply. How can containers be improved?

(a) Injection planting

In the area of injection planting, research is needed on biodegradeable containers, including the development of a non-wicking growing medium, some means of controlling root direction, and foolproof filling devices.

In handling these single containers there may be some advantages to designing or developing machines for use in the nursery to consolidate and sort seedlings before packing for shipping to the field.

(b) Growing medium

Other types of container would benefit as well from improvements to the growing medium. Peat is an inexpensive but delicate medium, and one which does not always behave suitably. It needs to be studied and experimented with so that its best properties can be used effectively. The Finnish Peat Institute has undertaken such work in the past, but further research could bring better germination, easier wetting, uniform and ideal growing conditions throughout the container, easier handling and consequently less breakup of the medium.

GREENHOUSES

Greenhouses themselves are not immune from critical analysis. In view of the fact that their main function is to provide a suitable environment for germinating seed and growing the seedlings to a plantable stage, some possible improvements come quickly to mind.

Glazing materials offer many options. General Electric has tested various kinds and thicknesses of polycarbonate plastic in Florida over the past five years. Rohm and Haas combined with Cyanamid to produce extruded double-wall acrylic. Monsanto developed a sunlight-resistant polyethylene, and in Canada CIL Plastics have come up with an alternative. Tempered glass seems to find favor with a lot of growers, while PVC (clear vinyl), fibreglass-reinforced polyesters (IBG's Denverlight) and woven polypropylene have all captured part of the market. Why are there so many different types of glazing materials? What advantages are there to any or all of them? A little unbiased research has been done but a lot more is needed.

In Alberta, the ideal greenhouse would allow for fairly high operating temperatures, CO_2 enrichment, a broad spectrum of useful light, and temperature reduction by shading. Research on the use of copper salts in solution passed between two sheets of plastic or glass has shown that 50% of the heat can be absorbed while still allowing the passage of useful light, thereby eliminating the need for ventilation and facilitating the maintenance of high CO_2 concentrations in sunny conditions. At present there are problems with leakage, maintenance of suitable plumbing, differential expansion and corrosion (Fig. 2), but research in this field holds promise.

Waste heat for greenhouses is being used in many areas where feasible. Light-gauge polyethylene will pass 002 but not NO_2, NO_3 or N2O3. Hot flue gas can thus be mixed with outside air to bring its temperature to a suitable working level, and passed between the two sheets of a double-poly greenhouse to keep the poly clear of snow and to raise the 002 level within the house.

GREENHOUSE SYSTEMS

It is important to take a systematic approach when developing a greenhouse operation. Factors such as the height of containers above the ground, type and height of bench, pallet and dolly system, methods for loading and unloading greenhouses, palletization for shade frames, transportation and

