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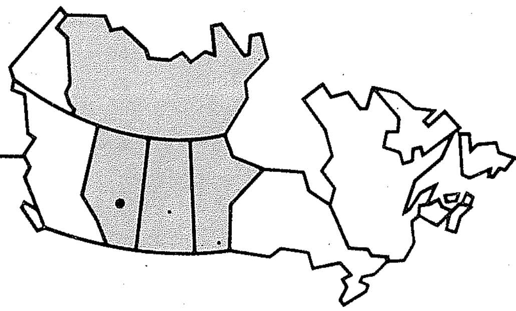
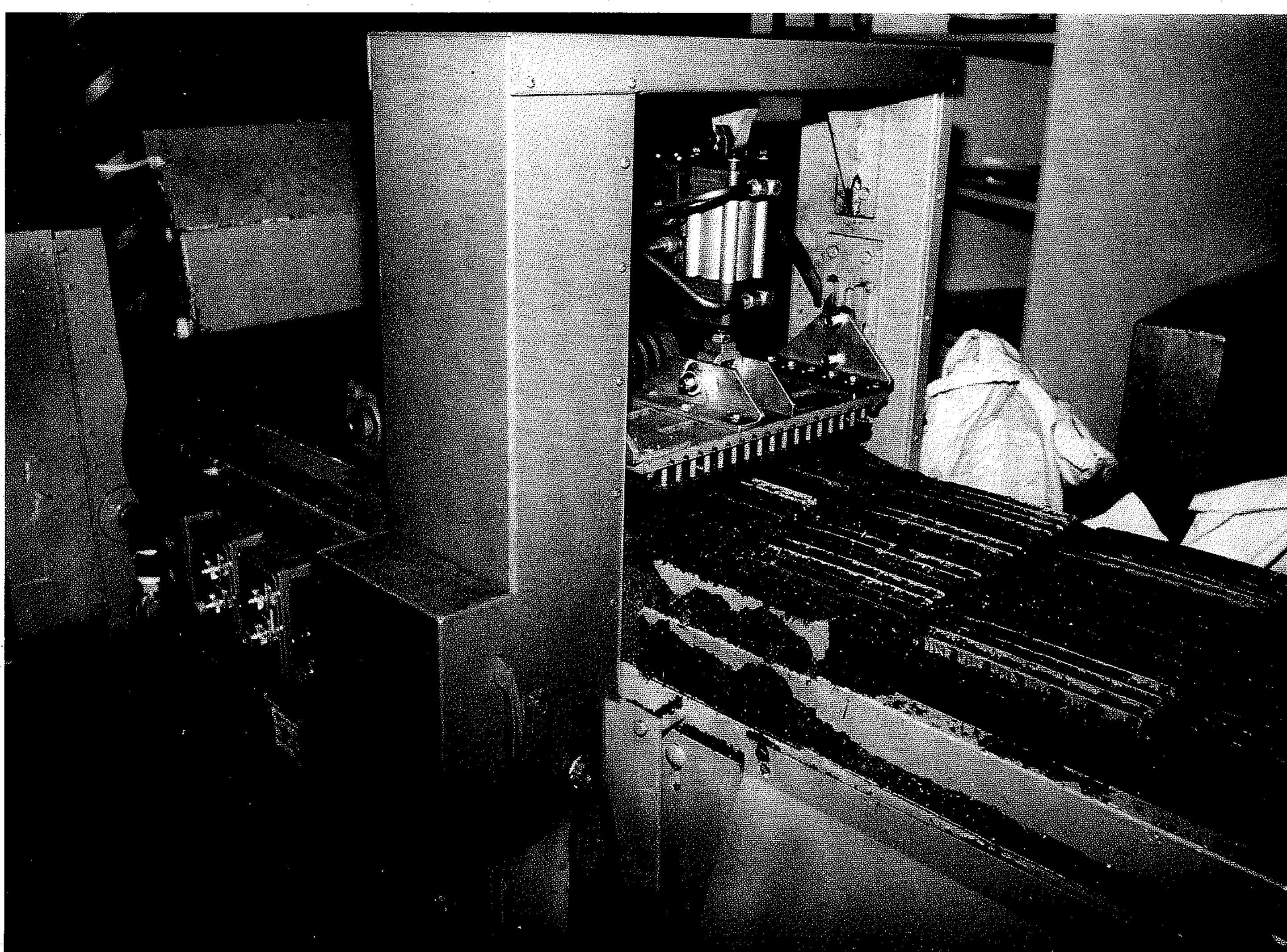
Proceedings of the 1986 Prairie Federal-Provincial Nurserymen's Meeting

E.M. Harvey, compiler



Information Report NOR-X-287
Northern Forestry Centre



The Northern Forestry Centre (NoFC) of the Canadian Forestry Service is responsible for fulfilling the federal role in forestry research, regional development, and technology transfer in Alberta, Saskatchewan, Manitoba, and the Northwest Territories. The main objectives of the center are research and regional development in support of improved forest management for the economic, social, and environmental benefit of all Canadians. Since 1982 the center has also assumed responsibility for the implementation of federal-provincial forestry agreements and employment stimulation programs in the forestry sector.

One of six regional centers, two national forestry institutes, and a headquarters unit, NoFC is located in Edmonton, Alberta, and has district offices in Prince Albert, Saskatchewan, and Winnipeg, Manitoba. Until joining Agriculture Canada in 1984 under a Minister of State (Forestry and Mines), the Canadian Forestry Service was part of Environment Canada.

PROCEEDINGS OF THE 1986 PRAIRIE FEDERAL-PROVINCIAL NURSERYMEN'S MEETING

September 9–11, 1986, in Edmonton, Alberta

E.M. Harvey, compiler

INFORMATION REPORT NOR-X-287

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ABSTRACT

The 1986 annual meeting was held to exchange nursery information between nursery personnel and researchers from the prairie provinces. Papers on nursery operations included such topics as production of container and bare-root stock; weed, insect, and disease problems; equipment acquisition and development; shelterbelts; and tree improvement. Papers were also presented on stock quality monitoring, cold hardiness, and the National Tree Nursery Weed Control Association.

RESUME

Le but de l'assemblée annuelle était l'échange d'information entre les chercheurs et le personnel des pépinières des provinces des prairies. Les communications présentées sur les opérations en pépinière portaient sur des sujets tels que la production de semis en contenant et à racine nues; les problèmes de mauvaises herbes, d'insects et de maladies; le développement et l'acquisition d'équipement; les rideaux abris; et l'amélioration des arbres. Des communications ont aussi été présentées sur le contrôle de la qualité des stocks, la resistance au froid et sur l'atelier du National Tree Nursery Weed Control Association (une association s'intéressant à la répression des mauvaises herbes en pépinières).

CONTENTS

NOTE

The exclusion of certain manufactured products does not necessarily imply disapproval nor does the mention of other products necessarily imply endorsement by the Canadian Forestry Service.

METHODS OF STOCK QUALITY MONITORING FOR THE PRAIRIE PROVINCES

E.M. Harvey
Northern Forestry Centre
Edmonton, Alberta

ABSTRACT

Samples were taken from all seed lots of white spruce (*Picea glauca* (Moench) Voss) and jack pine (*Pinus banksiana* Lamb.) bare-root stock lifted during the fall of 1984 and the spring of 1985 at the four Saskatchewan forest nurseries. Half of the samples were placed in −2°C storage and half were placed in +2°C storage for 3 weeks. Root growth capacity (RGC) tests were conducted after 7 and 21 days, and RGC was determined by measuring new root elongation (RE) and counting the number of new roots (RN). Conditioning the seedlings at +2°C for 3 weeks prior to testing resulted in significantly higher RGC. The 21-day test resulted in significantly higher RGC. RE results are similar to RN results. The latter are preferred for ease of measurement. The 7-day RGC test is insufficient for testing bare-root white spruce and jack pine grown on the prairies. At the end of a 21-day RGC test, counting only new roots longer than 1 cm for white spruce may suffice, but all of the new white root tips should be counted for jack pine.

INTRODUCTION

Alberta, Saskatchewan, and Manitoba shipped over 45 million bare-root and container seedlings in 1986. Although it is important to ship sufficient numbers of seedlings in order to maintain adequate stocking in the field, it is of equal or even greater importance to ensure that seedlings shipped are of a high quality so that they will establish and grow rapidly in the field.

Several researchers have measured a range of morphological features in an attempt to relate some morphological quality to field performance. The principal attributes measured to quantify the morphological quality of nursery stock have been height, root collar diameter, height-diameter ratio, top and root dry weight, top-root ratio, root area, and volume. These factors are sometimes combined to develop an integrated approach to quantify morphological quality. The following are examples of this.

1. Quality Index (Dickson et al. 1960):

$$QI = \frac{SDW}{\dfrac{Ht}{RCD} + \dfrac{TDW}{RDW}},$$

where SDW is the seedling dry weight (g), Ht is height (cm), RCD is the root collar diameter (mm), TDW is the top dry weight (g), and RDW is the root dry weight.

2. Seedling Index (Armson and Sadreika 1979):

$$SI = \frac{Ht}{RAI} \times RCD^2,$$

where Ht is height, RAI is the root area index, and RCD is the root collar diameter.

3. Quality Index (Iyer and Wilde 1982):

$$c = \frac{\dfrac{(x-h)^2 \times 100}{(n-1)}}{h}$$

$$QI = \frac{RCD}{Ht} + \frac{RV}{TV} + sg\ (stems) + CP + \frac{1}{c},$$

where c is the coefficient of variability, x is the height of individual seedlings (cm), h is the mean height (cm), n is the number of measured seedlings, RV is the root volume (cm^3), TV is the top volume (cm^3), sg (stems) is the specific gravity of the stems, and CP is the catalytic potential (cm Hg/plant).

These integrated approaches result in single values to which stock can be compared. Other researchers in Ontario (Scarratt and Reese 1976; Day 1985; Day et al. 1985) and in Oregon (Nicholson 1974) have developed size class standards based on a variety of morphological attributes.

Recently, terminal bud length (Thompson 1985) and the number of needle primordia in the terminal bud (van den Driessche 1984) have been used as measures to quantify morphological quality. These measurements may be indicators of potential growth the year after outplanting.

Classification of nursery stock using morphological characteristics is often not enough to predict outplanting performance. Many nurserymen and researchers are all too familiar with the case of planting stock with seemingly good morphological characteristics that belie expectations and die or perform poorly when outplanted.

The importance of the physiological quality of nursery stock was recognized in the 1940s by Wakeley (1948) who suggested that "a seedling's ability to resist excessive water loss, to take in water, and to extend its root system promptly might depend far less on its size and form than on its internal chemical or physiological condition—that is on its physiological grade." Ritchie (1984) similarly stated, "comparisons of seedling performance based upon morphological traits are valid only when seedlings are in the same physiological condition when tested."

The principal physiological attributes that have been used to predict outplanting performance in the field are root growth capacity, plant moisture stress, and vigor testing.

Although these measurements and tests have been conducted for several years and are used operationally as indicators for field performance in Ontario, British Columbia, and the Pacific Northwest, they have to be adapted and calibrated for specific conditions on the prairies (Navratil et al. 1986). Methodology and results for testing seedlings should not be taken from one region and used without modification in a second region.

METHODS

In 1985, five seed lots of bare-root 3 + 0 white spruce (*Picea glauca* (Moench) Voss) and three seed lots of 2 + 0 jack pine (*Pinus banksiana* Lamb.) stock were sampled from the four Saskatchewan forest nurseries (Table 1). Samples were taken from all seed lot-nursery-season combinations lifted during the fall of 1984 and the spring of 1985 with no duplications except for jack pine seed lot 1205018003 from Chitek Lake. Samples were taken for this seed lot from both thinned and unthinned beds.

Table 1. White spruce and jack pine seed lots sampled from the Saskatchewan forest nurseries in 1985

Species	Seed lot number	Seed lot	Nursery	Season lifted
White spruce	1	1207017801	Prince Albert	Fall
	2	1207017801	Prince Albert	Spring
	3	1309018001	Prince Albert	Fall
	4	1309018001	Big River	Spring
	5	1309018001	South Branch	Spring
Jack pine	1	1205018003	Chitek Lake (unthinned)	Spring
	2	1205018003	Chitek Lake (thinned)	Spring
	3	1205018003	Prince Albert	Spring

The samples were divided in half. Half were placed in frozen (−2°C) storage and half were placed in cold (+2°C) storage for 3 weeks. These storage temperatures were chosen because they are commonly used across the region.

Fifty seedlings from each storage temperature were selected for root growth capacity (RGC) tests. Twenty-five were tested according to the method used in British Columbia (7 days at 25°C days, 20°C nights) and 25 were tested according to the method used in Ontario (21 days at 24°C days, 18°C nights). The seedlings were potted, five per pot, in 15-cm bulb pans in a 3:1 peat and vermiculite mix. The experimental design was a 3^3 factorial randomized block design. There were five white spruce seed lots or three jack pine seed lots × 2 storage temperatures × 2 RGC tests × 5 replications × 5 seedlings/replication.

Root growth capacity was determined by estimating the number of small (<0.5 cm) and medium (0.5 to 1.0 cm) new white root tips in decile ranges and assigning a median length. The number of long (>1.0 cm) white root tips were accurately counted, and the accumulated length was measured.

All analyses were done on the Northern Forestry Centre's VAX computer using SAS programs (SAS Institute Inc. 1985). New root elongation (RE), new root number (RN), the elongation of new roots longer than 1 cm (LRE) and the number of new roots longer than 1 cm (LRN) were subjected to analyses of variance (ANOVA) (Steele and Torrie 1980). When ANOVA showed that there were significant differences between treatment means, a Student-Newman-Keul's test (SNK test) was applied to determine where these differences were (Steele and Torrie 1980).

RESULTS

In all cases, conditioning seedlings at +2°C for 3 weeks prior to the RGC tests resulted in significantly ($p = 0.0001$) higher RGC for each of the measured attributes (Table 2). The 21-day test resulted in significantly higher ($p = 0.0001$) RGC for each of the measured attributes (Figs. 1–12).

The results for the white spruce RGC tests are given in Figures 1–6. The RN results (Fig. 1) are similar to the RE results (Fig. 2). The LRN results (Fig. 3) are similar to the LRE results (Fig. 4). Generally, seed lots 2 and 4 had significantly lower RGC than the other seed lots. The effects of storage temperature are shown in Figures 5 and 6. There were no significant differences between the RGC test × storage temperature interactions for RE (Fig. 5). The 7 day, −2°C and the 7 day, +2°C RGC test × storage temperature interactions had significantly lower LRN than the other RGC test × storage temperature interactions.

Table 2. The effect of storage temperature on mean new root elongation (RE), new root number (RN), elongation of new roots greater than 1 cm (LRE), and number of new roots greater than 1 cm (LRC) for the 1985 RGC tests

Species	Storage temperature (°C)	RE (cm)	RN	LRE (cm)	LRN
White spruce	+2	28	64	11	4
	−2	19	52	5	3
Jack pine	+2	56	60	42	14
	−2	9	30	1	0

The results for the jack pine RGC tests are given in Figures 7 to 12. Again, the RN results (Fig. 7) are similar to the RE results (Fig. 8) and the LRN results (Fig. 9) are similar to the LRE results (Fig. 10). Seed lot 3 had significantly higher RE than seed lots 1 and 2 (Fig. 7). There were no significant differences between seed lots for any of the other attributes measured (Figs. 8, 9, and 10). The effects of storage temperature are shown in Figures 11 and 12. The 7 day, −2°C and 7 day, +2°C RGC test × storage temperature interaction had significantly lower RN than the other RGC test × storage temperature interactions (Fig. 11). The 21 day, +2°C RGC test × storage temperature interaction had significantly higher LRN than the other RGC test × storage temperature interactions (Fig. 12).

DISCUSSION

The 7-day RGC test is insufficient for testing bare-root white spruce and jack pine grown on the prairies. If all of the white root tips are counted and measured it may provide an estimate of RGC, but the results of the 7-day test should not be relied on too heavily.

The length measurement of new roots does not provide any more information than the number of new

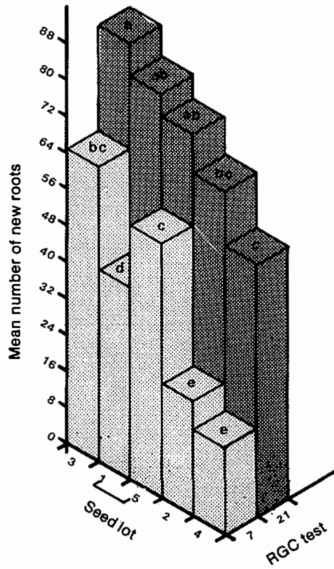

Figure 1. Number of new roots for white spruce RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

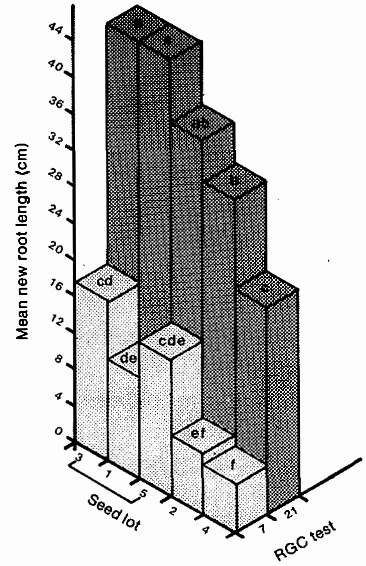

Figure 2. Length of new roots for white spruce RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

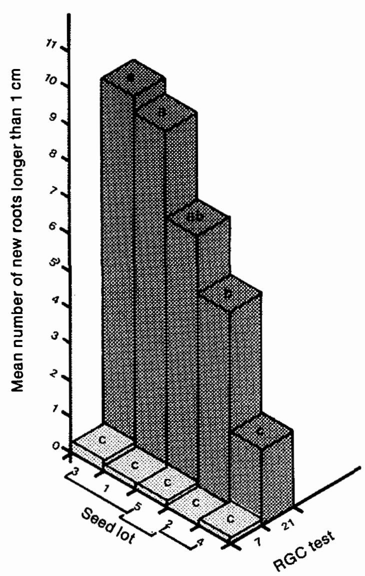

Figure 3. Number of new roots longer than 1 cm for white spruce RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

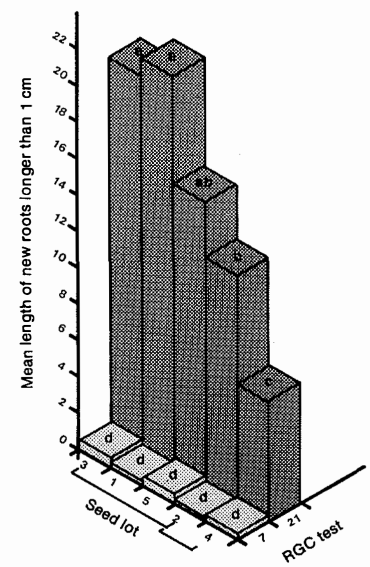

Figure 4. Length of new roots longer than 1 cm for white spruce RGC tests–seedlot × RGC test.

