WORKSHOP ON REARING CONIFERS IN CONTAINERS FOR TREE IMPROVEMENT JANUARY 1988

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This workshop was one segment of the technology transfer aspect within the Jack Pine Seed Orchard Development Program, which was funded by the Canada-Manitoba Forest Renewal Development Agreement. I am grateful to all participants who presented very informative papers at the workshop and shared practical experience. A special thanks to participants who provided copies of presented papers for inclusion in this report. I also extend a thank you to those who sent poster papers for the workshop. I thank C. Brown for doing all the audio work and S.M. Sokol for arranging and entering text material onto a processing terminal for printing.

FOREWARD

Dear Reader:

You are cordially invited to read all the papers and posters presented at a technical workshop on "Rearing Conifer Plants in Containers for Tree Improvement Programs" held in Winnipeg on January 26-28, 1988. For your convenience all presented papers and posters are compiled in this report.

1. The purpose of this workshop was; (a) to examine and discuss current rearing practices and determine how; (b) to improve efficiency and quality of output in the production of orchard and plantation assessment stock including all other kinds of stock specifically tailored for tree improvement program in Manitoba and the Boreal Forest Region.

2. To provide technology transfer on advancements in early cone production.

3. To tour the new Tree Improvement Complex at Pineland Nursery (Hadashville) and observe rearing practice.

The planned agenda specifically focused on the following operationally relevant rearing topics:

(i) stock parameters
(ii) selection of container
(iii) growing media
(iv) lighting type (high pressure sodium) and photoperiod
(v) prophyllaxis
(vi) canopy tailoring for cone production
(vii) cone induction in potted orchard stock
(viii) accelerated growth

This workshop was targeted specifically for professional and technical tree improvement staff of Forestry Canada (ForCan) and

Manitoba Forestry Branch (MFB) and other provincial, private and public forestry agencies that are actively working on the aforementioned subject.

The objective is: (a) to provide an opportunity to discuss common problems and solutions of similar nature; (b) to promote the development of an information network among colleagues; (c) to exchange innovative ideas in producing cost-effective propagules for forest renewal from tree improvement programs.

The workshop was conducted in an informal round-table discussions. Participants were encouraged to share their experiences and opinions on each topic. Some questions and answers for each topic and presentation are included. An elected moderator guided the discussion of each topic and assisted in the joint formulation of each summary.

Should you find the contents of value for your work or program, please send me your comments regarding needs for future workshops.

Compiled by: Al Nanka
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FAMILY-TEST STOCK PRODUCTION CONCERNS FROM A PROGRAM MANAGERS POINT OF VIEW

by

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The Manitoba Forestry Branch is currently planning and implementing an operational tree improvement program for black and white spruce in the five major breeding zones of the province. Long term plans call for the establishment of spruce programs in all seven breeding zones. This would result in the production of approximately 250,000 test seedlings; 120,000 orchard seedlings and 15,000 grafts. The estimated cost of establishment for the spruce program is $2 million. In addition to the spruce program the Jack Pine Tree Improvement Program coordinated by J. Klein and A. Nanka has already been established in the four active breeding zones. Production of the orchard crops is completed with plans for a gain test in effect. Initiation of a resistance to Western Gall Rust program is planned while the second generation crop for the Eastern Breeding District is currently growing.

Family Test - refers to a plantation established to evaluate individuals based on the performance of their relatives. In establishing family tests there are four key objectives.

1) Evaluate genetic worth of family or parent.
2) Establish a base population from which individuals can be selected for advanced generation breeding.
3) Estimate genetic parameters such as heritability, juvenile-mature correlations and genotype environment interactions.
4) Determine the level of gain achievable to act as a demonstration area to assist in program justification.

The primary objective of a family test is to provide a genetic evaluation of the families. Appearance and growth of an individual is a result of genetic and environmental influences. To effectively evaluate genetic influences, it is crucial that all environmental variation be minimized. Precautions must be made to ensure environmental uniformity in selecting orchard sites, seed processing and stock production phases. To meet the primary objective of providing a genetic evaluation of the family it is essential that rearing practices ensure identity, uniformity and quality.

Example: random placement of families and rotation of crop reduce edge effect during rearing phase.

The container system chosen should ideally lend itself to sorting, the family test design and overwintering. The Department of Natural Resources has chosen the styroblock 20 as the overall container to meet their purposes.

ACCELERATED GROWTH AND OUT OF PHASE DORMANCY

by

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There are three spruces native to Nova Scotia: Red, White and Black. Will not dwell alot on the black spruce because we do not handle any grafting stock of black spruce, so I will concentrate on the other species. The majority of plus trees are located on privately owned lands which must be climbed either with spurs or ladders to collect scions. Scions are cut, grafts are made and orchards are established. We then wait in the order of 5 to 8 years before flowering is prolific enough to allow for cross pollinating to initiate the second generation. We are looking at a number of ways to accelerate growth especially in the first generation which is a very expensive part of any tree improvement program. The following is a description of the facilities at our disposal to accelerate growth.

Our greenhouse was built in 1980. It is actually two greenhouses each 120 feet long by 42.5 feet wide. They are joined together by a 14 ft. wide corridor down the middle. Each greenhouse is divided width wise as well, allowing for four separate breeding zones each 60 ft. by 42.5 ft. Each zone is independently controlled with its own control system. The system used is a Wadsworth Step 500. The greenhouse has no night watchman so an alarm system adapted from a G.D.T. system is employed. The alarm is tied into the departmental radio system. Any alarm goes to the radio dispatcher then to designated employee who is on call 24 hours a day. A Honeywell humidistat controls a solenoid valve which activates mist nozzles to control humidity. Both humidity and temperature are monitored in each of the 4 breeding zones. A control sensor and hygrothermograph are situated in approximately the same location in each zone.

Watering is performed by an overhead boom. Well water used for irrigation is very cold so a mixing valve is used to mix warm water with it before applying to very young seedlings. Two fertilizer injectors, use soluble fertilizer mixed up from stock solutions.High pressure sodium lights (only 54 of them) light 1 of the 4 breeding zones. The growing medium used for normal grafting stock production for 1.5 growing seasons is 1/2 peat, 1/4 vermiculite and 1/4 sand.

A conveyor system moves stock from potting area into the greenhouse. This eliminates the cost of hiring labour to move stock around manually. Potting is performed by a three-man crew with a Boldwin and Lawson potting machine.

Mechanization reduces both labour costs as well as human error. Three-man crew averages 1500 pots a day. This includes mixing, potting and moving stock into the greenhouse via conveyor.

Spruce grafting stock is grown from the seed in multi-pot containers. The following spring, stock is transplanted into one gallon containers. In the case of white spruce this material goes directly outdoors with second-year production occurring entirely outside in a shade frame. The irrigation system within the shade frame employs a square nozzle which provides uniform coverage. Potted stock comes in for grafting around January and enters one of the four breeding zones where it thaws out. Grafting employs a side veneer graft. A first cut is made on the cutting and the second cut made on the root stock. All the grafting is signed by the respective grafter, providing a means to cull poor quality grafters. A fair amount of tending is performed while the grafts are in the greenhouse. This tending involves pruning of new foliage primarily on the root stock. Most of the lateral shoots are removed. If this maintenance is not performed massive foliage growth occurs.

