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Tools for Harvesting Tree Fruits

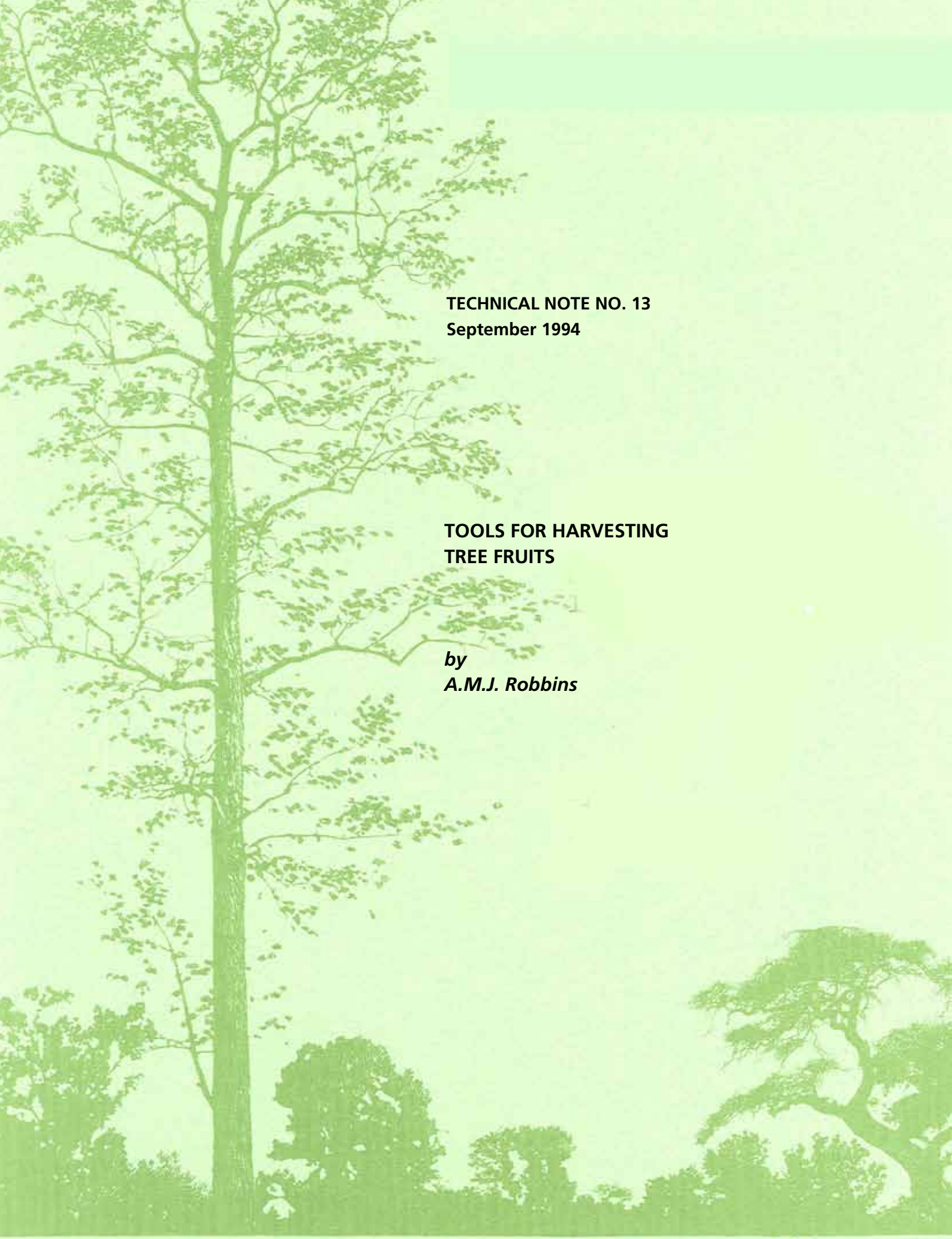
Robbins, A.M.J.

