JAPANESE PAPERPOTS FOR CONTAINERIZED PLANTING OF TREE SEEDLINGS. I. TOOLS AND EQUIPMENT

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IMPORTANT NOTE

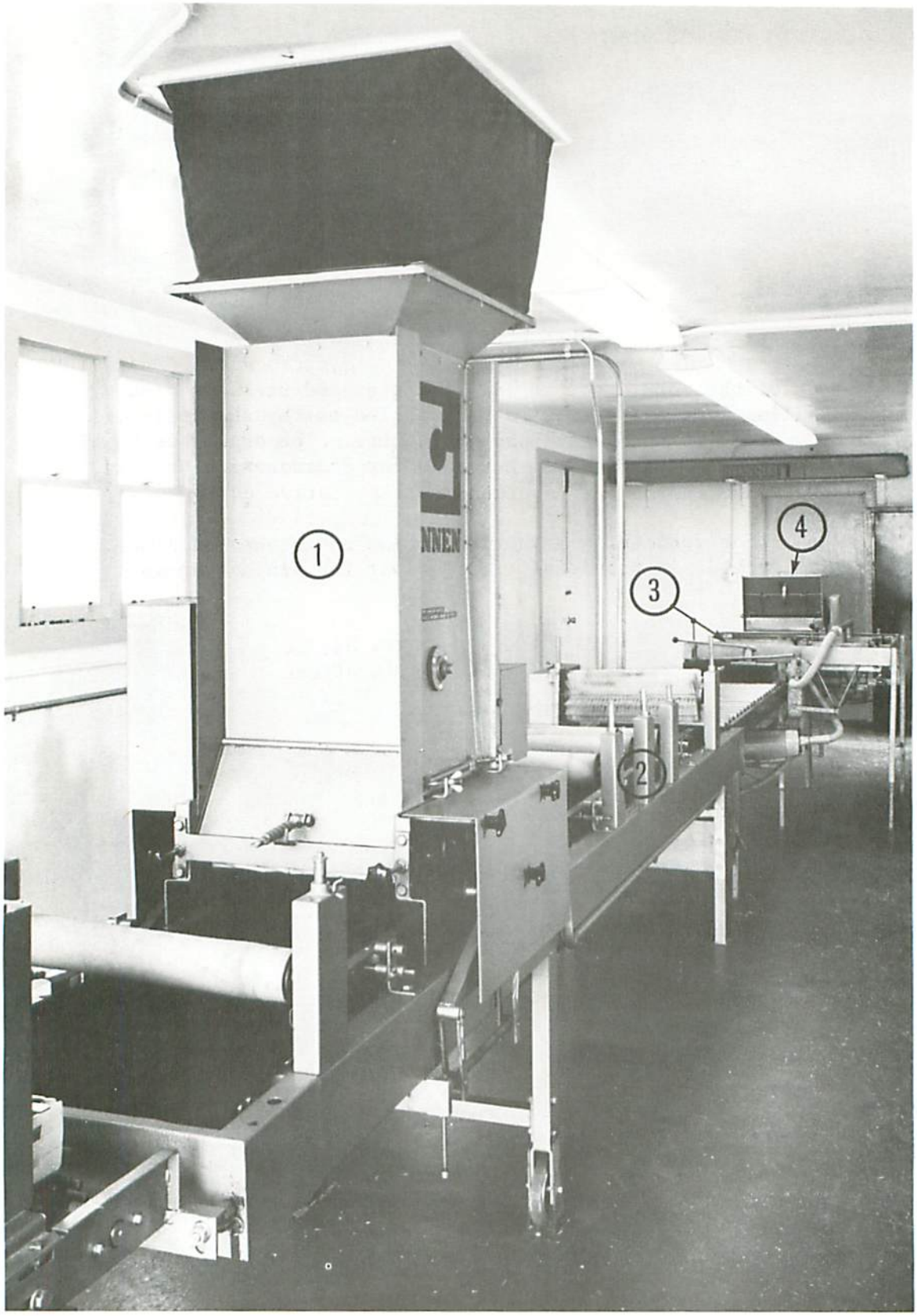
This report provides an introduction to a container system which is, for the most part, new to Canada. The intent, in the absence of detailed commercial literature, is to provide a description of the equipment available, together with brief notes on installation requirements and operation.

The description of commercial equipment in this report is for information only. No endorsement of the paperpot system or individual products is intended and none should be inferred.

ACKNOWLEDGEMENTS

Much of the work involved in setting up and preparing the paperpot filling line for operation was carried out by the engineering staff of the Great Lakes Forest Research Centre. The author is indebted to Mr. W.M. Ferguson and Mr. W.A. McDonald for coordinating and executing this work.

The author gratefully acknowledges the assistance of Kimberly-Clark of Canada Ltd. in providing tissue paper for lining paperpot trays.



Frontispiece. General view of paperpot filling line: (1) soil hopper, (2) vibrator table, (3) sowing machine, (4) sanding unit.

ABSTRACT

The Great Lakes Forest Research Centre has recently initiated trials to evaluate the biological and economic effectiveness of the Japanese paperpot system for use in Ontario. This report describes equipment that is being used, in the production of paperpot seedlings, for loading and seeding paperpots, together with some observations regarding its installation and operation. Alternative equipment, suited to small-scale production facilities, and planting tools are also described.

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INTRODUCTION

The involvement of the Great Lakes Forest Research Centre in container-planting research dates from 1967 when biological investigations, utilizing the 9/16-in. (1.42-cm) diameter "Ontario" split-plastic tube, were initiated in the White River District. Although these studies have now been largely terminated, the Centre has a continuing interest in the use of containerized planting stock for reforestation, particularly in the context of developing a fully mechanized container production and planting system for the boreal forest. Although the development of mechanized planting systems is being stressed, such systems are not likely to become a reality for a number of years, and the continuing requirement for a hand planting system is clearly recognized. It is logical, therefore, that future efforts in containerized production be directed to packages and techniques that are compatible with both hand and machine planting.

The principal requirements of a package are that it should be easy to handle, amenable to mechanized production, relatively cheap, and biologically acceptable. Some sacrifice in biological performance may be acceptable to achieve savings in cost or improved productivity, provided that there is no reduction in the effectiveness of regeneration. The main criticism of the plastic tube container has been its non-biodegradeability, and the possible effects this might have upon root development, tree stability, etc. Although the plastic tube does present a barrier to the early development of a normal rooting system, we have found no evidence to suggest that it presents a serious, long-term biological hazard, and our present opinion is that any temporary adverse effects are an acceptable compromise in return for a rigid, easily handled container. However, the results of investigations into the effects of container size upon seedling growth have clearly demonstrated the desirability of increasing diameter from 9/16 in. (1.42 cm) used in Ontario to a minimum of 1 1/4-1 1/2 in. (3.17-3.81 cm) (Scarratt 1972a). Unfortunately, adoption of larger plastic tubes would increase costs considerably and, on balance, consideration of alternative packages appeared desirable.

A critical assessment of those container systems which appear to have any practical forestry application has suggested that the Japanese paperpot is potentially the most suitable present alternative to the plastic tube for use in eastern Canada. Although attractive, the plug concept is considered unsuitable for eastern conditions owing to the inability of spruce and pine to develop a cohesive root plug within the production periods normally adopted for these species. In general, some form of enveloping package is essential to give support to the rooting medium--preferably one which will not prevent root egress after planting. By contrast with plastic tubes, the paperpot is biodegradeable; yet, when properly filled with growing medium, it appears to retain sufficient strength to withstand fairly rigorous handling. Moreover, it is available in a wide range of sizes and is relatively cheap

when compared with plastic tubes of equivalent dimensions. Biologically, the paperpot has been very successful in Scandinavia, where large numbers have been planted in recent years.

The decision to proceed with trials of the Japanese paperpot was made in late 1972, and since that time seedling production facilities have been installed, including a paperpot filling and sowing line. The aforementioned trials will consist of three series of closely related studies: (1) operational planting trials, (2) an economic assessment of the paperpot system in relation to bare-root planting, and (3) related biological studies aimed at specific problem areas. In the context of seedling production, demonstration and evaluation of the loading/seeding system will be an important feature of the project.

On the basis of earlier work, it is planned to use the size 308 paperpot (1.17 in. or 3 cm diameter x 2.96 in. or 7.6 cm deep) both for the operational planting trials and for other investigations. However, in some situations a larger container may be more desirable and the necessary machine parts have been obtained to permit loading and seeding of the size 408 (1.56 in. or 4 cm diameter) paperpot also.

This report describes equipment and facilities installed at the Great Lakes Forest Research Centre for the production of paperpot seedlings, with some observations on equipment installation and operation.[1] A wide range of loading and seeding equipment is available to suit the needs of different sizes of operation, and some of the alternative equipment is described here for the guidance of potential users. It is emphasized that the identification and description of commercial products in this report is for information only; no endorsement is intended and it should not be inferred. Prices are quoted for comparative purposes only, to provide an indication of the costs of setting up paperpot production facilities on various scales. Potential purchasers should refer to the respective suppliers (Appendix I) for up-to-date prices.

