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Leaflet 61

Tubed Seedlings

A J Low J S Oakley

Plate 1. Eight week old Lodgepole pine tubed seedling ready for planting. A3702

Cover: Loading the tubed seedling planter (*left*) and planting (*right*).

TUBED SEEDLINGS

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SUMMARY

Eight week old conifer seedlings raised intensively in small plastic tubes are capable of high survival and vigorous growth when step planted on ploughed peatland. The effective planting season is from April to August, and very high planting rates are possible with a special tool. Current recommendations are given for the production and use of Lodgepole pine and Sitka spruce tubed seedlings.

INTRODUCTION

The use of planting stock raised in containers is a long-established forestry practice, particularly in tropical and semi-arid regions where it may be essential in order to ensure satisfactory survival after planting. In other parts of the world, use of container grown stock has generally been restricted in the past by high production and planting costs relative to the use of conventional bare-rooted stock. However, over the past 10–15 years, considerable effort has been devoted to the development of container planting techniques suitable for economic large-scale use in temperate forestry (see e.g. Cayford, 1972; Low and Brown, 1972). One such technique, which originated in Canada, utilises young conifer seedlings grown in small open-ended and slit-sided plastic tubes (see Williamson, 1964). When only a few weeks old, these "tubed seedlings" are planted in the forest without removal of the tubes.

In 1967, it was decided to investigate the suitability of tubed seedlings (Plate 1) for use in Britain. Between 1968 and 1973, a major research and development programme was carried out with the aims of determining their limitations in relation to British type conditions, and developing satisfactory methods for large scale production and planting. Results of the first three years, work were described by Low 1971, and a detailed account of the entire project has been published as Forestry Commission Bulletin No. 53, *Production and Use of Tubed Seedlings* (Low, 1975, HMSO, £1). The following summary, which is quoted from that Bulletin, sums up the results obtained:

> "Using heated polythene greenhouses, Lodgepole pine (*Pinus contorta*) and Sitka spruce (*Picea sitchensis*) seedlings can readily be grown in small plastic tubes filled with a fertilised peat-sand mixture, and are normally ready for planting eight weeks after sowing. On ploughed peatland, step-planted seedlings are capable of high survival and vigorous early growth with an effective planting season from mid-April to late-August. Root development appears satisfactory and, in the case of Lodgepole pine, early stability is better than that of transplant stock. Browsing damage is the main adverse factor encountered, although much less serious than expected, and may necessitate some increase in protection costs. Weed growth is seldom a problem on the poorer upland peat, but may be excessive on flushed peat. Very high planting rates (up to 740 seedlings per man/hour) on previously stepped peat ridges are possible with a specially devised tool. Seedling use could lead to substantial savings in peatland afforestation costs, and large scale "user"

trials for tubed seedlings are proceeding satisfactorily in North Scotland.

In contrast, tubed seedlings have proved unsatisfactory for afforestation of ploughed mineral soil, due to severe frost lifting and poor height growth. Similar unsatisfactory results have been obtained in re-afforestation trials on a range of mineral soil types".

The major advantages of using tubed seedlings for afforestation of suitable peatland are as follows:

1. A very high rate of planting is possible, giving much increased output per man-day and reduced planting costs.
2. The special planting technique developed is simple, easily learned and requires much less effort than is required for planting conventional transplant stock.
3. The normal planting season can be considerably extended, thus reducing a seasonal peak in labour requirements.
4. The very short period required to grow seedlings allows much easier and more efficient matching of plant production to a planting programme.
5. Working conditions at the nursery are improved because all operations are carried out indoors on benches.

The more important disadvantages are:

1. The small size of the seedlings makes them more vulnerable than transplant stocks to damage by animal browsing.
2. They are unsuitable for planting in mineral soil. Their use is restricted to sites with a peat depth of 35 cm or more. The more fertile peat has to be avoided because of the risk of excessive weed growth.
3. Step planting in the plough ridges is required to provide essential early shelter for the seedlings and the steps have to be prepared prior to the planting operation (but use of a suitably modified step-cutting plough can produce a continuous step along the ridge with little or no increase in ploughing costs).

Practical recommendations for the raising and planting of Lodgepole pine and Sitka spruce tubed seedlings under British conditions have been developed from the results of the research and development programme. These recommendations follow.

PROCEDURE FOR TUBED SEEDLING PRODUCTION

Tube Loading

Extruded grey polystyrene tubes 7·5 cm long × 1·3 cm internal diameter, with a wall thickness of 0·3 mm and slit up one side (supplied to special order by Telcon Plastics Ltd., Farnborough Works, Green Street Green, Orpington, Kent) are packed in "honeycomb" formation in standard size 14·5 × 9 in (36 cm × 23 cm) polystyrene seed trays, each holding approximately 440 tubes. (The trays subsequently form the basic units for handling seedlings in the greenhouse, during transport and in the forest). A mixture of equal parts by volume of finely milled granulated horticultural sphagnum peat (pH 3·5–4·0, screened through 6 mm (0·25 in) mesh) and lime-free medium sand is used for filling the tubes and is added until approximately 1 cm at the top of the tubes remains empty after light compaction (e.g. with a dense stiff-bristled brush). Care should be taken to avoid air spaces remaining within the tubes.

