A FULLY INTEGRATED SYSTEM FOR PLANTING BARE-ROOT SEEDLINGS OF RADIATA PINE IN NEW ZEALAND

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Abstract. The establishment phase needs to be recognised as vitally important in the forest management cycle. The quality of establishment is best judged by vigour, tree form, and uniformity of growth in plantations.

Research trials and operational experience in New Zealand with bare-root seedlings of radiata pine (Pinus radiata) have shown the benefits of an outplanting system which fully integrates nursery and forest operations. Top quality tree stocks, careful handling procedures, good planting techniques, and thorough organisation and planning are the keys to success.

Additional keywords: seedling quality, seedling culling, planting techniques.

INTRODUCTION

Success in the establishment of forest plantations depends on site quality, site preparation, quality of tree stocks, and on a planting system appropriate to the climate. Improved land clearing, cultivation, and fertiliser treatments have increased growth rates and raised site indices to the degree that trees can now be grown on sites that previously were considered uneconomic to plant. Advances in the growing of bare-root tree stocks, such as the development of a precision sower, suitable root pruning, in-bed grading, and conditioning procedures enables nurserymen to produce high quality seedlings (Chavasse 1980; Menzies et al 1985).

The benefits of good site preparation and good nursery stock can be negated by poor handling practices between lifting and planting (Trewin 1978a). Consequently, a system for outplanting bare-root tree stocks was developed to ensure that stock handling can be minimised during this most critical phase.

Because of a general improvement in technique for establishing Pinus radiata in New Zealand, survival percentages on all but the harshest sites is usually at least 90%. However, deficiencies in outplanting systems, in particular poor root orientation at planting, can still give uneven growth and can contribute to toppling (Mason, pers. comm. 1985). Many foresters find it

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necessary to plant 1200 seedlings/ha to be assured of obtaining 200 - 300 well formed stems for high pruning and selection as crop trees. If more even growth rates with improved stability and tree form could be guaranteed, then initial stocking could obviously be reduced. This would result in reduced costs of establishment and tending and better use of genetically improved seed orchard stock. Until systems are adopted which adequately protect bare-root tree stocks during outplanting, such benefits will not be realised (Trewin 1981b).

The quality of new plantations can be related directly to the quality of nursery tree stocks and the effectiveness of the outplanting system. Failure of any one part of the system can result in poor growth and tree form. Individual effects of poor growing, lifting, packaging, transporting, and planting methods may not be significant. However, the cumulative effects of malpractice may be devastating. Therefore, all likely weaknesses in the outplanting system must be eliminated.

The aim is to return the bare-root seedling to the ground, as soon as possible after lifting from the nursery bed, at a correct depth and with minimal damage and root distortion. Delays between lifting and planting, and poor handling and planting techniques reduce the seedlings' biological potential, quality of the plantation and value of the final crop.

The quality of seedlings delivered to the planting site depends on careful integration of all nursery operations. Accurate forecasts of final-crop seedlings are essential for planning stock allocations and lifting and planting programmes. Monitoring seedling quality and numbers through all stages from sowing to harvesting should be the responsibility of a senior forester.

In the forest, quality and cost of planting is related directly to the efficiency of stock distribution - both to and on the planting site, the quality of stock, the effectiveness of the planting method, the standard of supervision and of quality control, and good incentives. When these elements are properly integrated the quality of planting is assured and the need for complex quality, control checks eliminated.

Before the start of each planting season it is advisable to hold training sessions. Staff and workers should be taken to the nursery and field to be taught lifting, planting, and quality control skills. It is important that nursery and field personnel have a thorough understanding of each others' work so that when problems arise they can be easily traced and rectified. Video and appropriate "handouts" can be used as training aids.

Competent nursery workers in New Zealand now receive certification through the Forestry Training Board of the New Zealand Logging Industry. The Board examines workers to see that their work methods are correct and issue certificates to this effect. Recognition of skills improves work quality and gives workers priority when applying for new jobs.

Since the FRI integrated sysem for outplanting 1/0 radiata pine seedlings and other bare-root tree stocks was first advocated (Trewin 1981b) there have been a number of improvements. This paper updates information and details procedures which are integrated to form the system. Equipment costs for packaging and handling seedlings are given in an Appendix.

IN THE NURSERY

1. Sowing

Benefits of spacing seeds/seedlings accurately in nursery beds are many. The importance of providing individual seedlings with adequate room to grow is well documented (van Dorsser 1969, 1981; Menzies et al. 1985). Precision sowing also facilitates early identification of individual, well-formed seedlings for final crop assessments and the culling out of unwanted runts and malforms. At lifting, roots of well-spaced trees are not entwined and are easy to lift and separate so that stripping, and the loss of valuable soil-mycorrhizae, is much reduced (Trewin 1981b).

2. Crop assessment

To assist establishment foresters in forward planning, nurserymen need to provide early and accurate crop forecasts. If seedling emergence is poor or subsequent losses occur, forest managers are informed immediately so that arrangements can be made for alternative seedling supplies or a cut-back in land preparation for planting. Also, to improve future returns from sown seed nurserymen need to be able to account for seed and seedling failure. To do this they should monitor and assess growth from sowing to harvest in crop assessment plots. These are best laid down immediately after sowing and checked regularly to assess percentages of emerging seedlings and the effects of pests and diseases. Instances of and possible reasons for failure are recorded and, where possible, remedial action taken. Plots should be positioned throughout the nursery beds. Local knowledge and experience in collecting data from nursery blocks is used in deciding sample plot, positioning, size, and numbers.

3. Thinning

When seedlings emerge too closely spaced they should be thinned early in the growing season so that residual seedlings have adequate room to grow (Trewin 1978b). Even when precision sowers are used, two or three seeds are occasionally sown together. Several large nurseries use a tractor-drawn thinning/culling frame which covers three beds in one pass (Trewin 1978b). Thinning and culling can be done at the same time (Trewin 1981a).

4. Culling

When seedlings reach an average height of 10 cms, culls (forked, multi-leadered, undersized, and unhealthy seedlings) can be identified (Trewin 1981a). If cull percentages are over 5%, unwanted seedlings should be removed from beds. Attempts to remove culls at lifting, especially with unskilled labour, are not always successful, and result in inferior seedlings being planted.

In-bed culling is a prerequisite for mechanical harvesting and automated packaging (Trewin 1976). No method has yet been or is likely to be devised which can separate good seedlings from bad during the lifting process. Culling at planting has been tried, but has proved impracticable due to inadequate planter training and supervision problems.

