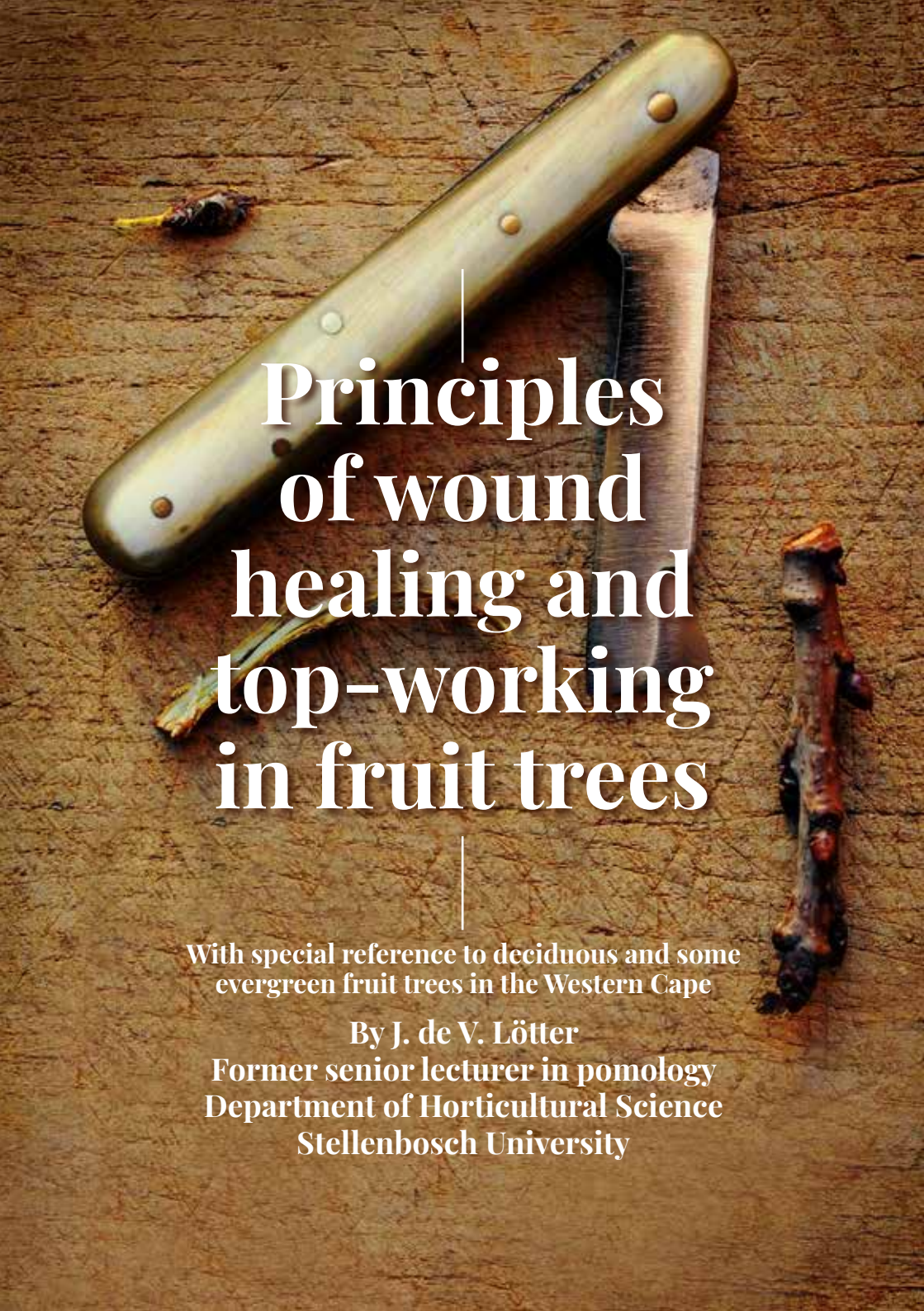

Principles of wound healing and top-working in fruit trees

With special reference to deciduous and some evergreen fruit trees in the Western Cape

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Western Cape Government
Agriculture
FOR YOU

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About the author

J. de V. Lötter, fondly remembered as Oom Koos by his colleagues and students, touched many lives during his 23 years as a lecturer in the Department of Horticultural Sciences at Stellenbosch University.

Lötter was born on 9 December 1926 near Villiersdorp in the Overberg. He grew up on a farm, joining the South African National Defence Force at the age of 18. During World War II, Lötter served on bomber crews in North Africa and Europe.

SUPPLIED BY K.I. THERON

Koos Lötter in his student days on his Harley-Davidson.

After the war, Lötter enrolled for a bachelor's degree in agriculture at Stellenbosch University. Like many ex-servicemen, he stayed in Helderberg Residence. He soon became well-known for his Harley-Davidson — with sidecar — that he purchased with savings from his army days. He graduated in 1951.

Lötter initially worked on pome fruit. He published papers on the successful use of a bin-harvesting system for apples and pears, and the pollination of deciduous fruit trees.

In 1968, Lötter returned to Stellenbosch University as a lecturer in the Department of Horticultural Sciences, where he remained until his retirement in 1991. His earlier work included research on grafting and top-working, which laid the foundation for this book.

Later, he turned his attention to alternative crops, lecturing on the topic, and earning the nickname Koos Kiwi for his work on kiwi fruit. He took his work home, planting all sorts of fruit trees at his house in the Stellenbosch suburb of La Colline.

Well-known South African cookbook author and food researcher, Renata Coetzee, was a close friend of Lötter and would visit him to experiment with preserving the harvest from his garden.

Lötter loved writing. His best-known book is *The Fig in South Africa*, published in 2014. He helped to identify old and select new fig cultivars for the historic farm Babylonstoren.

In 2019, Lötter was the first recipient of the Hortgro 1662 Industry Award for his lifetime contribution to the South African deciduous-fruit industry. Besides deciduous fruit and alternative crops,

HORTGRO

Koos Lötter (centre) receives an award for his lifetime contribution to the deciduous-fruit industry from Anton Rabe of Hortgro and Dr Ilse Trautmann of the Western Cape Department of Agriculture.

Lötter was also well-known in the grape industry, and in 2021, Van Loggerenberg Wines honoured his memory by naming a red wine after him.

Oom Koos passed away on 29 October 2019. His obituary released by Stellenbosch University quotes the then chair of the Department of Horticultural Sciences, Dr Lynn Hoffman.

"He will surely be missed for his zest for life in general, but also in particular for his passion for horticulture. His place as a long-standing friend and valued colleague over many years will now be empty."

SUPPLIED BY J. DE V. LÖTTER.

Top-working vase-shaped Packham's Triumph pear trees to Bon Chrétien in the Agter-Witzenberg, Ceres, in 1954.

CHAPTER
ONE

Introduction

Pruning is an annual practice in deciduous fruit orchards and is increasingly done in commercial evergreen fruit orchards. In addition to pruning, top-working established fruit trees to other cultivars is sometimes necessary. Both practices give rise to wounds that demand special treatment to ensure the success of grafting and pruning, and therefore the commercial survival of the orchard. In this publication, years of experience with wound treatment and top-working in the Western Cape are summarised for the benefit of fruit producers, students, and interested home gardeners.

J. de V. Lötter

CHAPTER
TWO

Wound healing in trees

The healing process

Pruning and grafting of fruit and ornamental trees cause numerous wounds that expose the tree to desiccation and infection. Immediately after wounding, the tree attempts to seal the wound and protect the exposed living tissue by plugging vascular tissue and forming callus, an unstructured mass of parenchymal cells that develops mainly from cambium and ray cells.