Publication date:
1984

Document version
Early version, also known as pre-print

Citation for published version (APA):
Robbins, A. M. J. (1984). *Tools for Harvesting Tree Fruits*. Danida Forest Seed Centre. Technical Note No.13 Uden navn

Download date: 13. Nov. 2026



TECHNICAL NOTE NO. 13
September 1994

TOOLS FOR HARVESTING TREE FRUITS

by
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DANIDA FOREST SEED CENTRE

Titel
Tools for harvesting tree fruits

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Publisher
Danida Forest Seed Centre

ISSN
0902-3224

Series - title and no.
Technical Note no. 13

DTP
Melita Jørgensen

Citation
Robbins, A.M.J. 1994. Tools for harvesting tree fruits

Citation allowed with clear source indication
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1. INTRODUCTION

The harvesting of tree fruits is defined by Tietz (1971) as the actual removal of the fruits from the tree, whereas collection is the next stage of getting the fruits into a suitable container. This Technical Note describes the tools required for harvesting and also the main methods of collecting the harvested fruits.

These operations present various problems: the fruits are widely dispersed over the crown; generally inaccessible; varying in size according to species; and often difficult to remove without damaging the tree. Damage must be minimised if the tree is to remain healthy and continue producing fruits. If these problems are to be reduced, it is important to have an adequate knowledge of the phenology of the tree, and some idea of the benefits versus the costs of reducing damage.

A variety of techniques and tools, which compromise speed of operation with degree of damage, have been developed for harvesting. The tools function in two basic ways: branches, tips of branches, or fruit peduncles are either cut off, or torn/broken off. Cutting tools are those with sharpened edges working with a shearing action, and they are preferred because of the clean wound produced. Tearing tools take a variety of forms, they are easier to use but cause more damage. Some tools both cut and tear.

Depending on the proximity of the worker to the fruits, tools can have different lengths of handle. The longer the handle, the more important it becomes to have the lightest possible weight of tool at the end. Heavy and cumbersome tools are difficult and dangerous to use, especially when the operator is using them within the tree crown.

2. TOOLS FOR HARVESTING

For the purpose of discussing tool types, harvesting techniques can be divided into three main methods: (i) severing complete branches; (ii) severing branch tips; (iii) severing fruit peduncles. Many species have to be harvested in two stages, first using methods (i) or (ii) on the standing tree, and then method (iii) to remove individual fruits once the branches have fallen to the ground.

2.1 Tools for severing branches (25 mm diam. +)

This method cannot be used where a tree is to be repeatedly harvested as it may seriously damage it, predisposing the tree to disease if rough wounds are produced. In general, the method is useful for small quantities of high value seed (eg. for research purposes), or for larger bulk quantities where an adequate number of seed trees with fruits are extremely inaccessible or { T difficult to harvest individually or in groups (e.g. Eucalyptus). The severest action taken would be to fell the trees which can be appropriate if combined with timber harvesting.

An important general principle of this method is that of undercutting. The branch should be partially cut on the underside (up to a quarter of the diameter) before completing the cut from the topside, so as to allow a clean break. If it is not possible to undercut, the weight of the branch will cause it to drop down and tear before the cut is finished, often stripping a length of resilient sapwood from the underside of the

stub, thus causing the branch to 'hang-up'. It can be very difficult to break this strip, and a large wound is produced. The more brittle the timber the less likelihood of hanging-up.

Simple breaking methods

Although not advisable because of the damage caused, branches can be broken by hand or by being bent and broken using a hook on a pole or rope, placed by means of the 'advanced line' technique. Some species will break readily and cleanly, whereas others are very resistant and pliable and will hang-up. Generally, the best way to break a branch is to pull it slightly backwards at about three-quarters of its length from the base, so that it tends to bow, and then suddenly snap.

Machetes and sickles

These are sometimes used to chop off branches, but are not recommended because of the damage they cause. They are dangerous when climbing.

Pruning shears or loppers

Heavy-duty two-handed pruning shears are available that will cut up to 55 mm diam. branches very cleanly. They are of limited reach and require both hands for operation. (Fig. page 3 no.1. Suppliers 1-5, 9).

Pruning saw

This is a versatile saw for cutting close to the base of the branch. The blade is slightly curved with cross-cut teeth on the concave side that cut on the pull stroke. The design is ideal for use above head height, but is difficult to use for undercutting. Blade lengths are made up to 50 cm. Standard handles are available, but the most useful type can be fixed to a pole handle, referred to in the trade as a 'pole saw'. The maximum practical handle length is about 3 m, beyond which it is difficult to control the blade and exert sufficient pressure. The saw will not work well if the branch can vibrate, since the teeth chatter, and the blade tends to jam in the kerf. (Fig. page 3, no. 2. Supplier 1-5, 9).