Ideally, beds should be culled to give crops of evenly sized, high quality seedlings. With improved supervision and training of lifters and planters, discarding of defective stock at all stages of outplanting can be encouraged.

When there are surpluses of stock, the opportunity should be taken to plant only the very best seedlings. When there are shortages it is preferable to maintain high culling standards and plant fewer trees. Inferior seedlings rarely produce good trees. Money spent on handling and planting such seedlings is wasted as they will either fail or be removed during thinning operations.

In the 1983-84 growing season in New Zealand one large private nursery thinned/culled a crop sown with a Stanhay sower. Approximately one million rejects were removed, leaving a final crop of nine million 1/0 radiata pine seedlings. The total cost of this operation was NZ$10,000.00, or $1.11/1000 residual good stock. The resulting crop was reported to be of a high quality.

5. Conditioning

Research at FRI on seedling quality and conditioning has concentrated on methods of producing seedlings that will withstand the stresses of transplanting, resulting in improved field survival and growth rates (van Dorsser and Rook 1972; van Dorsser 1981; Menzies et al. 1985).

Accurate undercutting and lateral root pruning makes for easier lifting and root trimming. If undercutting is too deep or lateral root pruning inadequate, long roots increase the forces needed to lift seedlings, resulting in root stripping and breakage.

6. Lifting

Seedlings need to be lifted carefully to avoid root exposure and damage. Soil should be loosened just prior to lifting by passing an angled bar (approximately 25° from the horizontal) one or more times under the seedling bed. When soils are heavy it may be necessary to start treatments some time before lifting when moisture levels are optimum. Very wet soils do not crumble, while some dry soils break up in lumps, forming clods around root systems.

In light soils well-loosened seedlings may be lifted singly, but where soils are heavy it is best that the seedlings are lifted in handfuls of 2 or 3, separated, and excess soil shaken free. It is important that some soil and mycorrhiza be left on roots to assist in their re-establishment in forest soils which are often vastly different to that of the nursery (Trewin 1978a, 1981b). Excessive knocking or beating of roots to remove soil is to be avoided.

7. Root trimming

Good root trimming is a prerequisite to good root orientation at planting and must therefore be given the highest priority. Root trim immediately on lifting, in small bundles, before lateral roots become tangled with handling. The correct procedure is for the person lifting trees to hold the foliage of the seedling bundle in one hand while drawing roots down with the other to be cut off just below the tap-root ends (approximately 10 cm below the collar). Holding bundles of seedlings up in one hand while attempting to snip off projecting laterals with the other will result in a very uneven trim; outside roots are cut too short, while those in the centre often escape attention.

Efforts to develop root trimmers on belt-lifters have not met with a great deal of success. Soil-covered roots are not easy to cut cleanly, so that root ends are frayed and valuable mycorrhizae are also knocked off.

Ideally, roots should be in-bed trimmed/pruned sometime before lifting. Treatments would be timed so that cut root ends callus before lifting to encourage initiation of new growth shortly after planting. Machine and hand lifting would then be simplified and outplanting shock reduced.

Trials to examine growth and stability after planting of in-bed trimmed (box pruned) and conventionally trimmed stock, lifted manually and mechanically, are presently being evaluated. A simple hand-held single rotating disc is used, across bed, to cut roots between precision-sown trees. Standard lateral root-pruning conditioning equipment (gang discs) cut between-drill roots. As roots are held firmly by the soil, they are cut cleanly on all four sides of the tree and soon callus.

8. Packing of seedlings in cartons

Seedlings should be lifted, root trimmed, and packed horizontally - to avoid root "thumping" and tap-root breakage -

direct into rigid boxes (waxed cardboard or plastic 540 mm x 220 mm x 340 mm), which also act as planting boxes in the field. These hold 100-200 1/0 seedlings, which are exposed for only a few seconds at lifting and when being removed in the field for planting. At lifting roots should be dipped in water if soil moisture or air humidity is low, but care must be taken not to wash off valuable nursery soil and mycorrhizae. Alternatively, a fine water spray or moisture pad (e.g., a hessian blanket or foam sponge) can be used. In addition, a small plastic sheet can be fitted to cover roots and prevent moisture loss. If storage is required before transit to the field, roots should be examined before dispatch, and, if dry, moistened.

9. Transporting crates

Containerisation of planting boxes reduces handling costs and damage to packages and their contents. In the nursery, crates holding empty planting boxes are carried on belt-lifters or placed adjacent to hand lifters. Boxes are removed, filled, and replaced in crates which are dispatched direct to the field or stored. Containerisation in transporting crates also facilitates the smooth flow of tree stocks from nursery to field, reducing the time between lifting and planting and the associated outplanting shock.

FRI pattern crates, 1200mm x 1200mm x 1200mm are recommended as being the optimum size for nursery and field storage and transport of seedling planting boxes. These hold 30 boxes, or 3000 large or 6000 small 1/0 seedlings. Larger crates are sometimes used, but these are often too heavy for small tractors or mechanical seedling harvesters to lift or to carry over ground where traction is poor. Larger crates are also difficult to handle in confined spaces such as cool stores or to move around in the field. The particular advantage of this module is that when crates are stacked two side by side and two high they have the same end section as a standard road/rail/shipping container. Transport on public highways is therefore no problem, especially as an increasing number of trucks are now being equipped to handle containers. A number of forests recognising the advantages of this modular system have fitted self-loading equipment to their trucks. Others hire local transporters for the duration of the planting season. Helicopters are also used to lift stock into areas where roading is inadequate for good distribution.

10. Storage

Some delays are unavoidable so that cool-store facilities are valuable.

Unless ambient air temperatures are relatively low (less than 5°C) temperatures within packages can rise sharply. Cool storage is therefore desirable if seedlings are to be held for more than 24 hours , as otherwise carbohydrate reserves are lost from respiration causing rapid deterioration in stock vigour (McCracken 1981). Where cool store facilities are not available, every effort must be made to see that stock is outplanted as soon as possible after lifting. This is especially important when humidity is low and temperatures high. Regular checks must be made to see that temperatures within packages are not excessive (at 15°C carbohydrate reserves are used at many times the normal rate). Should temperatures be high (over 15°C) then stock quality is suspect and may need to be rejected, depending on other factors such as time since lifting, root condition etc.