CONTAINER AND TRAYS

1. *The Japanese Paperpot*

Developed in Japan for agricultural use, paperpots are made of specially prepared paper and are delivered in space-saving folded sets (Fig. 1) which are then expanded for filling and sowing. When a set is

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[1] Details of the growth facilities (greenhouse, heating, irrigation) are not included since the scale of production here is not comparable with that of fully operational situations.

fully opened it has a honeycomb appearance and, since there is no space between individual pots, it provides maximum utilization of growing space.

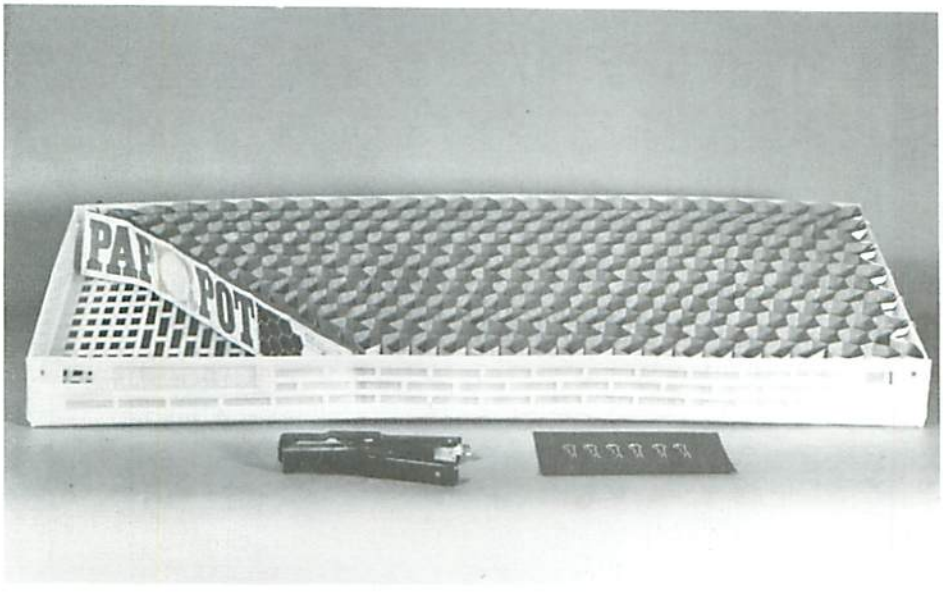

Fig. 1. Paperpot set and plastic holding tray, showing retaining clips (right) and stapling pliers (left).

Two types of glue are used in the construction of the "honeycomb" sets: an insoluble glue to form the individual pot and a water-soluble glue to hold together all pots in the set. The filled pots separate very easily when wetted but do not themselves disintegrate.

The approximate size of individual paperpots is designated by the pot number: for example, a 313 pot is 1.17 in. (3 cm) in diameter and 5.07 in. (13 cm) high. Twelve sizes are currently listed by the Canadian sales agent (Table 1), although a wider range is produced in Japan. It should be noted that pot height can be readily modified by sawing unopened sets to the required width.

Different qualities of paper are used in the production of paperpots to achieve different rates of decomposition after filling and wetting; under normal growing conditions BH pots break down in 3-4 weeks, VH in 6-8 weeks and FH in 6-8 months. A number of factors affect the breakdown rate of the paper (temperature, soil moisture, nitrogen availability, soil pH), but for most forestry applications the FH series appears to be the best choice for rearing tree seedlings where some part of the production phase is to be spent in a greenhouse.

Table 1 Sizes of paperpots available in Canada[a]

Pot size	Breakdown availability	Diameter (cm)[b]	Height (cm)[b]	Pot volume (cu cm)[c]	Pots per set	Sets per carton	Dimensions of expanded sets (cm)[b]	Pots per sq m[d]
213	BH	1.9	13	30.0	1,400	30	29.5 x 118	4,274
313	BH	3	13	79.0	700	30	33 x 118	1,709
305	FH	3	5	29.3	532	100	32 x 94	1,709
308	FH	3	7.5	44.0	532	60	32 x 94	1,709
408	BH, FH	3.8	7.5	70.4	336	60	34 x 94	1,066
505	VH, FH	5	5	81.2	420	70	38 x 180	616
508	VH, FH	5	7.5	121.8	420	45	38 x 180	616
605	VH, FH	6	7.5	116.9	280	90	37 x 180	428
608	VH, FH	6	7.5	175.4	280	60	37 x 180	428
808	VH, FH	7.5	7.5	274.0	168	70	36 x 180	274
1010	VH, FH	10	10	649.5	84	80	33 x 180	154
15	plastic laminate	15	10	1,461.0	39	120	34 x 180	68

[a] Reid, Collins and Associates Ltd., Vancouver, B. C.

[b] 1 cm = 0.39 in.

[c] 1 cu cm = 0.06 cu in.

[d] 1 sq m = 1.19 sq yd.

Since they are packed in compressed form, paperpots require considerably less space than most other containers for storage prior to use. As a guide, carton dimensions for a range of paperpot sizes are listed in Table 2. Dry storage conditions are essential.

Table 2 Carton dimensions for selected paperpot sizes

Pot size	Sets per carton	Dimensions (cm)[a]	Weight (kg)[b]
308	60	44 x 35 x 32	16.3
408	60	49 x 32 x 29	14.8
508	45	54 x 32 x 33	19.1
1010	120	46 x 33 x 34	17.7

[a] 1 cm = 0.39 in.

[b] 1 kg = 2.20 lb

The paperpot is manufactured in Japan by the Nippon Beet Sugar Manufacturing Company of Tokyo. It is sold under licence in Canada by Lännen Sokeri Oy of Finland through their Canadian agents, Reid, Collins and Associates Ltd., of Vancouver, British Columbia.

2. *Paperpot Holding Tray*

One of two approaches may be adopted in the rearing of paperpot seedlings: the filled and seeded paperpot sets may be set directly onto a flat growing surface without any holding device or they may be grown in trays for the duration of the production period. In the first method paperpots are stretched and attached to three-sided aluminum filling plates (Product Nos. 602001 - 602005)[2] for loading and seeding; they may then be taken to the growing area and the paperpot set pushed from the tray into position on the bench or frame. Where it is desired to store the filled paperpot sets for any reason, a support plate of hardboard or cardboard should be laid in the filling plate before attaching the set. The pots are filled in the usual manner, but can be stacked after filling by sliding the set with support plate out of the filling plate.

[2] Product numbers refer to items listed in Appendix II.

In this way pots can be filled in advance of sowing. Special lifting forks are available for handling paperpot seedlings where no holding tray is used (see page 21).

For situations in which seedlings are handled a number of times holding trays are desirable. Plastic-coated cardboard trays are available for a fairly wide range of paperpot sizes (Product Nos. 602027-602046), but have obvious disadvantages where production periods are long. Plastic holding trays are now available for 408 paperpots, the size most commonly used for forestry purposes in Scandinavia, and this greatly enhances the convenience of using paperpots (Product No. 602101). The tray (Fig. 1) measures 94 x 35 x 7.5 cm (37 x 14 x 3 in.) and will accommodate size 305 and 308 pots also, although when these are used care must be taken to ensure that the set is centred in the tray for correct register with available seeding equipment.

The plastic tray is probably the most useful for forestry purposes. Pots and seedlings remain in the tray for the entire production phase from loading and seeding through to final transport to the planting site. After the seedlings are removed the trays are easily collapsed into a form convenient for stacking and subsequent storage. Collapsed trays are readily handled in groups of 25, the dimensions of a bundle being 108 x 48 x 10 cm (42 x 19 x 4 in.) and the weight (uncrated) 22.7 kg (50 lb).

Since the bottom of the plastic tray is perforated, it is advisable to use a paper liner in the tray to prevent loss of growing medium during loading and initial handling. A previous report has shown that a thin paper such as Type 1300 Kimwipe (Kimberly-Clark Corp.) serves this function well, being sufficiently sturdy to withstand rough handling during tray preparation, yet breaking down relatively quickly under greenhouse growing conditions (Scarratt 1972b).

Paperpot sets are attached to the holding tray either by special clips or by staples. The latter method is somewhat quicker and more convenient, although it may be necessary to remove staples by hand after the plastic trays have been used a number of times. A suitable stapling plier (Fig. 1) is available in Canada (Appendix I).

Filling plates, plastic trays and clips are available from Reid, Collins and Associates Ltd. of Vancouver.

PAPERPOT LOADING EQUIPMENT

A variety of equipment is manufactured in Finland for loading and seeding paperpots. This equipment ranges from relatively simple devices suited to small-scale operations, and involving only a small capital outlay, to an automated filling and sowing line. The latter is

best suited to operations producing several million seedlings at a time; indeed, a single mobile machine with an experienced crew could probably fulfill the production requirements of a number of nurseries in a few weeks each spring. The individual units of the filling line are available separately, so that by selecting alternative equipment (see page 19) production facilities may be installed to suit any size of operation.

The equipment acquired by the Great Lakes Forest Research Centre is the complete filling line with semiautomatic sowing unit. It consists of a tray feeding unit, filling line, sowing machine and sanding unit. The individual units are first described separately. Comments on installation, operation and alternative equipment follow.

