RUNNING A TREE NURSERY

Running a tree nursery C 50
- introduction: training and maintenance

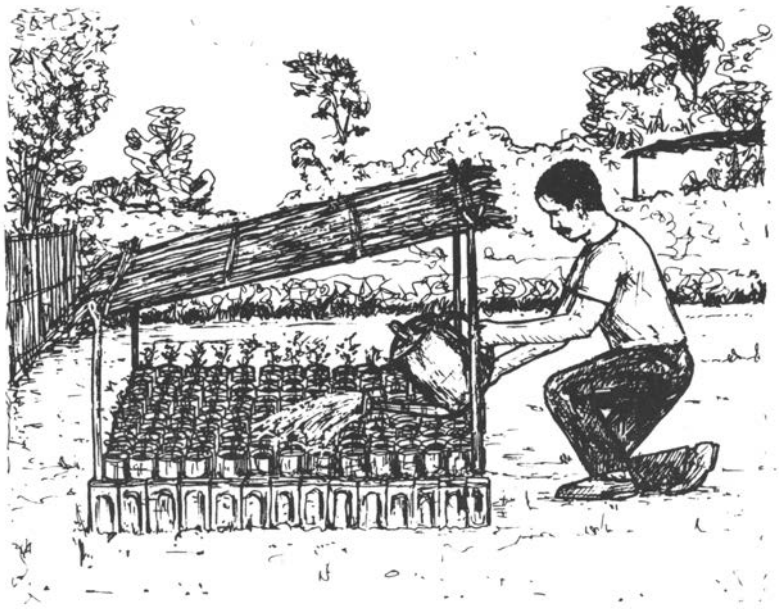
What sort of things are involved in running a tree nursery?

Being able to keep in mind a whole lot of different points, including:

(1) the scientific basis of growing good young trees for planting (C 10-15, C 30-32);
(2) technical aspects of good nursery practice (C 20-26, C 33-34, C 40-48);
(3) questions of economics: avoiding waste, spending wisely and meeting objectives;
(4) encouraging the people involved to keep learning more about the job (C 52);
(5) planning ahead and keeping good records (C 54); ***as well as***
(6) getting everything ready for the day-to-day work of the nursery (C 51).

Which are the most important things?

Learning about the job yourself, and building a good team of nursery staff and workers.



Why is that the top priority?

Because:

(A) there is always more one can learn about tree nurseries;
(B) remembering the many important points about growing good plants will be harder if time and energy are wasted through lack of co-operation and in settling disputes; ***and***
(C) a good working atmosphere is the best way of making steady progress, and of dealing with any problems promptly (C 3).

So I need a lot of patience?

Yes; and as a 'key person' (D 4 in Manual 4) you will need not only an understanding of how to treat other people, but:

(a) a basic grasp of how to run an enterprise;
(b) dedication to the job and determination to overcome obstacles;
(c) the ability to handle several different things at once; ***and***
(d) a willingness to try out ideas to see whether they work in your situation.

Does the science really matter much to the practical grower?

Yes it does, because the general principles described in these manuals are:

(1) not an optional extra, but the first foundation for success; ***and***

(2) based on research on trees that has been done for many years all over the world.

For instance, making do with less suitable genetic origins (C 5) might mean poorer trees being used for a long time, or even that a valuable species was mistakenly ruled out.

Isn't growing trees too easy to need to bother about technical details?

Not at all. It may look easy, but local experience throughout the world suggests that:

(a) there are many potential pitfalls (C 3), any one of which might damage or kill the young trees, and so hamper the production of enough good planting stock; ***and***

(b) planning a tree nursery carefully (C 20-26) and learning how to look after young trees in it (C 40-48) can save a great deal of time, effort and money.

A lot of useful trees, shrubs and climbers used to come up naturally, but now may not do so (C 1-2). Specific technical information for growing these is often lacking.

Will these things help to make an economic success of the tree nursery?

Such technical points form the second foundation for nursery success. Next comes the third aspect—important questions of economics, including costs and funding, but also:

(1) planning a logical and efficient internal layout for the nursery (C 22);

(2) deciding for each tree species whether to root cuttings (Manual 1), sow seeds (Manual 2), collect wildings (C 2) or use more than one method of propagation;

(3) working out how many young plants will be needed each year, and how much nursery space that will require (C 63-A,B);

(4) obtaining adequate supplies of materials (C 24) and tools (C 51) in good time, so that nursery work is not held up;

(5) maintaining tools, any equipment and vehicles in good condition by regular cleaning, checking, servicing and repairs;

(6) thinking about potential accidents or breakdowns (C 3), and making sure that daily and weekly checks are done (C 40, C 66); ***and***

(7) discovering the simplest and quickest way of doing individual tasks, or successfully combining two.

Good economics also takes into account the costs of ***not*** doing something, and the intrinsic value of a well-trained team (C 52).

But supposing there is a shortage of money for the tree nursery?

There usually is! But:

(a) small tree nurseries at home or on the farm (C 20-22) can usually function without much money; ***and***

(b) a lot can be done in moderate sized nurseries by using materials and containers that are cheap, or free because otherwise they would be wasted (C 33).

Large nurseries are the most likely to suffer if staff and workers are not paid for months.

How important is training?

It is vital to success, and can be seen both as:

(A) **training on the job,** consisting of such points as:

(1) explaining to staff and workers why careful handling of young trees (C 40-42) is important; and correcting any bad practice at the time it occurs;

(2) demonstrating how the regular watering is to be done (C 43), and making sure that the methods are learnt and followed;

(3) showing people what is needed when another job is to be done, and explaining why it should be done that way (C 52); ***and***

(B) **special courses,** where a new approach needs to be learnt, such as:

(1) changing from a temporary to a permanent nursery (C 21);

(2) rooting cuttings of trees (C 5; and Manual 1); ***or***

(3) inoculating young nursery trees with micro-organisms (C 31-32).

What about planning ahead and record-keeping?

These go together, helping the work to run smoothly (C 54). Some examples are:

(1) when you have learnt from experience the best time to set cuttings and sow seed, then:

(a) the planting stock is likely to be the right size (C 34) at the time it is needed;

(b) you won't be wasting effort and materials keeping it longer than necessary in the nursery, or find yourself trying to stimulate growth with fertilisers (C 33); ***and***

(2) if you make sure that simple basic records are properly kept (C 64-66), you can easily look up the data for previous years instead of having to guess.

And the day-to-day running?

This is really a question of organising a piece of the overall job, involving:

(A) routine operations like watering (C 43), weeding (C 44) and checks (C 40); ***and***

(B) specific tasks for the day.

Omit (B) rather than (A) if there is a sudden urgent request, or an emergency.

Does work with experimental trees take longer?

Yes, it usually does, though some tasks may be the responsibility of the research worker. More time will be needed in order to:

(a) understand what is involved (C 7);
(b) produce the necessary uniform growing conditions (C 15); ***and***
(c) look after the young trees particularly carefully (C 48).