Transporting crates must be well ventilated to allow the dissipation of any heat build-up due to respiration. Care must be taken not to impede ventilation by stacking crates too close together or against walls. Moisture pads (sponge polyurethane) can be fitted in crates to keep humidity levels high, reducing desiccation of stock and promoting cooling.

11. Stock dispatch records

Lifting and despatch dates should be clearly marked on stock dockets accompanying crates. There should also be space on the dockets for field staff to enter dates of receipt and the condition of stock, temperatures in packages etc, and the date of planting. Any deterioration in stock quality must be reported immediately to the officer in charge of establishment so that a decision can be made whether to plant the seedlings. Crates should be numbered so that accurate records of dispatch dates. can be maintained by nurseries. Any delays in crates being returned are reported by the nursery to the officer in charge of field operations. (The build up of tree stocks on forests and the inevitable loss in seedling vigour and establishment quality can thus be avoided.) A policy of no new tree stock dispatches should be enforced when crates are not returned on schedule. To facilitate nursery record keeping, crates could be colour coded for different forests. Forest field operators should be held responsible for damage to planting boxes and crates and for maintenance costs.

IN THE FOREST

12. Planning

Foresters in charge of outplanting should visit their nurserymen as often as possible during the seedling growing season to discuss quality and stock requirements for plantings. In New Zealand, by the end of March reliable final crop projections can be made from nursery crop assessment plots.

Due to different soils and climatic conditions growth rates vary between and in many instances within nurseries. Foresters, having personal knowledge of these variations in seedling quality and of the sites to be planted, can arrange stock distribution more judiciously. Large stock can be planted first on benign sites, allowing smaller seedlings to develop for later plantings. Once stock has been allocated to forests, communications regarding deliveries or cancellations of orders should be made direct between the forest and nursery, not through district offices. Confusion and delays between field and nursery can then be avoided.

13. Stock delivery

Forests should check that allocations of planting boxes and transporting crates are sufficient for their daily planting requirements. Daily delivery of stock should be aimed for. When planting programmes are small or distances from forests great, daily deliveries may not be practicable. This will happen when transporting costs mean that large transporters with a lot of stock must be used. To optimise use of transporting crates and reduce handling damage and costs, stock should not be held on the forest for more than two days. This allows one day for lifting, one day for transporting to the forest, two days for planting, and one day for transporting the crates back to the nursery. This is a total of 5 days maximum for recycling crates. A two-day recycling period will be possible when operations run smoothly:

* day one - lift during the day and transport that evening
* day two - plant and return crates the same evening.

Planting contractors working in forests close to nurseries often pick up stock early in the morning, plant it, and return crates the same evening. However, on large-scale operations unscheduled delays are likely so that five sets of crates should be allowed.

Fresh seedlings should be dispatched from the nursery only on receipt of empty crates from the forest. Stockpiling of full or empty containers in the forest is avoided and regularity of supplies assured. Individual forest crate sets should be colour coded and numbered for ease of identification. Cost of crates and repairs should be a charge on the forest. This ensures that care and maintenance of planting boxes and transporting crates is good.

14. Stock distribution

Distribution of stock on the planting site must be organised in advance. The length of planting runs, number of trees required, and the dumping stations should be clearly marked on compartment plans.

15. Planting gangs

Calculate number of planters needed/day to complete the programme on time. Allow for absenteeism due to sickness etc. Check that the numbers needed are available. Gangs of eight planters are easy to control and should be concentrated in one area. A small tractor and/or trailer can be used to keep stock close to planters. Fragmented planting gangs are difficult to supervise and keep supplied with seedlings. One additional worker per gang should be employed to carry seedlings to planters on a backpack. Backpacks hold four planting boxes so that two trips/planting run are needed to keep eight planters supplied. Where access is poor, additional stock distribution personnel may be needed. Up to 20% of planting time is wasted if individual planters walk out for tree supplies. Traditionally, supervisors have helped carry in trees to planters; they must not do this! Their job is to see that good stock and good planting techniques are used.

16. On-site storage

Deliveries must be carefully scheduled so that as little stock as possible is held on site. Stock needed on Mondays should be lifted on Friday, cool stored, and delivered to the site on Sunday evening or Monday morning. When cool storage is not available stock should be lifted as close to the time of planting as possible. Should stock have to be held on-site over the weekend then advantage must be taken of any natural shade. Crates must not be stacked close together as air movement and ventilation will be reduced. Exterior panels should be painted brilliant white to reflect sunlight and keep crate interiors cool.

17. Maintenance of seedling quality

Supervisors must check stock at time of planting. Of all quality checks, that of seedling quality at the planting hole is the most important. The forester in charge of planting must, in consultation with his supply nurserymen, decide on acceptable lifting, root trimming, and packaging standards at the beginning of each season. There will be some variation between nurseries and between early and late season stock. As a quality control measure, a full-scale colour photograph of a carefully lifted and root-trimmed seedling should be displayed at the nursery. A similar picture of a well handled tree, at the planting hole, should also be posted in the forest headquarters and in gang buses. Nursery and field personnel then have a good visual reference of a properly handled seedling.

Although stock may look good, overheating and long field storage periods reduce biological potential so that poor survival and growth rates are likely. Long cool storage periods, unless stock is handled and packed very carefully, have similar detrimental effects (Trewin 1981b).

Quality assessment check sheets should record temperatures in packages and the condition of roots and foliage. A visual assessment will show whether roots are properly trimmed, whether they are moist and in good condition. The number of days between lifting and planting must be recorded; should these be excessive (over 4 days) and temperatures be high (over 15°C), it may be decided to reject stock. Unless such information is carefully recorded problems will be difficult to trace and rectify.

18. Planting method

The aim is to return the seedling to the ground with as little root distortion as possible. Any planting technique that leaves the seedling firm, upright, and with roots which are relatively straight in well-cultivated soil can be considered good. While it is not practical to spend the time needed to replant a seedling's roots exactly as they were orientated in the nursery, integration of the following important facets of planting will, in most soil types, give good results: planting spot selection, planting spot clearing/ cultivation, planting hole opening, root placement, planting depth, and soil recompaction.

(a) Select the planting spot carefully: Good land preparation will provide the planter with a relatively weed- and debris-free planting spot. However, care must be taken to avoid planting over buried slash, rocks or on highly compacted areas which may retard or distort root growth. In high rainfall areas or low-lying land planting in small depressions should be avoided. These are likely to hold excess water so that trees may suffer from wet feet. In such areas the insistence on accurate spacing should be waived in favour of moving the planting spot, if possible, along the row to a better location.

