CONTAINER SEEDLING PRODUCTION: A PROVISIONAL MANUAL

by
R. G. Matthews

PACIFIC FOREST RESEARCH CENTRE
CANADIAN FORESTRY SERVICE
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DEPARTMENT OF THE ENVIRONMENT

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FOREWORD

This manual is a compendium of materials and techniques that have proven successful for growing coniferous seedlings in containers with a relatively small soil capacity. The technique could be described as "mini-container culture". It has evolved from four years of experimentation and practical growing of seedlings of British Columbia species in small containers for outplanting trials. Practically all of the work is based on greenhouse and outdoor facilities in Victoria and Duncan, on Vancouver Island. Although experience has been gained with several sizes of mini-containers, Walters' $4\frac{1}{2}$-inch bullet container has been the most commonly used test unit.

If container planting is to become a practical reforestation aid, cultural methods must be capable of mass-producing successive reproducible crops at costs competitive with those of conventional bare-root nurseries, and these crops must have the potential of a high degree of success after outplanting. Crop quality guidance has, and is being derived from the performance of thousands of seedlings planted in field trials being conducted by The Canadian and British Columbia Forest Services. As a consequence of this overall objective, biological desirability has often had to be balanced against the dictates of economic practicality. Without seriously compromising biological success, and where alternatives are available, low cost materials have been chosen ahead of costly components; materials readily available in commercial quantity and reproducible quality have been preferred to those that are more exotic or variable; simple facilities and techniques have been selected ahead of those that are more complex.

Within these limitations, the best presently available research and practice information has been incorporated into the total technique. Occasionally, however, techniques that have proven satisfactory for growing coniferous seedlings in comparatively unlimited soil volumes are not directly applicable to growing the same species in a tiny and constricted soil environment. Therefore, experimentation has been necessary to confirm or modify otherwise acceptable methods. Most of this work has been undertaken on a problem-solving basis, which is essential wherever minor changes in technique or materials are contemplated.

This manual is labelled "provisional" to emphasize that the recommendations are far from the final word in mini-container growing. Practice will demonstrate shortcomings; research will pave the way for improvements. Users of the information should diverge from the suggested procedures with utmost caution. Experience has shown that neglect of the basic plant requirements of light, moisture and nutrient can result in failure. Above all, it must be stressed that plant roots encapsulated in a mini-container cannot escape from the physical and chemical environment imposed upon them. Consequently, the impact of any deleterious substance can be disastrous. Even apparently harmless materials such as unknown water, peat or nutrient sources should be tested on small numbers of plants before being used in mass production.

Container growing has the potential of comprehensive care prescription. This manual is the first attempt to formalize a prescription for West Coast container growing of native conifers. At this stage of development, the interest and skill of the nurseryman remains highly important to success. No other single ingredient in the recipe can replace T.L.C. - "Tender Loving Care!" Beware the administrator who fails to provide or inspire this ingredient when planning container nursery production.

In formulating and testing these container methods, information and advice has been gleaned from many persons and sources. Many associates in The Victoria Forest Research Laboratory have been consulted, but the advice of Dr. H. Brix and Dr. W. J. Bloomberg is particularly acknowledged. Prescriptions are also the synthesis of testing and experimentation conducted by Messrs. C. P. Brett, E. Van Eerden and J. T. Arnott of the Liaison and Development Section. Details of this background work will be reported elsewhere. Production feasibility of the techniques has been tested through pilot container facilities built and operated in cooperation with the Reforestation Division of The British Columbia Forest Service at Duncan from 1968 to 1970. Validity of the recommendations will be put to a more rigorous test in 1971, when they will be applied to a new full-production unit of the B.C.F.S. at Surrey, B. C.

If container growing is to be undertaken in regions of more severe climate than that of the mild West Coast, facilities and schedules will have to be modified accordingly. Probably shorter growing seasons will require the use of greenhouse techniques presently practiced in Alberta and Ontario container programs. As new methods are proven in practice, and as new applications are found, it is intended that revised and expanded manuals will be prepared.

J. M. Kinghorn,
Project Co-ordinator,
Liaison and Development Section.

CONTAINER SEEDLING PRODUCTION: A PROVISIONAL MANUAL

Many aspects of the culture of container seedlings require further research and improvement. In the interim, this manual provides cultural information based on four years' experience of the Liaison and Development Section, Canadian Forestry Service, Victoria. Adherence to proven methods on all but experimental lots should result in the successful production of container seedlings.

CONTAINER TYPES

SECTION I.

1.1 Origin of Containers in Use in British Columbia.

Container seedling production has centered around variations of three basic container types.

a. The 9/16-inch diameter styrene "tube"[1/] developed in Ontario.

b. The $4\frac{1}{2}$-inch-long "bullet" container developed in the 1950's by J. Walters, Director of the U.B.C. Research Forest at Haney, B. C.

c. The B. C. Forest Service-Canadian Forestry Service (BC/CFS) Styroblock plug mould developed in 1970 by the Liaison and Development Section of the Canadian Forestry Service in co-operation with the Reforestation Division of the B. C. Forest Service. Specifications and illustrations of each container type will be found in Appendix II.

1.2 Comparison of Containers.

Since the development of the Styroblock, the use of the Ontario

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1/ A list of manufacturers and suppliers will be found in Appendix I.

tube was declined, leaving the 4½-inch bullet and Styroblock in general use.

1.2.1 Advantages of the bullet container are:

a. bullets allow sorting of blanks and culls.

b. bullets require less nursery space.

c. the uniform shape and rigidity of the bullet make it ideal for mechanical handling and planting.

d. bullets utilize a special planting "gun" which eliminates bending and increases planting rates.

e. a planter can reach through debris with a planting gun, placing seedlings in otherwise inaccessible microsites.

1.2.2 Advantages of the Styroblock are:

a. a lower per unit manufacturing cost.

b. a larger soil volume, i.e., 2½ cubic inches or about double that of the bullet container.

c. easier soil loading and top watering because soil and water are directed into cavities and cannot fall between, as is the case with bullets. Handling is easier because Styroblocks are moulded in solid units of 4 x 48 cavities.

d. the soil in the Styroblock is more protected, resulting in less evaporation from the soil in the nursery.

e. a higher quality of planting is possible. Another microsite is selected when a dibble strikes buried rock or wood, whereas the lower portion of a bullet can be unknowingly crushed on such objects.

f. a simple planting tool is used, i.e., a dibble having no moving parts.

g. higher survival and growth rates are becoming evident.

h. root growth is not impeded by the container after planting.

i. less frost heaving is expected.

SECTION II ADVANTAGES OF CONTAINERIZATION

Reforestation with container seedlings cuts costs in several areas. In the nursery, land requirements are reduced. One acre will support 2.5 million Styroblock seedlings or 3.2 million bullet seedlings. Also, a much wider choice of land is available for a nursery site, since former criteria such as the quality of the soil and the level of the water table are no longer considerations. Although considerable labor is involved in certain phases of the system at present, container seedling production could be highly mechanized, reducing labor costs. Planting costs are greatly reduced. On an incentive basis, company planting crews plant over 2000 bullets per man-day, or nearly 1800 Styroblock plugs per man-day as compared to 600-800 2-0 bare-root seedlings per man-day.

By using an artificial soil which is a homogenous and nearly sterile mixture, more uniform and reproducible seedling crops can be grown. Since soil constituents are practically devoid of nutrients, better control of nutrition is gained. Also, there can be no carry-over or build-up of insect, disease, weed or nutritional problems because fresh soil is used for each crop. Since the soil volume is limited, it can be thoroughly treated with fungicides or insecticides, and the nutrient balance can be readily altered with soluble fertilizers.

The mobility of containers allows germination to be conducted under controlled conditions with subsequent transfer into the nursery. This in turn makes germination throughout the growing season feasible, thus maximizing the use of facilities and equipment, and spreading labor intensive periods over a longer season. This kind of flexibility means that sowing dates can be scheduled according to the minimum period required to grow each species to a plantable size and quality. Where the need exists and economic factors permit, controlled environment facilities such as greenhouses may be used to grow container seedlings, plantable at any specified time of the year.

Container seedlings can be watered, fertilized or otherwise cared for during transport, or during intermediate storage at a hardening or planting site, ensuring that seedlings are in a vigorous condition at the time of planting. Since there is no physical damage to the root system due to lifting, planting shock to container seedlings is minimized.

SECTION III. SEEDLING PRODUCTION AND DEVELOPMENT OF FACILITIES

Although several other species have been grown in containers, the bulk of production has been in Douglas fir (*Pseudotsuga menziesii* var. *menziesii* Schw. Franco.), western hemlock (*Tsuga heterophylla* Raf. Sarg.) and Sitka spruce (*Picea sitchensis* Bong. Carr) for the coast; interior Douglas fir (*Pseudotsuga menziesii* var. *glauca* Mirb. Franco.), lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) and white spruce (*Picea glauca* Moench. Voss) for the interior regions.

3.1 Production to Date in British Columbia

1950's. J. Walters began annual production of experimental lots of bullet seedlings at Haney, B.C. These were grown in a lathhouse-type structure with subirrigation tanks for watering.

1967. The Canadian Forestry Service began annual production of experimental lots of container seedlings at Victoria. Seedlings were grown in a wooden frame structure covered with shade cloth. Subirrigation employed raised wooden tanks that gravity-fed the nutrient solution or water into successively lower tanks.

1968. A joint project between the B.C. Forest Service and the Canadian Forestry Service established a pilot container nursery at the B.C.F.S. nursery at Duncan. This unit produced about 100,000 bullet seedlings for experimental use.

This facility utilized plywood subirrigation tanks with plastic liners. Each tank was $44\frac{1}{2}$ inches square and held about 1500 bullet seedlings. The tanks were set on stringers and connected by means of risers to a common subirrigation line. Each of 6 subirrigation lines was filled in sequence by pumping nutrient solution from, and draining it back to a 600-gallon fiberglass reservoir. Shade cloth was supported by semicircular hoops attached to the tanks.

1969. The B. C. Forest Service doubled the capacity of the pilot nursery at Duncan, producing 200,000 bullet seedlings.

In Victoria, a new shade structure supporting a fiberglass roof was constructed. Shade cloth can be fitted over the fiberglass and around the perimeter when necessary. Plywood tanks were set into the concrete surface and connected to a subirrigation reservoir. This structure measured 22 by 88 feet and will hold nearly 175,000 bullet seedlings. It has been used in the production of seedlings for a western hemlock tree improvement program.

Also in Victoria, part of the experimental stock was grown on an asphalt surface and top-watered, using a Rain Jet square-pattern sprinkler head. Fertilizer was injected into the irrigation water with a Cameron Diluter. Superstructure was required only for shade cloth support. This method produced comparable stock while eliminating subirrigation tanks and reservoir.

1970. A second joint project with the B. C. Forest Service established a production model Styroblock nursery at Duncan. This unit produced nearly 1 million Styroblock plug seedlings. About 200,000 bullet seedlings were grown in the original subirrigation container nursery.