The callus is stimulated by wound hormones to make protective tissue called periderm on its surface (Bloch, 1952). Periderm consists of three layers: cork cambium (phellogen) that produces cork outwards (phellem) and secondary parenchymal tissue inwards (phelloderm). The cork cells die and develop into a waterproof barrier that constitutes the so-called primary protective tissue whereas the phelloderm supplements the callus (**Figure 1**).

The periderm provides short-term protection. Depending on the vigour of the tree and the size of the wound, the callus will gradually cover the exposed woody tissue, replacing the periderm as the main protective tissue. Rapid lignification of the callus cells creates an effective permanent protective barrier (Esau, 1960).

Grafting results in close contact between the wounds of the scion and rootstock, and their parenchymal cells grow together to form a joint callus. Some

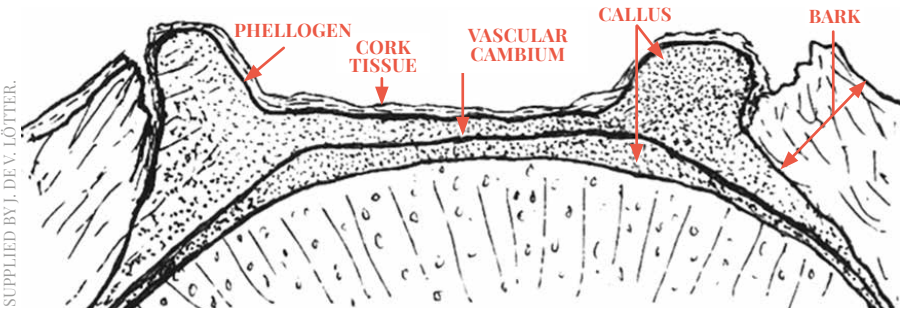

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Figure 1: Radial cross section of a wound on a shoot after healing has started.

Figure 2: The cambium of the scion and rootstock must be in contact to ensure a successful graft union.

of the cells subsequently differentiate into xylem and phloem that connect the vascular tissues of the scion and rootstock, a prerequisite for a successful graft union. For this reason, a skilled grafter will ensure the connection of scion and rootstock cambium, which are the areas of most active cell division (**Figure 2**).

Wound size and cambium activity determine how long a wound takes to heal — often longer than one season. The timing of pruning and other treatments like nitrogen fertilisation also influences healing speed.

The speed of wound healing is directly correlated to the vigour of the tree (or of its part). Young tissue is more vigorous than old tissue. Favourable growing conditions, such as sufficient water and nutrients (especially nitrogen), promote wound healing (Hudler, 1984; Mercer, 1983).

Growth is most active during spring and summer, as opposed to autumn and the cold winter months. Therefore, healing is generally impaired during the latter part of the season (Leben, 1985; Wensley, 1966).

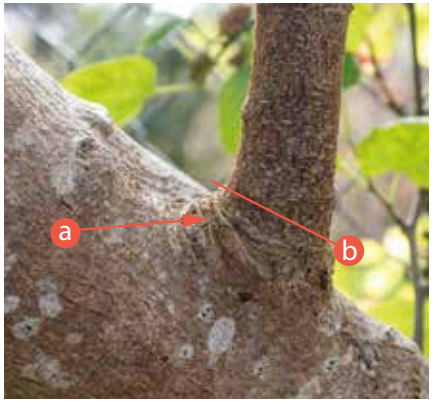
Trees under stress recover slowly, and extremely wet or dry conditions can retard callus formation (Shippy, 1930), as can certain diseases (Biggs, 1984). Different tree species also differ in their healing capacity (Martin & Sydnor, 1987).

The effect of pruning technique on healing

Incorrect pruning and wound treatment retard or prevent healing.

Branches should always be pruned back to a strong lateral (**Figure 3**). Special care should also be taken when cutting branches back to the trunk. In some species, collar-shaped swellings occur on branches where they meet the trunk (**Figure 4**). Cutting just above this collar promotes wound healing whereas cutting flush with the trunk (**Figure 5**) delays healing.

Figure 3: To shorten a scaffold or side branch, it should always be cut back to a strong side branch or shoot. The resulting wound slopes to promote water run-off. The wound edges should be trimmed so that the wound protectant clings better.



ANNA MOUTON

Figure 4: Some species develop a branch collar, seen as a swelling (a) where the branch meets the main stem or trunk. The best cut (b) is just above this swelling.

GRAEME HATLEY

Figure 5: Wounds caused by cutting branches flush to the trunk will heal slower than wounds made by cutting a branch above the branch collar.

According to Robinson (1991), Alex Shigo of New Hampshire, USA, thinks that lateral branches should not be cut flush to the trunk because it undermines the tree's natural defences. This is evidenced by the susceptibility of such wounds to decay organisms despite special wound treatment.

A flush cut creates a false impression of healing because the wood immediately

ANNA MOUTON

Figure 6: A wound on a tree trunk heals almost entirely by horizontal rather than vertical callus development.

Figure 7: Cutting back thick branches of certain species (such as apples, peaches, and plums) to long stubs creates a source of infection for the main stem, as the long stubs are very susceptible to wood-rot fungi.

behind the flush cut often remains firm and appears sound, and strong callus develops primarily along the sides of the wound — callus develops more actively on the sides than at the top and bottom of wounds (**Figure 6**). This is why vertical wounds heal faster than horizontal wounds (Neely, 1970, 1979). But when the callus does not form around the entire wound, rot usually sets in where the callus is incomplete.

The length of the remaining stub will vary with tree age and type, and each cut should be adapted to each situation. Branches without a noticeable collar should be severed 2–3 mm from the main stem — avoid unnecessarily long stubs (**Figure 7**).

Wounds from conventional pruning saws have rough surfaces and ragged edges (**Figure 8**) that hinder effective covering by wound protectants, leaving wounds vulnerable to infection. The conical smooth-cut pruning saw (**Figure 9**) is recommended because it leaves a smooth, clean surface which makes the trimming of the wound edges more effective on some stone-fruit and unnecessary on pome-fruit trees (Anon., 1996).

When sawing, make a slanting rather than a horizontal cut to facilitate run-off of water that could otherwise promote infection. Trim rough wound edges neatly to improve coverage by wound protectants and promote callus formation (Matthee & Thomas, 1977; Mercer, 1983; Thomas, Matthee & Hadlow, 1978).

Figure 8: Wounds from conventional pruning saws have rough surfaces and ragged edges.

Take care that branches do not tear off while being sawn. This causes excessively large, often jagged wounds that do not heal easily. Tearing of large branches can be prevented by cutting upward through about a quarter of the branch before making the main downward cut.

The correct timing of pruning is also an important determinant of infection risk. A tree is more likely to suffer infection if it is pruned in the wet season. In the Western Cape, for

GRAEME HATLEY

Figure 9: The conical smooth-cut pruning saw is usually preferred to the conventional pruning saw as it makes a wound which needs little or no trimming.

GRAEME HATLEY

Figure 10: Example of stub pruning of a branch under wet conditions. The stub will be completely removed during the following dry spring or summer, reducing the risk of wood-rot fungi reaching the trunk if the wound becomes infected.

instance, the infection of peach trees by *Chondrostereum purpureum* (the cause of silver leaf) can be drastically reduced by pruning the trees during the dry summer months (Thomas, Matthee & Hadlow, 1978).