Fertiliser Regime

Two alternative fertiliser regimes can be used —one based on the granular slow-release compound fertiliser "Enmag" (manufactured by Scottish Agricultural Industries Ltd and containing 5%N, 10·6%P, 8·3%K and 10% Mg) and the other on Fison's "FL3P" liquid fertiliser (7%N, 3·1%P and 5·8%K). In the first, "Enmag" at 1·5 kg/m^3, fritted trace elements (Frit 253A, distributed by Tennant Trading Ltd., 9 Harp Lane, Great Tower

Street, London EC3) at 0·25 kg/m³ and ground limestone at 3·0 kg/m³ are added to the peat-sand mix prior to filling the tubes, and no subsequent fertilising is required. In the second, fritted trace elements at 0·25 kg/m³ and ground *magnesian* limestone at 3·0 kg/m³ are incorporated prior to filling the tubes; subsequently "FL3P" at a dilution of 3 ml/litre is applied at weekly intervals beginning 3 weeks after sowing, using an application rate of 2·5 litres/m² of bench space. The "Enmag" regime is more convenient to use and may give greater average vigour, while the "FL3P" regime gives a slightly higher seedling yield and very uniform growth. (Note: Limited recent experience has suggested that Fison's "FL5P" (containing 10%N, 4·4%P, and 4·2%K) can be used as an alternative to "FL3P" and may give slightly better growth).

Seed Selection and Pre-Treatment

The seed used should be of maximum possible viability, with high germinative energy, and selection should be based on recent laboratory test data. It is desirable although not essential to have the lightest seed (approximately $\frac{1}{8}$th of total weight) removed by means of a vibrating gravity table. Before sowing, seed should be pre-chilled in a refrigerator or cold store to ensure rapid even germination. The pre-chilling procedure is as follows—soak the seed in cold tap water (3–5°C) for 48 hours; drain off the water and remove excess moisture from the seed with paper towelling; then store the moist seed in a sealed polythene bag at 3–5°C for 3 weeks, preferably opening the bag once a week to allow in fresh air. Seed lots which show some degree of dormancy will benefit most from pre-chilling, but it has been found in practice that all lots of Lodgepole pine and Sitka spruce seed used to date, whether dormant or non-dormant, have shown some improvement in rate of germination after such treatment. If for any reason (such as shortage of time) pre-chilling is not possible, then at the very least the seed should be soaked in cold water for 48 hours prior to sowing. No seed dressing of any sort should be used.

Seed Sowing and Germination

One seed is sown in each tube and covered with a 3 mm layer of medium/fine lime-free sand. Sand with a high proportion of very fine (less than 0·2 mm) particles should be avoided as caking may occur and reduce or delay germination. 60–70% of the sand particles should preferably be in the 0·6–0·2 mm class. The trays of tubes are then stood in shallow water (about 30 mm deep) until the peat-sand mixture is thoroughly moist, before being placed for 7 days on racks in an insulated germination room maintained thermostatically at a steady 25°C. (If such a facility is not available, trays can be taken directly to a greenhouse, but germination will be slower and less even; as a result a longer production period may be necessary). The trays are covered with polythene sheeting to minimise water loss and should not need further watering during this period. Continuous lighting is provided by a warm white fluorescent tube, but this is probably not essential. Plate 2 shows a germination room based on a design by the North West England Electricity Board (see Newton and Gould, 1967).

Greenhouse Regime

After 7 days the trays are transferred to benches in a greenhouse where approximate day and night temperatures of 21°C and 15°C are maintained by thermostatically controlled heating and ventilation (Plate 3). Adequate forced-draught ventilation is essential during sunny weather in summer. Using a fine spray, watering should be done as required—probably once every 2–3 days in early spring, increasing to once or even twice daily in warm sunny weather. The need for watering is readily determined by examining the soil mixture in the split tubes. Water should not be applied in strong sunshine because of the risk of scalding damage to seedlings. Both under- and over-watering should be avoided—the former because it may lead to seedling loss due to desiccation, and also encourages excessive root emergence from the tube bases; and the

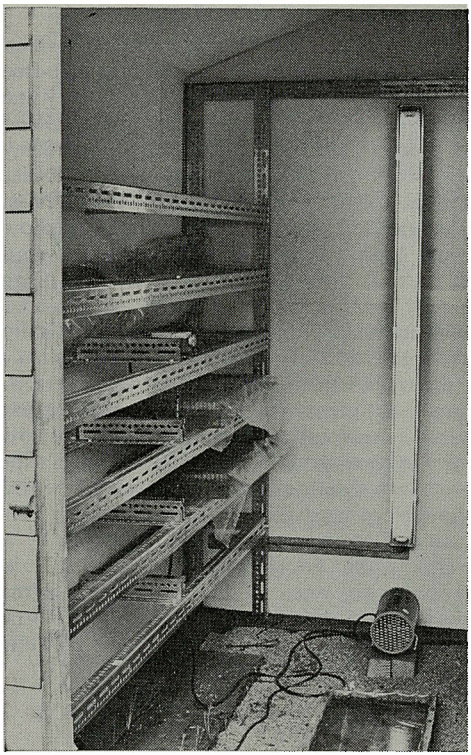


Plate 2. Insulated germination room used to promote rapid germination in tubes. Note heater, light and racking for trays which will be covered with polythene to minimise water loss. A3746

latter because it leads to poor root development and excessive loss of nutrients by leaching, and may encourage damping-off. A useful "rule of thumb" is to apply approximately 2·5 litres of water per square metre of bench area at each watering.