The surface of this Styroblock nursery was asphalt, measuring 100 by 160 feet. Eight irrigation lines laid on the surface each supplied 5-square-pattern Rain Bird sprinklers. Water flow was timed by a Rain Clox irrigation timer that controlled a solenoid valve at the head of each irrigation line. Fertilizer was injected into the irrigation system with a Hale Drug Proportioner. Shade cloth was supported by steel post and rail construction. Appendix III gives a detailed description of this

Styroblock nursery.

In Victoria, about 150,000 Styroblock seedlings and 75,000 bullet seedlings were produced in a temporary facility measuring 60 feet by 80 feet. This area had a gravel surface and four irrigation lines each supplying 3 Rain Jet square-pattern type sprinklers. Water flow was timed through solenoid valves and a Rain Clox irrigation controller. Fertilizer was injected with a Cameron Diluter. Shade cloth was supported by 4-inch square posts interconnected with heavy gauge wire. Details of a similar structure will be found in Appendix IV.

SECTION IV GROWING MEDIA

4.1 Media Descriptions

The soil medium used until 1969 was California "C" as described in The U.C. System for Producing Healthy Container-Grown Plants (Matkin and Chandler 1957). The mix was 50% fine sand and 50% fine peat moss with dry fertilizers added.

The 1970, all stock was grown in a mix consisting of 3 parts commercial peat moss to 1 part horticultural grade vermiculite. The reasons for changing mixes were the weight advantage of the peat-vermiculite, and the lack of a consistent grade and quality of fine sand. Also, bullets to be filled with California "C" must first receive about ½ inch of peat to prevent the California "C" from sifting or washing out of drainage holes at the bottom of the bullet.

4.2 Weight Comparison of California "C" and 3 Peat: 1 Vermiculite

Weight of 1 cubic foot (Dry Volume) - lb.

	Dry	Moist	Saturated	Water Gain
1 peat: 1 sand	54	64.5	84	30
3 peat: 1 verm-iculite	8.5	28.5	47.5	39

1 Styroblock (192 cavities) filled with water saturated media weighs:

1 peat: 1 sand - 27 lb.

3 peat: 1 vermiculite - 15 lb.

4.3 Preparing Soil

The peat moss should be a fine grade containing as little coarse material as possible. Since the acidity of peat moss will vary depending on its source, this should be determined and adjusted to about pH 5, by the addition of appropriate amounts of Dolomite lime during mixing.

The mixing area and tools should be washed down and rinsed with a bleach solution. Dilute commercial bleach (5% available chlorine) at 1 quart to 3 1/8 gallons to give a .47% solution (Baker, Roistacher and Chandler 1957).

For each cubic yard required, mix 3 bales (5.6 cu ft each) of commercial peat, 7½ pounds of Dolomite lime (12 mesh and finer) and 2 bags (4 cu ft each) of horticultural grade vermiculite. Avoid stepping on vermiculite as it will crush. Mix a few ounces of Soil Wet in hot water and add it to the medium as water is introduced. Continue adding water until excess can just be squeezed from the medium. Pass the medium through a soil shredding machine or silage blower for final mixing. Store the medium in covered bins or cover piles with polyethylene sheeting.

The current cost of soil materials is about .08 cent per Styroblock cavity.

4.4 Soil Loading

If large numbers of cavities are to be filled, soil loading machines must be constructed (Appendix V). One man can load about 80,000 plug cavities or 30,000 bullets per day by using this machine.

Plug cavities should be filled to within ¼ inch of the rim. Excess soil encourages some species to extend lateral roots into adjacent cavities. Also, disease organisms may spread through these soil bridges.

Soil compaction will be uniform if the water content of the medium is constant during loading. A good standard is the ability to squeeze a small amount of water from the medium. The time required on the loading machine is usually just over one minute.

Evenness of compaction across the block is ensured by having an excess of soil above all cavities during loading, particularly the edges and corners. With some experience, the operator can judge when loading is complete and further loading time is ineffective. Excess soil is removed as blocks are taken out of the machine.

A properly loaded block will be evenly compacted and contain no air pockets. Soil compaction should be as light as possible without allowing subsequent compaction when cavities are top-watered to saturation and undergo normal handling.

SECTION V SEEDING

5.1 Seed Sorting.

It is important to obtain the highest germination rate possible from each seed lot by sorting on a gravity table or by air separation of heavy and empty seed. The germination rate should then be determined and a decision made to single or double sow each seed lot. A small percentage of blanks is more acceptable than a large percentage of multiple seedlings. Since our field trials show that multiples are often co-dominant, the policy has been to clip to singles in the nursery. This is a costly, labor intensive operation which must be replaced by careful seed selection or perhaps by some form of pre-germination.

Seed used by the B. C. Forest Service for containers in 1971 will be the heaviest 10 or 20% separated on a gravity table. The bulk of the seed is returned for conventional nursery use.

A table of seed numbers per unit weight is given in Appendix VI.

5.2 Pre-germination Treatment

5.2.1 Stratification

Coastal and interior Douglas fir, and Sitka spruce seed are soaked for 24 hours and then drained of excess water. Western hemlock seed is soaked for 36 hours before draining. The seed is then sealed in small plastic bags and placed in a refrigerator regulated at 2°C, for approximately 3 weeks. Seed can be surface dried to prevent sticking together during sowing, but should not be allowed to dry more than is necessary.

5.2.2 Light Treatment For Lodgepole Pine and White Spruce Seed

The time required for stratification can be saved with some species by replacing stratification with a light treatment. Lodgepole pine and white spruce seed are soaked for 24 hours, drained, sown and exposed to an extended photoperiod similar to that described for lodgepole pine and jack pine by Ackerman and Farrar (1965).

Sown cavities can be covered with polyethylene sheeting to maximize humidity if care is taken to control temperature build-up. A more satisfactory method is to maintain high humidity, using portable humidifiers. A high seed moisture content is essential for white spruce during germination (Waldron and Cayford 1967).

The seeds are exposed to an 18-hour photoperiod with incandescent light at about 150 foot-candles. Higher light levels during the day will not affect germination as long as high humidity is maintained. Optimum temperatures are 70°F constant, or a daily range of 60°F to 80°F. After 5 days, the seeds are covered with #2 Granite Grit.

If a light treatment is impractical for these two species, as with large numbers of seedlings, regular stratification methods should be employed.

5.3 Seeding Methods

Prior to 1970, seeding was done manually or with simple vacuum seeding devices.

All BC/CFS stock in 1970 was sown mechanically with a prototype seeding machine developed by the Canadian Forestry Service. Precision seeding with this device proved too slow for large-scale container seedling production.

A new seeding machine, designed and constructed by the Department of Agricultural Engineering of the University of British Columbia (under contract to CFS), is now undergoing operational testing. The vacuum seed selection principle has been employed in an automatic seeding machine capable of seeding 30,000 Styroblock cavities per hour, and also in manual devices for smaller seeding requirements. Specifications of both these seeding devices will be available when initial tests are completed.

5.4 Seed Cover

Seed is covered with #2 Granite Grit after sowing. This technique follows the practice of the Northwestern Pulp and Power Ltd. tubeling nursery at Hinton, Alberta (Carmen 1967). Larger seeds such as Douglas fir are covered to a depth of about $\frac{1}{4}$ inch, and smaller seeds such as western hemlock, just deep enough to cover. During germination, grit aids penetration of the radicle and maintains a high humidity around the seed. In the nursery, grit provides physical protection from large water droplets and forms a mulch which keeps the soil surface relatively free of moss and algae.

Most of the particles in #2 Granite Grit range in size from 2 to 4 mm in diameter.

SECTION VI GERMINATION

6.1 Artificial Germination Environments

Artificial germination environments produce higher, more uniform germination rates than can be obtained outdoors in March or April. The practice also adds length to the growing season, valuable in the production of one-year-old planting stock. This is especially true for western hemlock, which may not be plantable as plugs at the end of one growing season without this treatment.

In 1970, at Duncan nursery, the cone-drying kiln was temporarily converted to a germination chamber. The temperature was maintained at 70°F. The humidity was increased by a row of misting heads at floor level. Styroblocks were stacked after being placed on pallets and moved by fork lift. Douglas fir and Sitka spruce required about 6 or 7 days in the germinator, while western hemlock required 8 to 10 days.

Once germination has been initiated as evenly as possible, the germinants must be moved outside. Since light is not provided in the germinator, germinants quickly become too elongated. This elongation must be avoided, since it results in very weak seedlings or may even cause death through dessication of the lower part of the stem once the germinants have been moved to a less humid atmosphere. Some frost protection should be available, if required, when germinants are moved outside.

6.2 Disease During Germination

Serious damping-off has not occurred during germination, probably due to the acidity (Peace 1962) and low microbial populations of the soil mix (Bloomberg 1971).

Fungicides are not used on seed or during germination. Tests conducted by Liaison and Development Section, C.F.S., Victoria, attributed failure of the radicle to penetrate the soil, and seedling deformation to applications of the fungicides Captan 50W and Arasan before or during germination. No damage occurred after germinants were erect and seed coats had dropped.

Similar damage by fungicides during germination has been reported by Waldron and Cayford (1965).

SECTION VII CULTURAL TECHNIQUES

7.1 Shade

Germinants of all species concerned require partial shade. Provide 46% shade for western hemlock, Sitka and white spruce, and 30% shade for interior and coastal Douglas fir and lodgepole pine. Saran shade fabric is available in these and other degrees of shade. The shade cloth should be removed later in the season to condition seedlings to full sunlight before planting out, or to avoid a snow load on the shade cloth.

Shade cloth also protects germinants from birds, reduces wind velocity in the nursery and provides some forest protection.

7.2 Irrigation

Provide an irrigation system with sufficient water flow and sprinkler head capacity to deliver a precipitation equivalent of 0.5 inch of water to all Styroblocks in a reasonable period of time. The capacity for effective frost protection must also be built into the system, i.e., the ability to deliver 0.1 inch of water per hour to all seedlings, with a cycling time not exceeding one minute.

Bullet containers can be top-watered in the same manner as Styroblocks but, because water can fall between bullets, they will require 3 to 4 times as long to become saturated. The easiest method of watering seedlings in the bullet container is through subirrigation. The advantages, however, must be weighed against the additional expense of subirrigation tanks and plumbing accessories.

Containers should not be watered on a fixed schedule, but rather as required by the seedlings. Bullet seedlings must be watered more frequently because of the smaller soil volume and increased exposure to evaporation. With either container, the need for watering will be dictated by the condition of edge plants.

A heavy top-watering with plain water must be conducted every two weeks for the purpose of leaching. This prevents the build-up of any fertilizer salt to a toxic level. To leach effectively, provide at least one inch of water to all containers on each occasion. The importance of this procedure is emphasized by Baker (1957).

To retain the wetting ability of the peat, introduce Soil Wet through the irrigation system on a monthly basis. One-half gallon of Soil Wet in 2500 gallons of water is an adequate treatment.

7.3 Nutrition

Dry fertilizers are no longer incorporated into the soil medium because of the difficulty of evenly distributing small amounts of fertilizers throughout a large soil mass. The nutrient content of the soil could then be highly variable when divided into the small volumes required for containers. However, calcium and magnesium are provided by adding Dolomite lime to alter the pH level. Other nutrients are injected into the irrigation water at each watering, beginning immediately after germination. All fertilizer concentrations refer to a dry weight of fertilizer dissolved in a stock solution and injected into each 100 Imperial gallons of water.