Note: Main effects that were not significantly different ($p = 0.05$) are joined by a line. Interactions that were not significantly different are assigned the same letter.

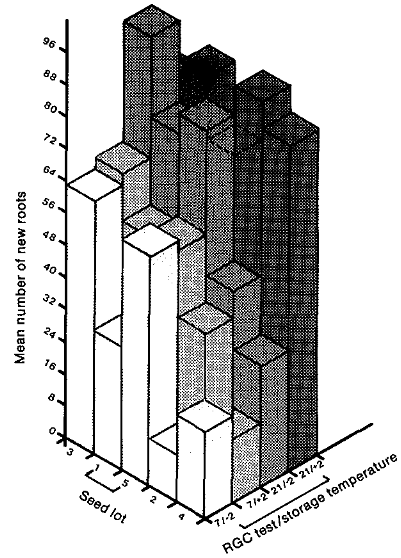

Figure 5. Number of new roots for white spruce RGC tests–seed lot × RGC test × storage temperature.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line.

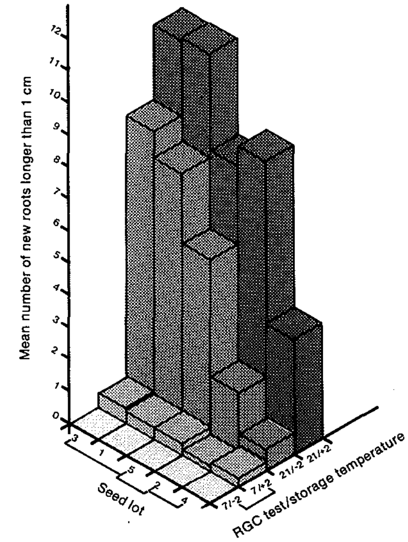

Figure 6. Number of new roots longer than 1 cm for white spruce RGC tests–seed lot × RGC test × storage temperature.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line.

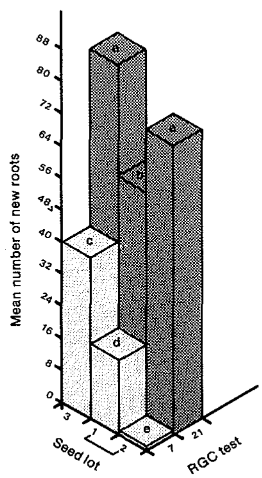

Figure 7. Number of new roots for jack pine RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

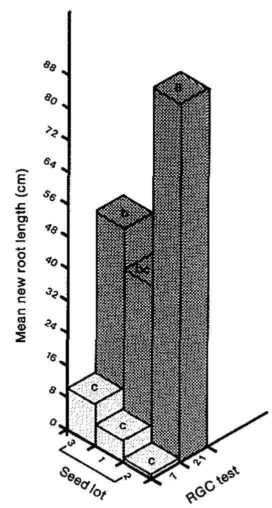

Figure 8. Length of new roots for jack pine RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

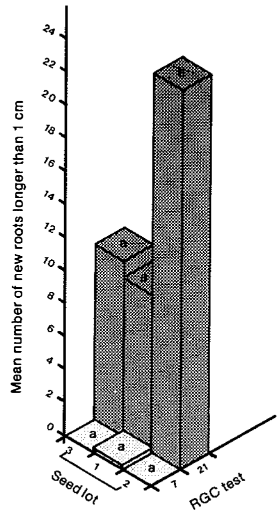

Figure 9. Number of new roots longer than 1 cm for jack pine RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

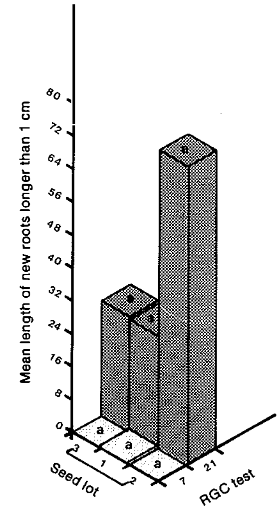

Figure 10. Length of new roots longer than 1 cm for jack pine RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line. Interactions that were not significantly different are assigned the same letter.

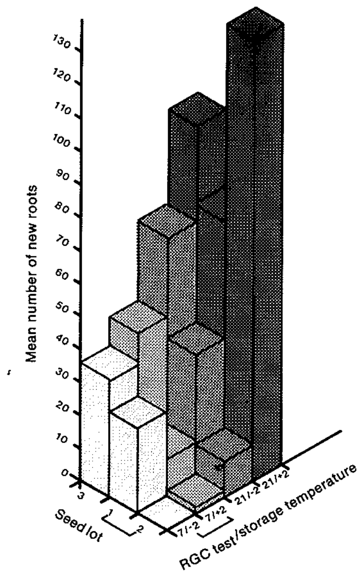

Figure 11. Number of new roots for jack pine RGC tests–seed lot × RGC test × storage temperature.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line.

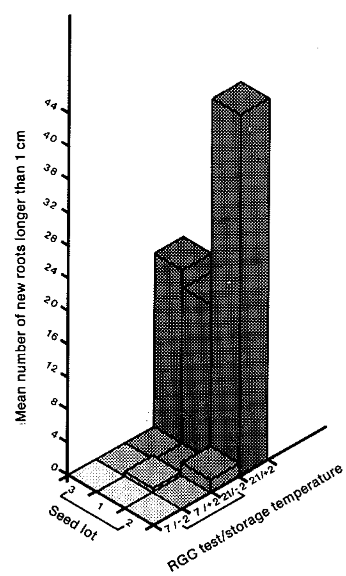

Figure 12. Number of new roots longer than 1 cm for jack pine RGC tests–seed lot × RGC test.

Note: Main effects that were not significantly different (p = 0.05) are joined by a line.

roots. Measurement of the former attribute should be dropped as it is extremely time consuming.

Counting the number of white root tips longer than 1 cm after 21 days may be sufficient for white spruce (Fig. 3) because these results are similar to counting all the new white root tips after 21 days (Fig. 1). A coding system such as Burdett's (Burdett et al. 1983) may therefore be used for white spruce after 21 days.

In order to achieve an accurate RGC test, all of the new white root tips should be counted for jack pine (Fig. 7). Counting the number of new roots larger than 1 cm does not provide an accurate assessment of RGC for this species (Fig. 9).

FUTURE MODIFICATIONS

Although a 21-day test appears to provide an accurate assessment of RGC, 3 weeks is too long to be operationally practical. A 14-day test should be tested in the future. Counting all of the new white root tips on a jack pine seedling can be extremely time consuming. Perhaps counting new white root tips longer than 0.5 cm would provide an accurate assessment of jack pine RGC.

ACKNOWLEDGMENTS

Wendy Mills (greenhouse assistant) and Roman Wasarab (term employee) were responsible for the seedling measurement and data entry.

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NOVAL ENTERPRISES OPERATIONS REPORT 1986

T.D. Ellis
Noval Enterprises
Calgary, Alberta

Noval Enterprises is a division of NOVA, An Alberta Corporation, a public Canadian energy company. The division's major focus is the operation of its two commercial greenhouse facilities using waste heat.

A 2-acre greenhouse is located at Princess, near Brooks, Alberta, at the site of NOVA's largest compressor station. The greenhouse grows mainly tomatoes and obtains its waste heat from exhaust from large engines that drive the compressors.

A 5-acre greenhouse is located at Joffre, near Red Deer, at the site of the Alberta gas ethylene plant. Waste heat is extracted from one of the process fluids and comes to the greenhouse in the form of warm water. Crops at Joffre are tomatoes, tree seedlings, potted plants, and bedding plants. The entry into growing tree seedlings was made possible in part by silvicultural expertise in NOVA's Environmental Quality Management Department, particularly that of Al Fedkenheuer.

Noval Enterprises' economic plan for raising trees makes use of waste heat; seeding is done in January at a time of high heat requirement. Shipping is normally done in August. This rotation allows time for a crop of poinsettias or a short crop of tomatoes or cucumbers in the same space. The combination multiple crops, each of which absorbs some depreciation, and waste heat provide a viable economic approach to seedling production.

Tree crops for 1986 have been as follows:

1. Canadian Forestry Service

   An order of 40 000 Colorado blue spruce was grown for delivery in two lots: one in late April and one in early June. The order was grown to a specified minimum height of 15 cm in the Styroblock containers, Econoblock 160. Seeding was done at the beginning of December, and supplemental light of roughly 8 000 lux was applied. Quality was generally good except that the cull rate on the earlier shipment was a little high due to underdeveloped roots. This problem can be eliminated by a slightly earlier start and a careful blackout treatment to induce bud set and more root and caliper development.

2. Canadian Forest Products (Canfor)

   An order of 155 000 white spruce and 45 000 lodgepole pine was grown for Canfor for its operations at Grande Prairie. Specifications were for a height of 15-25 cm and 3.0 mm caliper for the material, all of which was grown in Styroblock 5s. Seeding was done in mid-January and shipment in mid-August for fall planting. Canfor requires firm bud set for its trees to maximize field survival.

3. British Columbia Ministry of Forests

   The B.C. Ministry of Forests had major losses of container stock in November 1985 because of severely cold temperatures. As a result, out-of-province orders were awarded. Noval Enterprises grew 802 000 interior Douglas-fir and 482 000 Englemann spruce. Seedlings were grown in Econoblock 160 containers. Seeding began on April 15 for delivery late in 1986. Specifications for the fir were 12-25 cm height with a minimum root collar of 2.2 mm and target of 3.0 mm. Specifications for the spruce were 12-25 cm height, with a minimum root collar of 2.4 mm and a target of 3.0 mm.

Two problems that have occurred have been chlorosis of some fir and some frost damage by a −5°C night on September 5. Deliveries will therefore be somewhat below the numbers that were contracted.

Noval Enterprises is generally pleased with the benefit of tree seedlings to its overall operation and with its continuing improvement in expertise. As a result of orders received for 1987, a permanent position for a silviculturist has been created. We anticipate continued growth in expertise and look forward to serving the forest industry.

CHAMPION FOREST PRODUCTS (ALBERTA) LTD. 1986 FOREST NURSERY OPERATIONS

Larry Mattwic
Champion Forest Products (Alberta) Ltd.
Hinton, Alberta

INTRODUCTION

Champion Forest Products (Alberta) Ltd. currently operates a forest tree nursery in Hinton. Two and one-half million seedlings are grown annually in Spencer-Lemaire containers. Lodgepole pine is the major crop, and white spruce plays a minor role. All seedlings grown are outplanted on Champion's Forest Management Area.

Seedlings are grown using a 2-crop or 3-crop rotation system, depending on the number required. Approximately one half of the total production is planted in the current year, and the remainder is overwintered.

Personnel consists of four full-time employees with two additional people during the peak season.

Cone and seed collection and various tree improvement programs are also included in the nursery activities.

NURSERY OPERATIONS

1. Two crops of one million lodgepole pine seedlings each were grown in 1986. The first crop was sown in early March, moved to cold frames on May 23rd, and outplanted by August 29th. The second crop was sown at the end of May, moved to cold frames July 30th, and will be overwintered.

2. During the growing season, various fertilizers and fertilizer regimes were tried to assess their merits and to add flexibility to our rearing schedules.

3. Seedling height and caliper was monitored by sampling every 2 weeks. This will help us to assess the different fertilizer regimes and to develop growth curves for future reference. Root-shoot ratios were also sampled but with less intensity.

4. Heat build-up in the greenhouses continues to be a problem and will be addressed once a justification of funds is available.

5. Various seedling abnormalities have been observed through the year. Exact causes have not been determined at this time. Trials have been conducted to determine if the trees will put on normal growth after outplanting.

6. A new tray washer was manufactured for recycling Spencer-Lemaire trays. The increased efficiency hoped for has not materialized. An assessment of necessary modifications is ongoing.

7. Although we had a harsh winter with virtually no snow cover from mid-January until spring, we suffered minimal overwintering losses (1–2%). Manmade snow will be tried this winter to help moderate the conditions that the seedlings have to endure.

8. A comprehensive maintenance manual and schedule is in the development stage. It will cover all equipment at the nursery and will reduce maintenance and repair costs.

CONE AND SEED COLLECTION

Lodgepole pine seed collection progressed well, and the targeted amount of 741 hL was achieved. The cones have been shipped to Pine Ridge Forest Nursery for extraction. Anticipated yield is 205 kg. White spruce collection is currently in progress. At present we do not expect that more than 150 hL of cones will be collected. The collected seed is used for the nursery and aerial seeding operations.

TREE IMPROVEMENT

The measurement of established provenance trial sites continues. All eight provenance sites have had two measurements and are starting to reveal information relevant to our tree improvement program.

An intensive site maintenance program was severely curtailed due to a moratorium placed on forest herbicide spraying.

GREENHOUSE OPERATIONS AT THE PINELAND PROVINCIAL FOREST NURSERY

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INTRODUCTION

The Pineland Provincial Forest Nursery has 14 Quonset greenhouses that produce six million containerized seedlings annually. Black spruce accounts for 90% of production, with white spruce and jack pine making up the balance. Following is a look at some of the practices and procedures of the 1986 year.

CONTAINERS

A variety of containers are currently used for the production of greenhouse stock. They include Can Am (Multipot) numbers 1-5, Panth trays, and FH408 paperpots.

Growth monitoring is kept for each type of container. In addition, comments from greenhouse staff regarding crop rearing and from field personnel concerning stock quality and handling are noted. With this information, one or two types of containers will be chosen to be used solely for crop production. From here, improvements can be made to improve stock and develop a more sophisticated handling system. Preliminary findings indicate a preference for the Can Am number 1 and 2 trays.

FERTILIZING

Fifteen-gallon Gewa fertilizer injectors are used to apply the nutrient mix to the crop. Regulator settings of one to fifteen provide water-concentrate ratios of 300 L to 20 L. Once a setting is selected the ratio remains constant regardless of water volume or subsequent fluctuations.

Showing begins in late January for the first crop, and it is moved out to the shade house in late May. The second crop is sown in early June and is moved from the greenhouse in late October.

The crop is fertilized roughly every 4 days, and care is taken to prevent overwatering of the mix. Table 1 shows the schedule used for black spruce. Changes are sometimes made depending on growth rate, weather (sunlight), and other variables.

Table 1. Black spruce container stock fertilizer regime at Pineland Provincial Forest Nursery

Week	Fertilizer	Analysis (N-P-K)	Application rate (ppm nitrogen)
1-4	Water only	—	Frequent and light
5	Starter	10-52-10	50
6-7	Starter	10-52-10	100
8	Grower	20-20-20	100
9-12	Grower	20-20-20	200
13-14	Leached and moisture stressed		—
15-16	Finisher	4-25-35	50

SUNLIGHT

Excessive solar radiation can be a limiting growth factor in greenhouses, particularly in June and July. During this period, recently germinated seedlings of the second crop are susceptible to light saturation and associated dessication due to excessive temperatures.

Approximately 60% of incident solar radiation reaches the crop in a double polyethlylene greenhouse. Values of 6 000 foot candles are common in the summer months.

This year, all greenhouses were painted with a commercial greenhouse paint to reduce the light transmitted. This resulted in a reduction of approximately 15%. Values of 5 000 foot candles were recorded in the greenhouses at peak hours. This is still well above the optimum of 3 000 foot candles. Improved control of this aspect of plant growth is a major concern in the upcoming year.

GREENHOUSE TRANSPLANTS

This year, for the first time, the Pineland nursery is producing stock in the greenhouse for eventual nursery transplanting. These black spruce greenhouse transplants are grown in FH408 paperpot trays without any paperpots. Roughly 500 seedlings are grown in each tray using a 50–50 peat-vermiculite mix. This ratio facilitates the separation of the seedlings when sorting and discourages adhesion of the mix to the root system.

Seedlings are grown to a height of 7–10 cm and are transplanted in the nursery as a bare-root transplant. Stock grown in the first rotation (January to May) are transplanted in August, and seedlings from the second crop (June to October) are sorted in the fall and overwintered in cold storage for transplanting in the spring of the following year. Results have been favorable, and this system will be used again next year.

SUMMARY

This has been a year of challenge and innovation at the Pineland nursery. It is hoped that the experiences and observations gained will be used to improve the quality and handling of greenhouse stock in the coming years.

PINE RIDGE FOREST NURSERY PRODUCTION REPORT

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The seedling orders at our nursery are lower this year. Our production high in 1983 of 38 million is down to 21 million seedlings grown in the greenhouses and lifted from the fields. There are two reasons for this decline. First, the Alberta Government—sponsored "Maintain Our Forest" program has been completed, and we are now producing only to fulfill our regular reforestation responsibilities. Secondly, the influence from the new federal-provincial agreement has not reached the nursery. Table 1 provides details of container and bare-root production. Table 2 shows the current inventory of bare-root stock.

Table 2. Current inventory of bare-root stock

Current inventory	Spruce	Pine	Total
3 + 0	8 200 000[a]	0	8 200 000
2 + 0	7 000 000	84 000[a]	7 084 000
1 + 0	7 400 000	270 000	7 670 000
Plug + 1	566 000[a]	50 000[a]	616 000
Transplanted plugs	650 000	0	650 000

[a] To be lifted in the fall of 1986.

Table 1. Bare-root and container production report

	Number of seedlings		
	Spruce	Pine	Total
Bare-root			
Lifted October 1985 Shipped spring 1986	11 110 000 (3 + 0)	750 000 (2 + 0)	11 860 000
Container			
March sown	5 000 000	700 000	5 700 000
May sown	3 700 000	110 000	3 810 000
Total container sown			9 510 000
Spring shipping	3 890 000	349 000	4 239 000
Fall shipping[a]	7 570 000	375 000	7 945 000
Total container shipped			12 184 000

[a] Also shipped 80 800 Douglas-fir.

CONTAINER PROGRAM

There are several new developments in the container program this year. The first is a reskinning of nine of our twenty fiber-glass greenhouses with a double-walled acrylic sheeting. The roof and all but the north wall are being recovered. The bottom 3 feet in the new wall will have a solid insulated panel instead of the acrylic sheeting. Now, in hindsight, it is thought that the north wall should also have had the insulated panel. This improvement will give the houses double the heat retention value and will increase the light penetration from 60% to 90%.

The second item of interest is a study being conducted from our provincial headquarters to evaluate the performance of different types and sizes of container and bare-root seedlings in all areas of the province. The study is called Regeneration Performance Monitoring (RPM). From this study we hope to relate establishment performance to stock type, stock quality, planting site environment, and site preparation used.

The third and final development in the container program is the modification of our seeding line to accommodate four of the Spencer-Lemaire container types; the 40-cm^3 Ferdinands, the 66-cm^3 Fives, the 90-cm^3 Sixes and the 175-cm^3 Hillsons. This is being done in conjunction with the aforementioned RPM study to accommodate any possible change in seedling requests.

BARE-ROOT PROGRAM

There are two changes occurring in the bare-root program. The first development is the outplanting of container stock to produce Plug + 1 stock. To date we have no firm results, but we should have a good indication this fall after it is lifted.

The second development is the purchase and use of a Summit vacuum seeder from New Zealand. With this seeder we are getting an improved seedbed density, and we expect that this will improve seedling quality and outplanting performance. This seeder will be covered in detail later in the agenda.