As a precautionary measure against fungal attack, a captan drench at 2·5 litre/m² can be applied 2 and 4 weeks after sowing if the risk of damping-off is high (e.g. in cool, damp weather in spring) but the treatment should be used with discretion. "Orthocide Concentrate" at 1·5 g/litre or "PP Captan 50" at 2 g/litre are suitable for this purpose.

Hardening off and Sorting

Prior to planting (and usually 6 weeks after sowing) trays of seedlings are placed out of doors to harden-off for 2 weeks. During this period netting protection is desirable to prevent damage by birds and mammals, and hessian or other screening may be necessary early and late in the growing season in order to reduce the risk of frost damage. Before trays of tubes are despatched for planting it is desirable to bring them up to full stocking by removing and replacing all tubes without seedlings or with weak, under-sized seedlings. To ensure efficient use of greenhouse space this is best done as early as possible in the production period. With an eight week production period, sorting of Lodgepole pine and Sitka spruce could be done as early as three weeks after sowing, because seedlings germinating after that time are unlikely to be large enough for planting at eight weeks.

Seedling Out-turn and Growth

By following the above procedure and using seed with a viability of 85 % (a value frequently found for seed of the more readily available origins) it is possible to obtain 80% germination of both Lodgepole pine and Sitka spruce, with a usable seedling yield after eight weeks of 75% of tubes sown. If the seed used is of higher viability (more than 90%), then higher yields are possible and values exceeding 90%

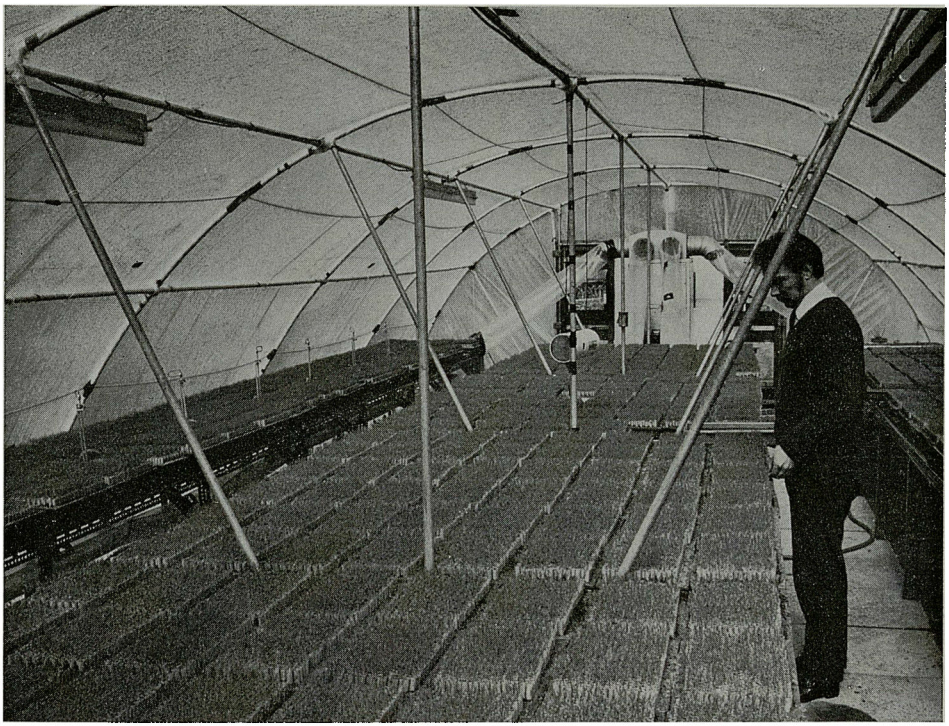


Plate 3. Interior view of polythene house used for tubed seedling production. Note oil-fired warm air heater at rear, and trays of 5 week old Lodgepole pine seedlings on benches. A4387

have frequently been obtained in both greenhouse experiments and stock sowings for forest trials.

Seedlings of pine and spruce usually begin to appear 5–6 days and 7–8 days respectively after sowing, and germination has been largely completed two weeks later. For lots sown in early spring, average seedling heights 8 and 12 weeks after sowing will be about 2·5 and 4·0 cm for pine and 2·0 and 3·5 cm for spruce. Because of more favourable growing conditions during the summer months (June–August), germination, yield and growth rates all tend to be higher than at the beginning or end of the growing season.