1. Tray Feeding Unit (Product No. 632002)

This device automatically feeds empty trays onto the filling line as space becomes available (Fig. 2). Up to four trays can be stacked in the unit at any time, thereby facilitating a continuous feed of empty trays. The unit is powered by the filling-line drive via a slipbelt; any holdup on the filling line causes the belt to slip and tray feed to be interrupted. Although the unit is by no means essential it is a great convenience where large numbers of trays are being handled.

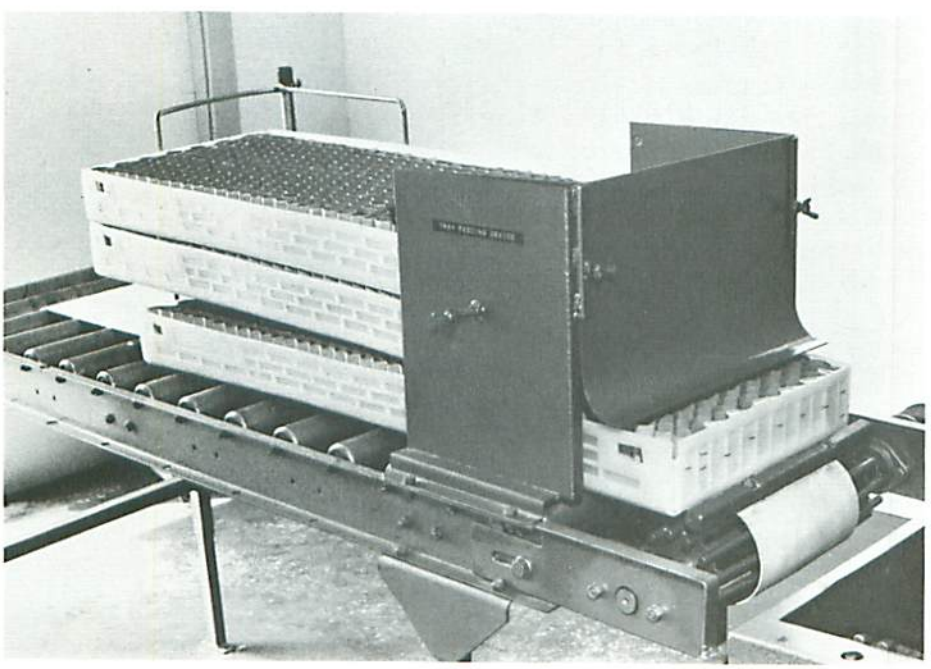

Fig. 2. Tray feeding unit.

The dimensions are as follows: length - 175 cm (5.75 ft), width - 53 cm (1.75 ft), overall height - 110 cm (3.65 ft), working height[3] - 76 cm (2.5 ft).

2. *Paperpot Filling Line (LÄNNEN) (Product No. 610590)*

The filling line consists of a conveyer belt, soil hopper, soil metering device, and vibrator table (Fig. 3). During operation, trays of empty paperpots pass under the soil hopper where they are filled with

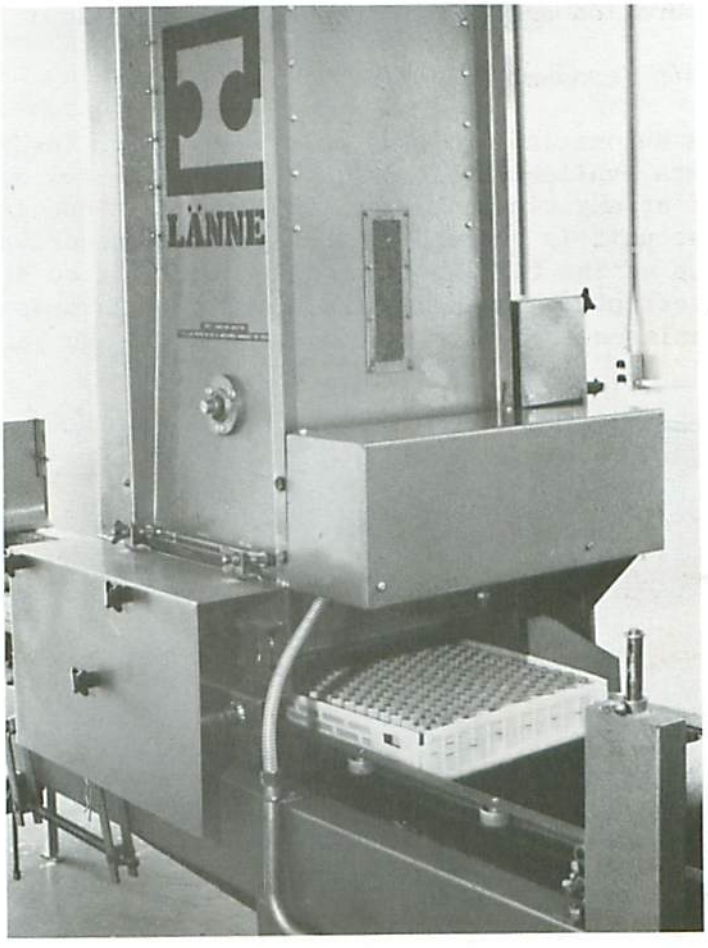

Fig. 3. Filling-line soil hopper.

[3] Except for the sowing unit, working height is the height of the belt transport.

metered amounts of growing medium via adjustable feed rollers. Rate of feed can be varied both by adjusting the distance between the rollers and by changing their speed of rotation; the feeding device is equipped with a two-speed motor.

The trays pass from under the filling device, loosely filled and covered with a layer of excess growing medium. This additional layer ensures that the pots are completely filled after passing over the vibrator plate. During its passage over the vibrator plate, the tray is held in contact with the conveyer belt by means of three pressure rollers covered with sponge rubber. Both the speed and strength of vibration are continuously variable, either by changing the drive-belt tension or by altering the position of eccentric weights on the vibrator drive shaft. A revolving nylon brush, placed beyond the vibrator plate, serves to remove excess growing medium from the filled trays and to prepare a clean sowing surface (Fig. 4).

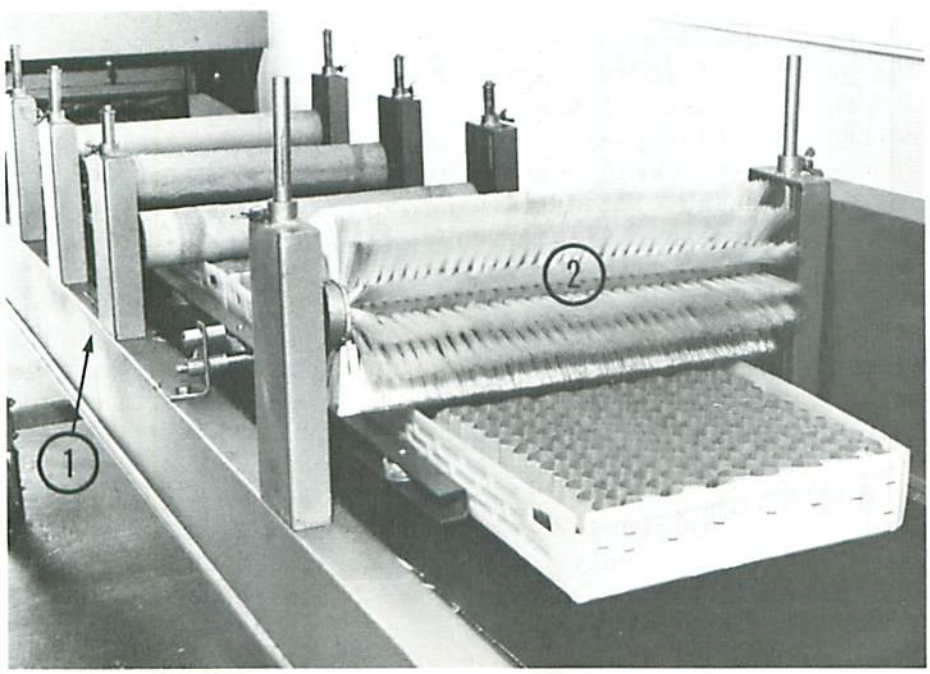

Fig. 4. Vibrator plate (1) and nylon brush (2).

The conveyer belt is driven by a two-speed motor. Drive-gear positions may also be reversed, permitting a total of four belt speeds for the unit as equipped. For the unit installed at the Great Lakes Forest Research Centre the relative belt speeds are as follows: gear configuration A - high (2.7), low (1.4); gear configuration B - high (2.0), low (1.0). At the lowest belt speed 136 plastic trays (37 in. or 93.98 cm long) can be processed per hour; at the highest speed 423 can be processed per hour.

The dimensions are as follows: length - 400 cm (13.15 ft), width - 64 cm (2.1 ft), overall height (soil hopper) - 200 cm (6.6 ft), working height - 76 cm (2.5 ft), number of motors - three.