(b) Cultivate the planting spot properly: Good planting spot cultivation is a prerequisite to good planting and root growth. In tractorable country mechanical cultivation, ripping, bedding, mounding, V-blading etc, or combinations of these treatments is popular. Where machines cannot be used, cultivation is normally done with a spade just prior to planting. In very compacted or stony soils where machine cultivation is not possible, it may be advisable to employ a special planting-spot cultivation gang. Minimum cultivation should be to a full spade's depth (30 cm) over an area of at least 40 cm x 40 cm. The one hit slit-type cultivation where the spade is thrust into the ground and the handle pushed back and forth until a V-shaped hole is formed should be strongly discouraged. Soil is rarely broken out at the bottom of the hole and is usually compacted either side of the hole where it is pushed by the spade. Roots of seedlings planted in V holes are pushed up as they are placed in the ground and are sandwiched in a single plane. Subsequent toppling of such trees is common.

(c) Open a good planting hole: The importance of opening up a good planting hole into which roots can be placed is NOT always emphasised. Slit planting and the associated root distortion is therefore common. Removing soil to create a good-sized hole is labour intensive and not always practicable. However, there is a relatively quick and simple method which gives good results (Fig. 1). In dry sand and some pumice soils this technique may not work as it is difficult to prevent soil crumbling back into the hole. When this happens it is necessary to remove soil and hold roots in the hand while easing them into the ground. Fortunately these loose soil conditions are not common. Heavy and wet soils also cause problems and opening these up for planting is labour intensive. Extra time spent in preparing a good planting hole will reduce greatly the likelihood of root distortion and is therefore time well spent.

(d) Position roots carefully: Of all the steps in planting correct root placement is the most difficult to set right. Because roots of a well-conditioned bare-root seedling are numerous, they tend to become tangled when placed in small planting holes, ending up like a bird's nest. Unfortunately, due to their being trapped by soil in this position, they remain permanently deformed. While initial growth does not appear to be too adversely affected, twisted roots give poor anchorage giving rise to instability and toppling in young stands (Mason pers. comm.). Also, roots twisted about the tap-root, close to the collar, can cause strangulation and restrict diameter growth. This greatly reduces the strength of the stem, which, when stressed by wind, is likely to break just below the ground.

Recent production-scale outplanting trials, in light pumice soils, have shown that roots of 1/0 radiata pine seedlings can be straightened at planting by giving them a POSITIVE PULL UP (PPU) through the planting-hole-fill just before firming in (Fig. 2). Root-straightening pull-up techniques are generally used before holes are filled, but as lateral roots are not held down by soil or the pull up is slight (only a few centimetres) the straightening effect is not always significant. The laterals of a well-trimmed seedling are approximately 10 cm long (the width of the palm in which they are held for trimming), a pull up of approximately 10 cm is therefore needed to straighten roots.

(CAUTION: CHECK ROOT PLACEMENT CAREFULLY! In heavy soils an excessive pull-up can cause "TUBING', the drawing down of roots, hard, against the main tap-root. This should be avoided; the long-term effects are not known.)