When grafted stock is ready for transplanting they are taken out of the one gallon pots, root-pruning is performed and they are transplanted into outdoor beds. This usually occurs around

June. Buds formed in the greenhouse usually stay dormant throughout the first year. The following spring any of the tops that are still on the grafts are removed. Trees are allowed to flush and then spend a second growing seasons in the transplant beds prior to being moved out to the orchard. This has been standard procedure in Nova Scotia for white spruce and is considered to be sound procedure for white spruce. Red spruce however reacts adversely to transplanting, and movement direct from greenhouse to orchard is considered preferable, although this raises the cost of initial tending.

The main tools available for accelerated growth in the greenhouse are:

(1) Control of photoperiod (control when the tree wants to go into the dormant stage), and

(2) Artificial chilling in order to satisfy the chilling requirements.

Preventing onset of dormancy for any crop growing in the winter is accomplished by exposing the crop to a night-time light break. Fluorescent tubes (V.H.O.) are mounted on a watering cart which travels the 60-foot length of the greenhouse for two hours with each tree receiving a light pass once every six minutes. The watering cart is tied into a time clock that fires it up for 2 hours at any predetermined time. This 2 hour light break has proven sufficient for all the species we are working with. This system does prevent bud set. Chilling requirements are satisfied by way of a cooler. Grafts are placed in the cooler which is run between 3 and 5 degrees celsius. Grafts are also exposed to an eight-hour photoperiod under fluorescent lights (controlled by a time clock within the cooler.) Typically the schedule we've worked out is to bring material from the cooler into the greenhouse at the beginning of January. The greenhouse is warmed up over a 1-week period to a growing temperature of 18 degrees to 20 degrees celsius, and the day-length extended to 20 hours at 5-6000 lux using the HPS lights. By mid-May, the trees should be sufficiently hardened off (by induction treatments) to be moved directly into the cooler. Inducing bud-set is accomplished by reduction of day-length and mild moisture stress. Irrigation (and fertilization) resumes after bud-set to ensure proper bud development. The cooler is set between 3 and 5 degrees celsius while stock is in the cooler for a period of six weeks or 1000 hours. The second cycle begins in July.

Studies from Irving Woodlands in New Brunswick indicate the minimum chilling requirement for any clone to be 1000 hours (six weeks). It was also found that 1500 hours was worse than 1000 hours although we have experienced no evidence of this claim. We, as well as Irving, are forming the impression that a limit exists as to how many of these acceleration treatments may be applied before becoming detrimental to the tree. It is generally felt that treatments can be applied for two full calendar years or four accelerated cycles and greater growth will be derived than would otherwise. However the trees seem to slow down during the second accelerated cycle of any given calendar year resulting in a poorer flush than that of the first cycle. We've come to the conclusion that the hardening off period in the middle of the summer is the most critical element of this whole process. This process must be carried out with extreme care with the tree fully hardened and the bud well developed before going into the cooler.

Propagation of Family Test Material - This involves the collection of open pollinated seed from black spruce. Felling of trees is generally the rule when making selections. We have a breeding population in the order of 1200 trees. Cones are brought into the Centre, air-dried on trays then placed into the kiln. Seed is extracted on a single-tree selection basis incorporating a homemade dewinger and seed cleaner into the process. When stock goes into the greenhouse, it is replicated and different colour tags are used to identify distinction between the replicates. All the replicates are sown at the same time for any given seed lot. Seedlots are sown in a random fashion in the seedhouse in any particular order. Sowing is performed by hand, if sufficient seed exists double sowing occurs. Seed is covered with silica grit after sowing and two identity tags are placed in each container one of which is buried. Replication exists in the greenhouse. Stock is tagged prior to sorting using a computerized tag which is placed high on the tree to ensure it stays clean as well as facilitating easier reading.

Nova Scotia family test sites are generally herbicided the year prior or the year of planting, to control higher growth such as raspberry and pincherry. Nova Scotia test sites are small, rarely exceeding more than 2 ha. Site preparation involves root raking and rome disking--this mixes the duff and mineral soil. Problems unique to Nova Scotia are the root-collar weevil which makes it very risky to plant softwood cutovers the year after cutting. Root-collar weevils are attracted by the fresh wood smell particularly on cutovers with no hardwood at all. Rocks and boulders present another problem and come into play where spacing of plantations is concerned.

Mapping takes place while the site is being planted. A handwritten map goes to the Tree Breeding Centre within a week of planting and a computerized map is produced. The computer is programmed to generate row, column and rep numbers for each plot. The computer also checks for duplicate numbers and other queries. The first computer draft goes back to the site, where these queries are double checked, and corrections made where necessary.

Q. What kind of a planting design do you usually use for your family tests?

A. Family-tests go out with six replicates of four-tree row plots, so there are 24 trees per family per site. Spacing is 2 meters in the case of black spruce.

QUALITY STANDARDS FOR CONTAINER-GROWN STOCK FOR FOREST TREE IMPROVEMENT

by

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Northern Forestry Centre

Tree improvement programs require populations of trees for provision of information on various aspects of genetic quality, for production of seed or cuttings, or for a combination of purposes. Fulfilment of these purposes can be expedited and enhanced by use of planting stock that is tailored to the objectives of the population. Container culture is well-suited to production of planting stock having the required attributes for a range of tree improvement purposes, because of the opportunity it offers for controlling and modifying growing regimes.

Genetic quality information and seed production differ as to the planting stock attributes which favour suitability. Within each category, the desired attributes vary in kind and degree according to the exact need in each instance. Some examples will be presented to illustrate the variety of desired attributes, or quality standards, for container-grown tree improvement stock, arising from the varying purposes of tree improvement populations.

Family Test

A family test is a plantation or a set of plantations containing trees of known parentage, designed to provide information on genetic quality. The information on genetic quality obtained from a family test is used to select genetically superior trees, either in the family test or in another plantation of related trees.

Family test plantations that grow promptly after planting are likely to show better expression of genetic differences and lower error variation than slow-starting plantations because they offer less opportunity for competing vegetation to become established. Early results are especially improved in reliability by improvement of growth in the years following planting. Capability for prompt growth after planting thus appears to be an appropriate standard for family test planting stock.

Achievement of prompt growth after planting requires correct matching of the length of the growing period to container size. Extending the growing period to increase top size in a small container will, if carried to excess, lead to pot-binding. Pot-bound trees will have reduced growth after planting, and are likely to be weakly anchored. If stock from a customary container does not meet the family test growth standard with the matching growth period, a larger container should be used.