To continue supplying high levels of nitrogen during the period of rapid growth in mid-summer and to reduce the amounts of other elements contributing to high soil salinity, 28-14-14 Plant Prod is alternated with other nitrogen sources. For Sitka spruce and western hemlock, ammonium sulphate is the alternate nitrogen source. For coastal Douglas fir, ammonium nitrate is preferred.

In nutrition tests, ammonium sulphate has been a satisfactory alternate nitrogen source for white spruce, but it has not been applied on a large scale to container-grown white spruce. Conventional nurseries find an advantage in using ammonium sulphate on white spruce beds (van den Driessche 1969).

Ammonium sulphate is no longer applied to lodgepole pine, as it has resulted in serious foliar damage on a few occasions.

Interior Douglas fir is raised using only Plant Prod. It is not known if applications of ammonium nitrate would be of benefit.

The rate of fertilizer application increases from 2.5 to 5 oz per 100 gallons during the growing season in all species except coastal Douglas fir. Good quality Douglas-fir seedlings were grown in 1969 at the 2.5 oz level, and increased rates have not resulted in increased seedling quality. Root dieback problems in coastal Douglas fir may also be related to higher soil salinity associated with increased fertilizer rates.

The fertilizers used contain the following elements:

	Major Elements-%			Trace Elements lb. per ton						
	N	P	K	B	Cu	Fe	Mn	Mo	Zn	S
28-14-14 Plant Prod.	28	14	14	.6	.1	.8	1.2	.06	.3	
15-15-30 Plant Prod.	15	15	30	.8	.05	.6	.9	.02	.28	
Amm. nitrate (34-0-0)	34									
Amm. sulphate (21-0-0)	21									X

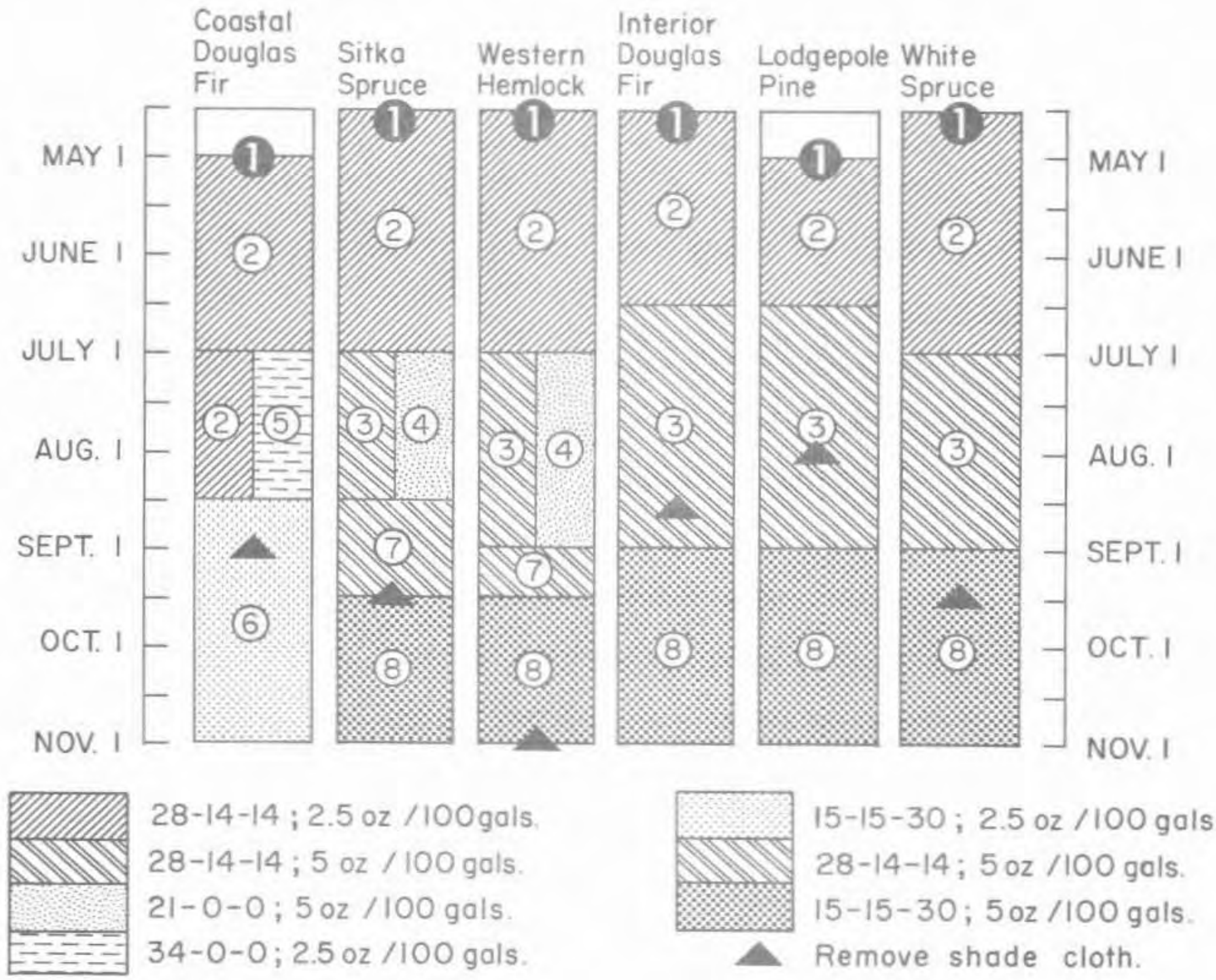
B - boron
Cu - copper
Fe - iron
Mn - manganese
Mo - molybdenum
Zn - zinc
S - sulphur
X - present

7.4 Cultural Schedule for Container Seedlings in a Coastal Nursery

a. General: Begin seeding in the latter part of March or early April in order to obtain plantable plug seedlings at the end of the growing season. Germinate all species in a controlled environment, with the possible exceptions of coastal Douglas fir and Sitka spruce. After germination, provide 46% shade for western hemlock, Sitka and white spruce, and 30% shade for interior and coastal Douglas fir and lodgepole pine. Provide sprinkler frost protection during early spring and autumn.

Fertilize at each watering, which will be 2 or 3 times per week during hot weather, less during cooler or rainy weather. After heavy rains, fertilizer should be applied. Discontinue fertilization at the end of October or at the onset of heavy rains and cold temperatures. Occasional fertilization through the winter may be of benefit.

During the nursery phase, apply Captan as a spray, on a monthly



Procedures:

❶ Latest sowing date recommended to provide for fall planting.

(2) Place germinants in the nursery under shade and begin applications of 28-14-14 Plant Prod at 2.5 oz /100 gallons with each watering.

(3) Increase 28-14-14 Plant Prod to 5 oz /100 gallons.

(4) Begin alternating applications of 28-14-14 Plant Prod with ammonium sulphate (21-0-0) also at 5 oz /100 gallons.

(5) Begin alternating applications of 28-14-14 Plant Prod with ammonium nitrate (34-0-0) each at 2.5 oz /100 gallons.

(6) Cease applications of ammonium sulphate. Replace 28-14-14 Plant Prod with 15-15-30 Plant Prod at 2.5 oz /100 gallons.

(7) Cease applications of ammonium sulphate. Replace with 28-14-14 Plant Prod at 5 oz /100 gallons as in (3).

(8) Replace 28-14-14 Plant Prod with 15-15-30 Plant Prod at 5 oz /100 gal.

basis, if possible. Make regular inspections for insect or disease problems. Conduct a thorough leaching every two weeks to avoid excessive soil salinity.

Dates given for changes in cultural techniques may vary with the provenance, season and sowing date.

b. Cultural problems

As noted in the cultural example for Victoria 1970, in Appendix VII, the white spruce was brought into a greenhouse on June 10 to prevent imminent bud set. This has been a recurring problem with white spruce in Victoria. Perhaps the problem is not nutritional, but due to other variables which can trigger bud set (Roche 1970).

Although stock is generally acceptable, the balance and sturdiness of some species could probably be improved through nutrition and spacing. Coastal Douglas fir, for example, often grows too tall and fails to set buds before October. Ideally, Douglas fir would set buds about the end of August, and the remainder of the season would be used for wood and root production. The best coastal Douglas fir produced to date has been grown at lower fertilizer levels (2.5 oz/100 gal).

Nutrition could also be involved in acquiring earlier frost hardiness, so that frost protection systems would be less critical and stock would be free of frost danger after early fall planting.

The possible benefit to container seedlings from mycorrhizal associations in the nursery has yet to be investigated.

7.5 Disease, Insect and Weed Control

a. Disease

The best protection against disease problems is good nursery practice. First, ensure that the water source for the nursery is clean. Maintain sanitary conditions during soil mixing, loading, seeding and germination phases. Keep the soil level in Styroblocks low enough that soil-borne diseases cannot spread. Provide adequate ventilation under containers so that roots will not extend onto the nursery surface and contact disease organisms.

Apply a monthly spray with the fungicide Captan 50W as a precaution (Peace 1962). Mix one tablespoon of Captan 50W in each gallon of water required. Stir occasionally during use, as Captan will settle out of suspension. Two gallons of Captan mix applied with watering cans will cover 100 square feet of container surface. Captan seems able to control Fusarium spp. fungi, which is responsible for damping-off.

Other disease organisms likely to be encountered and not controlled by Captan are Pythium spp. and Botrytis spp. The following are examples of disease problems that have been identified:

An outbreak of Pythium spp. was identified in Sitka spruce Styroblocks in 1970. Infected seedlings were wilting and had rotten roots. This disease is mainly transmitted by water-borne spores and could spread rapidly in tanks using subirrigation.

The fungicide Dexon, recommended for Pythium spp. by the manufacturer, was not applied, as the infection was limited and did not appear to spread easily in Styroblocks. Dexon has not been used previously, and large scale applications should be preceded by thorough testing.

Botrytis cinerea (gray mould) has been found on several occasions on western hemlock and Douglas fir. It occurs when foliage becomes thick and remains damp for long periods. It generally is located on lower, dead foliage where high humidity is maintained. There is a gray mould visible on affected parts.

The best prevention is to separate thick foliage to provide better aeration, and attempt to keep foliage drier. According to Peace (1962), Thiram can be used as a preventative, but once established, no fungicide has been found effective.

b. Insects

At Duncan in 1970, an infestation of the noctuid *Peridroma saucia* in Styroblocks was the first serious insect problem encountered in container seedling culture. The insecticides Dibrom and Malathion 800 were applied unsuccessfully. The problem was eliminated after spraying with the Carbaryl base insecticide Sevin 50W at 2 tablespoons per gallon. The subsequent disappearance of noctuids may have been the result of natural pupation.

c. Weeds

Weeds in containers and around the nursery should be pulled as they appear. Weeding a container nursery does not require much labor but it must be done regularly. Seedlings will be lost if fast-growing weeds are allowed to dominate.

7.6 Root Pruning

The design of the bullet container and the Styroblock incorporate a curved inner wall near the bottom which guides roots to the drain holes. The roots dry off as they emerge, and pot binding is eliminated. This process can only function if adequate ventilation is provided under the container. Containers placed directly on gravel or asphalt surfaces will soon extend roots into these surfaces.