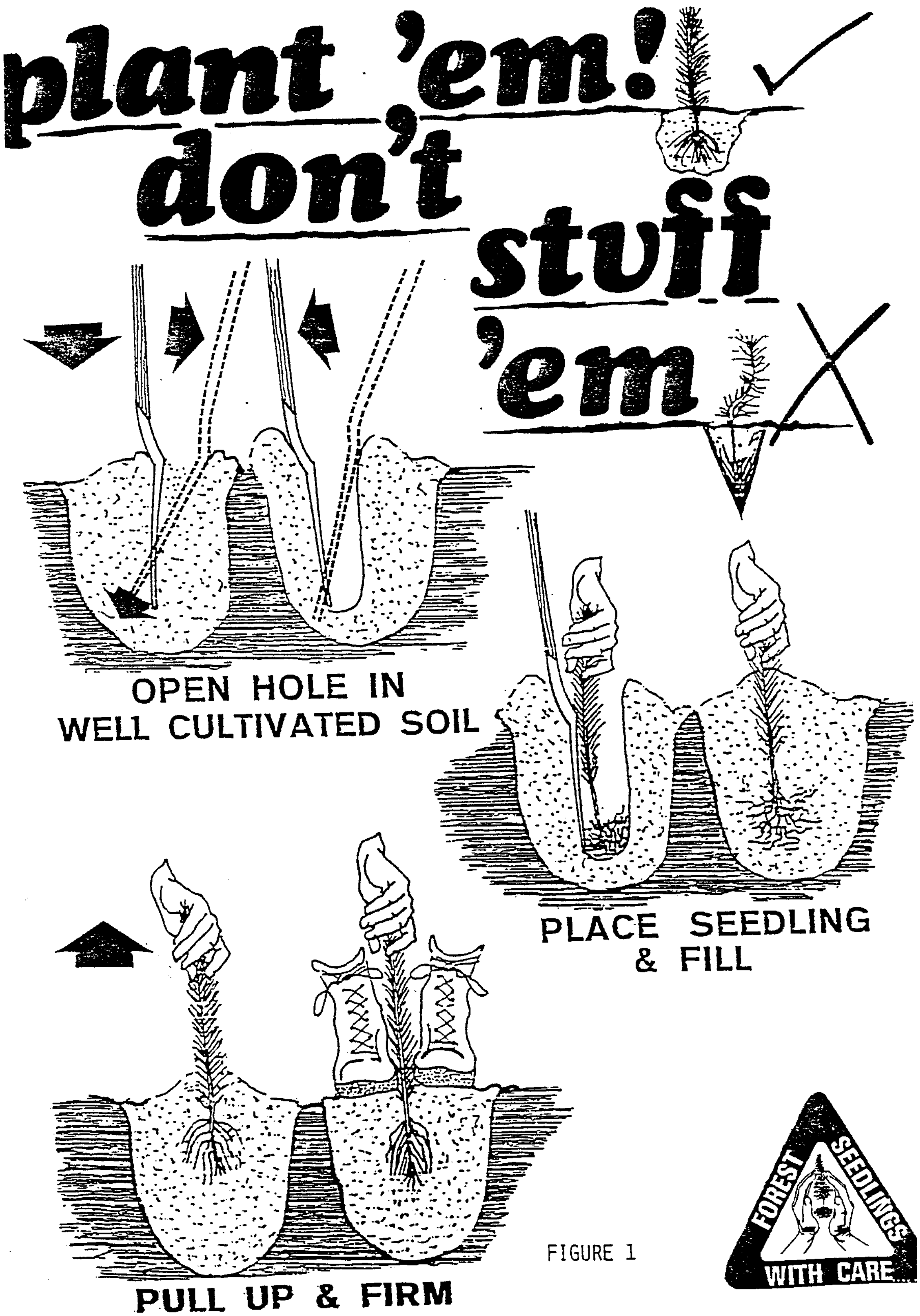
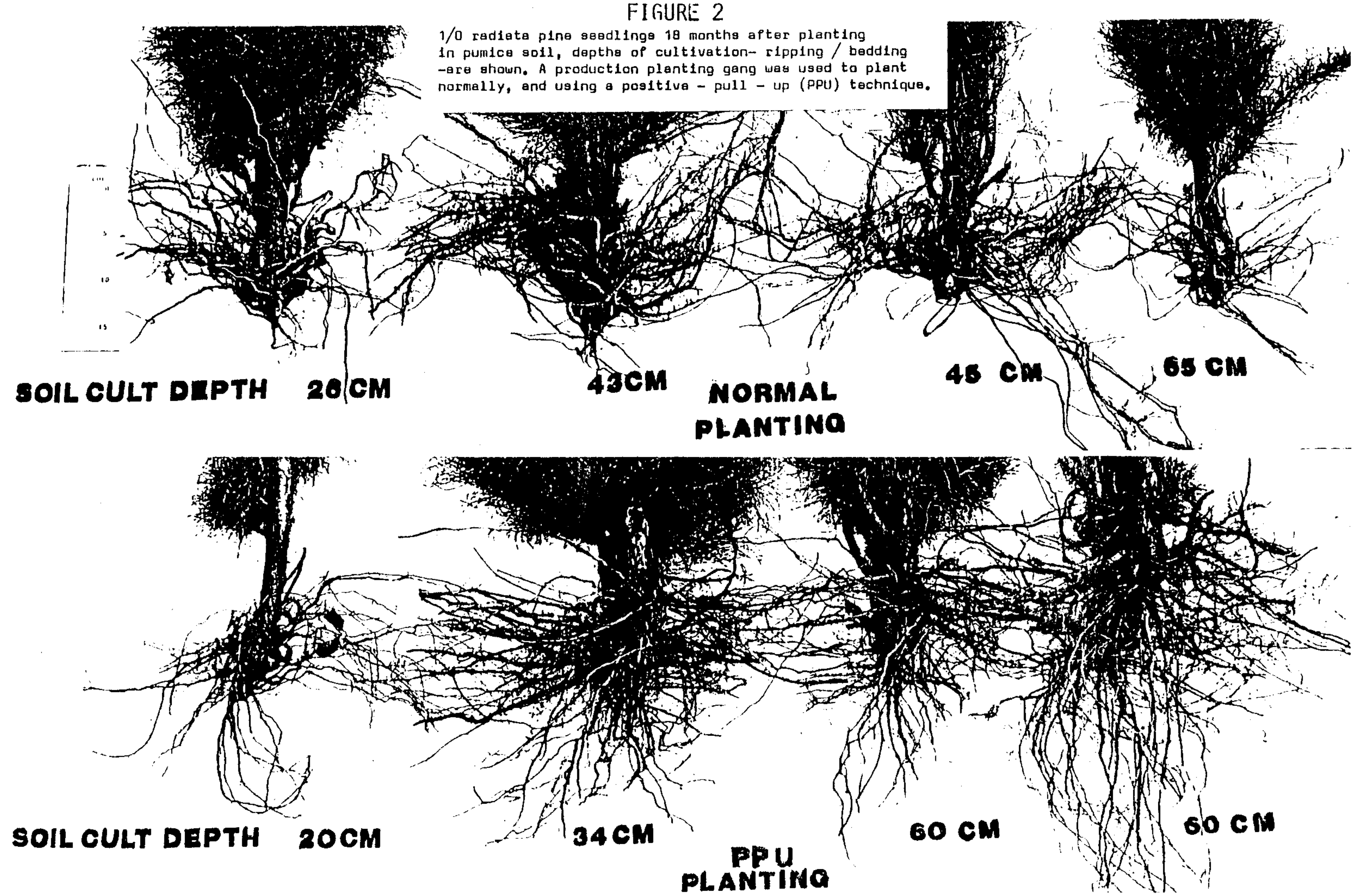

plant 'em!
don't stuff 'em
OPEN HOLE IN
WELL CULTIVATED SOIL
PLACE SEEDLING
& FILL
PULL UP & FIRM
FOREST SEEDLINGS
WITH CARE

FIGURE 1

FIGURE 2

1/0 radiata pine seedlings 18 months after planting in pumice soil, depths of cultivation- ripping / bedding -are shown. A production planting gang was used to plant normally, and using a positive - pull - up (PPU) technique.



(e) Plant at an appropriate depth for soil and ground conditions: Trials reveal that there can be no hard and fast rule with regard to the depth at which bare-root stock is planted. Ideally, seedlings would be returned to the ground exactly as they were in the nursery. However, due to many factors - root trimming after lifting and the difficulty of positioning the remaining roots for good anchorage, this is not possible. The first consideration is to bury the roots and sufficient stem so that the seedling is firm enough in the ground to stand up in high winds. In most ground conditions it has been found that burying 1/5 to 1/3 of the stem gives good results. In dry ground it is important to place roots at a depth where moisture is available and in wet areas shallower planting will give the best results. In some heavy soils burying of lower stem and branches can cause problems. In one area buried branches grew quickly and caused multileadering. Check previous plantings before deciding on a suitable planting depth.

(f) Firm soil around the planted seedling carefully: Even compaction of the fill around the planted seedling's roots is important for stability and growth. Soil that is too loose will not hold the stem firm and upright and over-compaction can inhibit growth. Due to the wide variety of soils and planting conditions, it is virtually impossible to prescribe or control accurately levels of compaction on any one site. However, we do know that the range of compactions in which roots will grow is wide. Experience shows that if fill is pressed down firmly with the sole of the boot, on two sides of the stem, then compaction is adequate. Heel-thumping should not be allowed. This can damage and distort roots and stems and give very uneven compaction. Water also collects in heel marks and can rot stems. In heavy or wet soils where good planting spot cultivation is difficult, extra care has to be taken at planting and when firming in.