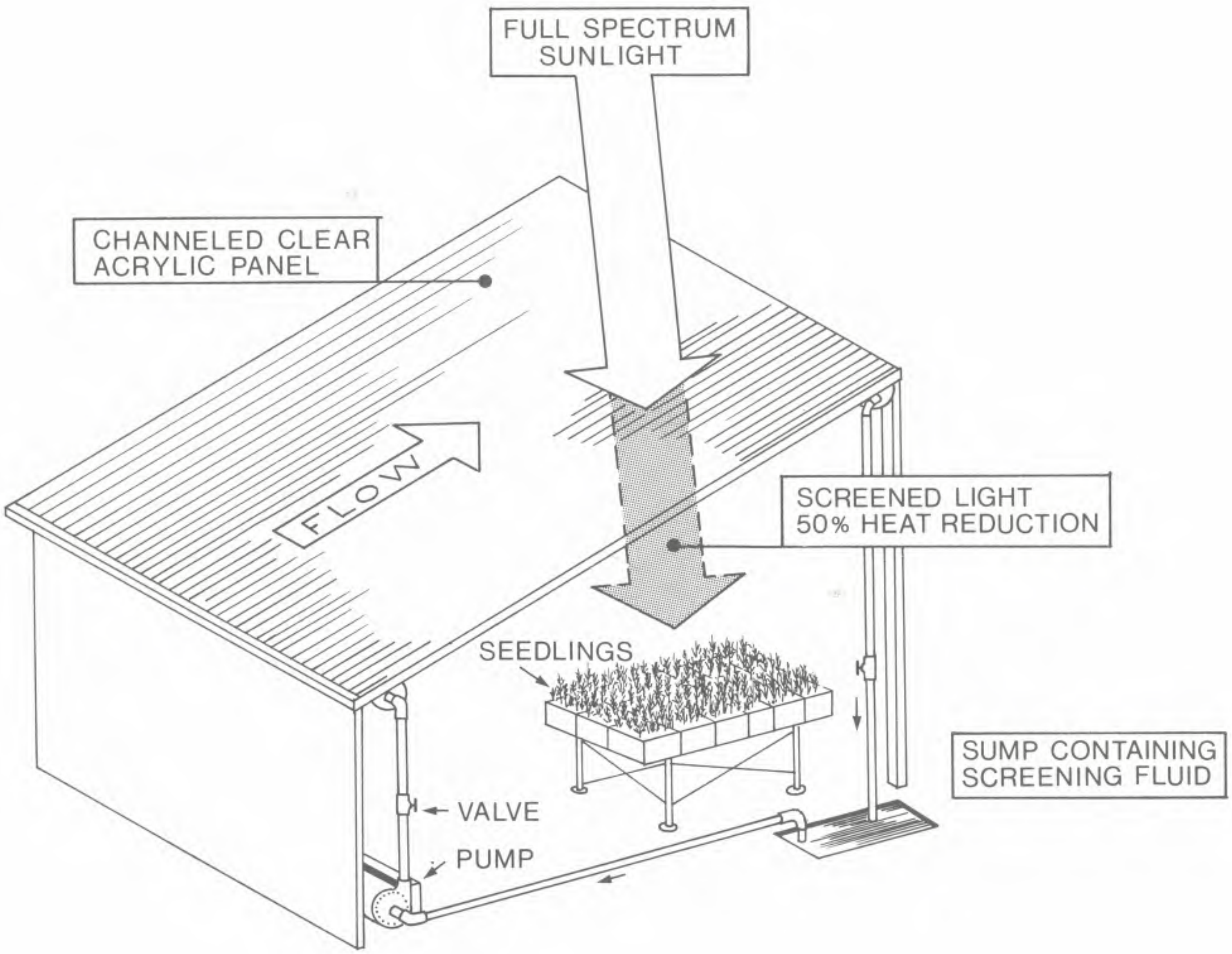

Figure 2. Screened light for greenhouse cooling.

field handling practices all need to be carefully analyzed. In the past many decisions have been made simply by rule of thumb. Some greenhouse operators keep their seedlings 5 to 8 cm above ground, others keep theirs at about 1 m above ground. Various factors affect the height that should be chosen, including the size and height of greenhouse, the style of container tray used, the degree of automation required, and above all, those factors associated with the growing cycle. Germination count will affect thinning, and thinning may require more aisle access than originally planned. Consolidation and grading of seedlings may compensate for heavy competition in the field. Watering may be critical in warm climates and the lighting system chosen and light availability may decide the benching system used. Some computer modelling has been done to study these factors, but a good deal more could be done to provide operational guidelines. Research to determine the most economical alternatives for various situations must be done critically and objectively.

Greenhouse systems are being developed. It is now quite practical to use travelling booms for watering and lighting. These could be improved further by eliminating the hoses, using instead a reservoir tank that travels with the boom, and is refilled at one end of the greenhouse. Greenhouse environment control systems have been developing rapidly, especially in Europe, and research in this field is very active. A visit to the cooperative growers' research establishment at Wageningen in The Netherlands would put the grower in touch with the most modern control systems available.

Practical research in controlled conditions is essential for the development of effective growing regimes. Dr. Richard Tinus of the USDA Forest Service in Bottineau, North Dakota, routinely tests seedlings of different provenance under growth chamber conditions and develops criteria for best growth in a series of isobar-like maps or graphs. Further research of this nature is required.

STORAGE AND CONDITIONING

To date, little research has been done on conditions for outside storage. Many growers have had problems with overwintering (e.g., inadequate snow cover, desiccation of roots, snow mold, etc.). Techniques that could be explored include the use of "Agri-foam", a material developed by the National Research Council of Canada to help save tomatoes from frost, or covering the needles of seedlings with a chemical like Gelgard to retard desiccation without suffocating the plants. More information is needed on factors influencing overwinter survival.

