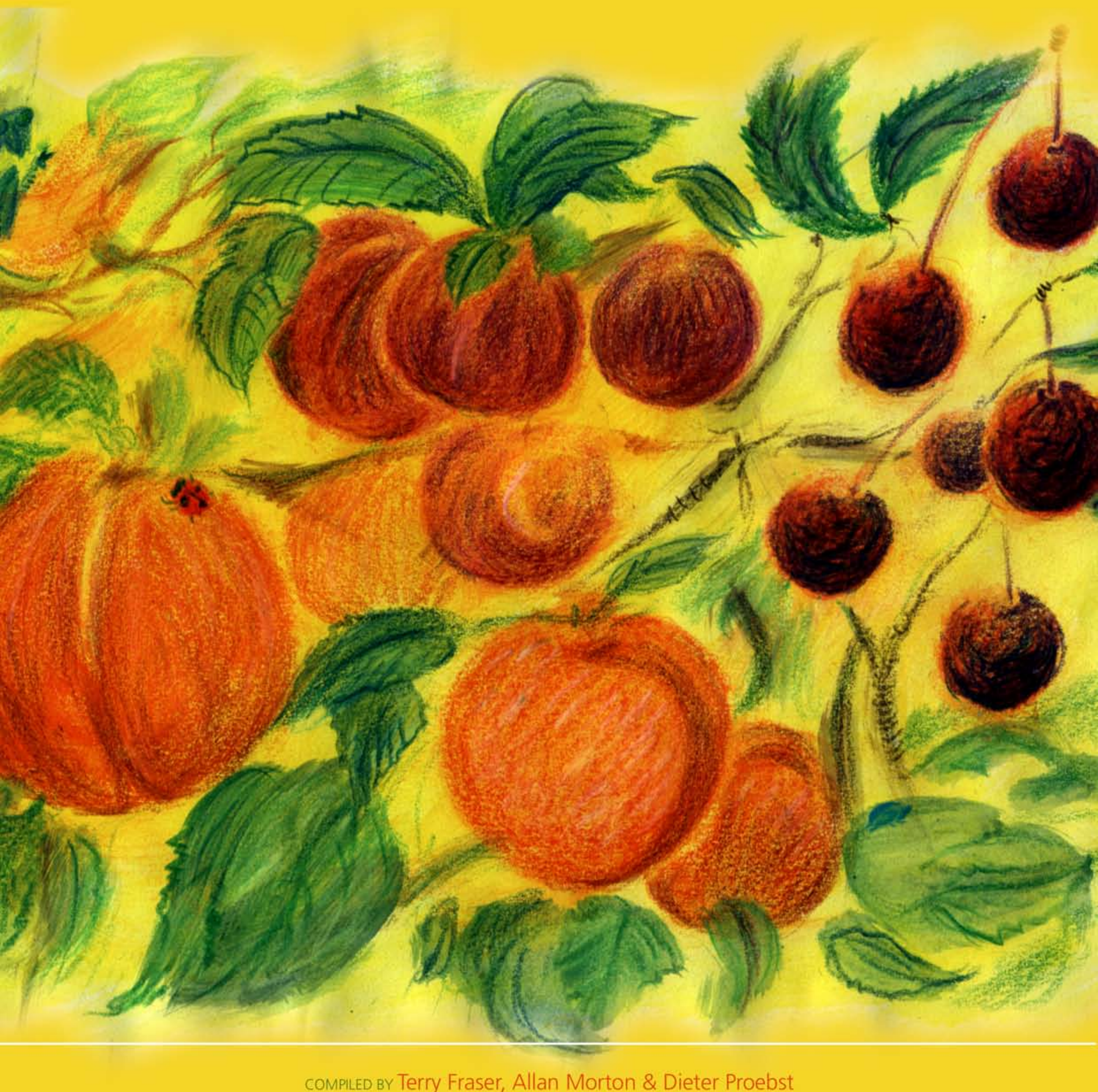
RESOURCE GUIDE

Organic Summerfruit



COMPILED BY Terry Fraser, Allan Morton & Dieter Proebst
PROJECT MANAGER Gavin Kenny ILLUSTRATED BY Fred Robertson

SOIL & HEALTH ASSOCIATION • EARTHWISE CONSULTING LTD • BIO DYNAMIC ASSOCIATION

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Illustrated by Fred Robertson, Artmoves Ltd

Project Manager: Gavin Kenny, Earthwise Consulting Ltd

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Organic Summerfruit Resource Guide

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Soil&Health Association of New Zealand Inc.

Earthwise Consulting

The Bio Dynamic Farming and Gardening Assoc. in N.Z. Inc.
Founded on the work of Rudolf Steiner

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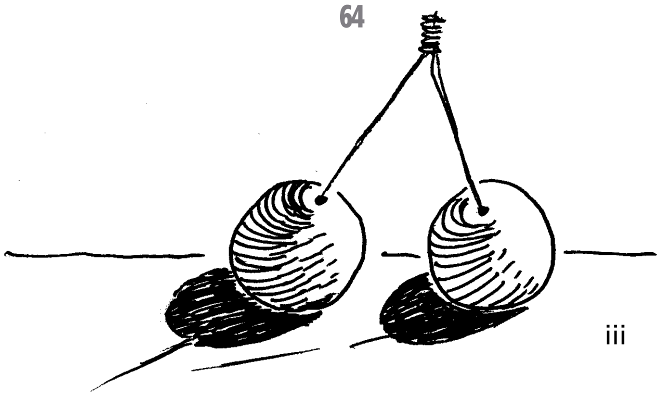


Preface

In the first half of 2001 a successful application to the Sustainable Farming Fund was made on behalf of the Bio Dynamic and Soil and Health Associations. The project aim was to draw on the knowledge and experience of established organic and biodynamic producers and make it more widely available. The first step was to identify key sectors where we felt the project would make a difference and involve experienced organic people associated with those sectors who were keen to contribute. As a result we focused the project on: dairy/pastoral farming; and avocado, citrus and summerfruit production. Successful organic producers are pioneers, as they acknowledge that there are always more questions than answers and thus are continually taking on new challenges. That capacity to take on new challenges has been very evident in this project. Individuals have taken on multiple challenges; they have acted as workshop facilitators, field day organisers and presenters and have written and collated material for a series of Resource Guides. Many others have contributed through their participation at workshops and field-days, by acting as reviewers and giving their time to make written contributions. This Resource Guide is a result of that work.

It is important to be clear as to what this Resource Guide isn't and what it is. It isn't a detailed technical 'how to' document, as there is no simple prescribed pathway towards successful organic production and there are still many more questions than answers. It is a number of things. First and foremost it is a multi-authored collation of existing knowledge, presented from a practical perspective. Second, there has been a deliberate weaving together of organic and biodynamic information. The purpose of weaving together a range of views is to provide you with choice – take what is relevant to you at any given time and ignore what you don't consider to be relevant. Third, it is intended to be a 'living resource". We've drawn together what is known to help you avoid making the mistakes that others have and achieve success more quickly and also to allow for clearer identification of gaps in knowledge so that these can be addressed. In summary, this document won't make you a good organic producer, it is not a technical 'how to' manual, it is intended to be a practical, living Resource Guide. It is meant to guide, not to prescribe.

Gavin Kenny, Earthwise Consulting Ltd
*Project Manager*August 2003

Avocado, Citrus, Pastoral and Summerfruit Resource Guides are available from the Project Manager (telephone 06 870 8466 or email gavinkenny@clear.net.nz) or in Adobe Acrobat (.pdf) format from www.organicnz.org and www.biodynamic.org.nz.

Introduction

Myself will search our planted grounds at home

For downy peaches and the glossy plum .

Vergil

The fruits of summer – juicy, soft, sweet and flavoursome fruits such as plums, peaches and apricots – are enjoyed by most people. They grow quickly from the showy blossom of spring to the first harvest in early summer, and harvest is mostly over before autumn. It is widely accepted that eating plenty of fruit is conducive to good health and longevity. The first aim of growing summerfruit organically is to capture as much of this natural goodness as possible. The orchard is part of a wider landscape and environment. We depend on the healthy functioning of our environment and this in turn depends on the health of its component parts, i.e., the orchards, farms, forests, rivers, mountains and air. The second aim of organic summerfruit growing is to make the orchard a healthy contributing component of the wider landscape. To meet these aims the orchard must also be economically sustainable.

Organic is both a well-defined approach to agriculture [1,2] and a marketing term indicating that the item has been produced organically. Organic farming systems refrain from the use of synthetic and concentrated chemical fertilisers, synthetic pesticides and herbicides and synthetic chemical food additives. They seek to minimise external inputs to the farm by conserving and recycling nutrients and to preserve and enhance the functioning of the orchard ecosystem so that it is self-regulating. This means that pests and diseases are kept in check by the natural processes of nature and the need for direct intervention by the grower is minimised. This approach means that the impact of farming operations on the environment is reduced and the long-term productivity of the land is preserved for future generations.

Organic agriculture is part of and often leads, a general trend towards greater sustainability in agriculture. The theme of constant improvement is a noted feature of this drive towards increased sustainability. This has been described by Stuart Hill [3] as consisting of a three stage succession. First comes the stage of 'efficiency' when there is a reduction of inputs by better timing and placement. This is followed by the stage of 'substitution' when more benign inputs are substituted for broad-spectrum insecticides and other 'hard' inputs. Finally comes the stage of 'redesign' when causes rather than symptoms are treated. In this stage the farm is redesigned to foster natural ecological balances, thereby avoiding many problems altogether. Redesign represents the frontier of the move towards sustainable land use and the production of quality food. It is the present-day challenge offered to organic growers and if successfully met will ensure that organic agriculture retains its leadership position at the frontier of modern agriculture.

Summerfruit, also called stonefruit, is a group of thin-skinned fruits with a hard pit or stone containing a single seed (almonds and olives are also stonefruit but are not usually included as summerfruit). They are grown in a wide range of mainly temperate climate zones throughout the world. Types of summerfruit include European plums (prunes, damsons, gages and bullaces), Japanese plums, sweet and sour cherries, peaches, apricots and nectarines. There are also hybrids, such as crosses between plums and apricots called pluots, plumcotsor apriums. Tolerance to humid conditions and the requirement for winter chilling varies between the different summerfruits and between cultivars within each type. In New Zealand commercial production is concentrated in Hawke's Bay, Blenheim, Waikato and Central Otago and these areas are likely to remain best suited for organic summerfruit production. Summerfruit orchards producing mainly for local markets are, however, found in most other districts.

Good quality organically grown summerfruit is a valuable and sought-after item in many markets. Although the shelf life is short and the fruit is easily damaged during transit, with good management, the selection of markets to match the fruit's post-harvest properties and with the cooperation of the weather, summerfruit production should be a worthwhile activity for the careful grower. The susceptibility of many summerfruit varieties to disease means that only disease-resistant cultivars and suitable orchard sites should be used for organic production. Growers need to recognise that options for management tend to be long-term rather than "quick fix". Growing organic summerfruit is likely to become easier as superior techniques and cultivars are developed.

This Resource Guide has been compiled from the combined inputs of experienced organic growers, consultants and horticulturalists. It is designed to guide growers new to organics and to horticulture by promoting an understanding of the basic principles of organic growing. Many additional sources of information are included throughout the Guide. It is intended that the Resource Guide will be a living document that will be added to and improved as knowledge and experience of organic summerfruit growing is extended.

The pathway to success

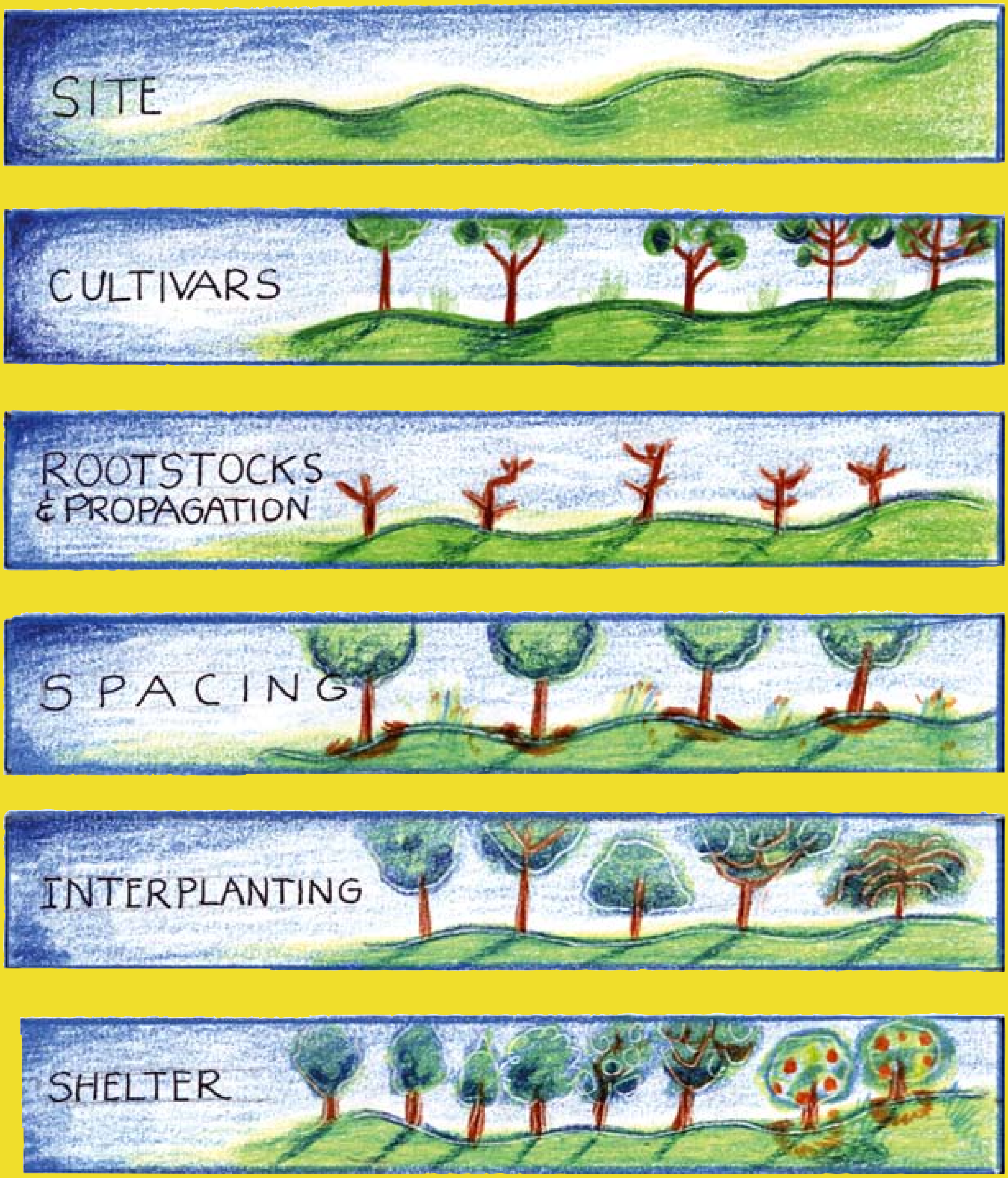
There are two important ingredients to being a successful organic grower:

1) **Access to information – this Resource Guide provides you with a start**
2) **Support from others. You can achieve this by:**
   - **Joining an organic discussion and support group can be a big help. This enables you to have support, especially through the transition period. Once you have some experience, this will in turn help support others in the group;**
   - **If there is no discussion group in your area, try and get one going, even if it is only two or three people; and,**
   - **If this is not possible, find yourself a mentor who you can phone and visit when you need to.**

As part of this project there is an associated email discussion group for sharing information and experiences. To join the group send an email to Peter Urich (pbu@waikato.ac.nz) expressing interest in the group and you will be subscribed.

1. Le Guillou, G. & Scharpe, A. (2000). *Organic farming: guide to community rules.* Luxembourg: European Communities. Retrieved 9 April, 2003 from World Wide Web: home.prolink.de/~hps/organic/abio_en.pdf
2. Gold, M.V. (1999). *Sustainable agriculture: definitions and terms.* Special Reference Briefs Series no. SRB 99 – 02 . USDA. Retrieved 9 April 2003 from the World Wide Web: www.nalusda.gov/afsic/AFSIC_pubs/srb9902.htm#term1
3. MacRae, R.J., Hill, S.B., Mehuys, G.R. & Henning, J. (1990). Farm-scale agronomic and economic conversion from conventional to sustainable agriculture. *Advances in Agronomy, 43: 155-198.*

Orchard Design



Perhaps the most challenging aspect of organic growing is that of design. This is because new models are needed that effect a better and more harmonious integration of the farm or orchard within the landscape. Such improved integration should reduce the damage caused by pests and diseases and other problems that, otherwise, demand disruptive and harmful interventions. The ideal orchard is one that can produce high quality fruit without compromising its environment. It should be part of and contribute to, a healthy, functioning, self-sustaining ecosystem and peopled landscape.

Site selection

Tolerance to humid conditions and the requirement for winter chilling varies between the different summerfruits and between cultivars within each type. Peaches, nectarines and apricots need a period of winter chilling (the length varies between varieties) and then a prolonged, hot, dry summer. Rain during blossom and over the fruit ripening period will bring on many of the problem diseases. The most suitable areas in the world for growing these summerfruit varieties organically are those where the climate provides appropriate winter chilling, a prolonged hot summer and where spring and summer rainfall is at best minimal or at least predictable. Predictability allows the grower to take preventative measures against disease caused by moisture. Plums and cherries are more tolerant of moist conditions, although rain close to harvest can cause splitting, especially with cherries. Most European plums and cherries need more winter chilling than Japanese plums.

A note on climate change

There is compelling evidence that our global climate is becoming warmer, along with likely changes in rainfall patterns and extreme events, as a result of greenhouse gases building up in the atmosphere. In New Zealand, over the next 50 to 100 years we are likely to see, on average, warmer and drier conditions in the east and warmer and wetter conditions in the west. This will impact on horticulture by changing the suitability of some crops to particular areas. Crops like peaches and apricots may become better adapted to the eastern areas. Southern areas may have less frost and therefore be more suited to early flowering cultivars. Reduced winter chilling may make some cultivars no longer suitable for an area. In general, warmer climate will mean new cultivars will need to be found and the main areas of production may change.

Summerfruit prefer sites with deep fertile and well-drained loam soils. Peaches, nectarines and apricots are highly intolerant of wet soil conditions, unless grafted onto a plum rootstock. Cherries are also intolerant of wet soils. Trees can fail even in reasonably well-drained soils in wetter climates. In this case, the best sites would be close to riverbanks or on hillsides where soils can sometimes be better structured than on alluvial flatland soils. Light, coarse textured soils (sandy) are more suitable than heavy fine textured soils (clay). Planting on raised mounds or ridges can also help the peach roots survive in wet climates. Plums are much more tolerant of wet and heavy soils. Less fertile soils may be made productive with plenty of organic matter inputs and patience.

In dry climates some irrigation will be needed, especially during the establishment phase. Sheltered valleys may be subject to spring frosts that could damage early flowering varieties. Hillsides, by allowing cold air to drain away, may be more suitable than the flat land below. Sites exposed to high or constant wind are unsuitable, unless effective shelter can be provided. However, some wind or air movement is needed to promote quick drying which helps to reduce diseases. It might also be best to plant shelter several years before planting the orchard.

Organic growers are like pioneers and are often required to step out into unknown territory to manage orchard cultural issues. This is because the best ways to manage fruit crops organically are still being discovered, mostly by trial and error in the field. Organic production will also benefit from the large amount of research now being done in the international development of integrated fruit production systems (IFP), such as SummerGreen in New Zealand.

Peaches and nectarines can be treated as a short-term crop with longer-term crops interplanted, or with blocks replaced as soon as brown rot pressure becomes too great.