SEED PROGRAM

This year in the seed program there have been some significant changes in the cone collection process. All forest regions in the province have initiated the identification of stands of superior trees for special cone collection. From these collections we expect to get improved seed for growing nursery stock. It is expected that the seedlings produced would exhibit the superior phenotypic characteristics of the parent trees. These collections are being done until seed from our Genetics and Tree Improvement Section seed orchard comes on stream for growing nursery stock.

In some of these collections a trial method of collection was done. In the trial, an operator maneuvering a clipper from the open door of a helicopter removed the tops from the superior parent tree. The cones were then removed and processed. This method ensures the exact identification of a seed source.

In 1986, a total of 5 073.1 kg of seed was collected. The total used in aerial seeding was 4 954.3 kg; in bare-root seeding, 48.0 kg; and in container seeding, 70.8 kg. The seed production report is given in Table 3.

Table 3. Seed production report

	Pine	Spruce	Other	Total
Current inventory (kg)	10 852	30 184	1 462	42 498
Expected cone crop 1986 (hL)	4 300	3 000	0	7 300
Expected seed yield 1986 (kg)	860	3 000	0	3 860

Our seed program is getting much more involved with the responsibilities of the entire cone collection process. We are stressing crop forecasting so that collections will be centered in areas having low seed inventories. We are also stressing more quality control with the collection being done to ensure only the best quality cones are being paid for rather than a lot of old, poor cones, and dirt, needles, and debris. It is expected that this will help give improved seed for growing better quality nursery seedlings.

NUTRIENT REGIMES AND COLD HARDINESS IN CONIFER SEEDLINGS

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ABSTRACT

Lodgepole pine, jack pine, white spruce, and black spruce seedlings were grown in the greenhouse for 16 weeks, hardened-off for a further 10 weeks, tested at −5°C and −10°C, and were then observed in the greenhouse for 2 weeks. During hardening, the seedlings were treated with five nutrient solutions containing N, P, and K at different concentrations to determine which nutrient regime was associated with cold hardiness. The spruces were similar; high survival in both was associated with high K. The pines were dissimilar; lodgepole pine reacted to low N, but survival of jack pine was highest with high P. Cold hardiness appears to be related to the degree of bud set.

INTRODUCTION

Although numerous authors have reported on nutrient requirements for conifer seedlings during their early growth phase (Carlson 1983; Etter 1971; Matthews 1971; Swan 1960), few have reported on experiments to determine nutrient requirements during hardening (Lowenstein 1970; Tinus 1974). It was known that low nitrogen (N) combined with high concentrations of phosphorus (P) and/or potassium (K) produced more root growth relative to shoot growth. The lower shoot-root ratio that resulted was found to be associated with higher survival on droughty sites (Lowenstein 1970). Although many growers have used a low-N plus high-P regime during cold hardening (Carlson 1983), recommendations were not always based on original data for boreal conifer species. The objective of the present study was to determine under local conditions, the nutrient regime (concentration of N, P, and K) that was associated with greatest survival of lodgepole pine, jack pine, white spruce, and black spruce at low temperatures.

MATERIALS AND METHODS

The steps followed are shown in the flow chart (Fig. 1). The seeds were sown in peat-filled Spencer-Lemaire 5s (after liming the peat to pH 5.2) in mid-January, and the seedlings grew for 16 weeks. The greenhouse environment during this period was as follows: temperature, 24°C during the day and 16°C at night, relative humidity 62–65%; light intensity (high pressure sodium lamps), PAR = 260 $\mu mol.m^{-2}.s^{-1}$; and photoperiod, 18 hours. From weeks 4 to 16 inclusive a general nutrient solution (125–60–159) was applied to all seedlings, and they were watered as needed.

In conditioning for bud set, supplementary light was turned off and photoperiod was reduced to 8 hours using a blackout cloth. The trays were leached with water to remove nutrient solution from the peat and allowed to dry out until they were near constant weight (10 days). The seedlings were separated into batches, and each batch received one of five hardening solutions (Table 1) applied to saturation, weekly. Concentrations of N, P, and K were selected to bracket those that were being used locally. At the end of this period a random check of degree of bud set was made.

In conditioning for low temperature, the trays were moved to a growth chamber in which photoperiod was 8 hours (fluorescent light) PAR = 58 $\mu mol.m^{-2}.s^{-1}$, relative humidity was 20%, and temperature was 10°C during the day and 2°C at night. The weekly application of hardening solution was maintained.

For the low temperature test each batch of seedlings was divided and while one subgroup acted as a control (remaining in a 10°C-day and 2°C-night environment), the other was put into cold rooms with temperatures of −5°C and −10°C for 24 hours (Table 2).

RESULTS AND DISCUSSION

Mortality of seedlings that were tested at −5°C was low compared with the control lot, and only the results of seedlings from the −10°C test will be reported here. Survival of lodgepole pine is shown in Table 3. A low

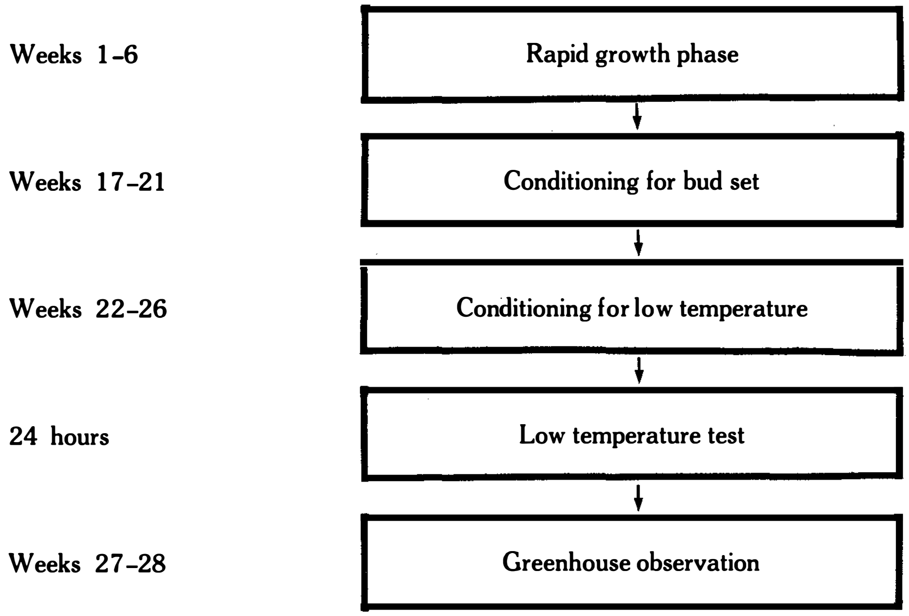

Figure 1. Flow chart of experimental procedure.

Table 1. Nutrient regimes tested

Solution	Nutrient regime (ppm) N	P	K
I	2.2	101	150
II	22	101	150
III[a]	44	101	150
IV	44	202	150
V	44	101	300

[a] Present recommendation.

Table 2. Temperature regimes tested

Regime	Temperatures (°C) Day	Night
I	+10	+2
II	−5	−5
III	−10	−10

Table 3. Results for lodgepole pine at −10°C

Nutrient regime (ppm) N	P	K	Survival (%)
2.2	101	150	81
22	101	150	67
44	101	150	77
44	202	150	39
44	101	300	49

Table 4. Results for jack pine at −10°C

Nutrient regime (ppm) N	P	K	Survival (%)
2.2	101	150	24
22	101	150	20
44	101	150	24
44	202	150	56
44	101	300	32

Table 5. Results for white spruce at −10°C

Nutrient regime (ppm) N	P	K	Survival (%)
2.2	101	150	81
22	101	150	95
44	101	150	85
44	202	150	100
44	101	300	98

Table 6. Results for black spruce at −10°C

Nutrient regime (ppm) N	P	K	Survival (%)
2.2	101	150	40
22	101	150	21
44	101	150	8
44	202	150	24
44	101	300	76

concentration of N was associated with highest survival (81%). As N concentration increased, survival decreased, slightly if P and K remained constant and sharply if P or K increased in concentration. The data indicate that the nutrient regime that is currently recommended for hardening lodgepole pine seedlings in the prairie region is near optimum. The results for jack pine (Table 4) indicate generally low survival, but the high P concentration was associated with best survival (56%).

The survival of white spruce (Table 5) was generally high over all nutrient regimes and increased sharply as N and either P or K increased. The present recommendation for hardening solution is near optimum; however, survival with Solution II is not significantly different from that with Solution IV, and the former would be a more economical recommendation.

Black spruce showed poor survival generally, but it was best for Solution V (Table 6). Low concentration of N was associated with only moderate survival, and as N increased, survival declined. For black spruce, high survival was related to high levels of K.

The present recommendation of hardening solution for the region was made on the basis of a review of published literature; no local data had been obtained at the time of publication of the guidelines for the prairies (Carlson 1983). It is obvious that for the provenances of the species tested and for the local growing and conditioning regimes, the survival of only lodgepole pine and white spruce was near optimum with the solution presently prescribed. Jack pine responded to higher P than prescribed, and black spruce responded to higher K.

Although the present guidelines will be revised to update the information on hardening and overwintering prescriptions, two points should be kept in mind. First, these results are for a temperature of −10°C whereas overwintered stock is stored at −2°C. At the latter temperature the present stock would be expected to have high survival. Secondly, a low temperature test (−10°C) by placement in a cold room is not an ideal method of testing because of rapid cooling and, consequently, there is a greater chance of cell damage due to intracellular ice formation. Confirmatory tests will be done using prescribed rates of cooling, but a programmable freezer is required.

Survival rates for lodgepole pine and white spruce were generally higher than those of jack pine and black spruce. The low degree of bud set (25–50%) within the latter compared to 80–90% in the former pair was a likely explanation of this trend. It is possible that at a similar degree of bud set and development, cold hardiness would be similar in the four species.

CONCLUSION

Although the survival of lodgepole pine was near optimum with the solution presently prescribed, it responded to lower N concentration. Jack pine responded to higher P, but black spruce responded to higher K than that in the present prescription. Higher survival of white spruce was associated with higher P or K in the hardening solution. Degree of bud set was related to survival at −10°C.

ACKNOWLEDGMENTS

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PINE RIDGE FOREST NURSERY PROCEDURE FOR OVERWINTERING CONTAINERIZED SEEDLINGS

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INTRODUCTION

Protecting containerized seedlings from harsh winter conditions is just as important as the growing regime for producing a sturdy frost-hardy seedling. The seedlings are grown in Spencer-Lemaire Rootrainers. The overwintering regime currently being used was developed at Pine Ridge during the first 5–6 years of nursery operation (1978–1984). We use a raised pallet system for all seedling handling, from seeding to shipping. It was therefore desirable to develop a method that would incorporate this pallet system into a successful technique that would minimize the amount of tray handling.

PROCEDURE

Our crop consists of two main species: white spruce (*Picea glauca*) and lodgepole pine (*Pinus contorta*). The proportion varies yearly; white spruce represents 85–95% of the crop, and lodgepole pine makes up the remainder. White spruce seedlings are easily overwintered in the pallets, but the lodgepole pine must be removed from the pallets.

Preparations begin after our fall shipping period has been completed, usually by the end of September. At this time all remaining seed lots are moved into large groups to minimize the perimeter length. The perimeter and all holes left due to the support posts of the shade frames are lined with used trays. These trays are stacked to the lip of the pallet or what would be the ground level for the seedlings. The purpose of these trays is to extend the layer of snow cover around the seedlings. The trays are 20 cm wide and therefore extend the cover of the insulating blanket of snow by that distance. We had found that the snow on the edges of the raised pallets was being eroded away by the wind and sun during periods of low snowfall throughout the winter season. This would expose seedlings along the edge, resulting in them being freeze-dried. With the trays in place the weather works on this edge, leaving the seedlings protected in the snow.

The main change in the preparation of pine for winter is that the trays must be removed from the pallets and placed on the asphalt. This group of pine seedling trays is then surrounded by two rows of trays containing spruce seedlings. This entire arrangement is in turn surrounded by one row of empty used trays stacked two layers high. Pine is extremely sensitive to the air spaces under the pallets and in the empty used trays that were originally used alone to surround the pine seedling trays. With the elimination of these spaces by removing them from the pallet and placing filled trays around the perimeter, there is no significant overwintering loss.

The final step for the overwintering preparation is to surround the block of seedlings with a snow fence. This will help catch and hold snow and also aid in the control of rabbit damage.

By using this reasonably simple technique we have reduced our overwintering loss to virtually nil.

BARE-ROOT PRECISION SEED SOWING

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Precision sowing of tree seed in nursery beds is a major innovation in nursery practice. The advantages of growing plants of various types at precise spacings have been known to growers the world over for many years, so why wouldn't the same hold true for tree seedlings in a nursery bed?

This is a question that has been asked many times at Pine Ridge Forest Nursery. It has long been felt by the staff of Pine Ridge that two major obstacles would have to be overcome to produce a more uniform vigorous crop of bare-root seedlings. The availability of better quality seed is one problem and the other is the spacing of seedlings at even intervals within the nursery beds.

A comprehensive improvement program is currently being developed and implemented that should improve the overall quality of Alberta's tree seed. Part of this program will see the collection of seed from selected superior stands for nursery use. This program is in its infancy, but some headway is being made. A few collections from selected stands will be made this year, and it is hoped that by this time next year the program will be well on the way to implementation and results will be starting to show.

CHOOSING A PRECISION SOWER

The problem of regular spacing of seedlings in the nursery beds is also being addressed. Final crop spacing can only be reasonably achieved by precision sowing of the seed in the first place. A number of machines capable of achieving precise seed placement have now been developed. Our first task was to determine which of the readily available models would work best for our tree species and in our soil conditions.

We focused on three different types of precision sowers: the Weyerhaeuser double row vacuum system in use at Weyerhaeuser's Armstrong Nursery; the Germany-manufactured Miniair; and the New Zealand-manufactured Vacuum Drum Sower in use at various British Columbia Forest Service nurseries. If none of these were suitable it was hoped that one could be developed in-house.

Initially the users were contacted, and a preliminary study of the three units was carried out. This was accomplished through the cooperation of the B.C. Forest Service and Weyerhaeuser, and it was decided that it would be best if a demonstration seeding could be arranged at Pine Ridge. Preliminary investigations indicated that the Weyerhaeuser unit and the Miniair were quite similar in operation; it was therefore decided that only one of these two would be brought to the nursery with the Summit Precision Vacuum Drum Sower. The Weyerhaeuser unit was tried out with the idea of comparing the double-row concept versus the more traditional single-row.

In late spring 1985, these two units were brought to Pine Ridge, and a trial sowing of white spruce was carried out with each unit. After observing both units operating, it was concluded that the Summit sower was most suitable, although some modifications might be required for seeding the small seed of white spruce. It was also felt that the Summit would likely give less problems in the long run than either of the other two. Weyerhaeuser's double-row concept looked interesting, but it would have meant a complete overhaul of all of our current seeding equipment.

A decision was made to purchase the Precision Vacuum Drum Sower from Summit Equipment in New Zealand. The unit could also be ordered with fertilizer and lateral pruner attachments. The unit was ordered in early 1986 complete with a lateral pruner attachment and a mid-May delivery date requested.

THE SUMMIT PRECISION VACUUM DRUM SOWER

The Summit Precision Vacuum Drum Sower is three-point linkage-mounted and can be easily operated by a 30–40 horsepower tractor. To give best results, however, a tractor with a hydrostatic drive is recommended because infinite speed control can be achieved.

Grooves for the seed are made by a series of small cultivator-style shoes mounted behind two small packing drums. Seeding depth can be adjusted depending on the size and type of seed being sown.

Seed sowing and metering is accomplished by a drum that rotates at a constant height above the seedbed. Around the drum are rows of holes. A partial vacuum is maintained inside the drum by a P.T.O.-driven blower. Seed fed from a series of hoppers is taken up and held on these holes. Adjustable raker teeth help to remove extra seeds from the holes so that only single seeds are sown. Seeds closest to the ground are discharged into the grooves by a series of mechanically operated pins that shut off the vacuum and physically push the seeds off the drum. Flaps gently grade soil over the seed, and a spring-loaded roller compacts the soil.

Seed spacing is controlled by changing drive sprockets. Seed spacing definitely affects the forward speed of the unit. The closer the desired spacing, the slower the unit has to travel to properly do the job.

For use with small-seeded species commonly grown on the Canadian prairies such as white spruce and lodgepole or jack pine, a drum with 1-mm (.044-inch) pinholes is necessary. The unit can be ordered with various row spacings to fit different bed dimensions. The most common ones are the 8-row on a 137-cm (54-inch) bed or 7-row on a 122-cm (48-inch) bed.

The entire sowing system is easily removed from the tool bar, and a rear steerage lateral pruner attachment can be installed in its place.

PRECISION SOWING TRIAL

Due to a number of delays, the unit arrived at our nursery approximately 2 weeks after the normal spring seeding date. Following a hasty calibration and tryout period, production seeding of our 1986 order of 6.25 million bare-root seedlings started.

Prior to the arrival of the Summit unit it was decided to drop our target density per bed-metre for 3 + 0 white spruce at harvest to 260 seedlings from 300 and to leave lodgepole pine at 200 seedlings per bed metre. The trick is to seed enough viable seeds per bed-metre to achieve these densities at harvest. Although no set rule is used at Pine Ridge, an average of 420 viable seeds per bed-metre for spruce and 360 viable seeds of pine seems to be needed to achieve these results. This is based on germination rates and past performances of the various seed lots.

Needless to say, only seed of high purity will work well with this unit, and higher germination seed allows for wider spacing and therefore easier seed placement.

The actual seeding this spring was slow because the crew was unfamiliar with the unit. A total of 27 678 bed-metres was sown in approximately 45 hours of field time for an average of 615 bed metres per hour.

The Summit sower performed well, although perfect spacing was not always achieved. It would appear at this point that it is a great improvement over the Oyjord seeder utilized at Pine Ridge since 1978. The slightly larger seed of lodgepole pine seems to be easier to space properly. Some gaps in the seeding were evident in both species, however; densities are therefore slightly lower than the targets.

The Summit Precision Vacuum Drum Sower was designed in New Zealand primarily for seeding large-seeded species. It works on smaller species such as lodgepole pine and white spruce, but will probably work even better with some modifications to accommodate these smaller seeds. The Equipment Development Section of the Alberta Forest Service is currently attempting to carry out some modifications recommended by us after our first seeding. These include replacing the rakers with an airbrush and checking the drop pins to make sure they are all of equal length.

EXPECTED BENEFITS

Research done by the New Zealand Forest Service Research Institute has shown several major benefits of adequate and even seedling spacing in the nursery bed:

1. The cull rate is drastically lowered; there are no spindly seedlings.
2. The effectiveness of undercutting and wrenching treatments increases, resulting in improved fibrous root development.
3. There is reduced root damage during lifting.
4. There is a significant increase in survival under harsh field conditions.

The proof of these benefits in our case and for our species will take time. The first step has been taken, and more results will become known as our crops reach harvest age. Preliminary results look good, and it is felt that the purchase and use of this sower is a significant step towards the ultimate goal of producing a more uniform, healthier bare-root seedling that will survive and grow on a variety of forest sites.