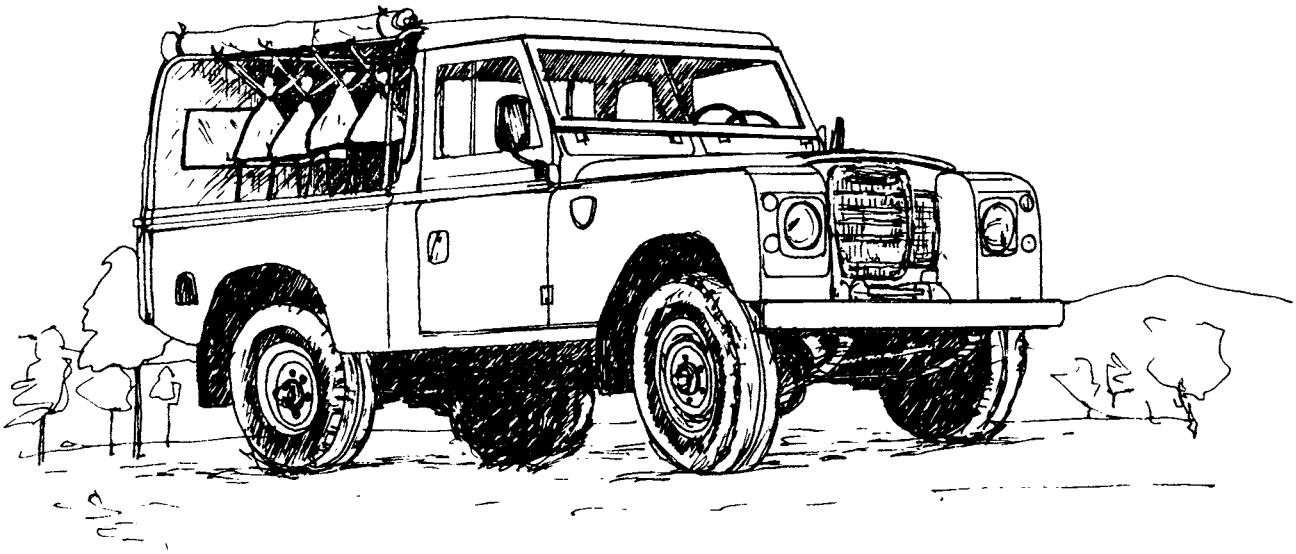
Periodic observations (C 55), measurements and analyses (C 67-69) may also be needed.

Does maintenance matter much in a tree nursery?

Yes it does, because 'a stitch in time saves nine'. Maintenance includes not only checking, servicing and repairing any vehicles, buildings and equipment, but also:

(1) cleaning out filters and doing timely repairs to the nursery water supplies (C 24);
(2) looking after tools (C 51); ***and***
(3) keeping up fences, gates and hedges (C 46).

It is also important to 'maintain' and occasionally review the arrangements for responding to emergencies such as flooding, fires (C 3) or snake-bites (D 66 in Manual 4).

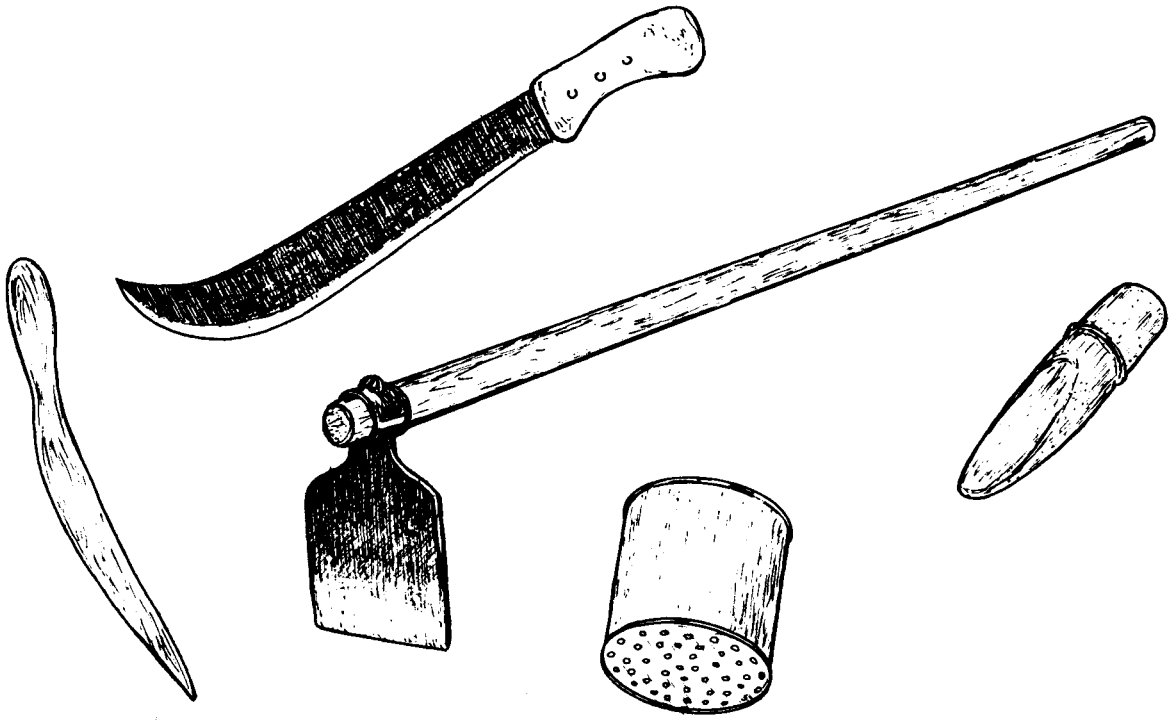


Running a tree nursery C 51
- tools and materials for the nursery

Which sort of tools are required for nursery work?

It is possible to run a small nursery quite effectively with just a few basic tools, so a lack of money need not prevent good trees being grown. For instance, you could use:

(1) the farm tools used locally for cultivating the soil and for cutting poles and weeds;
(2) a shovel for mixing up potting soils (C 6), and a hand tool for filling the containers;
(3) a pail and an old plastic bottle or can with holes in the bottom for watering (C 43);
(4) convenient pieces of wood or metal to lift out newly rooted cuttings and small seedlings (Manuals 1 and 2); for potting up or transplanting (C 42); and for weeding (C 44).



What other tools would be useful if some funds were available?

(a) **a spade** for digging out materials for potting mixtures (C 6), and for preparing beds and level standing ground for young trees in containers;
(b) **a sieve** for removing stones and other large items from soils and composts (C 33);
(c) **a funnel** for filling or part-filling pots (C 42);
(d) **a pickaxe** or **crowbar** for fencing (C 46) and making access paths (C 22);
(e) **a hammer and nails, a saw** and **a ladder** for such jobs as making wooden seed-boxes, fencing and general improvements and maintenance around the nursery.

Do such tools need any maintenance?

Some may need sharpening, an occasional replacement handle and perhaps hammering straight. All will last longer if they are:

(A) used with reasonable care; ***and***
(B) cleaned, dried and kept inside afterwards.

Which kinds of materials may be needed?

The first requirement is for continuing supplies of suitable components (C 24) for making rooting media (A 35 in Manual 1), seed germination media (Manual 2), potting mixtures (C 6, C 63-D), and for improving nursery soils (C 23).

Other needs depend on whether the nursery is temporary or permanent (C 21), and also on its size (C 22).

What would be the minimum for a temporary nursery?

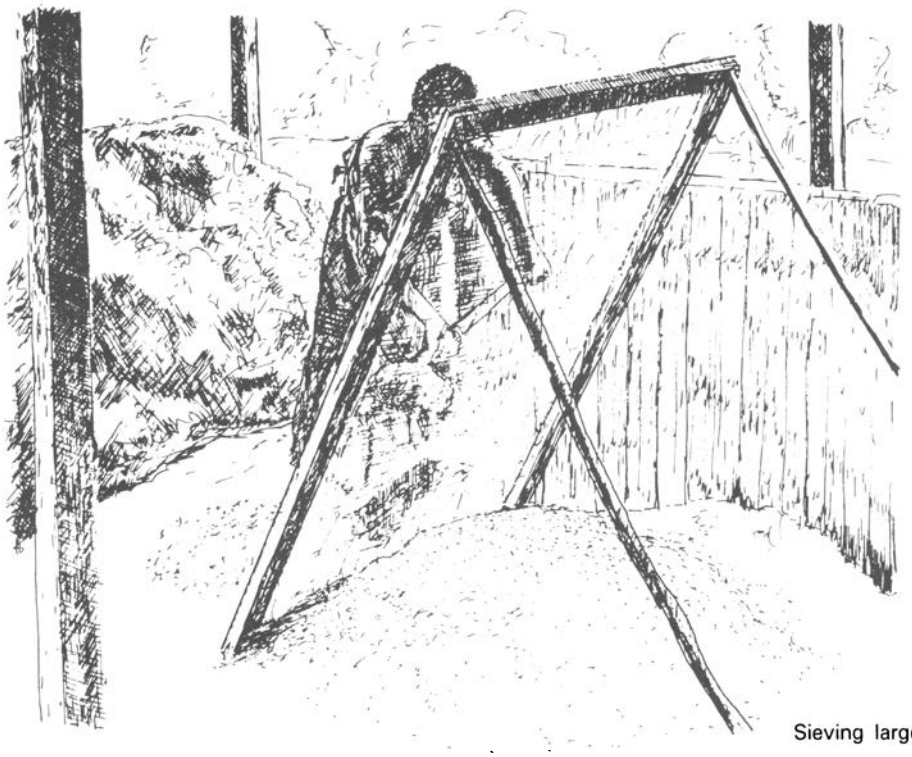
Besides soil mixes, you might need a supply of:

(1) free or waste items that could be used as containers (C 6, C 33);
(2) suitable materials to use in putting up shade (C 41); ***and***
(3) a small notebook and pencil for plans and records (C 54).