Land value is also a factor in site selection. Requirements for a return on capital or high debt levels can demand levels of productivity that might be difficult to achieve under organic management. When buying or establishing an orchard, it should be known beforehand what markets will be available for the fruit. Buying an established orchard for conversion to organics should be done carefully: Are the varieties suitable? Will there be markets? Is the orchard contaminated with chemical residues? What are the neighbouring properties? Are there any areas of natural vegetation?

Cultivars

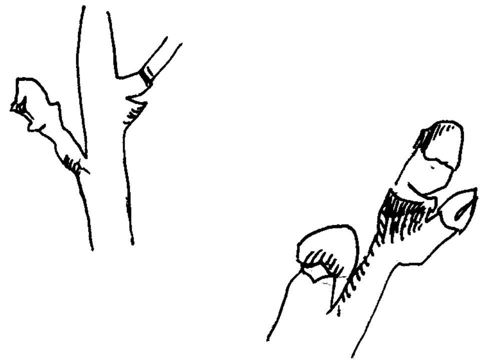
Many modern peach and nectarine varieties are unsuited to organic production because of low levels of disease resistance, whilst many plum and cherry varieties are very suitable. One reason diseases like brown rot and leaf curl are so problematic is that, until recently, summerfruit breeding has not been selected for disease resistance, but has tended to focus instead on fruit qualities, such as appearance, size, yield and various postharvest characteristics, such as shelf life and firmness. Control of diseases has been left to chemical fungicides. Thus many modern cultivars are highly susceptible to fungal and bacterial attack and are difficult to grow without continuous chemical protection. Another reason for the low disease resistance is that modern varieties have been developed from a narrow genetic base [4, 5]. For example, the main apricot cultivars come from just one of five eco-physiological groups [6]. This means that there is a large untapped genetic resource waiting to be drawn on and which could introduce many desirable qualities to breeding programmes, including improved disease resistance. Present breeding programmes should lead to a larger range of varieties suited to organic production becoming available in the near future.

Disease resistant cultivars may be found among existing commercial varieties and among old fashioned or 'heirloom' varieties. These are often found growing in old orchards or settlement sites around the country. Some collections have been made and are now available from specialist nurseries (e.g. Koanga Gardens in Northland, Harrison's Trees in Manawatu, Treedimensions in Nelson).

Summerfruit cultivars vary in their requirement for winter chilling. Varieties with a high or moderate chilling requirement may not fruit well in warmer northern districts. Apricots are very site sensitive and so cultivars known to be adapted to a particular area should be chosen.

In Hawke's Bay there are at least seven growers who grow a wide range of organic summerfruit including peaches, nectarines, plums and apricots. An orchardist in Hamilton and another in Kumeu are both growing organic plums, while in Central Otago there are at least six growers who have apricots, nectarines, plums, cherries and peaches. No doubt there are numerous other organic orchards spread through many districts producing varying quantities and varieties of summerfruit.

New Zealand growers have commented that some varieties and species are much more suitable (easier to grow, more resistant to disease etc.) under an organic regime. Generally later maturing varieties are more liable to pest and disease damage than the earlier varieties.



Those that are being grown currently include:

Japanese plums: Fortune, Omega, Black Doris, Santa Rosa, Victory, Billington, Rosy, Black Amber, Red Beaut. Duff's Early Jewel, Purple King, Sultan, Satsuma.

Disease resistant in Northland: Duff's Early Jewel, Purple King, Sultan, Hawera, Tamaki Special, Burbank, Yellow Gold, Satsuma, Red Doris.

Difficult in Northland: Omega (bacterial spot), Black Doris (blast), Freedom (blast).

Most Japanese plums have a low chilling requirement while most European plums need more.

European plums: Coe's Golden Drop, Angelina Burdett, President, Monarch, Greengage.

Prunes: Italian, Stanley, Yukima, Hauszwetschge, Sugar, Weatherspoon.

Peaches: Snow Bright, White Lady, Golden Tatura (borderline) Golden Queen, Spring Crest, Early Crest, Spring Lady, Tasty Zee.

Resistant to brown rot in Northland and low chilling requirement: Redhaven, Carmen, Blackboy. Paragon II – heavy cropping, grown organically successfully by Lothorien Orchards in Puhoi.

From Koanga: Blackboy, Apricot Queen, Hokianga Golden Queen, Hams Special.

From Treedimensions: Rich Lady, Gordon Glory, Belle of Georgia.

Difficult: Elegant Lady, Fire Bright, Flamecrest. *(One grower also commented that Golden Queens were too difficult)*

Nectarines: Spring Red, Diamond Bright, Armadark, Fire Bright, Snow Queen, Bright Pearl, Spring Bright.

From Koanga: Goldmine, Kaitaia Goldmine, Black Pearl.

Difficult: Red Gold, Fantasia.

Apricots: Golden Waiata, Sun Drop, Royal Rosa, Trevatt and high-chill varieties like Moorpark, Judge Turner, Tilton.

Difficult: Benmore, Gabriel, Clutha Gold (not cropping for one grower).

(Apricots are prone to sulphur shock, which reduces cropping.)

Rootstocks & propagation

Peaches and nectarines are usually grafted onto peach seedlings (often Golden Queen because of its availability from canning operations). Peach is also often used as a rootstock for plums. Peach roots are highly susceptible to disease in wet soil conditions. Even short periods of water logging can result in root death. In wetter parts of New Zealand, especially if on fine textured clay or alluvial soils, peach rootstocks are not generally suitable.

Propagation: usually by budding (T or inverted T budding).

Myrobalan (cherry plum) is a hardy and vigorous wild plum and is the standard rootstock for Japanese and European plums and sometimes for peaches and nectarines. It tolerates a wide range of soil conditions, especially heavier soils.

Propagation: hardwood cuttings taken in late autumn.

Plums can also be grown directly from cuttings (young shoots) taken in autumn. All plum cuttings should be inserted in coarse sand and mulched with shredded bark or similar to maintain soil moisture and control weeds.

Apricots are usually budded onto peach seedlings, but can also be grown on apricot seedlings or Myrobalan plum stocks.

Cherries are usually grafted onto Colt rootstock although Mazzard sweet cherry, which is fairly tolerant of wet soil conditions or Mahaleb, suitable for lighter and drier or drought prone soils, can also be used.

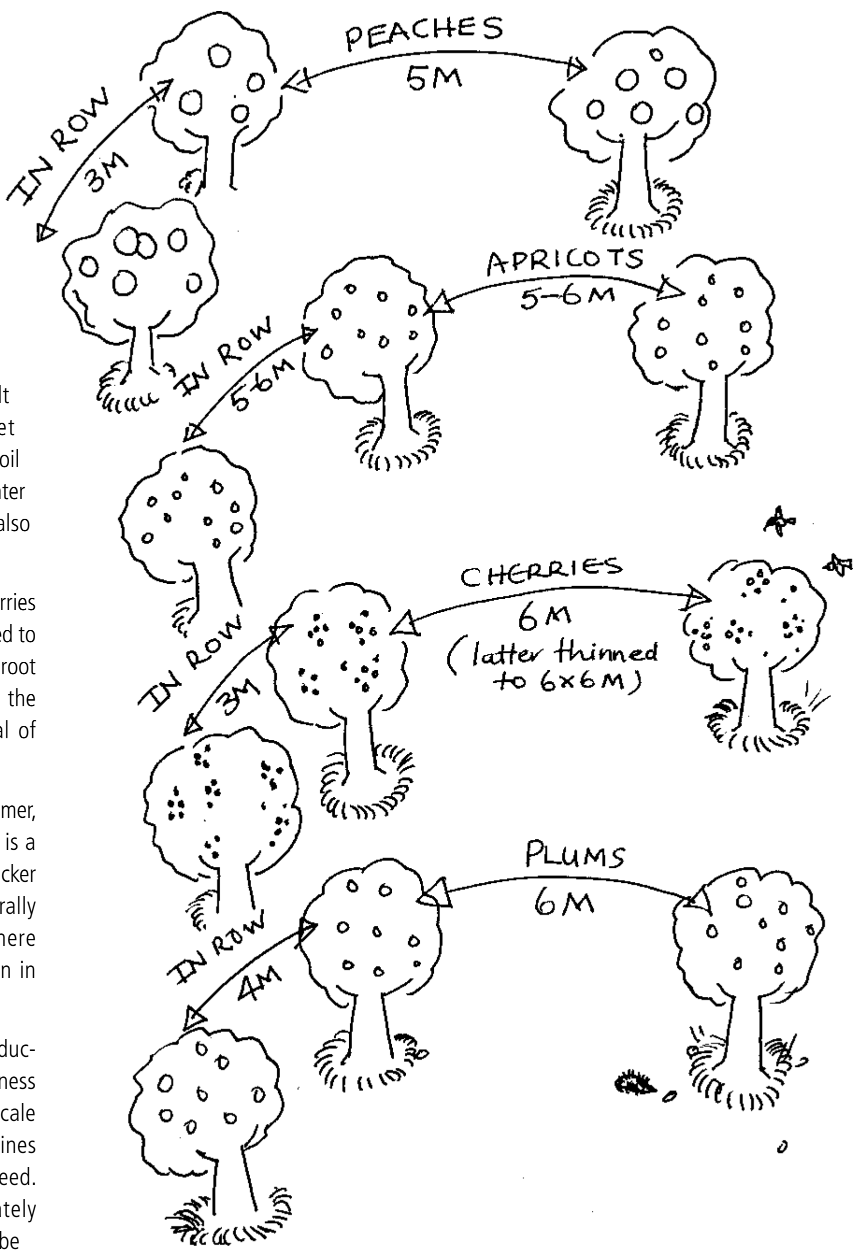
Dwarfing rootstocks for plums and cherries are available but are not generally suited to organic growing because their weaker root systems are less able to compete with the vigorous sward (groundcover) typical of organic orchards.

Summerfruit are usually budded in summer, rather than grafted in winter. Budding is a less drastic propagation technique, quicker to perform and the results are generally more positive with summerfruit. There is also less risk of silver leaf infection in summer.

Ungrafted seedlings can also be productive, although their commercial usefulness would probably be limited to small-scale local marketing. Peaches and nectarines are particularly easy to grow from seed. Stones should be planted immediately and not allowed to dry out. They can be labelled and mulched. A better 'strike' is obtained if stones are first cracked open in a vice and the kernel extracted. The kernel can then be planted in sand. However, great care should be taken not to damage the kernel.

An advantage of seedlings is their genetic variability that gives the opportunity of discovering new disease resistant strains. The health of the orchard and its produce might also be greater using seedlings compared to grafted monocultures of a few cultivars. Plums can also be grown successfully from seed and again the chance of finding novel or disease resistant strains makes the practice attractive to keen organic horticulturalists.

Spacing



Tree spacing varies according to the vigour and eventual size of the scion-rootstock combination. Fertile sites are likely to produce bigger trees that need more space. Vigour varies between varieties and according to the rootstock. Climate and irrigation will also affect vigour. Although closer spacing can increase early and cumulative yields, wider spacings are usually more suitable for organic summerfruit. Wider spacings allow better airflow and more rapid drying of foliage after rain or dew. This helps to reduce disease and is particularly important for the more disease susceptible varieties. Also, wider spacings, by reducing the intensity of the production system, might make the establishment of a more self-sustaining orchard ecosystem easier. Spacings recommended for conventional plantings could be increased by about half a metre each way.

Peaches, apricots and cherries can be planted in rows five metres apart and three metres within the row. Closer planting is also possible, with trees trained as spindle bushes or where it is planned to remove alternate trees after several years. Better air movement might be attained by planting apricots on the square at five or six metres each way and cherries with an initial spacing of six by three metres to be later thinned to six by six metres (7).

Plums can be planted five by three metres or six by four for the more vigorous varieties (e.g. Duff's Early Jewel, Purple King).

These are rough guidelines and the spacing should be adjusted for variety, rootstock, soil fertility, climate and disease susceptibility.

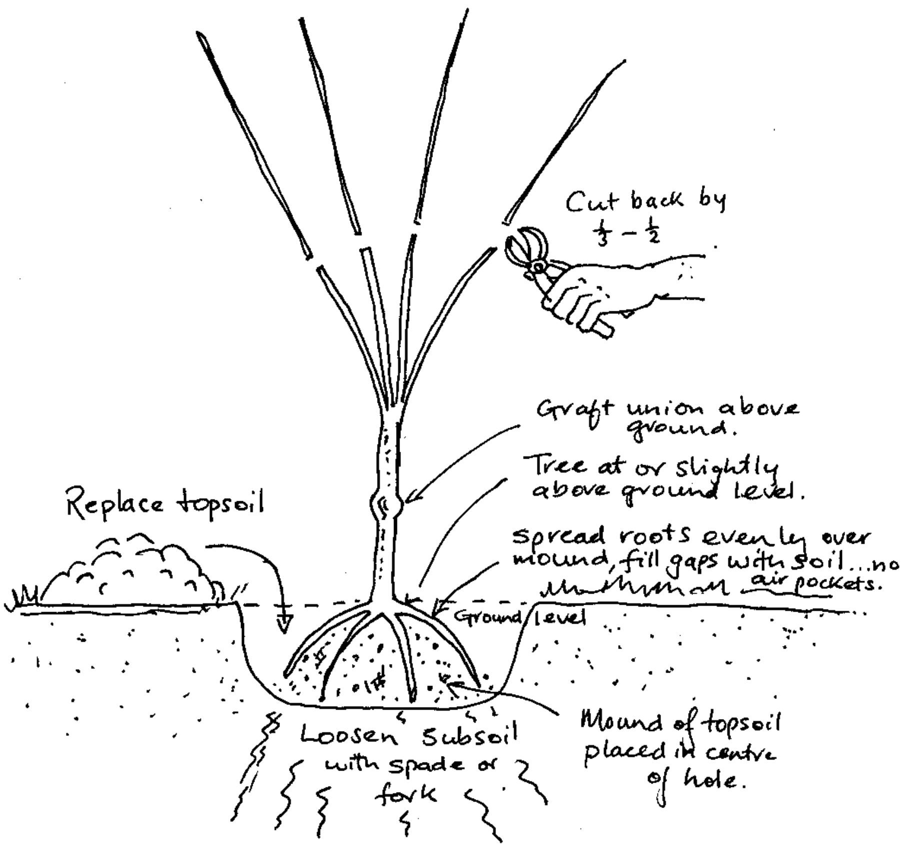
Tree management

To obtain regular good crops of high quality fruit the trees must be well cared for right from the start. Apart from good nutrition, proper planting and pruning techniques are the basis of good tree care.

Planting

Before planting a new orchard, the soil should be tested and any nutrient deficiencies or pH deviations corrected. Biodynamic practice would tend to work with existing conditions rather than super-imposing an 'optimum' standard onto the land. Cultivation of the whole area to be planted can assist root development and tree establishment. Intercrops, such as sweet corn, can provide shelter to the young planting, as well as some supplementary income. However, cultivation can damage soil structure and expose it to erosion and nutrient leaching – factors that need to be taken into consideration.

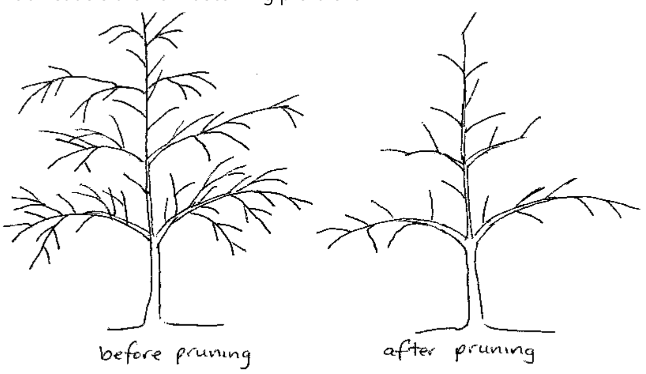
Usually, one-year-old (from grafting) trees are selected and planted in winter. In warmer districts roots can start growing earlier or winter rain can make soils unworkable, so early winter planting would be preferred. Ensure that the roots are kept moist at all times before planting. Allowing roots to become dry can greatly reduce growth the following spring. They should be set on mounds in the centre of holes that are wide rather than deep. The tree is usually set at the same level in relation to the ground as it was in the nursery. Graft unions should not be buried. It is also useful to plant in straight rows, lining the trees by sight and measuring tree and row spacing accurately (an out of line tree is more likely to be hit when mowing). Remove any damaged roots and spread the roots evenly over the mound. The longest roots can be aligned into the prevailing wind to assist in anchoring. A hardwood stake can also be driven in beside the tree (avoiding the roots). As the soil is returned to the hole take care to work it snugly around the roots. If water is available, temporary puddling may help to settle the soil around the roots and expel large air pockets. Otherwise, gentle tramping will consolidate the soil and a tie can be added to the stake to prevent excessive movement in wind. If necessary the tree can be watered, although in most districts winter rain will be sufficient.



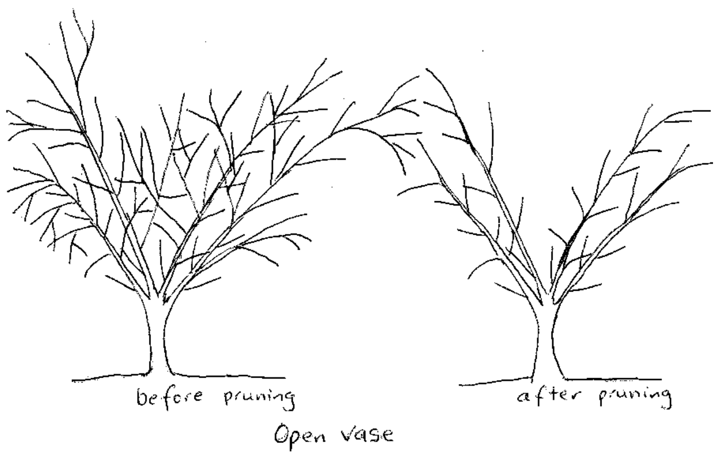
During the first season the trees should be kept well mulched with hay or compost and watered when necessary. A small, undeveloped root system will be quick to suffer from dry soil conditions and competition from grass and weeds. Maintaining a large area of mulch around each tree will encourage the roots to spread widely.

Pruning

Pruning is necessary in summerfruit to maintain open, light-filled trees and to stimulate the production of new fruiting laterals. Pruning removes old unfruitful or diseased wood. Trees are also trained by pruning to a particular shape to promote fruitfulness and ease of management. Summerfruit are usually trained as open centred vases or as central leaders. They are also sometimes trained to a support system such as a Tatura trellis, which was developed for peaches in Australia. An open centred tree has six to eight main branches with fruiting laterals spaced evenly around and along them. It is shaped like a vase. The branches emerge from a single trunk at about 70cm from the ground. The central leader has one central stem from which a series of branches and laterals emerge at intervals. The central leader is wide at the base and tapers towards the top. The vase shape is suitable for all summerfruit and tends to be their natural form. However, the central leader is a more efficient tree form, especially in terms of light interception. Yields are closely related to light interception as is fruit quality. Central leaders are commonly used for intensive peach and nectarine plantings and cherries (especially where dwarf rootstocks are used). Apricots and plums are commonly grown as vases, although central leaders are now becoming prevalent.



Central leader



Open vase

The vase

At planting the main branches are cut back by about one third to one half (this may already have been done by the nursery before despatch). Remove broken or badly placed laterals. Thereafter do only minimal pruning to reduce the risk of silver leaf infection and promote early production. The centre of the tree should be kept open by removing strong inward growing laterals and any other laterals, crossing over or crowding, can also be removed.

The central leader

It is best to start with a single stemmed tree with symmetrically arranged weak laterals (feathers). Remove any strong laterals. These are liable to compete with the central leader and the tree will then quickly revert to a vase shape. The tree should not be cut back but the feathers may be thinned, leaving four to six emerging from about 90cm from the ground. These will become a bottom tier of branches. To convert trees that have already formed multiple branches in the nursery to central leader, it will be necessary to remove all but the most upright and centrally positioned branch and ruthlessly suppress any vigorous regrowth of laterals. Only weak laterals are used as side branches in central leader training as this maintains the dominance of the leader. This rule is followed for the life of the tree.