If making large wounds during the wet winter months is unavoidable, thick shoots or branches should be pruned back to a stub of about 10 cm long (the so-called stub method) (**Figure 10**) that can be removed during spring or summer (Anon, 1996; Schwabe, 1996). In the event of infection, the movement of the fungus down the stub will be too slow to reach and infect the trunk before removal.

Unfortunately, the best time for grafting deciduous trees is in the winter, which is also the rainy season in the Western Cape. Grafting should therefore be limited to days with fine weather. Removal of the larger branches of trees that will be top-worked can already be done after harvest during the dry summer months. The resulting wounds must be trimmed and covered by a wound protectant.

Wound protectants and graft sealants

The thin-walled parenchymal cells of callus tissue are vulnerable to desiccation, and hot, dry weather will inhibit callus formation. Certain disease-causing organisms also infect plants more readily

Figure 11: Suitable wound protectants usually promote the healing of large wounds.

Figure 12: Wounds are susceptible to infection by woolly apple aphid (*Eriosoma lanigerum*).

through wounds. Exposed plant tissue can be temporarily protected against desiccation and infection by covering the wounds with a suitable substance (Biggs, 1986; Mercer, 1983).

Wound protectants or wound sealants (**Figure 11**) promote the healing of large wounds by preventing the desiccation of exposed meristematic tissue and promoting the formation of the callus so that a permanent natural covering develops more rapidly. Although wound protectants do not always safeguard pome-fruit trees against wood-rot fungi, when applied immediately after pruning they can prevent the primary infection of stone fruit by certain wood-rot fungi.

Wound protectants have the additional advantage of keeping wounds on apple trees free from woolly apple aphid (*Eriosoma lanigerum*) infestation (**Figure 12**).

Some authors have questioned the ability of wound protectants to prevent primary infection (Kramer & Kozlowski, 1979; Schwabe, 1996). The key to success is immediate treatment of wounds (Anon, 1996).

However, certain infections, for example, soft wood rot in pome fruit caused by *Trametes versicolor* and

Figure 13: The wound protectant flaked from this wound in less than one season, and needs reapplication.

Figure 14: This graft union has healed and the sealant is no longer needed.

Coriolus zonatus, can be stimulated when wound protectants are applied on infected trees (Helton, 1962; Matthee & Thomas, 1977; Schwabe, 1996).

Wound protectants and graft sealants share many requirements. The viscosity of both must facilitate application without run-off. They should seal wounds effectively, dry rapidly after application, and become rainfast within an hour of application. Both materials must be waterproof to prevent desiccation of the meristematic tissue and to exclude excess water (Matthee & Thomas, 1977) that can promote infections.

Graft wax and graft tape are also effective graft sealants.

Neither wound protectants nor graft sealants should be phytotoxic to callus cells (Matthee & Thomas, 1977). Wound protectants should remain effective for at least one season and cling to the wound without flaking off (**Figure 13**). On the other hand, graft sealants need only cover the graft union until the scion takes (**Figure 14**).

Although materials with a polyvinyl-acetate (PVA) base are extremely durable and are included in most wound protectants, PVA-based materials prevent the effective take of grafted scions on apples and pears. For this reason wound protectants containing PVA cannot be used as graft sealants (Lötter, 1982).

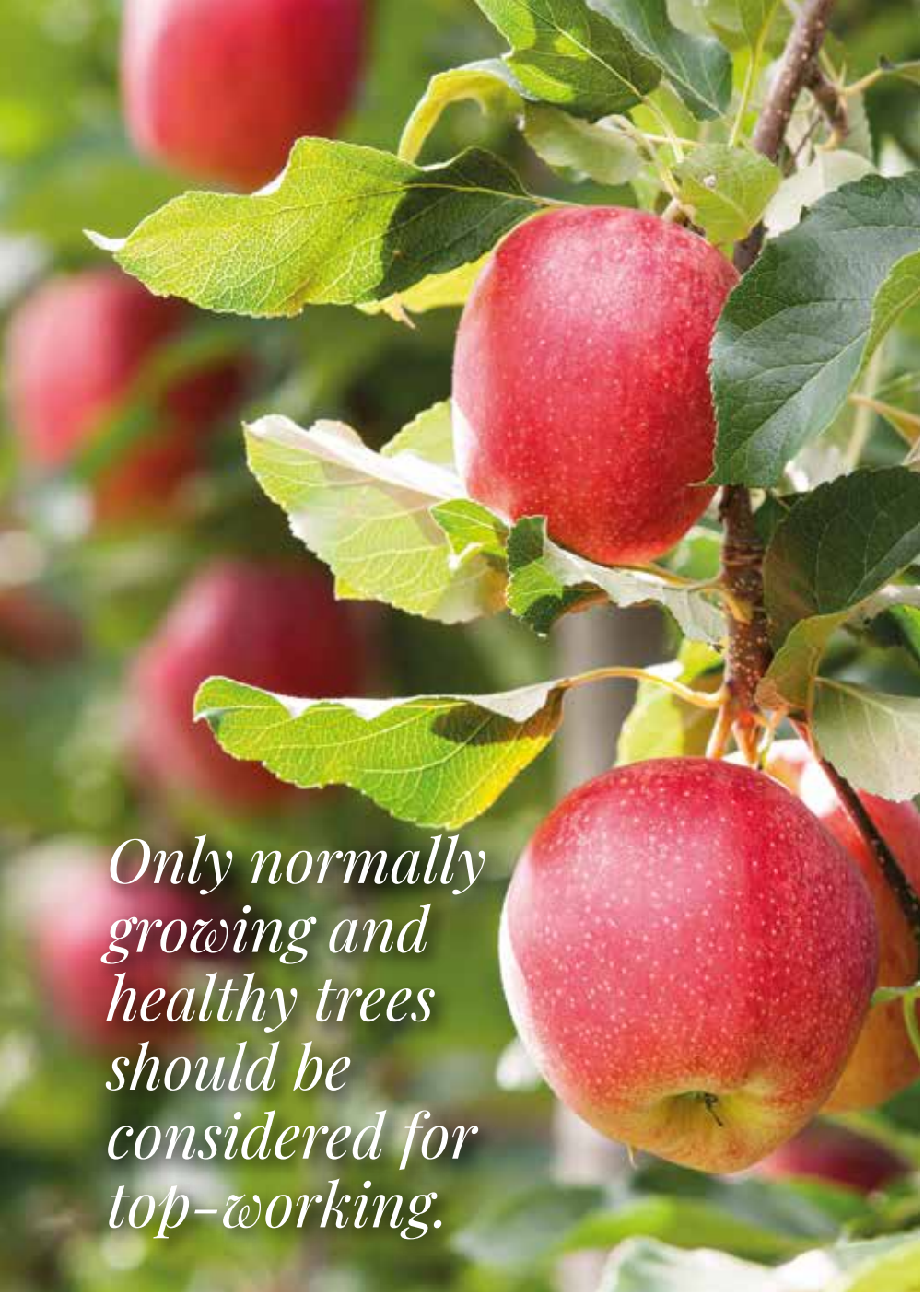
Various bitumen-based graft sealants, either with or without fungicides, have given excellent results in the Western Cape over many years. Trials conducted by the author found that Tree Seal Grafting Grade (a.b.e Construction Chemicals) delivered the best results compared with other graft sealants (Lötter, 1970, 1981, 1982, 1990).

Once dry (within one to two hours on a sunny day), Tree Seal Grafting Grade is water-repellent and rainfast. Therefore, it is also an effective short-term wound protectant, lasting one season under normal conditions.