3. Sowing Machine (SATOR 5) (Product No. 622101)

The SATOR 5 is a vacuum sowing device with a vacuum cleaner providing the suction. It is available for use with 3-, 4-, 5-, 6- and 8-cm (1.17-, 1.56-, 1.95-, 2.34- and 3.12-in.) diameter pots only. Constructionally, the machine consists of three primary elements: a vacuum seeding manifold, a seed tray or reservoir, and an adjusting plate (Fig. 5). The seeding manifold comprises a movable mouthpiece carriage connected to a suction hose which is alternately positioned over the seed tray and the adjusting plate. The mouthpieces are located on the lower side of the carriage (Fig. 6) and are spaced to correspond with the size of paperpot being filled. Consequently, a different carriage is required for each paperpot size (Product Nos. 622203-622207). The mouthpieces may be drilled with one to five holes depending on the number of seeds to be sown in each cavity. The equipment installed at the Great Lakes Forest Research Centre has only one hole per mouthpiece, with a diameter of 0.45 mm (.02 in.). For convenience, the same size of mouthpiece orifice is used for sowing white spruce (*Picea glauca* [Moench] Voss), black spruce (*Picea mariana* [Mill.] B.S.P.) and jack pine (*Pinus banksiana* Lamb.). A bleed valve in the suction hose enables the vacuum to be adjusted to suit individual species requirements; a test of sowing precision is summarized in Table 3. Where small-seeded species are to be sown almost exclusively, it may be desirable to specify a smaller orifice than the above; however, seed cleanliness will then be more crucial for efficient sowing.

The seed tray measures 96.5 x 37.5 x 2.1 cm (38 x 14.75 x 0.81 in.). To avoid blank pots it is essential that this tray be kept filled with seed; the mouthpieces should be covered by seed when the tray is lifted into position for seed pickup. Some adjustment of tray height is possible, but in order to reduce the volume of seed required to fill the tray we have found it expedient to place a 1/4-in. (.10-cm) hardboard filler in the tray bottom.

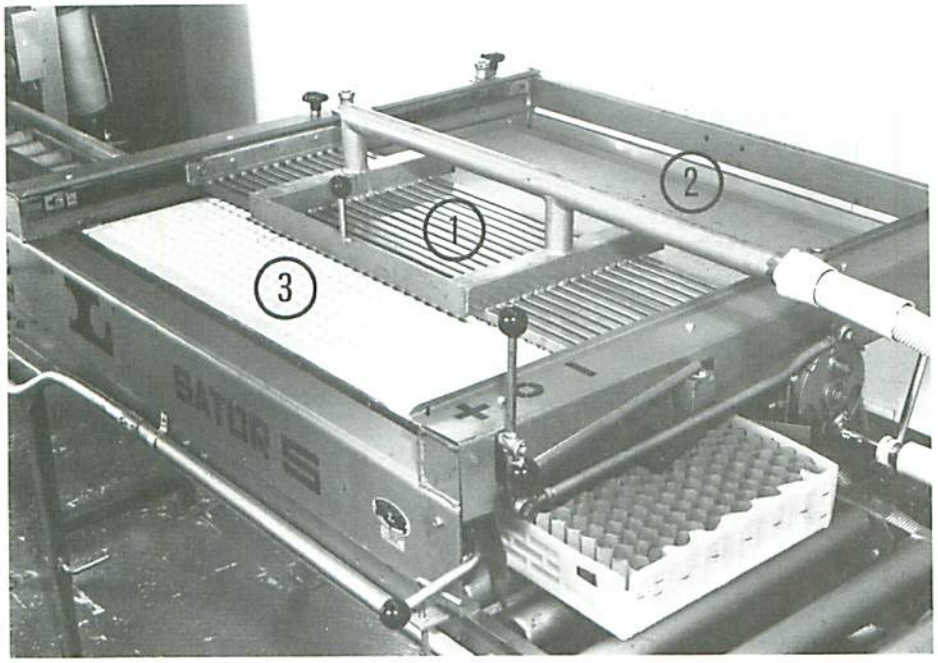

Fig. 5. View of sowing machine showing vacuum seeding manifold (1), seed tray (2), adjusting plate (3) and control levers.

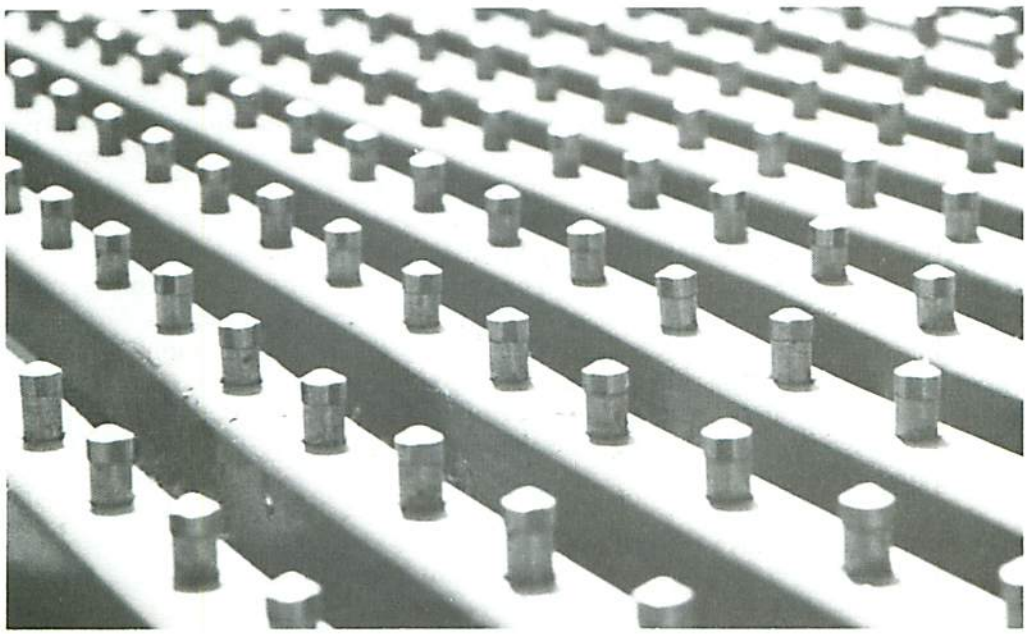

Fig. 6. Mouthpieces on lower side of mouthpiece carriage (inverted).

Table 3. Sowing precision of SATOR 5 for three seed sizes using a 0.45-mm[a] diameter suction orifice

Seeds per cavity	Black spruce (%)	White spruce (%)	Jack pine (%)
0	4.4	5.5	10.1
1	50.4	79.9	80.5
2	28.3	10.1	8.9
3	10.6	3.4	0.4
4	6.3	1.1	0.1
Vacuum-bleed position	Fully closed	Half open	Fully open

[a] 0.45 mm = 0.0177 in.

Note: Each series of means is based on 10 sowings of a 308 paperpot set (532 cavities).

In operation the mouthpiece carriage is moved into position over the seed tray with suction switched on; the seed tray is then lifted to bring seed into contact with the mouthpieces. As the tray is lifted the seed mass is automatically vibrated to bring seeds into contact with the suction orifice in each mouthpiece. After a few seconds the tray is dropped, the carriage is pulled into position over the adjusting plate and the suction is removed. The seeds drop into conical holes in the adjusting plate (a different size for each pot size) corresponding with the paperpot cavities. The cavities in the adjusting plate are blocked by a steel shutter at this point, allowing the operator to fill any blanks by hand (Fig. 7). Opening the shutter allows seed to drop into the paperpots positioned below.

The sowing machine installed at the Great Lakes Forest Research Centre has manual carriage control. A semiautomatic version is also available, enabling the carriage to be moved by air pressure. The dimensions are as follows: length - 152 cm (5.0 ft), width - 110 cm (3.65 ft), overall height and working height - 96 cm (3.15 ft), number of motors - one plus vacuum cleaner.

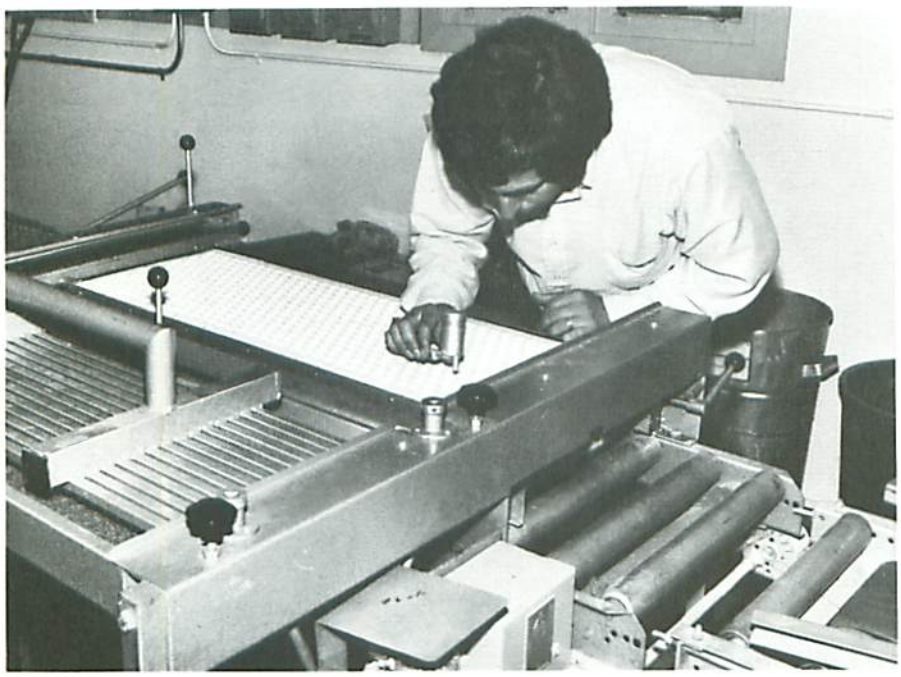

Fig. 7. Sowing machine operator filling blanks in adjusting plate.