Spindle bush

This is a variation of the central leader used for very intensive plantings. The main stem is kept free of permanent branches and tiers. A continual replacement of laterals from the main leader maintains the form. Spindle bush plantings could be suitable where the crop is being treated as a short-term one, rapid production is wanted and a good supply of trees is available.

Maintaining production

On peaches and nectarines a continuous supply of one-year-old shoots is maintained by removing laterals that have already fruited. One-year-old shoots are the fruit producing ones. Peaches and nectarines need to be pruned fairly hard, to thin out the year-old laterals. Young fruiting wood should be evenly distributed over the frame of the tree. When removing a lateral, leave one or two buds at the base of the shoot from which replacement shoots can emerge. If left unpruned, the productive wood on peaches and nectarines will be mostly at the top of the tree, with lower parts being shaded out. Major pruning cuts would then be necessary to produce new growth at a lower level.

Plums fruit on young shoots and on spurs. Pruning to remove old spurs will promote a steady supply of young fruiting wood. Some varieties that blossom and fruit heavily (e.g. Duff's Early Jewel) can be thinned by shortening fruiting laterals. Severity of pruning is decided by the vigour of the tree – a tree that makes little growth should be cut back harder than a more strongly growing tree.

In apricots, pruning of the productive tree consists of removing crowding and inwardly growing laterals, shortening back longer laterals by about a half and removing weak fruiting spurs. Any strong upward growing shoots (watershoots) should be removed completely.

Cherries have traditionally been pruned to a vase shape, but central leaders are now more common and this method is better suited to the cherry's characteristic strong apical dominance. Cherries are pruned relatively hard to encourage the development of fruiting laterals and to keep the tree size within bounds.

Pruning is best carried out at or right after, harvest, while the weather is still dry (i.e., summer pruning). Advantages of summer pruning include:

- *Reduced risk of silver leaf infection*
- *Light can penetrate the canopy to mature the fruiting wood for the following season*
- *Rapid callus formation to protect pruning cuts because the trees are still physiologically active*
- *High UV light levels that have a sterilising effect on exposed pruning wounds*
- *Sugar content of the wood is at a seasonal low level and less suitable for the growth of disease organisms*
- *Buds are mostly committed and unlikely to regrow until the following season.*

Branches that are likely to hang down with the weight of next year's crop and be in the way of orchard operations, such as mowing, should be shortened, removed or tied up out of the way of passing traffic. Peaches and nectarines can also be 'summer pruned' before harvest to remove unwanted shoots and allow light into the canopy to assist fruit development and the maturation of replacement shoots. Sometimes trees grow too vigorously but carry little fruit. In this case bending laterals downwards can encourage the development of fruit buds. Once the tree has begun to fruit properly, crop load will tend to regulate tree vigour. This approach is often more effective than trying to manage excessive vigour by pruning alone. Bent laterals can be held in place by tying to wire support systems, tying with string to pegs in the ground or by using braces. Never prune summerfruit trees in the rain. Remove suckers emerging from the ground or below the graft union.

All larger cuts, especially on apricots, should be protected with a pruning paint tar, grafting wax or a special organic preparation (check certification standards; see "Organically acceptable fungicides" in the Crop Protection section for tree paste recipe).

Biodiversity

Encouraging a greater number of species of plants and animals into the orchard may increase the stability and resilience of the ecosystem. A wide range of sward, shelter and crop plants helps to maintain a diverse population of beneficial insects and other organisms, both in the canopy and in the soil. In the soil, biodiversity helps to maintain the recycling of nutrients as well as protecting against root pathogens. The root systems of different plant species act together to prevent the leaching of nutrients. A high level of plant biodiversity fosters a correspondingly diverse microbial and insect diversity, reducing in turn the number of empty niches available for colonisation by pest organisms. Soil health and microbial and plant diversity are closely linked.

Interplanting summerfruit with other fruits would increase biodiversity and break up continuous canopies of a single plant species (monoculture) that tend to attract pests and diseases. The deeper root systems of interplanted trees are able to capture and utilise nutrients that have leached down beyond the reach of the shallow citrus roots. Native vegetation including self-sown seedlings within the tree rows can bring beneficial plant-soil interactions and have positive effects on the orchards' insect communities. While interplanting might make management more difficult in larger orchards, the practice could be a successful strategy in small orchards where routine crop-specific sprays are less common.

Peaches and nectarines could be grown as a short-term crop, to be replaced by a longer-term interplanted crop. This takes advantage of their precocious fruiting habit, while avoiding problems of brown rot becoming epidemic in the orchard as the trees age. For example, peaches interplanted with pecans. In this case every other row of peaches has pecans planted at suitably wide spacings. The peaches provide income until the pecans become productive. Other crops that might suit interplanting with summerfruit include apples, pears and feijoas. Avoid inter-cropping with crops such as tomatoes and potatoes, which may carry root diseases of summerfruit such as verticillium wilt.

Shelter

Windbreaks and hedgerows have important roles to play in the organic summerfruit orchard. They are able to raise average temperatures within the orchard, prevent wind damage to the fruit and trees, add to the biodiversity of the orchard ecosystem, capture and return nutrients to the orchard ecosystem, and host and enhance populations of beneficial insects and birds. Windbreak trees may also supply timber and firewood to supplement the orchard's income. Enclosing the orchard with a windbreak or hedge will help to exclude unwanted pests from outside, including birds, insects and some disease spores[8]. Hedges have been shown to reduce disease spores being carried by wind into peach orchards. They can also block spray drift from neighbouring non-organic properties. The need for shelter will change as the orchard matures. Young trees need more shelter, but as the trees fill their allotted spaces 'self-sheltering' may replace some of the need for additional shelter. The yields of most horticultural crops can be reduced by exposure to wind. Wind tends to reduce the rate of photosynthesis, which is always closely related to yield and growth. It can also cause crop damage and increased rates of water loss from the orchard.

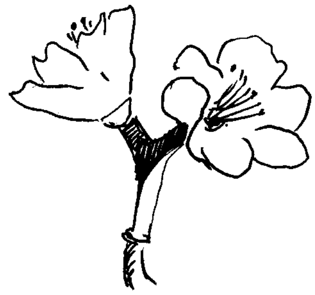
However, shelter needs to be carefully placed and be of suitable dimensions to reduce but not prevent air-flow, to avoid air turbulence and wind funnelling and not compete unduly with the crop for light, water and nutrients. Where there are adjacent horticultural properties windbreaks should also be compatible on a wider landscape scale. Taller trees should be spaced apart rather than being solid walls, which can increase wind damage to the crop by the creation of turbulence. A windbreak will provide shelter for a distance equal to about 10 times the height of the windbreak. Many species used traditionally for orchards become too large and require regular pruning to reduce their size. They may also increase frost risk if cold air builds up above them.

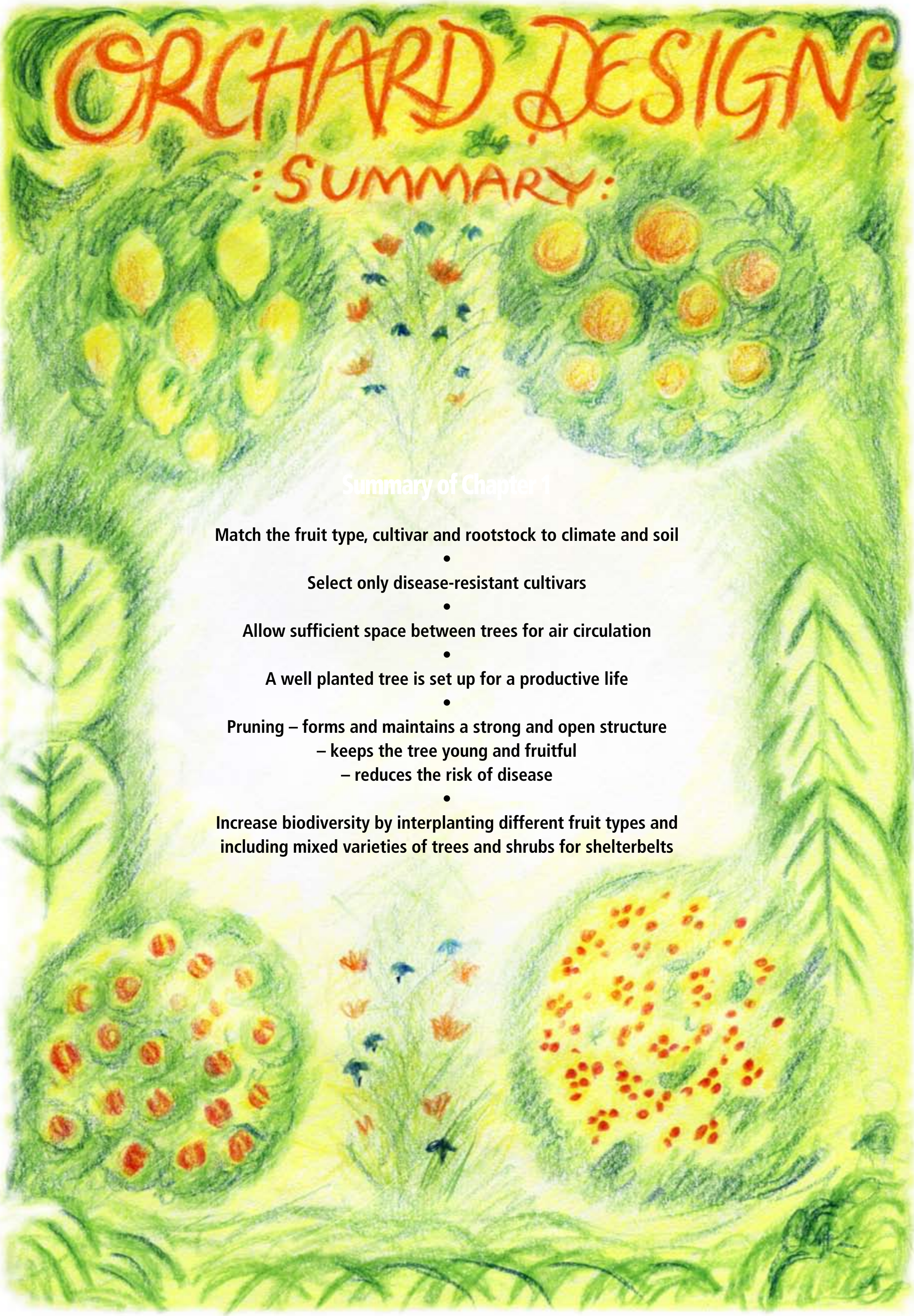
Flags kept flying at points around the orchard can be used to monitor wind and, as they become tattered with age, give an indication of wind frequency/strength in different parts of the orchard.

Generally, taller evergreen trees are placed on the southern boundaries, while smaller sized mixed evergreen and deciduous species are placed on the other boundaries. Windbreaks should include smaller shrubs and trees as an under-storey. Species known to attract birds and beneficial insects are selected, while species known to host pest and diseases should be avoided. For example, Tasmanian blackwood and conifers can host ladybirds while poplars and willows host silver leaf.

It is possible that native plants (e.g. *Pittosporum* sp.) will increase biodiversity further by supporting native plant and animal species. Native birds also tend to prefer native fruits to exotic cultivated fruits. Flowering trees and shrubs attract and enhance populations of many beneficial insect species. A diverse mix of trees and shrubs will also encourage a diversity of birds, which will act to prevent populations of fruit-eating birds becoming dominant. Most birds are territorial and enclosed within the orchard's shelter will be a resident population. These 'locals' help to keep out other non-resident birds. To satisfy the appetite of local birds for fruit, include plenty of 'sacrificial food-banks' ('wild' plums and figs are popular) in the windbreak or hedges.

Competition with the crop from shelter trees for nutrients and water can be reduced by root pruning, root barriers (e.g. trenches)and using deep rooting species (e.g. alders). Careful shelter design (species and positioning) can avoid many problems.





Summary of Chapter 1

Match the fruit type, cultivar and rootstock to climate and soil

•

Select only disease-resistant cultivars

•

Allow sufficient space between trees for air circulation

•

A well planted tree is set up for a productive life

•

Pruning – forms and maintains a strong and open structure
– keeps the tree young and fruitful
– reduces the risk of disease

•

Increase biodiversity by interplanting different fruit types and including mixed varieties of trees and shrubs for shelterbelts

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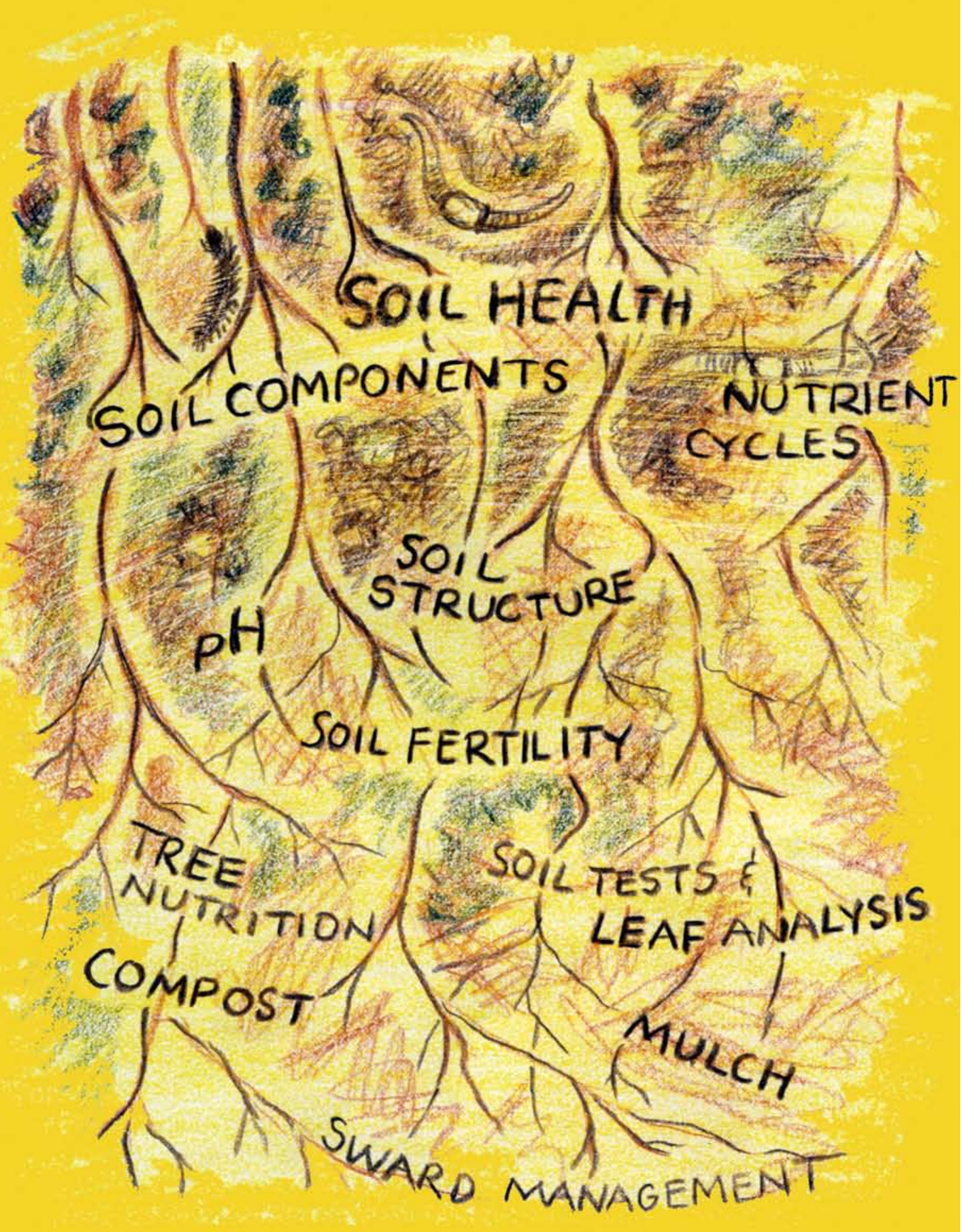
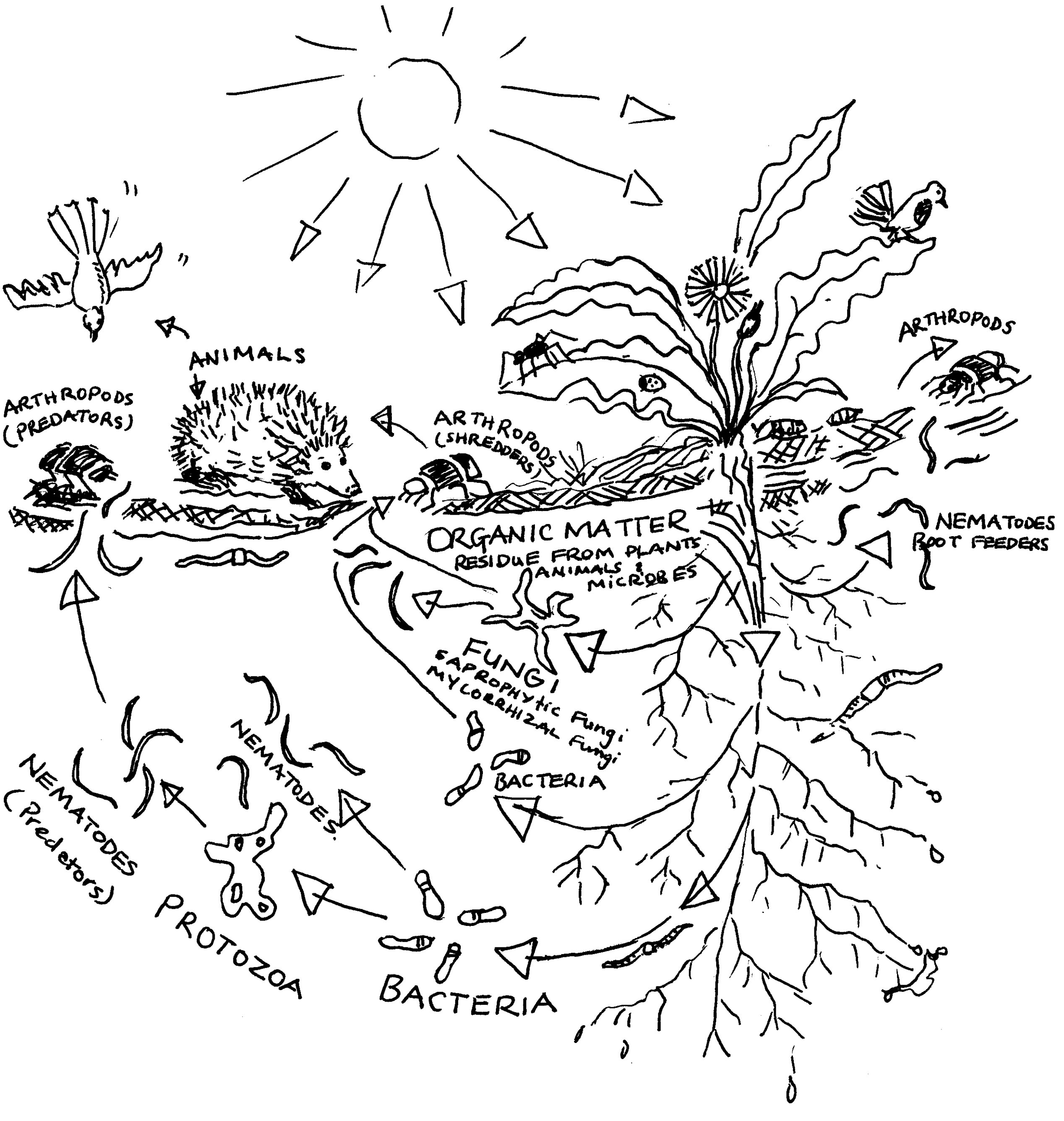
Soil Management



The orchard and its annual offering of fruit is a product of its soil. A biologically active, well-structured and fertile soil is a healthy soil, able to produce and to sustain healthy plants. The most important activity on an organic orchard is the creation and maintenance of healthy soil.