19. Planting rates

Planting rates are related to ground conditions (cultivated or uncultivated), surface debris and, to a lesser extent, stock size. Where soils are uncultivated, heavy and covered with slash 300 trees may be the maximum number per man day that can be planted properly. On good or cultivated land up to 1000 trees per man day are possible. While many planters will exceed these targets, much higher rates achieved must be considered suspect and quality checked carefully. Planting supervisors should raise or lower targets slightly to accommodate changes in ground condition. They should maintain a daily record of plantings, recording change in targets and commenting on quality of stock and planting. Quality not quantity should be emphasised. There is, however, no reason why quality and quantity cannot be combined to give good planting rates. Planting incentive bonuses should be based on all facets of planting. If the prescribed planting method has been followed then a bonus target could be calculated. If the target is not reached then the bonus should be removed. On the other hand, if the planter's work is good and he exceeds the target then he should get paid for both quality and the number of trees planted. Both the quality and quantity aspects of the bonus would naturally be forfeited for high numbers of poorly planted trees.

20. Supervision and quality control

Ease of supervision is very important. A good planting system is one where all facets are closely integrated and easy to supervise. If it is not possible for a planting gang supervisor to judge quality of stock and planting by simple visual and physical checks, then the system is no good.

Supervisors must keep planters together and stay with their gangs at all times. They must see that stock distribution personnel keep planters well supplied. It is not advisable to allow individual planters to walk out to collect stock. When this happens much time is wasted, gangs break up, and good supervision is impossible.

Planters can make or break a forest! It is important that they are expert, as any mistakes will have long-term consequences.

Planting spot selection, planting spot cultivation, root orientation, planting depth, and soil firmness around roots must all be checked. A 6-mm diameter 1-metre long steel probe is a useful tool for supervisors and quality control officers to carry. This is used to test for subsoil obstructions such as stones and old roots. Depth of cultivation and firming of soil can be checked by walking down rows immediately behind planters and pushing the probe into the ground 10 cm away from planted seedlings. If cultivation is shallow (less than 20 cm) root distortion is virtually unavoidable, as there is insufficient depth to allow a root-straightening pull-up. If cultivation is deep then there is every likelihood that planting quality is also good. However, supervisors should excavate trees from each planter's row at regular intervals throughout the day (a one percent sample being sufficient unless a particular planter's work is suspect). Any defects should be brought to the planter's notice immediately and recorded. Planters repeating mistakes must be reported.

It is suggested that a stock quality assessment check-list be issued to planting gang supervisors, together with a compartment plan showing the area to be planted, spacing, stems/ha, direction of rows, the planting target and crate dumping stations. Depending on gang size, the target and the number of seedlings/planting box, the daily crate requirement can be given. Items on the check-list should also include:

* date of lifting
* date received on the forest
* quality of roots at planting
* seedling size and uniformity
* nursery cool storage period
* date planted
* quality of foliage at planting
* weather conditions during planting

21. Management support

Forest officers in charge of establishment and quality control personnel should visit planting gangs regularly to inspect work and give supervisors and planters support. They must check stock, planting and quality assessment sheets, discuss problems and see that these are rectified.

Gang supervisors should be directly responsible for the quality of work. Quality control officers must check immediately behind planters and discuss defects with the supervisor and planter concerned. If the supervisor has not first reported poor planting by a particular member of the gang, then he must be held responsible for poor supervision. However, if he has cautioned a particular planter for faulty work then the planter must be cautioned and if faults persist appropriate action taken.

Quality control checks after planting gangs have moved away from the immediate area are of little use. Stock quality is then difficult to assess and faults cannot be traced to individual planters. Even if planting quality is good and seedlings appear healthy, important defects such as overheating and drying out of roots in packages cannot be traced.

22. Indicator plots

There is presently no standard assessment procedure in forests by which the quality of establishment or the effects of new practice can be accurately gauged. It is therefore suggested that, as an aid to forest management, consideration be given to the introduction of an "Indicator Plot" system to all forests.

An increasing number of forests use Quality Control Indicator Plots (Trewin 1981b) to check efficiency of their outplanting systems. Establishment foresters visit supply nurseries regularly during the planting season to supervise lifting and packaging of Indicator Plot tree lots. They take stock to planting sites and supervise planting of plots amongst production plantings. By comparing early growth in plots with adjacent normal plantings, the efficiency of bulk seedling handling and planting systems can be gauged.

One forester using quality control Indicator Plots in 1984 plantings reports:

"When actual operational establishment of P. radiata is compared side-by-side with potential (ideal) implementation of our prescription techniques for lifting, dispatch, and planting it is found that first year growth of seedlings established on an operational basis is falling short of potential growth. Loss of potential growth amounts to 2.8 mm in diameter (21% of potential), 15 cm in height (18% of potential and 44% of potential bulk growth). Survival is also down to 92% of potential survival".

Another forester reported:

"Two years after indicator plots were established, they are still showing the same degree of advantage in growth and survival as they showed in the first assessment, which was undertaken one year following planting."

He concluded:

"It is obvious that improvements in the planting system can make worthwhile gains in growth and survival, and therefore objects of minimal handling, storage, and correct planting techniques should be pursued.

DISCUSSION

It is evident that crop failures, attributed to harsh sites, pests, and diseases are often caused by poor tree stocks and inadequate outplanting systems. Most outplanting systems do not adequately protect bare-root tree stocks from exposure and handling damage, or ensure that roots are properly orientated at planting.

In New Zealand the majority of State and private forests in the North Island and an increasing number in the South Island now pack seedlings direct into rigid planting boxes. Higher survivals, improved growth, and better uniformity within stands are apparent. This, together with improved genetic stock and more intensive tending treatments, has allowed a significant reduction in initial stocking levels and in the cost of establishment and tending. Several forests have reduced initial stocking levels, on good sites, to 750 stems/ha.

The introduction of any new system needs careful planning, otherwise maximum benefits are unlikely to accrue. Users must first be convinced that the new technology will in fact improve results before they phase out well-established practices.

Most forests adopting the recommended outplanting system had first planted Indicator Plots. The results of these production-scale plantings convinced them of growth advantages.