In some Asian countries, for example, Taiwan, pear growers use different types of adhesive polyester tape to seal graft unions (**Figure 15**). The advantages of the adhesive tape are that weak graft unions can be strengthened and that grafting is faster and cleaner. However, tapes can only be used in grafting positions which can be easily tied.

Growth hormones such as indole-3-acetic acid, abscisic acid, and gibberellins, and elements like zinc and aluminium can sometimes promote callus development. Although the increase in callus formation may be spectacular, there is no evidence that these hormones are essential for wound healing (Brana & Jackson, 1982; Crowdy, 1952; Davis, 1949; Helton, 1962).

Figure 15: Graft unions can be sealed with adhesive polyester tape.



CHAPTER
THREE

Top-working of deciduous fruit trees

Reasons for top-working fruit trees

Top-working refers to changing the cultivar of existing trees by grafting them with scions of a different cultivar. The reasons for fully or partly top-working existing plum, pear and apple orchards include:

1. To supplement insufficient cross-pollination by converting a number of the trees either fully or partly to cross-pollinating cultivars. For example, converting some trees in Packham's Triumph orchards to Winter Nelis or December.

2. To convert existing young and healthy, high-density orchards to a more profitable cultivar, for example, Granny Smith apples to Braeburn or Cripps Pink, especially when significant replant problems are expected. Old, unprofitable orchards should preferably be removed and replaced with a high-density planting of the preferred cultivar.

3. To obtain an early crop and propagation material of a new cultivar of which only a limited amount of budwood is available.

It is important to note that a weak and sickly tree cannot be revived by top-working — only normally growing and healthy trees should be considered for top-working.

Scion requirements and handling

Scion characteristics

As for propagation material in the nursery, the quality of budwood for top-working is important. Only true-to-cultivar, disease-free budwood should be selected.

Although older wood can be used successfully when grafted with care, mature, one-year-old wood is preferred. Discard any shoots with brittle tips and basal shoot ends with underdeveloped buds (Lötter & Steenkamp, 1980). Avoid scions that show any signs of desiccation.

Thicker scions have greater nutrient reserves, which promote take and survival, so scions should be as thick as practical for easy grafting. Scions that are thinner than 0.5 cm should be discarded as they take poorly. Experimental results

have shown that 0.5–1.1 cm is the best thickness (Lötter & Steenkamp, 1980).

The scions should have as many buds as possible, in other words, be as long as possible without increasing the risk of being knocked or blown off. Usually, scion length is limited to 8–10 cm for commercial top-working (Lötter & Steenkamp, 1980). Fruit buds on scions are advantageous, as they can provide a light crop during the same season while retarding vigorous shoot growth.

The buds on the scions must be completely dormant to ensure that the cambium layers will join, and the resultant vascular tissue will be complete by the time the union has to sustain the new scion growth.

Scion storage

Scion wood to be used after bud break should be kept cold so that buds remain dormant. Special care should be taken to prevent the desiccation of budwood, by packing it in moist bags or sawdust, or closing it in plastic bags. The risk of desiccation is further reduced by delaying cutting into grafting sticks until after storage.

Budwood of deciduous fruit trees store best at temperatures of -0.5–2.5 °C in ordinary fruit cold stores. Local studies have shown that dormant budwood of several types of deciduous fruit stored in this manner can remain undamaged for up to 18 months. Budwood can even be frozen but must be thawed gradually before exposure to external conditions.

Budwood should never be stored together with fruit, especially packed

grapes. The packaging material releases sulphur compounds that are toxic to budwood. In Europe and the United States, fruit trees and scion wood kept at temperatures higher than -0.5 °C suffered ethylene injury when stored with apples and pears, or in the presence of free ethylene (Howard & Bramwell, 1970; Janick, 1975).

Number of scions per tree

Tree size and shape, and scion length (longer scions have more buds) determine the number of scions per tree. Old, large, vase-shaped trees require anything from 50–125 scions; mature, central-leader trees rarely need more than 15–20 scions. Younger trees need even fewer.

The number of buds grafted onto a tree determines the success in restoring production, irrespective of the length of the scions. As shoot growth is more vigorous on short than long scions, and the cost of grafting is the same for long and short scions, long scions (having eight buds or more) are preferable. This will reduce vigorous, unproductive growth.

In areas with strong winds in early summer, shorter scions are justified as they are less easily blown off. The number of scions must, however, be increased accordingly. If budwood is in short supply, preferably use fewer short scions rather than more long ones, since the latter requires more severe cutting back of the trees, reducing the size of the framework unnecessarily.

Top-working methodology

The most common method of top-working that will ensure a speedy return to full production is frame-working in which the scaffold of the tree is retained and only bearing wood is replaced by the new cultivar (**Figure 16**). It differs from crown grafting in which almost the entire tree is cut down, and a limited number of scions are added through cleft or side-bark grafting (**Figure 17**).

Although crown grafting is much quicker and requires less budwood than frame-working, it is not recommended for plums, apples and pears as the trees take longer to return to full production. Also, in the Western Cape, the large wounds become infected by wood-rot fungi, causing die-back.

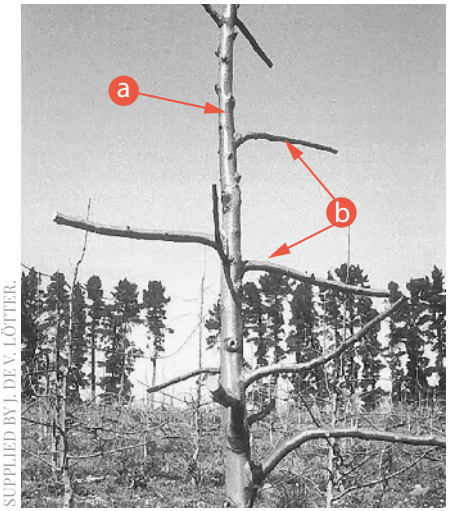


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Figure 16: A young central-leader apple tree that has been prepared for frame-working. a) basic scaffold which is retained b) bearing wood to be substituted.

Frame-working through stub grafting is the most popular top-working method and has not changed much from the technique recommended by pomologists in the 1930s (De Wet & Micklem, 1936). It involves selecting a limited number of scaffold and main lateral branches in closed-vase- or vase-shaped trees, cutting out unnecessary wood, and then grafting well-spaced scions of the new cultivar close to the scaffold or main lateral branches.

Only the lower one or two side branches are maintained on central-leader and closed-vase trees, and each branch is regrafted with a maximum of three to four scions. The rest of the scaffold is regrafted close to the main stem(s) with evenly distributed scions.

In principle, top-working vase-shaped, closed-vase-shaped, central-leader, and hedge-type trees is the same; each retains its original framework and shape.

Figure 17: In crown grafting, the tree is cut down and a limited number of scions added.

Timing

The best time to top-work deciduous trees is when the first signs of cambium activity, such as bud movement and bark slip, are noticed at the end of winter (July or August). This will ensure enough time for the development of sustainable vascular connections between trees and scions to support the new scion growth.

However, trees can be top-worked successfully earlier in winter, provided desiccation of the scions on the trees is prevented, especially in dry winter areas.

Although pome fruit can be top-worked successfully after full bud break (September or October) in cool areas, seasonal warm weather induces too-rapid shoot growth on the scions, causing many to fail following a successful initial take.