Healthy soil is the basis of successful organic horticulture. The soil is full of life, including plant roots, animals, insects, bacteria, fungi and other microorganisms. The aim of organic horticulture is to manage the soil so that this living system thrives continuously, to ensure a fertile soil and optimum conditions for growing healthy plants. Without soil organisms, the organic matter in the soil is simply putrefying material and of no use to the soil, its structure or its fertility. The soil organisms, in turn, depend on the photosynthetic activity of the plants, which produces the raw material and energy for their existence. The flow of energy and mass between all the soil organisms has been described as a soil food web.



Soil components

The basis of terrestrial life, the soil, is a dynamic matrix of minerals, plant roots, microorganisms, soil animals, humus, water and air.

Minerals The mineral fraction of the soil represents the parent material from which the soil is derived (e.g. basalt, granite or greywacke) and that is being weathered to release its elemental components (typical to the rock type), many of which are important for plant growth. Mineral particles include very small clay particles, medium sized silt particles and large sand particles. Of course, some soils also contain stones and rocks. The distribution and proportion of clay, silt and sand largely determine the soil's texture and account for the different soil types. Soil texture is an important factor in determining air, water and nutrient holding capacity. Sandy or coarse textured soils are usually free draining and well aerated, but have a low water and nutrient holding capacity. Clay or fine textured soils are more likely to have impeded drainage and limited aeration, but have a high water and nutrient holding capacity. Silty soils are somewhere between these two extremes.

Organic matter Soil organic matter (SOM) includes living organisms as well as their residues and dead remains. While SOM forms only a relatively small proportion of the total soil bulk, its functions are the basis of soil fertility and productivity, especially in organic systems. Increasing SOM levels is an important part of managing soil organically. Between 4 and 10% would be considered ideal.

Plant roots are by far the largest component of SOM in terms of total biomass (average about 20t/ha). Roots exude and shed carbon compounds into the soil that are an important food source for microorganisms, particularly bacteria. In fact, the soil's microbial activity is concentrated around plant roots in a zone known as the rhizosphere ('rhizo' meaning root).

Plant roots and above ground parts are constantly being recycled, and this is the main source of food and energy for the soil food web. It is the energy fixed by photosynthesis into carbon compounds that supports virtually all life forms. Plant roots also fix most of the soil's nitrogen supply. Nitrogen is a major nutrient for life forms and its rate of supply is an important regulating influence on growth.

Microorganisms largely control the rate that nutrients are recycled and become available for plant uptake. They are the basis of the soil's life. A diverse range of organisms is needed to successively break down the wide range of compounds contained in organic matter and to release nutrients from soil minerals. Plant diversity, as well as organic matter inputs, are important factors increasing the diversity of soil microbial populations. Organic practices such as the use of compost, covercrops, crop rotations, intercropping and mulching will all contribute to soil microbial diversity and proliferation. As nutrients are mineralised and enter the soil solution they are rapidly absorbed by plant roots or by other organisms.

If nutrients and moisture are available, soil pH is close to neutral and soil temperatures are within 10 to 30°C, then soil microbes will flourish; if the food substrate is diverse, then populations will also tend to be diverse. If soil conditions are not ideal, most soil microbes and many of the soil animals can enter a dormant stage in the form of cysts or spores enabling them to survive periods when conditions are not suited for growth. However, as soon as conditions become suitable growth can be very rapid.

Fungi are next to plant roots in terms of total biomass (typically: 2–5 t/ha). They are active in the decomposition of mainly dead organic matter, although some species are also pathogenic. Some species (mycorrhizae) form symbiotic relationships with plant roots, providing the plant with nutrients and water in return for a supply of carbohydrate. Mycorrhizae also protect plant roots from attack by pathogenic organisms.

Bacteria are the most numerous soil organisms and are active in the decomposition of organic matter. Individual bacteria are much smaller than fungi and their total biomass is typically 1–2t/ha. Organic matter consists of many different compounds and the breakdown of especially the larger compounds requires specific microbe species for each stage of the decomposition. Both the processes of decomposition and the formation of humus require a large and diverse bacterial population in the soil. Some bacteria are able to fix atmospheric nitrogen. Of these species, the most important are those that form symbiotic relationships with legumes (rhizobia).

Actinomycetes have characteristics of both fungi and bacteria. They are active decomposers and some species are pathogenic. They contribute much of the earthly smell of soil. Total biomass: 0–2t/ha. Algae are another bacteria-like group of organisms that live mainly near the surface where there is light. They are photosynthetic and some species can also fix nitrogen.

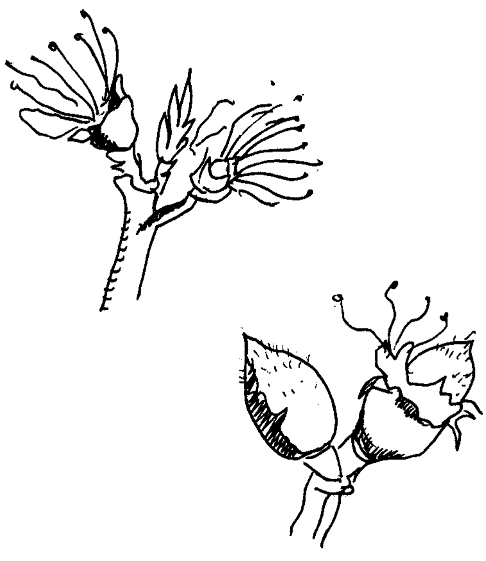
Protozoa are small, mainly predatory soil animals (microfauna) that 'graze' on soil microbial life. They swim in soil water and can access microbes in all but the smallest soil pores. Protozoa activity is determined by the availability of microbial prey and soil moisture. Their grazing activity can release nutrients from the microbial biomass, which are then available for plant uptake. Bacterial biomass may be reduced or remain the same (increased turnover), while fungal biomass may increase, as a result of grazing by protozoa and other soil animals. Other soil animals include nematodes, springtails (*collembola*) and mites. Soils typically contain vast populations of these animals (*mesofauna*).

Earthworms are the most important of the larger soil animals (macrofauna). Others include molluscs, ants and centipedes. The larger soil animals break organic matter down into smaller pieces and incorporate (and inoculate) it into the soil for microorganisms to decompose. They also graze on microbes, other soil animals and plant roots, releasing nutrients and spreading inoculant. Earthworms and other macrofauna are also important in creating space in the soil (soil structure) for other soil organisms.

Humus is partially decomposed organic matter that is resistant to further decay as a result of the microbial and chemical processes of humification. Humus forms aggregates with soil mineral particles, often being enclosed in a mineral coating and therefore protected from further microbial decay. It has a high nutritional content and represents the soil's long-term nutrient supply. The more stable humus can have a turnover rate of tens or even hundreds of years.

Water and air are essential for nearly all life forms including those found in soil. Soil water holds dissolved nutrients for plant uptake and many soil organisms need a water film to swim around in. Organic matter, especially humus, adds to the soil's water holding capacity.

Air is needed for aerobic (air-breathing) organisms, including plant roots. Aeration or gas exchange is also necessary to allow the removal of metabolic wastes – gases such as carbon dioxide and methane produced by soil organisms (also including plant roots).



Soil structure

Soil structure is the formation of soil particles into aggregates, their arrangement relative to each other and the stability or resistance to stress of the resulting 'structure'. It is within the structure of the soil that water and air are held. A strongly structured soil is able to retain a crumbly texture even after repeated cultivations and has the strength to resist compaction. A weakly structured soil, if cultivated or disturbed, will soon collapse into fine sand or silt particles and is easily compacted. A soil with good structure will be porous and light, roots will penetrate it easily; its water and air holding capacity will be high and it will drain quickly. Humus, with its role in aggregate formation, is important in the formation of soil structure, as is the activity of plant roots and root-microbe interactions. Microbes produce 'glues' and coatings that bind soil particles and organic matter together forming aggregates. Other factors involved in the creation of soil structure include wetting and drying cycles, clay particles and metal oxides that have a cementing action.

If there is too much water in the soil, so that even the larger pores are water filled and there is little air or gas exchange, then soil is likely to become 'anaerobic'. Where there are anaerobic conditions, the soil's biological activity changes, with many organisms becoming inactive or dying, while others switch to an anaerobic metabolism, creating waste products that are toxic to plants and soil organisms (e.g. methane, alcohol, hydrogen sulphide). Plants vary in their tolerance of anaerobic or water-saturated soils. During spring and summer, when plant roots and soil organisms are most active, there is a greater demand for oxygen and gas exchange. At these times plants and other soil organisms will be less tolerant of excessive soil water. Species also vary in their tolerance of wet soils. Peach and apricot roots are particularly intolerant at any time of year and affected trees will quickly die.

It can now be seen that the soil's biological activity is very much dependent on its structure. Therefore the maintenance and improvement of structure is a major part of soil management. Soil structure in the orchard can be damaged by compaction by machines or animal treading, especially during wet weather or when the moisture content is high. Vehicles should be excluded from the orchard as much as possible and traffic confined to designated routes. It might also be useful to consider the type of machinery being used – small lightweight machines with air-filled balloon tyres would cause less compaction. Another way structure is harmed is by the repeated use of herbicides that interrupt the recycling of organic matter. Bare ground is also liable to structural damage. Structure is improved by inputs of organic matter and by having an active and diverse sward, both of which will encourage earthworms, microbial activity and aggregate formation, leading in turn to the development of soil structure.

Mycorrhizae are fungi that form symbiotic relationships with the roots of most plants, receiving carbohydrates from the plant and in return supply the plant with a wide range of nutrients, including phosphorus and amino acids (nitrogen). Furthermore, mycorrhizal associations protect the plant from root pathogens and may produce hormones (e.g. *cytokinnins*) that stimulate the growth of the host plant[9]. The network of fine fungal threads greatly extends the plant's root-system and increases the soil volume able to be utilised in the search for nutrients. Mycorrhizal associations with summerfruit roots can contribute to increased growth rates and protect the roots from water-logging damage[10]. The most benefit is likely to be gained in situations of relatively low fertility. Excessive applications of P fertilisers can reduce mycorrhizal activity, as can many other conventional agricultural practices (e.g. chemical fertilisers, pesticides, tree girdling). Inoculation with preferred species of mycorrhizal fungi is possible. Organic soil management practices including sward and crop diversity will encourage mycorrhizal fungi.

Earthworms are one of the most important soil organisms. Their abundant presence in soil can be used as an indication of high levels of soil biological activity and health. For example, in a one spade-square hole (i.e. 20–20cm) at least 15 to 20 worms should be found. Earthworms improve both the physical and the chemical fertility of soil. Their tunnelling improves drainage and incorporates surface organic matter into the soil. Soil and organic matter that has passed through the gut of a worm (casts) is microbially and nutritionally enriched. Earthworm activity can be encouraged in the orchard by minimising soil tillage, applications of organic matter to the soil, increasing soil calcium levels by liming, avoiding dry and exposed soil and minimising copper fungicide use.

Rhizobia are bacteria that form symbiotic relationships with legumes and are able to fix atmospheric nitrogen (N) and supply this to the plant, receiving in return a supply of carbohydrates. They are most active in neutral to slightly alkaline soil with adequate soil moisture levels. They are less active in a soil already rich in N from fertiliser or other nitrogeneous inputs, because the legume will prefer to obtain its N directly from the soil, without having to pay the rhizobia for it with carbohydrates. Additionally, in a N-rich soil grasses will become more competitive and will tend to replace legumes such as clover. In the orchard the N contained in legumes becomes available to other plants when the sward is mown and the clippings decompose or naturally as the legume roots and foliage die off and decompose. The greatest amount, however, may be deposited directly into the soil from the roots [11].

The rhizobia form visible nodules on the roots of legumes and their nitrogen fixing activity can be confirmed if these nodules have a pinkish colour inside. On clover plants if the nodules are clustered near the soil surface this could indicate unfavourable soil conditions.

Managing soil structure

There are many different ways in which soil structure may be damaged including:

- Surface soil removed or disturbed for site planning and not restored
- Orchard equipment and machinery compacting the soil and creating poor drainage
- Cultivation of the soil when it is too wet
- Many years of cropping, causing depletion of the soil's organic matter and nutrients
- Chemical fertilisers harming the soil's biology needed for the formation and maintenance of structure.
- Bad farming practices causing erosion and loss of fertile topsoil.

Successful soil management will first require testing the soil to identify any problems that may be present. This testing can range from visual assessment carried out by the horticulturalist or adviser, to complex biochemical analyses carried out in a laboratory. Results of these analyses will provide recommendations for soil improvement that could include:

- Addition of inputs to encourage soil life
- Addition of organic matter, e.g. by digging or tilling into the surface of the soil, by planting green manure crops or by applying mulches or composts that are allowed to break down over time
- Increased planting of different species which are able to access and cycle nutrients from other levels of the soil or that have nitrogen fixing properties to enhance soil nutrition
- Implementation of rotational cropping practices (where practical)
- Improvement of soil drainage
- Adding specific organic soil amendments to correct pH or mineral imbalances.

Demeter certification standards have a number of requirements related to the use of their specific preparations for soil improvement. The following are listed as their minimum generally acceptable practices:

- Preparation 500 (horn manure) should be applied to the production area at least twice a year
- Preparation 501 (horn silica) should normally be applied at least once to each crop and at least once per year to permanent and semi-permanent plants such as pasture grasses

- Compost preparations 502–507 should be used to direct all fermentation procedures in liquid manures and composts. Such fermented materials should be regularly applied to the land
- All preparations must be from a source assessed and approved by the licensing committee.

The biodynamic preparations can be obtained at a cost from the Bio Dynamic Farming and Gardening Association

Biodynamic practice aims at balancing the processes of humification and mineralisation and pays particular tribute to the interactions of physical, chemical and biological processes within the soil. This life-supporting environment is considered more than a visible material phenomenon and rather an opportunity to translate vitality into other spheres, including that of human nutrition.

It should be recognised that there are no overnight or even single season organic solutions for an unbalanced soil. Organic horticulturalists boost nature's fertility through two, three, four and even ten year programmes that result in a fertile rich soil.

Soil pH

Soils can be either acidic or alkaline to varying degrees and the measure of this is called the pH of the soil. A soil is neutral at pH 7 (neither acidic or alkaline). Maintaining the correct soil pH is important for soil organisms and for chemical nutrient availability. Most nutrients that plants need are readily available when the soil is slightly acidic to neutral. Below pH 5.5 some nutrients such as nitrogen, phosphorous and potassium are less available. When pH exceeds 7.5, iron, manganese and phosphorous are less available. A pH-induced manganese deficiency is the most common trace element deficiency in summerfruit. The optimum pH for most fruit species is usually considered to be between about 6.0 and 6.5.

Several other soil–plant factors are also affected by a low soil pH:

- *Aluminium and manganese become more soluble and can become toxic to plants*
- *Soil biological activity is reduced, slowing the turnover of organic matter and reducing the release of nutrients. The activity of soil organism is inhibited, including earthworms and nitrogen fixing bacteria, including those in symbiosis with legumes*
- *Soil cation exchange capacity (CEC) is reduced. Soil CEC is an important indicator of the soil's capacity to store (exchange) nutrients (cations).*
- *Soil surface structure affecting water infiltration, water retention and aeration are often reduced.*

Elemental sulphur or iron sulphate could be used to lower soil pH. To lower pH by one unit (i.e. from pH 7.5 to pH 6.5) would require between 100 and 250kg sulphur per hectare. However, it is more usual that soil pH will need to be raised, not lowered. The usual method to raise pH is to add lime or dolomite. Dolomite contains magnesium carbonate as well as calcium carbonate, but if magnesium is not required then lime is the cheaper option. However, the liming effect of many other materials is often overlooked. For example, compost, seaweed, crushed shells, wood ashes and rock phosphate can all raise soil pH (rock phosphate has about 50% of the liming effect of ground limestone). If the soil is already alkaline, that would be an additional reason to take account of the liming effect of organic soil amendments.

The amount of lime needed to raise soil pH varies according to soil type (i.e. soils vary in their response to the same amount of lime). Typical applications range from between 1.25t/ha to 2.5t/ha depending on soil type, and initial and target pH. To avoid excessive pH changes in a narrow soil layer, large applications of lime should be avoided. Small but frequent applications that include allowance for other pH altering inputs and combined with periodic pH monitoring, is better. Before planting a new orchard, larger lime applications could be needed (e.g. up to 4t/ha); the lime could be cultivated into the soil. Organic systems that include pH-raising inputs such as compost and rock phosphate might not need regular liming. Lime should be applied separately from nitrogenous inputs, such as compost, to avoid the loss of N in the form of ammonia that can result from high pH.

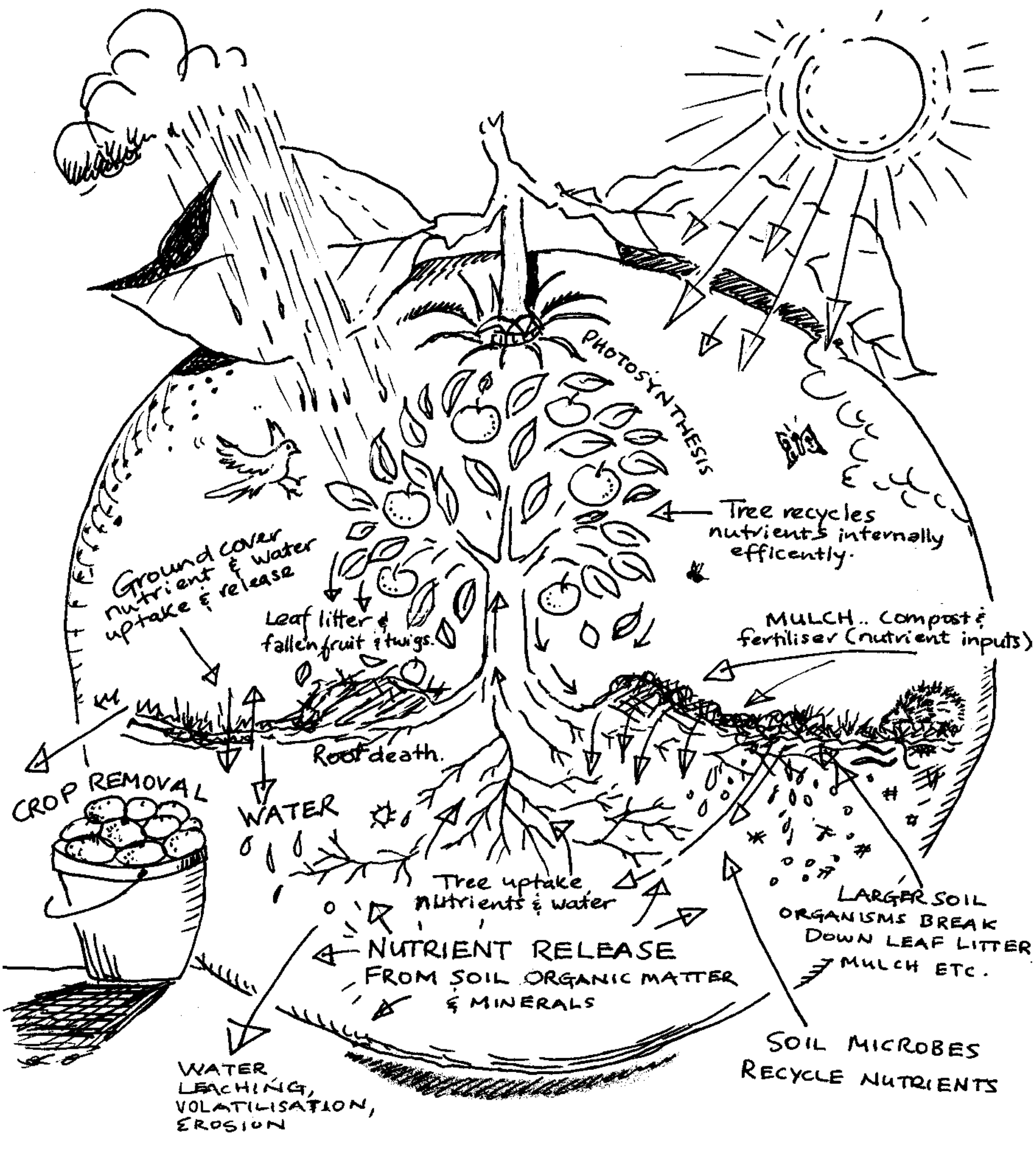
Nutrient cycles

The organic method encourages use of nature's ecosystems to produce its own fertilisers. Nature's cycle of growth, death and decay is continuous. The orchard's nutrient pool is contained in the leaves, wood and roots of the fruit trees, in the leaves, stems and roots of the sward plants, dissolved in the soil solution, stored more or less permanently in or on soil minerals and humus, incorporated into the bodies of soil organisms and contained in the residues of animals and plants. Nutrients are moving between these forms as plants grow and die, minerals are weathered and precipitated, humus is broken down and formed and soil organisms live and die. The sun drives the whole system via photosynthesis and the fixing of atmospheric carbon by plants.