For adequate ventilation, containers should be elevated on pallets. Pallet construction is described in Appendix III-3.

7.7 Frost Protection

Some frost protection can be provided by shade cloth. For species that continue growing late in the season such as western hemlock, shade cloth should be retained until after the first few frosts of autumn.

Nutrient control will probably be an important method of achieving frost hardiness earlier in the season. At present, this control has not been achieved, making sprinkler frost protection an essential part of the nursery design.

The sprinkling system is thermostatically set to provide frost protection (34°F). According to Wolfe (1969), two criteria must be met for successful protection. First, the sprinklers must deliver sufficient water to maintain a coating of free water on all ice-covered plants, i.e., 0.1 inch per hour with intervals not exceeding one minute. Second, the sprinklers must remain on until the air temperature is above freezing and will remain so, or until all ice is melted from the plants.

Seedlings in Styroblocks are not extractable when the soil-root plug is frozen.

7.8 Overwintering

A portion of the container-grown coastal Douglas fir has suffered root die-back in each of three winters in Victoria. In September or October, 1970, root damage occurred to part of the western hemlock grown in Styroblocks at Duncan. Western hemlock foliage may die, or may remain green when some live root is present in the upper part of the container. Douglas-fir foliage generally appears healthy, and root-damaged plants have been used unknowingly in spring plantings. Root damage is typified by a dark brown outer layer that easily strips from the woody portion of the root.

Damage is possibly caused by freezing temperatures alone, or by excessive soil salinity, water or fertilizers.

Root damage to container-grown plants in horticultural nurseries has been attributed to frost killing of roots, which are much more sensitive than the stem or foliage (Lanphear 1971). These and other factors are presently under study to determine the cause of root die-back in container grown Douglas-fir seedlings.

The best precaution seems to be to remove stock from tanks with poor air drainage before the first frost. Seedlings on pallets should have adequate air drainage around them. Avoid hollows, or areas with obstructions to free air drainage, as these will form frost pockets (Geiger 1965).

Root systems of other species seem resistant to damage, as many container seedlings have been successfully overwintered.

SECTION VIII PREPARATION FOR PLANTING AND TRANSPORT

8.1 Preparation

Each Styroblock is molded in 4 units of 48 cavities each, for economy of production and ease of handling in the nursery and during transport. The joints between the units must be weakened to ease separation in the field, so the planter can attach one 5 x 14-inch unit to the planting belt. The best method for doing this is to construct a frame that supports three heavy gauge resistance wires. These #16 gauge nickel-chromium resistance wires are positioned to cut between the units and at a height above a base which will allow the Styroblock to be cut to within 1 inch of the top surface. Guided by corner posts, the Styroblock is lowered over the electrically heated wires, which melt the plastic to within 1 inch of separation. The wires can also be mounted on a rigid frame and moved up through the block from below. After cutting, the Styroblocks are still strong enough for transport, yet they can be easily broken into units in the field.

The three 22-inch cutting wires are joined in series to a 25-volt transformer of 500 VA capacity. The high capacity transformer is necessary as the circuit draws about 16 amperes at 20 volts. The wires should be spring-tensioned to hold them straight and taut as they heat and move through the block.

If #16 gauge resistance wire is not available, the same effect can be obtained by braiding together two strands of #20 gauge wire.

8.2 Transport

Trucks have been equipped with braces bolted to inner walls.

The ends of 2 x 6-inch boards are fitted into these braces as the truck is filled. Styroblocks, supported by these 2 x 6 boards, are stacked in layers. A 3-ton truck will carry about 50,000 Styroblock seedlings in this manner.

During hot weather, it may be necessary to arrange air scoops to force air into the truck. Occasional stops for water spraying will also help control temperature.

Another method is to construct frames that hold tiers of Styroblocks on pallets. These are loaded onto an open truck with a fork lift.

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APPENDIX I

Manufacturers and Suppliers

The following list of products is for the convenience of those establishing a container nursery and is based on products with which we have gained experience. No endorsement of these products or sources is implied, nor is disapproval implied of similar products or sources not mentioned.

1. Ontario tube.
   Building Products of Canada Ltd.,
   Acton, Ontario.

2. Walters' bullet container and plastic holder.
   Columbia Plastics Ltd.,
   2155 West 10th Ave.,
   Vancouver 9, B.C.

3. BC/CFS Styroblock
   Beaver Plastics Ltd.,
   12806 - 63rd Street,
   Edmonton, Alta.

4. Saran shade fabric

   Harry Sharp and Son Greenhouse Eqpt.
   609 Eastlake East,
   Seattle, Washington 98109, U.S.A.

   or 620 Malkin Street,
   Vancouver 4, B. C.

   or Ickes-Braun Glasshouses (Can.) Ltd.,
   90 Bartlett Road,
   Beamsville, Ontario.

   or Nurserymen's Exchange,
   475 Sixth Street,
   San Francisco, California 94103, U.S.A.

5. Plastic subirrigation tank liners. 42 x 42 x 4 inches.
   Cameo Plastic Products Ltd.,
   20412 Locke Avenue,
   P.O. Box 947,
   Langley, B.C.

6. Fiberglass reservoir.
   Versatile Fiberglass Mfg. Co. Ltd.,
   5447 Rocky Point Rd., R.R. #1,
   Victoria, B.C.

7. Rain Jet sprinkler head. Model RJ 66 25 x 25 feet square pattern
   Irrigation system suppliers.

8.	Rain Bird, Rain Clox. Model RC-8 sprinkler system controller. Rain Bird sprinkler head, 25 x 25 feet square pattern	Rain Bird Sprinkler Mfg. Co. (Canada) Ltd. 1391 William Street, Vancouver, B.C.
9.	Cameron Diluter.	Nursery supply catalogues.
10.	Hale drug proportioner.	Alfred A. Rudolph and Sons, 26 Evelyn Avenue, Vineland, N.J.
11.	The U.C. System for Producing Healthy Container-grown Plants.	Agricultural Publications, University Hall, University of California, Berkeley, California 94720, U.S.A.

$1.00 is payable to the Regents of the University of California.

12.	Peat moss.	Western Peat Moss Ltd., Box 399, New Westminster, B.C.
		or Garden supply centres
13.	Horticultural grade vermiculite	Terra-lite Brand, Grant Industries.
		or Garden supply centres
14.	Dolomite lime.	Green Valley Fertilizer and Chemical Co. Ltd., North Surrey, B.C.
		or Garden Supply Centres.
15.	Soil shredding machine	Nursery Supply catalogues,
		or Equipment rental agencies.
16.	Granite grit #2.	Valley Granite Products Ltd., Chilliwack, B.C.
		or Feed and seed suppliers.
17.	28-14-14 Plant Prod. 15-15-30 Plant Prod. Soil Wet.	Plant Products Co. Ltd., 70 Wesley Avenue, Port Credit, Ontario.
18.	Ammonium nitrate (34-0-0) Ammonium sulphate (21-0-0)	Garden supply centres.
19.	Dibrom, Malathion, Sevin 50W, Dexon, Thiram, Captan 50W.	Garden supply centres.

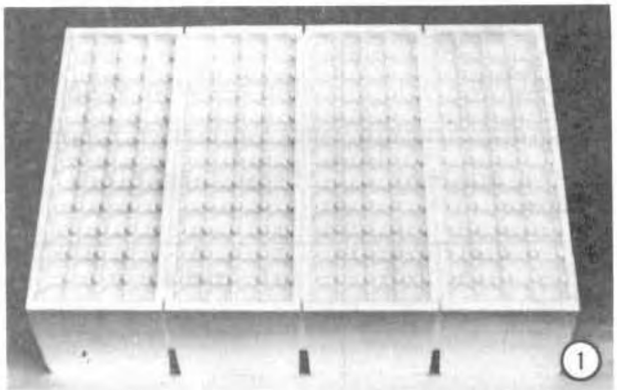
APPENDIX II

DATA RELATING TO CONTAINER TYPES

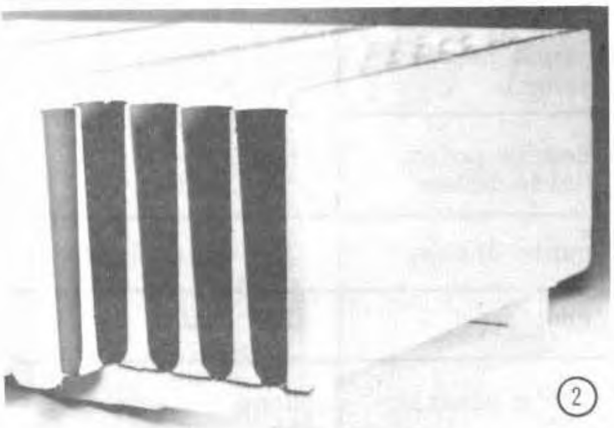
	Tube	Bullet	Styroblock Plug
Material	Extruded styrene	Injection moulded styrene	Styrofoam block
Length	3 inches	2.5, 3.5, 4.5, 5.5 inches	4.5 inches
Diameter at top	9/16, 3/4 inch	3/4 inch	1 inch
Taper	None	.035 inch per inch length	.070 inch per inch length
Bottom	Open	Rounded to point with side holes	Rounded to 3/8 inch hole
Volume	.6 cubic inch	1.2 cubic inches	2.5 cubic inches
Cost per cavity	.3 cent	1.2 cents	.75 cent*
Holder	Re-usable plastic	Re-usable plastic	None
Holder cost	90 cents*	35 cents	-----
Holder or block size	8½ x 14 x 2½ inches	5 3/8 x 10 13/16 x 3 3/4 inches	14 x 20¼ x 5 5/8 inches
Cavities per holder	200-300	50	192
Space per cavity	.6 square inch	1.16 square inches	1.47 square inches
Trees/square foot**	242	125	98
No. filled/cu yard of soil	75,000	36,000	18,000
Planted with	Dibble	Gun	Dibble
Planting rate/ day	2000	2000+	1500+

* sliding price scale depending on number ordered.