And what else if the nursery is likely to be permanent?

Amongst other items, you might also need:

(a) larger supplies of several kinds of containers;
(b) plastic sheeting and wood for making poly-propagators (A 31 in Manual 1);
(c) hand-sprayers for keeping high humidity (A 34), restoring wilted plants (C 13), and controlling diseases and pests (C 45);
(d) posts, gates and fencing materials (C 46);
(e) broken stone or coarse gravel for improving access roads and paths (C 22);
(f) foundations, wood, roofing and preservative for building a shed; ***and***
(g) sundry items like labels (C 54) and perhaps fertilisers (C 33).



Sieving larger quantities.

What other things might a large nursery require?

You could also consider whether to:

(A) put up a wooden framework and shadecloth over part or all of the nursery;
(B) install a better water supply (C 24);
(C) buy a small portable electric generator (or a *micro-hydro* unit) for lights and power tools; ***or***
(D) get a four-wheel trolley, van or pick-up truck for transporting materials and young trees.

Running a tree nursery C 52
- the nursery team

Who needs to be part of the team?

Everyone who is involved with the work of the tree nursery. For example:

(A) all members of the family, for a small nursery at home or on the farm;
(B) two or three working colleagues, for a medium size, jointly-run nursery;
(C) all the staff and workers, for a big nursery; ***and additionally***
(D) specific people at headquarters and abroad, for an international research project.

How can a good team spirit be built up?

The way the 'key person' (C 50) works is the crucial point. It is important to:

(1) explain clearly what is involved in a successful tree nursery;
(2) show just how each job is to be done;
(3) decide clearly who is going to do what when; ***and***
(4) make sure that the work is done promptly and properly.

In larger nurseries, it might also be useful to:

(5) hold regular staff meetings; ***and***
(6) ask individual staff members to be specially responsible for different parts of the nursery work.

Supposing someone is causing problems?

What to do depends upon the circumstances. If for instance a worker or a staff member often comes late, makes mistakes or is slow to learn, you could explore whether he/she:

(a) had previously been used to a different style of working;
(b) hadn't understood properly what was required;
(c) has been having a difficult time, because of bereavement, illness or other reasons;
(d) is in fact beginning to improve.

However, if someone:

(1) cannot be relied upon;
(2) keeps on saying they know best;
(3) upsets other team members by arguing or abuse; ***and***
(4) does not show signs of improvement when warned more than once; ***then***

It is likely that the team would be better off without them.

Aren't staff meetings just a waste of time?

Sometimes they could be, for example:

(a) if no preparation has been done or agenda drawn up;
(b) if the discussion is ill-disciplined, contentious or long-winded; ***or***
(c) at times when there are far more important priorities.

However, provided these pitfalls are avoided, they can often be useful in:

(1) encouraging good communication amongst the staff and workers;
(2) listening to views on problems and anticipating difficulties;
(3) promoting the making of clear, appropriate decisions, and planning ahead (C 54);
(4) allowing easy checking of whether things were done to plan, or why they were not.

But aren't decisions up to the person in charge?

In the long run they may be, but:

(A) sensible decisions depend on first being well-informed; ***and***
(B) people work better if their ideas, experience and grumbles are taken into account.

What about training?

This is very important, for both staff and workers (C 50).
In one sense, training may go on for much of the time, as people continue to gain further experience of different aspects of nursery work, changing seasons and various species.
As well as this, they may also need to gain new knowledge about fresh approaches or improved techniques, either on the job or by attending a specific course.

Will training increase the output of the nursery?

Yes, it can decrease the losses of young trees; and also improve nursery efficiency by:

(1) increasing the quality and uniformity of planting stock;
(2) reducing the time the young trees spend in the nursery; and damage to them;
(3) avoiding waste of water and materials;
(4) decreasing the time taken to do nursery jobs, and the amount of supervision needed; ***and so***
(5) keeping down the running costs.

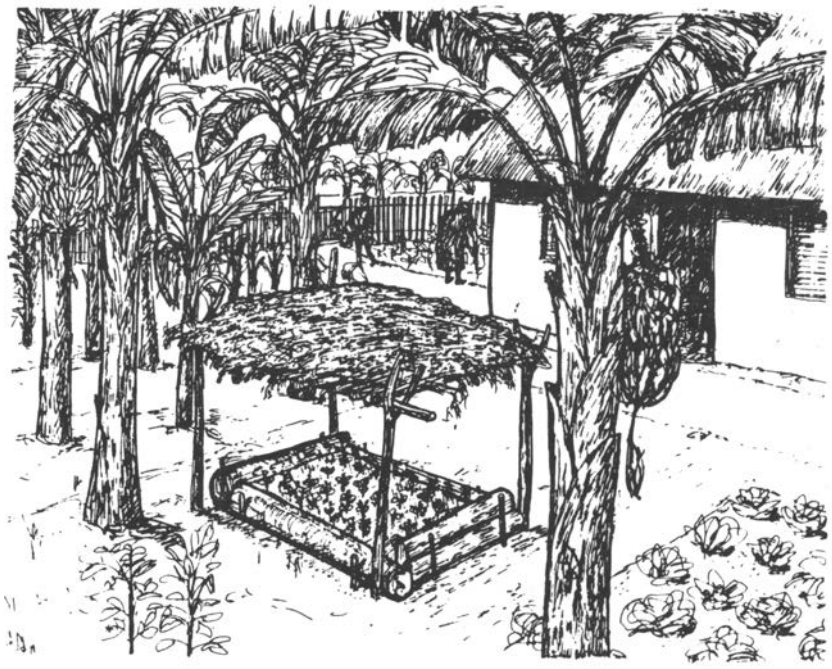
Can nursery maintenance be improved by training?

Yes, especially when:

(a) a maintenance schedule is drawn up for all the appropriate aspects (C 50); ***and***
(b) the checks, servicing and any repairs needed are actually carried out.

Isn't all this unnecessary for a family nursery?

Not really, for many of the above points can be adapted to these circumstances.
A system where only one person knows how and when to do the work is liable to break down when they are busy, away from home or taken ill.



How about a community nursery?

Similar questions apply here, and it is especially important to achieve:

(1) good communication between all those with an interest in the tree nursery and the planting of trees (C 53; and D 5 in Manual 4);
(2) fair sharing out of the work, the available information and the young trees; ***and***
(3) effective checking that the jobs are being done, and control over standards of work.

Otherwise, despite people's efforts, it is unlikely that successful tree plantings will result.

Running a tree nursery C 53
- useful contacts

Why would I need to get in touch with other people?

Because there can be a lot of mutual benefits from not just working away on your own. It could be helpful to link up with people and organisations:

(A) in the neighbourhood;
(B) elsewhere in your region or country; ***and***
(C) abroad.

What sort of links could I make nearby?