Inputs to the orchard nutrient pool come from the weathering of soil minerals, from biological fixation (nitrogen) and from applied soil amendments and fertilisers. Small amounts also come from atmospheric deposits (sulphur, nitrogen, potassium, sodium). In natural ecosystems very few nutrients are lost from the system. Nutrients are cycled between plants and soil and back into plants. The orchard system, however, loses nutrients through the removal of harvested products, as well as by increased rates of leaching and erosion. Ideally nutrients should be returned to the orchard soil from where the fruit is consumed. In the future this may become a reality[12], but at present nutrient management in the organic orchard consists of reducing nutrient losses from the system by sward management (including the use of legumes to add nitrogen) and by adding nutrients from outside sources.

In the organic system, crop nutrition is based on the slow microbe-mediated release of nutrients from soil organic matter (SOM). Nutrients are added mainly in an organic form such as compost. The conventional approach to crop nutrition is based on the use of highly soluble chemical fertilisers that release

Nutrient Cycling



large amounts of nutrients simultaneously into the soil solution, effectively forcing plant uptake. This can lead to unbalanced growth and environmental contamination. Unbalanced growth can lead to increased susceptibility to pest and diseases and unhealthy levels of some compounds in the produce (e.g. high nitrate levels). Conventional fertilisers can also cause the depletion of other nutrients and SOM and interfere with the processes of humification[13].

In the organic orchard the emphasis is placed on feeding the soil and its microbial population rather than directly feeding the crop.

Soil fertility

Soil fertility is the capacity of the soil to support the growth and productivity of the crop. The two main components of fertility are soil structure and the quantity of nutrients that are available for plant uptake. The availability of the nutrients to the crop and for that matter to the rest of the soil community, largely depends on soil structure. Thus the maintenance of fertility is as much about building and preserving soil structure as it is about adding nutrients.

Most horticultural systems are operated with relatively high levels of soil fertility compared to other farming systems and, particularly, to natural ecosystems. The organic ideal of independence from external nutrient inputs (developed with less intensive pastoral and arable farming in mind) does not apply so well to organic horticulture. The level of production expected by most organic summerfruit growers can only happen in highly fertile soils and will usually require significant nutrient inputs to be maintained. Soils vary greatly in fertility and, therefore, in the amount and range of nutrient inputs that will be needed for satisfactory production. Some soils are naturally fertile (e.g. alluvial river flats and some volcanic loams), while others have had their fertility raised by a history of legume based pastures and intensive fertiliser programmes. High yields may not be sustained if this initial fertility is depleted by inadequate nutrient inputs. Local knowledge of a particular soil and its best management is often a valuable resource not to be overlooked.

High fertility increases the risk of nutrient loss by leaching and erosion. These losses can then cause pollution elsewhere in the environment. Such losses are less likely to occur from organic orchards because of more efficient nutrient cycling, better soil structure, less bare ground and a more vigorous sward. However, they could still occur if excessive quantities of an organic soil amendment were applied before heavy or prolonged rain. Therefore, it is important to limit nutrient inputs to quantities able to be utilised by the trees and sward, and to reduce the risk of runoff by maintaining vegetative buffer zones around the orchard, especially adjacent to waterways.

Repeated applications of the same type of organic soil amendment can result in soil nutrient imbalances. For example, annual applications of composted chicken manure can result in excessive soil phosphate levels. Soil nutrient levels should therefore be monitored by regular soil tests and the nutrient composition of amendments should be known either by analysis or by reference to published information sources[14] (Tables 1 – 3). The nutrient value of many organic soil amendments is variable, both between different batches and over time, as they mature or age. Therefore, estimation of application rates should be guided by nutrient analysis of bulk inputs.

Fertilisation of the orchards has two stages; building fertility and maintaining fertility. Where necessary, fertility must be built up over a period of years with relatively large nutrient inputs. Inputs can be reduced to maintenance levels once soils have been improved to a satisfactory extent as indicated by soil tests, foliar analysis and tree productivity and appearance. Nutrient inputs should then be estimated on the basis of nutrients removed in crops, while allowing for other factors such as winter leaching loss and tree growth[15,16]. A 10t/ha crop of peaches is estimated to remove about 23kg of nitrogen, 2kg of phosphorus and 19kg of potassium[17]. Young trees that are making rapid growth, need relatively higher nutrient inputs than mature trees.

The management of soil fertility depends on maintaining a biologically active soil, which can release nutrients from the soil making them available for crop growth. If this can be achieved, then dependence on purchased fertilisers, mineral or organic, can be reduced without necessarily any significant yield reduc-

tions. A nutrient deficiency problem should be solved by assessing and amending the physical and biological condition of the soil, the balance of rotations and suitability of horticultural practices. Building a healthy fertile soil is a long-term process and is unlikely to be achieved in one or two seasons.

For certified properties before soil amendments are used, reference should be made to the standards of the relevant certifying body (e.g. Bio-Gro, Demeter or AgriQuality).

Tree nutrition

There are at least 16 nutrient elements that plants must obtain from the soil. A deficiency in any one of these can reduce growth, fruit yield and fruit quality. Nutrients must be dissolved in the soil water to be taken up by plant roots. Trees, including summerfruit, are able to efficiently recycle nutrients. Nutrients are recovered from senescing leaves and stored in the wood and roots until the following spring, when they are relocated to developing flowers and shoots. In fact, early development is supported more by nutrients (particularly nitrogen) relocated from storage tissues than by direct root uptake; root activity is often limited in early spring by cold soil conditions. Summerfruit generally have a high demand for nitrogen and potassium.

The productivity of the trees is more determined by the long term management of tree nutrition in contrast to 'quick fix' attempts to fertilise the crop directly. Feed the soil not the crop.

Nitrogen (N). As soil organic matter levels increase under an organic management regime, the need for additional nitrogen inputs should be reduced. Its availability to the trees is then controlled by sward and soil management, i.e. by mowing and mulching to maintain moist soil conditions. Practically all the soil's nitrogen reserves are contained in organic matter. Soil organisms play an essential role in making nitrogen available to plants. If the soil's total nitrogen content amounted to 9000kg N/ ha (soil content normally ranges from 2000 to 12000kgN/ha) and is mineralised at the rate of 1 to 2% per year, there would be 90 to 180kgN/ha available for plant uptake per year. This is likely to be enough to meet the nitrogen requirement of most summerfruit orchards. However, nitrogen is easily lost by leaching during heavy rain or irrigation. Legumes in the sward can make a significant contribution to the orchard's nitrogen requirement. Between 118 and 126 kgN/ha/2yrs was reported fixed by white clover in an organic apple orchard[18]. Plants take up nitrogen as nitrate, ammoniumor as organic forms, such as amino acids and proteins, with organic forms probably playing a larger role in organic systems[19]. A deficiency of nitrogen could be indicated by pale green or yellowed foliage, reduced growth and leaf size, small more highly coloured fruits and premature leaf drop. Excess can cause split stones and less colour.

The most concentrated sources of nitrogen for the organic orchard are the protein-containing animal products such as meat & bone meal, dried blood and fish-meal (Table 1). Alternative less concentrated but generally preferred sources of nitrogen, include animal manure, compost and green vegetable matter (e.g. grass clippings and green manure crops). Soil amendments being used to supply nitrogen are usually applied in early spring, although uptake might be increased with early autumn applications. There is greater risk of leaching from autumn applications so care should be taken to apply no more than can be taken up by the trees or orchard sward and applications should be made earlier rather than later. Most of the nitrogen in compost will be mineralised (become plant available) during the three months following application. So, compost applied in May will release nitrogen during some of the wettest and coldest months of the year (June, July) when plant uptake will be reduced and leaching at a maximum. Spreading the compost or manure evenly will reduce leaching loss with the interlaced root systems of sward and trees more likely to intercept and utilise mobile nutrients. Liquid manures applied sparingly, evenly and often, are an efficient way of supplying nitrogen.

The amount of nitrogen needed by a summerfruit orchard will vary greatly according to such factors as the fertility of the soil, type of summerfruit and the age or size of the trees. Young trees have a relatively higher demand than mature trees, but total tree requirement depends more on tree size. Unpruned trees need more than pruned trees. Fruit thinning can also reduce the demand. Conventional recommendations (up to 250 kg N/ha/yr) are often in excess to the actual tree requirement. Peaches and nectarines tend to have a higher nitrogen requirement than plums and summerfruit generally have a higher requirement than apples. As a guide, meat & bone meal or fishmeal could be used at between 1 and 2kg/tree/year for mature trees in moderate to low fertility soils. Assuming five by three metre tree spacing, this would equate to 40–80kgN/ha/yr. In a certified organic orchard these materials would have to be hot composted before use. The nitrogen content of compost varies widely depending on composting method, age and feedstock (Table 1). To supply 50kgN/ha from a compost containing 8.25kgN/tn (6.6kg/m3) would require about 6 tonnes ($8m^3$) of compost. There may be a limit for nitrogen applications imposed by certifier e.g. 170kgN/ha/yr for Bio-Gro.

Potassium (K) can be removed in relatively large amounts in harvested fruit and the soil's ability to sustain this loss depends largely on soil mineralogy. Some soils contain large potassium reserves in mineral parent material (e.g. recent alluvial soils), while others have low reserves (e.g. peats and the older volcanic soils of Northland). Potassium exists in the soil in different forms of varying availability to plants. Soil tests generally only show the immediately available potassium. Knowing the long term ability of the orchard's soil to supply potassium from its mineral reserves would help to manage potassium inputs to ensure long term sustainability. Potassium is relatively mobile within the soil and so is liable to be leached. It also competes with other nutrients for positions on exchange sites (where nutrients are stored on the surfaces of soil particles) displacing them, which can lead to their loss by leaching. Similarly, potassium competes with other nutrients for plant uptake, most notably with magnesium. Consequently magnesium deficiency can result if excessive potassium is applied. Plants can take up excessive and toxic amounts of potassium if it is available (termed – luxury uptake). Repeated applications of organic soil amendments that are high in potassium, such as hay, straw, some composts and particularly the highly soluble forms such as potassium sulphate, potassium chloride, Patenkali and wood ashes, could result in excessive levels of potassium in the soil. Potassium can also be obtained from less soluble minerals such as feldspars and micas, but they would need to be finely ground and perhaps composted first. Plums are often responsive to additional potassium. Deficiency symptoms include reduced size of leaves, shoots and fruits. Leaves can become brown with scorched margins and fruits are poorly coloured and sour. Potassium is considered important in plant health, hardiness and resistance to disease.

Phosphorus (P) is not required in large amounts by summerfruit and will normally be present in sufficiency in the soil and in organic soil amendments. Rock Phosphate (RPR) can be applied to stimulate clover in the sward. Young trees are more likely to benefit from additional phosphorus than older trees. Similarly, sulphur (S) and sodium (Na) will usually be adequately supplied by most soils and are present in most organic soil amendments. Elemental sulphur could be applied if a deficiency was discovered. Calcium (Ca) can be supplied in lime, dolomite, gypsum, ground shell or wood ash. It is also present in many other organic soil amendments such as compost. Most soils are well supplied with calcium. Magnesium (Mg) can be supplied if necessary by dolomite, kieserite or Epsom salts. The rock minerals Patenkali and langbeinite supply magnesium and potassium.

Table 1. **Approximate nutrient content in some common organic soil amendments (kg/tonne).**

Material	Nitrogen	Phosphorus	Potassium
Compost (municipal green waste)	8.25 (6.6)*	1.38 (1.1)	5.50 (4.4)
Compost (fish/bark)	12.3	1.4	3.3
Meat & bone meal	60	70	
Chicken manure	9.0	10.0	9.0
Fishmeal	80	40	-

*numbers in brackets = kg/m3

Note: American and European sources measure phosphate and potassium content of fertilisers according to the oxide content (P2O5 & K2O), whereas in NZ the elemental content is measured (P & K). To convert %P2O5 to %P divide by 2.3; to convert % K2O to %K divide by 1.2

Trace elements

Trace elements, although needed in only 'trace' or very small amounts, are nevertheless essential for plant development. Some soils may be inherently deficient in one or more trace elements or plants may not be able to extract them due to some nutrient imbalance or microbial factor. For example, high levels of NPK can lead to reduced zinc (Zn) and copper (Cu) uptake by inhibiting mycorrhizal activity[20]. Identifying the soil type, being aware of local knowledge concerning it and particularly leaf analysis, can help discover trace element deficiencies.

Trace elements will usually be well supplied with organic soil amendments, so that trace element deficiencies may be less likely to develop in organic orchards. Fish and seaweed products are especially good sources of trace elements. Different plant species (dynamic accumulators) are able to accumulate higher amounts of some trace elements (Table 2), sometimes, in the case of deep rooting plants such as chicory and comfrey, obtaining them from deeper soil levels and bringing them to the surface where they can become part of the orchard's nutrient pool.

Rock dusts can also be a source of trace elements. Common rock based products including rock phosphate, lime, dolomite and various potassium minerals, usually contain many other elements in varying amounts. However, they can also contain toxic elements such as cadmium and arsenic or trace elements in excessive and toxic amounts. To be effective rock dusts need to be finely ground. The bio-availability of the nutrients contained in rock dusts could be improved by composting.

Animal manures and particularly municipal bio-solids (sewage sludge) and fish-based products (especially deep-sea derived), can also contain toxic trace elements such as cadmium, mercury and lead. The technology to remove heavy metals from municipal wastes is at least theoretically possible and in the future this huge resource will be doubtless be utilised, making far more sustainable agricultural systems possible[12].

Zinc (Zn) is a common deficiency in summerfruit in Central Otago. Deficiency symptoms include: small, yellowed leaves in rosettes on shoot tips and spurs (plums); crinkled leaf margins; and delayed foliation in spring (peaches). Fruit are likely to be small and misshapen. High levels of phosphorus, calcium and a high pH can inhibit uptake of zinc. Zinc is often present in unavailable forms in soils. Increasing soil biological activity is likely to make these reserves more available. Zinc is supplied with many organic soil amendments and is also present as an impurity in RPR. If a deficiency is identified, it can be supplied in the form of zinc sulphate: as a foliar spray (400g $ZnSO_4$: 400g hydrated lime:100L water) or soil applied (10kg/ha). Zinc sulphate might also be included in compost heaps.

Manganese (Mn) deficiency induced by a high pH is not uncommon in summerfruit. Deficiency symptoms are similar to nitrogen or magnesium deficiency (yellow leaves). If a deficiency is identified and is pH related, it would be better to reduce the pH than to apply more manganese. Some basalt rock dusts contain large amounts of manganese. Foliar sprays can also be used (600g $MnSO_4$: 800g hydrated lime: 100L water).

Molybdenum (Mo) is needed for the nitrogen fixing activity of legumes. It is commonly applied in pastoral farming as sodium molybdate (50g/ha) to stimulate clover growth. It can also be present as an impurity in limestone.

Iron deficiency occurs mainly in alkaline soils and is best rectified by lowering the pH. Iron chelate (50–100kg/ha) can be applied to soil in spring.

Boron deficiency is more likely in apricots than in other summerfruit types. If necessary a foliar spray of boric acid (100g/100L) or borax (200g/100L) can be used. Peaches and nectarines are very sensitive to boron toxicity. Boron is routinely applied in apple orchards so sites that have been used for apples in the past may have high boron levels in the soil.

The use of soluble salts to supply trace elements needs certifier approval and is only appropriate where a deficiency has been identified and there is no practicable alternative.

Foliar nutrition

Plants can absorb nutrients through the leaves as well as through the roots. Foliar sprays of fish emulsion are often used to supply extra nitrogen and other nutrients (e.g. potassium and trace elements). Seaweed, humates, amino acids, molasses, compost teas and various other mixtures are also used. Supplementary foliar nutrition can be especially useful around the times of flowering and fruitset when the tree's nutrient demand is increased. Foliar nutrition is an effective way to correct a trace element deficiency. Young tissues (i.e., young leaves, growing tips, flowers and fruitlets) absorb nutrients more effectively than mature leaves. Absorption is also promoted by high humidity and daylight when leaf stomata are open. Some materials can cause fruit blemish. Quick drying conditions when sprays are applied or spraying after harvest would help to reduce or avoid such damage. It is useful to leave some trees unsprayed to monitor the effect of the spray material on fruit finish as well as for general effects on fruit size, fruit set, etc.. This applies not only to foliar nutrient sprays but also to any material sprayed onto the trees.

Microbiological contamination of food is an area of growing consumer concern. Therefore, care should be taken to avoid the use of animal protein based foliar sprays (e.g. fish emulsion) close to harvest. Care would also be necessary with the use of compost teas (e.g. suitable compost materials and process) for the same reason.

Nutrient sprays such as liquid fish and seaweed can have other benefits such as repelling pests and triggering plant defences against pest attack (see the Crop Protection section).

Soil tests and leaf analysis

Soil tests are used to determine the nutrient reserves held in the soil, monitor long-term trends in soil fertilityand help design soil management programmes. NZ soil testing laboratories use tests that have been standardised and calibrated for NZ conditions. Most of the variation found in soil tests is due to spatial variation within the orchard/field and temporal variation due to seasonal changes in moisture, temperature and biological activity. Nutrients shown to be present by soil tests are not always available to plants. Another limitation of standard soil tests is that they do not measure nutrients contained in SOM or the biological activity of the soil, both of which are important factors for organically managed systems.

When sampling, soil should be taken from the same depth as the main tree feeder roots. Also be mindful of differences that might occur between the tree lines and the inter-row strips as a result of compost and other soil treatments. Soil can also vary widely within an orchard – look for different topographical features, e.g. humps, hollows, terraces; wet spots; markedly different vegetative growth in the sward and/or trees; and different sward species.

Where production levels justify the cost, soil testing should be done annually, at least until a balance in nutrient levels is established. The results should be carefully filed for long term monitoring. Soil samples can be taken at any time of the year but successive tests should be done at the same time, because of seasonal fluctuations in nutrient levels.

The pH of orchards can be measured with colour indicator strips, pH meters or as part of routine soil analysis undertaken by soil labs.

Leaf analysis allows the nutrient status of the trees to be compared to optimum levels for the variety. They give an indication of how well the tree is managing to obtain

nutrients. Leaf analysis can indicate a nutrient deficiency before visible symptoms appear and productivity has been affected; but it is harder to use for adjustment of close to optimum levels. The results of leaf analysis need to be interpreted with care, however, as many factors can cause variation in leaf nutrient levels including seasonal effects, crop load, tree age and vigour, pruning history, orchard floor management and the variety and rootstock combination. Also, there is not always a close co-relation between levels of nutrients in the soil and levels found in leaves. For example, a soil test showing low Olsen P (standard measure of P in NZ) might still have high foliar levels of P. Interpretation is made more difficult still by the generally inadequate comparative data. Despite their limitations, leaf and soil analyses interpreted along with historical records and evaluation of tree condition (age, crop load and vigour) are still a valuable tool for growers. They help to achieve good crops, to build healthy soil, to select the most efficient nutrient inputs and can detect deficiencies (or excesses) before productivity is seriously impaired.