Plate 4 shows a tray of 440 eight week old Lodgepole pine seedlings ready for transport to the forest.

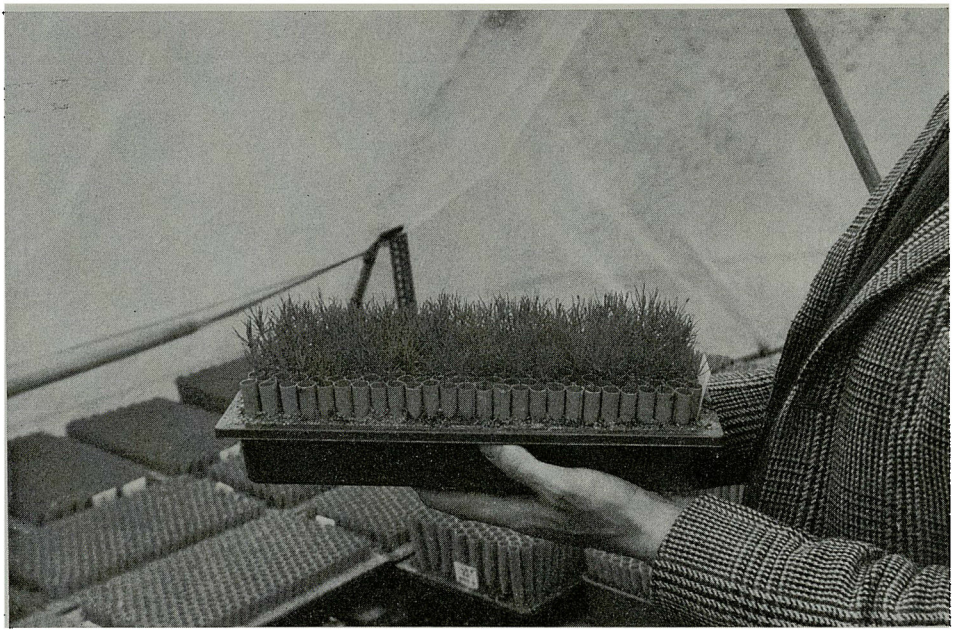


Plate 4. Tray of 440 eight week old Lodgepole pine seedlings ready for planting. A3720.

USE OF TUBED SEEDLINGS FOR PEATLAND AFFORESTATION

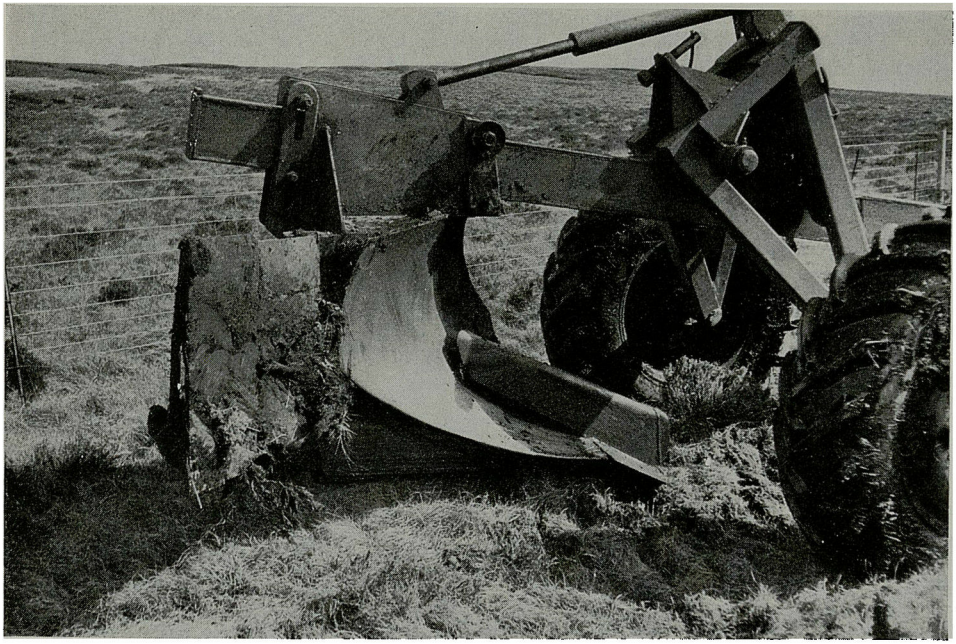
Suitable Site Types

Tubed seedlings of Lodgepole pine and Sitka spruce can be used successfully for afforestation planting on a range of upland peat sites (including some peaty gley soils with a peat depth exceeding 35 cm, as well as deep peats). As a general rule, use of tubed seedlings should be restricted as far as possible to the poorer peat types, where there is little risk of vigorous growth of *Molinia* or other grass species. Suitable sites normally fall within the various unflushed or poorly flushed blanket or basin bog categories, with fibrous or pseudo-fibrous peat. The principal ground vegetation species associated with these are heather (*Calluna*), cotton grass (*Trichophorum*) deer hair grass (*Eriophorum*) and *Sphagnum* mosses in varying proportions; *Molinia*, if present, should be sparse and non-vigorous. Well-flushed bogs should be avoided because of the vigorous *Molinia* growth which follows ploughing and because the amorphous peat may cause frost-lifting of tubes.