MONITORING VIABILITY OF OVERWINTERING CONTAINER STOCK

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INTRODUCTION

Dormancy and cold hardiness are two physiological processes that are very closely linked to the successful overwintering of containerized nursery stock. In order for a nursery to successfully grow, harden-off, and overwinter most conifer seedlings, the personnel involved should have an appreciation for the physiology behind the events occurring within the seedling. Both the genetics of the parent trees and the environment in which the seed developed in the maternal tree will have an effect on overwintering capability of the young seedlings (Kramer and Kozlowski 1979; Levitt 1980; Wareing and Phillips 1981).

Nursery practices are tailored to assist the seedlings in adapting to the harsh environment that they will face during overwintering outdoors. Several authors have recently outlined current practices used in greenhouse production of container stock and hardening strategies used (Tinus 1982; Carlson 1983). Initially, supplemental lighting will be reduced to a short day-length (6–8 hours), shut off completely, or the seedlings might be moved outdoors to shade structures or cold frames. Seedlings are then usually leached of rapid growth fertilizer with excessive amounts of water. Hardening fertilizer regimes can be prescribed for each species. Withholding of water may then be used to assist in the initiation of bud set and the promotion of seedling dormancy (Tinus 1982). In rare instances where the facilities exist, greenhouse personnel can reduce the supplemental lighting to well below the critical day-length and can reduce the daytime temperature regime. This is only possible where fairly sophisticated facilities exist and is not usually the case for a production nursery.

Production nurseries have to rely on the shortening photoperiod and decreasing temperatures that exist in their shade structures in the latter part of the summer to initiate the onset of dormancy in their seedlings. The gradual reduction in day and night temperature regimes assists in the gradual development of cold hardiness. The induction of dormancy and the onset of cold hardiness must be achieved in a relatively short time frame, particularly in cold, temperate regions, for the nursery personnel to successfully overwinter their containerized stock (Tinus 1982; Carlson 1983).

It is therefore imperative for nurseries to have at their disposal, rapid methods for determining the dormancy status and the degree of cold hardiness that exists in their stock, particularly during periods when the onset of severe frost is a real possibility during the late summer and early fall. This has recently been emphasized by Navratil et al. (1986) in their review of planting stock quality monitoring as it relates to the prairie provinces. It is equally important to know the dormancy status and degree of cold hardiness that exist in the seedlings during the late winter and early spring. If seedlings emerge from dormancy and lose their cold hardiness before all possibility of severe spring frost is passed, in the event of a severe frost there is the chance that a seedling crop that was successfully overwintered could be severely damaged or lost altogether.

Our continuing investigations on overwintering physiology of conifer seedlings have had three purposes in light of the preceding discussion:

1. To evaluate methods proposed for the testing (determination) of dormancy and cold hardiness that are currently in use or proposed in the literature;

2. To investigate the relationships between the terminal bud, cambium, and root tips (shoot-root interactions) in the phenology of dormancy and cold hardiness onset, maintenance during the winter, and loss during the spring;

3. To provide a broader understanding of the basic physiological and biochemical events that occur and regulate successful overwintering.

This presentation will provide some insight into the study results obtained from the work on evaluating methods for monitoring dormancy, cold hardiness, and the overwintering success of four of the five conifer species that have been examined to date.

MATERIALS AND METHODS

Growing Schedules

Seedlings of white spruce, black spruce, lodgepole pine, jack pine, and red pine were reared in the Northern Forestry Centre greenhouse according to the methods of Carlson (1983), using Schedule 2 for Frost Hardiness Zone 3. Thus, seedlings were reared in the greenhouse for 14 weeks under a photoperiod and temperature regime of 18-h days and 6-h nights, 25°C days and 16°C nights from 0400 h to 2200 h during the day period and from 2200 h to 0400 h during the night period.

Supplemental lighting was provided continuously during the day period by high pressure sodium vapor lamps (photosynthetic photon flux density [PPFD] of photosynthetically active radiation [PAR 400–700 nm] = 260 μmol.m^{-2}.s^{-1}). The fertilizer regime used during the 14-week period of growth was the pine-spruce mixture recommended by Carlson (1983), with N–P–K = 125–60–159 mg/L plus 5.5 mg/L iron chelate and micronutrients. The pH was adjusted to 5.6 using 1N sulphuric acid. The fertilizer was applied weekly at a rate of 2.0 litres per container (tray) of 70 seedlings. Seedlings were grown in Spencer-Lemaire 5s.

Seedlings were normally moved outdoors to shade frames after 14 weeks of growth in the greenhouse. This normally occurred between the 2nd and 3rd week of August in each of our experimental seasons. Seedlings were flushed for a day with water to leach out as much of the rapid growth fertilizer as possible. One week later, weekly applications of hardening fertilizer (Carlson 1983) were begun (N–P–K = 45–99–165 mg/L plus 5.5 mg/L iron chelate and micronutrients, pH adjusted to 5.6) at a rate of 2.0 litres per container (tray) of 70 seedlings.

Test Sampling Schedules

Initial studies during 1983–84 were carried out on black spruce and lodgepole pine seedlings. Studies during 1984–85 were carried out on white spruce and red pine, with supplemental (replicate) work done on black spruce and lodgepole pine. Studies during 1985–86 were initiated on jack pine, and supplemental (replicate) work was carried out on the four other species. In 1986–87, supplemental (replicate) work is being completed on all species. A final year of sampling on jack pine will be completed during 1987–88. In total, our studies for all aspects of this research will have been replicated over at least three experimental seasons for each species examined.

The results to be presented will focus primarily on the 1984–85 results because these are the most complete to date, and involve four of the five species that have been studied to date. Some photographic records of seedling progress were made during 1985–86. Complete photographic records of the 1986–87 season are in progress and will be reported on at a later date.

Dormancy Testing

Weekly or biweekly sampling began one week prior to, or coincident with, moving the tree seedlings outdoors. Cambial (stem) dormancy was monitored using the oscilloscope-square wave deformation (SWD) method of Ferguson et al. (1975), and stem activity was scored as shown in Table 1. Root growth capacity (RGC) testing was carried out similar to the method of Burdett (1979). The rating scheme for RGC testing is shown in Table 2. Equivalent numbers of seedlings were potted and kept under the same conditions as those for RGC testing in order to monitor time to bud break (TTBB). These were regularly examined and scored until all seedlings had flushed. The number of days from potting to bud break was then calculated.

Cold Hardiness Testing

Freezing Tolerance and Survival Assessment

Cold hardiness (freezing tolerance) tests were conducted in growth chambers or walk-in cold rooms and freezers. Test seedlings were placed at −5°C, −10°C, and −15°C, and controls were kept at +20°C for 24 h without any preconditioning. After 24 h they were then moved to the headerhouse, warmed to room temperature, and either used for further tests or were moved to the

Table 1. Relative oscilloscope-SWD ratings for stem (cambial) activity and related seedling growth characteristics

Rating	Seedling growth characteristics[a]
5	Very actively growing
4	Moderately active
3	Slightly active
2	Dormant
1	Stem damage but not dead
0	Dead

[a] Oscilloscope-SWD readings were made after seedlings reached room temperature. This normally occurred within 2–3 hours after being brought indoors or out of the freezing tolerance test conditions.

Table 2. Relative root growth capacity ratings and scoring characteristics

Rating	Root growth characteristics[a]
5	More than 30 new white roots over 1.0 cm in length
4	11–30 new white roots over 1.0 cm in length
3	4–10 new white roots over 1.0 cm in length
2	1–3 new white roots over 1.0 cm in length
1	Some new white roots, none over 1.0 cm in length
0	No new roots or white root tips evident

[a] Seedlings were potted (4 per pot; 5 pots per species) and placed under optimal greenhouse conditions that approximated the conditions of Burdett (1979) for 8 days, prior to assessing root growth capacity. They were then carefully washed of potting medium and kept moist with wet paper towels until scoring.

greenhouse. Oscilloscope-SWD testing was carried out on half of the remaining seedlings (Ferguson et al. 1975), and then these seedlings were also moved to the greenhouse. Damage to shoots and roots of both sets of seedlings was then assessed after 4 weeks under optimal greenhouse conditions according to the indexes outlined in Table 3.

Relative Conductivity and Index of Injury

Conductivity testing was carried out on shoots and roots of the remaining seedlings using a method that was adapted from that of Colombo et al. (1982, 1984). Ten seedlings from each treatment were cut into roots and shoots. The roots were washed of growing medium, and the shoots and roots were placed in individual, separate, capped 25 × 150-mm test tubes filled with distilled water. The tubes sat for 24 h at room temperature (+20°C). Tubes were then well mixed by vigorously shaking, and the conductivity was read with a temperature-compensated conductivity meter and electrode. Tubes were then boiled for a minimum of 20 minutes in a controlled boiling water bath, allowed to cool, and sit overnight at room temperature for 18 hours. Final conductivity measurements were then measured.

The relative conductivities of the test and control shoots and roots were calculated from the before and after boiling conductivity measurements. These values were used to calculate a cold hardiness (freezing tolerance) index of injury for the roots and the shoots as shown in the following scheme similar to the method of Colombo et al. (1984):

1. The relative conductivity of the control seedlings, RC (control), is that proportion of the shoot (or roots) total electrolytic content that is released without freezing. This is calculated as follows:

$$\text{RC control} = \frac{\text{EC control}}{\text{EC boiled control}} \times 100$$

where RC (control) is the relative conductivity of controls, EC (control) is the electrical conductivity of unfrozen live tissue, and EC (boiled control) is the electrical conductivity of unfrozen boiled tissue.

2. The relative conductivity of the frozen seedlings, RC (frozen), is that proportion of the shoot (or roots) total electrolytic content that is released with freezing at the specified temperature. Calculations are shown as follows:

$$\text{RC frozen} = \frac{\text{EC frozen}}{\text{EC boiled frozen}} \times 100$$

where RC (frozen) is the relative conductivity of frozen tissues, EC (frozen) is the electrical conductivity of frozen tissue, and EC (boiled frozen) is the electrical conductivity of frozen boiled tissue.

3. Cold hardiness (freezing tolerance) is expressed using an index of injury (It), which is calculated as follows:

$$\text{It (\%)} = \frac{\text{RC frozen} - \text{RC control}}{\dfrac{1 - \text{RC control}}{100}}$$

The formula is based on one published by Flint et al. (1967). The index of injury values are independent of

Table 3. Scale for assessing visible freezing damage of seedling shoots and roots and calculating seedling survival potential

Rating	Symptoms for spruce shoot damage assessment
0	No visible damage to the shoot terminal, stem, or needles
1	Terminal bud alive and first cm of adjacent stem; fewer than 20% of needles brown or red in color
2	Terminal bud may or may not be killed; 20–50% of needles brown or red in color
3	Terminal bud killed; 50–90% of needles brown or red in color
4	Terminal bud killed; most of the main stem and some lateral shoots killed; just a few lateral branches or needles alive, primarily near the base of the stem
5	Shoot completely dead, no living tissue evident
	Symptoms for pine shoot damage assessment
0	No visible damage to the shoot terminal, stem, or needles
1	Terminal bud alive and first cm of adjacent stem; fewer than 20% of needles brown or red in color
2	Terminal alive; 20–50% of needles brown or red in color
3	Terminal alive, but may be damaged; 50–90% of needles brown or red in color
4	Terminal bud killed; most of the main stem and some lateral shoots killed; just a few needles emerging from lateral needle primordia on the stem, primarily near the base of the stem or a lateral branch
5	Shoot completely dead, no living tissue evident
	Symptoms for spruce and pine root damage assessment[a]
0	More than 10 new white roots over 1.0 cm in length visible on the seedling plug exterior
1	4–10 new white roots over 1.0 cm in length visible on the seedling plug exterior
2	1–3 new white roots over 1.0 cm in length visible on the seedling plug exterior
3	Some new white roots, but none over 1.0 cm in length visible on the seedling plug exterior
4	No new white roots or white root tips visible on the seedling plug exterior; roots are turgid, show good color (brown to dark brown), and appear intact
5	Dead roots evident; dark brown to black in color; no turgor in roots; visible molding and bacterial growth on root surfaces

[a] Assessment was carried out 4 weeks after seedlings were returned to optimal greenhouse growing conditions following freezing tolerance testing. Seedlings were examined visually and rated according to the above scales without washing the container growth medium from the plugs.

sample volume and of seasonal variations in the quantity of free electrolytes in the shoot that are released without freezing (Flint et al. 1967; Colombo et al. 1984).

Environmental Parameter Monitoring

Weather data has been collected over the respective experimental overwintering (fall, winter, and spring) periods using Environment Canada, Atmospheric Environment Services data for the Edmonton Municipal Airport and Ellerslie Weather Stations. Root and shoot temperature records were collected using a Campbell Scientific CR-7 data logger and copper-constantan thermocouples.

RESULTS

The following data show results from 1984–85. Figure 1 shows the major weather parameters from late August 1984 through to the end of June 1985. The black vertical lines represent the range of daily minimum and maximum temperatures recorded for the experimental season. This data is overlaid on the mean daily minimum and mean daily maximum temperatures recorded for the 30-year period from 1941–1970 at the Edmonton Municipal Airport. The daily extreme minimum and daily extreme maximum temperatures recorded from 1885 to 1985 are also shown. The black component of

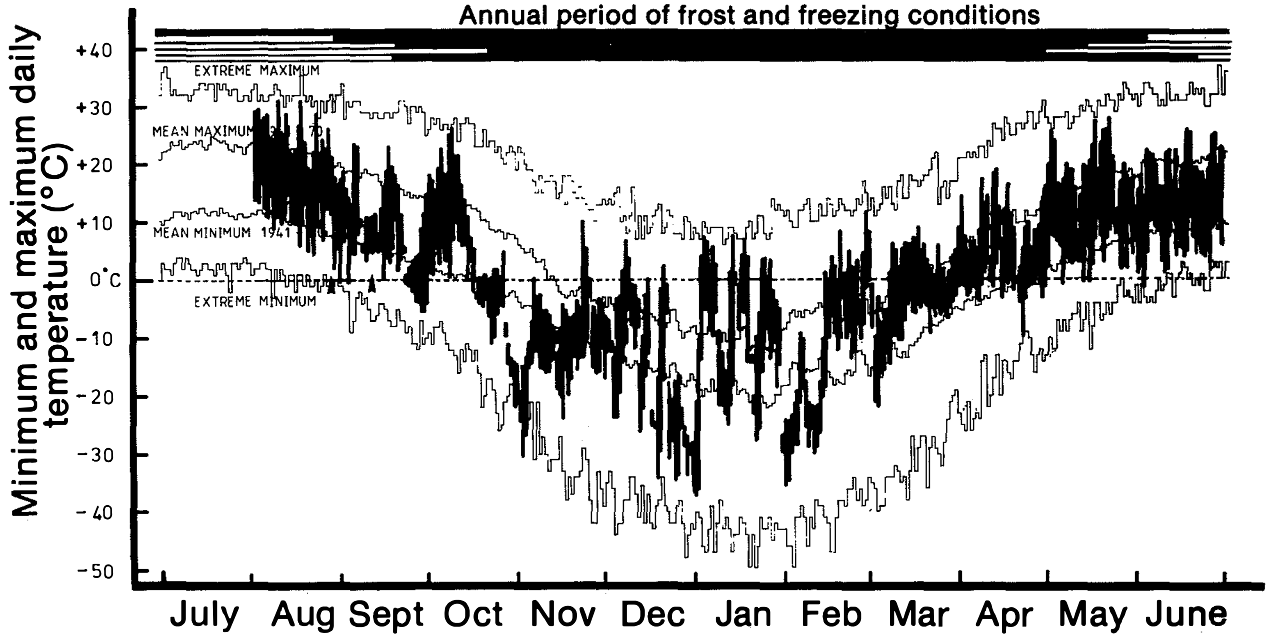

Figure 1. Weather data over the 1984–1985 overwintering period.

The data shown represent the daily minimum and maximum temperature ranges that the seedlings were exposed to (black vertical bars); the mean daily minimum and maximum temperatures from 1941 to 1970; and the extreme daily minimum and maximum recorded temperatures from 1885 to 1985. Data shown in the top portion of the figure, indicated by the horizontal black bars, represent in descending order: a) the 1984–85 period from first to last frost; b) the 1941–70 mean period from first to last frost; c) the minimum period from first to last frost, recorded in 1975, that was available from 100-year records; and d) the maximum period from first to last frost, recorded in 1942, that was available from 100-year records.

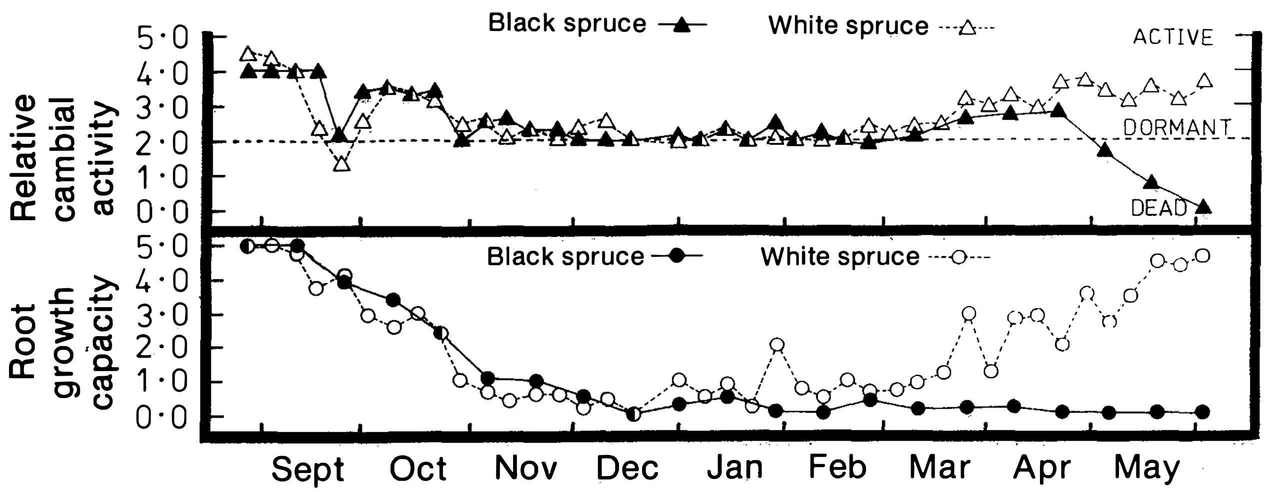

Figure 2. Dormancy data for shoots and roots of black and white spruce seedlings over the 1984–1985 overwintering period.

Relative cambial activity of black and white spruce seedling shoots was determined using the scale in Table 1 after seedlings reached room temperature, 1–2 hours after being brought indoors from the shade frame on each of the respective sampling dates. Root growth capacity of black and white spruce seedlings was determined 8 days after potting using the scale from Table 2. Each data point represents the mean value for ten and twenty seedlings from cambial activity and root growth capacity tests, respectively.

the horizontal bars across the top of Figure 1 represent (in descending order from top to bottom):

a) the 1984–85 period from first to last frost;
b) the 1941–1970 mean period from first to last frost;
c) the minimum period from first to last frost recorded in 1975;
d) the maximum period from first to last frost recorded in 1942.