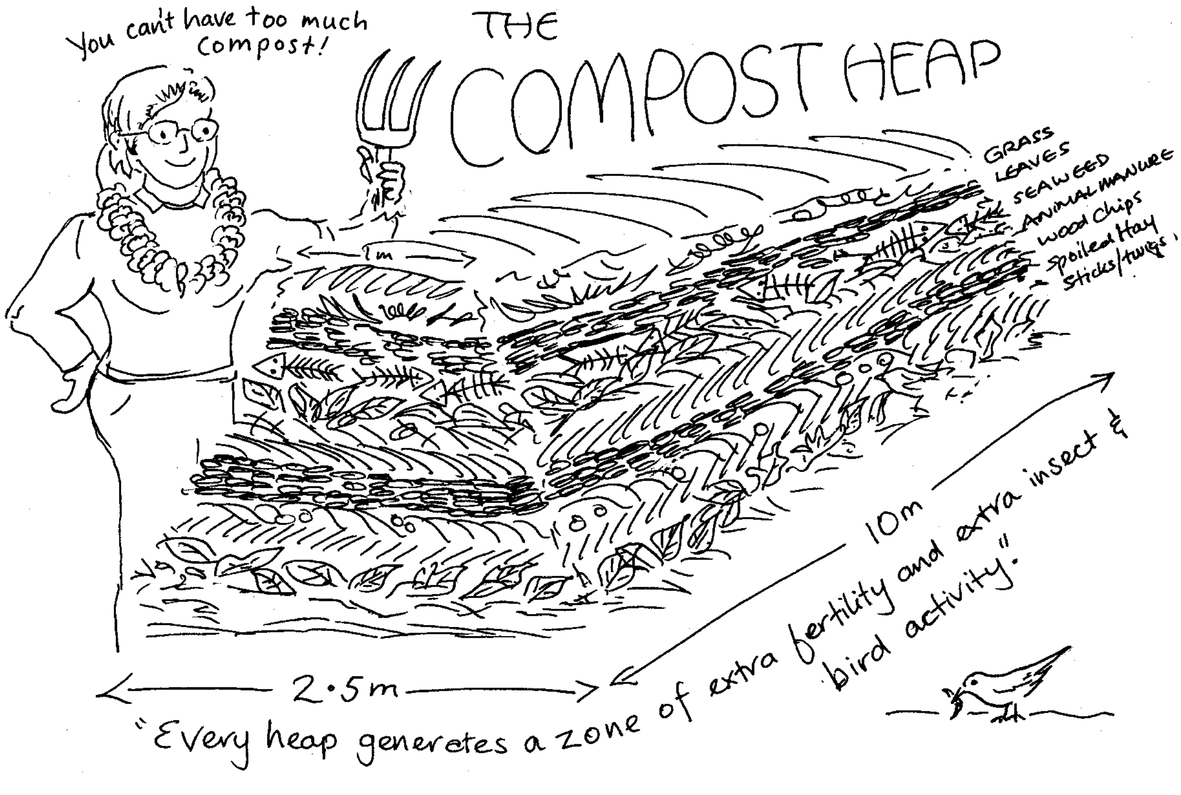
For peaches and nectarines mid-shoot to basal leaves are selected, while for plums, non-fruiting spur leaves are used. Samples can be taken January to March. Different aged trees and rootstock/scion combinations should be sampled separately. Leaves should be washed clean, dried, placed in paper bags and sent immediately to the laboratory.

Visual analysis can with practice be used to determine the nutrient status of trees, although this should complement and not replace, soil and leaf analysis. An experienced eye can distinguish subtle colour differences in plants, which can be early indicators of stress or deficiency. Leaf shape might also reflect growing conditions[21]. Soil health can also be assessed using a system such as VSA[22]. This is an easy-to-use on-farm soil testing system that uses visual assessment to rate various soil quality indicators.

Compost

Compost is the ideal way to add nutrients to the organic summerfruit orchard. It will usually contain a wide range of plant nutrients and release them slowly for efficient use by the crop. Compost can also add beneficial soil organisms and humus, while at the same time it can improve soil structure. Beneficial organisms fostered in and by compost include fungi and bacteria species needed for important soil processes such as the formation of humus (humification), as well as anti-pathogenic species that destroy harmful disease-causing microbes (such as Phytophthora spp.). Used as mulch, compost can conserve soil moisture.

Applying un-decomposed materials directly to the soil can have adverse effects. For example, nutrients can be lost when materials applied directly to the soil rapidly release nutrients in excess of what plant roots can take up. Also many materials can produce toxic compounds during the early stages of decomposi-



tion that can harm the crop. Raw animal manures can damage tree roots, especially those of young trees. These adverse effects are usually avoided if the materials are first composted. Hot composting can also help to destroy synthetic chemical residues, pests and their eggs, disease spores and weed seeds present in the raw materials.

There are many ways to make compost but whatever method is used care should be taken to preserve as much of the nutritive value of the compost ingredients as possible. Nutrients can be lost (especially N) if the pH is too high, insufficient woody material (e.g. hay, bark) is added (C:N ratio too low)or the heap is too wet or exposed to rain. Compost heaps are a potential source of environmental pollution and should be covered to prevent leaching. If leachate is produced it should be recovered, e.g. a contoured base draining into a suitably sized container). Most methods try to maintain aerobic (aerated) conditions and decomposition processes by periodically turning the heap and including coarse ingredients such as bark or straw. When starting a heap the raw materials should be chopped finely and either thoroughly mixed together or layered thinly. Although composting anaerobically (no air) can reduce N losses, aerobic composting is likely to create a superior microbial profile.

Many compost ingredients will tend to raise the pH of the heap. High pH will cause the loss of N (as ammonia) to the atmosphere. For this reason lime should not usually be added to the heap. Composting poultry manure with sulphur (to reduce pH) and straw (to absorb ammonia) can reduce the loss of N[23]. Materials such as straw, bark, peat or zeolite, added to the compost, can absorb N and help to prevent its loss[24]. The carbon: nitrogen ratio (C:N ratio) can give an indication of the maturity of the compost and how much N will be plant available. A high C:N ratio (>30:1) suggests an immature compost likely to cause N immobilisation, while a low C:N ratio (10:1–20:1) is typical of a properly matured compost with a large proportion of its N likely to become plant available in the first season.

Biodynamic composting uses special herbal preparations to guide the composting process: yarrow, dandelion and chamomile blossoms, stinging nettle shoots, oak bark and valerian extract (Preparations 502–507) (Table 7). These result in higher composting temperatures, faster compost development and different N characteristics[25]. It is also believed that their use results in a more balanced product that has a higher absorp-

Table 2. **Important nutrients in some plants used for composting.** Adapted from Pearce[27].

Plant	Nutrients
Thistles	nitrogen, copper, silicon
Bracken fern	potassium
Comfrey	phosphorus, calcium, iron, potassium, sodium
Alfalfa	potassium, nitrogen, phosphorus
Buttercup	cobalt
Chickweed	copper, boron, zinc, phosphorus, iron
Ragwort	copper
Sorrel	calcium, phosphorus
Inkweed	potassium
Fennel	copper, potassium, sodium, sulphur
Willow	calcium
Blackberry	iron
Broom	magnesium, sulphur
Borage	potassium
Yarrow	sulphur, potassium
Stinging nettle	iron, phosphorus
Gorse	nitrogen
Horsetail	silica, calcium
Banana leaves	phosphorus, potassium
Grass	nitrogen, potassium
Hay	potassium, nitrogen

Table 3. **Important nutrients in some compost materials.**

Material	Nutrients
Seaweed	potassium, sulphur, calcium, nitrogen, iron, plus other trace elements
Fermentation sludges	nitrogen, calcium
Hair, feathers and wool	nitrogen
Wool wastes	nitrogen, potassium, phosphorus
Leather dust	nitrogen
Pea residues	nitrogen, potassium
Wood ashes	calcium (liming effect), potassium, phosphorus, magnesium, zinc
Animal manures	nitrogen, phosphorus, potassium
Basic slag	phosphorus, calcium, magnesium, plus other trace elements
Citrus residues	potassium

tion and vitality rating. Using a wide range of materials helps to ensure the compost contains all the essential elements as well as having a rich microbial profile that will continue the decomposition process (Tables 2 & 3).

The certified orchard will need to use certified organic materials for composting. Ready-made composts would also need to be certified. Special permission can be sought from the certifying organisation to use non-certified materials. Some indication will need to be provided that such materials do not contain chemical residues or other contaminants.

The amount of compost to apply depends on the quantity of other nutrient inputs, the size of the trees, the planting density and the quality, availability and cost of the compost. Applications of between 5 and 20 tonnes/ha/yr (12.5–25m3/ha/yr) are probably realistic for mature orchards. Germination tests using cress or lettuce seeds can be used to determine the maturity of the compost before use. A germination test can be done by soaking a paper towel in leachate from the compost, placing the seeds on the wet towel and placing in a hot water cupboard on a suitable tray. The presence of toxic compounds in the compost would inhibit the germination of the seeds[26].

Compost tea can be brewed from compost with greatly increased microbial concentration. This can be applied to the soil or sprayed on to the trees.

Vermicompost is made by using worms to process organic materials. Trials on grapevines showed yield increases between 15% (application rate: 10L/m3) and 50% (application rate: 20L/m3) for at least 3 harvests following one initial application. The vermicompost needed to covered with straw mulch to gain the yield increase[28].

Mulch

Covering the ground with mulch reduces the rate of evaporation from the soil surface. Placed around the trees, it can maintain moist soil conditions in the tree root zone and by suppressing the understorey, reduce competition for nutrients. Mulching young trees greatly improves their growth and establishment. Organic mulches add nutrients to the soil as they break down, reduce fluctuations in soil temperature, improve soil structure and increase soil humus content. All of these effects are beneficial for microorganisms and the trees. Mulch can also prevent rain splashing, disease-causing spores from the ground into the tree canopy (e.g. peach scab).

Mulch is best applied to moist soil. Excessively thick layers of dense mulch material can cause anaerobic soil conditions (especially harmful for peaches, nectarines and apricots). Mulches should not contact the tree trunk because they could cause rots to develop in the bark.

Suitable mulch materials include hay, straw, compost, newspaper, grass clippings, gorse chips and aged wood chips. Materials such as hay, straw and woodchips have a high C:N ratio and will tend to be slower to break down and therefore last longer as mulches than materials with a low C:N ratio such as grass clippings, animal manures and composts. Woodiness represents carbon while greenness represents nitrogen. Green materials break down quicker but introduce more nitrogen to the system. Wood chips and other high-carbon mulch materials could cause a temporary soil nitrogen deficiency, especially if incorporated into the soil. In general, the more resistant plant materials will contribute more to humus and soil aggregate formation than those that decompose rapidly. Permanent synthetic mulches are not as suitable because they interrupt the humus forming and nutrient cycling processes in the important rooting areas closest to the tree.

The sward

The sward or understorey, fulfils a number of important functions in the organic orchard (Table 5). One of the most important is its role in building soil structure and increasing soil organic matter (SOM). Interactions between plant roots, soil and soil microbes play a large role in the formation and maintenance of soil aggregates – the basis of soil structure. The recycling of sward vegetative parts and roots adds large quantities of organic matter to the soil. The sward also helps prevent the leaching of nutrients. This function is related to the way the different root dimensions and growth cycles of the sward species form an interlaced network of roots that intercept and take up mobile nutrients (especially N).

However, the roots of the fruit trees are concentrated in, and derive nearly all their nutrient and water requirements from, the same top layers of soil as do the roots of sward plants. Many plant species within the sward can be highly efficient nutrient foragers and therefore are very competitive with other sward plants and, more importantly, with the trees. In particular, grass species are among the most competitive of plant species, which is why natural grasslands are usually very stable and durable ecosystems. A point to note about grassland ecosystems is that the total amount of organic matter, both living and stored in soil, is similar to that of forest ecosystems. The difference is where it is stored: in the forest it is mostly above ground; in grasslands it is nearly all below the surface in roots or stored in SOM. This indicates the large proportion of the orchard's nutrient pool that can be 'tied up' in the sward. For example, in an orchard where the sward has become overgrown (knee-high or higher) the harvestable vegetation may contain approximately 180kgN, 18kgP and 120kg K per ha. (assuming 6000kgDM/ha). This quantity of nutrients would be likely to represent a significant proportion of the orchard's total plant available nutrients.

A rapidly growing sward, as is often found after mowing or in the spring and autumn, would be even more competitive. Because fruit yields are not just the product of the current season's conditions but are also strongly determined by the conditions of previous seasons, strong competition from the sward during the current season can depress the yields of subsequent seasons[29].

Competition from the sward for water and nutrients is perhaps the single most limiting factor in crop productivity and growth in organic orchards.

To gain the benefits of a healthy sward while minimising its competitive effect with the trees, it must be properly managed. Sward competition to the trees is minimised by regular mowing,

Table 5. **Sward functions in an organic orchard**

Attribute	Function
Root – soil interactions	Improved soil structure and drainage, gathering of nutrients from deeper soil profiles
Legumes	Fixation of nitrogen
Biodiversity	Ecosystem stability, enhanced soil biological activity – rapid nutrient cycling
Nutrient uptake	Nutrient concentration for increased availability for fruit trees, interception of leaching nutrients
Insect host	Enhanced populations of beneficial insects
Supplementary food for animals	Insect predation (by poultry) and manure, secondary production (e.g. eggs, meat)
Ground cover	Protection of soil from weathering, run-off, erosion and temperature extremes
Plant material	Source of mulch and means of transferring nutrients to trees, increased SOM

preferably timed to coincide with the periods of maximum tree uptake or with periods of dry weather when the clippings mulch the surface and conserve moisture. Mowing is best postponed during winter to protect the soil from damage from mowing machinery or heavy rain and to maximise the capture and storage of nutrients by the sward – preventing their loss by leaching. Where the roots of the trees do not extend all the way across the row (e.g. in young plantings), benefit may be gained by directing the clippings to the tree line with a side delivery mower (Table 6).

However, this is not the end of the story. Flowering plants in particular play an important role in encouraging beneficial insects. If there are many flowering plants present before mowing, alternate rows or one side of each row can be left un-mowed to preserve the flowers. Orchards that are well provided with headlands and other wild areas may already have sufficient habitat to preserve beneficial insect species. Organic orchards may not appear as 'tidy' as conventional orchards with flowering 'weeds' left un-mowed or sprayed, but such areas in reality play an important part in the orchard ecosystem.

Legumes should be encouraged into the sward. White clover will not fix nitrogen nor successfully compete with most grass species if stressed by dry soil conditions. To promote clover, consider irrigating the row centres during summer and apply RPR and lime to the whole orchard floor, not just to tree lines. Regular mowing (mowing height about 5cm) will also encourage clover. Therefore, mowing alternate rows not only preserves flowering plants but will also help to maintain clover.

Deep rooting species including chicory and comfrey may be less competitive with the trees than grasses and can also bring nutrients from deeper soil levels into the orchard system. Other deep-rooted weeds such as carrot weed, which makes excellent mulch, are also beneficial. Some weeds can host pest insects, e.g. dock is host to leafroller. Weeds growing into the trees need to be controlled, although many of these probably have other more beneficial attributes. For example, weeds such as ink weed, nightshade and cleavers are rich in nutrients, can successfully compete with perennial grass weeds and through root-soil interactions may have beneficial effects on the health of tree roots. Plaintain readily forms mycorrhizal associations and may encourage their proliferation in the orchard.

Legumes including red, subterranean and white clover and lotus major can be over sown. Herbal leys, manure crops and wild flower seeds can be broadcast in spring or autumn. Many species will need repeated sowings to maintain their presence in the sward. Comfrey can be introduced by planting root cuttings.

Vigorous perennial grasses (e.g. kikuyu, twitch) can be very competitive with fruit trees and can severely inhibit the growth of young trees. They do however make good compost and mulch, and with regular mowing can add plenty of organic matter to the soil. When using hay for mulch, beware of introducing unwanted perennial weed species into the orchard.

It is more important to vigorously suppress the sward within the tree row (i.e. within the drip line of the trees) than between the rows (the row centres). In many orchards the row centres are well maintained but the tree rows are left uncut. While mowing the centres might be easier and faster it will do little to help the trees compete with the sward. This is because the main feeder roots of the trees are found within the area closest to the trunk and competition from the sward within this area will have most impact on the trees. The sward is usually suppressed either by mowing or by mulching. Shallow cultivation could also be used provided care is taken not to damage the tree roots and soil degradation is avoided by compost additions or by allowing

Table 6. **Annual inputs of nutrient applied along the tree row (1m band) in an apple orchard.** **Source: Marsh et al, [30].**

Treatment	Annual addition of nutrient (g/m^2)			
	N	P	K	Ca
Control: mowing with a mulch mower spreading clippings over the whole orchard floor	5.3	0.3	4.3	1
Pea straw mulch applied to the tree line as a 1m band	40	3	45	70
Mowing with the clippings applied to the tree line only	32	2	26	6

the sward to re-establish between cultivations. Other alternatives include flaming and organic herbicides although the cost effectiveness of these approaches could limit their use. Flaming would be likely to encourage perennial weeds; herbicides would tend to reduce sward diversity (certain species able to withstand the herbicide would dominate).

Mowing

Mowers can be expensive pieces of machinery. However, second-hand mowers can often be bought and reconditioned cheaply. Second-hand machines are not necessarily the cheapest option in the long term. They can also be adapted to better match the orchard's needs. For example, the cheapest mower that will deliver the cut material from the row centres to mulch the tree lines is a standard rotary-slasher with one side open for side delivery. Such a machine can be adapted to be at least slightly offset. Belt-driven triple-spindle mowers are available, including offset and side delivery versions. Mowing machines must be matched to the horsepower of the driving tractor or else either one may be damaged. They must also be suited to any contouring or mounding of rows in the orchard.

Swing-arm mowers are probably the most suited to cutting the sward close to the trees. A cheaper alternative might be a disc mower, such as are used for cutting hay. Scrub bars or weed-eaters are noisy, can damage the trees and are hard on the operator; a traditional hand scythe can be faster, quieter and much less stressful on the operator. The knack to using a scythe is to pretend you're cutting bread – don't hit it, slice it with a sawing motion; touch up the blade with a stone or file after every tree or so. Self-propelled walk behind rotary or sickle-bar mowers may also be suitable.