** exclusive of walkways.



1. Four units of 48 cavities each, are moulded as one Styroblock.

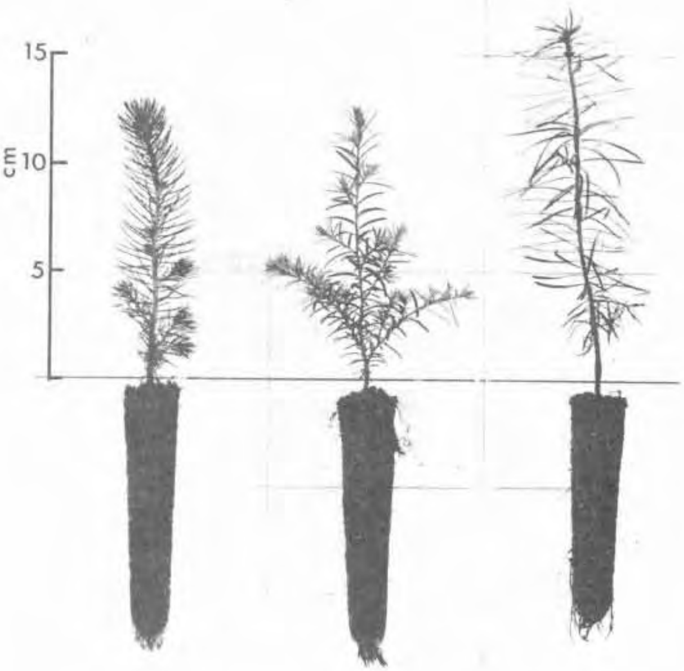


2. Cross section of cavities showing the taper which allows seedlings to be extracted easily.

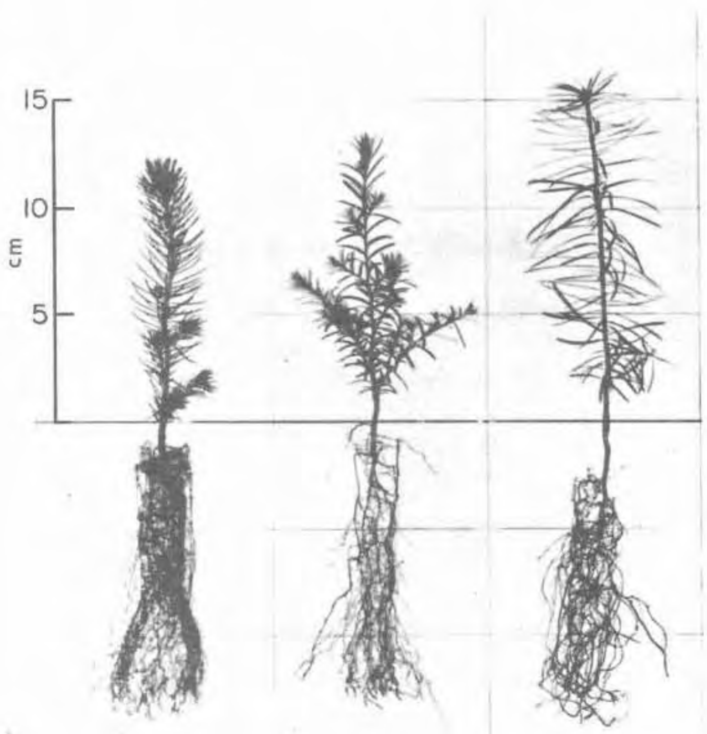
3. Sitka spruce seedlings grown in a Styroblock at Duncan nursery, 1970.

1. Fifty bullet containers and plastic holder.

2. Lodgepole pine seedlings grown in bullet containers.



1. One-year-old sitka spruce, western hemlock and Douglas fir plug seedlings.

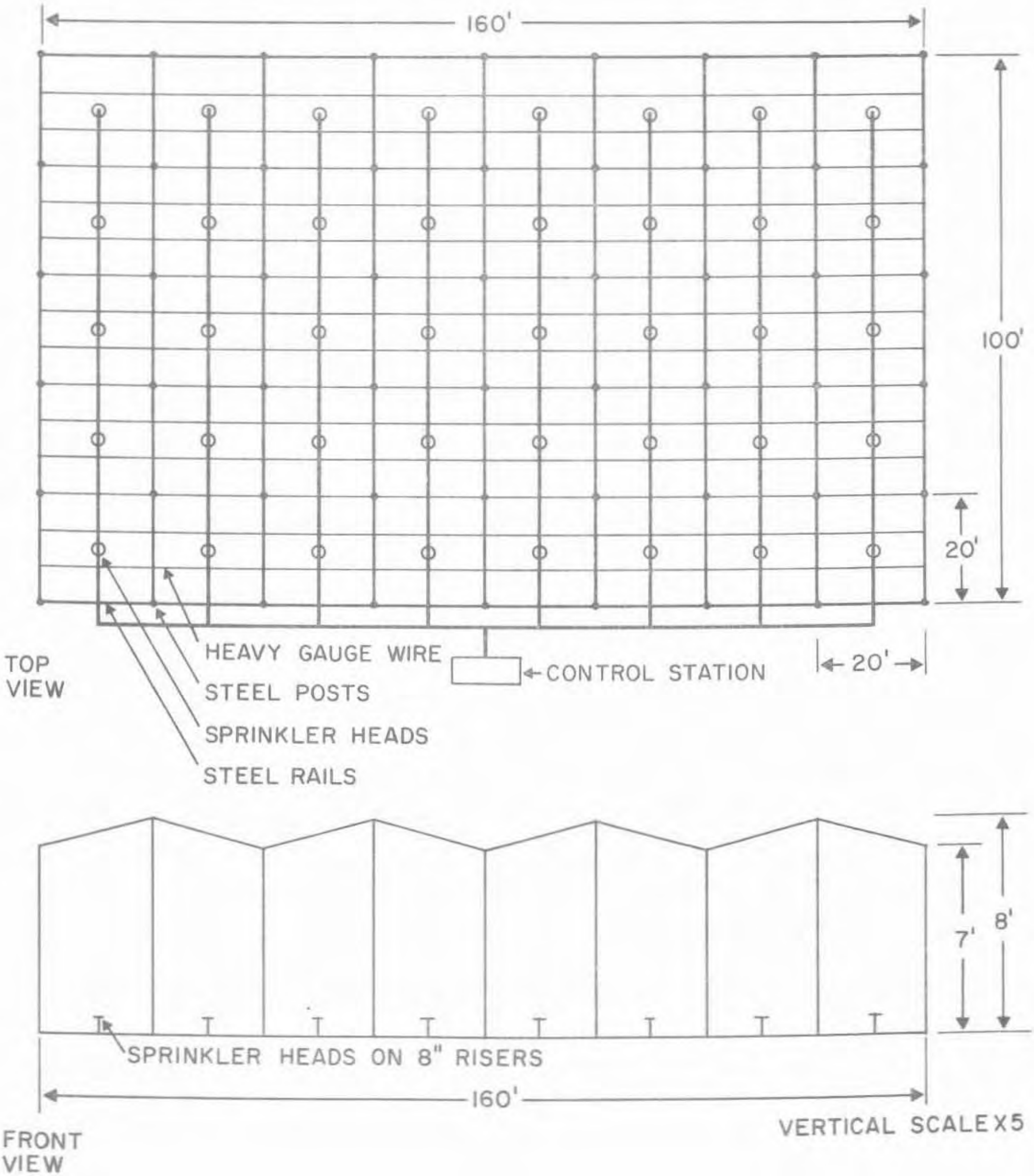


2. The same seedlings as in (1) with soil removed, showing root development.

APPENDIX III

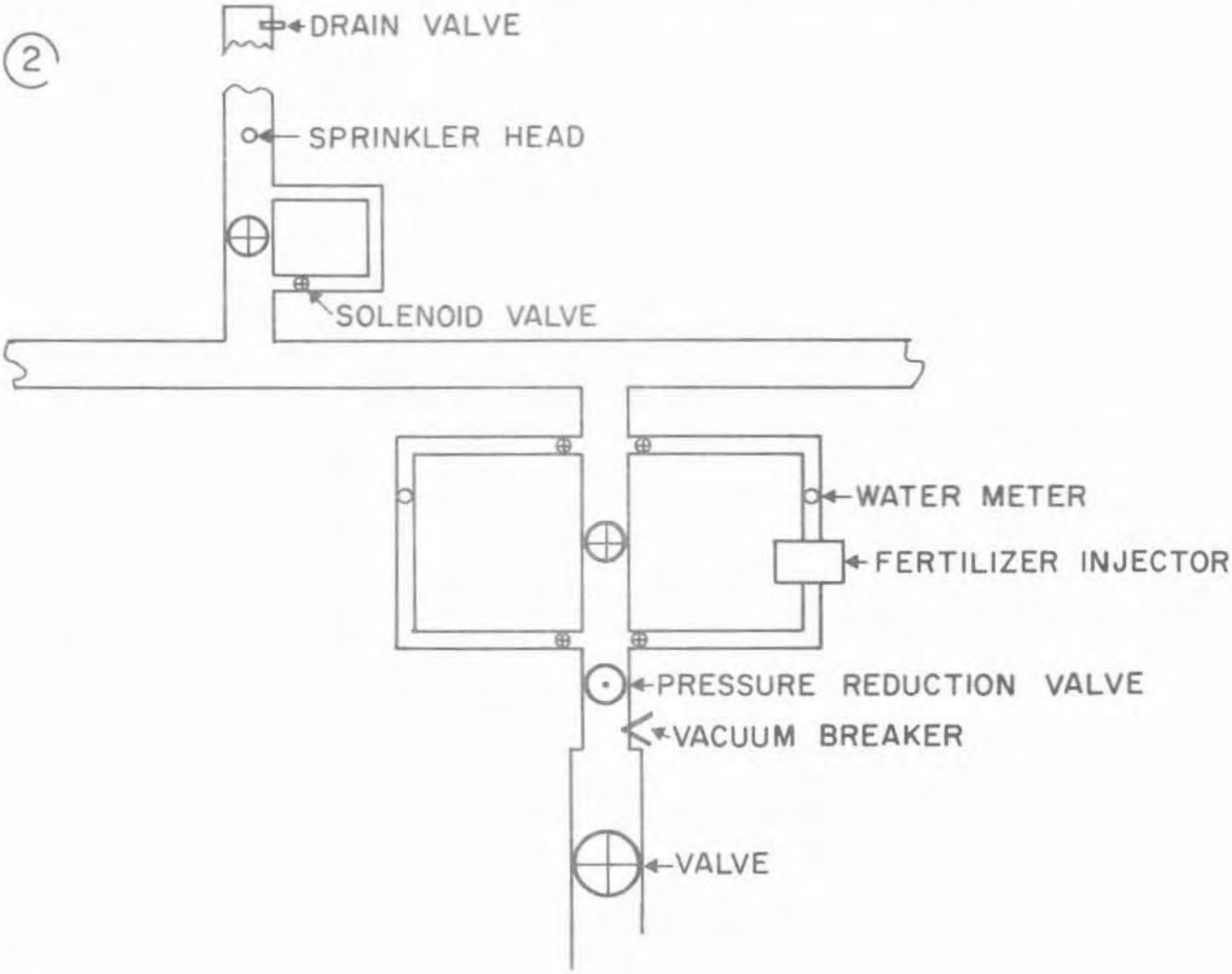
DIAGRAM AND DESCRIPTION OF DUNCAN STYROBLOCK NURSERY, AND PALLETS

(1) DUNCAN STYROBLOCK NURSERY

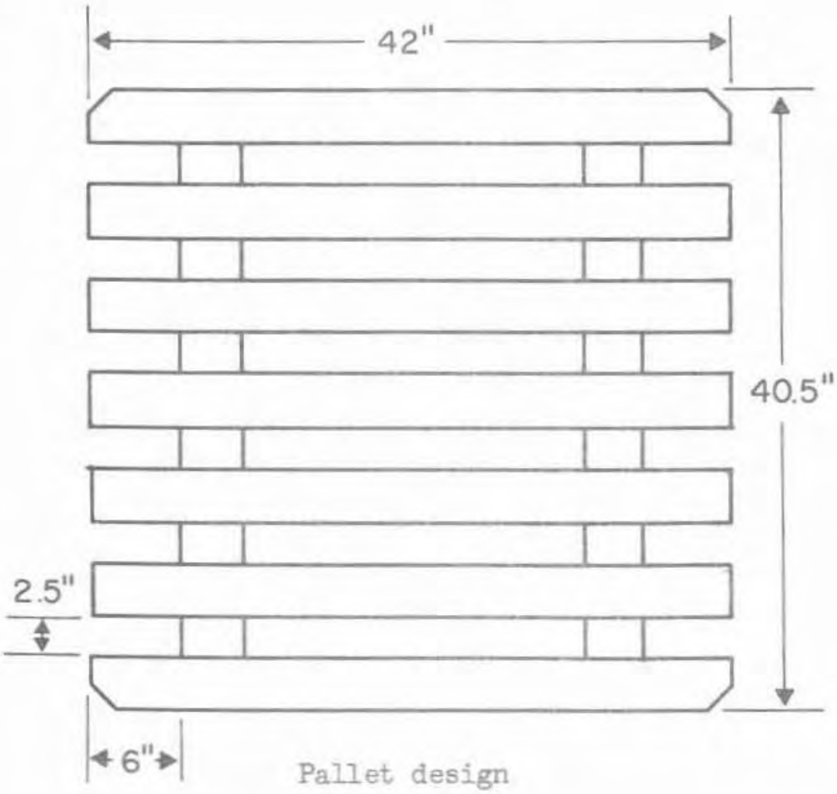


Detail of the irrigation system of the Duncan Styroblock nursery.