There are standards for family test stock production in addition to growth capability. Stock must be correctly identified through the rearing period. Labels must be applied during the rearing period to maintain identity until verification of plantation labelling and mapping after planting, free of errors, fading, tag loss, or damage to the stock. Variation in growth capability after planting introduced by environmental variation across the rearing environment must be minimized and the residue appropriately distributed. Some accessory equipment or procedures can be directed towards reducing environmental variation within a crop's growing space. Rotation of trays can reduce the impact of greenhouse variation on the stock. Variation of rooting environment can be important between neighboring cavities as well as between different trays. Control of this kind of variation begins with awareness of its potential importance, and is exercised by refining physical procedures for filling, sowing and rearing.

The real measure of the quality of a growing system for family test stock would be the growth rate, root morphology, and error variation of a crop after planting. Any tree improvement program can assess and refine its rearing program by investing some staff time over several years in recording and analyzing observations on seedling crops before and after planting. For programs that can not afford a formal quality monitoring system, awareness of these criteria on the part of grower and tree improvement staff may be useful.

Tested Seed Orchard

For seed orchards derived from trees selected by use of family test results, the only stock production criterion is the promotion of early, abundant and sustained seed production. This kind of plantation is defined by the completion of selection before planting of the stock. All or most of the trees planted will be used for seed production, and are thus relatively high in value.

Planting stock usually consists of grafts or control-pollinated seedlings. Basic container culture would consist of operational procedures for seedlings or procedures required for grafting success for grafts. Basic culture may be appropriate for species which grow rapidly after planting of seedlings or grafts.

Accelerated container culture can be useful for establishing a tested seed orchard. It consists of growing the plants indoors in containers under optimum conditions, possibly with artificially induced dormancy to provide two growth periods in each calendar year, until the plants have reached a desired size or development state for outplanting.

Accelerated container culture requires investment in growing facilities beyond what is required for basic container culture, but can reduce costs in later phases of seed orchard establishment. If growth of grafts or seedlings is slow under normal culture, accelerated container culture can reduce tending costs by confining the plants to the more controllable greenhouse environment while they are small and slow-growing.

When they reach a size large enough to be awkward for greenhouse culture, they would be ready for planting. The period from investment in seed orchard site development to harvest a seed crop would also be shortened by delaying development work until the trees are through their stage of slow growth. Finally, accelerated culture may expedite the onset of commercial seed production by several years, which would shorten the delay from the expense of selection and propagation to the payoff of improved seed.

Use of accelerated container culture for seed orchard establishment depends upon a judgement that the technique is capable of expediting establishment and production, and that the benefits are sufficient to justify the extra costs. Because the seed orchard's purpose requires seed production to be sustained as well as early, care is needed to avoid pot-binding, which could shorten the useful life of seed orchards.

Potted Indoor Breeding Garden

A potted indoor breeding garden consists of plants grown to produce flowers for controlled breeding and seed from that breeding, for the next generation of selection and breeding, or seed orchards, or for research. The quality standard for this kind of population is production of flowers of both sexes as early as possible. Quantity and duration of production are less important than earliness. The level of investment in each plant is likely to be higher for this purpose than for other kinds of tree improvement plantations, partly because the purpose is entirely implemented indoors in containers.

Mass Selection Seed Orchard

A mass selection orchard is a plantation of genetically variable trees planted at close spacing and thinned periodically to leave only the trees with the best growth, health and quality. A small proportion of the planted trees remain to produce seed. Seed produced in a mass selection seed orchard has value only to the extent that the thinning choices favour the genetically superior trees. All of the planted trees should be accurately assessed so it is important to minimize the effects of variation of rearing environment on performance after planting.

Capability for seed production is relatively unimportant in this instance. Only a small proportion of planted trees will be used for production of improved seed. By the time selection has been completed, the remaining trees will be close to sexual maturity regardless of the rearing regime.

OPTIMIZING LIGHT SOURCES AND PHOTOPERIODS TO GAIN MAXIMUM USE OF YOUR GREENHOUSE SYSTEMS.

by

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This text is edited from the recorded proceedings of a technical report presented by the author to the CANADA/MANITOBA Tree Improvement Workshop on "Rearing Conifer Plants in Containers for Tree Improvement Programs", that was held from January 26-28, 1988, in Winnipeg, Manitoba.

Study NOR 36-01, File Report #1

With the increasing use of greenhouses to grow containerized stock for reforestation purposes across the prairies that began during the late 1960's and continues to this date, it became apparent that there would be problems unique to container production that would have to be addressed. One obvious factor for nursery production personnel, that was identified, was the need for adequate supplemental lighting systems for greenhouses. This was necessitated by several realities faced by nursery staff.

Firstly, the location of the greenhouses (i.e. latitude & longitude would determine the number of hours of available sunlight and its angle of incidence during the winter months at the beginning of the first growing season. This, in turn, would determine the amount of sunlight available to the seedlings for growth. Secondly, an early seeding date in January or early February, is essential if a nursery is to maintain a two or three crop schedule, as has been outlined by Carlson (1983). We know, for example, in Edmonton on the first day of February, which corresponds to the seeding date for Crop 1 of Carlson's three crop schedule for Hardiness Zone 3 (Carlson 1983), that the day-length (hours from sunrise to sunset) is only 8 hours 55 minutes long. This is far short of the critical day-length needed to grow most conifer species, as I have previously reported (Dymock and Wilson 1986).

I first became interested in greenhouse supplemental lighting systems when I began working at the Northern Forestry Centre in early 1981. Two matters drew my attention. Firstly, I was appalled at how some research staff, particularly the forest pathologists, grew their seedlings under far less than ideal, or controlled conditions. They then subjected them to various pathological diseases or agents, and, of course, the trees would die. It seemed apparent to me, that the pathogens were killing the trees because they were being applied to extremely weak seedlings. These views were also shared by a number of other people who were working on physiological aspects of air pollution. They, however, had their own unique problem.

As part of their research program, they were rearing conifer seedlings in the greenhouses, up to a predetermined age, at which time they would subject the seedlings to environmental pollutants, and study the physiological responses. This study required seedlings at regular intervals, twelve months per year. The system was working fine throughout the spring and summer months of 1982, until they reached the middle of October, when all of their research stock, regardless of age, set terminal buds and entered dormancy. This was a serious impediment. Growth chamber facilities at the Northern Forestry Centre were not large enough to meet the space demands that were needed to produce the required number of seedlings.

I should point out that the NoFC greenhouses were equipped with banks of movable fluorescent light fixtures, that were used to extend the daylength to 18 hours. It was also thought at the time that these supplemental lights would also provide high enough light energy to keep seedlings actively growing. This, however, did not turn out to be the case, as I have mentioned.

We were thus confronted with a very basic problem. How could we best utilize our greenhouse facilities to provide optimum seedling growth for our research purposes. The fluorescent lights that were already in place were inadequate for our needs. Coincidently, at this time, one of the scientists involved was discussing the situation with the greenhouse manager from the Botany Department of the University of Alberta. He described how they had overcome low light levels in their growth rooms by installing high intensity discharge lamps (both high pressure sodium vapour lamps, and mercury vapour or metal halide lamps). The combination of the two types was necessary in growth rooms, where no natural daylight was present, in order to provide the proper spectral balance that would ensure optimal growth of plant specimens for both research and teaching needs.