TRANSPORTATION AND PLANTING

A number of papers dealing with the handling and planting of containerized seedlings were presented at the A.S.A.E. Symposium held in North Carolina in 1981. A careful study of the research on which these papers were based reveals that much remains to be done. Scandinavian companies seem to have advanced more quickly than others in the field of mechanized planting, although their techniques are not readily applicable to those parts of British Columbia, Washington, and Oregon where slopes are so steep that men would find it difficult to drive machines. A spiderlike vehicle with a central pod that is always balanced seems worthy of study. Such a vehicle could adapt to steep slopes and still carry a large number of seedlings (Fig. 3).

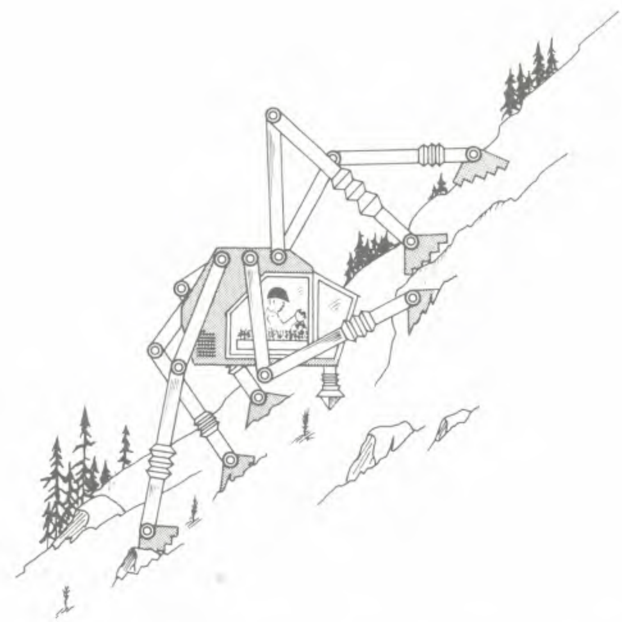

Figure 3. Mechanized planter for steep slopes.

CONTAINER MANUFACTURE

In the past, most Canadian container systems were designed without consideration of the effects of rising petroleum prices and consequently the greater expenses incurred for raw materials. Those of us who manufacture plastic products may have to make containers from better quality materials so that they can be used for a long time and thereby justify the higher cost.

THE CRYSTAL BALL

As automation becomes more precise, we may see, for example, the development of a container with sowing spaces that serves as its own pallet, is easily sterilized and will last for 15 years. Greenhouses will have automated handling systems that fill these containers with a treated homogenous wood waste medium containing slow-release fertilizers. Seeds will be pre-germinated and sown automatically with suitably gentle equipment.

Greenhouses will be designed so that they require no more heat than the sun provides, and watering systems will not need fertilizer controls. High levels of CO_2 (and any other gases that benefit photosynthesis) will provide rapid cellulose buildup. Pallets will be handled mechanically at all stages from nursery to field. Automatic, mechanized planting will require only one operator, and machines will pre-scan, spot-scarify, prepare the soil, plant continuously, and be able to travel without compacting the soil. Seedlings grown from hybrid seed will mature in 20 years in Canada and will provide us with all we need in the way of timber, pulp, paper, and chemical products.

With a lot of dedicated and imaginative research, it can happen.

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SUMMATION:

CONTAINERIZATION - BOON OR BOONDOGGLE?

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In several recent provincial and national studies and at various meetings the need for intensifying forest management across Canada has been stressed. Dramatic increases in the rate of forest renewal, particularly by planting, are considered essential if fibre shortages are to be avoided. The use of containerized seedlings may have the potential for expanding planting programs rapidly, but are the cost and field performance of these seedlings as satisfactory as their proponents claim? Do successes exceed failures sufficiently to justify the current upswing in container seedling production, or are we simply riding a wave of enthusiasm that cannot be sustained by operational performance?