The white component represents the frost-free period for each respective year or mean period for 1941–1970.

In the 1984–85 experiments, supplemental lighting was terminated on August 20. Seedlings were heavily leached, and hardening fertilizer was first applied on August 24. Seedlings were moved outdoors to shade frames on August 27 as indicated in Figure 1 by the black arrow. The first frost (−0.5°C) occurred on August 30. It was followed by a second light frost of −0.5°C on September 2. Some tip damage was evident on some black spruce seedlings and on several white spruce seedlings several days after the second frost.

A cold period of 8 days followed from September 22–29, and minimum daily temperatures ranged from −0.5 to −5.5°C. This cold period was preceded by heavy rains followed by a total of 10.6 cm of snow. Such extremes in weather conditions in the first 4 weeks of outdoor hardening had a detrimental effect on seedling condition and overwintering survival. The weather conditions did moderate considerably after September 30 and were normal or above normal through to the middle of October. Conditions then deteriorated rapidly to below normal day and night temperatures that were maintained well into November. This was moderated slightly by over 30 cm of new snow that covered the seedlings October 16–18. Some record low temperatures were recorded during late October and early November as shown in Figure 1.

The results of oscilloscope-SWD and root growth capacity testing are shown in Figures 2 and 3 for white and black spruce and for lodgepole and red pine. Both cambial activity and root growth capacity declined in the early fall, coincident with the late September period of below average weather conditions. Some fluctuations in both activities were evident for all four species (Figs. 2 and 3). By November, there was little cambial or root activity. This remained minimal until January 1985, when white spruce and red pine began showing low levels of fluctuating cambial and root activity. Very little activity was seen in either black spruce or lodgepole pine.

During March 1985, both white spruce and red pine began showing very regular cambial and root activity (Figs. 2 and 3). Some cambial activity was evident in black spruce and lodgepole pine in late March and early April, but it declined rapidly in late April and early May. This decline coincided with a low temperature below −10°C that was recorded in late April 1985 (Fig. 1). This sharp drop in temperature over one night was the likely cause for the sudden increase in seedling mortality for these two species in this time. This was corroborated by the lack of root activity from the RGC tests. It therefore appeared from these two tests that white spruce and red pine had survived the adverse winter conditions, while black spruce and lodgepole pine had not.

The results of the cold hardiness (freezing tolerance) tests are shown in Figures 4 through 9 for all four species. Early damage-survival results for each test temperature (Figs. 4 and 5) indicated that cold hardiness was developing gradually, at slightly different rates for each species. When the severe weather conditions of mid to late October struck, however, only white spruce and red pine were able to complete developing adequate cold hardiness as determined by visual damage assessment results shown in Figures 4 and 5. Visual damage assessment results for black spruce and lodgepole pine indicated that these species had undergone severe, but not fatal, injury at this time. Subsequent rounds of severe temperatures ultimately contributed to the decline in seedling viability seen in black spruce and lodgepole pine from which they were unable to recover (Figs. 1, 4, and 5).

Results of conductivity testing (Figs. 6 and 9) were less clear than those of visual damage assessment. The data for relative conductivity (Figs. 6 and 7) and index of injury (Figs. 8 and 9) did show trends towards an increase in cold hardiness with time at the different test temperatures. The lower the calculated index of injury for conductivity measurements, the greater is the level of cold hardiness (freezing tolerance), with negative values possible, as were observed (Figs. 8 and 9). The results also showed the decline in cold hardiness that begins later in the winter and early spring. This was evident for both shoots and roots. Generally, the roots develop hardiness at a slower rate than do the shoots. Although there is obvious variability in the data, it is apparent that the roots did not develop cold hardiness to the same degree as the shoots. Roots also lost their cold hardiness earlier in the spring (Figs. 6–9).

Results of identical tests carried out during the 1985–86 winter are still being collated and analyzed and thus cannot be shown at this time.

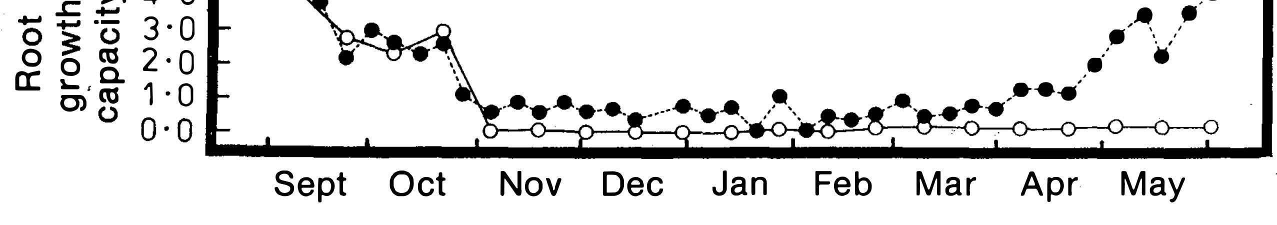

Figure 3. Dormancy data for shoots and roots of lodgepole and red pine seedlings over the 1984–1985 overwintering period.

Relative cambial activity of lodgepole and red pine seedling shoots was determined using the scale in Table 1 after seedlings reached room temperature, 1–2 hours after being brought indoors from the shade frame on each of the respective sampling dates. Root growth capacity of lodgepole and red pine seedlings was determined 8 days after potting using the scale from Table 2. Each data point represents the mean value for ten and twenty seedlings from cambial activity and root growth capacity tests, respectively.

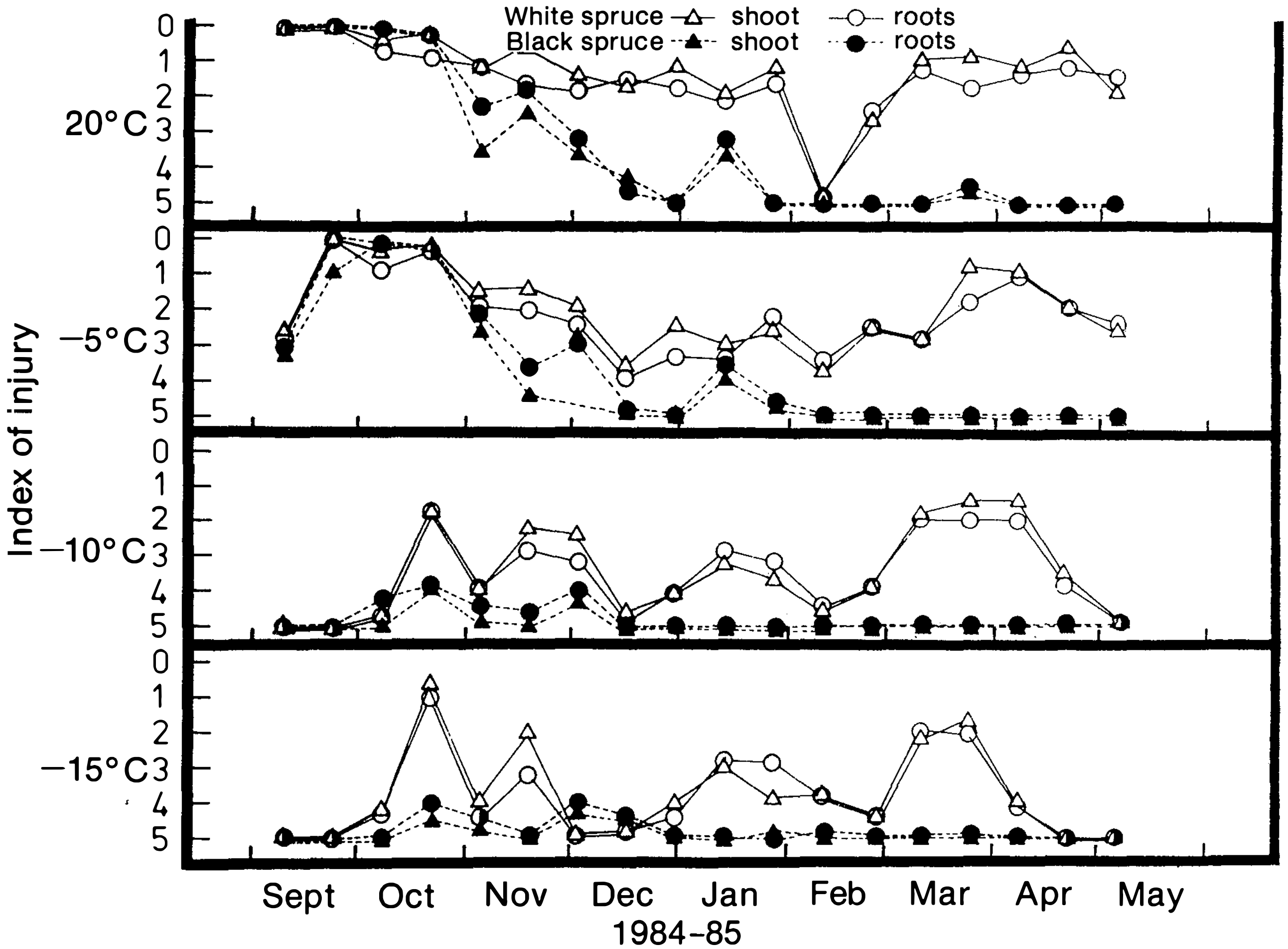

Figure 4. Visible damage assessment of shoots and roots of black and white spruce seedlings following freezing tolerance testing over the 1984–1985 overwintering period.

Visible damage was assessed 4 weeks after seedlings were returned to the greenhouse according to the scale in Table 3. Data shown represent black spruce shoots and roots and white spruce shoots and roots. Each data point represents the mean value for ten seedlings.

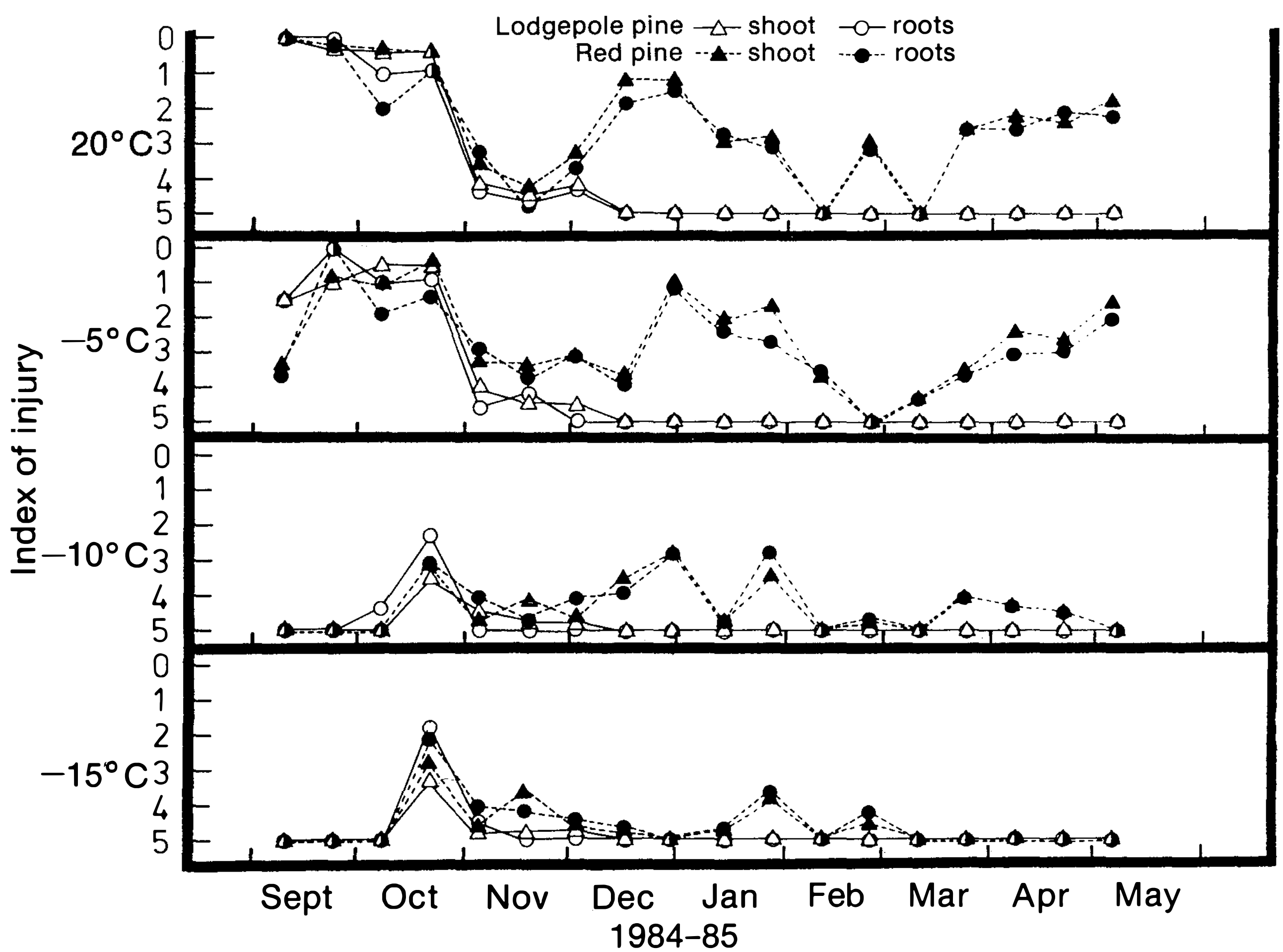

Figure 5. Visible damage assessment of shoots and roots of lodgepole and red pine seedlings following freezing tolerance testing over the 1984–1985 overwintering period.

Visible damage was assessed 4 weeks after seedlings were returned to the greenhouse according to the scale in Table 3. Data shown represent lodgepole pine shoots and roots, and red pine shoots and roots. Each data point represents the mean value for ten seedlings.

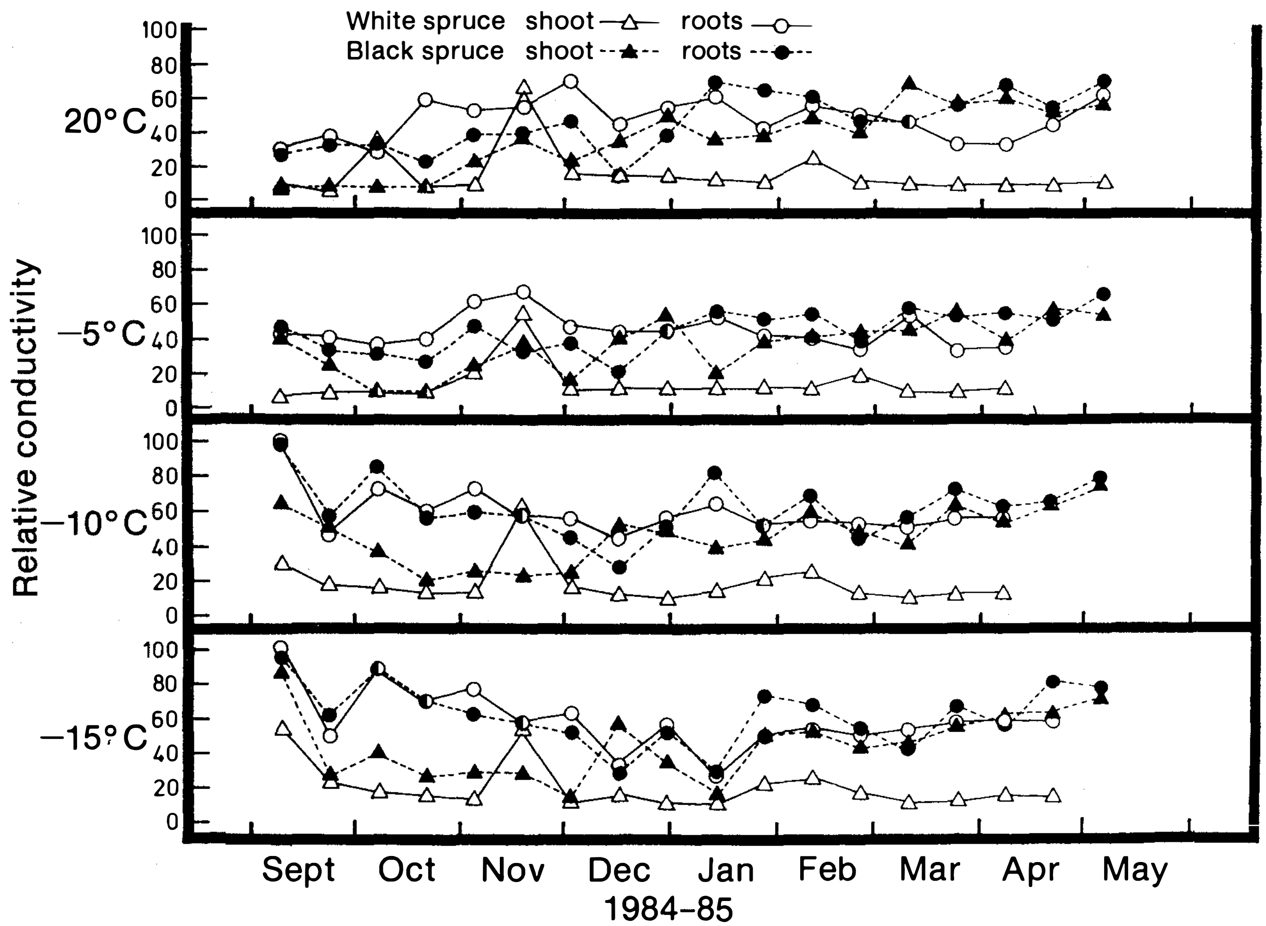

Figure 6. Percent relative conductivity of shoots and roots of black and white spruce seedlings following freezing tolerance testing over the 1984-1985 overwintering period.

The percent relative conductivities of shoots and roots were calculated as outlined in the Materials and Methods section. Data shown represent black spruce shoots and roots and white spruce shoots and roots. Each data point represents the mean value for ten seedlings.