This seemed like an interesting proposition to us. Some further investigation indicated that we would likely only need to install high pressure sodium vapour lamps in our greenhouse situation. A small number of high pressure sodium vapour lamps were then purchased and installed in a small compartment. Their effectiveness in providing an optimum environment for the growth of conifers was then evaluated against the existing fluorescent system, using 12 species of conifers. The results of this study have been previously reported (Dymock and Wilson 1986). Our conclusion was that we could provide near optimum growing conditions through the use of high pressure sodium vapour lamps as the only supplemental light source, for most of the conifer species that we had tested.

In early 1983, funds became available to replace all of the fluorescent lights in two of our three greenhouses with high pressure sodium vapour lights. We now had greenhouse facilities with a superior supplemental lighting system, that could satisfy the requirements of most research personnel. Each house is divided into five different compartments of differing size: three small ones, one intermediate, and one large one, all capable of providing close to an optimum growing environment for conifer seedlings. Thus we could satisfy most requests for quality research space.

With this brief history behind us now, I can return to the matter of rearing conifers in containers for tree improvement programs. As a plant physiologist with a background in growth regulation, and having graduated from a Ph.D program at the University of Calgary, I have been closely associated with Dr. Richard P. Pharis, and have known of his work in the stimulation of flowering in conifers through the use of growth regulators, primarily gibberellins (Pharis and Kuo 1977; Ross, Pharis and Binder 1983) for some time. I was also aware of the success of Dr. Nicholas Wheeler, in which he was able to promote accelerated growth (Wheeler 1979) and early flowering (Wheeler,k Ying and Murphy 1982) in lodgepole pine seedlings and grafts, through the use supplemental lights to provide a continuous 24 h photoperiod. This was done under greenhouse conditions, during the first six months of growth. The supplemental lights used were a combination of fluorescent and incandescent fixtures.

Following subsequent examination of related literature, I was surprised to find there was very little published on the effects of using high intensity discharge lamps, regardless of whether they were high pressure sodium vapour or metal halide sources. Most people had grown conifers under controlled environment conditions using either fluorescent or incandescent light sources. Wheeler's report on flowering in lodgepole pine (Wheeler et. al. 1982), made me wonder how this species would respond under our high pressure sodium vapour lights, particularly if the seedlings were grown in large containers for up to six months.

We had initially looked at growth responses of twelve species of conifers to continuous day-length under both fluorescent vs. high pressure sodium lights as I have previously mentioned (Dymock and Wilson 1986). So, it was decided to incorporate the fluorescent plus incandescent light combination into our study by retrofitting two of our remaining small compartments, that were still equipped with fluorescent fixtures, with incandescent lights. We now had six identical five square meter benches, with three types of supplemental light sources, under which we could examine two photoperiods (18h day/6h night vs. continuous 24th daylight).

We then went into each compartment and measured the light quantity on the benches, pot by pot, and produced a grid map of each compartment, in order to see if we were getting any light quantity gradients. We measured the photosynthetic photon flux density (PPFD) using a LI-COR Model LI-185 Quantum/Radiometer/Photometer equipped with both a quantum sensor and a photometric (lux) sensor. The PPFD is a measure of the photosynthetically active radiation (PAR) in the visible light spectrum, from 400-700 nanometres. It is this light energy that plants utilize for photosynthesis, with the trapped light energy being converted to chemical energy, for use during growth and development. It is expressed in units of energy received/unit area/unit of time, and the correct units to use are micromoles/square metre/second ($\underline{u}moles.m^{-2}.s^{-1}$). It corresponds in wavelength to light from the blue to the red ends of the visible light spectrum. The red and blue regions of visible light are the most important wavelengths used in photosynthesis. To check the light quality, we monitored those areas that gave PPFD readings closest to the calculated means, from the grid networks, using a LI-COR Model LI-1800 Spectroradiometer, that scans a wide spectrum from 300-11000 nm. The distances that the light sources were placed above the pot surfaces were approximately 80 cm for fluorescent and fluorescent plus incandescent units and 100 cm for high pressure sodium vapour lamps. These distances provided optimum light levels and area distribution to each bench, with the least amount of shading of natural daylight from the overhead fixtures.

The calculated mean values for the PPFD/bench for each type of light source were as follows:

Fluorescent only	57.6 umoles.m^{-2}.s^{-1}
Fluorescent plus Incandescent	71.5 umoles.m^{-2}.s^{-1}
High Pressure Sodium Vapour	260.0 umoles.m^{-2}.s^{-1}

The addition of incandescent fixtures to fluorescents only increased the mean PPFD by 14 umoles.m^{-2}.s^{-1}, whereas the use of high pressure sodium vapour lights provided 4.5 times more usable photosynthetic light to each bench. If similar light measurements were taken using a light metre that provides output in lux, you would be fooled into believing that you had equivalent amounts of light available from each source. <u>This is, however, not true</u>! The reason is that a lux metre has its maximum sensitivity in the green region of visible light and also registers much of the infrared radiation (or heat energy). Neither of these regions are photosynthetically active. Therefore, greenhouse operators <u>should not rely on lux metres</u> to establish the amount of light being provided by supplemental light sources, or from daylight, unless it is done at the same time with a quantum sensor that measures PPFD.

We were also interested in effects of photoperiod and day-length extension, including the use of continuous daylength provided by supplemental lights, based upon the previous results obtained by Wheeler (1979) and Wheeler et.al. (1982). We wished to determine whether there was any advantage to be realized by gains in growth and development with the use of continuous photoperiods with each system. Thus, we used our standard 18h day/6h night vs. continuous daylight in a series of experiments with each of four species (lodgepole pine, white spruce, jack pine and black spruce) which began in the fall of 1983.

After thirty weeks under the six treatments for each species examined, it was apparent that high pressure sodium lights used with the 18 h day/6h night resulted in more vigorous seedling growth, than either of the other two light types using either photoperiod. Height growth was greatest in most species under the 18 h sodium light treatments. Root development was significantly greater under the 18 h high pressure sodium vapour lights. Roots of seedlings grown under fluorescent lights showed very little or almost no lateral root branching, and had low root mass. Root development under fluorescent plus incandescent lights showed better development, but not anywhere near the root mass seen under 18 h sodium lights. In all cases of the supplemental light treatments, the 18 h sodium treatments produced a much greater stem diameter with a better balanced shoot/root ratio for dry weight.

However, a word of caution must be made. There was no further advantage reached by using 24 h sodium lights, as this treatment had no significant effect on height growth, but actually retarded both stem and root development. Similar results were seen for 24 h photoperiods using the other two sources.