The attendance of over 300 people at this symposium indicates that containerized seedlings have at last achieved a degree of popularity, if not respectability. Heretofore, Canadian container enthusiasts often believed that they were in the vanguard of a new technology. Mr. Räsanen reminds us, however, that a form of containerization antedated bare-root practice as the principal means of planting forests in Europe. In reality, therefore, bare-root planting is the new, cheap method of reforestation. We are now rediscovering, with new materials and techniques, a very old reforestation option. Are research and development providing sufficient guidance for us to meet the demands of increased production? The Ontario tubed seedling program of the late 1960s demonstrated the hazard of production outpacing technical development and nursery expertise. Annual production, which rose from zero to 20 million plants in only three years, declined to a token quantity within a decade. The number of seedlings produced is not the best criterion by which to judge the success of a method; successful production will be sustained, hut production leading to successive plantation failures will decline and ultimately disappear. Very rapid increases in production may only signify popularity, but sustained production provides a real measure of acceptability.

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The excellent review of reforestation in the Scandinavian countries by Räsanen should inspire some confidence in containerized methods. Try to visualize the magnitude of these programs. Container-grown stock in Norway, Sweden and Finland currently accounts for 357 million seedlings per year, a total exceeding all types of planting stock produced in Canada! Notwithstanding some setbacks, high levels of container seedling production have been sustained in Scandinavia for more than a decade.

The status reports given at the beginning of the meeting indicate that Canadian container seedling production now totals about 140 million per year; projections estimate that production could reach 220 million by 1983. In comparison with a production of 17 million and an attendance of only 40 people at the 1972 Kananaskis container workshop, current production and conference attendance show that interest, expertise and production have all increased exponentially over the last 10 years. The status reports also show that container production is concentrated in British Columbia, Alberta, the Atlantic provinces and the Pacific northwest United States. Like the northeastern and north central United States, Ontario and Quebec have not yet increased their container seedling production to any degree. One must assume that in these regions planting stock demands have been relatively static, and that bare-root production is providing sufficient low cost planting stock to meet reforestation goals. It is not surprising that interest in containerization has lagged in the southern pine region of the United States. There, enormous bare-root programs have been satisfying demand for decades with excellent, inexpensive short rotation crops. A radical change in technique cannot be justified unless a reliable improvement over present practice is clearly demonstrated. If a technique is serving adequately, change should not be sought simply for the sake of change or popularity.

By contrast, there are some good reasons for seeking change in the harsh climates of the northern latitudes. Open field culture is riskier and more uncertain than it is in milder southern climates. Container methods permit compact nurseries in which the growing environment can be controlled economically. Although good bare-root stock can be grown in harsh climates, it is often difficult to maintain a constant and predictable level of production. Where three or four years are needed to grow each crop, erratic production creates havoc with reforestation planning. Often the container option is chosen by default because the short-rotation container crop can quickly fill the short-falls in bare-root production.

At a time when demands for more planting stock are on the increase in many parts of Canada, perhaps the most compelling reason for adopting container systems is that production can be initiated quickly and effectively.

Neither default nor panic is a very good reason for adopting new methods, but both are influences that cannot be ignored. I have heard it said that the rapid expansion of the Swedish planting program could not have been effected without the aid of containerization. Similarly in Canada, the urgency for accelerated planting will result in increased container seedling production, regardless of the readiness of the technology or the availability of expertise capable of translating promises into practice.

The purpose of meetings such as this is to provide guidelines for rational expansion of production so that the potential of containerization can be realized and the risk of repeated boondoggles or failures can be minimized.

Papers, posters and commercial exhibits presented at this Symposium update the state of the art. Although a detailed review of this wealth of material is neither possible nor appropriate at this juncture, I will comment briefly on highlights I consider significant, and draw attention to a few glaring deficiencies.

Both Tinus and Van Eerden provide principles and prescriptions for growing seedlings that merit repeated attention. While Tinus stresses the need to understand the effects of environmental manipulation on seedling physiology, Van Eerden exhorts new growers to heed container growing techniques that have evolved and have proven successful for over 10 years in British Columbia. He draws from a long and intimate association with the largest and most diversified container seedling program in Canada. In our eagerness to innovate, we are often guilty of wasting time and effort by failing to copy exactly, or at least to mimic closely, successful methods demonstrated elsewhere.

The three papers on contrasting approaches to container seedling production provide details of current production methods. It is interesting to note, however, that the various cultural methods now have more in common than they have differences. Perhaps this reflects the maturing of technology and a lessening of extremes in approach.