Bow saw

A version of the standard two-man bow saw is available for use with one hand, and it cuts larger branches than the pruning saw. The operator must be within arm's length of the branch. (Fig. 3. Supplier 1-5, 9).

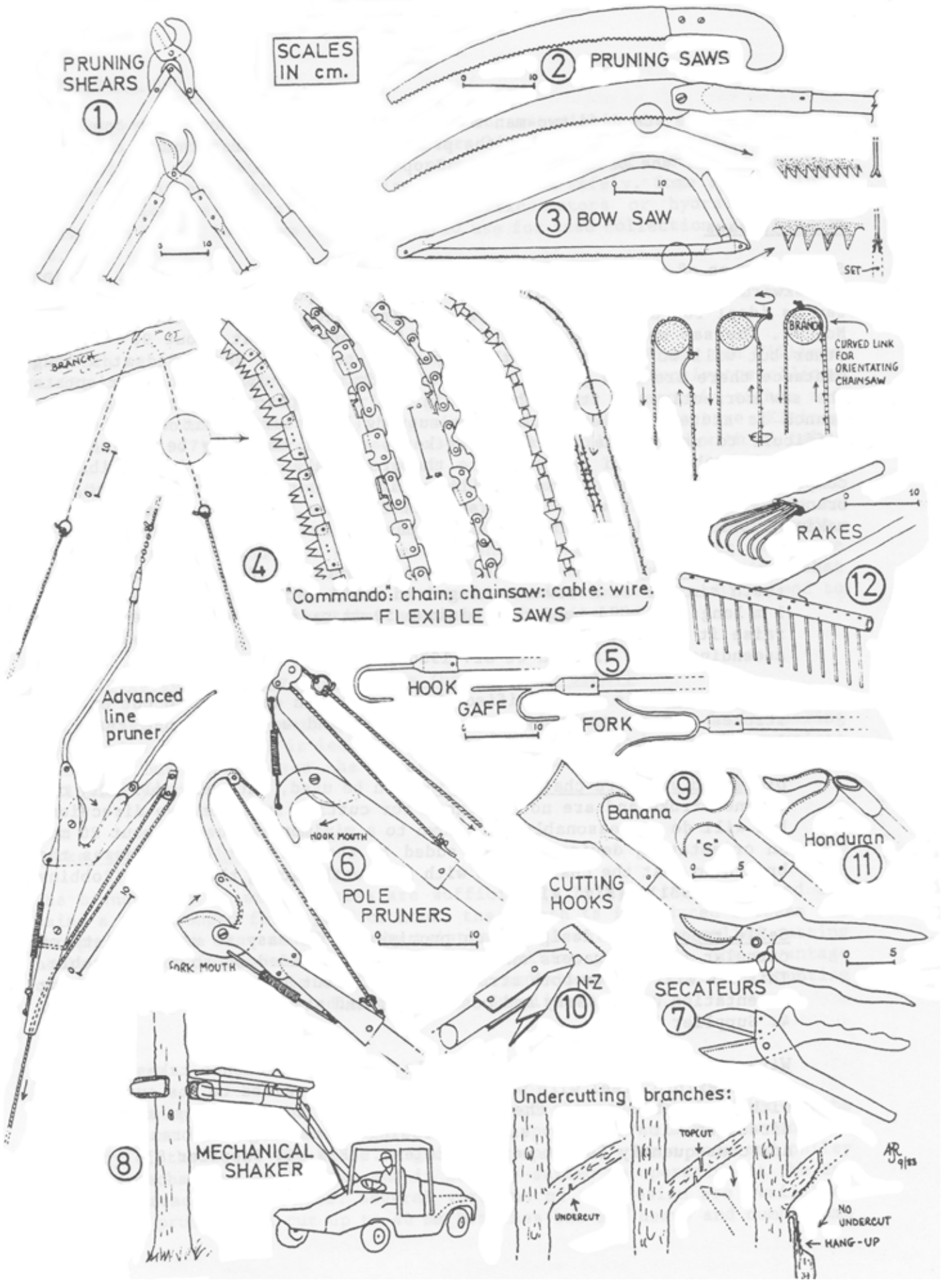
Flexible saws

Several types of this saw are available commercially and are ideal for cutting in awkward places or at long distance. Handles are pulling ropes, and thus the saw is ideal for use with the 'advanced line' technique (see Technical Note No. 7). The saw works best when the pulling ropes are at about 90° to each other but will work even when the ropes are parallel. When used at a long distance there are some points to note: (i) it may be difficult to orientate the saw correctly and start the cut in the right place, especially if the branch is acutely angled; (ii) once cutting has started, it will be very difficult to remove the saw from its kerf, and it can only be pulled free easily when the branch is severed - therefore make sure it is possible to complete the cut before starting; (iii) as it is not possible to undercut, the branch may hang-up; (iv) if the branch is flexible, teeth-chatter may occur making cutting difficult. The various types are as follows:

Commando type: This type is used in Australia (Boden, 1972) and has teeth similar to a bow saw hinged in small sections. The saw is about 1 m long, and will bend to a minimum 50 mm radius. Skill is required to raise it to a cutting position and it is difficult to use on acutely ascending limbs (Boland *et al.* 1980). (Fig. 4).

Chain type: This is a modified chain saw chain designed to cut on both strokes and is probably more

TOOLS FOR HARVESTING TREE FRUITS



efficient and easier to use than the 'commando' saw. (Fig. 4. Suppliers 6, 7)

Discarded standard chain saw chains can be used, but they will only cut on one stroke and are not designed for cutting in a concave direction, but will do so reasonably well down to a minimum radius of about 20 mm. An orientating device must be added to the end that first passes the branch so that the chain bends with the teeth facing the branch (Robbins *et al.*, 1981). (Fig. 4).

Cable type: A new design which promises to be easy to use consists of circular teeth, spacers and depth guides threaded on to a wire cable. This saw will cut on both strokes, and will cut in any direction, making orientation unnecessary and positioning and starting much easier. (Fig. 4. Supplier 1).