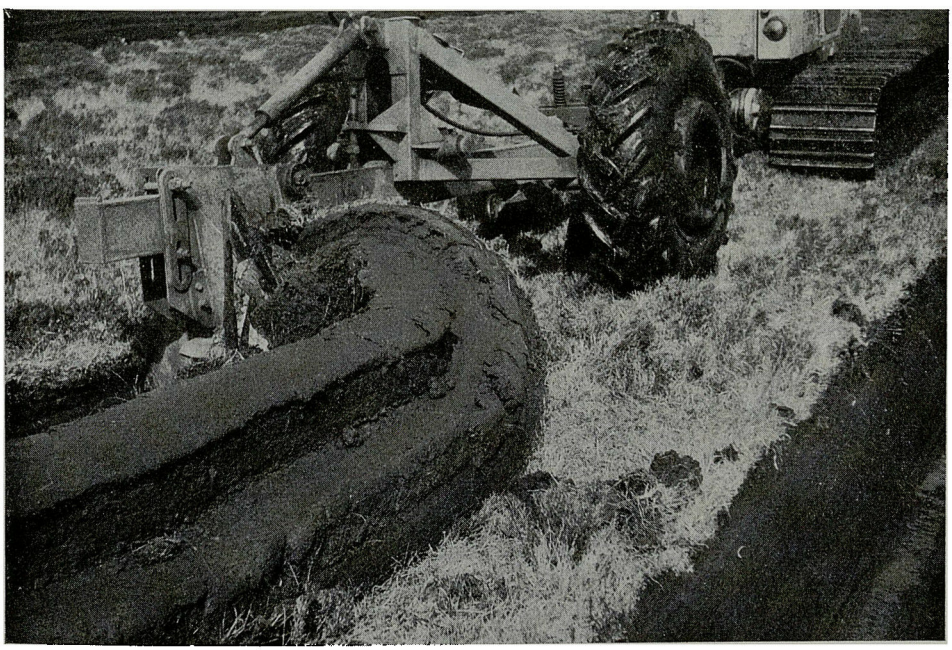
Ploughing and Step Cutting

Spaced furrow ploughing with a relatively *deep-going* single mouldboard turfing plough produces the most satisfactory planting ridge for establishment and early growth of tubed seedlings.

It is not yet clear whether or not the deep double mouldboard turfing plough currently being developed by the Forestry Commission will produce ridges suitable for tubed seedling planting.



Plates 5. Single mouldboard plough fitted with a "Logan" sock (*above*) which produces a continuous step along the peat ridge (*below*). A4417 and 4415.



Shallow double mouldboard ploughing is *not* satisfactory.

Use of a single mouldboard plough suitably modified to produce a continuous step along the ridge (Plate 5) will provide adequate early shelter with little or no increase in ploughing cost.

If such a plough is not available, planting steps should be cut by hand at appropriate intervals along the ridges prior to the actual planting operation.

Whether produced by plough or by hand, the step base should preferably be approximately 20 cm above ground level (in practice, about half ridge height in many cases). For large planting programmes hand stepping is likely to be impracticable because of the labour requirement, as well as being a relatively costly operation. (Nevertheless, because of the low cost of planting tubed seedlings, the combined cost of hand stepping and planting may well be similar to the cost of planting bare-rooted stock).

Planting Season and Seedling Age

For most locations the effective planting season is from mid-April to late August, with the optimum period from May to July inclusive. However, April planting of actively growing seedlings should be avoided in areas prone to late spring frosts or to severe weather conditions, particularly if Sitka spruce is being used. Eight week old seedlings will generally give satisfactory results, but with Sitka spruce on the more testing sites, ten week old seedlings will give slightly better survival. Planting of over-wintered dormant seedlings in March and April is a possible means of extending the planting season, but results are less reliable. There are also practical difficulties involved in raising and over-wintering large numbers of seedlings for such early plantings.