The four papers on photoperiod and temperature manipulation for preventing premature dormancy and for inducing cold hardiness describe techniques that have now reached the stage when they are practicable for operational use.

Although mycorrhizal manipulation may enhance seedling quality, it is evident that much work is still required before quality gains are realized.

The possibility of root form problems with container-grown stock is a source of continuing debate. Wall ribs, air root pruning, and correct matching of stock to site can reduce the risk of root problems. The two papers on chemical root pruning demonstrate that it is now possible virtually to eliminate the risk of instability due to root form problems. I find it curious, however, that active investigations are still under way in Ontario and Quebec, in an attempt to reinvent forms of the paperpot and the biodegradability of various wood pulp and synthetic fibre combinations. At least three Scandinavian innovations are serious attempts to improve on root form without relying on uncertain rates of biodegradability.

With respect to the technical aspects of rationalizing and planning container operations, Canadians have much to learn from Scandinavia. The papers and exhibits presented by the Scandinavian delegates illustrate the sophistication of attempts to improve all aspects of container processing and handling, including the possibilities of mechanical planting. It is to be hoped that some of these innovations can be demonstrated on a practical scale in Canada. It would be appropriate if the Canadian Forestry Service were to continue its leadership role by encouraging the introduction and demonstration of the more promising new methods. In the meantime, Canadian growers should concentrate on means of maximizing crop quality within the limits of currently available containers.

Field trials provide the basis for judging the merits of various classes of planting stock. Trials have been established long enough now that they have earned a degree of credibility. However, many of the earlier experiments were established with stock that would now be considered completely inadequate in size and quality. In some of the papers presented, investigators are still attempting to compare non-comparable nursery products--a practice akin to comparing apples with oranges. Two new classes of trials and appraisals are now common. First, there are those trials concerned with matching stock quality with site quality and condition, including improved methods of site description. The results of these investigations will represent a step forward in defining future regeneration prescriptions. Second, appraisals are now being undertaken that use as an information base large numbers of operational plantations rather than a few carefully controlled experimental plots. With this type of appraisal, results reflect the full impact of the operational process. Similar appraisals need to be instituted whenever container seedling production is introduced so that any problems can be identified and corrected quickly. Without ongoing operational appraisal, planting practice can atrophy long before a planting system is optimized.

Whereas reports of field performance are plentiful, cost appraisals of various planting systems are notably lacking. Tunner presents a useful methodology for comparing options and presumably his illustrative examples reflect realistic costs in British Columbia. But where are the hard cost data for other Canadian programs? The organizers of this meeting were unable to elicit other specific contributions on capital and operating costs, let alone economic analyses. This is a curious phenomenon. We meet to ascertain the advantages of one planting system over another, and yet half of the effectiveness equation is missing.

Mechanization of the planting process has always been considered the principal potential advantage of containerization. Walters is consistent in reaffirming that planting should be precisely mechanized, and that a rigid-walled container is the best-suited to this purpose. Sutherland and Heikurinen outline some of the problems facing machine design and the practical difficulties of machine planting. But even if progress in mechanical planting is slow, Canadian container programs would not have reached their present stage of operational readiness without Walters' enthusiasm and dedication. It should not be forgotten that several important features of container design and cultural practice were learned from early trials of his rigid bullet container.

As Armson has noted, now that more industrial and private growers are being permitted to participate in planting stock production, the base of nursery expertise is being broadened and diversified. Excellence --and incompetence--should become evident quickly, as the masking influences of a few state enterprises are stripped away. If the expertise base is broadened, more frequent opportunities for technology transfer will be needed. This symposium marks the arrival of containerization at a new plateau of respectability and acceptability. Perhaps this should be the last Canadian meeting devoted exclusively to containerized seedling production. It is time to integrate container seedling production with bare-root production. Although the techniques may differ, the goal of both systems is to produce stock that will yield biologically and economically viable plantations. Container transplants represent a hybrid form of planting stock that is becoming popular and useful in the west. Rather than competing with each other the two systems can reinforce and complement one another. Similarly, bare-root and container nurserymen should complement, rather than compete with each other. More regional integrated stock production meetings will ensure that both systems are a boon to reforestation.