Note:

Mulching mowers pulverise the sward – good for rapid recycling of nutrients

Sickle bar mowers, scythes and scrub bars leave the cut sward mostly intact – good for a longer lasting mulch effect

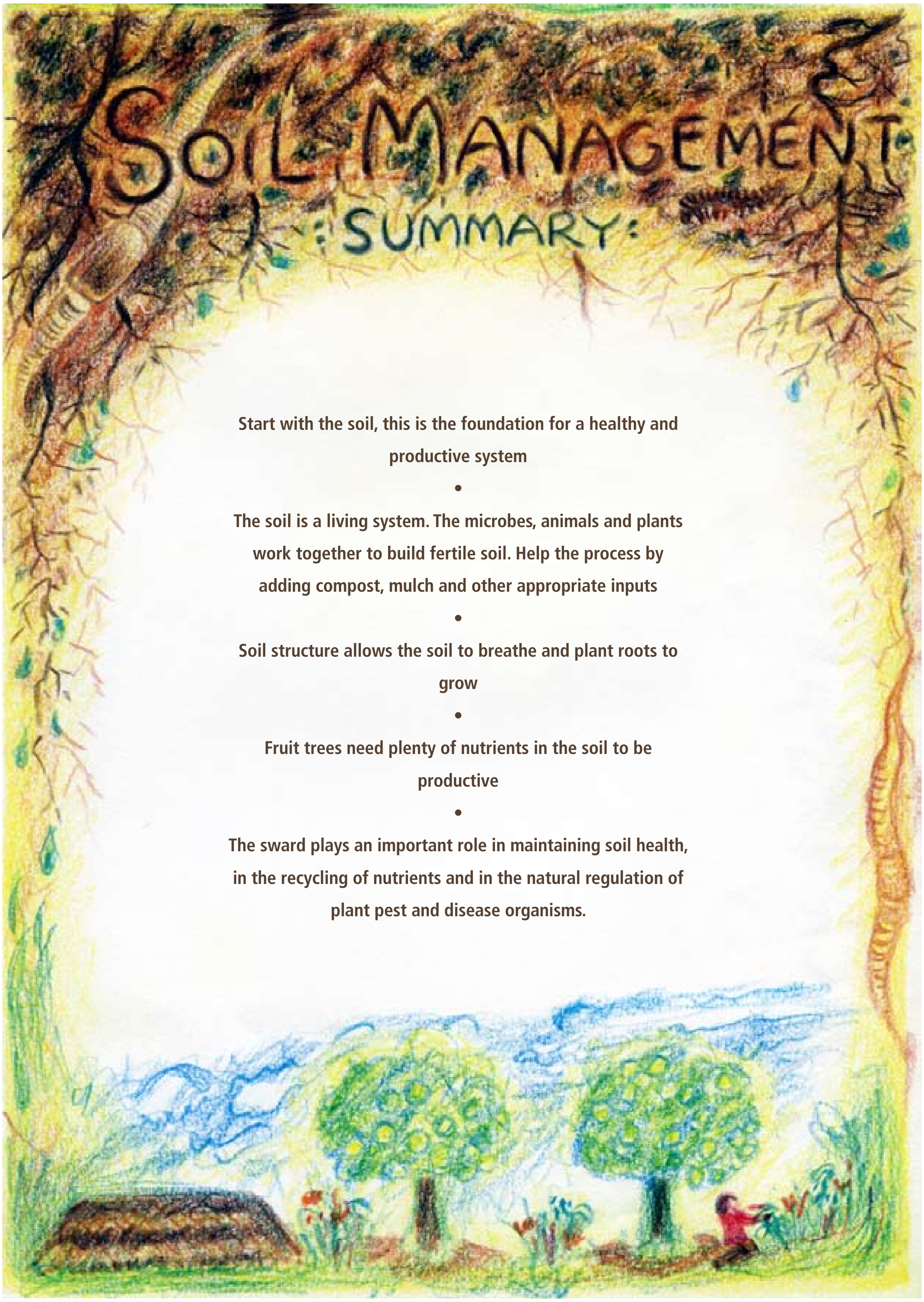
Slow speed rotary mowers – intermediate between mulching mowers and sickle bars.

Within the tree lines the sward should be cut as short as possible during the spring, summer and autumn. Within the tree rows the mower can be set depending on how much mulch is needed or what sward species are being encouraged. For example, shorter mowing during early spring and autumn can promote white clover and other low growing or spreading species by reducing competition from the grass component of the sward.

Cutting the sward in early spring with a side delivery mower can also allow rosette-forming biennials such as carrot weed to establish and can also expose the surface and allow emerging beetle larvae to be predated by birds.

A recent survey of organic stonefruit growers shows that current practices for managing the understorey and sward include:

- *Encouraging development of a wide range of plant species (including weeds) to provide a balanced environment and encourage beneficial insects. These species are being encouraged in the sward, understorey and also along headlands, shelterbelts and in some cases on adjacent property. Particularly suited to this are species with umbelliferous flower heads*
- *Mowing the sward, usually with a mulch mower and/or swing arm and in many cases directing the clippings to the under tree area to provide mulch*
- *Grazing sheep over the winter months is an option, provided growers are cautious about damage, particularly to young trees and to moist soil (compaction)*
- *Avoiding mowing any more than necessary to avoid soil compaction and also to allow plants to flower to encourage insect life. In some cases this is achieved by alternate row mowing*
- *Growing a range of specific species such as clover assists in maintenance of nitrogen in the soil. Fungal activity should be encouraged so that nitrates which are produced by legumes such as clover can be converted into plant available Nitrogen i.e. ammonium*
- *Most growers felt that young trees struggle to establish when there is competition with weeds and grasses, however they also indicated that this could be minimised by using mulches such as compost or straw to prevent weed development. There are some herbicides now approved for restricted use on young trees. Growers should check the certification standards before use*
- *Most growers indicated a desire to use more compost and mulch in the understorey, however issues such as cost and in the South Island easy access to a suitable supply meant that very few felt able to do as much as they would like in this area*
- *Consideration needs to be given to the ease of location and removal of fallen and decaying fruit in management of the understorey. This may mean that close mowing or mulching is required at times so that it is easy to find/ destroy rotting fruit. This is not only to prevent spreading of brown rot but also in many areas to discourage infestation of Carpophilus beetle.*



Start with the soil, this is the foundation for a healthy and productive system

•

The soil is a living system. The microbes, animals and plants work together to build fertile soil. Help the process by adding compost, mulch and other appropriate inputs

•

Soil structure allows the soil to breathe and plant roots to grow

•

Fruit trees need plenty of nutrients in the soil to be productive

•

The sward plays an important role in maintaining soil health, in the recycling of nutrients and in the natural regulation of plant pest and disease organisms.

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Further composting information:

Nutrient content of organic materials:

www.soil.ncsu.edu/publications/Soilfacts/AG-439-18

Further information on compost tea making can be obtained from Soil Foodweb Institute Pty.Ltd. 1 Crawford Road, East Lismore, NSW, Australia 2480. Web address: www.soilfoodweb.com

Books:

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Soil fertilisers and amendments:

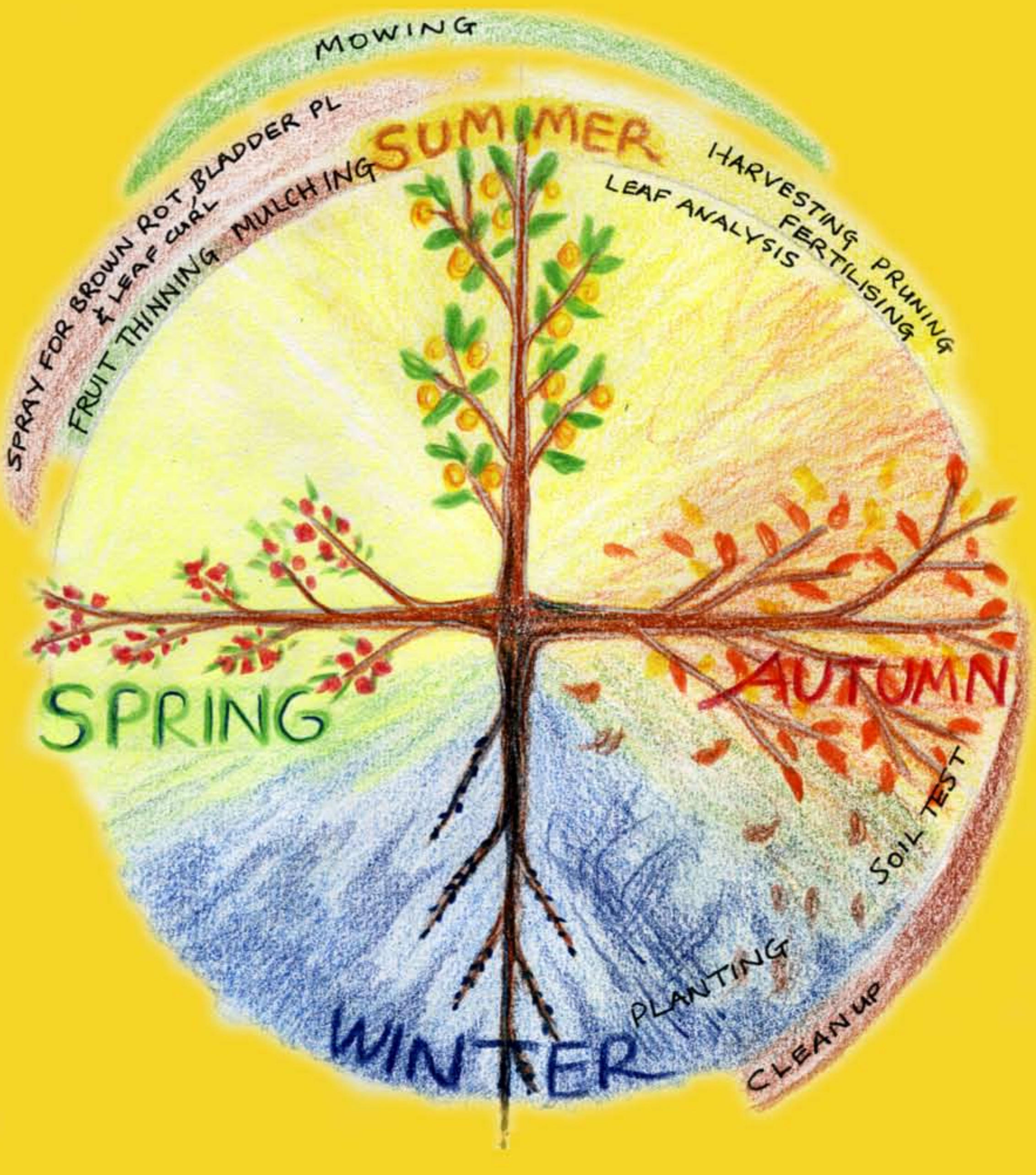
A list of sources can be found in any issue of Organic NZ and on the website: organicpathways.co.nz

Fertiliser companies will often supply certified or approved organic fertilisers such as rock phosphate, dolomite, gypsum and blood and bone. Limestone is usually available from local lime quarries. Fishmeal is available from Talley's in Nelson; blood and bone from local freezing works. Availability and price of compost and bark products varies. Local councils sometimes operate or contract out composting operations. Quality, availability, and price vary – check out local transfer stations or councils. (Caution: immature compost can be toxic to plants). Your local Environment Centre may also be able to help find materials and information.

Some sources:

Agrissentials (Tauranga) – rock dust, organic fertiliser blends
Agrich Organics (Napier) – fish-bark compost, bark mulch, compost tea
Ocean Organics (Paeroa) – liquid seaweed
Sieber – Moana liquid fish
VITEC Fertilisers - (Tauranga) – liquid fish and seaweed

Crop management



Given a fertile soil and well-formed healthy trees (see two previous chapters), the crop itself must be tended carefully to ensure a worthwhile harvest is obtained. From pollination in early spring, to protection from pest and disease damage until harvest and beyond, close observation guiding intelligent interventions is the recipe for a successful season.

Pollination

Fruit crops rely heavily on insects for pollination in New Zealand. Feral or hived honeybees do most of this pollination, but other insects, such as bumblebees and native bees, are also important.

Some orchardists take up bee keeping for this reason. However, management of hives is very demanding, requiring attention at a time when growers are usually already busy. Better results can often be obtained by having an arrangement with a beekeeper. This arrangement could either be with a commercial beekeeper (usually for a set fee) or a hobbyist looking for an apiary site. Many beekeepers prefer having their hives on an organic property as this reduces the devastating effects of insecticides on their colonies' production.

Depending on the duration of flowering, bees are generally needed in the orchard for at least two to three weeks. Correct positioning of the hives contributes to effective pollination. They need a warm sheltered site that receives plenty of morning sun. If you have bees permanently on your site, you may not get the best pollination as, once the bees have established, they soon orientate to other crops within a three to five kilometre radius.

Some varieties of summerfruit are self-fertile and can be pollinated with their own pollen or with the pollen from adjacent trees of the same cultivar. Other varieties that are not self-fertile need to be pollinated with pollen from a compatible but different cultivar. Peaches are generally self-fertile with some exceptions (e.g. cv. J.H.Hale.). Plums are mostly not self-fertile and are best planted so that suitable pollinating cultivars are nearby. A suitable pollinator must not only have compatible pollen but must also flower at the same time. Hence there is some variation between districts as to suitable combinations. For Japanese plums, good pollinators are Duff's Early Jewel (early flowering), Sultan, Red Doris and Santa Rosa. For European plums, Coe's Golden Drop, a gage or one of the D'Agen prunes are good pollinators. Older apricot varieties are mostly self-fertile but most of the recent releases benefit from cross-pollination (e.g. Sundrop, Clutha Gold, Vulcan). Most of the older cherry cultivars need cross-pollination and choice of pollinators is an important factor in successful cherry growing. Many new cherries are recognised as being self-fertile but do appear to benefit from some cross-pollination.

Where fruit set is poor, despite intense flowering, several approaches may be tried. Blossoms of some other variety of the same fruit type can be cut and hung in containers of water in the trees. A suitable pollinating variety can be grafted into the centre of the tree and allowed to grow as a cental branch. Fruiting spurs of plums can be shortened during flowering. Shelter can be planted to improve bee activity or more hives placed in the orchard. During flowering the trees should be busy with bees. If they are not, check where the bees are working. Shelter trees or sward plants flowering at the same time as the fruit trees could be more attractive to the bees. It might then be necessary to prune the shelter and mow the sward.

Pests affecting bees

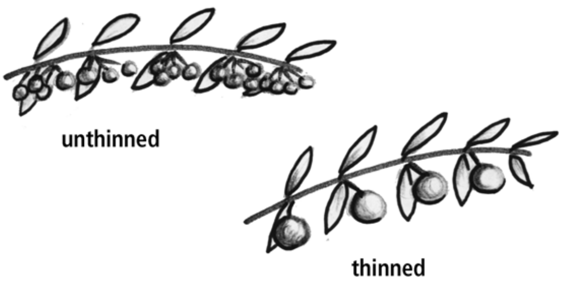
Sawfly and clover weevil are pests that can attack and damage plants (willows and clover respectively) that are important food sources for the bees.

Varroa mite was first found in Auckland in 2000 and attacks bees by attaching itself to the bee and sucking its blood and by entering either worker or drone cells before they are capped. With the arrival of Varroa mite in New Zealand, feral colonies will not survive. Orchardists will have to rely more heavily on beekeepers to ensure pollination of their crops. Orchardists should check with the beekeeper which Varroa treatment they are using or are going to use. Only Formic acid and Oxalic acid have been approved for use in organic production. If the beekeeper has used other treatments there will need to be a withholding period. Be sure to check your organic standards or consult your auditor.

American Foul Brood (AFB) is a serious disease affecting honeybees in New Zealand. Control of the disease is primarily done on a management basis and by destroying all hives found to contain AFB. Beekeepers must be registered with AgriQuality NZ and are required to submit a 'certificate of inspection' annually.
Bee keeping clubs are located in most districts — for details contact N.B.A. (Inc), PO Box 715, Wellington or www.nba.org.nz.

Thinning

Peaches, nectarines, plums and apricots will often set too many fruits resulting in large crops of small sized fruit. Tight clusters of fruit also provide sheltered habitats for fruit damaging insects such as leafrollers. Trees allowed to crop too heavily can also have reduced growth (most important with young trees), suffer broken limbs and irregular bearing (biennial bearing – heavy one year, light the next). Thinning also allows the removal of any damaged or misshapen fruit. Thinning of fruit is best done soon after fruit set and before the stone hardens. In some varieties there is a natural fruit shedding soon after fruit set, in which case thinning should be delayed until after this period. In organic systems early thinning may be somewhat lighter to allow for later thinning of fruit as insect or disease damage becomes apparent. Leave the largest fruits in a cluster. Peaches, nectarines and apricots are usually thinned to single fruits about 10 – 15 cm apart. Plums can be thinned to a single fruit or to two fruits in a cluster.



Thin to get bigger fruit

Water

Summerfruit are often grown in areas where dry conditions are common. To be productive, fruit trees must be able to obtain an adequate supply of water from the soil. Deciduous fruit trees are most sensitive to soil water deficits during flowering and fruit set. A water deficit during this period could result in reduced yield, poor growth or even permanent damage to the trees. In the case of young trees, a soil water deficit during the growing season could extend the time until full production and reduce the cumulative yield of the orchard. Irrigation can increase the growth and productivity of fruit trees. Adequate soil moisture is also needed to sustain soil biological processes that are essential to maintain soil fertility and to supply nutrients to the crop.

The amount of water a soil can hold for plant use depends on its effective rooting depth and physical characteristics such as texture, structure and humus content. For example, coarse textured soils (sandy) hold less water than fine textured soils (clay); deep alluvial soils, by allowing a greater volume for root development, provide more water to the crop than soils with a shallow topsoil overlying a dense and impervious subsoil.

Water exists in the soil within variously sized soil pores and as a film around soil particles. While water quickly drains from the larger sized pores, it is held by capillary forces against gravity within the medium and small sized pores and on the surfaces of soil particles. The maximum amount of water that can be held against gravity is termed the field capacity of the soil (FC). PAW (plant available water) is the fraction left after drainage and that can be effectively utilised by plants. Irrigation is usually started when 30%–50% of PAW (the most easily extracted fraction) has been absorbed by the roots of plants or lost to evaporation. Applying more water than is needed to return the soil to FC, not only wastes a limited resource, but can also cause nutrients to be leached from the soil.

Regardless of the water holding capacity of the soil, a tree can only make full use of the resource if it has a well-developed root system and if there is not excessive competition from the groundcover plants. Trickle irrigation systems, although efficient in terms of water use, usually wet a relatively small fraction of the root system. This can be insufficient to supply the tree's full water needs and can also lead to smaller root systems confined to the wetted area. Trickle systems can also cause problems with nutrient leaching and imbalances. On lighter soils, where there is less lateral soakage, micro-sprinklers or multiple droppers can give more uniform water application than single droppers.

Although overhead sprinklers can also be used for frost protection, when used for irrigation they can increase the incidence of fungal diseases such as brown rot and interfere with crop spray programmemes. On frost-prone sites a duel overhead and under-tree micro-irrigation system may be justified.

While soil water deficits can harm young trees, a carefully controlled level of water stress – a system known as regulated deficit irrigation (RDI) – in established trees can improve fruit quality and yield, reduce vegetative growth and help to conserve local water resources. RDI can allow some of the benefits of dwarfing rootstocks to be had (smaller trees), while retaining the benefits of vigorous rootstocks (rapid establishment).

Mulching the trees, especially during the establishment phase, not only adds organic matter to the soil, but can also conserve soil moisture by reducing evaporation and weed competition. Mulching can increase productivity, growth and irrigation intervals of fruit orchards and is especially beneficial in aiding the rapid establishment of young trees[31].

To determine when to irrigate and how much water to apply, soil moisture levels are monitored using a water budget and tensiometers or Watermark™ sensors. Water budgets track changing soil moisture levels by recording estimated daily evapotranspiration (evaporation from all orchard surfaces plus plant transpiration) and water inputs either as rain or irrigation. Data for the water budget are usually available from local bodies such as regional councils. These data are then adjusted to allow for the actual evapotranspiration of the crop and should be supported by soil moisture readings with tensiometers placed at two soil depths around the orchard (one in the main root zone and one just below this zone, but above any pan or gravel layer). The budget shows when PAW has reached a pre-determined level of depletion for irrigation to be initiated and also shows how much water needs to be applied in the irrigation to restore soil to FC. Only sufficient water to bring soil to FC should be applied to minimise the likelihood of leaching and to conserve the water resource.

Application rate should not exceed the infiltration rate of the soil. A micro-irrigation system with micro-sprinklers or jets obtaining 60–80 % coverage of the main root area should be properly installed. The system should be regularly monitored to ensure uniformity of water application.