Wire type: A light-duty saw suitable for small branches takes the form of a flexible steel wire with abrasive spikes welded to its surface. As with the cable type, the saw will cut on both strokes and in any direction. It 'cuts' by simply abrading or tearing the branch tissues and consequently is not very efficient. (Fig. 4. Supplier 8).

Power chain saw

Lightweight chain saws, that are suitable for use within the tree crown, are available from many manufacturers. Some are light enough to use with one hand. They have the advantages of speed of operation and ease of cutting in awkward positions, but experience is required to use them safely. Some special long-reach versions are available using electric motors or hydraulic drive (Bridgeman 1976), but seem to have limited use for seed collection. (Suppliers 1-5, 9).

Rifle

A branch can be shot at with a rifle so as to break it. Green and Williams (1969) carried out extensive tests using this method for *Eucalyptus obliqu*a and found that a .222 calibre rifle provided with x8 telescopic sights and firing PSP (pointed soft point) 50 grain projectiles was effective. Kleinig and Boland (1977) preferred to use a .308 calibre rifle fitted with x4 telescopic sights, also firing soft point projectiles. The ease and speed of breaking a branch depends on the timber brittleness. The method works best for larger branches up to 15 cm, in which bullets have sufficient distance to expand and shatter the timber, causing sudden breakage. As with other methods, it is important to undercut with several shots, before completing severance with further shots, so as to avoid hang-ups. Green and Williams consider that hollow point projectiles would be better for smaller branches, which tend to hang-up if soft point projectiles are used. (Supplier 11).

2.2 Tools for severing branch tips (up to 25 mm diam.)

The easiest way of harvesting the fruits is by cutting off the fruit-bearing branch tips. The method is less damaging to the tree than harvesting complete branches, but still poses the problem of reduced fruit production in the following years.

Forks, gaffs and hooks

The branch tips of many species are sufficiently brittle to be snapped off using a two-pronged fork, gaff or hook; the branch is introduced between the two prongs, then bent and broken by twisting the tool. Many so-called cutting hooks are used for twisting rather than for cutting peduncles. The advantage of the tool is that it is simple and light and therefore ideal for mounting at the end of long pole handles. (Fig. 5. Supplier 9, 10).