A section of dead roller transport should be installed on either side of the sowing unit to provide a degree of operational flexibility and to separate the machine from sources of dust (filling line and sanding unit). Where space is available a length of 1.5-2.5 m (5-8 ft) on either side of the sowing machine appears desirable. Where the amount of dust from the growing medium is excessive, enclosure of the sowing unit may be necessary to avoid blockage of the mouthpiece orifices.

4. Sanding Unit (Product No. 630001)

The sanding unit (Fig. 8) is a simple roll metering device with an adjustable gate for varying the depth of seed cover. The sand drops onto a moving belt, under a levelling plate and onto the surface of the filled and seeded paperpots passing underneath on the main conveyer belt. The sanding unit is activated by a microswitch only when a tray is on the conveyer belt. The dimensions are as follows: length - 152 cm (5.0 ft), width - 67 cm (2.2 ft), overall height - 130 cm (4.25 ft), working height - 76 cm (2.5 ft), number of motors - one.

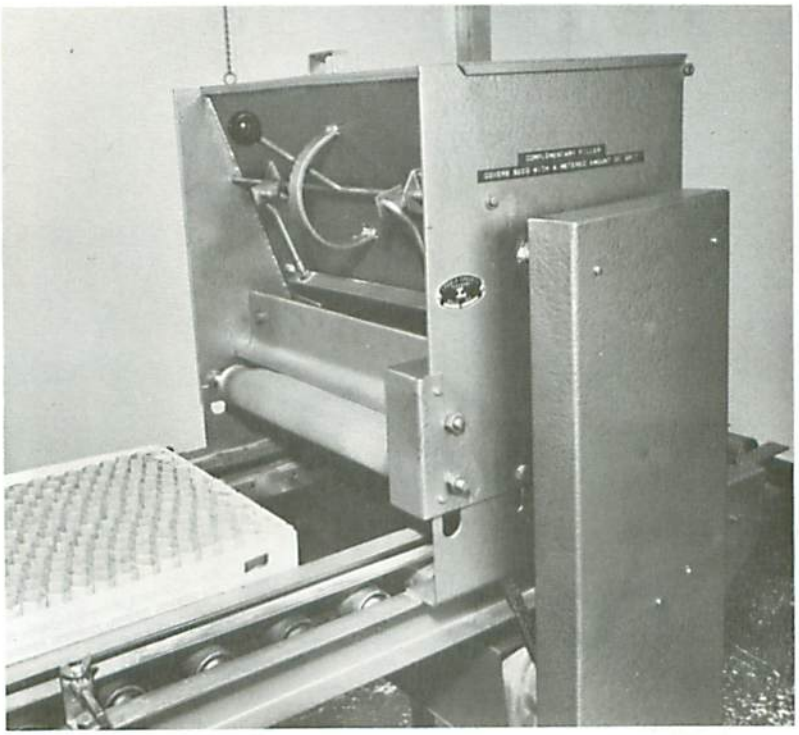

Fig. 8. Sanding unit for covering seeded paperpots.

5. Conveyer/Elevator

An essential piece of equipment for use with the filling line is a conveyer for feeding growing medium into the soil hopper. An agricultural conveyer is adequate, the length depending on the particular installation. At the Great Lakes Forest Research Centre peat is fed to the filling-line hopper through the header-house roof, using a 24-ft (7.31-m) "Little Giant" portable elevator (Fig. 9). In this installation the conveyer is operated outdoors and a special cover and terminal chute have been constructed to exclude rain and prevent the peat from being blown away (Fig. 10).

6. Installation

The paperpot filling and sowing line purchased by the Great Lakes Forest Research Centre is installed in a simple header-house extension measuring 13 x 3.5 m (43 x 11 ft) (Fig. 11). This probably represents the smallest size of accommodation suitable for the efficient operation of the equipment. If a section of roll conveyer were to be installed between the sowing machine and sanding unit, as suggested earlier, a longer building would be required. No storage space is

Fig. 9. Header-house and peat conveyer.

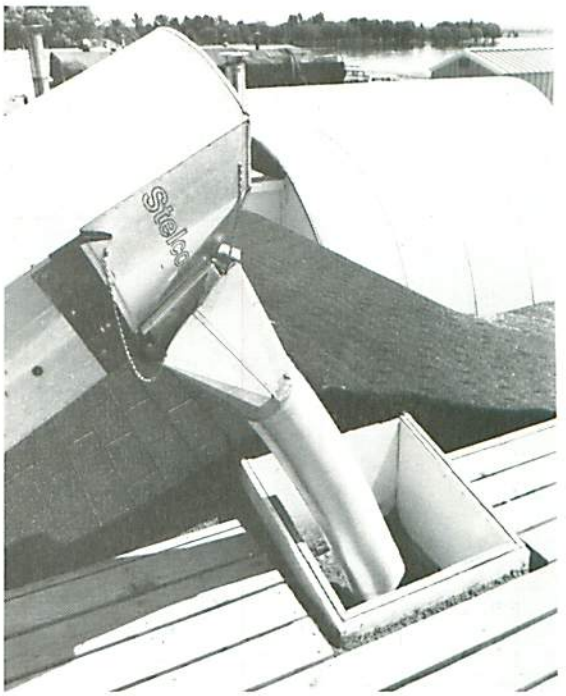

Fig. 10. Conveyer chute and access to soil hopper.

provided in the building; for operational situations, additional working space would probably be necessary, plus adequate storage for plastic trays, paperpot cartons, fertilizers, growing medium, etc.

The equipment may be installed either in a straight line (Fig. 11) or, using a curved roll conveyer (Product No. 633025), in a right-angled configuration. Alignment and levelling of the equipment, particularly the sowing machine, is important, and all units must be bolted to the floor to maintain this condition.

Growing medium (milled and screened *Sphagnum* peat is used at the Great Lakes Forest Research Centre) is fed to the filling-line hopper through a trapdoor in the header-house roof (Fig. 9 and 10). A flat roof section is adopted at this point to provide a working area above the hopper; this is especially desirable where a growing medium such as peat is used because of the tendency to bridging in the hopper and the necessity of clearing these blockages rapidly. The trapdoor is connected to the hopper by means of a flexible sleeve of rubberized fabric (see Frontispiece).