For example you might be able to:

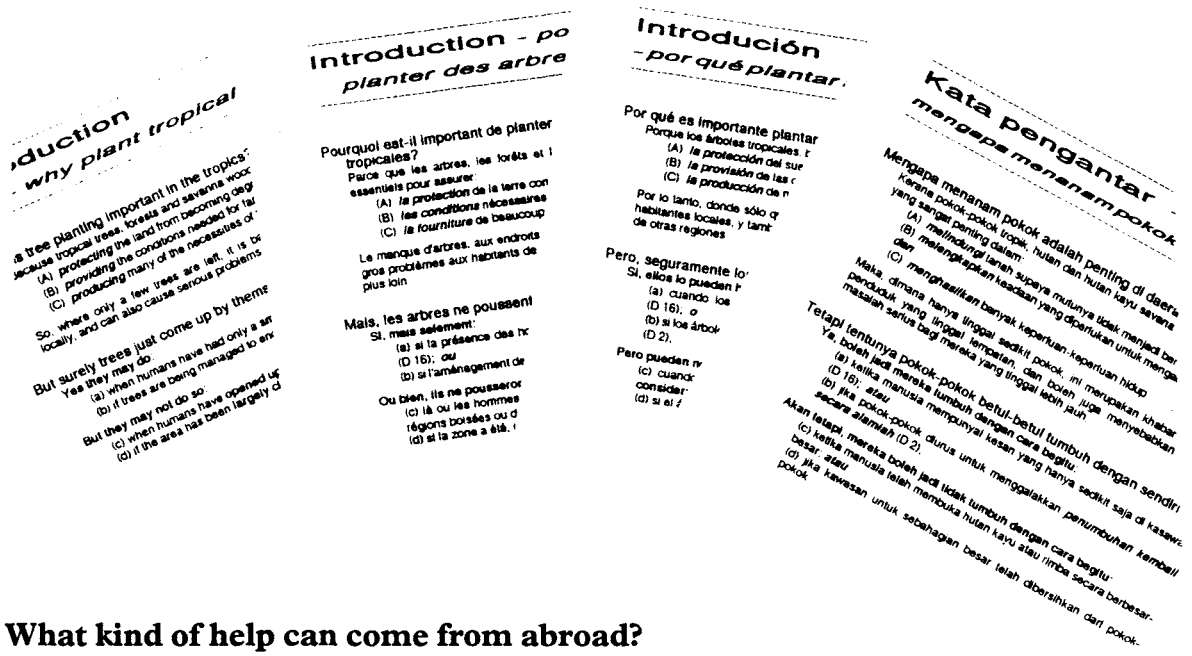
(a) learn more about growing good trees from experienced individuals, and from any local demonstrations, exhibitions or workshops;
(b) use your own experience to help a new project get off to a good start;
(c) exchange ideas, plants, cuttings or seeds with other tree nurseries and growers; ***or***
(d) sell young trees to people or groups wanting to plant them.

Who might give regional or national advice?

Valuable ideas and suggestions can sometimes be obtained from:

(1) government forestry, agriculture and parks departments, extension offices and research stations;
(2) private growers, large and small; ***and***
(3) agroforestry projects run by local non-governmental organisations.

Remember that it is not a one-way process - your views and knowledge are important too!



What kind of help can come from abroad?

(a) Publications, practical manuals and videos about nursery techniques and tree species (C 61; and D 70-72 in Manual 4);
(b) Data about which genetic origins of commonly planted trees have been found to thrive in different climates and sites (C 62-E); ***and***
(c) Findings of international projects concerned with growing trees, especially those that involve joint studies with local farmers or communities.

Will all this be relevant to me?

Probably not; but it is well worth checking up on what is available, because:

(1) some of the possibilities might be just what you need;
(2) the benefits could be considerable and long-lasting; ***and***
(3) it may cost you little or nothing.

Progress in science and technology can often be stimulated by the exchange of ideas and experience among people working in widely different fields.

But it could be difficult to find out about such things!

That's often so, which means that everyone is the poorer. Here are a few hints:

(a) keep your eyes open for newly planted trees that are thriving, and go and enquire;
(b) look out for other nurseries, whatever species are being grown;
(c) ask your friends to tell you if they hear of anything relevant; ***and***
(d) listen to what the children have been learning about and doing at school.

Supposing things are being stolen from the nursery?

As well as 'negative' action like putting up a strong fence (C 46), having a night watchman or notifying the police, you could try more positive steps such as:

(1) contacting local mayors, chiefs, elders or other people for advice;
(2) explaining the importance of tree planting to teachers or to a community meeting;
(3) giving local people a stake in the success of the nursery by employing some of them; ***or***
(4) advertising how cheap the trees are to buy, rather than steal.

What if I want help with an informal trial?

(A) Look through the points made in sheets C 7 and C 15, and the relevant parts of D 6 and D 55 in Manual 4;
(B) Grow a batch of uniform plants that is larger than you need, giving you a chance to select the ones for the experiment;
(C) Read and think about the particular aspect you are interested in studying, and discuss it with anyone who has relevant experience;
(D) Work out the treatments you want to apply, how many plants you will need for each, and how you will avoid bias;
(E) Get everything ready the day before, including labelling (C 54), and try to complete the setting up of the trial in one day;
(F) Make appropriate initial measurements (C 55, C 67);
(G) Mix all the treated plants together, or put them into a suitable *randomised* layout (C 15, C 62-F);
(H) Check and look after them especially carefully (C 48), watch out for any differences between treatments, and think about how you might assess the results (C 55).
(I) Consider:

(1) what conclusions you can draw from the trial;
(2) who might be interested in the results;
(3) whether to alter your nursery practice; ***and***
(4) how you might follow up this trial with another.

Are there any other contacts that could help?

Yes. One might for example explore the possibility of:

(a) working closely with a local community, farmers' co-operative or company wanting to plant trees; ***or***
(b) giving a talk, for instance to school-children or a church group, perhaps when the government is planning a tree-planting week.

Running a tree nursery C 54
- planning ahead, labels and records

Is planning ahead particularly important for a tree nursery?

It is crucial to success.

Why is that?

Because with forethought one can have:

(1) fewer breakdowns, and reduced damage to and loss of trees;
(2) less waste of water, materials and effort; ***and***
(3) more thriving young trees, produced at a lower cost.

What kind of things need to be thought about?

(A) **Nursery layout:** how the areas within the nursery for beds and containers, working space, storage of materials, and so on, can be arranged for greater convenience and efficiency (C 22);
(B) **Risks:** reducing both the likelihood and the extent of any damage to young trees caused by accidents (C 3), various types of stress (C 41), or diseases and pests (C 45);
(C) **Smooth running:** building up a good nursery team (C 52), doing regular checks (C 40, C 66) and keeping sufficient tools and materials (C 51), so that the work is not held up by lack of understanding, poor communication or shortage of an essential item;
(D) **Adaptability:** having alternative work thought out, in case weather conditions, illness or delays prevent the planned job being done;
(E) **Costs:** Estimating the approximate overall costs of the various nursery operations and purchases, avoiding waste, and spending wisely to achieve the production of good planting stock (C 50); ***and***
(F) **The future:** including changing needs for planting stock; using experience to avoid problems; seeing a need for extra contacts (C 53); and planning improved schedules for the next season.

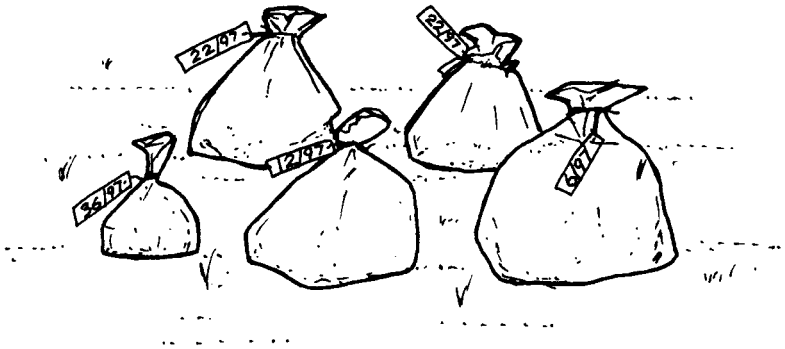
Is labelling really required in a tree nursery?