The operating costs for each of the three lightning systems and the two photoperiods used in the experiments, were then estimated. Costs were extrapolated from the daily available $PPFD.bench^{-1}$ and the power consumption $used.bench^{-1}.day^{-1}$. This was converted into cost $(\$).bench^{-1}.day^{-1}$ for total consumed electricity as shown in the following table:

Bench Area = 5 m^2

Parameter / Photoperiod used	Fluorescent	Fluorescent + Incandescent	Sodium
Daily PPFD			
18 h	19.3 moles	27.5 moles	69.3 moles
24 h	25.7 moles	36.7 moles	92.6 moles
Power consumption			
18 h	9.7 kWatts	45.7 kWatts	36.0 kWatts
24 h	13.0 kWatts	61.0 kWatts	48.0 kWatts
Electricity costs			
18 h	$0.38	$1.78	$1.40
24 h	$0.51	$2.38	$1.87

The bottom line was that the fluorescent lights were the cheapest to operate but gave you the least amount of useable photosynthetically active light. The sodium lights were 3.6 times more expensive to operate, but they did provide up to 4.5 times more usable photosynthetically active radiation. Combined fluorescent plus incandescent lights were the most costly to operate, and only provided 1.4 times more usable light than fluorescents only, and only 27% of the usable light provided by less costly sodium lights.

One other unforseen consideration was the amount of heat energy generated by the different source types. Both fluorescent plus incandescent and sodium lights generate significant amounts of heat. We used this to our advantage by installing fans to circulate this excess heat within each compartment. The end result was that the steam heating units were used far less during the time the lights were on in these two compartments, even during the coldest part of the winter. Steam heating was on far more frequently in the fluorescent only compartments, as these lights do not generate excessive amounts of heat from the bulbs, but do from the ballasts, which, The roots in particular, seem to be weakened and become more susceptible to otherwise normal saprophytic problems of both insect and disease origins. With sodium lights, we have very vigorous growth and far fewer pathological problems, especially under the 18 h day. We have, however, encountered increased insect and disease problems in trees grown under continuous (24 h) photoperiod, under sodium lights. Again, this is likely related due to the lack of dark period, during which the tree would normally translocate resources from the stem and roots. The increased photosynthesis results in a larger shoot, in the case of lodgepole pine, but under a 24 h photoperiod, the root dry weight is only half of that seen in trees under the 18 h day sodium lights.

The take home lesson here, then is that for tree improvement programs, where you are rearing stock, particularly large stock in large containers in greenhouses, for either breeding purposes, or seed orchard establishments, then you can achieve the greatest cost/benefits from the use of high pressure sodium lights as your supplemental light source. You will end up with more vigorous, well balanced, healthy stock, providing you use moderation in the form of the 18h day/6h night photoperiod.

indoor potted orchards (cost justification for polystructure) vs outdoor potted orchards revealed the following:

1) Double the females initiated indoors
2) Percent cone survival was greater indoors
3) Total seed per cone greater indoors
4) Percent filled seed greater indoors
5) Percent germination, no difference between outdoor and indoor orchards.

The bottom line is: Outdoor orchard produced on average 1,500 filled seed per tree compared to 6,000 filled seed per tree indoors which more than pays for simple plastic structure.

<u>Question and Answer</u>

<u>J. Klein:</u> I've heard orchard managers say that 80% to 90% of the seed in an orchard comes from 10% or 20% of the clones. Does this also occur with the indoor potted orchards?

A. Eastham: No it doesn't. We get 80% of the clones come into production as they age. The problem one encounters then are physical orchard management problems due to height of clones.

Will Fogal: In your white spruce seed production where do you think your problem lies. Is this a pollination problem?

A. Eastham: It's not a pollination problem. I think a lot of my losses are occurring at fertilization; it either does not occur or we suffer losses in the late development phase. The megagametophyte tissue starts to turn grey. There is no evidence of insect or physical injury. I've read Sarvas (who worked on Norway Spruce) who found that in the spring when pollination is occurring there are cold temperatures. While these cold temperatures do not give you frost injury, the pollination process ceases to function.

A. Nanka: At the present where you stand with interior spruce seed production, what would be the cost differential between soil based compared to potted seed orchards?

A. Eastham: I can't give you a very reliable figure for two reasons. We have not been able to do it operationally and our soil based orchards are so young we don't know what their production costs will be. Initially the capital required with respect to land costs results in the container seed orchard being cheaper. Graft costs are the same but potted orchards require slightly more trees to achieve the same annual seed production.

REARING SEEDLINGS IN CONTAINERS FOR TREE IMPROVEMENT PROGRAMS

by

Albert (Al) M. Nanka
Tree Improvement Specialist
Forestry Canada
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In this presentation I will focus on four key factors that influence the production of quality seedlings for tree improvement programs and give you a brief outline of the cultural practice that I use. In a systems approach, cultural practice is most important. After having reared numerous crops and assessed various tree improvement plantations over the past 18 years, I view the four following factors most important.

(a) Procurement of an optimal growing facility with good environment controls,

(b) Commensurate crop specifications to site conditions

(c) appropriate container selection and

(d) choose a proven cultural practice.

Growing Facility

It is essential that the facility has a climate control system capable of maintaining near optimum growing environment (temp, light quality and intensity, humidity and air circulation). Growing facilities in this latitude must have high pressure sodium lights (approx 300 U moles m^{-2} s^{-1}) to grow quality conifer crops between September and February.

Crop Specification

Container limitations and planting site conditions (climate, soil type, site preparation and competition) must be known before crop specifications can be set. I recommend selecting a suitable planting site which will meet the test requirements. Knowing the field conditions for the planting site, usually generates some parameters for determining crop specifications. When you know the field conditions that your crop is going to encounter (growth rate of competition) crop height parameters can be specified more accurately. Another reason for selecting a planting site prior to determining crop specification is to pre-empt site preparation needs which are equally important for the success of a tree improvement program. I will limit this discussion only to factors that have a direct effect on production of quality seedlings.

Container Selection

A difficult task, because all containers have limiting constraints. Furthermore, crop performance reports on container suitability vary widely among growers because of variable growing conditions and cultural practice. The advantage in using containers for rearing seedlings for tree improvement stock is that they facilitate the opportunity to grow a crop under controlled conditions (greenhouse, uniform fertilizer regime etc). The main disadvantage in using containers is the cavity shape which restricts natural root expression and causes root deformity, more so in pine than spruce. Once root deformation has commenced it is difficult or even impossible to correct. For example, root deformation or restriction in jack pine seedlings can start as early as eight weeks in some containers and continue to have an adverse affect on growth performance for many years after planting. It is important to know the required parameters for proper root development when setting crop specifications for height. An approach which pre-determines root development requirements for specific species in relationship to crop height will help to eliminate undesirable containers and assist in choosing the right type and size of container. A suitable container must accommodate growth characteristics without having any adverse effect on field performance of seedling. For example, root pruning feature in container design is essential, but must not impede root distribution after planting. Meanwhile container should not compromise in the production of the required seedling size. Ideally, a near natural root and shoot growth pattern is required to reflect accurately the test environment (site and climate) x genotype interaction.