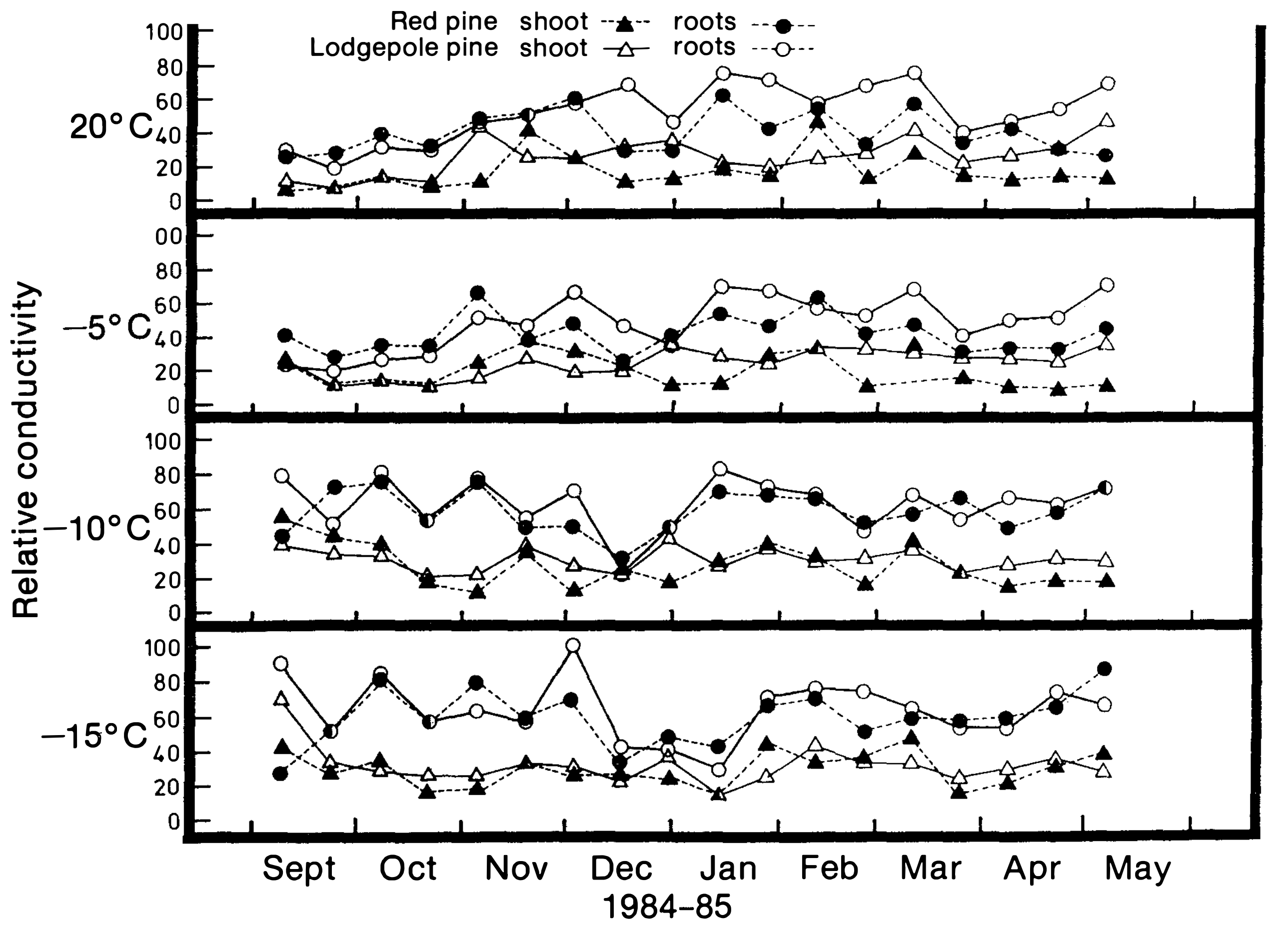

Figure 7. Percent relative conductivity of shoots and roots of lodgepole and red pine seedlings following freezing tolerance testing over the 1984–1985 overwintering period.

The percent relative conductivities of shoots and roots were calculated as outlined in the Materials and Methods section. Data shown represent lodgepole pine shoots and roots and red pine shoots and roots. Each data point represents the mean value for ten seedlings.

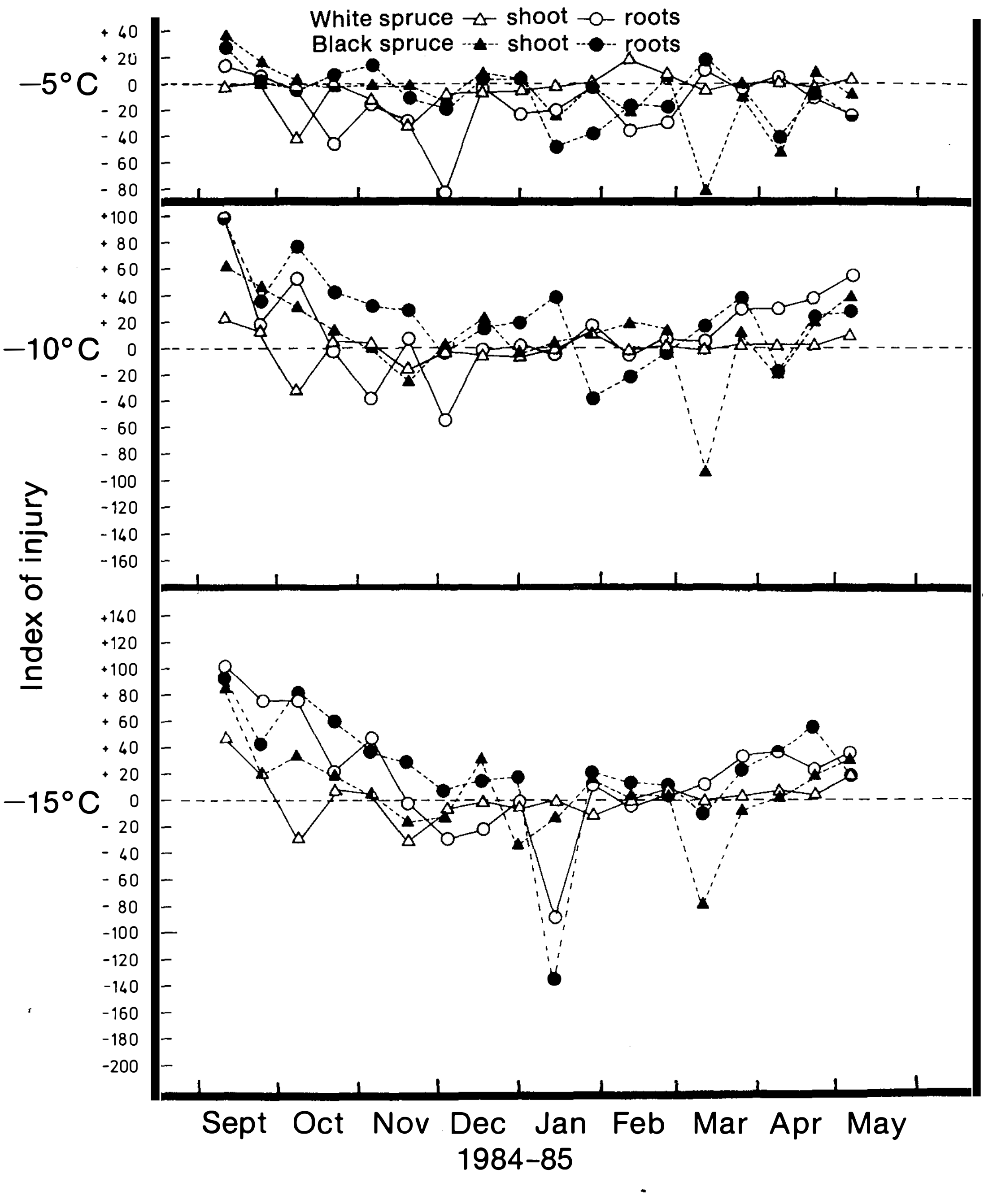

Figure 8. Index of injury data of shoots and roots of black and white spruce seedlings following freezing tolerance testing over the 1984–1985 overwintering period.

The index of injury of black spruce shoots and roots and white spruce shoots and roots was calculated from the respective relative conductivities as shown in the Materials and Methods section. Each data point represents the mean value for ten seedlings.

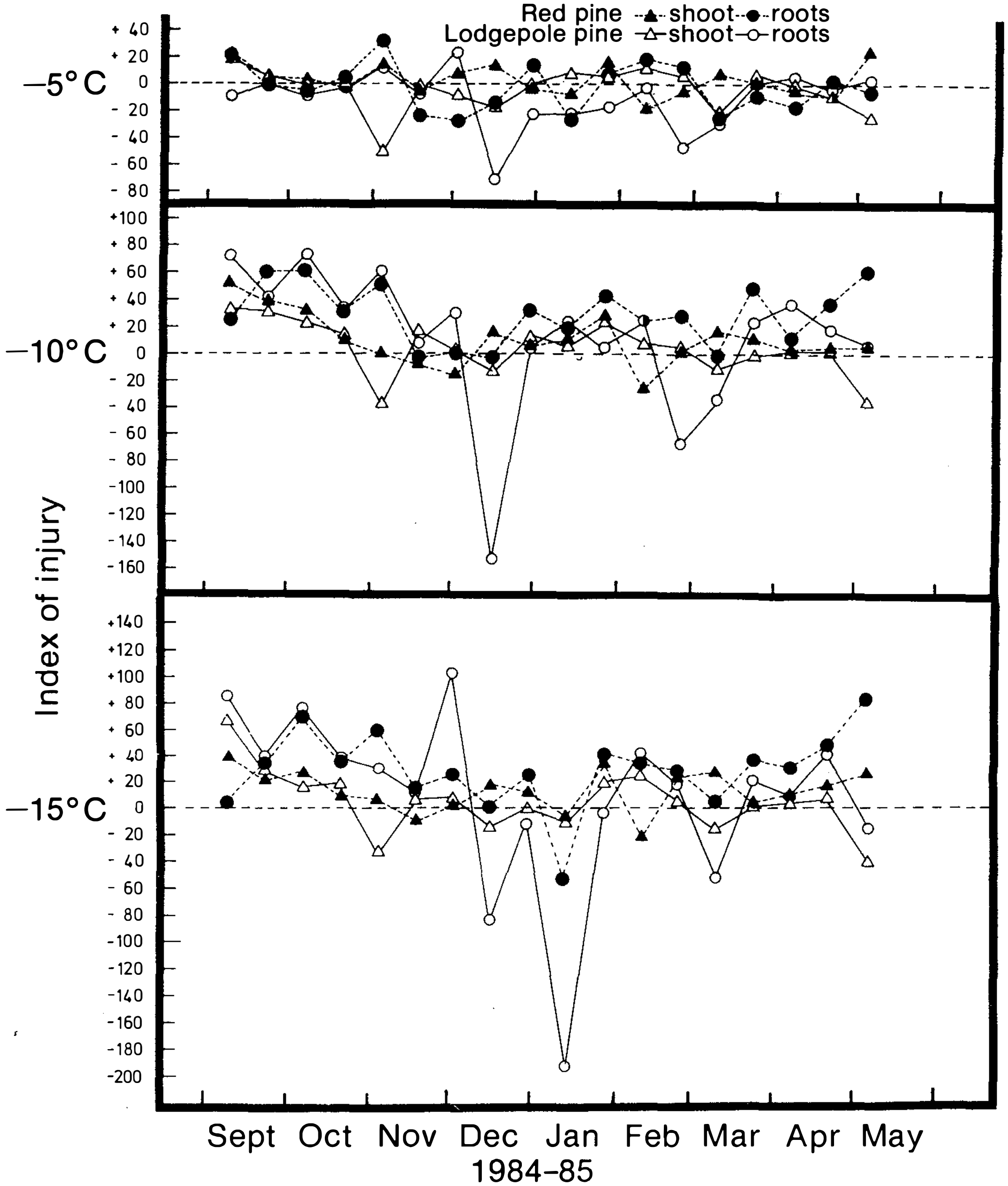

Figure 9. Index of injury data of shoots and roots of lodgepole and red pine seedlings following freezing tolerance testing over the 1984–1985 overwintering period.

The index of injury of lodgepole pine shoots and roots, and red pine shoots and roots was calculated from the respective relative conductivities as shown in the Materials and Methods section. Each data point represents the mean value for ten seedlings.

Photographic records of the 1985–86 and the 1986–87 overwintering stock in the shade frames have been taken periodically, as have those taken to document visual damage assessment for the cold hardiness (freezing tolerance) and survival tests. These illustrate the trends that were observed over the 1985-86 experimental season. The photographs are shown as part of the presentation, but will not be included in the proceedings due to the cost associated with color printing. Black and white photographs will not be substituted, as the details of fall color changes and those seen with frost damage are best observed in color.

The first series of slides showed the progress of seedlings in the shade frames starting on September 9, 1985. The second slide showed a close-up of the five species: moving from left to right on the screen for lodgepole pine, black spruce, red pine, white spruce and jack pine. These seedlings were three weeks into the hardening regime of Carlson (1983).

The third slide was from October 21, 1985, nine weeks into hardening. The distinct color changes that have occurred in the needles of some species were duly noted. Snow cover was evident by November 12, 1985. After this time, very cold temperatures persisted throughout the rest of November into December. Snow cover was lost in late February, and by March 4, 1986, visible damage was evident in seedlings outdoors. A final photograph from May 13, 1986, showed the extent of winter damage and survival for the five species. Few lodgepole pine or black spruce survived the winter of 1985–86 as was the case with these species in the 1984–85 experimental season. Jack pine suffered extensive damage during 1985–86, but white spruce and red pine survived both winters with minimal shoot and root damage.

Both winters were distinguished by severe climatic conditions during the early part of the winter followed by warming trends in the mid-winter that resulted in loss of permanent snow cover by mid-February. This undoubtedly contributed to the poor survival of both black spruce and lodgepole pine.

DISCUSSION

The climate had obvious effects on the survival of overwintered container seedlings in both years. Black spruce and lodgepole pine had both been successfully overwintered during 1983–84 under the same cultural conditions but under far less severe winter climatic conditions (data not shown). Oscilloscope-SWD results for that year confirmed the visual damage assessment results. The same seed sources for these two species did not survive either of the following two, quite severe, overwintering seasons with any degree of success.

White spruce and red pine were successfully overwintered during the latter two winters, however. All seed sources were from similar ecotype regions and should have similar genetic potential for developing cold hardiness and overwintering capabilities. This was not the case.

The 1984–85 data shown in Figures 1–9 for the four species examined that winter show the trends that occur as these species enter dormancy and start to develop cold hardiness. The earliness at which it can be lost in late winter is also well illustrated. This has been further corroborated by the results for 1983–84 and 1985–86 (data not shown).

The methods employed to date for monitoring dormancy (oscilloscope-SWD, root growth capacity, time to bud break) and cold hardiness (visual damage assessment, conductivity testing) have all proven very useful in monitoring stock progress over the winter months. Visual damage assessment has been the most reliable to date, but results take up to 4 weeks to obtain. The oscilloscope-SWD results are instantaneous, but they have not proven as reliable in detecting or confirming that severe (but not fatal) damage may have occurred. Root growth capacity testing is reliable but takes up to 8 days to obtain results. The results do not necessarily provide an accurate assessment of the survivability of seedlings during midwinter, when seedlings are easily shocked by moving indoors for testing (data not shown).

The results of conductivity testing are very promising for cold tolerance testing but take up to 4 days to complete. The combined results of our testing program over the 3 years for each species, coupled with the yearly climatic data, should provide us with a more accurate assessment of each test's reliability in monitoring the overwintering success of container stock.

This should lead to the development and implementation of better monitoring procedures and the concomitant development of improved overwintering storage practices. Increased research efforts in overwintering technology should become a priority as the demand for greater numbers of containerized stock for reforestation purposes increases.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the technical assistance of Ms. Janet Haley, Ms. Betty Thomson, and Ms. Joanne Macen, all of whom were employed as student assistants at various times under the Federal Government Career Oriented Summer Student Employment Program. We also acknowledge the assistance and advice of Mrs. Wendy Mills, the Northern Forestry Centre greenhouse assistant, in the early stages of this research study.

The authors thank Dr. Ivor K. Edwards for giving the oral presentation to the Federal-Provincial Nurserymen's Meeting on such short notice as neither author was able to attend due to last minute changes made in their work plans.

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SUMMARY OF 1986 ACTIVITIES AT THE PFRA TREE NURSERY

Tree Nursery Staff
PFRA Tree Nursery
Indian Head, Saskatchewan

The PFRA Tree Nursery supplies seedlings to prairie farmers for use in farmstead shelterbelts, field windbreaks, and roadside belts. Nursery staff are divided into four groups: Administration, Production, Distribution, and Investigations. The following is an update on activities at the nursery in 1986. Further details on these reports can be found in the 1986 report of the PFRA Tree Nursery. Copies of the report may be obtained by writing to Dr. J.A.G. Howe, Superintendent, PFRA Tree Nursery, Indian Head, Saskatchewan, S0G 2K0.

PRODUCTION AND MAINTENANCE REPORT

Compiled by David Gruber
Presented by Gene Burstyk

Harvest operations began on September 25, 1985, and were completed on November 6. A total of 5 963 325 deciduous and coniferous seedlings were sorted, counted, and stored. Of this total 1 092 115 deciduous seedlings were stored in 278 bins in cold storage, and the remaining 4 755 860 were heeled in. The 115 350 conifers harvested were put into poly-lined bins and stored in cold storage. The remaining 442 065 conifers were harvested during the spring packing operations. There was an average of 205 000 seedlings sorted and counted per day during the fall harvest. Due to wet weather at the end September and first part of October, lifting operations could only be done in the mornings before the frost was out of the ground. This only had to be done for the first one and one-half weeks of harvest, and when the fields dried the harvesting operations went along smoothly.

Packing of prepacked and special orders started on April 9, 1986 and was completed on April 11. This operation was performed by full-time staff only. Due to rain and wet snow, packing operations had to be shut down for 3 days. On April 18 the casual staff started work, and the Alberta load was completed. Bulk shipments began on April 21. The seasonal and casual men were brought on staff at this time. A total of 6 266 975 coniferous and deciduous seedlings was distributed to 9 775 applicants in 43 057 bales. Packing operations were completed on May 8.

Transplanting of 2–0 conifers began on May 21 and was completed May 27. An estimated 480 000 Colorado blue spruce, 170 000 Scots pine, and 250 000 white spruce were planted. This estimated total of 900 000 conifers was planted to 5.1 acres (2.04 ha) in 5 days with a crew of 30 employees. Each plot was 0.34 acres (0.136 ha). Immediately after planting, each plot was irrigated for a short period of time, packed between rows, sprayed with linuron (70 ounces, bulk) in 63 gallons of water per acre, and then irrigated for approximately 3–4 hours depending on the moisture in the soil. The plots were then irrigated and weeded throughout the summer months as required.

Planting of poplar and willow hardwood cuttings began on May 21 and was completed on May 30. An estimated 390 000 poplar (Northwest, Walker, P38P38 and a new clone named Assiniboine) were planted. The Assiniboine poplar is not yet in full production.

There was an estimated 525 900 willow (Acute, Laurel, Silverleaf, and Chermisina) planted. After planting, the cuttings were packed and sprayed with linuron (Afolan F) 45% flowable at 70 ounces in 54 gallons of water per acre. The fields were irrigated immediately after spraying. This operation required a crew of 14 to operate two four-row planters and two tractors. Approximately 200 000 cuttings could be planted per day.

Sowing of caragana began on June 16 and was completed on June 23. There were seven fields or 22.3 acres sown at a 32-inch row spacing, and two fields or 5.3 acres were sown in beds. These sowings required 2 021 pounds of seed. Sowings were sprayed with chloroxuron (Tenoran) 50% WP at 10 pounds (bulk) in 54 gallons of water per acre. The fields were irrigated immediately after sowing.

There were 100 feet of American elm and 100 feet of Japanese elm sown into four rows on June 24. Siberian elm was sown into the remainder of the field. Trifluralin (Treflan) 54.5% EC and 30 ounces (bulk) in 54 gallons of water per acre was applied and incorporated to a depth of 2 inches 7 days prior to sowing. Irrigation was applied immediately after sowing.