(2)



(3)



Pallet design

Duncan Styroblock Nursery Design (Figure 1)

Dimensions: 100 feet by 160 feet. Area .37 acre.

Capacity: 1 million seedlings in Styroblocks.

Surface: Asphalt, which is graded 6 inches in each direction from the centre of the nursery.

Module size: 20 feet square, containing 25,000 trees and serviced by 1 sprinkler head.

Shade support: One- and one-half-inch steel posts were erected at 20-foot spacing after the asphalt was laid. Perimeter posts were set in 3 feet of concrete. Interior posts were set in 18 inches of concrete. The staggered height of the posts (8 feet and 7 feet) was an attempt to control where dripping might occur. Since rain seemed to come through shade cloth without collecting and dripping, a future nursery would probably have all posts at an 8- or 9-foot level.

Steel top rails joined the perimeter posts and interior posts across the width of the nursery. Top rails were drilled and pinned to their aluminum connectors. Heavy gauge wires spaced at 6 2/3 foot widths, ran the length of the nursery and were clamped to the top rails. All wire ends were taped, and bolts were positioned to prevent snagging shade cloth.

Shade cloth: Shade cloth was purchased in 8 sections, measuring 20 feet by 100 feet, with grommets installed every 18 inches around the edges for wiring the shade cloth to the top rails. Two pieces of shade cloth 8 feet by 100 feet covered the ends of the nursery and 4 pieces 8 feet by 80 feet covered the sides.

The manufacturer recommends allowing 3% extra length for shrinkage.

Duncan Styroblock Nursery Irrigation System (Figures 1 and 2)

Plumbing: A 3-inch main is supplied to the nursery. A vacuum breaker is installed so that, in the event of negative water pressure, fertilizer or insecticide will not be drawn back into the city water supply. Such a device is required by some municipalities. A pressure reduction valve, next in the line, allows control of water flow for optimum sprinkler coverage. A valve at the control station can be used to supply pure water to the seedlings or, when closed, it can divert water through the two water meters and the fertilizer injector. At present, these lines are 3/4-inch hose. Water flow then goes to a $1\frac{1}{2}$-inch pvc header pipe which supplies 8, $1\frac{1}{2}$-inch pvc laterals. Each lateral has a valve that can be opened manually, but is usually closed to divert flow through a 1-inch galvanized pipe. In this pipe is a solenoid valve controlled by a Rain Clox model RC-8 irrigation timer at the control station. The end of each lateral is equipped with a valve that opens in the absence of water pressure, enabling laterals to drain when not is use. This minimizes problems that might occur with nutrient water stagnating in pipes.

Sprinklers: Five sprinkler heads are mounted on each lateral on 8-inch risers. Each Rain Bird square pattern type head covers one module, 20 feet square. These heads give a rather uneven coverage, being heaviest at the corners and lightest near the sprinkler. Standard circular pattern oscillating nursery heads may give more even coverage if used in an overlapping design; however, this introduces the problem of keeping sections discrete if species requiring different fertilizers are adjacent.

Fertilization: Operating at 50 p.s.i., each line of 5 sprinklers distributes 100 gallons of water in 5.2 minutes. A stock solution of fertilizer is prepared by dissolving the weight of fertilizer required per 100 gallons into the amount of fluid introduced by the injector in the 5.2 minutes. At Duncan, the injector introduced 25.5 oz. in 5.2 minutes. If 2.5 oz. of fertilizer are dissolved in each 25.5 oz. of stock solution, fertilizer will be applied at 2.5 oz. per 100 gallons. If 65 oz. of fertilizer are dissolved in 4.1 gallons, sufficient stock solution is available to fertilize each of the 8 lines for 15-20 minutes each. The total amount of water used is 2500-3000 gallons.

The timing of irrigation is controlled by a Rain Clox model RC 8 irrigation system controller. The controller operates the solenoid valve on each line in sequence, giving a range of applications from 30 seconds to 30 minutes. The controller can be set to operate automatically at any time.

Part of the Western hemlock section of the Styroblock nursery at Duncan, 1970.

Pallet Design (Figure 3)

The pallets are constructed of 1 x 4 cedar, and 2 x 4 cedar. Thirty-two 2-inch galvanized nails are required for each pallet. If a large number is to be made, a jig should be constructed. Each pallet supports 6 Styroblocks.

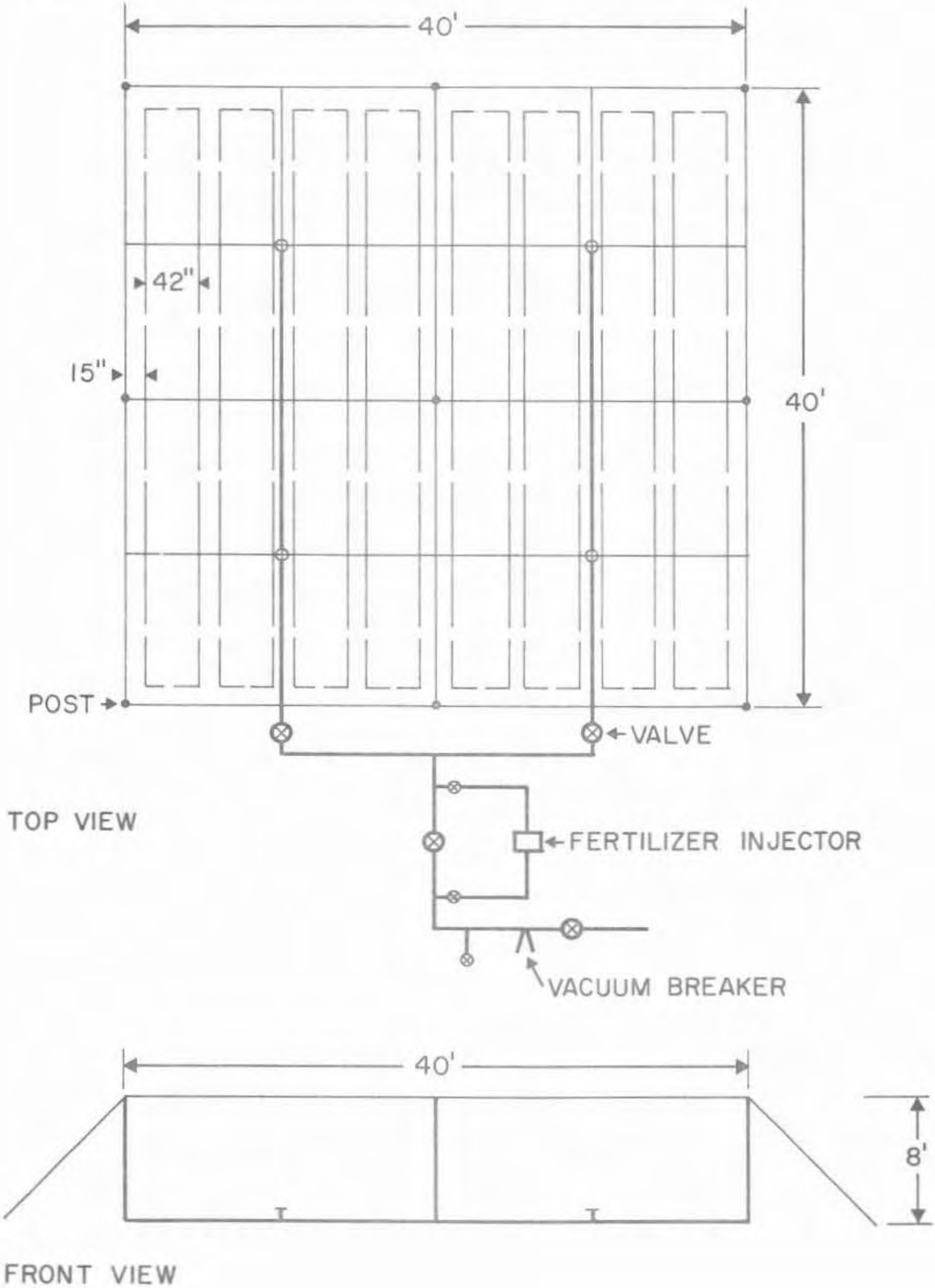
If pallets are placed so that 2 x 4's run across the row, ventilation underneath will probably be adequate. If pallets must be placed with 2 x 4's parallel to the row to facilitate handling with a fork lift, then the air will become trapped as 2 x 4's are butted together. In this case, it will probably be necessary to set each pallet on 2 x 4 cleats to gain adequate ventilation under the blocks for root pruning. This increase in height should be compensated for by putting sprinkler heads on 12-inch risers instead of 8-inch ones.

Pallets constructed with 2 x 4's on edge may provide better ventilation under the pallet.

APPENDIX IV

MINIMAL COST CONTAINER NURSERY FOR 100,000 STYROBLOCK SEEDLINGS

(4) Diagram of a minimal cost container nursery.



Minimal Cost Nursery Design (Figure 4)

Site: The area should be open to the sun and have good water drainage. If wind protection can be gained without blocking sunlight and air drainage, it will be an advantage (Geiger 1965). A domestic water supply or clean water source must be available.

Surface: A satisfactory surface can be made by grading and rolling about 6 inches of coarse, clean gravel. In all pathways except where irrigation lines run, 2 x 12-inch boards are used for walks.

Dimensions: The size of the nursery is 40 feet square, with guy wires extending another 6 or 8 feet on each side. Pathways are 15 inches, with the center aisle being 24 inches.

Capacity: Each line contains 11 pallets holding 66 Styroblocks or 12,672 seedlings. The total area holds 528 Styroblocks or 101,376 seedlings.

Shade cloth support: Nine 4 x 4-inch cedar posts are spaced at 20 feet and set in 2 feet of concrete, leaving 8 feet above the surface. Heavy gauge wire connects the top of the posts and is anchored to the ground outside the nursery. Additional wire can be run diagonally to prevent shade cloth from sagging in the centre of the modules. Wire around the perimeter at ground level will provide an anchor to which the lower edge of the side shade can be tied.