Logistic features like interchangeable cells (Leach-Tube) are more practical, but not essential. Ultimately, container selection should be based on achieving crop specification without long term adversity in field performance rather than choosing container by appearance, economy of scale or ease of handling aspect.

Cultural Practice

I consider cultural practice the most vital task to rearing quality seedlings for tree improvement. After planting, only a top quality seedling can express an accurate environmental x genotype interaction. For example, a progeny seedling must have good root growth potential (have ample root tips ready to promote root distribution) when planted in the test environment to enable it to reflect accurately its growth rate potential commensurable with the test population (its neighbours). If this is not achieved, than the entire investment has been sacrificed. Seedlings with spindly or succulent shoots are more likely to perish than woody shoots. Yet, rearing and planting investment is nearly the same as for quality stock. Ramifications from poor stem quality or deformed roots are enormous. Poor quality seedlings which linger just long enough (5-7 years) to yield erroneous data are the worst prospect. Therefore, it is imperative to choose a proven cultural practice to optimize shoot and root growth development, beginning from rearing through to plantation establishment and beyond. Finally, prior to shipping date, test stock should have a near natural root and shoot growth potential.

Current Cultural Practice I Use for Rearing Jack Pine Orchard Stock

The following is a brief outline of the rearing methodology I use to grow jack pine stock for mass selection seed orchards. Some of these crop growing techniques have evolved over the past 15 years while I was rearing program test stock for the jack pine breeding program at the Northern Forestry Centre. I used various fertilizer regimes in earlier crops. A few reasonable crops were reared using 20-20-20, N-P-K fertilizer for the entire rearing period. Over a period of 8 years I have followed the fertilizer regime outlined in Carlson's manual NOR-X-214E. In more recent crops by changing fertilizer regime (to lower nitrogen and higher phosphorus) at 11 weeks instead of 14 weeks, I was able to develop seedlings with a better root system and more shoot diameter (wood fibre). After planting, these seedlings continued to exhibit better growth and drought tolerance for several years in comparison to seedlings reared with 20-20-20 N-P-K fertilizer regime. Now I will refer to Table 1. Current Cultural Practice for Rearing Jack Pine Orchard Stock. I want to emphasize some points in reference to Table 1. For several reasons it is important to maintain stringent effort when filling all cavities to a uniform level as well as density. The most important reason is to achieve crop balance. Cavities that are less than full media dry out sooner, have less capacity to retain nutrition and less rooting volume. Another important point. Apply cultural treatments on a regular schedule. For example, irrigate on Mondays and fertilize on Fridays, weekly. This practice reduces the risk of crop damage due to drying out over the weekend. Also allows you to sample growing media during mid-week, when nutrition level has stabilized for more precise pH and EC determinations. Table 1 is self-explanatory as presented.

TABLE 1 - Current Cultural Practice for Rearing Jack Pine Orchard Stock

Time (weeks)	Task #	Cultural Practice
(0)	(1)	Set greenhouse temperature day 25°C/night 20°C
	(2)	Prepare growing media, check pH level in bagged "Sunshine" brand Peat.
	(3)	Adjust pH level to 5.5 by adding $CaCO_3$ (powdered lime, horticultural grade) to bagged peat in mixing hopper prior to adding water.
	(4)	Bring moisture level in peat to desired level by misting with metered amount of water while breaking lumps in hopper with minimum of mechanical mixing.
	(5)	Fill container with peat to top of container. NB: maintain uniform level and density.
	(6)	Test peat filling density for optimal density. Medium should not settle more than 1cm after being saturated with water. NB: To prevent over compaction of medium, allow 1 hour for excess water to drip off before moving trays, or move gently.
	(7)	Saturate trays thoroughly prior to sowing. Sow 2 seeds per cavity, label trays. Commence sowing 2 hours after saturation or within a couple of days. Saturated trays should be covered overnight to prevent surface drying of medium.
	(8)	Cover peat surface totally with #2 granite grit immediately after sowing.
	(9)	Cover sown trays with clear or opaque polyethylene by pulling taunt and tucking tightly around corners and edges to retain moisture. Do not irrigate until germination is complete.
(1)	(10)	Six to nine days after seeding (when most cotyledons touch plastic cover) remove polyethylene.
	(11)	Mist with boom at 1100 hrs and 1300 hrs for 6 to 8 days after removing polyethylene.
	(12)	Set photoperiod 0200 hrs - 1600 hrs supplementary high pressure sodium light @ 300 $\underline{u}$ moles/$m^{-2}s^{-2}$.
(2)	(13)	First application of fertilizer during establishment phase: 115-15-77 ppm N-P-K @ 5L/100 cavities (750 cm^2)

Continued on Next Page

TABLE 1 - Continued

Time (weeks)	Task #	Cultural Practice
(2)	(14)	Weekly (Mon) irrigation 5L/100 cavities (750 cm^3).
↓	(15)	Monitor for Crop diseases.
(3-10)	(16)	Weekly (Fri) Fertilizer during rapid growth phase: 229-29-154 ppm N-P-K = 5 ppm Fe @ 5L/100 Cavities (750 cm^3). 125-60-159 ppm N-P-K = 5 ppm Fe @ 5L/100 Cavities (750 cm^3).
	(17)	Manicure and rotate crop: pluck off first needles from bottom up to about 7 cm. to prevent disease.
↓ (11-16)	(18)	Weekly (Fri) Fertilizer during hardening phase: 45-99-165 ppm N-P-K + 5 ppm Fe @ 10L/100 Cavities (750 cm^3). Weekly (mon) irrigation @ 10L/100 cavities.
↓ (17-25)	(19)	Weekly sample growing medium to determine pH and Ec level, pH target 5.5 to 6.5. Ec/ms/cm growing range .28 to .60. Leach crop when greater than .70.

WEEKS	NITROGEN	PHOSPHOROUS	POTASSIUM	IRON CHELATE
03-10	229	29	154	5 ppm
11-16	125	60	159	5 ppm
17-25	45	99	165	5 ppm

GROWING REGIME USED FOR TREE IMPROVEMENT CROPS AT PINELAND

Presented By Wendy Kozmak

At this time, two crops have been grown to the larger size specifications required for the tree improvement program. (20-25 cm ht, 3-4 mm root collar, and a S:R ratio of between 4 and 5 to 1). From this, we have drawn up some guidelines to follow for growing tree improvement crops.

Styroblock 20 containers are used. The plug volume is approximately 330 c.c., and there are 45 cavities per tray. a 70-20-10 mix of peat, vermiculite and perlite is used. Trays are filled on our seedling line ahead of time and moved to the tree improvement facility prior to seeding.