It is important whenever confusion could arise, for example between:

(1) various batches of seeds and seedlings of the same or similar tree species;

(2) bags containing shoots for vegetative propagation and rooted cuttings of different clones;

(3) plants for research, especially before treatments are applied and during the experiment.



How many labels will I need?

Two labels are a minimum, for instance with:

(a) one inside a bag of seeds, and one on the fastening tie;

(b) one at the start and one at the end of a batch of seeds that have been sown; ***and***

(c) one in the first and one in the last of a set of pots, or in a section of nursery bed.

Labelling each plant is sometimes needed, for example with:

(A) **vegetative propagation,** in order to gain the benefits of knowing which clone a tree belongs to (C 5; and A 11 in Manual 1); ***and***

(B) **experiments,** so that the influence of treatments and of genetic origin upon the growth of individual trees can be studied (C 7, C 15, C 55 and C 69).

Which kind of labels are most suitable?

(a) **Material:** labels are often made of plastic, metal or wood.

(b) **Type:** those that have a blunt point at one end and a small hole near the other are convenient, as they can be pushed into the soil, and later attached to the tree with a tie. If holes are missing, they can be drilled through a number of labels held tightly together.

(c) **Size:** relatively small labels are usually most suited to nursery work, for instance about 8-12 cm long, 1-2 cm wide and 0.5 -2.5 mm thick.

(d) **Colour:** writing is more distinct on white or pale coloured labels, so it may be worth painting wooden or metal labels white; and the paint might also make them last longer. Plastic labels come in many colours, which can prove useful for temporary labelling of young trees that are to receive a particular treatment.

Can I make my own labels?

Yes, they could be made for instance out of:

(1) thin, smooth pieces of wood, bamboo or waste veneer;

(2) plastic containers or strong bags, cut up into strips; ***or***

(3) tough leaves that rot only slowly.

If the young trees are in containers, an alternative might be to label the pots.

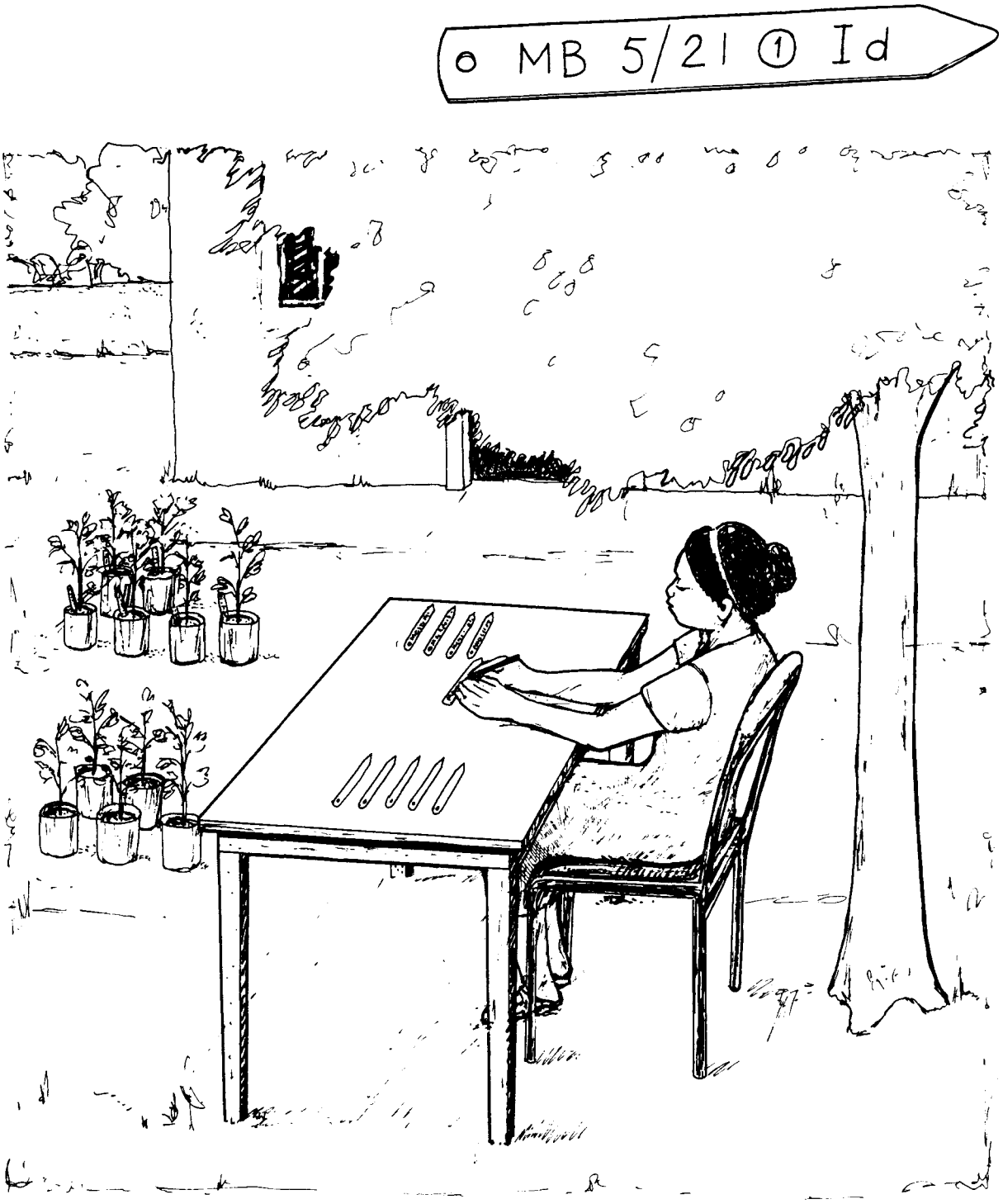
What should I write with?

(A) **Pencil** is often the best with plastic and metal labels. Press firmly with a good HB, H or B grade pencil;

(B) **Waterproof felt-tip pens** can be effective on wooden labels, and also directly on to clean, dry stems of trees with smooth bark, and the outsides of containers. Note that 'waterproof' ink may wash off or fade on some plastic and metal surfaces during propagation.

Do I need to write a lot on the labels?

Only the essential points, in an abbreviated form (see A 64 in Manual 1), provided that the full details can easily be found in the records.



How should I attach the labels?

(a) *For small plants:* push the label into the soil, avoiding damage to the roots;
(b) *For larger plants:* use a loop of wire, strong string or a specially manufactured tie to attach the label to the tree. Do this loosely enough for the stem to grow thicker without becoming 'strangled', but not so large that the loop comes off.

Some types of thin plastic labels are made to be looped around the tree and passed through a slot. However, they can be difficult to attach if leaves or branches are crowded together, and they tend to become brittle after a while.

What other labelling problems might I have?

It is quite difficult to provide permanent identification of young trees in the tropics, because:

(1) the writing may become indistinct, or disappear altogether;
(2) labels may become brittle, tarnish or rot;
(3) they may get blown away, buried in the soil or chewed by certain animals;
(4) labels can be misplaced when transplanting or potting up (C 42) and during transport (C 47). It is best if they are routinely transferred from the soil to the plant, and from the main stem to a suitable side branch, as the trees get bigger; and are rewritten or replaced as needed.

Won't records prove to be a waste of time?

Occasionally they could do, if, for instance:

(1) only a few trees are being grown; ***or***
(2) the people involved have long experience with the kinds of trees being grown; ***but***

Generally they are definitely useful, in order to:

(a) learn from experience, so that plans are steadily updated and losses minimised;
(b) know the genetic origins of trees (C 5), so that those that are proving more successful can be used again, while those less suited to the district can be replaced by new selections (C 5); ***and***
(c) lay out experiments without bias (C 15), and know which trees received what treatment.

What are the key things to record?