Small-scale top-working, as in a home garden, can be delayed as far as full bloom when fully dormant scions are used, and scions are protected as in top-worked citrus. Plants that tend to bleed excessively from pruning wounds at bud break or even earlier, such as kiwis, must be regrafted in early winter, as moisture due to bleeding may cause graft-union failure.

The grafting process

Preparing the tree for grafting provides the opportunity to reduce too-tall trees and to reshape trees for maximum light interception. Remove higher lateral branches, and superfluous scaffold branches in closed-vase- and vase-shaped trees. Select smaller laterals and shoots in the positions where the scions

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Figure 18: The first step in grafting is to make a fairly long, slanting, straight cut in the base of the lateral shoot, as close as possible to the scaffold.

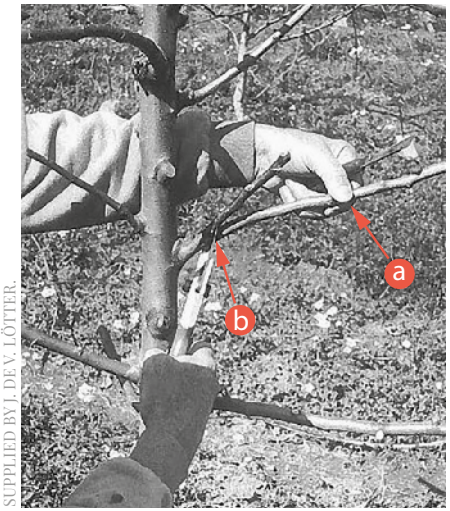

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Figure 19: Grafting is a gentle, two-handed operation: control the shoot or twig in which the slit is made (a) with one hand. With the other hand, place the scion into the slit, and cut off the rest of the shoot immediately above the scion (b).

are to be grafted and cut away the rest of the wood — but leave more than needed. Shortening the shoots left for grafting can improve grafter access.

Make a fairly long, slanting, straight, slit in the base of a lateral branch or shoot (**Figure 18**) as close to the framework as possible. Select a scion that is about as thick as the lateral to be grafted, and cut its base into a wedge that matches the slit on the tree (**Figure 19**). Placing the scion as close as possible to the scaffold or lateral branch limits the amount of old wood to be suckered.

Bend the lateral down carefully to open the slit, insert the scion so that there is contact between the cambium (growth tissue under the bark) of the scion and the lateral, and release the lateral to clamp the scion into place. Cut the lateral off as near above the graft union as possible. Immediately cover all wounds with an appropriate graft sealant (**Figure 20**).

Figure 20: Cover all the graft unions with a suitable graft sealant immediately.

Figure 21: Even tiny cracks in the graft-union seal may cause the scion to fail. They must be re-covered immediately after grafting.

If there are no lateral branches or shoots suitable for grafting on the scaffold or main lateral branches, side grafting can be done directly onto the scaffold or main lateral branch. A slanting slit is made into the wood of the branch and a scion, cut in an asymmetrical wedge shape, is inserted firmly, and sealed.

The success of top-working hinges on immediately and effectively covering any exposed tissue at graft unions and wounds with graft sealant. Even a tiny crack in the graft-union seal may cause failure or infection (**Figure 21**). Therefore, all graft seals should be inspected for cracks an hour after application and resealed if necessary.

Rain within hours of grafting may wash off some graft sealant — inspect the top-worked trees and re-cover if necessary. However, cracks in the graft seals later in the season result normally from active callus growth at the graft union, signalling that the scion has taken successfully. It is unnecessary to re-apply graft sealant at this stage.

Bitumen coverings of graft unions should not be too thick or repeated unnecessarily as this leads to an excessively thick black layer that may develop lethally high temperatures in the sun on warm spring days, resulting in graft failure. Re-covering entire graft unions is therefore not recommended; only re-cover cracks.

Organisation

The type and sharpness of the grafting knife largely determine the efficiency of grafting. Top-working cannot be done with a blunt knife, so a whetstone must be kept handy. Any thin-bladed knife with a comfortable handle may be used (**Figure 22**). Some grafters prefer a sharp, curved vineyard knife.

Figure 22: Example of a suitable knife for grafting trees. Its most important characteristic is a sharp edge.

To reduce the risk of accidentally knocking off newly grafted scions, top-work the tree from the top to the bottom. When using an orchard ladder, cover the graft wounds at the top of the tree before moving the ladder.

Experience has shown that large-scale top-working requires division of labour. The first team prunes the trees to shape, the second team grafts, and the third team seals the grafting and pruning wounds.

Regular and competent inspection of all aspects of both regrafting and wound sealing is essential, especially when contract grafters are employed. The trees should be pruned to shape under the personal supervision of management who decide on the length and number of the scions per tree. To encourage grafting quality, remuneration can be contractually linked to the final success.

Aftercare

Top-working of especially older vase-shaped trees often exposes previously shaded branches to direct sunlight, which can result in sunburn. Vulnerable parts of the tree should be protected by whitewashing immediately after grafting (**Figure 23**). Any white, water-based, latex

Figure 23: Trees can be whitewashed to protect newly exposed tissues against sunburn.

or acrylic paint (dilute 1:1 with water) is suitable. Whitewashing top-worked central-leader trees is seldom necessary.

Any growth from the scaffold and main lateral branches should be removed as early as possible, even if the scions show very little growth. The development of scions is delayed by uncontrolled shoot growth and spurs left to provide a transitional crop or to protect against sunburn. As a result, the top-grafted trees are slow to reach full production. It is better to use alternative methods to control sunburn (Lötter & Steenkamp, 1980).

As with severe pruning, top-working induces vigorous shoot growth from the scions, which delays fruiting. Vigour can be somewhat controlled by using long instead of short scions, and by grafting as many buds on the tree as possible. Retain as many scaffold branches of vase-shaped trees and as much of the trunk of central-leader trees as possible. But even these precautions will not entirely prevent vigorous growth.

Good results can be obtained by bending vigorous lateral shoots horizontally, or by cutting them back to four or fewer buds in summer. Minimal pruning during the first winter after top-working will promote fruiting and reduce vegetative growth. Remove scions in the wrong positions during the summer.

Cut back the terminal shoots of scions of Granny Smith, Top Red, and Royal Gala after bud growth has started. This will promote the development of secondary (sylleptic) shoots.

Wound application of supra-optimal quantities of auxin in the form of 1% 1-naphthalene acetamide ester, incorporated into a bitumen wound protectant or an aerosol, can minimise troublesome water shoots on apples, pears, pecans, and even citrus and avocados. Effectiveness is increased by the addition of 2.5% ethyl hydrogen 1-propylphosphonate (Boswell et al., 1973, 1979).

Common mistakes

The most common mistake made by Western Cape producers when top-working vase-shaped trees is cutting back too severely while leaving too many scaffold branches onto which too few scions are grafted. With central-leader and palmette-shaped trees, the tendency is to cut back the central leader too severely in proportion to the main side branches.

In both cases, the scions produce unwanted vigorous, upright pole-like growth that requires manipulation to reduce vegetative growth and promote fruiting. Sometimes incorrect manipulation aggravates the problem.

When there is enough budwood, always aim to graft the maximum number of buds on the tree.

Another common mistake is placing scions in the wrong positions on the scaffold. These scions must then be removed during the following winter to maintain the correct tree shape. The grower is often reluctant to do this, necessitating severe pruning, with all its disadvantages, to correct the problem later.

A third mistake is using too-thin or too-short scions, resulting in poor take and unnecessarily vigorous growth.