Transport to the Planting Site

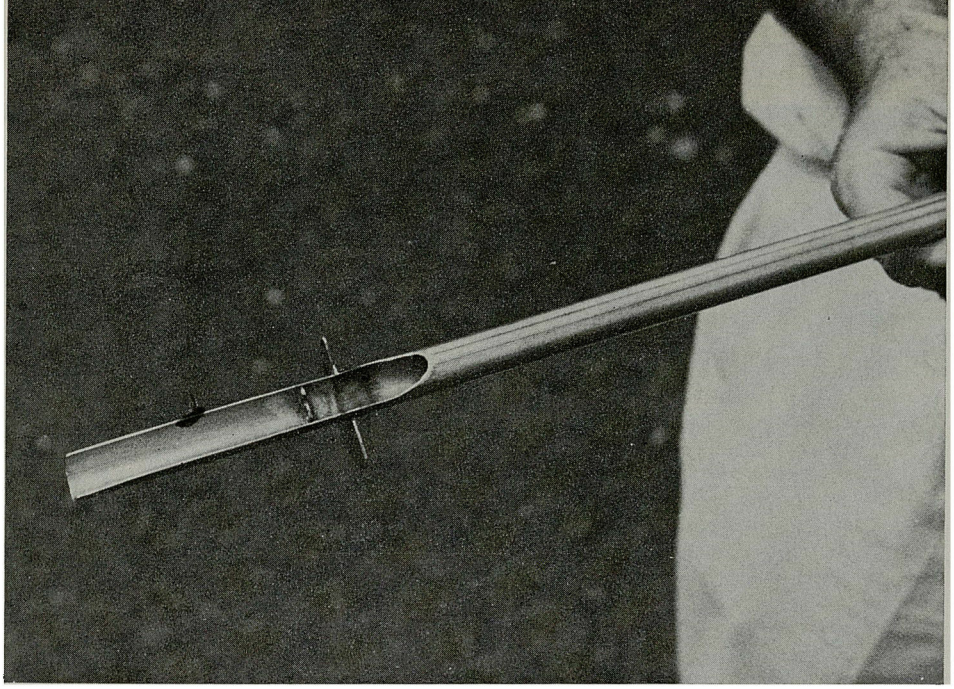
Trays of seedlings can be sent from the nursery to the forest in a suitably racked, covered vehicle at any time during the two week hardening-off period. For delivery of small quantities, a van can be fitted out easily and cheaply with suitable shelving, and for transporting larger quantities frames can be made to fit on a normal flat-bed lorry.

Seedlings must be in good condition when despatched and must be watered as necessary to prevent drying out during any subsequent storage period prior to planting. Netting protection against bird and mammal damage may also be required.

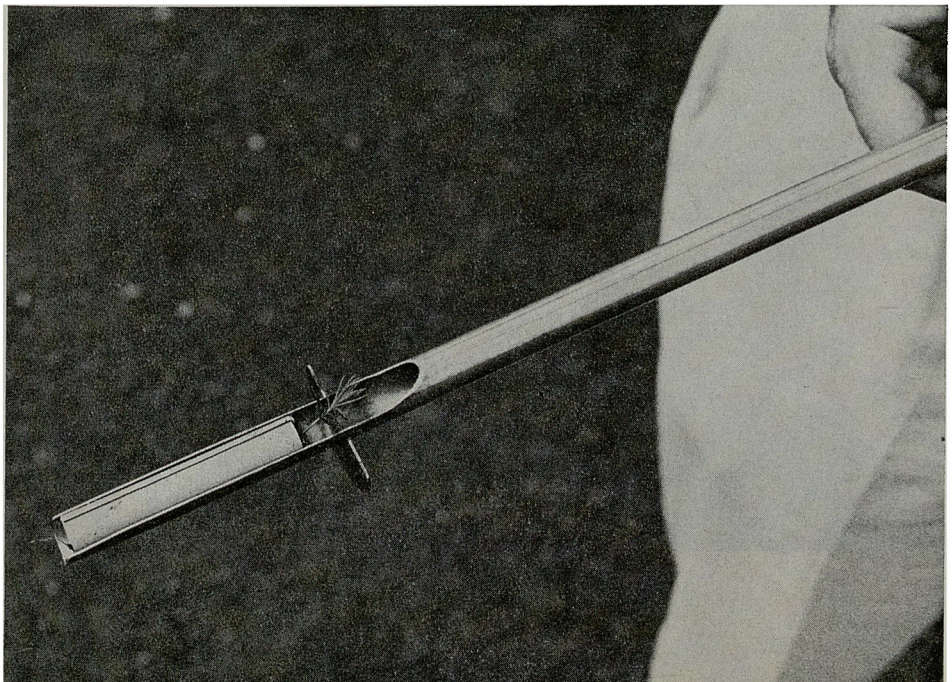
Prior to the planting operation, the trays should be distributed within the planting area to minimise time spent by planters walking to collect them. (The *average* distance walked for this purpose should preferably not exceed 25 m.) For distribution up to a distance of 150 m from a road, the carrying of the tubed seedlings in hand frames is the easiest and cheapest method. Where greater distances are involved, a cross-country vehicle or tractor and trailer with suitable racking should be employed.