Three of the most important points for tree nurseries are:

(1) **origins** and **dates** of collection and receipt of all the seeds, cuttings and plants coming into the nursery. A sample record sheet is shown in C 64;
(2) **records** of each batch of plants grown in or received by the nursery (C 65); ***and***
(3) **details of checks** made during propagation (C 66).

Other points might include times taken for jobs, cost of materials, and observations on the progress of the young trees (see also A 64-68 in Manual 1).

Are there some practical hints on keeping records?

(a) Write brief but clear notes on the same day, not leaving it till later;
(b) Photocopy a simple form for records and assessments (C 67) that will be repeated several times, and use a clipboard to make writing easier; ***and***
(c) Keep the records tidy in a looseleaf file or notebook.

Can record-keeping help with planning ahead?

Yes, this is one of its main advantages. For example:

(A) next time, the dates of propagation can be moved forward or back, in order to obtain planting stock of the desired size (C 34) at the best planting time;
(B) a close watch can be kept during stages when trees previously suffered from stress (C 41), or when losses occurred from pests or diseases (C 45); ***and***
(C) other improvements in technique can more easily be made.

Running a tree nursery C 55
- *assessing pot experiments*

What needs to be recorded during an experiment?

For most experiments one needs to make:

(A) **Observations** on the young trees, especially any differences that appear between those receiving a treatment and the controls, or between plants of various genetic origins; ***and***

(B) **Measurements,** generally repeated, about how fast the young trees are growing.

Sometimes these basic types of assessment might be supplemented by:

(C) **Destructive sampling,** in order to obtain estimates of *dry weight* or to study chemical composition;

(D) **Detailed study** of processes going on in the trees, such as manufacture of sugars (C 10), uptake of nutrients (C 14) or changes in water content (C 13); ***or***

(E) **Recording** features of the environment that the trees are growing in.

When should assessments be done?

This depends partly on:

(a) the type of experiment, and how long it is likely to last;

(b) what appears to be happening in your experiment, as well as any previous experience of what may be expected.

Useful assessment times are:

(1) at the end of the experiment;

(2) at the beginning;

(3) when changes seem to be occurring rapidly; ***and***

(4) at regular intervals during the course of the experiment.

NOTE: **in all cases, remember to write down the date of the assessment (C 67).**

Could most observations be left to the end of the experiment?

No, because it is usually much better to write a simple note on a record sheet or notebook, ***at the time that you first notice the change,*** because it may not be visible later on.

Soon afterwards, it may be useful to do a scoring assessment (C 68).

What sort of observations might I do?

Some examples are to record when you noticed:

(a) alterations in the **patterns of shoot growth;**

(b) **colour** changes; ***or***

(c) signs of **stress** or **damage**.

What sort of changed patterns of shoot growth might I look for?

(1) New shoots starting to expand after a dormant period (C 12);

(2) The end of a period of stem extension and leaf expansion;

(3) The loss of old leaves; ***or***

(4) New branches beginning to form.

Why not just measure these differences?

Measuring shows ***how fast*** growth is occurring, and may provide sufficient information about height growth when the leading shoots of the young trees grow continuously, producing new leaves and extending internodes without a break.

Observations can provide additional important data, especially on trees where the shoots grow by successive 'flushes' (C 12), such as *Khaya, Lovoa* and mango, and also about other changes in a tree's development of a ***'yes/no'*** type.

Recording when a new flush occurs could help to show up any:

(A) **different responses** of clones or varieties to the **same conditions;** as well as

(B) **effects of treatments** on trees of **similar genetic potential.**

Is it easy to see when a new flush starts?

The date of budbreak (C 12, C 68) can generally be pinpointed most accurately by:

(a) noticing expanding buds, or several small leaves emerging at the tips of shoots; ***combined with***

(b) finding that measured shoots which were previously not increasing have become longer.

What about the time that shoot growth stops?

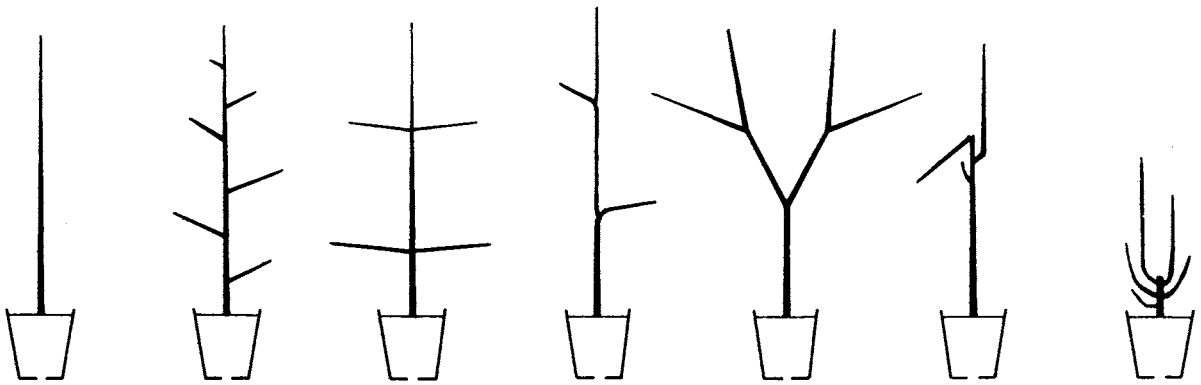
The start of bud dormancy (C 12) is not so easy to spot, but can be detected by:

(1) no more new leaves appearing at the shoot tips;

(2) the leaf (or leaf pair) nearest to the tip being already fully grown and often becoming a darker green; ***and***

(3) a measured stem ceasing to increase in length.

In some tree species, the growing point at the tip of the leading shoot shrivels up at this stage, and further growth in height will be made from a lateral bud.



Common types of branching.

Where do new branches appear?

Branches may grow out from buds in many different places (C 12), according to the branching habit of the species, but they often come from:

(a) **newly formed lateral buds** near the tip of the main shoot, as it grows;

(b) **existing lateral buds,** often those near the tip of the *previous* flush;

(c) **older lateral buds,** especially when shoots have been slightly damaged; ***or***

(d) **small, inactive basal buds** or **newly-formed buds** in replacement shoots growing out from pruned plants or coppiced stock plants (A 21 in Manual 1).

Do branches need to be recorded?

A note of the date when branches first appeared can be quite important in comparing different species or genetic origins for 'branchiness' (A 13 in Manual 1), and might well help to distinguish the effects of treatments.

You could also make observations on the branching habit (C 68), and record whether all branches continue to grow obliquely, or some are turning up and becoming main stems.

How can one score colour?

(1) Look through all the trees in the experiment to see the range of colours present;
(2) Select 5-10 sample leaves showing a sequence of colours, for example from pale yellowish green through to dark green (preferably taking them from similar plants that are not part of the experiment);
(3) Attach these sample leaves to a piece of card, and number them in order;
(4) Do a quick trial run, matching leaves on experimental trees with those on the card, in order to get your eye in;
(5) Assess the whole experiment (C 68), giving a score to each tree, or to comparable sample leaves on it.

Couldn't photographs be used?

Yes, they can be valuable in recording what the colours were, and more generally for:
(a) recalling just what was occurring in an experiment; ***and***
(b) presenting the results to other people in discussions, talks or exhibitions.

Taking a picture of every young tree in a trial is seldom possible, but photographs of some of them in 2-4 lines, arranged in treatments or genetic origins, can be very informative.

What sort of damage needs to be recorded?

For example:
(1) **Loss of shoot tips,** especially of the leading shoot, because this may influence both height growth and branching habit. It can cause problems with measured shoots getting 'shorter', and difficulties with which replacement shoot to record; ***and***
(2) **Reduction of leaf area,** through leaves being partly or completely eaten, torn by the wind or distorted by virus attack (C 45), all of which could affect growth.

Try to distinguish at the time between damage that might be linked to treatment or genetic origins, and accidental or chance breakage.

How can damage be assessed?