Pole pruners
These commonly used tools comprise a cam-shaped sharpened blade which can be rotated so as to shear the branch which is supported in an anvil formed from the body of the tool. The blade is generally operated with a rope and pulley giving a mechanical advantage, and is ideally suited to operation at the end of a long-reach pole handle. Several versions of the design are available: heavy-duty pruners can cut up to 40 mm branches but are heavy and cumbersome to use at the end of long handles and they are best manipulated with the handle as vertical as possible, using other branches for support; hook-mouthed pruners are the standard design and have to be pulled back onto the branch; fork-mouthed pruners are pushed onto the branch and are more difficult to position as the branch cannot be used to support the handle, but they are useful if foliage is very dense; an 'advanced line' pruner, a version of the fork-mouthed design, has been developed by Collis and Harris (1973) for use with the 'advanced line' technique in which ropes are used both to position and operate the pruner. (Fig. 6. Suppliers 1-5, 9).

Branch breaking device
Collis and Harris (1973) have also developed a branch-breaking device for use with the 'advanced line' technique, which gripped the branch so that it could be hauled back to the operator. It was not as satisfactory as the pruner.

2.3 Tools for severing fruit peduncles

Harvesting individual fruits will produce least damage to the tree, but is often precluded by time and hence cost. However, it is almost always necessary to do this as the last stage of a two-stage harvesting, when the branches are on the ground. There are few commercially available tools specifically designed for harvesting individual tree fruits, and most tools have been designed and made by forest departments. A practical design must be simple, sturdy, light, and capable of severing as many fruits as possible in one operation.

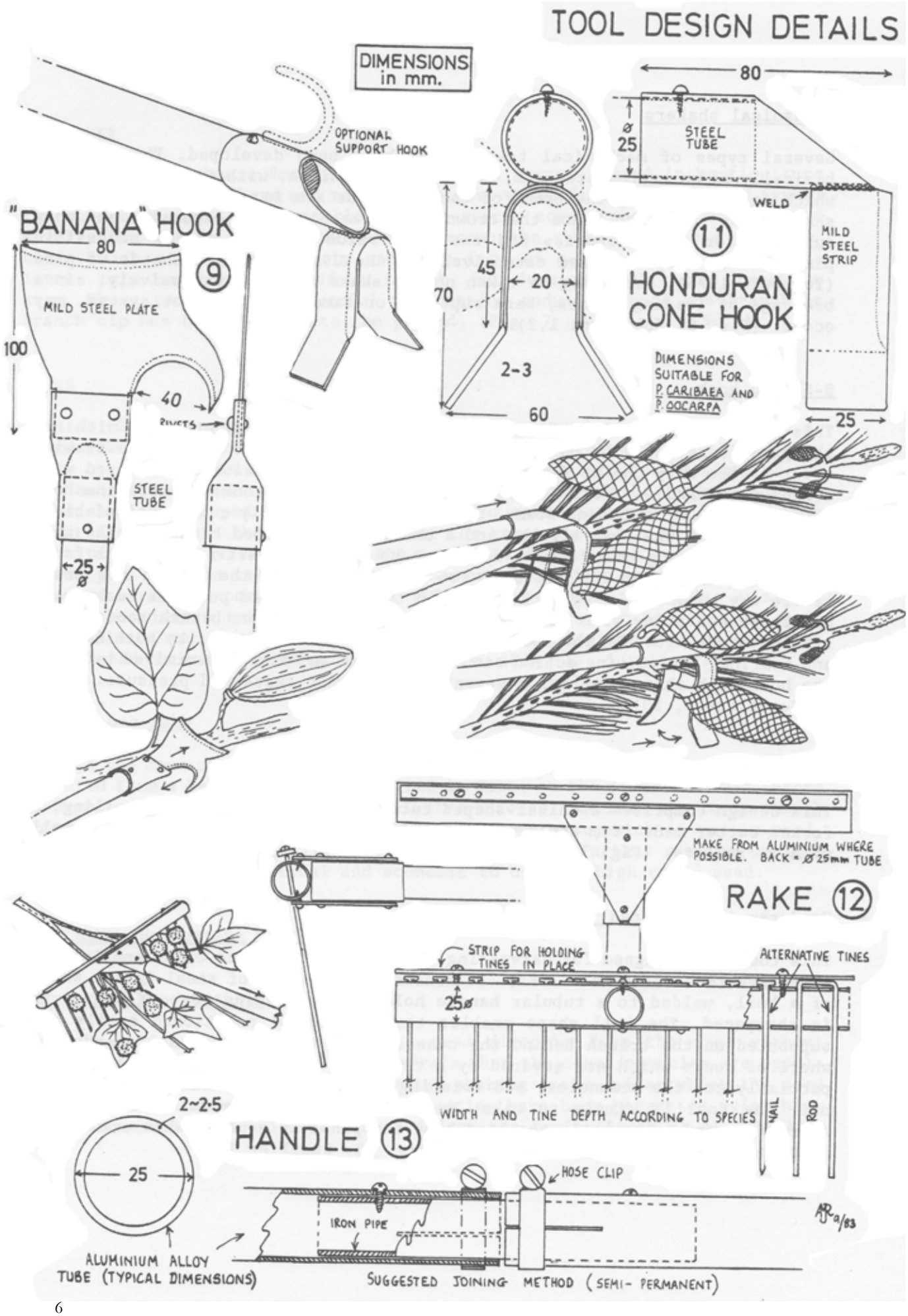
Hand picking
It may be practical to use no tools and pick by hand, especially if the branches are already on the ground. Gloves will be useful to protect the skin. The best way of breaking the more resistant peduncles is to twist the fruit at the same time as pulling or jerking. When picking within the crown, a light-weight hook on a pole is useful for pulling the branches within reach.