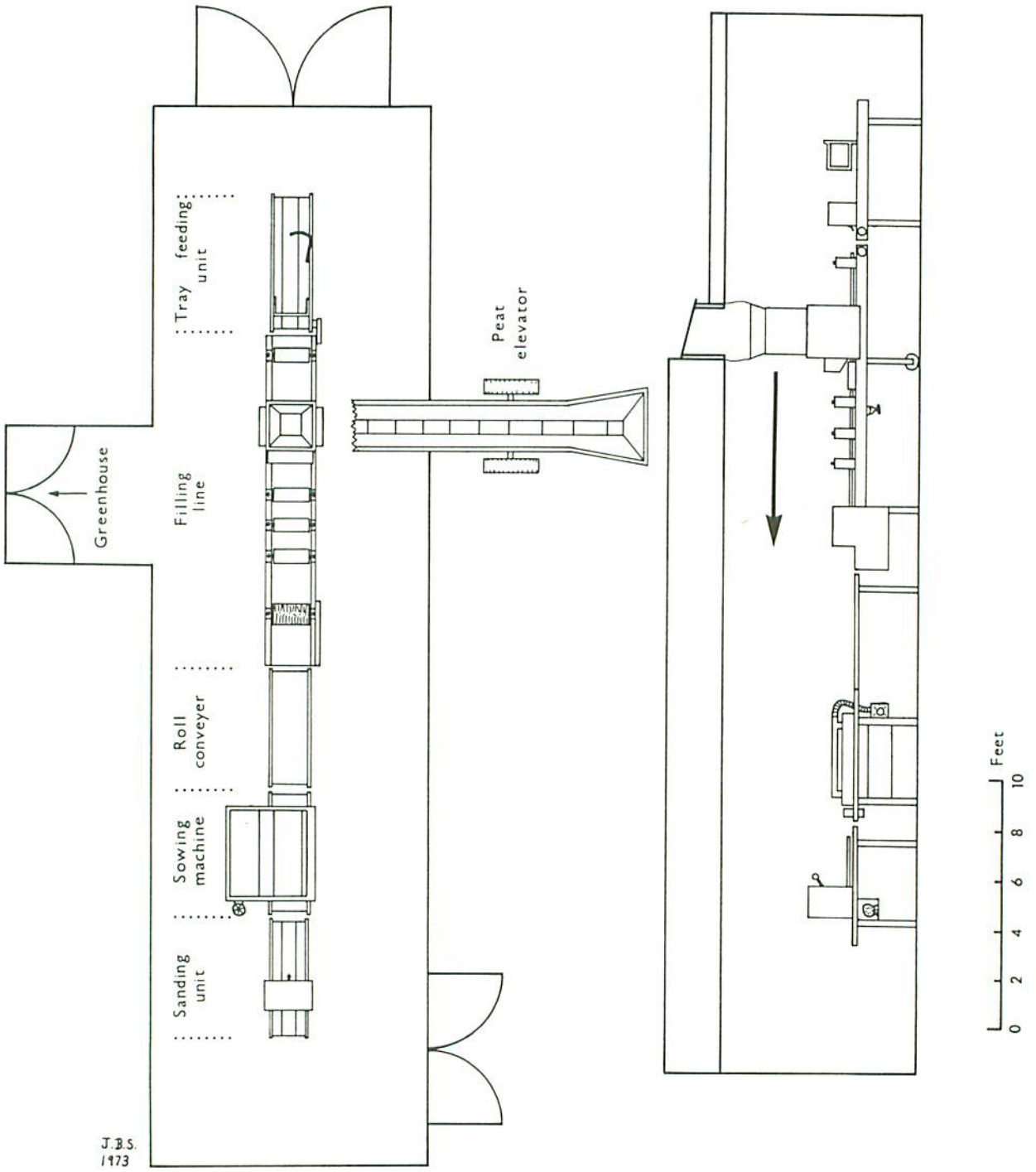

Fig. 11. Great Lakes Forest Research Centre: Paperpot loading and seeding installation.

With regard to electrical installation, North American purchasers must decide whether to adapt their power supply to the equipment as supplied, or to attempt to install American-standard motors. The motors supplied with the equipment are all built to European specifications as follows:

Filling-line belt transport
- 1 Nord gear-head motor, two-speed, type SK 01-71 L/4-2, 380V, three-phase, 50 hz, 1.1/1.3 amp, 0.3/0.45 kW, 27 and 54 rpm.

Filling-line soil feed
- 1 Nord gear-head motor, two-speed, same specifications as for filling-line belt transport.

Filling-line vibrator table
- 1 Stromberg motor, type HXUR A2 B3, 220/380V, three-phase, 50 hz, 1.1 amp, 0.37 kW, 1500 rpm.

Sowing machine (vibrating seed tray)
- 1 Stromberg motor, type HXUR A4 B3, 220/380V, three-phase, 50 hz, 0.75 amp, 0.12 kW, 750 rpm.

Sanding unit
- 1 Nord gear-head motor, type SK 01-63 L/4, 220/380V, three-phase, 50 hz, 0.5 amp, 0.18 kW, 27 rpm.

Vacuum cleaner for sowing machine
- 220V, 1.5 amp, 0.32 kW.

At the time the equipment described in this report was being installed, suitable North American-standard alternatives could not be located for all of the above motors. Even where the operating specifications could be matched, the physical dimensions of the North American motors were generally greater than those of their European equivalents, a feature which would have necessitated structural modifications to the filling line in order to accommodate them.

Because of these problems it was decided to adapt the power supply to the original motors. In practice this was not difficult, the only special items required in addition to five industrial fused switches being one 5KVA, 208-volt, three-phase autotransformer (Northern Electric), and two 380-volt, 60 hz, two-speed starters (Allen-Bradley).

7. Operation

Our initial experience suggests that a minimum of three persons are required to operate the filling and sowing line efficiently, with four others in supporting roles. These are stationed as follows: soil

preparation and filling soil hopper - 2, tray feeding unit - 1, paperpot filling line and general supervision - 1, sowing machine - 1, sanding unit and moving filled trays to growing area - 2. Operation of the sowing machine is the most demanding task in the sequence, controlling the overall rate of production, and it is essential that a competent individual be employed for this task.

Tray preparation is not included in the above summary. To ensure operational efficiency we have found it convenient to prepare trays for filling in advance of the main production. Initial experience indicates that two men should be able to make up 200-250 trays in an 8-hour day (fold plastic trays, fit paper lining, stretch paperpot sets, and staple into tray).

Seeding is the controlling element in the production sequence and we have found the slowest filling-line belt speed (i.e., 136 trays per hour) to be the most compatible with rates of sowing for 308 and 408 paperpots. Sowing rates quoted by the manufacturer for the SATOR 5 are 120-140 trays per hour (408 paperpot), and this, at the belt speed quoted, would ensure a relatively smooth operation. However, actual sowing rates achieved to date with the 308 paperpot have averaged only 75 trays per hour, suggesting that, even if this rate can be improved, some further reduction in belt speed may be necessary to coordinate the two elements in the loading/seeding sequence. Even so, at the rate quoted, production was close to 40,000 pots per hour. However, there does not appear to be any reason that, to take advantage of the greater loading capacity of the filling line, rates of production cannot be increased by using two or more seeding units in conjunction with a single filling line.

The main problems encountered in operating the equipment have resulted from poor packing of the growing medium in the pots and blockage of the mouthpiece suction orifices on the sowing machine. The ease of filling pots depends very much on the moisture content of the *Sphagnum* peat: if the material is too moist it will not drop into the cavities satisfactorily when being fed from the hopper; if it is too dry it may not be compacted sufficiently during its passage over the vibrator table. The rate and strength of vibration may be easily varied, but the best settings can be determined only through trial and error. Unfortunately, the moisture content of commercial peat may vary considerably from bag to bag, so that it is advisable to select adequate material of similar moisture content before starting a production run to avoid loading problems.

Since the sowing machine controls the overall rate of production, it is important that it operate as efficiently as possible. Blanks caused by faulty operation have to be filled by hand and rapidly increase the sowing time per tray. The suction orifices are easily blocked and, if in successive sowings certain cavities remain blank, it is necessary

to remove and clean the mouthpieces in question. Clean seed is an obvious requirement, but where the growing medium is particularly dusty it may be necessary to isolate the sowing machine from the rest of the operation, as suggested earlier. No oil or grease should be used on the mouthpiece carriage; on receipt of the equipment it is recommended that the carriage be dismantled and the manifold washed out with detergent and steam-cleaned to remove all traces of oil. Similarly, the mouthpieces should be removed and washed in gasoline followed by detergent.

8. Alternative Equipment

The equipment described in the preceding pages is best suited to large-scale operations geared to substantial annual planting targets. For smaller operations alternative aids are available to facilitate loading and seeding at considerably less cost. As noted earlier, the individual units of the filling line are also available separately, so that equipment may be selected to suit any size of operation.

For pot loading an individual vibrator table is available (Product No. 613001); this helps to compact the growing medium uniformly and is an invaluable aid in standardizing production procedures. If it is used in conjunction with a locally constructed hopper for the growing medium, reasonable loading rates should be possible.

Sowing by hand is out of the question for all but small trial situations and mechanization of this operation is obviously an important requirement. Three mechanical sowing devices are available - the SATOR 5, described previously, and two simpler devices, the SATOR 1 and SATOR 7. Because of the variation in quality, size and shape of different species of seed, and variations in pot size, each of these sowing devices is equipped with changeable parts (cylinders or carriages) to match these variations (see Appendix II).

The simplest sowing device is the SATOR 1 (Fig. 12) (Product Nos. 621090-621095), a precision-sowing, hand-operated machine with an interchangeable seed drum or cylinder. The cylinder is varied for the size of pot and the size of seed to be sown (Product Nos. 621020-621030), and is said to be suitable for sowing both pelleted and unpelleted seed. The sowing machine is operated on a sowing frame (Product Nos. 621080-621085) which stands over the tray of pots to be sown. The frame is equipped with chains which engage gear wheels on the machine and activate the cylinder; one pass of the sowing machine over the set takes about 20 seconds.

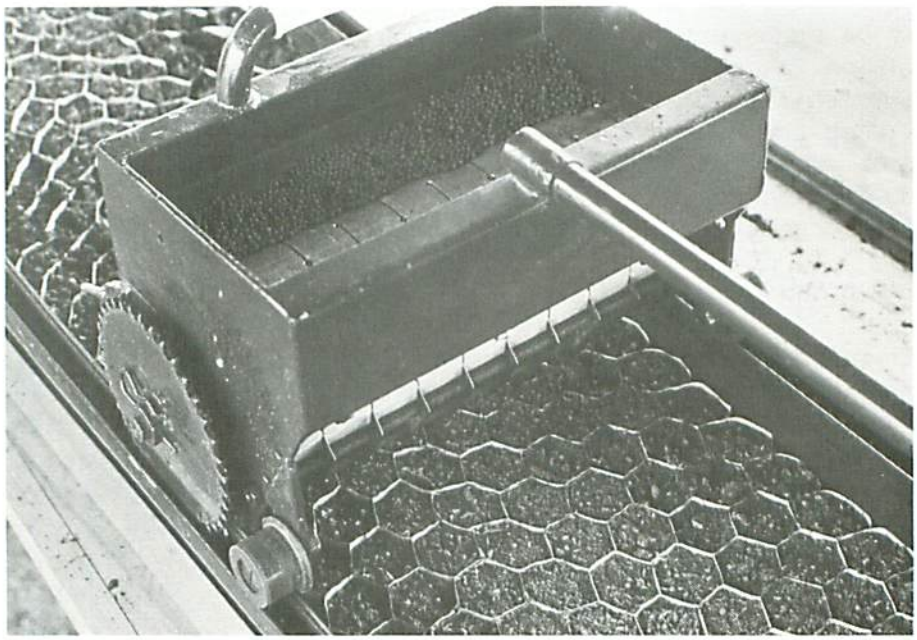

Fig. 12. Sowing machine SATOR 1 in position on sowing frame.