Supervision of grafting, especially of sealing the graft unions, is often neglected, with catastrophic results. A common mistake is the use of a wound protectant instead of a graft sealant.

Weak trees, which are often infected by wood-rot fungi, are sometimes top-worked. This is a recipe for disaster. Such orchards should rather be pulled out and replanted, taking note of the replant problem.

Top-working inevitably causes many large wounds. Many growers have done away with wound protectants from all fruit trees because their application does not guarantee, for example, the protection of pome-fruit trees from wood rot. This is short-sighted, ignoring the benefits of wound protectants for callus growth and permanent wound healing of well-prepared wounds on healthy strong-growing trees.

The immediate application of wound protectants is essential when top-working trees.

CHAPTER
FOUR

Guidelines for other fruit types

Avocados

Limit the top-working of avocado trees to young, strong-growing seedlings or uneconomical cultivars. Cut the tree down close to the ground in early spring, trim the wound, and cover it with a wound protectant that contains a suitable disinfectant.

Water shoots will develop from the trunk or rootstock within four to five months. Select a few shoots evenly distributed around the trunk and remove the rest. Whitewash the trunk and lower parts of the shoots with a water-based, latex or acrylic paint (dilute 1:1 with water). Re-apply as necessary.

Grafting must take place in the cool time of the year, just before the active growth period (July and August). Select three to four shoots and cut these back to 15–60 cm, depending on the thickness. Cut the scions from one-year-old hardened shoots. Select scions 3–5 buds long, match the diameter of each to that of the stock to be regrafted, and remove the leaves.

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Figure 24: Make corresponding cuts on the scion and stock, and match the cambium layers carefully.

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Figure 25: Tie the scion and the stock together with grafting tape.

Make corresponding 45° cuts on both the scion and stock (**Figure 24**), match the cambium layers carefully, and tie the two together firmly with grafting tape (**Figure 25**). Avocado trees are finicky: special attention should be given to cambium

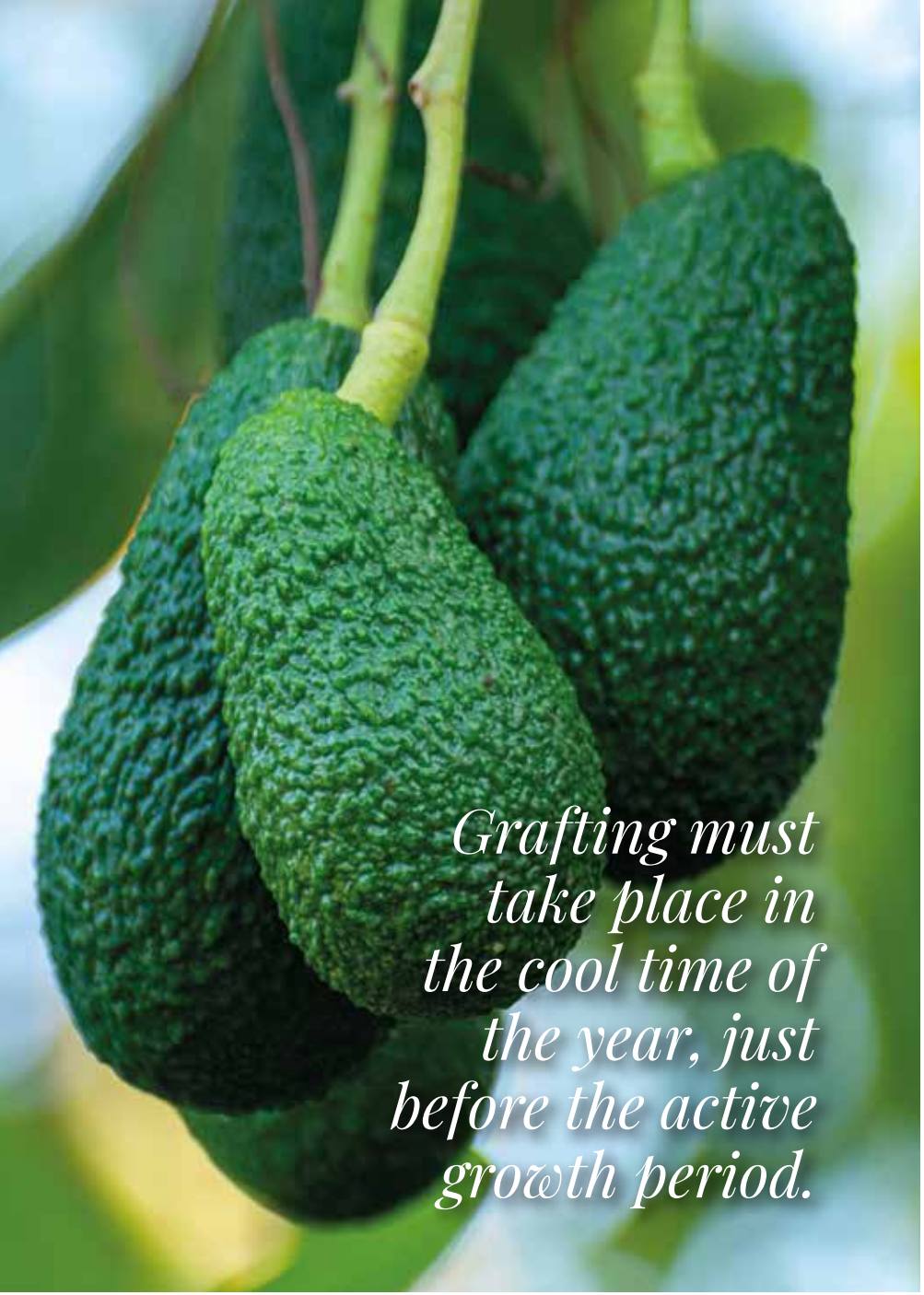

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Figure 26: Wrap the scion and graft wound with Parafilm to prevent desiccation.

contact, and desiccation must be avoided at all times. Wrap the scion and graft wound with Parafilm (**Figure 26**) — Parafilm will not inhibit bud growth.

Be careful not to disturb the scions for at least six weeks. New growth from the scions should be staked or tied for support. Water shoots developing from the stock should be removed regularly and the bare crown of the tree kept whitewashed.

An alternative method of top-working is to apply bark grafting as for olives and citrus. Cut back the trees to about 60 cm, preferably below the crown. Unlike citrus, scaffold branches of avocado trees should preferably not be regrafted.

Scions can be wrapped in Parafilm (**Figure 27**) before grafting or covered with a plastic bag after grafting to prevent moisture loss. Place a paper bag over the Parafilm or plastic bag to prevent overheating. Cover all the wounds thoroughly with graft sealant.

Maintain orchard practices like irrigation and weed and insect control. However, to prevent phytotoxicity, delay the treatment of top-worked trees with fosetyl-Al against root rot (*Phytophthora cinnamomi*) until shoots have hardened.

Figure 27: Parafilm protects the graft unions on these avocado seedlings from desiccation.

Citrus

Citrus trees can be top-worked successfully using bark grafting (**Figure 28**). Select three to four well-placed scaffold branches and remove the rest. Trees up to three years old can be headed below the crown. Prune back the scaffold branches to the correct height early in spring as soon as the bark starts slipping. Trim the wounds.

The bark will soon stop slipping, so trees must be grafted on the day of cutting back. If this is not possible, wait a month and attempt grafting after cutting the tree back further. Wounds that are not regrafted must be covered with a suitable wound protectant, and can also be treated to inhibit water-shoot formation.