Simple shaking methods
Many species have fruits with relatively weak peduncles and shaking a branch will produce enough momentum in the fruit to break its peduncle (e.g. *Cedrela*). The most common tool for shaking is a simple hook or gaff on a pole with which to hold and shake the branch. Sometimes beating with a stick may suffice.

Alternatively, a rope can be used placed in position over the branch using the 'advanced line' technique. The actual point at which the branch is held is important for producing maximum shake. Generally the best point lies between half way and three quarters of the way along the branch from the base.

Mechanical shakers
Several types of mechanical tree shaker have been developed. They consist basically of an articulated arm, mounted on a vehicle, with a clamp at the end which is used to grip the trunk of the tree. The arm is made to vibrate, thus shaking the trunk and hence the crown. These machines are expensive and only suitable for a few species and for high value seed in easily accessible plantations. They are used extensively

TOOL DESIGN DETAILS



in the USA for seed orchards of pine (Turnbull 1975). Care must be taken not to shake the tree excessively, since breakage of leading shoots, bark rupture, or damage to the root system, may occur. (Fig. 8. Suppliers 1, 2).

S-Shaped hook

This general purpose tool is a common design made from sheet steel with two sharpened edges used by pulling or pushing. It is slow to use, since it will sever fruits only one at a time, and is difficult to position when used with a long pole handle. There are several variants of the hook: perhaps the best is used for cutting banana stems; it has a large, slightly convex chisel blade for cutting on the push stroke, and a smaller hook-shaped blade for the pull stroke. When using these hooks, care must be taken to exert force on the fruit such that the branch is not bent too much, otherwise the branch may break before the peduncle; thus workers within the crown should push the hook away, and those operating from outside should pull, so that the branch tends to be straightened. Although the hooks have a sharp edge, they sever by both cutting and tearing. The cutting action can be maximised and damage minimised by using the hook with sharp, jabbing movements rather than sustained pressure. (Fig. 9. Suppliers 9, 10).

'New Zealand' cone hook

This design comprises a chisel-haped cutter for pushing and, for pulling, a forked cutter made from angle iron. Thulin (1980) reports that it works well with *P. radiata*. (Fig. 10. Supplier 10).

Honduran 'bell-shaped' cone hook

This tool was designed for harvesting Central-American pine cones and is very effective (Robbins *et al.* 1981). It consists of a strip of steel in the shape of a bell, welded to a tubular handle holder. The leading edge of the strip is sharpened. The bell shape enables the tool to be positioned easily and supported on the branch behind the cones. It is then slid along towards the whorl of cones which are severed by a combination of jabbing strokes, which partially cut the peduncles, and twisting, which finally tears the peduncles off. The tool is simple to make, easy to use, cuts several cones in one operation, and is probably the best hook for pines in general when used by an operator from within the tree crown. (Fig. 11. Supplier 10).