The SATOR 1 is suitable for small-scale operations, where it is used as an independent unit. It may also be used, in modified form, mounted over the conveyer belt of the LÄNNEN filling line as a less expensive alternative (Product No. 621002) to the SATOR 5.

The SATOR 7 is a cheaper, hand-operated vacuum sowing device (Product Nos. 623073-623076) using the same mouthpiece carriage and mouthpieces as the SATOR 5.

For covering seed, the sanding unit described previously (page 13) must be used for independent operation. However, where the SATOR 1 is used in conjunction with the LÄNNEN filling line a simpler, cheaper machine is available (Product No. 630002) which may be mounted adjacent to the sowing unit. Both units are then powered by the filling-line drive.

An abbreviated list of paperpot loading and seeding equipment is given in Appendix II. Soil elevators are available from agricultural dealers in most areas.

C. ANCILLARY EQUIPMENT AND TOOLS

A number of aids (see below) are available for handling and planting paperpot seedlings. Unless otherwise stated these items are manufactured in Finland.

For handling paperpot seedlings in the nursery

1. Plant Forks: Unless seedlings are to be grown in portable holding trays some means of lifting groups of seedlings is required. Simple plant forks are available which allow whole paperpot sets or part sets to be lifted undisturbed. Long-handled plant forks (Fig. 13) (Product Nos. 603005-603020) allow seedlings to be lifted and moved from a standing position. They are available in three widths (36, 47 and 94 cm or 14.04, 18.33 and 36.66 in.) to move part or whole sets, and are equipped with a push bar to facilitate loading seedlings into transportation boxes. For situations where seedlings are grown directly on the ground, long-handled plant forks are available with a cutting blade on the leading edge to sever roots growing into the soil.

   A short-handled plant fork (Fig. 14) (Product No. 603025) is a useful item for moving small quantities of seedlings, and may be used in the field to transfer groups of seedlings from holding trays into planting baskets. It is available only in the 30 cm (11.70 in.) width, without cutting blade.

Planting tools and accessories

2. Planting tools: Dibbles which remove a core of soil are the simplest type of planting tool manufactured specifically for use with paperpots. Available for 10 pot sizes (Product Nos. 640001-640015), these planting sticks contain no moving parts and should be suitable for use on most soil types. However, the planter or his assistant must bend to plant the seedling.

   A more convenient tool, which eliminates the necessity for bending during planting, is manufactured in Sweden by Falu Redskapsfabrik AB. It consists of a dibble, which throws the core of soil out to one side, with a tube affixed to the shaft (Fig. 15) (Product No. 900). It weighs 1.75 kg (3.85 lb). In use, the dibble is forced into the ground to remove a soil core; the dibble is then removed and the tube sighted over the previously made hole. A seedling is then dropped down the tube into the hole made by the dibble.

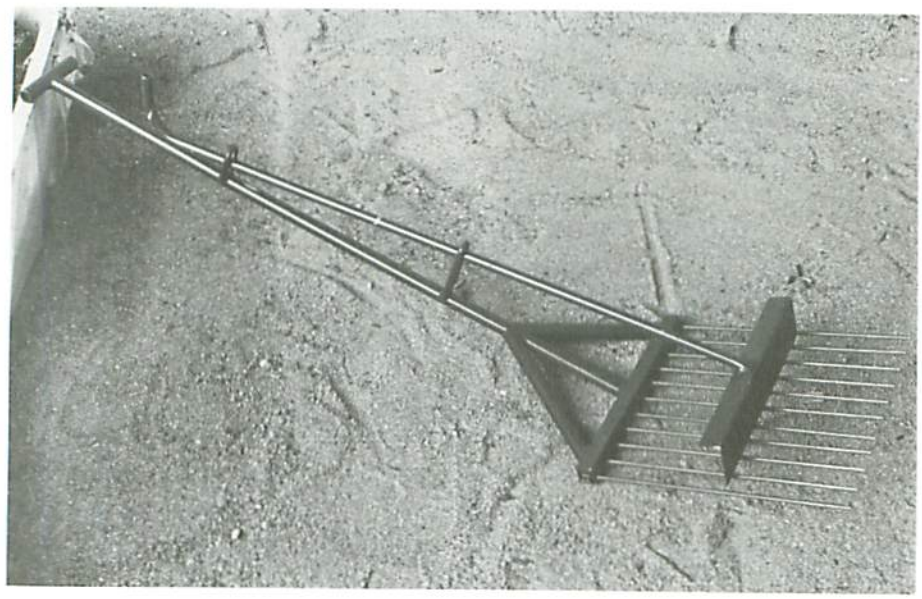

Fig. 13. Long-handled plant fork.

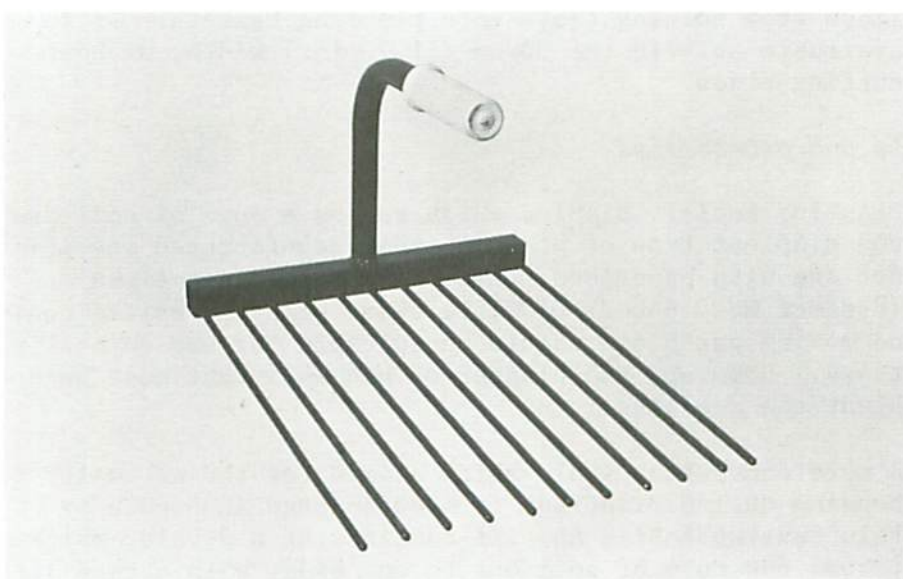

Fig. 14. Short-handled plant fork.

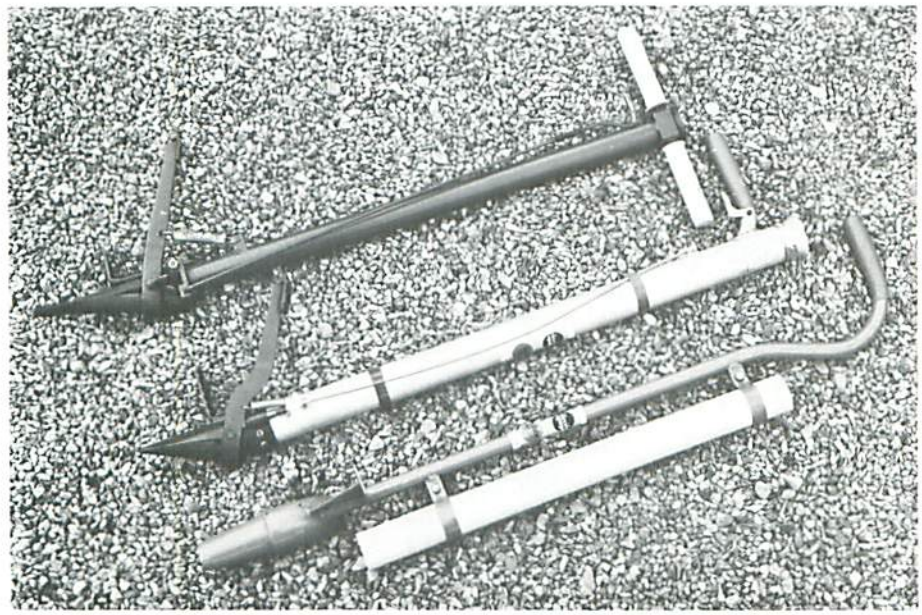

Fig. 15. Commercially available tools for planting paperpot seedlings: (top to bottom) Finnish "Pottiputki", Swedish-made equivalent, Swedish corer.