Figure 28: Bark grafting in citrus. The plastic wrap keeps the grafts in position while also protecting the graft unions. The wound should also be sealed to prevent infection and desiccation.

To save time when grafting, the superfluous main scaffold branches can be removed earlier in the season, but pruning back the remaining scaffold branches must be delayed until grafting time. These wounds must also be sealed as soon as possible.

Cut scions from firm, green, round shoots of the current season's growth. Scions must be 6–12 mm thick and 4–6 buds long. Remove the leaves, cut the scion to the required shape, and insert it into the vertical slit in the bark.

Graft more than one scion to a branch to ensure success. Secure the scions with string or tape, and cover all wounds with graft sealant.

Place a plastic bag over the scions after grafting to prevent moisture loss. Cover the plastic bag with a paper bag and tie

it to the trunk (clothes pegs are handy) to prevent overheating. After one month the bags can be gradually removed to allow acclimatisation of the new growth. Protect the scion from wind damage and the trunk against sunburn.

An alternative method to prevent moisture loss is to wrap the budwood in Parafilm before trimming. The Parafilm replaces the plastic bag, but the scion must still be covered by a paper bag for at least a month (Anderson, Duffy & Mooney, 1991).

Parafilm need not be removed from the developing scion as it disintegrates without impeding shoot growth. After completing regrafting, whitewash the framework of the tree with water-based, latex or acrylic paint (dilute 1:1 with water) to prevent sunburn.

Scions should be thinned to one per branch as soon as they are growing satisfactorily. Mark scions with a spot of bright paint to distinguish them from adventitious growth, which should be removed as soon as possible.

In windy areas, the trees should be protected, or the new shoots supported. If any of the scions fail, water shoots developing from the branch can be nursed to be budded later in the season as a replacement.

If budwood is in short supply, citrus trees can be pruned back in a similar way as described above, allowing water shoots to develop at strategic positions, and these can be budded later in the same season.

Grapevines

Only trellised grapevines can be regrafted successfully. The best results are obtained by cutting the trunk back in winter and chip budding (yema budding, **Figure 29**) the resultant green shoots with dormant

Figure 29: Chip budding a grapevine.

(winter) buds during early summer (Jacobs & Goussard, 1992).

Cut back the trunk to about 35 cm below the cordon during June or July. Trim and seal the wound. Choose the strongest new shoot and support it with a string tied to the cordon wire. Sucker all the other shoots except for a spare that is cut back to two buds. This shoot is removed later if not required.

As soon as the shoot which has to be regrafted is 25–30 cm above the cordon wire, fasten it to the cordon wire and remove all the leaves and buds from its base to the wire. Depending on the region and cultivar, the shoot will be ready for regrafting between mid-October and early November. Use budwood with dormant buds that was cut in winter and stored at 2–4 °C. Chip bud the green shoot at a comfortable height.

Ensure that the budwood and green shoot are equally thick to ensure cambium contact. If necessary, more than one bud per shoot can be grafted. Tie the bud tightly to the shoot with grafting tape to keep it in position and cover the whole bud with Parafilm or graft sealant to prevent desiccation (**Figure 30**).

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Figure 30: Normal bud break can be expected three weeks after budding when a dormant bud grafted between mid-October and mid-November is treated correctly.

Cut back the grafted shoots to just above the cordon wire after about two weeks, but maintain a leaf and bud at the end of the shoot. Only remove these leaves and buds about three weeks after grafting when the grafted buds are growing actively. Head back the new shoots as soon as they reach the cordon wire, and protect the lateral shoots from wind damage. Shape the cordon as usual. The framework of a grapevine can be replaced within one season and reach full production the following season.

Although grapevine propagation material has been greatly improved, some clones of rootstocks and scions are still virus infected. The health status and compatibility of vines and grafting material must be determined before regrafting. However, there are only a few incompatible graft combinations. Infected vines cannot be regrafted successfully and should be replaced. Grafted vineyards should receive normal irrigation and vineyard practices to ensure success.

Guavas

Established guava trees can be top-worked using bark or cleft grafting after the tree has been cut back to a limited number of scaffold branches close to the crown, in August or September. Use only mature (round) shoots from the previous season with buds that do not show any signs of growth. Special care must be taken to prevent desiccation, as for avocados.

Greater success can be expected by chip budding vigorous shoots developing

Figure 31: A kiwi-fruit vine that has been side-grafted.

from the framework that has been pruned back severely. These two top-working methods can also be combined.

Top-working mature guava trees has limited success and is not recommended for commercial orchards.

Kiwi fruit

Kiwi-fruit vines are easily regrafted by cutting the stem back to about 30 cm above the ground, and bark or cleft grafting (**Figure 31**) with one or more dormant scions, each with two to three buds. Trim the bark around the wound and seal it. Graft in mid-winter as kiwi-fruit vines tend to weep (bleed) close to and during bud movement, hampering scion take.

The regrafted stem is prone to sunburn and the young shoots developing from the scions are easily blown off by

the wind. The regrafted stump must be protected by placing three evenly spaced stakes around it and attaching material onto these, leaving a 15-cm gap at the base to allow air movement. Shade netting or even discarded fertiliser bags will serve. Reduce the scions to one per stump once they are growing well.

Allow only one shoot per vine to grow. The new shoot grows vigorously and must be supported with string or stakes. The shoot must be untwined periodically and tied in to prevent twisted stems. Regrafted vines should be in full production within two seasons.

Olives

Bark grafting of a limited number of scaffold branches which have been cut back to the crown gives good results. The best time is in spring when the trees start growing.

Cut scions from shoots of the previous season. These should be round and at least 5 mm thick. Ensure that the buds on the scion show no signs of growth. Do not cut the scion wood later than July, depending on the cultivar. Defoliated scions can be kept successfully in cold storage at about 2 °C for short periods, but store in plastic bags to prevent desiccation.

In arid regions or during a dry period, scions can be enclosed in Parafilm before trimming to prevent desiccation.

Select one to three branches (depending on the size of the tree) and cut back to the crown. Make a vertical incision in the bark and loosen it (**Figure 32**).

Trim the scion obliquely on one side only (**Figure 33**) and insert in the slit in the bark (**Figure 34**). Graft more than one scion to a branch to ensure success. Secure the scion with tape or string (**Figure 35**) and cover both the wound and the graft union with graft sealant (**Figure 36**).

Young shoots developing from the scions must be supported as they blow off easily. Thin the number of scions to one in the correct position as soon as they show satisfactory growth. Nurse branches are unnecessary in the Western Cape. Remove any new growth developing from the original cultivar as soon as possible.

Figure 32: Make a vertical incision in the bark.

Figure 33: Trim the scion obliquely on one side only.

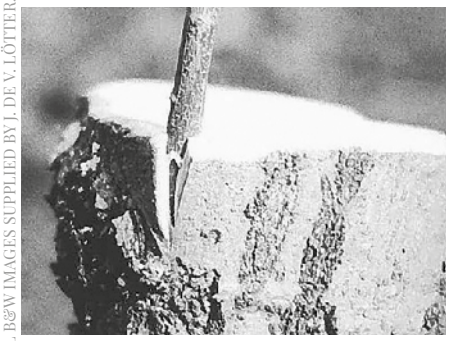

Figure 34: Insert the scion in the slit in the bark.

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Figure 35: Tie the scions to the stem by means of string or tape.

Figure 36: Cover both the wound and the graft-unions with a suitable graft sealant.

Pecans

Cut back the trees to be top-worked as soon as bud movement is noticeable in August or September, maintaining a limited number of scaffold branches about 0.5 m from the crown.