Seeding is done by hand. 90 cavities are sown per family at 2 seeds/cavity, with a desired target of 69 plantable seedlings/family. Once the trays are sown they are labelled with the family member and gritted by hand. The two trays from each family are placed in different spots in the greenhouse. Once all the trays are in the greenhouse, they are watered till the plug is wet half way down, and covered with poly. Temperature is maintained at 27-30C, and high pressure sodium lights are used to extend the photoperiod to an 18 hour day. Poly is removed when the radicle is growing into soil, and before the seed coat touches the poly. One 10% germination is achieved, the crop is fertilized once a week. H_3PO_4 (phosphoric acid) is used to acidify the water to a pH of 4.5. Fertilizer is injected into irrigation water with an injector pump. During the juvenile growth stage 20-20-20 is injected at 50 p.p.m. This is increased to 100 p.p.m. during the exponential growth stage. Once 10% germination is reached, an application of fungicide is used to protect the crop from damping off. Temperatures are lowered to 25C(day) and 18C(night), and the 18 hour photoperiod is maintained through the juvenile and exponential growth stages. The E.C. of the media is monitored and the crop is leached if the E.C. exceeds 2000 umhos.

When the crop reaches 18-20 cm in height, the hardening off process is begun. Fertilizing stops, the crop is leached and then drought stressed, supplemental lighting is stopped, and the crop is sprayed with fungicide to prevent botrytis. Once the bud has been initiated fertilizing is resumed, using 8-20-30 at 50 p.p.m. Two weeks prior to stock moving out, the stock is exposed to outside temperatures to acclimatize it. When the stock is moved into the shadeframe it is protected with 50% shade for 7-10 days and irrigation and fertilizer applications continue till the crop is shipped.

TREE IMPROVEMENT IN NOVA SCOTIA

Poster by Tim Mullin

Planting Program

Reforestation in Nova Scotia currently amount to 35 million seedlings planted annually. About 85% of these are grown in multipot style containers. Greenhouse facilities are operated by the Department of Land and Forests (3 + 1 under construction) and by each of the 3 major pulp and paper companies in the Province. There are 2 bareroot nurseries operated by the Department.

Tree Improvement Working Group

A cooperative breeding program has been in place since 1977. Coordination of the program is the responsibility of the Department of Lands and Forests, which also operates a specialized propagation facility to service the program. Technical assistance and supporting research is provided by the Canadian Forestry Service - Maritimes. Seed orchards and field test are managed by the Department and the 3 industrial cooperators: Bowater-Mersey Paper Co. Ltd., Scott Worldwide Inc., and Stora Forest Industries.

Species and Strategies

The primary focus of the breeding program is on the key reforestation species: black, red and white spruce. Together, these three species account for 85% of the annual nursery production.

For black spruce, open-pollinated seed in collected from field-selected "plus trees:, and used to establish seedling seed orchards. Family tests are established concurrently on typical planting sites and used to identify the top 10% of the original families. Selections made within these families are then grafted into second-generation orchards and included in polycross and single-pair mating schemes. A slightly different strategy has been employed for the Cape Breton Highlands area, taking advantage of clonal propagation techniques already in use for planting stock production.

Red and white spruce are grafted directly to clonal seed orchards from selected plus trees. Early flowering on grafts is used to carry out polycross and single-pair matings. Progeny tests of this material will identify good "general combiners", and provide pedigreed material for second-generation selection.

Minor programs are carried out with white pine and Norway spruce. Recent interest in exotic larches has led to seed source trial concentrating on Japanese larch and European-Japanese hybrids.

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Tree Breeding Centre
Debert, Nova Scotia

ONTARIO TREE IMPROVEMENT COUNCIL

Poster By: Jim Coles

OTIC began operations in January 1985 and since then has concentrated on the classical approach to tree improvement in five breeding zones across Northern Ontario. The strategy employed for both black spruce and jack pine is the extensive selection of individuals from wild stand followed by the establishment of seedling seed orchards and open-pollinated family tests. Seed orchards will be rogued of their poorest families based on the results of the family tests.

NORTHWESTERN REGION

Boise-Cascade Ltd., Great Lakes Forest Products Ltd. and the Ontario Ministry of Natural Resources are cooperating to improve jack pine in two adjacent breeding zones centred around Fort Frances and Dryden. Approximately 900 plus trees have been selected and will be established in two seed orchards and six family test by 1989.

NORTH CENTRAL REGION

Abitibi-Price Inc., Great Lakes Forest Products Ltd. and OMNR are cooperating to improve black spruce and jack pine in a large area to the west of Lake Nipigon. Roughly 450 jack pine has been selected and were established in a 14 ha. seed orchard and four family tests this past summer. Approximately 500 black spruce has been selected and will be established in two 16 ha. seed orchards and four family tests during 1988.

NORTHERN REGION

Abitibi-Price Inc., OMNR and Quebec & Ontario Paper Co. are cooperating to improve black spruce in the Lake Abitibi-Cochrane area. 450 plus trees have been selected and will be established in a 36 ha. orchard and four family tests by 1989.

OMNR, Quebec & Ontario Paper Co., and Waferboard Corp. are cooperating to improve both black spruce and jack pine in the Timmins-Kirkland Lake area. Roughly 450 selections have been found for each species and 12 ha. of Sb and 16 Ha. of Pj along with the family tests will be outplanted this coming spring.

Because of the large quantities of seed required, OTIC has opted to establish soil-based orchards within the pertinent breeding zones for our first generation production. The opportunity exists, however, to move quickly to potted indoor orchards for seed production in the second generation or for those species with smaller planting programs. Over the past 30 years, OMNR has intensively selected hundreds of white spruce whose ramets are languishing in clone banks and unproductive orchards. These excellent clones could be regrafted, placed in potted indoor orchards and brought to production quickly to supply the Sw seed requirements for virtually all the North Central and Northern region. In addition, of interest is whose in a species such as tamarack, a potted indoor orchard could be quickly established with a few intensively selected individuals. Likewise, as the best individuals from the best families are identified in our current tests, OTIC may utilize the inherent flexibility of potted indoor orchards to produce second generation seed for such high value planting programs as on prime sites.

WEYERHAEUSER CANADA LTD., SASKATCHEWAN DIVISION
PRINCE ALBERT PULPWOOD
(Prince Albert, Saskatchewan)

Poster By: Diane Roddy and Spencer McDougald

The Pulpwood Division of Weyerhaeuser Canada Ltd. is responsible for supplying chips and roundwood to the Prince Albert Pulpmill. The pulpmill used jack pine, black spruce and white spruce to produce a softwood pulp for light-weight papers and trembling aspen to produce a hardwood pulp for medium bulk papers.

We began a tree improvement program for jack pine in 1978 and a program for white spruce in 1983. Clonal orchards have been established in both programs. The jack pine orchard is now producing small amounts of seed for operational planting and we have started doing cross pollinations within the orchard. Family tests for 200 select jack pine are established and the oldest one have now had seven (7) growing seasons in the field. In the white spruce program a seed production area has also been established (to provide a seed supply until the orchard comes into production) and we are currently working on a program to establish family tests of 200 select spruce trees.

On our seed orchard site there is one small experimental greenhouse in which we raise seed form selected pine and spruce parents to outplant in the family tests. This greenhouse is also used for grafting -- to get material to supplement our regular field grafting program for the orchards with.