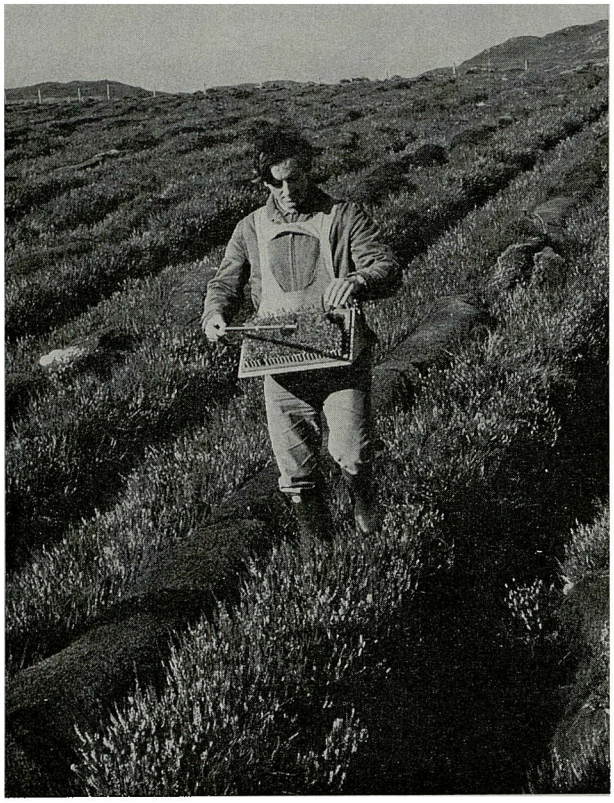
Planting Equipment

Planting is done with a specially devised tool (Plate 6) made from a 1 m length of stainless tubing with an outside diameter of 15 mm and a wall thickness of approximately 0·75 mm. At one end, half of the circumference (not more) is cut away for a length of 12 cm and any rough edges are filed smooth. An internal "stop" (made from half of a suitably sized washer) is welded 8·3 cm from the end of the tube. An external depth gauge is welded round the outside of the tube 9·5 cm from the end. (The difference between the gauge locations ensure that after planting the top edge of the tube is slightly below the peat surface.) The other end of the tube is bent to form a handle. Prior to use, the cut-away end is adjusted with pliers to ensure that tubes are held with sufficient pressure to prevent their dropping-out before the tool is inserted into the peat. Planting tools can be made to special order by Highland Universal Fabrications Ltd.



Plates 6. Special tool for planting tubed seedlings in peat shown unloaded (*above*) and with seedling in position (*below*). Note cut-away portion of tube, internal "stop" and external depth guage. A4401 and 4402.





Plates 7. Planting tubed seedlings on ploughed peatland using the special tool and tray-carrying harness. The ridges have been stepped by hand prior to planting. The worker loads the tool while walking from one planting spot to the next (*left*). As he pushes one seedling into the peat he selects another in preparation for re-loading (*right*). A4343 and 4339
(*N.B.* The current model of harness differs slightly from that shown above; the support webbing has been modified to give improved ventilation).

Harbour Road, Inverness (price £3·20 in September 1974).

In order to leave both hands free for loading and using the planting tool, each worker requires a special tray-carrier on a harness to support a tray of seedlings in front of him (Plate 7). The tray-carrier is made of aluminium and is sloped away from the worker to give maximum stability to the tubes remaining in the tray after planting has begun. The tray is joined to a harness by a pressure plate which rests on the worker's stomach. The harness is made from polythene-coated synthetic fabric and is designed to give as much ventilation as possible. Carriers can be obtained to special order from Messrs. R. MacDonald and Son, 24 Queen Street, Inverness (price £9·25 in September 1974).

Planting Method

Planting tubed seedlings is a simple and very rapid operation if the correct procedure is followed. The worker walks alongside the previously stepped plough ridge, carrying the planting tool in one hand (usually the right but left-handed operation is relatively easy even for right-handed persons). During loading, the tool is held more or less horizontally in a convenient position in front of the tray. Using the thumb and forefinger of the free hand, a tube is picked from the tray and slid into the cut-away channel of the tool, with slight downward pressure, until it rests against the internal stop with the seedling shoot projecting beyond the stop. This sliding motion ensures that the tube is correctly positioned in the tool, and at the same time the top edge of the tube clears away any sand or peat adhering to the inside of the channel. The loaded tool is pushed smoothly and vertically into the peat as far as the depth gauge allows, and is then withdrawn. The tube is retained by the adhesive nature of the peat and remains inserted with its top edge slightly below the peat surface. While the tube is being pushed in, the free hand is selecting the next seedling to be planted (see Plate 7). Tubes should always be taken from the tray corners nearest the planter's body.

Procedures for Maximum Output

For maximum output to be achieved, the following important points must be kept in mind:

(1) It is important that tube selection and loading of the tool are done while the worker is planting the previous tube and walking to the next planting spot; and that all movements are carried out as part of a steady rhythm. With relatively little practice, planting can be done at a slow but steady walking pace.

(2) If a tube is dropped, the planter should *not* stop to pick it up, but should ignore it, select a further tube and continuing planting. Only where a substantial number of tubes fall from the tray is it desirable to pick them up, and to do so the worker must bend at the knees and keep his back erect so as to avoid further spillage from the tray.

(3) Where cross drains have been ploughed prior to planting, workers should progress backwards and forwards between two successive drains. This avoids not only the break in continuity inherent in crossing such drains, but also the very real risk of stumbling or falling in the process with consequent spillage of seedlings. Cross drains should preferably be cut after planting, so as to give the longest possible planting runs.

(4) The worker should not normally start planting a new row outwards from his supply location unless he has sufficient seedlings to enable him to plant out to his turning point and back again. In this way he avoids having excessive unproductive walking time resulting from his running out of plants at some distance from his supply point.