A third design incorporates the dibble and tube in a single unit, so that the dibble is not removed before planting the seedling. The "Pottiputki", manufactured in Finland in four tube diameters from 38 to 70 mm (1.48 to 2.73 in.), is essentially a steel tube with foot-operated jaws at the lower end (Fig. 15) (Product Nos. 640030-640033). The tool is forced into the ground with the jaws closed; the jaws are then opened with the foot pedal and a seedling is dropped down the tube into the planting hole. After removing the planting tool the seedling is firmed by the foot. The tool for use with 308 and 408 paperpots weighs 2.7 kg (5.94 lb).

A similar tool is manufactured in Sweden by Falu Redskapsfabrik AB (Fig. 15) (Product No. 901). It weighs 2 kg (4.4 lb). While both of these tools should favour high rates of planting on most sites, difficulties may be encountered in operating the foot pedal under conditions of heavy slash.

There is no ideal tool for hand planting containerized seedlings, and the choice for a particular situation must take into consideration such factors as site conditions, potential planting productivity, and the

scale of planting. Modifications of existing tools tend to produce variants suited to local conditions: Ontario experience has shown that in general the simpler designs tend to be the most effective for large-scale planting.

3. Plant carriers: A sturdy plant basket of plasticized canvas, with a capacity of approximately 200 size 308 paperpot seedlings, is manufactured in Finland (Product No. 603505). This is carried at the waist on a shoulder strap (Fig. 16). The basket weighs 1.25 kg (2.75 lb). A similar item is available from Sweden (Product No. 911).

   Smaller than the above is an aluminum planting tray produced by Falu Reskapsfabrik AB. This consists of a belt which supports an aluminum frame at the waist; an aluminum tray

Fig. 16. Finnish carrying basket.

holding the seedlings is then clipped to this frame (Fig. 17). The whole weighs 1.25 kg (2.75 lb) and has a capacity of about 100 size 308 paperpots.

All of the above plant carriers are convenient to use with the tubular planting tools. However, they would probably be unsuitable for situations or with planting tools where the planter is called upon to bend frequently.

4. Tray carrying handles (Product No. 603503): A simple convenience, made of heavy-gauge wire, for carrying individual plastic or cardboard trays of paperpot seedlings, this is particularly useful for distributing trays over the planting area.

Fig. 17. Swedish carrying tray.

REFERENCES

Scarratt, J.B. 1972a. Effect of tube diameter and spacing on the size of tubed seedling planting stock. Can. Forest. Serv., Sault Ste. Marie. Inf. Rep. O-X-170. 10 p.

Scarratt, J.B. 1972b. Air space controls root extension from open-ended containers during seedling production. Forest. Chron. 48(5): 242-245.

APPENDICES

APPENDIX I

MANUFACTURERS AND SUPPLIERS

1. Bostitch Canada Ltd.,
   19 Rangemoor Road,
   Toronto 18,
   Ontario.
   [Stapling pliers]

2. Falu Redskapsfabrik AB,
   Box 60 118,
   79107 Falun 7,
   Sweden.
   [Paperpot planting tools and carrying trays]

3. Lännen Sokeri Oy,
   Paperpot Department,
   27820 Länsi-Säkyla,
   Finland.
   [Manufacturer of paperpot filling and sowing line, ancillary production and planting equipment]

4. Reid, Collins and Assoc. Ltd.,
   Forest Industries Bldg.,
   550 Burrard Street,
   Vancouver 1,
   British Columbia.
   [Canadian sales agent for paperpot production and planting equipment]

APPENDIX II

EQUIPMENT AVAILABLE FOR THE PRODUCTION AND PLANTING OF PAPERPOT SEEDLINGS

1. Manufactured by Lännen Sokeri Oy, Finland[a]

Product No.	A. TRAYS AND ACCESSORIES	Unit price FOB Vancouver ($ Canadian)
	Filling plates, aluminum	
602003	118 x 35 x 10 cm[b] + 20 clips	19.90
602005	180 x 40 x 7.5 cm + 10 clips	33.80
602001	94 x 37 x 7.5 cm + 14 clips	18.95
602006	60 x 42 x 14 cm + 10 clips	16.55
	Filling boxes, cardboard, plastic laminated for growing paperpot seedlings	
602045	Size 213, 118 x 30 x 8 cm	0.70
602046	" 313, 118 x 32 x 6.5 cm	0.75
602030	" 305, 94 x 32 x 5 cm	0.55
602035	" 308, 94 x 32 x 7.5 cm	0.65
602040	" 408, 94 x 35 x 7.5 cm	0.60
602039	" 408/2, 94 x 35 x 4 cm	0.55
602027	" 505, 90 x 37.5 x 5 cm	0.55
602028	" 508, 90 x 37.5 x 7.5 cm	0.70
	Plastic trays, 94 x 35 x 7.5 cm (305, 308, 408)	
602101	1000 - 4999	2.65
602101	5000 - 9999	2.40
602101	10,000 or more	2.15

[a] Prices are quoted, as a guide only, for the reader who wishes to calculate the approximate cost of setting up paperpot production facilities. They are abstracted from the list of Reid, Collins and Associated, Ltd., dated September 1, 1973; no responsibility is taken for their accuracy. Prices quoted are based on package quantities; for smaller quantities the prices may be higher.

[b] 1 cm = 0.39 in.

(continued)

APPENDIX II (continued)

Product No.		Unit price FOB Vancouver ($ Canadian)
	Retaining clips	
602203	45 mm for use with plastic trays	0.10
602202	80 mm for use with filling plates and boxes	0.10
602210	Fork for stretching paperpot sets	2.75
	B. PAPERPOT LOADING EQUIPMENT	
613001	Individual vibrator table, complete	602.50
610590	Filling line LÄNNEN, complete with filling and vibrating devices, conveyer belt and three motors (does not include sowing machine, complementary filler or electrical installation)	4,177.20
632002	Tray feeding unit	504.00
633020	Roll conveyer, straight	181.85
633025	Roll conveyer, curved, 90°	387.85
	C. SOWING EQUIPMENT	
	Sowing machine SATOR 1 with cylinder and sowing frame	
621090	Pot size 213	398.10
621091	" " 313, 305, 308	379.95
621094	" " 408	352.90
621092	" " 505, 508	352.90
621093	" " 605, 608	346.55
621095	" " 808	346.55
621002	Sowing machine SATOR 1 for use with filling-line LÄNNEN, less cylinder	193.95
621020	Cylinder for SATOR 1, pot size 213	199.50
621022	" " " ", " " 313, 305, 308	181.25
621028	" " " ", " " 408	154.20
621024	" " " ", " " 505, 508	154.20

(continued)

APPENDIX II (continued)

Product No.		Unit price FOB Vancouver ($ Canadian)
621026	Cylinder for SATOR 1, pot size 605, 608	147.85
621030	" " " ", " " 808	147.85
622101	Sowing machine SATOR 5, with motor, adjusting plate and vacuum cleaner (does not include mouthpiece carriage)	3,904.65
622203	Mouthpiece carriage for SATOR 5, complete, pot size 305, 308	716.25
622204	" " " " ", " " " 408	546.85
622205	" " " " ", " " " 505, 508	349.75
622206	" " " " ", " " " 605, 608	285.15
622207	" " " " ", " " " 808	285.15
694001	Vacuum cleaner with hose, 220 volt	201.10
	Sowing machine SATOR 7, with adjusting plate and vacuum cleaner (uses same mouthpiece coverages as SATOR 5)	
623073	- for pot size 305, 308, 313	1,049.20
623074	- for pot size 408	937.90
623075	- for pot size 505, 508	850.45
623076	- for pot size 605, 608	812.30
	D. SANDING UNITS	
630001	Sanding unit with roll conveyer and motor, for use independently or with filling-line LÄNNEN	1,182.45
630002	Sanding unit for use, mounted with SATOR 1, on filling line	245.95
	E. HANDLING	
603025	Short-handle plantfork, width 30 cm	12.35
603005	Long-handle plantfork, width 36 cm	23.05
603010	" " " , width 94 cm	37.75

(continued)

Product No.		Unit price FOB Vancouver ($ Canadian)
603020	Long-handle plantfork, width 47 cm, with knife blade	34.25
603015	" " " , width 94 cm, with knife blade	39.80
603030	Plant spade, width 94 cm	35.80
603507	Plant transportation box, cardboard, 35 x 94 x 15 cm	1.30
	F. PLANTING TOOLS AND ACCESSORIES	
640001-15	Planting sticks (dibbles and corers), available for paperpot sizes 213, 213/2, 313, 308, 408, 505, 605, 608, 808 and 1010	12.70
640030	Planting tube "Pottiputki" 38 mm diameter	28.30
640031	" " " 50 mm "	28.30
640032	" " " 60 mm "	32.80
640033	" " " 70 mm "	32.80
603505	Planting baskets, plasticized canvas	23.30
603503	Carrying handles for cardboard and plastic holding trays	5.25

2. Manufactured by Falu Redskapsfabrik AB, Sweden

Product No.		Unit price FOB Falun, Sweden (Swedish Crowns)[a]
900	Planting tube	81.00
901	Planter, 44 mm diameter	125.00
910	Carrying tray, aluminum	44.00
911	Carrying basket	

[a] Conversion rate: 1 Swedish Crown = 24.21¢ (11.9.73)