The different facets which make up an outplanting system can be compared to links in a chain: failure of one link causes complete failure and weakness in any link greatly reduces strength.

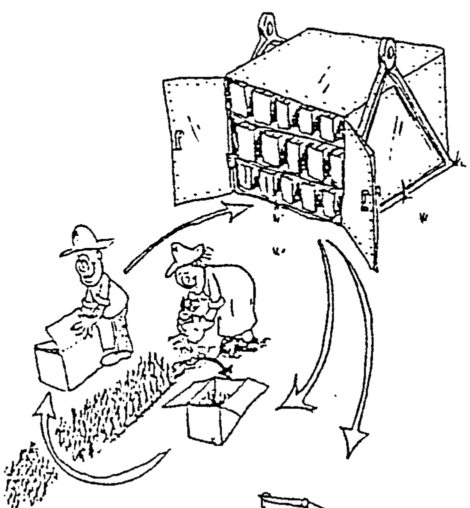
SUMMARY

For good bareroot seedling establishment, land must be properly prepared, and planters must be given good quality seedlings. This means that nursery and field practice must be good, including:

IN THE NURSERY

CULLING to remove runts and malformed seedlings - only the very best stock must be used.

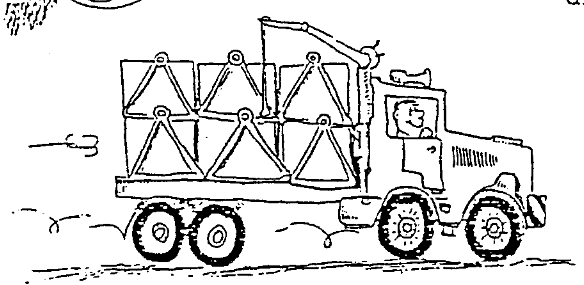
SOIL LOOSENING (wrenching) before lifting so that seedlings can be lifted without damage.



CAREFUL LIFTING, leaving some soil on the roots to protect them and hold beneficial mycorrhizae.

TRIMMING IN SMALL BUNDLES, of five large or ten smaller seedlings. Roots to be drawn down in the palm and trimmed to 10 cm from the collar, or less for heavy soil types. Long roots are difficult to place in a planting hole without distortion.

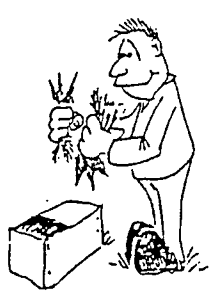
ROOT MOISTENING, to ensure that roots do not dry out on the way to the planting hole.



CAREFUL PACKING DIRECT FROM THE NURSERY-BED, into rigid planting boxes which should in turn go straight into transporting crates.

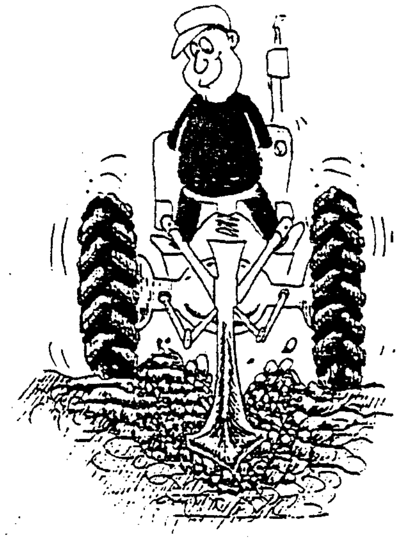
DIRECT TRANSPORT TO THE PLANTING SITE so that seedlings are out of the ground for as little time as possible. Delays cause seedlings to dry out and/or overheat.

IN THE FOREST



If all nursery operations have been properly carried out, the seedlings should arrive in good condition.

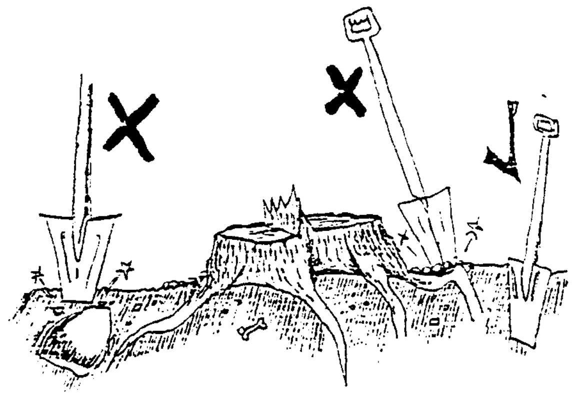
CHECK STOCK QUALITY IN CRATES AND AT PLANTING, to make sure that seedlings are in good condition. Roots should be moist and seedling size even; poor stock must be returned to the nursery immediately.

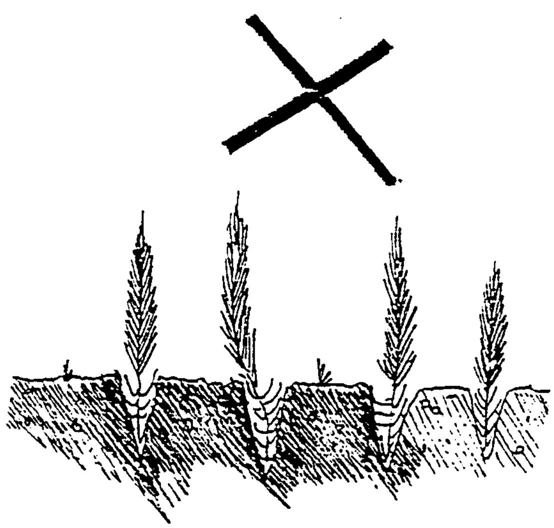


CULTIVATE PROPERLY TO A FULL SPADE'S DEPTH - this makes planting easy and allows new roots to grow straight.

Where soils are hard, mechanical cultivation to a depth of 70 cm is recommended. Most soils benefit from deep cultivation.

AVOID OBSTRUCTIONS, like roots and rocks - these will cause root distortion. Shift your planting spot.





AVOID SLIT PLANTING:

Don't settle for a narrow V-shaped slit - the roots will be swept upwards as the seedling goes in.

OPEN UP AS LARGE A HOLE AS POSSIBLE, to allow the roots to spread more naturally.