Ash (12 A), Manitoba maple (2.7 A), and lilac (10 A) will be sown in October. Manitoba maple is grown as a 1-0 crop. All the 1-0 deciduous species are sprayed in the late fall with linuron 45% flowable at 70 ounces (bulk) in 60 gallons of water per acre.

Oats (8.6 A) and grass (20.4 A) were sown in early June at 2 bushels and 20 pounds per acre, respectively. A field of fall rye was sown at 1.5 bushels per acre on August 27.

Shrub beds and shrub field sowings were sown on various dates from the first week in September through to the middle of October. Hawthorn and snowberry, which we are just starting to grow on a very limited basis, were sown in July. One bed of bur oak was sown in June.

Approximately 1.1 acres of shrubs will be sown into fumigated beds this fall. Shrub beds are fumigated by incorporating Basamid 98% G at 312 pounds active per acre in moist soil approximately one month prior to sowing. Incorporation should be to a depth of 3 inches. The bed should be packed lightly and one-quarter inch of overhead irrigation applied. The soil surface should be kept moist for 3-5 days following Basamid application. At the completion of sowing, silica sand is spread on the beds approximately one-quarter inch deep. Irrigation is applied if soil conditions are dry.

Conifer seedbeds are sown in the fall and spring. White spruce will be sown in October. Colorado spruce and Scots pine will be sown in May. Beds are fumigated in the fall and sideboards erected in preparation for sowing. Conifers are grown in seedbeds for 2 years (2-0) before being lifted and planted into the transplant plots. These seedlings will remain here for 2 years (white spruce and Scots pine) and 3 years (Colorado spruce).

Harvesting of the 2-0 conifer seedlings usually begins around October 15, with the Investigations Section advising when the seedlings are ready for lifting. Approximately 1 000 000 2-0 seedlings are lifted and stored in cold storage. The seedlings remain in cold storage until March and are then taken out and sorted. Those of poor color, or with root damage or stunted growth are culled, and the seedlings are returned to cold storage until they are planted in May.

Some equipment fabricated at the nursery this past year included: ten shelterbelt planters; bin tippers for the new counting and sorting line; a spray boom rack, for storage of spray booms; a belt conveyor for the counting and sorting line (there will now be two counting and sorting lines with 16 counters and three Saxmayer tiers on each line); a sprayer boom for the all-terrain-vehicle (ATV); and a hydraulic press for installing sideboard stakes on the conifer seedbeds.

DISTRIBUTION AND DEVELOPMENT REPORT

Compiled by Howard Fox
Presented by Dan Walker

In the spring of 1986, the nursery distributed approximately 6.3 million trees to 9 775 tree planters. Caragana remained the predominant species, accounting for about half of the total tree distribution.

Demand for trees for use in field belts has increased significantly over the last few years. In 1984, 14.4% of the total trees distributed were planted in field belts; in 1985, 22.8% were planted; and in 1986 the percentage of total trees planted for field belts increased to 31.5%.

Approximately 700 on-site visits to farms will be conducted this summer and fall to assist farmers in planning their farm shelterbelts. This includes members of approximately 25 soil conservation associations whose prime concern is field shelterbelts. It is anticipated that members of these groups will be planting 650 km of field shelterbelts in 1987.

Although caragana still represents 75% of all field plantings, green ash has increased to 17.8%. Other species used to a lesser extent in field plantings include willow, lilac, buffalo berry, chokecherry, and Siberian larch.

On July 3 a field day was held at the nursery. Tours of the nursery and demonstrations of the operations and equipment were given. As well, displays on farmstead planning, home landscaping, and investigation activities were featured. Approximately 2 000 people attended the field day activities.

INVESTIGATIONS REPORTS

Shelterbelt Tree Improvement

Compiled by Bill Schroeder and Dan Walker
Presented by Dan Walker

Tree improvement has been carried out at the tree nursery for many years. Current emphasis is on genetic improvement of shelterbelt species through plus tree selection, provenance testing, establishment of seed orchards and progeny pine, Siberian larch, and green ash.

Poplar

Because of its very rapid growth, poplar has been used in prairie shelterbelts for many years. Problems occur with poplar 15–20 years after planting, however, which makes it undesirable for farmstead shelterbelts.

The emphasis of the poplar improvement program is to develop a species that is hardy, vigorous, has good form, and is resistant to insects and disease. It must also be easy to propagate on a large scale.

Several selections have been made from over 100 different poplar clones, most of which are from open-pollinated populations of *Populus deltoides* Walker and controlled breeding populations that include *P.* Walker, *P.* Northwest, *P.* Saskatchewan, *P.* tristis, and *P.* serotina de selys.

A test planting of ten poplar clones in northeast Saskatchewan was evaluated after 20 growing seasons. Of the clones tested, *P.* Northwest, *P.* Brooks #1 and *P.* Walker were best suited for farmstead shelterbelt planting in this region of Saskatchewan.

Scots pine

The objective of the Scots pine tree improvement program is to develop a tree with a vigorous, upright growth habit, superior crown density, and dark green foliage with good needle retention for farmstead and field shelterbelts in the prairies. The improvement program includes provenance trials, progeny tests, and controlled mating as well as importation of seed from its natural range. Without exception, seed obtained from natural stands in the Soviet Union has performed best under prairie conditions.

In 1962, a provenance test that included 28 Soviet Union seed sources was established at the tree nursery. Twenty-year data for this planting showed that seed from three specific regions of the USSR and Siberia was best adapted for shelterbelt planting in southern Saskatchewan.

The progenies of 20 seed sources from the 1962 provenance test were field planted in south-central Saskatchewan. After 5 years, trees from the same regions as mentioned above were the most vigorous.

In 1983, each tree in the provenance planting was rated for desirable shelterbelt characteristics. Twenty-four superior phenotypes were selected as the breeding population for the development of an improved strain of Scots pine. Controlled breeding of superior trees was done in 1983 and 1986, and full-sib progenies from these matings will be used to design a clonal seed orchard.

Ponderosa pine

In 1967, a provenance test of ponderosa pine was established at Indian Head. Indications were that several Nebraska and South Dakota seed sources were adapted to prairie conditions. A mass selection progeny test of three seed sources from Valentine and Ainsworth, Nebraska and from Rosebud, South Dakota was then established near Indian Head in 1983. Also, an open-pollinated progeny test consisting of 84 families from 12 seed sources in Nebraska, South Dakota, and Montana has been established near Indian Head.

Siberian larch

An improvement program for Siberian larch was initiated at the tree nursery in 1983. The seed source currently used originated from the Soviet Union, and seed is currently collected from a mature plantation on the nursery established in 1905. Seed is also collected from nursery shelterbelts established in the mid 1970s that originate from this mature plantation.

In 1983, superior trees from these shelterbelts were selected and vegetatively propagated for inclusion in a clone bank for future breeding programs. Seed of Soviet Union origin was also received in 1983, and seedlings produced from this seed have been planted in various locations in Saskatchewan. Seed from the native range of Siberian larch has also been obtained from the Soviet Union so that a base population breeding program can be established.

Green ash

The green ash tree improvement program involves the following:

a) selection of superior phenotypes from their natural range in the prairie provinces and northern great plains of the United States;

b) vegetative propagation of the superior phenotypes and establishment of a clone bank;

c) progeny tests of the selected phenotypes at various locations in the prairies;

d) recurrent selection for increased genetic gains in second generation seed orchards.

Seed and scion wood were collected from representative stands in Saskatchewan in 1984 and 1985; collection from Manitoba stands commenced in the fall of 1986. Budding of selections from South Dakota, North Dakota, and Nebraska was done in 1986 at the tree nursery.

Herbicides Report

Compiled by Lyle Alspach
Presented by Tim Loeppky

Studies are being conducted for sowings of Colorado spruce, white spruce, Scots pine, green ash, and honeysuckle; for transplants of Colorado spruce, white spruce and Scots pine; and for cuttings of Walker, Northwest, Assiniboine, and P. × 210 poplar, and Acute, Laurel, Silverleaf and Chermisina willow. Final 1986 data is yet to be summarized. Promising treatments include: oxyfluorfen (Goal) for conifer sowings and transplants and for poplar cuttings; linuron (Lorox or Afolan) for green ash sowings and willow cuttings; sethoxydim (Poast) for conifer transplants; and in the past, chloramben (Amiben) for honeysuckle sowings.

A number of routinely used herbicide treatments were mentioned in the Production report. In addition, there are some other treatments listed in our program that can be used if necessary. These include: bifenox (Modown) at 2.2 kg/ha for conifer sowings; bifenox at 3.4 kg/ha for 1-0 and 2-0 conifer seedbeds and 2-1 conifer transplants; EPTC (Eptam) at 4.0 kg/ha prior to sowing caragana; and 2,3-DB (Cobutox) at 1.7 kg/ha for rising 1-0 caragana.

Entomology Report

Compiled by Bruce Neill and Don Reynard
Presented by Tim Loeppky

The main insect problem during the 1986 growing season was aphids. Most tree and shrub species had aphids this year, and controls were required for aphids on poplar, caragana, chokecherry, and honeysuckle. Other pests requiring chemical controls this year included spider mites on Colorado spruce transplants and Siberian larch shelterbelts, spruce budworm on Colorado spruce shelterbelts, cottonwood leaf beetles on poplar stooling beds, and grasshoppers on caragana seedlings. It should be noted that the grasshoppers were not nearly as bad as in 1985. Our main disease problem this past year has been a storage mold on Colorado blue spruce seedlings in freezer storage.

Pesticide screening trials were conducted on the following during 1986: caragana aphid on common caragana; poplar aphid on poplar rooted cuttings; honeysuckle witches' broom aphid on tatarian honeysuckle; spruce budworm on Colorado spruce; prestorage fungicide treatments for Colorado spruce; and prestorage fungicide treatments for poplar hardwood cuttings.

The nursery continues its effort to look for alternatives to pesticides by working with insect pheromones. This year we continued our trap-out of the cottonwood crown borer, and we cooperated in a trial on the native elm bark beetle. Results from all of these trials are being analyzed and will be presented in our next annual report.

Soils Report

Compiled by Bill Schroeder
Presented by Tim Loeppky

The objectives of the soils unit are as follows: 1) to provide a soil testing program for the tree nursery, 2) to increase seedling growth and quality through improved soil management, and 3) to provide recommendations on site preparation techniques for tree planting in the prairies.

Current projects include fertility trials for nursery production of Manitoba maple and caragana, salinity tolerance of green ash, and site preparation techniques for Siberian larch and caragana on various soil types.

Shelterbelt Studies Report

Compiled by John Kort and Tim Loeppky
Presented by Tim Loeppky

The Shelterbelt Studies Unit, established 2 years ago, is involved in examining the effect of shelterbelts on soils and crops. The amount of competition between shelterbelts and adjacent crops and the protection offered by the shelterbelts to soils and crops are two important factors to consider when studying shelterbelts.

Over the past several years we have been conducting a root-pruning experiment on a Siberian elm shelterbelt. In this study the trees were root-pruned to a depth of 60 cm at 4 m or 6 m from the center of the belt.

Soil moisture, nitrogen, crop height, and yield have been monitored over the growing season. The crop height data from this year show the effect of the root-pruning treatments. The crop height and density was much less within the root-pruned zone. Although moisture curves for 1985 followed similar trends, this year the moisture levels did not seem to be limiting; therefore, we will be looking into the possibility that factors other than direct competition for moisture and nutrients may be playing a role. The effects of the root pruning on the trees is also being monitored.

We are also studying the effects of shelterbelts on special crops, in this case, potatoes. This study is being conducted in conjunction with Blair Geisel of the Keystone Vegetable Growers Association, near Carberry, Manitoba. The data from 1985 revealed an average gain of approximately $850.00 per field due to shelterbelts. This higher value reflected the increased yield and quality of the potatoes. Control values used were measured at a distance of 20 times (20 H) the height of the shelterbelt.

In another study, wind profiles on the leeward side of various shelterbelts are being collected. Both summer and winter profiles have been measured. It was assumed that open wind speeds were attained at a distance of 20 H. As expected, protection provided by the shelterbelts is much greater during the summer. It is important to note the large difference between summer and winter profiles for green ash, where minimum winter wind speed is 80% of open wind speed and minimum summer wind speed is 40% of open speeds. Because green ash is late breaking bud and early defoliating, the winter profile is in effect during much of the spring and fall when soil drifting is a problem. Maximum protection was provided between 3 H and 5 H in all cases. Collection of data is continuing.

Since many shelterbelts across the prairies were planted in the 1930s and 1940s or earlier, they are now reaching the stage where some form of renovation is required. This might include removal of deadfall, selective removal of certain species, or removal of entire shelterbelts and replanting. Any information on methods of renovation, appropriate equipment, handling and use of cut wood, and costs would be very beneficial to our studies.

Further information on all of our studies will be available in the PFRA Tree Nursery Annual Report.

GOAL TRIAL AT THE PRINCE ALBERT FOREST NURSERY

J.D. Thompson
Department of Parks and Renewable Resources
Prince Albert, Saskatchewan

A Goal herbicide trial was carried out this year at Prince Albert Forest Nursery. The results from the experiment have not yet been analyzed, and the experiment itself is not complete until the Conifer Tolerance Assessment has been done. All data from the experiment should be complete in October 1986.

Initial observations indicate complete control of weeds for up to 6 weeks for the preemergent and the first postemergent applications. The 0.25 kg/ha active ingredient appears to be just as effective as the 1.0 kg/ha active ingredient for the control of lamb's quarters, portulaca, and shepherd's purse. The first postemergent application was applied at the two- to four-leaf stage. The last postemergent application achieved some control, but in the case of the lowest concentration (0.25 kg/ha active ingredient), the weeds recovered.

REPORT ON THE NATIONAL TREE NURSERY WEED CONTROL ASSOCIATION WORKSHOP

Eileen M. Harvey
Northern Forestry Centre
Edmonton, Alberta

Approximately 20 people attended the National Tree Nursery Weed Control Association Workshop, chaired by John Maxwell of the B.C. Ministry of Forests and held at Fraser Valley College, Abbotsford, British Columbia, from July 15 to 16. Representatives from New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia were in attendance. There were also guests from the state of Washington.

Regional reports of weed control practices in the Maritimes, Quebec, Ontario, and British Columbia were presented during the morning of July 15. During the afternoon, nursery tours of Pelten Reforestation and Surrey Nurseries were conducted.

Individual nursery reports of weed control practices were presented during the morning of July 16. During the afternoon a tour of Chilliwack Nursery was conducted.

The committee met after the nursery tour on July 16. The 1987 meeting will be hosted by Jean Paul Campagna at Berthieville, Quebec. Jean Paul Campagna will be the 1987 Chairman, and John Maxwell will act as Vice-chairman. Jean Paul will appoint local officers to assist with the logistics of the meeting. The national Goal trial will be continued and expanded to include container stock in 1987. A national Poast trial will also be designed for both container and bare-root stock and sent for review to the regional committee members in 1987. It was suggested that the official name of the committee be the National Tree Nursery Weed Control Association.

The association will operate as an independent body, making it easier to obtain funding, etc. Eileen Harvey will write up a draft of the constitution and send it to committee members for review. The final name of the organization will also be voted on at this time. The Northern Forestry Centre (NoFC) in Edmonton was suggested as a tentative location for the 1988 meeting.

The 1986 Goal trial appears to be going well. Saskatchewan is currently the only prairie province that is conducting the trial to specifications. It looks quite promising for control of portulaca in Saskatchewan nurseries. This trial will provide valuable data for registration of this herbicide for forest tree nurseries under the Minor Use Program Subcommittee (MUPS) of the Expert Committee on Weeds (ECW).

The general concensus at the meeting was that although there are several useful products available for weed control in forest tree nurseries, very few of these products are registered for that purpose in Canada. The national trials conducted by the association should provide valuable information enabling these herbicides to be registered under the MUPS program.

Copies of the proceedings will be available from:

1. Mr. John Maxwell
   B.C. Ministry of Forests
   3605 - 192 Street
   Surrey, British Columbia
   V3S 4N8

2. Fraser Valley College
   33844 King Road, R.R. #2
   Abbotsford, British Columbia
   V2S 4N2

PRINCE ALBERT FOREST NURSERY 1986 OPERATIONS

Larry D. Rempel
Supervisor, Prince Albert Nursery
Prince Albert, Saskatchewan

Spring harvesting operations began this year on April 23 and were completed by May 8. A total of 4 256 660 bare-root seedlings were lifted and packed for reforestation planting projects. Of this amount, 1 941 000 were planted by the provincial government and 1 871 350 were planted by industry. An additional 337 220 white spruce containers were planted by industry. This fall, industry is slated to plant 450 000 bare-root seedlings, and the province will be planting 125 000 bare-root and 385 454 containers held over from the spring. This will bring total distribution this year from the Prince Albert nursery to 2 658 570 for industry and 2 451 454 for government. Total distribution to reforestation projects by both industry and government from all nurseries will be 8 124 124 seedlings.

In addition, 200 000 seedlings were distributed to various other planting projects.

As in the past, weed control was carried out using a combination of hand, mechanical, and chemical methods. Chemicals used were Varsol, Enide, and Roundup. A herbicide trial was carried out this year using Goal.

In the spring of 1986, 28 000 linear metres of white spruce were seeded for a target production of 8 million seedlings. No jack pine was seeded at the Prince Albert nursery. One crop of containers was seeded this spring consisting of 393 200 white spruce, 217 272 jack pine, and 156 693 jack pine specials for the Pulpwood Division of Weyerhaueser Canada Limited.

During the fall and winter of 1985, 490 hL of white spruce cones were collected and processed. This year only about 300 hL of jack pine cones are expected to be collected.

Last fall, natural gas was piped into the nursery but was not hooked up due to the lateness of the season and budgetary restrictions. We are now in the process of converting the oil and propane heating systems to natural gas, which should result in a large reduction in heating costs.

The construction of a new pump house commenced in December 1985 and is now nearing completion. This new system is a wet-well design and will supply water for the fields, greenhouses, a fire protection system, and for domestic water treatment equipment.

The irrigation system has a sulphuric acid injection system to lower the pH of the water. The pumping system consists of two 5-horsepower electric jockey pumps that keep the system pressurized at all times and three electric vertical turbine pumps that cut in and out on water demand. One pump is also equipped with a natural gas-fired engine by means of an angle drive for a backup water supply if a power outage occurs for an extended period.

BIG RIVER FOREST NURSERY 1986 OPERATIONS

John McCutcheon
Department of Parks and Renewable Resources
Prince Albert, Saskatchewan

A total of 3 011 600 seedlings were shipped from Big River Forest Nursery this spring. Of these, 75 000 were 2–0 jack pine, and the remainder was 3–0 white spruce. No fall lifting for reforestation is scheduled for this fall, although we plan to lift a partial field of 4–0 white spruce to test our new double-belted conveyor system in the packing shed.