Cut completely dormant budwood, about 2 cm thick, to a length of six buds and bark graft onto the scaffold branches, two to three per branch, depending on the size of the branch. Secure the scion with tape or string and cover all wounds with graft sealant.

To prevent sunburn, whitewash the framework of the tree with water-based, latex or acrylic paint (dilute 1:1 with water). By early summer the superfluous scions should be cut away, leaving one per branch.

Vigorous shoots are easily blown off and should be staked or tied. If the wound has not healed properly by the end of the season, it must be re-covered with graft sealant. If all the grafts on a branch fail, any water shoot that may have developed in the correct place can be reworked using ring budding (Le Roux, 1961).

Persimmons

Established persimmon trees can be top-worked using stub grafting, like pome fruit, provided that the scions are well protected with Parafilm, that they are grafted late in spring when the trees

are already quite leafy, and that extra precautions have been taken to prevent the graft unions from drying out.

The immediate application of graft sealant on graft unions and wounds is essential, as top-working occurs when it is already warm. However, persimmons have the advantage of resistance to wood-rot fungi and wound treatment is only applied to prevent desiccation.

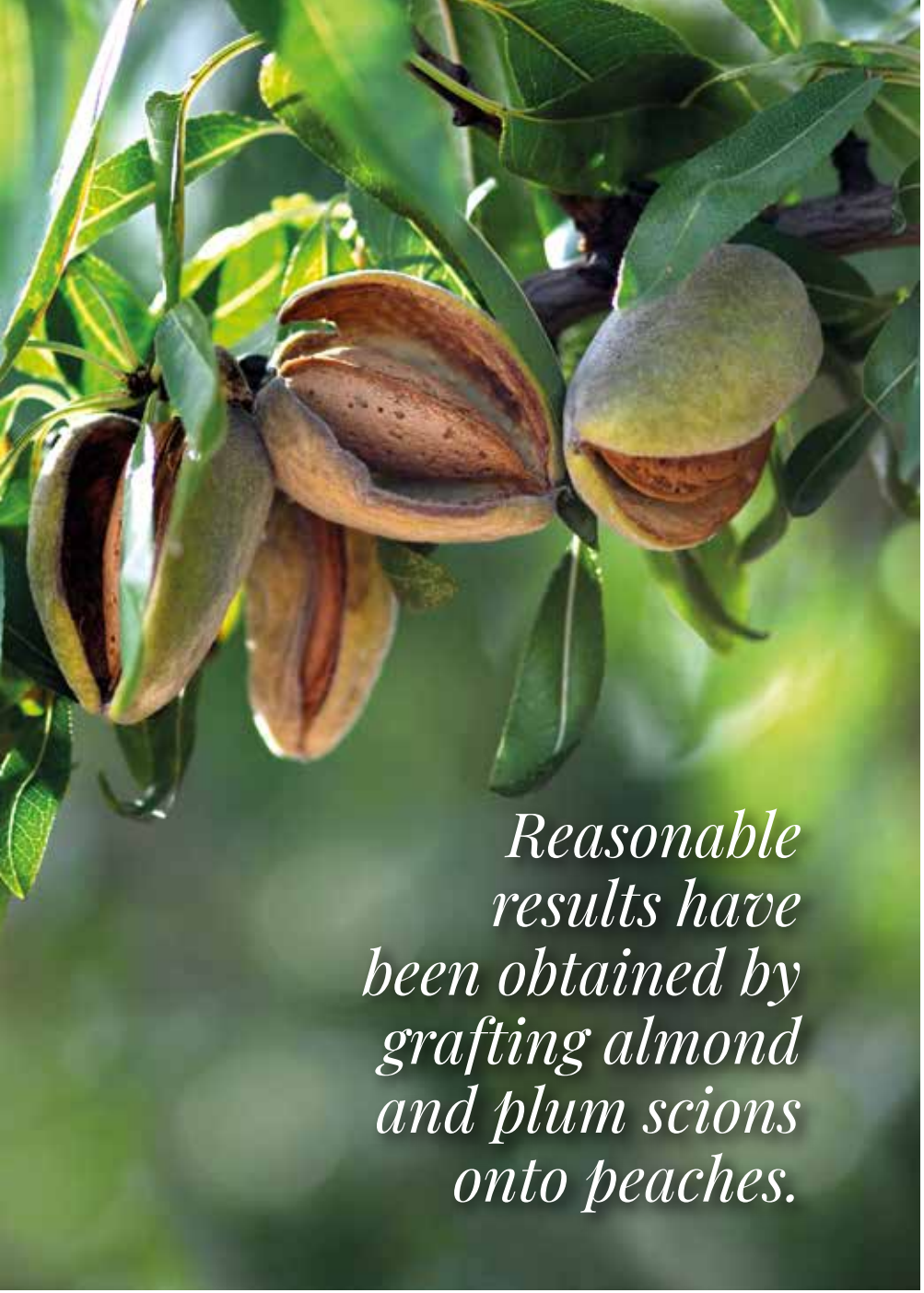
Scions must be at least 8 mm thick and have three to four buds each, which are kept fully dormant and protected from drying out until grafting. The usual aftercare for stub-grafted trees is necessary.

Established persimmon trees can also be top-worked using bark, side-bark, and cleft grafting, but these methods are not recommended commercially. Reasonable success can be obtained by chip and T-budding shoots developing from a pruned framework, similar to stone fruit. Chip budding is also handy to follow up stub-graft failures on top-worked persimmon trees.

Stone fruit

Although healthy almond and cherry trees can be top-worked fairly successfully using stub grafting, this method is less suited to apricots and peaches due to the poor take of the scions. Reasonable results have been obtained by grafting almond and plum scions onto peaches.

Stone fruit can also be top-worked by budding. In winter, prune the tree back severely to an optimum scaffold, depending on the shape and size of the tree. Remove all the shoots and branches from the scaffold. Identify the shoots destined to be budded later in



summer (January to March) and sucker all superfluous growth in November.

Graft the buds on the shoots close to the scaffold branches. Use T-budding while the bark slips in spring, and chip budding thereafter. Nearly 100% success can be obtained if the graft is covered with Parafilm as well as grafting tape. Any bud failures can be re-budded the same season.

The biggest drawback of these top-working methods is the many relatively large wounds (especially on older trees) caused by severe pruning, inevitably in the wet season in the Western Cape. Under these conditions, stone-fruit trees are prone to infection by diseases like bacterial canker (*Pseudomonas* spp.), and wood rots like silver leaf (*Chondrostereum purpureum*) and Eutypa die-back (*Eutypa lata*). These diseases reduce the economic life of the trees.

Much progress has been made to prevent the infection of trees with these diseases. Use only smooth-cutting pruning saws to ensure a smooth surface and apply a wound protectant immediately. Both promote callus formation and reduce infection. Consider removing large branches soon after harvest during dry conditions in late summer.

In addition, when pruning the trees in wet conditions in winter, stub-cut branches and shoots with a diameter larger than 20 mm (**Figure 10**) and remove the stubs during the dry summer. Do not neglect the usual wound treatment in either instance.

In summer-rainfall areas, peaches and apricots can be top-worked by budding in winter without serious risk of infection. However, in the Western Cape, the same method should only be considered for healthy peach and apricot orchards up to five years old. On such trees, most wounds will be small enough to heal easily. Older peach and apricot orchards, and orchards with even mild wood rot, should rather be grubbed and replanted, taking into consideration any replant problems.

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