USE A GOOD PLANTING TECHNIQUE -

One method that works well in most soils is this:

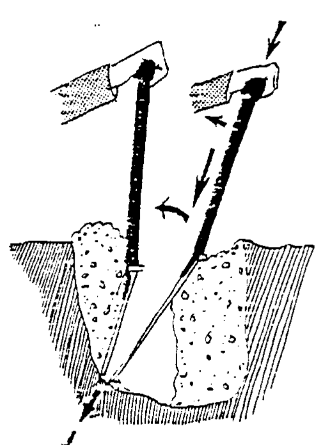
Sink the spade in vertically to its full depth.

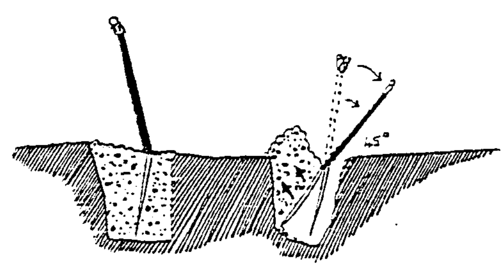
Push the handle away to an angle of 45°.

Push downwards, to anchor the tip of the spade,

and pull the handle back to open a planting slot.

Repeat if necessary, until you have opened a clear slot, large enough to take the roots without much distortion.



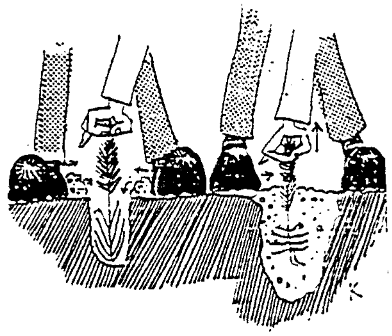


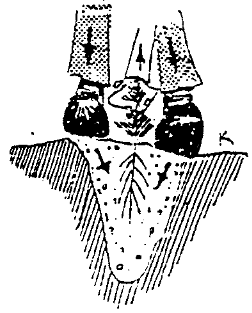
Place the seedling in the slot.

Replace the soil around the roots;

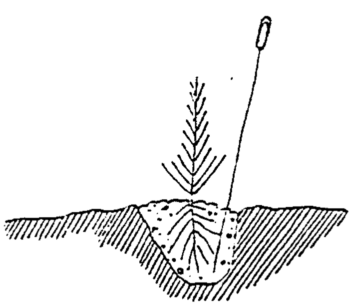
and PULL THE SEEDLING UP about 10 cm - this will straighten any roots that were twisted or swept up.

Then firm the soil around the seedling, using the SOLES of the boots, NEVER THE HEELS.





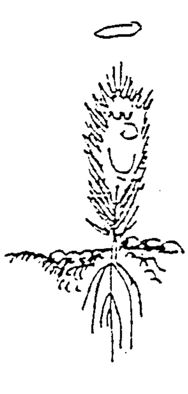
SUPERVISE CAREFULLY - gang supervisors must stay with their planters and keep them together. They must insist that each planter uses the specified technique.



CHECK CULTIVATION DEPTH, using a steel probe.

CHECK ROOT PLACEMENT, by removing seedlings in situ and breaking soil away carefully to expose roots.

Good planting is likely to result only if all the steps in the sequence are carried out correctly.



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APPENDIX

EQUIPMENT COSTS FOR PACKING AND HANDLING

Costs of delivering trees to the planting site vary depending on size of stock, distances from forests, ease of access, and modes of transport. Planting costs also vary considerably depending on the size of stock, planting hindrances, and soil conditions. It is not possible, therefore, to accurately calculate transport and labour costs for individual forest sites and no effort is made to include these here. However, by basing costs on a planting programme of one million trees, a planting box capacity of 125 seedlings and a transport crate capacity of 30 boxes, the following calculations give an estimate of equipment costs in New Zealand.

Nursery lifting/planting programme	1 million trees
Number of lifting/planting days	60
Number of seedlings/day	16 667

<u>Cost of packing in waxed cardboard boxes (540mm x 220mm x 340mm)</u>

Boxes can be used, on average, for five trips to the forest. At 125 trees/box/trip, this gives a total of 625 trees/box.

Cost of box for packaging 625 trees	$2.80	
Cost of packaging in planting boxes per thousand		$4.48

<u>Cost of containing planting boxes in crates at $450 per crate</u> (1200mm x 1200mm x 1200mm, tanalised 12 mm ply on 5 mm angle-iron frame)

Seedlings per day	16 667
Trees per box	125
Boxes per day	133.33
Boxes per crate	30
Crates per day (called a set)	4.45 (5 crates)

A 4-day recycling period is allowed for crates, one set of 4.45 per day, or 5 crates for final calculations.

<u>DAY ONE</u> SET 1

1. Loading in nursery/transporting

DAY TWO SET 2

2. Transporting to forest/planting

DAY THREE SET 3

3. Planting/return crates to nursery.

DAY FOUR SET 4

4. Return crates to nursery/loading.

BUFFER SET - SET 5

5. Buffer set for emergency - breakdown of transporting truck, etc.

Cost of transporting stock in crates is calculated on total number of trips per crate. Initial costs of crates at $450 plus maintenance at $10 per annum give a crate cost over a 5-year, normal discount period, of $500.

Should 5 sets of crates be used, the initial cost of equipment is increased by approximately 20%, but the total cost of transport (more crates do fewer trips and last longer) remains the same.

Cost of containing planting boxes in crates per 1000 trees	$2.30

Cost of planting frames

Number of trees planted per day	16 667	
Trees per planter, say	800	
Number of planting frames per day, 20.8, say	21	
Cost of frames at $30 each for 21 planters	$630	
(frames to be discounted over 2 years or 2 million trees)		
Cost of planting frames per 1000 trees		$0.31

Cost of backpacks for carrying planting boxes in to planters

Where access is reasonable three people can keep a gang of 24 supplied with planting boxes. Three backpacks are needed @ $60 each or $180

Cost discounted over 2 years

Cost of backpacks per 1000	$0.09

Cost of transporting trailer

A tandem trailer fitted with lifting gear is used for on-forest transport or for supplying forests with small replanting programmes. Cost of using this trailer to assist in distribution of 5 million trees is discounted over a 5-year period.

Cost of trailer	$3000	
Trailer cost per 1000 seedlings		$0.60

Summary of equipment costs per 1000 seedlings

Waxed cardboard planting boxes	$4.48
Transporting crates	$2.30
Planting frames	$0.31
Backpacks	$0.09
Tandem trailer	$0.60
Approximate cost per 1000 seedlings	$7.78