Planting Output

The rate of planting achieved varies with the walking conditions and with the type and condition of peat in the ridges. The walking conditions affect the ease with which the worker can walk alongside the plough ridges, while the peat conditions determine both the

ease with which the planting tool can be inserted into the peat and whether or not the tube is retained effectively by the peat.

In North Scotland, average output per man (including allowances for associated work and rest) has ranged from 740 seedlings per hour with easy walking and peat well suited to the technique, to 415 seedlings per hour with difficult walking and barely suitable peat. Table 1 gives a guide to the expected output for various combinations of site conditions. The various categories of walking and peat conditions are defined in footnotes to the Table.

TABLE 1

TUBED SEEDLING PLANTING OUTPUT (NUMBER OF SEEDLINGS PER HOUR) IN RELATION TO SITE CONDITIONS

Walking Conditions	Peat conditions		
	Good	Intermediate	Poor
Easy	740	655	585
Intermediate	585	530	485
Difficult	485	450	415

Notes

1. *Walking conditions*

Easy. Little danger of stumbling or tripping; ground reasonably firm; possible to walk easily on either side of ridge (at least 0·3 m between ridge and furrow on both sides).

Intermediate. Impediments to walking necessitate care at times; walking may be very difficult on one side of ridge.

Difficult. Care necessary to avoid falls; little room to walk alongside ridge; ground may be very wet.

2. *Peat conditions*

Good. Peat fibrous or pseudo-fibrous, firm and moist (but not waterlogged); tubes penetrate easily and remain in peat.

Intermediate. Peat fibrous to amorphous, occasionally hard with patches of mineral soil and stones; tubes usually penetrate easily and remain in peat, but may occasionally break or fail to remain.

Poor. Sphagnum peat or very friable amorphous peat giving easy penetration but very poor retention of tubes; also peat with tough dried-out surface layer which makes penetration difficult and leads to broken tubes.

3. *Allowances included*

An allowance of 22% has been made for necessary work other than actual planting (collecting trays from nearby supply point, crossing from one furrow to the next, etc.); rest time was also included as 20% of time spent in planting and other necessary work.

Fertiliser Treatment

Fertiliser treatment at time of planting tubed seedlings can be carried out in the same way and at the same rates as for transplants. Spot and broadcast methods of application appear to give similar results. On the poorer peats, the use of fertiliser supplying both P and K (rock phosphate—muriate of potash mixture at 565 kg/ha, rather than P alone (rock phosphate at 375 kg/ha) should give a worthwhile growth response. If necessary for management reasons, fertiliser can be applied slightly in advance of planting but a lengthy period between fertilising and planting is undesirable because of the possible effect on weed growth.

Animal Damage and Protection

Unacceptable losses and delay in establishment are likely if serious browsing damage occurs. Exclusion of red deer and sheep is essential, and control of hares and roe deer may be necessary. In the trials, serious damage has been much less frequent than expected. However, there is obviously little point in planting tubed seedlings on sites where the occurrence of *severe* browsing damage by hares, deer or black grouse (*Lyrurus tetrix*) is highly probable and cannot be prevented.

Weed control

Control of weed growth will usually be unnecessary if planting of seedlings is confined

Plate 8. Lodgepole pine (of coastal Washington provenance) step planted in June 1968 as 8 week old tubed seedlings on a poor blanket peat and photographed after 5 seasons' growth. Stems have remained straight and upright despite vigorous growth. Tighnabruaich Forest, Argyll, Strathclyde Region. A4394

Plate 9. Sitka spruce step planted in June 1969 as an 8 week old tubed seedling on a poorly flushed blanket peat, and photographed in September 1971 after 3 seasons' growth. Selm Muir, Lothian. A3896

Plate 10. Root system of vigorous Lodgepole pine (of coastal Washington provenance) $6\frac{1}{2}$ years after being planted as an 8 week old tubed seedling on a poorly flushed blanket peat in Naver Forest, Sutherland, Highland Region. Note excellent distribution and depth of root system which penetrated over 30 cm below the original ground surface. A4421

to the poorer upland peats, as described above. However, it is inevitable that on some sites control of grass growth will be required (e.g. where *Molinia* responds to ploughing and fertilising more vigorously than expected). In such cases dalapon treatment (at 10 kg/ha active ingredient) provides an alternative to costly hand weeding. The chemical should be applied as a medium volume spray in water immediately prior to flushing of the trees in the season after planting (or in subsequent seasons if required).

Seedling Performance after Planting

When used in appropriate circumstances, tubed seedlings give high survival and vigorous early growth (Plates 8 and 9). The basic height growth pattern is similar to that of transplant stock planted on similar sites, but differs in absolute terms because of the much smaller initial size of the seedlings. For both Lodgepole pine and Sitka spruce, the difference is likely to be equivalent to between one and two seasons' growth. Root development is generally satisfactory (Plate 10), and in the case of Lodgepole pine provenances from coastal Washington and Oregon, tubed seedling stock is likely to give improved early stability and a consequent reduction in the development of basal bowing.

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