Secateurs

These are small shears for use with one hand, commonly used in horticulture for pruning bushes. There are various designs, which fall into two main types: the most common has a curved blade which slices across one side of a curved anvil, like the action of a pair of scissors; the other type has a straight blade which cuts down directly onto the face of a soft metal anvil; this latter type requires more effort to cut, but does not twist the branch or stem. These tools are very useful for cutting peduncles once the branch or branch tip has been dropped to the ground. (Fig. 7. Suppliers 1-5, 9).

Rakes

Species that have many small fruits widely dispersed over the crown (e.g. *Liquidambar*) can often be harvested by combing the crown with rake-type tools which catch the fruit and tear them off. The distance between the tines of the rake must be somewhat smaller than the minimum width of the fruits, and the tines should be sloped slightly backwards (for rakes that are pulled) so that the fruits slide to the back or spine of the rake. The depth of the tines and width of the rake will determine the number of fruits that can be harvested at one pull. A wide rake is generally better than a deep one. Suitable rakes are not available commercially and will have to be custom-made: a simple design comprises a tubular back with holes drilled out to accept tines made from nails or rod, preferably of aluminium alloy for lightness. Tines can then be replaced or modified to suit the species. (Fig. 12. Supplier 10).

Aerial cone rake
Perhaps the most exotic harvesting tool ever devised was a large circular rake operated from a helicopter, as described in Dobbs *et al.* (1977). It was tested (*Pseudotsuga* and *Abies* spp. with relative success. The rake was large enough to cover the whole cone-bearing part of the crown over which it was lowered, and it harvested the majority of cones in one pull. Further simpler designs may be sufficiently practical and economic to use for high value seed.

2.4 Other Harvesting Methods

Harvesting seed without the fruit
It is sometimes possible to harvest seed directly from the tree without removing the fruit (e.g. *Pinus* and *Cedrela* when the cones/capsules are open). The seed is generally dislodged by using shaking tools, after which the seed is collected on sheets etc. Some bush species have been harvested using high power vacuum cleaners to suck the seed from the fruit (Stein *et al.*, 1974).

Natural harvesting
The fruits of many species will eventually fall to the ground through natural dehiscence, and even if the fruits are persistent, the seed will always be dispersed at some time. Because of the expense and difficulty of harvesting, this can be a practical alternative that has been used for many species (e.g. *Quercus, Fagus, Tectona, Gmelina, Shorea*) (Turnbull, 1975). In the USA methods are being developed for collecting natural seed fall in seed orchards of *Pinus* (Tietz, 1971). Experiments have been carried out to speed up natural fall using abscission chemicals, which may be a useful tool in the future.

2.5 Tool Handles

Many of the tools mentioned will be used with long-reach pole handles. These must be light weight, rigid and strong - difficult requirements to meet if the pole is up to 6 m long. Suitable natural materials are bamboo, cane or woody saplings/stems, but these tend to be heavy for lengths beyond 3 m. Dowelling or sawn timber may be used for short handles. Aluminium alloy tube of approx. 25 mm diam. is very versatile and is the most common commercial material for handles, although fibreglass poles are becoming popular, having the advantage of being exceptionally strong.

Since a long handle can be unwieldy to move around the crown, it may be preferable to have handles in sections that either screw into each other or which are telescopic. This latter type is very convenient, but is often not very strong. Where possible, it is better to have one-piece handles, since they are stronger and lighter.

Tubular aluminium handles can be made from locally available tube, but care must be taken to check the alloy strength. Many tubes available in hardware stores are used for furniture etc. but they are unsuitable in that they will bend easily. A suitable tube should be extremely difficult to bend by hand. See fig. 13 for dimensions and joining methods.

3. COLLECTION METHODS AND TOOLS

Collection of harvested fruits (i.e. gathering and placing them in a suitable container for transport) is an integral part of obtaining fruits, and the technique used will often determine the harvesting method and tool.

Collection at time of harvest

It is generally quickest to put the fruits into a container as they are harvested. The worker can carry light baskets or sacks with him into which the fruits are put as soon as they are removed. If this is done while climbing in the tree crown, sacks can be hung from branches using a meat hook or similar tool. If the fruits are light, then small quantities can be collected in bags attached to the harvesting tool itself (e.g. a pole pruner).