Shade cloth: This nursery will require 2 pieces, 20 feet by 40 feet, and 4 pieces, 8 feet by 40 feet. Grommets should be installed every 18 inches on the perimeter of each piece.

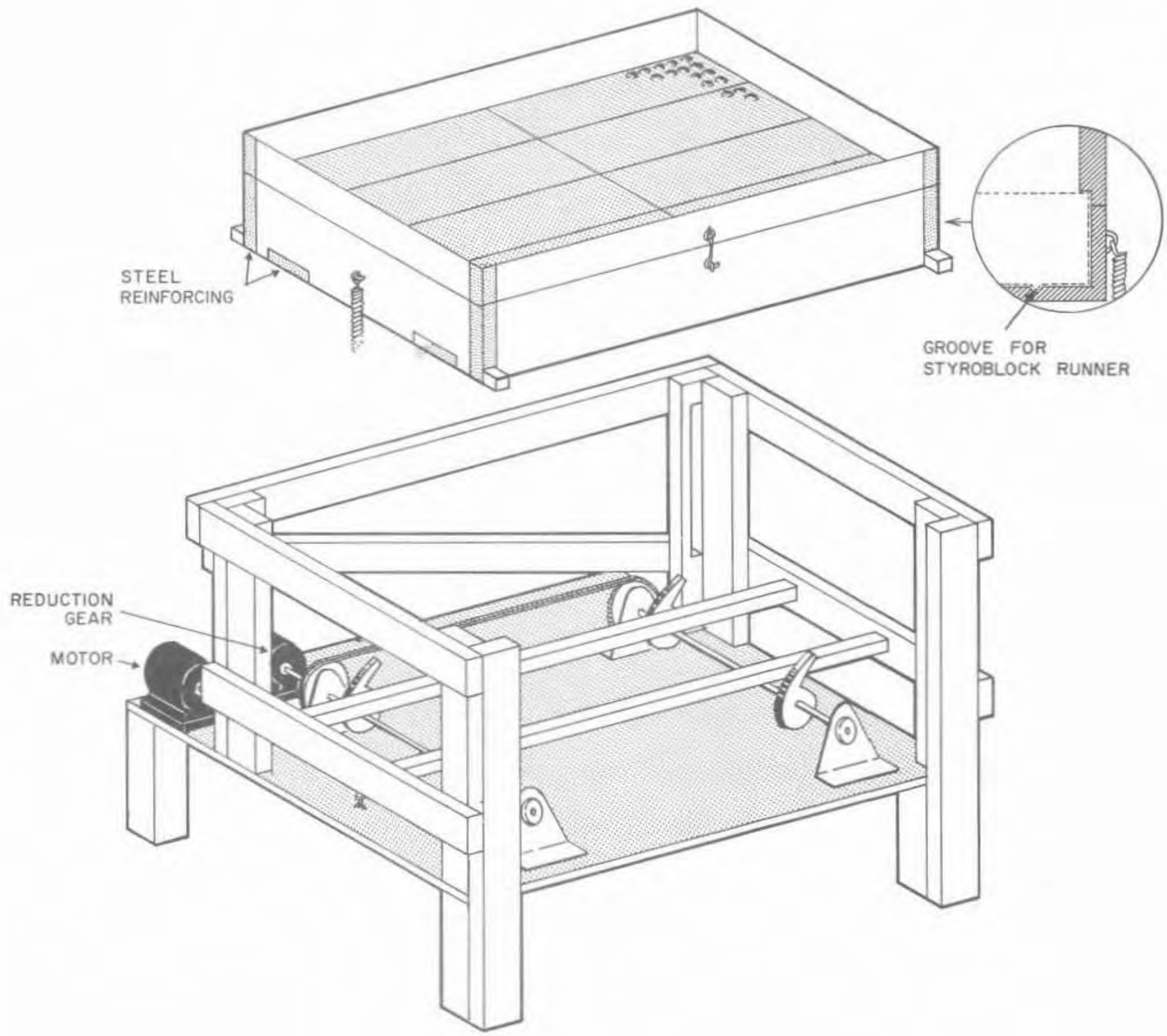
Irrigation: The two irrigation lines are $1\frac{1}{4}$-inch pvc, with 2 square pattern Rain Jet heads mounted on 12-inch risers on each line. Manually operated valves at the base of each line allow each section to be given different fertilizers if two species differing in nutrition requirements are desired. Fertilizer can be injected with a 2-gallon capacity Cameron Diluter.

Materials: - 30 yards coarse, clean gravel.

- 9 cedar posts, 4 by 4 inches by 10 feet.
- 2 by 12 boards, 280 feet.
- heavy gauge wire, 1000 feet.
- shade cloth, 2 pieces, 20 by 40 feet, 4 pieces, 8 by 40 feet.
- Cameron Diluter, 2-gallon capacity.
- 4 Rain Jet square pattern sprinkler heads.
- 100 feet of $1\frac{1}{4}$-inch pvc pipe, fittings.
- 4 risers of galvanized pipe 3/4 inch by 12 inches.
- galvanized pipe at control station.
- 7 valves and various fittings.
- 1 vacuum breaker.
- 88 pallets.
- 528 Styroblocks costing about $1,160 or 1.15 cents per cavity.
- soil mix of peat and vermiculite.

Capital costs exclusive of land for this nursery are about 3 cents per seedling based on a single crop.

A temporary shade facility at Victoria showing germinants in Styroblocks and bullets.



APPENDIX V

A SOIL LOADING MACHINE

Figure 5. The major components of a soil loading machine.

No other principle of soil loading has worked as well as a vertical, banging motion with an excess of soil supplied above the cavities.

The machine, first developed by H. Yerex, Canadian Forestry Service, Victoria, consists of a base, rotating cams, and a box restricted to vertical motion by a frame.

The base is constructed of 4 x 4's, 2 x 4's and 3/4-inch plywood. On the base is mounted an electric motor and reduction gear resulting in about 45 r.p.m. Two steel axles are mounted above the base and are supported by pillow block bearings. At the ends of the axles furthest from the operator, sprockets are welded and the two axles connected and synchronized by chain drive. A second sprocket on one axle connects it to the reduction gear.

Four cams are cut from 3/8-inch plate steel. Each is shaped to have an even, gradual rise and about a 3-inch sudden drop per revolution. The axles and cams are positioned and synchronized to drop each corner of the box simultaneously, and then the cams are welded to the axles.

The framework positions the box and restricts it to vertical motion. Part of the frame stops the downward motion of the box before it strikes the cams. The downward velocity of the box is increased by connecting the base and each side of the box with a door spring.

The plywood box can be constructed to hold 10 trays of bullets with an adapter reducing the inside dimensions for 2 Styroblocks, or to the exact dimensions of 2 Styroblocks. For either container, the bottom of the box should have grooves positioned to allow individual containers to contact the bottom of the box during loading. The lower edges of the box have replaceable steel sections for the cams to ride on. All corners of the box are steel reinforced. The upper part of the box is a hinged fence that holds the

Styroblocks in position and contains the excess soil. The fence should be locked in position during loading. When loading is complete, the fence is lifted and excess soil scraped from the surface of the containers.

A soil hopper is positioned behind the loading machine so that the operator can pull soil down onto the containers in the box.

Oneman can load about 80,000 Styroblock cavities or 30,000 bullets per day on this machine.

APPENDIX VI

SEED NUMBERS PER GRAM AND OUNCE

(Western Forest Tree Seed Council, 1966)

Species		Number of seeds per gram[2]	Number of seeds per ounce[2]
Douglas fir - coastal	P. menziesii	95	2630
Douglas fir - interior	P. menziesii var. glauca	85	2380
lodgepole pine	Pinus contorta	225-300	6400-8440
ponderosa pine	Pinus ponderosa	25	750
Sitka spruce	Picea sitchensis	465	13100
western hemlock	Tsuga heterophylla	655	18600
western larch	Larix occidentalis	315	8940
white spruce	Picea glauca	405	11500

2. These figures refer to unsorted seed. If the heaviest fraction of seed is chosen for container use, the figures can only be used as a guide.

APPENDIX VII

CULTURAL EXAMPLES

The following are examples of nutritional combinations that have resulted in the production of acceptable stock.

a. 1970 Victoria

Container:	Bullets and Styroblocks.
Species:	Interior Douglas fir, lodgepole pine, white spruce.
Germination:	Greenhouses and growth chambers with an 18-hour day length provided for lodgepole pine and white spruce.
Nursery:	Gravel surface.
Irrigation:	Sprinklers with fertilizer injected at each watering. Bullets watered to saturation about 3 times per week, Styroblocks 2 or 3 times, decreasing to once a week after September.
Shade:	Douglas fir and lodgepole pine - 30%. White spruce - 46%.

March - stock sown.

May 14 - Fertilization started at 2.5 oz/100 gallons 28-14-14 Plant Prod.

June 1 - 28-14-14 Plant Prod. was increased to 5 oz/100 gallons.

June 10 - The white spruce was brought into a greenhouse to prevent buds from setting. These seedlings were returned to the nursery between August 7 and 25.

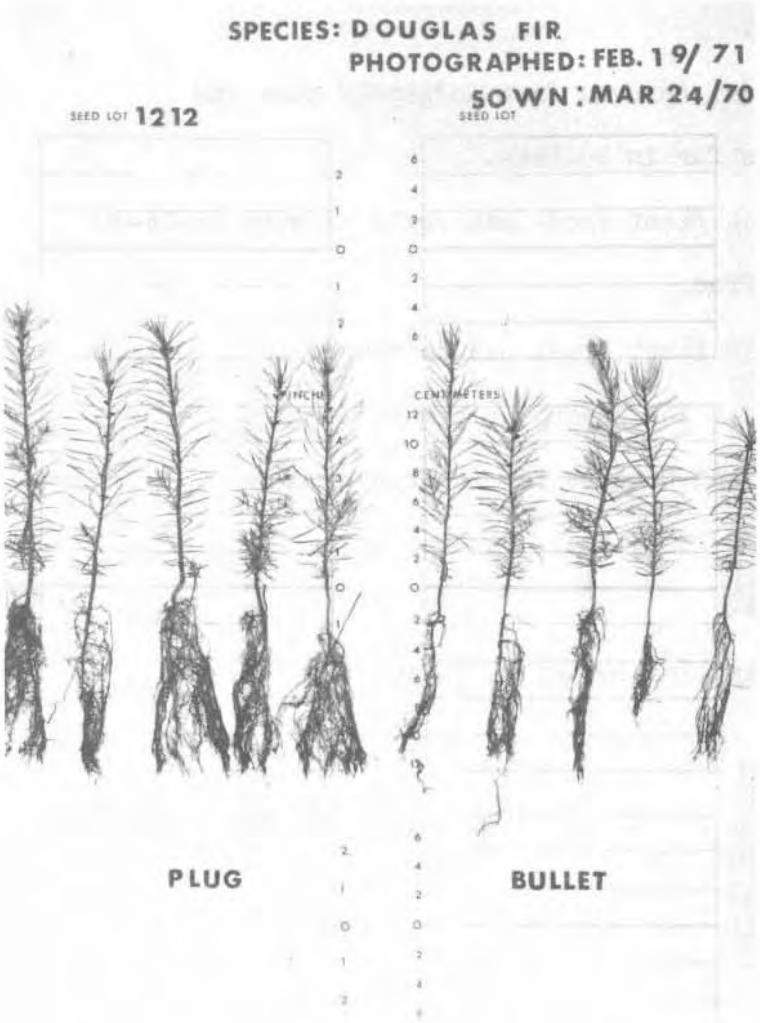
July 27 - Shade was removed from lodgepole pine and Douglas fir in bullets.