(A) ***By counting*** the number of damaged:
(1) plants in each treatment or origin; ***or***
(2) leaves or shoot tips on each plant.
(B) ***By scoring*** the extent of damage (C 68). You could, for instance, assess whole plants or sample leaves, using a scale of 0 (no damage) to 5 or 10 (very damaged).

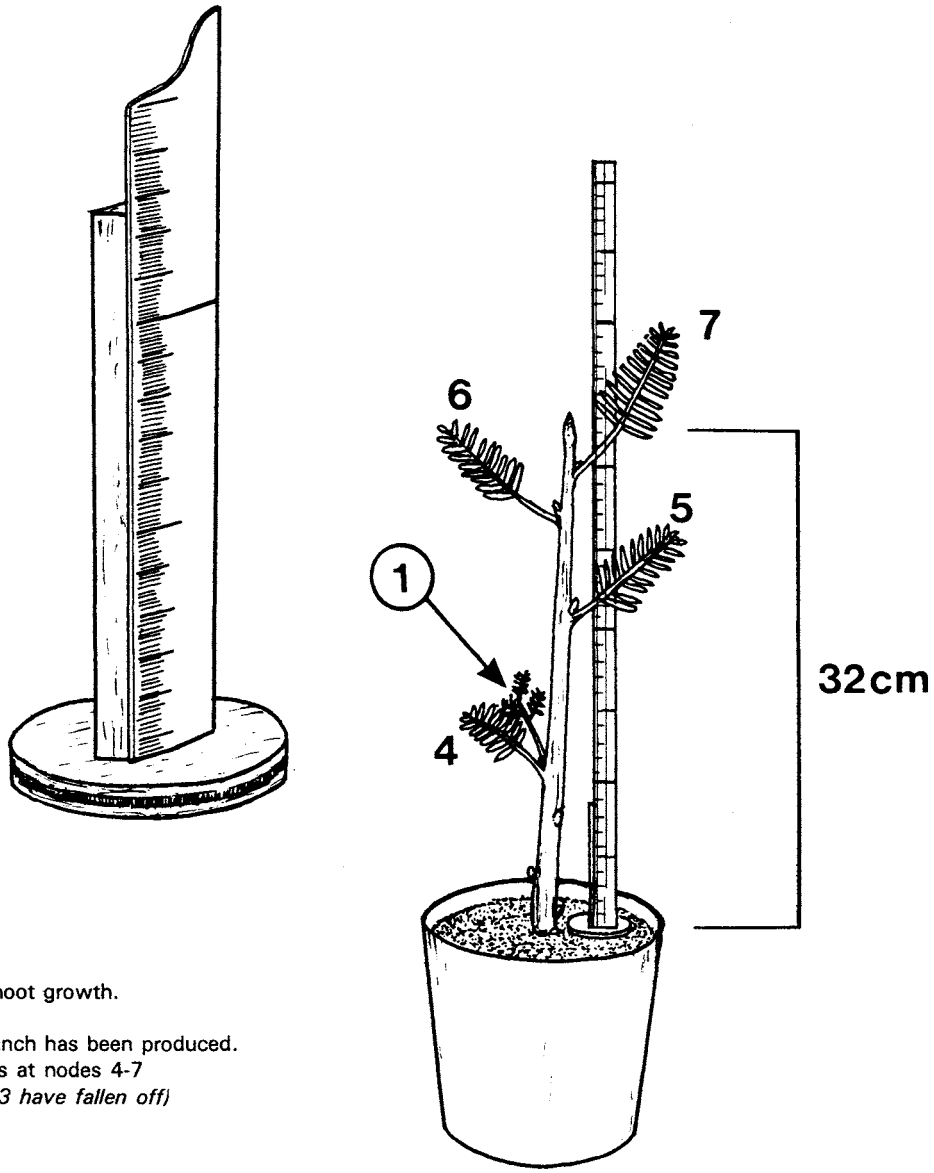
Is it really necessary to do a whole lot of measuring?

That depends a great deal upon the circumstances. In general, try and avoid either:
(a) ending up without important information about the results which could easily have been obtained; ***or***
(b) collecting a mass of figures for no particular purpose, or just because a previous (but no longer appropriate) decision had been made to do so.

What are the most useful measurements to make on trees?

The commonest simple, non-destructive ones are of the:
(1) **height** of the tree;
(2) **diameter** (or girth) of root-collars or stems;
(3) **numbers** of leaves that are produced or fall off;
(4) **length** of leaves or branches, and sometimes of individual internodes (C 12).

The ***gain*** that has been made since the experiment started is often a valuable calculation.



Assessing shoot growth.

① – one branch has been produced.
4-7 – leaves at nodes 4-7
(the bottom 3 have fallen off)

Why use the *gain* in height?

Because the *total* height of the trees includes the different sizes of the trees when the experiment started, and this variability can make it harder for real treatment and/or genetic differences to show up.

Similarly, using the gain in diameter, numbers, length and dry weight can remove a lot of variation, making *significant* results more likely (C 69).

Sometimes the amount of growth relative to the initial size is studied.

How accurate do measurements need to be?

To the nearest centimetre for height and length (or millimetre for detailed measurements);
To the nearest millimetre for diameter and girth (or 0.1 mm for detailed measurements).

What is the easiest way of measuring height?

Usually with a 'fixed' ruler made of suitable wood, plastic or metal. This should be marked in mm or cm, and might be 15, 30, 50 or 100 cm long, whichever is the most convenient. Other alternatives include:

(a) folding or roll-up rulers; ***or***
(b) straight bamboo canes with intervals carefully marked on them with a waterproof marker or paint.

Where should I measure from and to?

(A) **Choosing the base:** measuring from the ground surface is easy, but can be inaccurate because the soil may settle or be washed out, and the ruler may dig in.
For detailed measurements you could:

(1) put in a plastic golf tee or similar object, so that you always measure from the same firm point;
(2) attach a small flat disc to the bottom of the ruler, making sure that it gives a correct measurement from zero; ***or***
(3) measure from a mark made with a waterproof marker or paint at a convenient point on the stem. (*Note: this mark must be on tissue that has stopped elongating* (C 10.))

(B) **Choosing the tip:** it is best to measure to ***where you estimate the growing point of the main stem to be.*** Avoid measuring to the highest point, as this may be part of a leaf or a branch, which will make your data inaccurate and also more variable.

Is it easier to measure diameter or girth?

It is difficult to use a girthing tape on small trees because:

(a) the tape is hard to get straight for reading the girth;
(b) there are often leaf-bases and sometimes branches in the way.

Diameter is usually easier to measure, but getting accurate data depends on:

(1) having calipers of reasonable quality;
(2) not pressing the instrument into soft tissues;
(3) measuring at a standard distance up the stem, while avoiding places where there are irregularities such as the bases of branches; ***and***
(4) marking the stem so that subsequent readings can be made at the same height and on the same sides of the stem.

Is it easy to record the numbers of leaves?

Leaves are surprisingly difficult to keep track of, because:

(a) new leaves may appear in flushes rather than regularly;
(b) some nodes (C 12) may not carry foliage leaves;
(c) older leaves may fall off or be eaten between assessments.

What are the alternatives?

Method A - simply record the number of leaves present on the given date: ***or***
Method B - mark the main stem at a convenient point at the start of the experiment, and count the number of visible leaves and nodes, both towards the tip and towards the base. Then when you make the same assessment later, you can calculate for each tree:

(1) how many new leaves it has produced altogether;
(2) how many have gone;
(3) what is the current number of leaves;
(4) how many new nodes have been formed; ***and***
(5) what is the average length of new internodes.