Collection after harvest

Because of the large quantities of fruit involved, their weight and accessibility, it is often impractical to put the harvested fruits from standing trees into containers at once. In this case, branches, branch tips, or individual fruits are allowed to fall to the ground, where final collection is carried out afterwards.

There are two main problems when doing this:

i) The harvested material can catch-up in the crown and not fall to the ground. If branches are being harvested, one solution is to choose only those that have a clear fall. Branch tips can often be flicked free of the crown with the harvesting tool, whilst individual fruits often can be shaken free from the foliage in which they have lodged.

ii) Once on the ground, it may be difficult to find the harvested material, especially if the undergrowth is dense or if there is a steep slope down which the material can fall. There are various ways of reducing this problem:
   - The undergrowth can be cleared around the base of the tree using a machete, sickle or similar tool. Rakes can then be used to gather branch tips or fruits to speed the operation.
   - Tarpaulins, canvas or cotton sheets or polyethylene netting can be placed over the cleared area to facilitate gathering of the fruit. Nets that are mechanically rolled up have been used in seed or chards (Tietz, 1971, Hallman and Casavan 1979).
   - If the undergrowth consists of small trees and bushes, it may be practical to suspend a sheet or netting on poles above the under growth. Some workers have suggested constructing a funnel around the trunk of the tree to collect natural seed fall (Hallman and Casavan, 1979).

Collection can be mechanised in seed orchards and various makes of sweeper and vacuum collector have been tried (Tietz 1971), but these would generally be too expensive and impractical for normal operations.

4. TOOL MAINTENANCE

Tool heads should be checked periodically for secure fixing to the handle. Shearing tools will rarely need to be sharpened, but when necessary they should be honed with an oilstone. Saw type tools should be sharpened frequently with an appropriate file, and at the same time the set of the teeth should be adjusted to ensure that the saw leaves a kerf (i.e. saw-cut) that is wide enough to prevent the saw blade jamming. Keep all tools well oiled and free from debris.

5. SAFETY RULES

- Use the right tool for the job and keep it properly maintained.
- When working in the crown, make sure of the support before using tool.
- The ground assistant must wear a safety hat at all times; falling branches, parts of branches, fruits and tools can be lethal. Take particular care of the eyes when looking upwards. The climber should wear a safety hat if it does not interfere with his ability to see; hats without peaks may be better.
- Beware of electric power lines when using long metal handles.
- When resting a tool (particularly hooks) in the tree crown, make sure it is secure - a falling S-hook or 'banana' hook can be extremely dangerous.

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7. SUPPLIERS

Note: Availability of makes and types of tools should be checked with suppliers before ordering. Tools that have particular trade names are given after the relevant supplier.

All contact details have been checked and updated as of August 2011.

1	Ben Meadows U.S.A.	Suppliers of general forest equipment. Cable type flexible saw = "High Branch Tree Saw". www.benmeadows.com/
2.	Forestry Suppliers P.O. Box 8397 205 W. Rankin Street Jackson Mississippi 39284, U.S.A.	Suppliers of general forestry equipment. www.forestry-suppliers.com
3	General Supply Corporation P.O. Box 9347 Jackson, Mississippi 39204, U.S.A.	
4	Honey Brothers Ltd., New Pond Road, Peasmarsh Guildford, Surrey,	Suppliers of tree surgery equipment. Heavy-duty pole saw set : "The Treeman Cutter". www.honeybros.com/
5	Stanton Hope 11 Seax Court Southfields, Laindon Basildon, Essex SS15 6LY , U.K.	Suppliers of forestry equipment. www.stantonhope.co.uk/
6	Green Mountain Products Inc. Mullar Park, Norwalk CT 06851, U.S.A.	Chain flexible saw = "High Limb Chain Saw". www.tyvekcoveralls.com/index.html
7	Holst, Inc., Michigan (Not found)	Chain flexible saw "High Limb Chain Saw"
8	Local camping supplier.	
9	Local agricultural and horticultural suppliers.	
10	Home made from local materials.	
11	Local hunting suppliers.	.222 Rifle = Remington Model 722