August 25 - 28-14-14 Plant Prod. was replaced with 15-15-30 Plant Prod.

September 8 - 15-15-30 Plant Prod. was decreased to 2.5 oz/100 gallons. The shade was removed from white spruce and Douglas fir in Styroblocks.

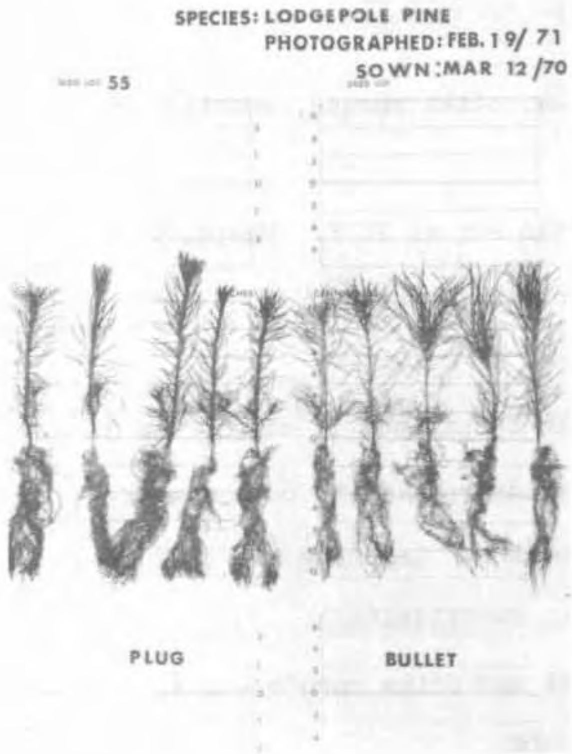
October 14 - 15-15-30 Plant Prod. was increased to 5 oz/100 gallons.

October 26 - Final application of 15-15-30 Plant Prod.



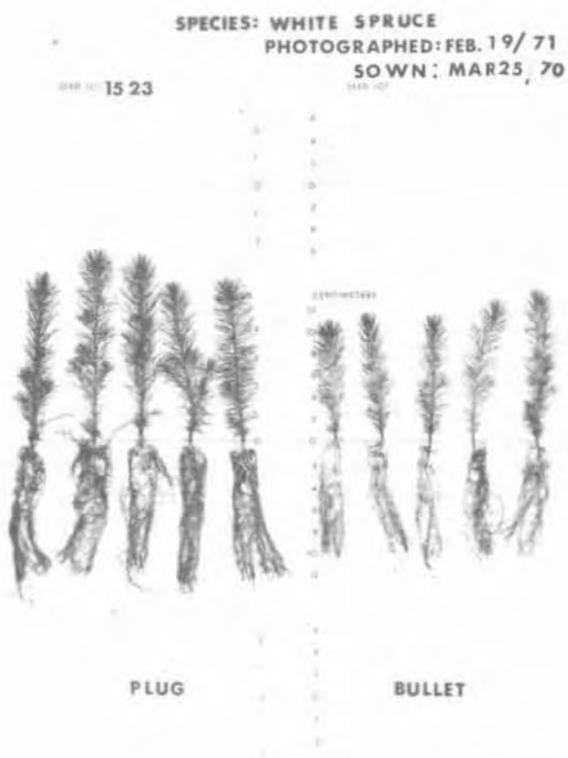
Interior Douglas fir sown March 24, 1970 and photographed Feb. 19, 1971.

- well balanced plants.
- average height 5 to 6 inches.
- good wood production.



Lodgepole pine sown March 12, 1970 and photographed Feb. 19, 1971.

- well balanced plants.
- average height 5 to 6 inches.
- good wood production.



White spruce sown March 25, 1970 and photographed February 19, 1971.

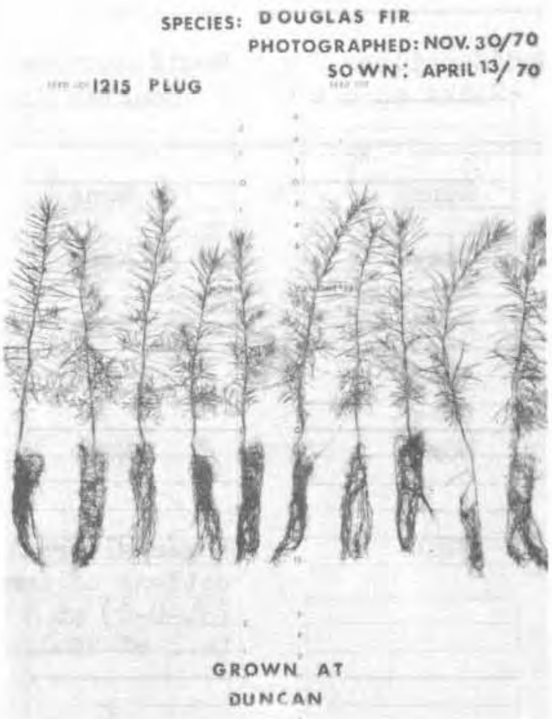
- average height 4 to 6 inches.
- good wood production.

b. 1970 Duncan Styroblock Unit

Container:	Styroblocks.
Species:	Western hemlock, Sitka spruce, coastal Douglas fir.
Germination:	Cone-drying kiln set at 70°F. Humidity increased with misting heads.
Nursery:	Asphalt surface.
Irrigation:	Sprinklers with fertilizer injected 2 or 3 times per week, decreasing to once a week after mid-September. Leaching was conducted weekly prior to fertilization.
Shade:	Western hemlock and Sitka spruce - 46%. Douglas fir - 30% Side shade - 46%

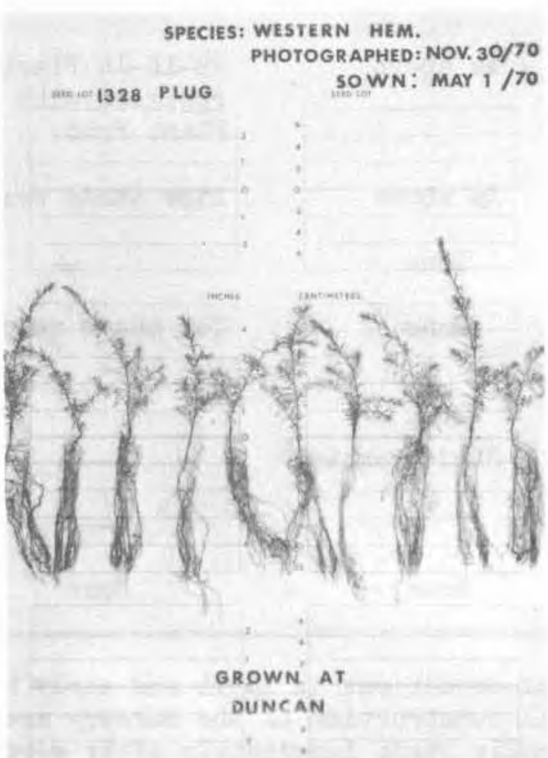
Date	Standard Treatment Western hemlock	Modifications for Sitka spruce	Modifications for Douglas fir
April	Stock sown	None	None
May 15	Moved into nursery	None	None
May 21	Fertilization started at 2.5 oz/100 gal, 28-14-14 Plant Prod.*	None	None
July 6	28-14-14 Plant Prod increased to 5 oz/100 gal	None	None
July 10	Began alternating 2 applications of ammonium sulphate (21-0-0) at 5 oz/100 gal to 1 application of 28-14-14 Plant Prod.	None	Began alternating 2 applications of ammonium nitrate (34-0-0) at 5 oz/100 gal to 1 of 28-14-14 Plant Prod.
July 27	Changed to 1 application of 21-0-0 to 1 of 28-14-14 Plant Prod.	None	Changed to 1 application of 34-0-0 to 1 of 28-14-14 Plant Prod.
July 31	As above	21-0-0 discontinued	34-0-0 discontinued.
Aug. 12	As above	As above	28-14-14 Plant Prod replaced with 15-15-30 Plant Prod.
Aug. 13	As above	As above	Side shade removed.
Aug. 14	21-0-0 discontinued	None	—
Sept. 4	28-14-14 Plant Prod replaced with 15-15-30 Plant Prod.	None	Top shade removed.
Sept. 11	As above	Shade removed	—
Sept. 18	Shade removed	—	—
Oct. 16	Final application 15-15-30 Plant Prod.	None	None

* Stock was germinated under artificial conditions in April and early May and was held in temporary areas until construction of the nursery area was completed. Fertilization would normally begin immediately after germination, since there are few nutrients in the soil mix.



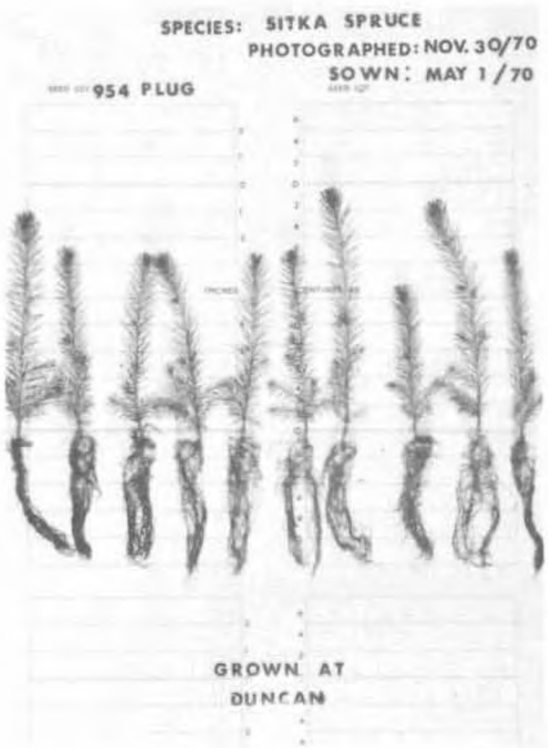
Douglas fir sown April 13, 1970 and photographed Nov. 30, 1970.

- generally tall and spindly with the exception of one seed-lot.
- average height 6 to 8 inches.
- wood production inadequate due to inability to cease height growth and achieve bud set before October.



Western hemlock sown May 1, 1970 and photographed Nov. 30, 1970.

- generally well balanced plants with root systems forming adequate plugs.
- average height 5 to 6 inches.
- good wood production late in season.



Sitka spruce sown May 1, 1970 and photographed Nov. 30, 1970.

- generally good but some too tall for good balance (8 inches +).
- root systems formed good plugs.
- average height 5 to 7 inches.
- fair wood production late in the season.