Seed collected from the jack pine orchard and any batched "leftover" seeds from select trees (not needed for the family tests) are raised in the provincial government greenhouses. The provincial government also provides us with larger seedlings to use as grafting rootstock.

Cone and seed processing for all tree improvement material is done right at the seed orchard, using a cone drying trailer and equipment for processing small seedlots.

B.C. MINISTRY OF FORESTS AND LANDS

Research Laboratory

Poster By: Andrea Eastham

Current Activities in Tree Improvement Research

The seed supply research group at the laboratory consists of four professionals and five technicians. The professionals and their area of expertise are:

- Steve Ross - project leader, flowering physiology
- Joe Webber - pollen management
- Carole Leadem - seed physiology
- Andrea Eastham - horticulture, container seed orchard (CSO) development

Dr. Ross is currently studying crown management, plant growth regulators and cone induction treatment timing for soil-based orchards and CSO's in Douglas-fir, western hemlock and interior spruce; also, developing the CSO system to operational status. Dr. Webber has been actively studying pollen viability, storage, handling and pollination in Douglas-fir, western hemlock and more recently in yellow cedar and interior spruce. Dr. Leadem has been working with the nurseries and seed centre on such problems as seed storage, handling, testing, pelleting and stratification in a number of species. Ms. Eastham's research has been directed towards the CSO system development and the culture of large potted conifers - growing media, fertilization, irrigation, pest control, crown pruning and accelerated growth in several species; also, conducts research in cone and seed development, seed pre-conditioning and seedling growth.

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SHELTERBELT TREE IMPROVEMENT - PFRA TREE NURSERY

Poster By: W.R. (Bill) Schroeder

In recent years several new tree improvement programs have been initiated at the PFRA Tree Nursery. Current emphasis is on genetic improvement of shelterbelt species through plus tree selection, provenance testing, establishment of seed orchards and progeny tests. Work has concentrated on the following species:

1. Poplar
   Poplar improvement has involved hybridization and selection of superior trees. In the past five years over 200 selected clones have been propagated. In 1986 one of the selections, 'Assiniboine', was released for planting in prairie shelterbelts.

2. Green ash
   In 1985 and 1986 seed was collected from the northern range of green ash in North America. This included 36 sources from Nebraska, N. Dakota, S. Dakota, Manitoba and Saskatchewan. In total 100 families are represented. Provenance planting will commence in 1989.

3. Scots pine
   Interprovenance breeding of Scots pine continues. To date over 300 crosses have been completed. Progeny tests are established at several locations in 1987 and plus trees were grafted for establishment of a clonal seed orchard in 1988. A superior Siberian strain of Scots pine has been developed with first production stock being available in 1991.

4. Siberian larch
   The Siberian larch program was initiated in 1985 with the collection of seed from the native range of larch in

Siberia. Once a base population exists interprovenance breeding will be initiated. Plans are for provenance tests to be established in the fall of 1987. Extensive research on propagation (seed and cuttings), nursery management and establishment techniques for this species is underway.

5. Ponderosa pine

The GP13 ponderosa pine progeny test was established on a farmstead near Indian Head in 1986. The planting is three acres in size, includes 65 families arranged in a randomized complete block non-continuous design for a total of 1365 trees. The planting is surrounded by a one row buffer planting of Scots pine. Final spacing of the planting was 2.5 x 3.6 m (8' x 12'). Immediately after mechanical planting the seedlings were hand watered and shaded with cedar shingles. The planting was kept weed free during 1986 using mechanical cultivation. A fall application of linuron in 1986 will provide weed control during the 1987 growing season. In late fall the seedlings were sprayed with rodent repellant and antidessicant.

The 1986/87 winter was very mild by Canadian standards and snow cover was nonexistent. In spite of these conditions overwinter survival was excellent (ranged from 95 to 100 percent). The major problem to date has been soil erosion within the planting. Plans to erect rows of snow fencing perpendicular to the prevailing winds.

6. USSR seed collection

In July of 1987 a delegation including John Kort and Bill Schroeder will be touring the Soviet Union. One of the objectives of the tour is to obtain germplasm of tree and shrub species that could be incorporated into our shelterbelt program. Some of the species we will be attempting to obtain are:

- Ulmus pumila var. arborea
- Ulmus laevis
- Siberian crataegus
- Picea obovata
- Pyrus baccata
- Fraxinus viridus
- Larix sibirica
- Pinus sibirica
- Cornus sibirica
- Ribes nigrum

The preceding species are commonly used in Siberian shelterbelt planting programs. In return we will be providing the Soviets with seed of native Canadian species used in our shelterbelt programs.

FAST GROWING FORESTS

Tree Improvement Program

Poster By: B.A. Barkley

The Fast Growing Forests Group (FGF), Brockville, Ontario, is currently engaged in two major parallel programs in tree improvement. Poplar tree improvement has been an ongoing program since the early 1970's and is currently at an advance stage of clonal testing and deployment. A conifer tree improvement program for the Eastern Region was initiated in 1985. The major species for improvement, are in order of priority, white pine (Pinus strobus L.), Norway spruce (Picea abies (L.) Karst) and three species of larch (Larix laricina (Du Roi) K. Koch, L. leptolepis (Sieb. & Zucc.) Gord, and L. decidua Mill.)

Conifer tree improvement efforts over the past two years have focused primarily on the establishment and maintenance of controlled seed collection areas (SCAs and SPAs), plus tree selection and grafting, white pine breeding, and the development of indoor breeding facilities and treatment regimes.

Conifer plus tree selection throughout the region has resulted with over 400 conifer selections made to-date. Selections are made from native populations. Scions of selected trees are grafted onto potted rootstock. Grafts are allocated to archives, production seed orchards, and the breeding hall.

Breeding work for all species is carried out in a breeding hall located at Kemptville Nursery. This gutter-connected greenhouse measures 22m x 33m, for a total floor area of approximately 722 sq.m., and has 3.05 m straight sidewalls. To-date, breeding work in the hall has focused primarily on white pine. A total of 60 controlled crosses have been made to-date. The ensuing progeny trials will provide the basis for rouging two 8 ha. white pine production seed orchards that are to be established over the next several years. These progeny trials will also provide the source of second generation selections.

Development work is ongoing in the breeding hall, aimed at accelerating the breeding cycle by reducing the time required for grafts to flower. Studies have been initiated to define treatment regimes that 1) enhance vegetative growth and crown development, and 2) promote precocious enhance flowering. Treatments now under study include the application of gibberellin, root pruning, moisture stress, and forcing early bud break.

Poplar tree improvement work has been ongoing since the early 1970's. To-date, over 2000 plus tree selections have been made of native poplar species (*Populus deltoides*, *P. tremuloides*, *P. grandidentata*, and *P. balsamifera*). Emphasis on breeding of *P. deltoides* has been increasing, with aims of exploring and enhancing the native gene pool. Additionally, interspecific crosses are being made to produce first generation hybrid populations from which to select individuals for systematic testing in clonal screening trials.

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