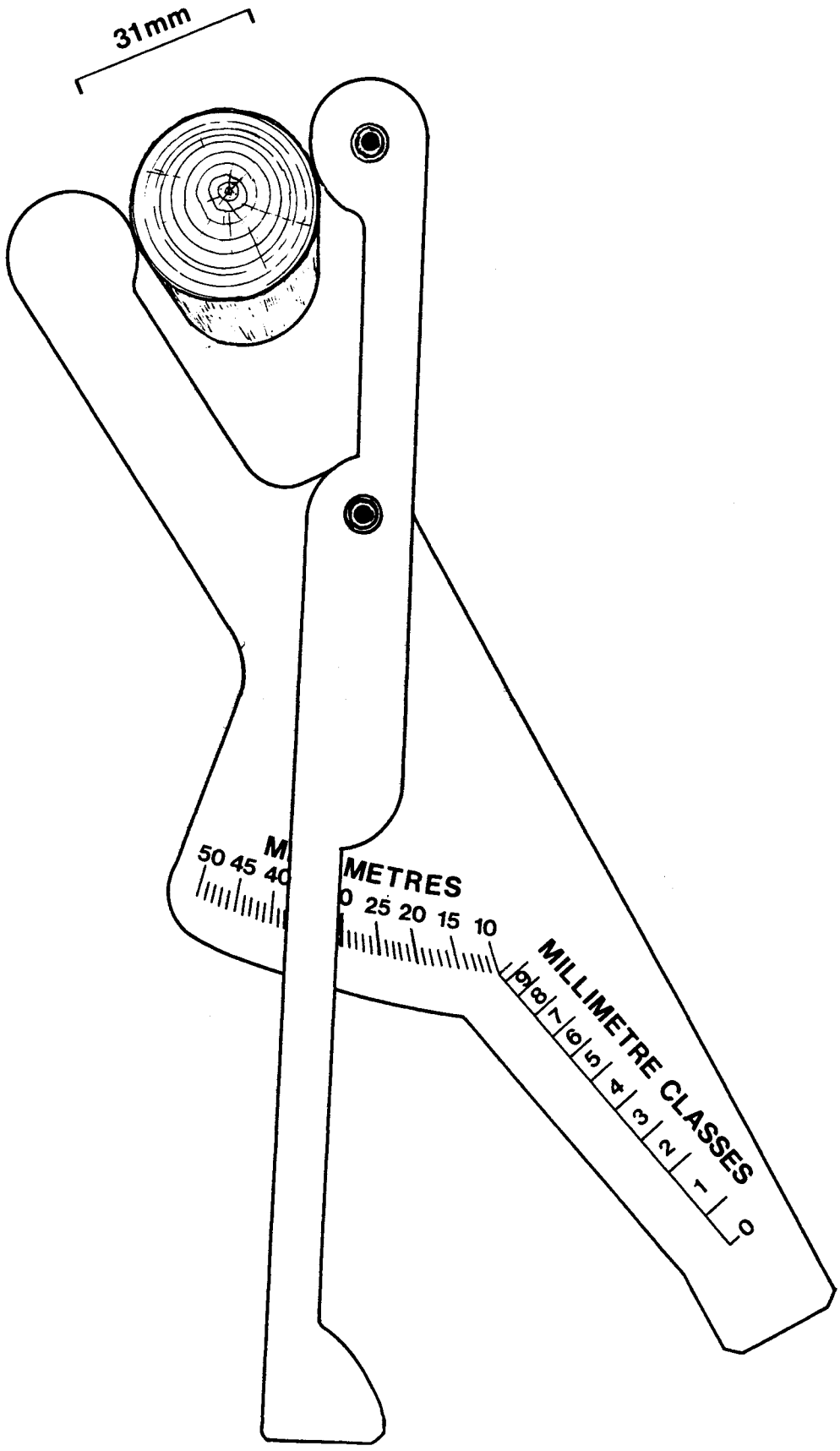
Method B also allows you to select specific sample leaves (or internodes) of **comparable age** for more detailed study of any treatment or genetic differences.

Why measure the length of leaves?

(a) Because it is easy to do; ***and***
(b) Since the length of the leaf *blade* often turns out to have a close relationship with its area, which is likely to influence the potential amount of photosynthesis (C 12) and the overall growth of the young tree.

If you need to know leaf areas, they can be measured by:

(1) drawing round the leaf on squared paper, counting the number of squares that are at least half included, and multiplying by the size of a square; ***or***
(2) using a *leaf-area meter* with such pieces of paper or with detached leaves.



Calipers designed by U.K. Forestry Commission Research Branch.

Would branches need to be measured?

Branch lengths may sometimes be useful, if they can be measured without damage.

How about root growth?

Although this is very important, it is difficult to assess accurately without damaging the young trees, except for:

(a) experiments on rooting of cuttings (A 45 in Manual 1); ***and***
(b) germination tests (Manual 2);

where, with little or no damage at these early stages, you could:

(1) note the first appearance of roots, and how many there are; ***and***
(2) measure the total length of root that has been produced.

Won't destructive sampling disturb the results?

Yes, it can do, particularly if:

(a) the numbers of trees in each treatment are limited;
(b) several other trees were lost during the experiment; ***or***
(c) random sampling happens to remove, for instance, some of the largest trees from one of the treatments.

In addition, as many plants as possible may be needed later on for:

(1) continued measurement;
(2) planting in a field trial; ***or***
(3) using as stockplants (A 6 in Manual 1).

What other non-destructive measurements can be made of roots?

Rough estimates of root development are sometimes made by:

(A) gently tapping out the intact root ball from a tapered pot (C 6), and counting the number of root tips that can seen without disturbing the soil, or scoring the amount of root growth that is visible (C 68);
(B) planting the young trees in a root observation box that has a sloping glass surface through which the progress of individual roots can be followed *(Note that the glass surface needs to be covered with black polythene sheeting except when observations and measurements are being done, in order to exclude light);* ***or***
(C) growing the young trees in a mist box, with the roots in air that is continually being filled with small drops of water; or in aerated water as in the 'bubble-bath' system (Manual 1).

Supposing I need to know the dry weights?

Unless plenty of young trees are available, you might consider whether it would be adequate to record:

(A) an initial set, using equivalent plants to those in the experiment; ***and***
(B) a final sample, at the end of the experiment.

If some destructive measurements are to be made, you could take the opportunity of washing out the whole root system carefully, photographing it, scoring the amount and distribution of roots, and finding the dry weight at each successive depth in the soil.

What is the procedure for measuring dry weights?

(a) Wash out the roots from the soil carefully, trying not to break the small ones;
(b) Cut up each tree into separate sections (usually stem, leaf and root). Remove surplus water, and weigh them if you will need fresh weights to calculate moisture contents.
(c) Dry batches in an oven at a chosen temperature (generally between 80° and 105°C).
(d) Cool in a *dessicator* to prevent moisture being re-absorbed.
(e) Weigh some of the bulkier samples, dry them again, and weigh again, until a constant weight is recorded. Then dry the remaining batches for a standard period that will have brought them to a constant weight.

Samples of known fresh or dry weights can then be used for any chemical analyses.

Why should I record what happens to the growing conditions?

In some cases this is unnecessary;
In most experiments it can prove useful, because:

(a) a change in weather may influence the rate at which your experimental trees grow;
(b) if some or all of your plants had suffered from wilting, this could be a possible explanation for sudden fluctuations in growth rate or loss of leaves; ***or***
(c) if pests or diseases were noted, these might also have had effects on growth rates.

In detailed studies, measurement of the environment may be an integral part of the research. Sensors and automatic recorders are now available which can provide a continuous record of temperature, light and humidity, for example.

How should I use the measurements of growth that I make?

Even if the experiment has a complex layout, it is usually best to work out the main averages as you go along, and if possible draw some simple graphs. These might suggest for example that:

(1) treatment or genetic differences are starting to have an effect;
(2) measuring needs to be done more often, or less frequently;
(3) observations or scoring could now be relevant, for example if shoot growth seemed to be slowing down, or restarting;
(4) it may soon be time to stop the experiment.

Computers can do many things these days, but leaving all the calculations until afterwards means that you may remain unaware of important aspects until it is too late to respond.

What about analysing the data?

Some advice on statistical analyses is given in sheets C 67-69.