PROBLEMS ENCOUNTERED THIS SEASON

Last year our Basamid supply arrived late in the fall. We decided that soil temperatures were too cold for Basamid to work properly and we did not apply it to our fields. This subsequently caused many problems on our spring-seeded 1–0 crop this year. Normally we can easily handle weed infestations in our 1–0 crop with hand weeding after Basamid treatment, but this year the weeds got out of control and about one-quarter of our 1–0 crop had to be treated with Roundup at 0.5 pounds active ingredient per acre to control mushrooming weed populations.

The Roundup effectively controlled the weeds, but some retardation of growth occurred in the 1–0 white spruce. Hand weeding efforts were concentrated on the 1–0 crop for the remainder of the summer, and the weeds were held in check.

Because the Basamid was not applied to our 1–0 fields prior to seeding we also had a major problem with damping-off, particularly in 1–0 jack pine. Captan at 15 pounds (bulk) per acre was sprayed on rising 1–0 in an attempt to control the damping-off problems. Some control was accomplished, although repeat treatments were necessary on severely affected fields.

Horsetail continues to be an increasingly problem weed at the Big River nursery and is particularly severe in low areas and wet areas near irrigation lines. Control attempts of fallow areas were again tried with Amitrol T at 8.86 pounds active ingredient per acre with inconclusive results.

NEW DEVELOPMENTS

A new pump house was constructed at Big River Forest Nursery this past year, funded under the federal-provincial agreement. The irrigation portion of this project has been operable since May of this year; however, the potable water system and acid injection will not be completed until mid-September.

Work has progressed all summer on a new packing shed, cold storage, office, and lunchroom complex at the nursery. Four double-belted conveyors with 64 grading stations and racked cold storage for 5 million seedlings are included in the design. The completion date for this project is mid-October. This project is also funded under the federal-provincial agreement.

SATELLITE NURSERIES 1986

Joe Chernysh
Department of Parks and Renewable Resources
Prince Albert, Saskatchewan

CHITEK LAKE FOREST NURSERY

Lifting, Packing, and Shipping

Lifting and packing operations began on April 28, 1986. A total of 195 600 3–0 white spruce were shipped. To fill woodlot orders, 15 620 1–3 Spenser red pine transplants were shipped. A total of 1 412 large ornamental trees and shrubs were potted and picked up for various parks and recreation sites.

To complement our six regular staff members, 12 casual laborers were hired for 2 weeks during the spring lifting operations.

Nursery Production

The bare-root production target has been reduced to the number that can be produced on one field per year; approximately 800 000 seedlings. The underrun this year is a direct result of high mortality from snow blight (*Rhizoctonia soloni*) infection in the 2–0 white spruce in the winter of 1984–85.

We have a reverse problem in one field of 2–0 jack pine, where inventory is 1.5 million. The crew of six is currently making a futile attempt to hand-thin the seedlings.

No fungicide was used in the soil preparation for spring seeding, and as a result, damping-off was a real problem. We continue to use raised beds for seeding.

Undercutting was done twice in 2–0 and 3–0 seedlings. Vertical pruning was done only once in the 3–0 seedlings.

A conveyer table no longer needed at Big River will now be used in the Chitek Lake lifting and packing operations.

There will be no fall lifting, with the exception of 5 000 white spruce, individually bagged with peat moss, to be used for special projects.

SOUTH BRANCH NURSERY

Lifting, Packing, and Shipping

The lifting and packing operations began on April 21, 1986. A total of 270 000 3–0 white spruce, 299 000 4–0 white spruce, and 9 260 4–0 blue spruce were shipped out. A total of 3 560 large ornamental trees and shrubs were potted and picked up for various provincial parks and recreation sites.

Twelve casual laborers were hired for 2 weeks to assist in the lifting operation. A staff of six remain to continue the regular nursery operations.

Nursery Production

Bare-root production has also been reduced to what can be grown on one field per year or approximately 800 000 seedlings. In some cases, extra seedlings may be grown for special purposes or projects. These species are usually lodgepole pine, Scots pine, blue spruce, and Siberian larch in smaller quantities.

There are approximately 22 000 1–4 Spenser red pine transplants that we hope can be sent out for woodlot purposes next spring. These trees have been stressed to reduce top growth, and some larger ones may have to be potted to ensure survival.

Raised beds are used to grow bare-root seedlings. The schedules for root wrenching and vertical pruning are similar to those at Chitek Lake.

Problems Encountered this Year

Damping-off caused significant mortality in the rising 1–0 white spruce and lodgepole pine Basamid was not applied in the preseeding soil preparation. Weeds also grew in the beds where it was thought that the weed problem had been eliminated before summer fallow. One application of liquid No Damp controlled the damping-off problem. Water from the South Saskatchewan River might contribute to weed infestation in irrigated fields.

High pH values of 7.5 cause problems in 1–0 seedlings with the exception of blue spruce. In preparation for seeding next spring, 1 680 kg/ha of sulfur was applied to the soil. Another application will be added prior to seeding. Ammonium sulfate fertilizers are also used.

Special Projects

Some of the potting production this spring was coordinated with the Growth Enhancement and Tree Improvement people in moving established trees from the nursery to the adjacent seed orchard area.

We moved 1 405 mass selected white spruce planted in 1978, 1979, and 1984, and to date the survival rate is over 99%. The rejected or unsuitable trees were potted for the parks.

Seven hundred and seventy grafted jack pine planted in 1980, 1981, and 1984 were potted and replanted in the seed orchard. To date the survival rate is also over 99%. Jerry Klein, who did most of the grafting, should be pleased with the survival rates. These trees were moved during a spring heat wave when temperatures ranged between 29 and 35°C.

There will be no fall bare-root lifting except for a small quantity of 5–0 Siberian larch that one of the southern parks had requested. Approximately 300 larger trees will be potted for two of the parks as well.

OPERATIONAL MANAGEMENT PROBLEMS AT THE WEYERHAEUSER CANADA LTD. SEED ORCHARD

Diane Roddy
Weyerhaeuser Canada Ltd.
Prince Albert, Saskatchewan

INTRODUCTION

Some of the participants of last year's Prairie Nurseryman's Meeting in Prince Albert visited the Prince Albert Pulp Company's seed orchard during the field tours. Since that time, Weyerhaeuser Canada Ltd. has bought the assets of the Prince Albert Pulp Company, including the seed orchard and officially took ownership on September 9, 1986.

Just to give a little background information on our company and the Tree Improvement Program, we are a forest industry that produces pulp at the pulpmill in Prince Albert. Under the new owners we will also soon be producing paper. The Pulpwood division of the company is responsible for supplying wood to the mill and properly managing the forested areas leased to us. Our forest management activities include the reforestation of our cutover areas.

In the late 1970s a tree genetics program was started because upper management recognized the advantages of and the need for one to complement our regular forest management activities.

A tree improvement program was started to capitalize on the natural variation found within our local commercial trees, and to use only those trees with desirable traits in future regeneration work. In 1978 a genetics program for jack pine was started, and in 1982 it was expanded to include white spruce.

The strategy decided upon for both the pine and spruce programs was to establish a grafted seed orchard from untested super-tree material and to use that orchard to supply seeds for the company's reforestation needs until proven genetic material, from longer term open pollinated genetic tests, were available for seed production.

A quarter section of land in the farm belt north of Prince Albert was selected as a seed orchard site because of its access to irrigation water, lack of surrounding jack pine that could contaminate the seeds harvested there by "fathering" them with unwanted pollen, and because of its nearness to a seasonal work force and the mill.

Rootstock was planted, and the first grafting of super-tree material was done in 1979. That first section of orchard has grown since then so that we've been harvesting seeds from it for the past 3 years. The white spruce orchard is still being established, and the last grafting for it should be done next season.

Seeds from the orchard are taken to the provincial government nursery in Prince Albert to be raised in their greenhouses and then outplanted in our cutovers. The first crop of orchard seed was started there this spring.

MANAGEMENT PROBLEMS

1. **Soil management** has been the largest operational problem in our seed orchard to date. Tests done by Dr. I. Edwards of the Canadian Forestry Service (CFS) have shown that the surface soil horizon ranges in pH from 6.2 to 8.2.; the optimal soil pH for conifers is 5.0 to 6.0.

   Although the topography appears flat, the land is undulating enough to have significant low-lying areas. It is in these areas, where the water lies in the spring, that the pH was the highest (8.2). The nutrients were subsequently "tiled up" and unavailable to the trees, making them very chlorotic, especially in the fall.

   Corrective measures for this have included using acid fertilizers, putting drainage ditches through the low-lying areas, incorporating elemental sulfur around each tree, and irrigating with water acidified to a pH of 5.0 to 5.5. The watering system is set up so that any combination of 8 parts of the orchard can be irrigated at one particular time, so the water pH level can be adjusted to suit the soil pH in each of the areas.

   Each spring and fall we measure the pH levels in a grid across the orchards so changes in the pH can be monitored. Last year was the first year we had the ability to irrigate with acidified water, and the pH level dropped one full point. In the sandier areas, pH levels are now optimal, and all over the orchard the trees have improved in color. Each year we also send soil samples to Eileen Harvey (CFS) as part of the soil management program, and she prescribes the fertilizers and other soil amendments to be used that season.

2. **Irrigation** scheduling is another major management activity. In 1984 and 1985 a drip irrigation system was installed in the orchards, and this allowed us to put the acidified water on the fields. Water is pumped through two large filters to get it very clean and is then carried by underground main and submain lines to the fields. From there aboveground lines carry it to each tree where an emitter, punched into the line, drips at the rate of 1 gallon per hour. The emitter openings are small and plug easily, so a very thorough filtering system is needed.

   The pH of the creek water rises as the creek dries up and stagnates towards fall, so the rate of acid injection into the lines has to be adjusted accordingly. Thirty-three percent sulfuric acid is injected in pulses into the flow of water and mixes with the water as it travels, so that by the time the water reaches the fields, it is an even pH throughout the orchards.

   Tensiometers monitor the soil moisture at three different rooting depths, and irrigation is scheduled according to those readings.

   There is currently only one emitter per tree, punched into the line at the base of it. As the tree grows and requires more water, that emitter will be replaced by two emitters inserted at about one-half of a metre on each side of the tree. The wetting circles made by each emitter will then overlap at the base of the tree, and the larger wetted area should promote better root development.

3. **Soil compaction** is also a management concern, because over the years the use of heavy vehicles around the trees could make subsoiling necessary, and we would like to avoid that problem if we can. We therefore bought a trike with large tires that spread the weight over a larger area, and now that is the only vehicle allowed inside the orchards around the trees.

4. **Weed control**, of course, is another problem. We used to rototill and hoe between the trees in the rows to keep the grass and weeds from competing with them for moisture; however, because of concerns over root damage and labor costs, we have switched to spraying Roundup down the rows. We also tried laying a woven, black ground cover down in the rows. It did an excellent job (nothing grew under it), but the mice loved it under there where it was warm and there were handy tree stems to girdle. Also, we were worried that the ground covers would change the soil temperature so much that the trees would be susceptible to frost damage, so we don't use them anymore.

   The decision to keep the soil black within the rows of trees and to sow grass between the rows was a compromise between having the fields grassed (allowing workers to get on them sooner in the spring to do the grafting), and not having any grass (or weeds) to compete with the trees for moisture.

5. **Insects and disease**, especially cone insects and diseases, are another continuous management problem. The seeds produced in the seed orchard are very valuable and expensive, so more intensive measures to protect the male and female flowers that form that cone crop are justified. The use of a systemic insecticide is the best way to control cone and seed insects because the insect dies when it feeds on the tree, whether or not it has been hidden inside a cone and protected from exposure to the contact spray. Dimethoate (Cygon) is the systemic we plan to use next year. Problem insects this year included jack pine and white spruce budworm, and sawflies.

   Two types of gall rusts were present in the orchard at one time and probably were brought in on the grafting material (branches) collected from super trees in the bush. These galls have all been removed and burned as they were found, and now they are almost completely eliminated from the orchard.

6. **Other orchard pests** have included mice, gophers, moles, beavers, and rabbits. They can harm high-value trees by girdling, digging around the roots, and browsing. Because of the danger from rabbits and porcupines, the jack pine orchard is fenced with stucco wire that is dug about one foot into the ground to discourage them from tunneling under it. We borrow the provincial government nursery's "gopher getter" machine to try and poison the gophers, and we regularly set out traps for them.

   This spring we had a new pest. Some animal, perhaps a fox, chewed up a fairly large section of the aboveground irrigation lines, so many lines had to be replaced or patched.

7. **" J-rooted"** and **unhealthy rootstock** have also created problems. Any grafts done on trees with the typical "hockey stick" root system are very unstable and have to be staked continuously to keep them from leaning or being blown over. Also, any grafts done on unhealthy rootstock are poor and unhealthy themselves, if they live. We have found that it is very important to have the best possible rootstock when establishing a grafted orchard.

8. **Graft incompatibility** can also be a problem in grafted (clonal) orchards of certain species. We have one jack pine super tree which, when grafted, will grow for a few years and then develop an incompatibility with the rootstock it is grafted onto. A saddle overgrowth starts to form at the grafting union, and the graft eventually dies. This has happened everywhere we have grafted super tree #8, and we now have lost that tree from the orchard.

9. **Grafting in the field** presents its own problems because you often want to create a moist, protected, greenhouse environment around each graft to ensure better grafting success. We cover our grafts with a plastic bag to keep them moist, but then it is necessary to cover that plastic bag with something else so that the sun's heat does not build up inside it and kill the tree. We found that a 2-L milk carton, open on one end and placed over the graft through two supporting stakes, works the best. These coverings are weatherproof and very stable, even in the highest winds.

10. **Harvesting cones** from the jack pine orchard presented problems at first, because when the cones were picked they took a small stem of wood from the center of the branch with them, which killed the branch from that point up. Cutting through the cone and leaving the base of it on the tree has worked well to avoid this damage, and that is the harvesting method we now use.

11. **A lack of male flower production** by certain clones in our orchard is currently a problem. The grafts of some of the super trees are slower in producing males than others, and this means that only a few trees have fathered the entire orchard cone crop, giving it a very narrow genetic base. The lack of male flowers also makes the presence of the budworm (which is often found feeding on male flowers) a particular worry, for we don't want the few males that are produced to be destroyed.

To overcome the lack of male flowers, we plan to try some flower-promoting techniques next season, such as applying gibberellins (growth hormones) and putting the trees under stress.

Finally, it is important to note that there is a tremendous amount of record keeping involved in managing an orchard, both for each individual tree in it and for the activities that are carried out. Just keeping the records can sometimes become another orchard management problem in itself.

DEVELOPMENT OF WESTERN GALL RUST RESISTANT JACK PINE IN MANITOBA

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In 1982, the Forest Protection and Tree Improvement branches initiated a joint project to develop western gall rust resistant jack pine. Western gall rust (*Endocronartium harknessii*) is a common disease of jack and Scots pine in Manitoba. Unlike most rusts, there is no alternate host, with infection occurring directly from pine to pine. The disease causes globose swellings or galls on seedlings and older trees, sometimes resulting in severe deformity or mortality. Orange-colored aeciospores develop on mature galls in late spring. Spores are wind disseminated and infect young shoots of susceptible pines. The rust may kill an entire tree or that portion distal to the infection.

Main stem galls were especially prevalent on stock originating from the Pineland nursery several years ago. Since then, a sanitation program has all but eliminated the disease from the nursery.

Naturally occurring resistant jack pine trees had been observed regularly in Manitoba in areas heavily infected with gall rust. Scions and cones were collected from candidate resistant jack pine in the Grand Beach area in 1982. The same were collected for nearby heavily galled trees for comparison.

Seedlings were inoculated by dusting rust spores onto new shoots moistened with water at 5 months of age. In November 1983, seedlings were examined for gall formation. A lesion, swelling, and profusion of needles can develop at the site of infection. It generally takes 6 months to one year for symptoms to become visible. Seedlings showing resistance are reinoculated each year. All galled seedlings were discarded after positive identification of the rust fungus.

In 1985 the study was broadened to include 40 jack pine families that had been developed as superior breeding stock by Jerry Klein of the Canadian Forestry Service. Jerry has developed two breeding districts in the province of Manitoba. The Central Breeding District straddles the Saskatchewan-Manitoba border in the Duck Mountains. The Eastern Breeding District encompasses southeastern Manitoba.

Trees have been selected based on tree height, diameter, and form. Unfortunately, the disease pressure in both areas is very low due to a low incidence of western gall rust in the surrounding jack pine stands.

Scions from the 40 selected families were grafted in 1985 and inoculated the following spring. In the summer of 1986 all potted stock was transplanted to the Birds Hill Research Nursery facility. Seedlings will be examined this fall for gall formation. All stock identified as infected will be culled.

Grafted stock will be maintained at a reasonable level for each of the selected families from both breeding districts. Over time any family or seedling parent showing high susceptibility will be discontinued. After several years of evaluation it is hoped that the remaining resistant stock will be incorporated into the jack pine breeding program.

The study will be further expanded next year to include Jerry Klein's seed orchard located near Birds Hill Provincial Park. There has been little if any rust pressure in the area. A portion of the seeds collected each year from the orchard for bare-root production will be tested for rust resistance. Scions from orchard trees will also be collected and tested.

To date, western gall rust has had its major impact in nurseries and outplanted infected stock, where it has attacked seedlings at an early age, often causing main stem infections. In natural stands its impact has been small and perhaps beneficial as it can sometimes act as a thinning agent. When selecting a small number of families to possibly be the parents of all future jack pine plantings in the province, however, the impact of gall rust can become significant. Losses will be substantial if even one family proves highly susceptible. The possibility of this occurring is very real, as some families may have been selected in the absence of rust.

ACKNOWLEDGMENTS

Thanks and appreciation go to the speakers for taking the time to prepare and present their papers. A special word of thanks goes out to the Manitoba Department of Natural Resources, especially to Mr. Frank McKinney, Superintendent, Birds Hill Nursery; Mr. Shane Tornblom, Nursery Manager, Clearwater Nursery; Mr. John Thorpe, Greenhouse Supervisor, Clearwater Nursery; and Mr. Greg Carlson, Forester with the Northern Region, for hosting an enjoyable and informative meeting. Thanks also go to the Alberta Forest Service for providing transportation for the Alberta contingent.

BUSINESS MEETING

The business section of the meeting was chaired by Eileen Harvey. The 1987 Prairie Federal-Provincial Nurserymen's Meeting will be held at Indian Head, Saskatchewan at approximately the same time. The 1988 meeting will be held at Smoky Lake, Alberta. The 1986 proceedings will be published by the Northern Forestry Centre, Canadian Forestry Service. This procedure will continue provided the proceedings can be out within one year. Papers must be submitted no later than October 15, 1986.

It was decided that the meeting should continue to be held on an annual basis. Next year the agenda will be changed to include more panel discussions and growth clinics. The host of the 1987 meeting should get the agenda out in advance. Red Rock Nursery at Prince George, other interior British Columbia nurseries, Thunder Bay Nursery, and Dryden Nursery should be invited. It is essential that these nurseries receive early invitations so that they can get permission to attend. Larry Lafleur of the Pine Ridge nursery at Smoky Lake, Alberta, voiced the opinion that to keep the meeting alive, we must key in on problems.

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