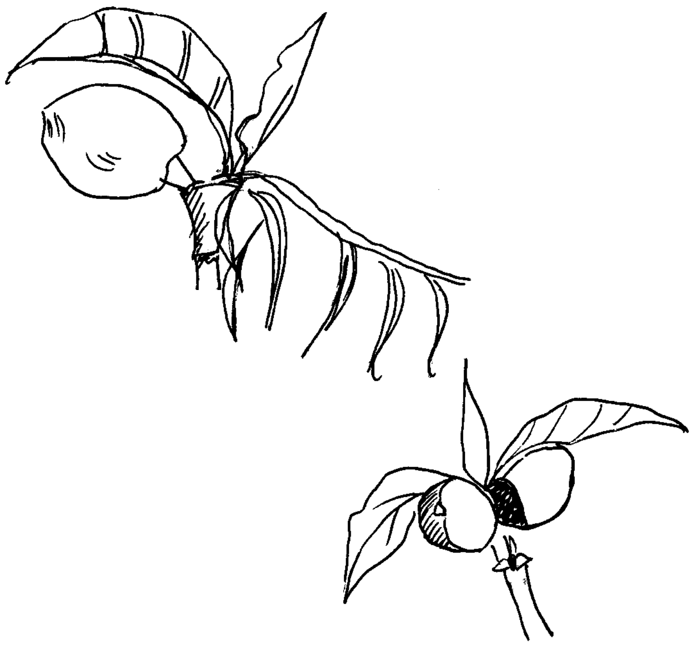
Crop protection

Summerfruit trees and fruit can be damaged by a range of pests. These include: animals such as birds and opossums; insects such as leafrollers, aphids and thrips; fungi, causing diseases such as brown rot, leaf curl and silver leaf; bacteria causing diseases such as blast and bacterial spot; and viruses such as Prunus necrotic ringspot virus and prune dwarf virus.

In organic horticulture the aim is to produce a stable orchard ecosystem, allowing pest populations to be regulated naturally. If good care is taken of the soil and plants, so that they are healthy, problems caused by insects, diseases or weeds should be reduced. It is accepted that there will always be some damage because insects eat plants. However, in a healthy ecosystem natural predators and parasites will help keep pest populations below the level of serious economic damage. Organically acceptable chemical intervention is only used as a last resort when all other methods are inadequate.

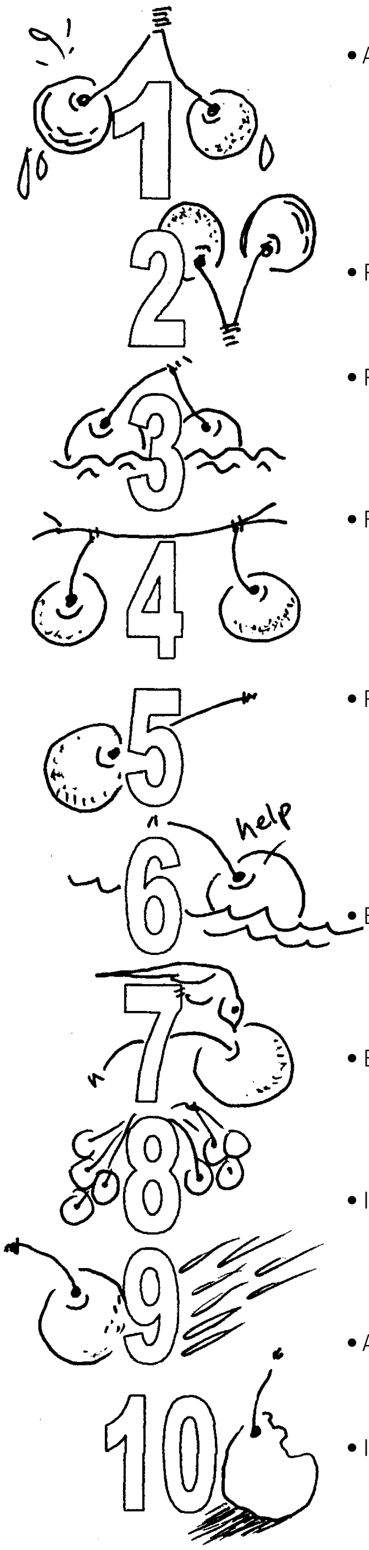
Organic horticulture is an integrated system approach, in which farm components should be in harmony and balance rather than in conflict with natural systems. All aspects of the farm should be taken into account when devising pest and disease management strategies. Rotation and crop diversity, fertile soils with a high level of biological activity, cultivation techniques, choice of cultivars, habitats for beneficial organisms and orchard hygiene are all vital components. Organic management of pests and diseases can be divided into two types:

- Preventative measures – *recommended and often involves long-term systems*
- Physical interventions – *control methods that are used when a problem has emerged*



Preventative measures

Ten key points for the prevention of pests and diseases in the organic orchard:



- Avoid sites with excessive rainfall or wind, damp shaded valleys, south facing slopes and old orchard sites that might have toxic levels of copper, boron or other residues from years of chemical sprays. Frost and wind damage can provide entry sites for disease causing pathogens

- Plant only healthy disease-free trees and select cultivars with high levels of natural resistance

- Promote tree health by building levels of soil organic matter and soil fertility with additions of compost, animal manures and mulch and where necessary organic or approved mineral fertilisers

- Remove dead and diseased wood from the trees and orchard and preferably burn it. Dead and diseased wood is a source of disease spores that are splashed by rain onto foliage and spread throughout the tree

- Prune or remove overcrowded trees and encroaching shelter-belts and cut or trample long grass. Maintain a reasonably open canopy. These steps maintain adequate air movement, ensuring rapid drying of foliage and preventing the build up of pests and diseases such as brown rot

- Ensure good drainage. Some form of contouring or planting on mounds can allow surface water to drain quickly away. Surface water can damage tree roots, often with fatal results

- Encourage insect-eating birds within the orchard by planting diverse shelter-belts. Poultry, ducks, geese and guinea fowl are very effective at reducing pest insects and cleaning up any fallen fruit

- Increase shelterbelt, crop and sward diversity, and encourage beneficial insects by planting nectar sources – flowering shelter trees and sward plants

- Avoid the use of broad-spectrum insecticides such as pyrethrum and derris

- Identify and remove alternative pest and disease host species from the orchard and shelter belts (e.g. willow and poplar).

Physical interventions

Tillage can be used to destroy or bury pests and disease. Caution should be taken here as tillage will also kill worms and other soil microorganisms.

Mowing reduces populations of pests living in the sward such as leafroller.

Use of traps: Pheromone traps can be used to monitor the emergence and levels of pests in the orchard, allowing control measures to be accurately targeted.

Mating disruption, pheromones (usually in the form of twist ties) are also used to disrupt the mating patterns of insects such as leafroller and oriental fruit moth. This approach can be effective in larger orchards but is less effective in smaller blocks where pregnant female insects can fly into the orchard from adjacent uncontrolled areas.

Repellents: Reflective mulch has been shown to be an effective repellent for thrips on stonefruit[32]. Some plants and herbs such as marigold, pyrethrum, chives, onion, lavender and dill, are also said to have pest deterrent properties, although the effectiveness of these have yet to be thoroughly researched.

Companion planting, host plants and sacrificial plants: A range of effects can occur using these methods of pest and disease control, including:

- Camouflage of crop plants by other plants either by smell or visually. This might be achieved by interplanting summerfruit with other fruits affected by a different range of pests
- Trap crops can be chosen that are more appealing to pests and lure them from crop plants (e.g. feijoa can attract bronze beetle) which will cluster on the shoot tips from where they can be gathered and destroyed
- Barriers such as tall crop plants or hedges to disrupt flight paths
- Establishing a species-rich sward can provide habitats for beneficial insectsand also may have a camouflage effect
- Flowering plants can attract beneficial organisms to the crop
- Disruptive crops where a suitable food plant for the pest is grown to encourage the pest to emerge from the soil. The crop is then destroyed starving or killing the pest. A variation is the use of plants that encourage emergence but are resistant to the pest. These techniques involve a degree of risk; the problem could be exacerbated if the technique is applied incorrectly.

Biological forms of pest and disease control

The three types of biological control agents are predators, parasites and pathogens.

Predators and parasites

Characteristics of effective predators and parasites include:

- Good searching ability – to seek, find and feed on insects
- High reproductive ability – the predator or parasite's population growth rate needs to keep up with the population growth rate of the prey or pest
- Adaptation to the environment – an introduced predator or parasite might come from a completely different set of environmental conditions
- Ability to survive pest-free periods by using alternative food sources or by physiological changes
- The predator or parasite must have a life cycle compatible with that of the pest so that they emerge at the same time.

An increasing range of beneficial insects that parasitise or predate pests are becoming commercially available. Much of their use has so far been restricted to greenhouse cropping due to their cost and the greater ability to control the greenhouse environment. However, species suitable for outdoor use are becoming increasingly available. They have limited value as a curative treatment because of the time they require to become established. It is more economic to release them early, so they can multiply and affect control before pest populations exceed the threshold of economic damage.

LADYBIRD LARVA

ELEVENSPOTTED LADYBIRD

Some of the predators in organic summerfruit orchards include:

Lady birds – adults and larvae prey on aphids, scale insects, mealy bugs, mites and other soft-bodied insects

Lacewing – adults and larvae prey upon aphids, mealy bugs, scale insects and other soft-bodied insects

Hoverfly – two species have larvae that prey on aphids, caterpillar eggs and larvae

Praying mantis – a generalist predator

Predatory mites – (e.g. *Typlodromus pyri*, Whirlygig mite and *Phytoseiulus persimilis*) are important predators of plant feeding mites

Harvestman spider and hunting spiders – prey on aphids, mites and caterpillars

Ground beetles (carabid beetle)

Damsel bug

Paper and German wasps

Many bird species will feed on insects and caterpillars

Hens, ducks or geese in the orchard are effective predators of soil dwelling insect pests.

Parasites are generally smaller than their host insect and are generally host-specific wasps or flies. The adult female lays an egg(s) onor in, the immature stage of the host – egg, larva or pupa. Development of the parasitic larva proceeds inside the host, with the larva feeding and devouring the host's body contents before the parasitic larva pupates, leaving only the remains of the host. Adult parasites are free living and feed on honeydew or nectar. Some of the parasitic wasps relevant to stonefruit growers include:

Xanthomimpla rhopaloceros, Gladridorsum stokesii, Glyptapanteles demeter, Anagrus armatus – some of the leafroller parasites

Litomastix maculata – a green looper parasite

Scale insect parasites.

Plants to encourage beneficial insects and spiders:

Tansy phacelia – parasitoids and predators

Buckwheat – parasitoids of leafroller caterpillars.

Cleome and mustard – catchcrops for green vegetable bug

***Asteraceae (Compositae)* family:** chicory, oxeye daisy, thistles, rayless chamomile, dandelions, tansy, sow thistle, calendula, cornflower, sunflower, etc. – paraistoids and predators

***Apiaceae (Umbelliferae)* family:** wild carrot, wild parsnip, parsley dropwort, stone parsley, fennel, dill, etc. – parasitoids and predators

Tasmanian blackwood, persimmon – hosts populations of ladybirds

White clover – phytoseiid predators

Wild flowers – parasitoids and predators

Pathogens contributing to biological control in the orchard include bacteria, fungi, viruses, protozoa and nematodes. Under the right temperature and moisture conditions, spectacular outbreaks of disease in pests caused by pathogens can result in a high level of control. Pathogens can be applied as sprays and are generally host-specific. Their mode of action varies and includes antagonism, disease induction, parasitism or the production of antibiotics and toxins. A few pathogens are used preventively. Care should be taken that the use of pathogens for control does not destroy beneficial microlife. At present few pathogens are available commercially but these include:

Bt (*Bacillus thuringienis***)** (Trade names Thuricide, Dipel, Agree 500, Biotrol), a bacterium found widely in soil and toxic to certain insects when ingested.

Serratia entomophila, a bacterium that will infect soil dwelling insects such as grass grub.

Agrobacterium radiobacter (trade name Dygall), a bacterium used to control crown gall on many nursery plants, including rose, peach, kiwifruit, hops, raspberry and boysenberry.

Chemical methods of control

A small number of permitted 'natural' chemicals are allowed for pest and disease control. These are mostly plant extracts and are often broad-spectrum in their action. A broad-spectrum pesticide will kill more than just the target pest. When beneficial insects are also killed, often a major control of pest populations is removed and a new pest outbreak, sometimes in epidemic proportions, can occur.

Chemical intervention is used only as a last resort if pests and diseases cannot be managed by the combination of good husbandry, the natural resilience of a healthy orchard ecosystem and biological controls. There are only a limited number of chemicals that are acceptable for use in organic production and that ensure compliance with certification standards. Organic horticulturists should always check their certification standards before using any chemical interventions. Some of the acceptable interventions include:

Organically acceptable insecticides:

(*Note:* many of these are only approved for use on a restricted basis under organic certification standards. Be sure to check the standards carefully before using these products.)

Natural pyrethrum and mixes such as garlic and pyrethrum. These are fast acting nerve poisons causing knockdown and paralysis of insects. They are effective against soft-bodied insects such as aphids and caterpillars (e.g. leafroller, codling moth and insect larvae). Problems can be caused because pyrethrums are broad-spectrum and are toxic to many beneficial insects (and fish!).

Neem oil. This is extracted from the Neem tree. It is the only botanical systemic spray and has strong anti-feeding, repellency, sterilizing and growth regulating actions against a wide range of insects. Neem may also be toxic to some beneficial insects and mites.

Rotenone (Derris Dust) is derived from the dried and finely ground roots of Derris and Lonchocarpus plants. Its active ingredients are more toxic than pyrethrum. It acts as a stomach poison affecting nerve and muscle cells of insects. It is effective against leaf feeding caterpillars and beetles but is highly toxic to earthworms, fish and pigs (and possibly people [33]).

Mineral oils are used for problems such as scale and aphids, although vegetable oils are preferred if they will give the required control. Mineral oil sprays are not permitted by Demeter standards

Bacillus thuringiensis (Bt) (see Pathogens)

Potassium-based soft soaps – contain the salts of fatty acids, effective against soft-bodied insects including aphids, thrips, scale crawlers, whiteflies, leafhoppers and mites. Can be phytotoxic (cause plant damage) and may harm beneficial insects.

Lime sulphur acts as an insecticide against mites and scale and as a fungicide against brown rot and powdery mildew. Can be phytotoxic under some conditions and to susceptible plants (e.g. apricots). It is also toxic to soil life.

Approved forms of homoeopathic preparations.

Diatomaceous earth (marine sediments with microscopic needles) effective against many soft bodied pests and generally safe to beneficials.

Organically acceptable fungicides:

(many of these are also only approved for use on a restricted basis under organic certification standards)

Bordeaux, burgundy mixtures

Copper hydroxide

Baking soda (sodium bicarbonate) can be used to prevent fungal spores from establishing themselves

Sulphur

Lime sulphur

Plant-based sprays such as garlic and horsetail

The biodynamic Preparation 501, prepared from ground silica, is intended to facilitate the response to cosmic growth factors via the light and warmth forces and thereby helps control rampant vegetative growth as well as susceptibility to bacterial and fungal attacks. Preparation 508 made from the plant Common horsetail (*Equisetum arvense*), which contains high levels of biological silica, is also applied to toughen up the surface of crop-plants and to help balance growth with structure. Silicon has a long history of use for disease prevention in agriculture and its use has recently been revived[34].

Pruning paste

There are several biodynamic recipes for tree pastes but they mainly rely on cow manure (and/or cowpatpit = cow manure fermented with the BD compost-preparations) as a base ingredient. Usual additions are clay, like bentonite, to help with plasticising. Other substances that can be used for making the paste stick better are sodium silicate or egg-white. Diatomaceous earth (handle with care!) to spike soft-bodied pests could also be added. Basalt meal and powdered seaweed, as well as various liquids like comfrey- and stinging-nettle tea, are used to turn the whole application into a thick paste that is plastered on by hand if really thick or sprayed on made into a thinner slurry. The thicker the paste and the younger the trees or portions of them it is being applied to, the more readily it will crack off with movement. The main point is to smother unwanted life-forms and to supply nutrients to the trees in a topical fashion.

Other treatments for pruning cuts and wounds are Stockholm tar (check standards), grafting wax and paint containing trichoderma – a natural control for silver leaf infection.

There are many other potentially useful spray materials that could be tried on summerfruit including:

Myco-San & Myco-Sin – based on an extracts of Equisetum arvense (horsetail), basalt and sulphur or diatomaceous earth. Found effective against both fungal and bacterial pathogens in several crops.

Neem oil or soap – has both insecticidal and fungicidal properties. Neem soap mixed with olive oil makes an effective spray to control powdery mildews.

Soybean oil mixed with a spreading agent has been found effective against red mite in apples.

Soap based sprays – (e.g. Natrasoap, Protector, coconut soap and homemade soft soap sprays) found to be active against some microbial pests and can also control aphids.

Compost teas – properly prepared there is much interest in these as disease preventive sprays. The principle is to inoculate the leaf or fruit surface with a healthy population of microbes. These deny pathogenic organisms access to food resources on the fruit surface essential for their early development and initial infection. There is some promising anecdotal evidence emerging concerning the control of plant diseases by compost teas.

Seaweed – is widely believed to enhance plant resistance to pests and diseases by improving plant health and eliciting plant defences.

Fish emulsion – as a deterrent to pests.

Hydrated lime – is effective against fungal organisms in crops (e.g. black spot in apples). It is also effective in the postharvest control of brown rot in peaches. It seems reasonable to believe that it may also have a role in pre-harvest brown rot control. Hydrated lime is an ingredient of Bordeaux mixture and its antifungal activity may explain the continued effectiveness of Bordeaux mixtures containing very small amounts of copper sulphate. Other calcium salts may also be worth trialling (e.g. finely ground limestone, calcium silicate, calcium sulphate [gypsum]). Lime sprayed at leaf fall may help the decomposition of the leaves and disease spores and their incorporation into the soil (by encouraging earthworms). The relatively small amounts of lime used in this way are unlikely to significantly affect soil pH.

Clay powder – has insecticidal or protective properties against a range of pests.

Repeated drenching sprays of water or dilute seaweed – drown and wash pests out of the foliage.

A thick solution mix of potassium sulphate, hydrated lime, waterglass, with diatomaceous earth is used by grapegrowers as a trunk spray to kill lichen and over-wintering mealybugs. This could be an alternative to Bordeaux for cleaning up the trunk and main frame of neglected trees.

A badminton shuttlecock can be made into a baited trap. The bottom of the shuttlecock is replaced with a vial containing an attractant (e.g. a mixture of 3-methyl-1-butanol, pentanol and acetic acid) or a pheromone dispenser. The feathers are soaked in a synthetic pyrethroid (permethrin).

When using any spray material leave one row unsprayed as a control and always keep records of rates, conditions and date for future reference and comparison. This is especially helpful when trying out some new material.

Copper compounds can be very effective fungicides and bactericides and are restricted materials in most organic certification systems (i.e. they can be used but restrictions apply; see standards of certifying body). Copper is an essential plant and animal nutrient, although only small amounts are required. It can be deficient in some soils, but can also accumulate to toxic levels as a result of repeated fungicide applications. Even at the rate of 3kg Cu/ha/yr, as allowed in organic certification standards, copper could accumulate in the soil to toxic levels over a 50-year period[35]. Copper is toxic to earthworms and copper sprays inhibit the activity of predatory insects such as ladybirds. A copper residue in or on marketed fruit is not compatible with organic consumer expectations.

The NZ Demeter Certification Standards list wettable copper as a restricted material (a remedy of last resort) with a maximum of 3kg Cu /ha/year on permanent crops. No routine spraying is allowed, only prophylactic sprays at known effective times. Monitoring of accumulation in soils may be necessary.

Bordeaux is a traditional copper fungicide and is made by mixing dissolving copper sulphate in water and then adding hydrated lime (added to water to make a slurry). It can be more persistent than the more common modern form of copper hydroxide perhaps because it contains three fungicidal ingredients - copper, sulphur and lime. However the total copper applied in a Bordeaux mix will tend to be greater than that applied as copper hydroxide.

To calculate the amount of active ingredient (elemental copper) applied:

- Bordeaux - *multiply amount of copper sulphate used by 0.25*
- Copper hydroxide - *multiply amount used by 0.5*

Rock phosphate and compost are both able to remove copper from the soil solution - preventing plant uptake. Phyto-remediation with copper accumulating plants (e.g. fennel, ragwort, chickweed) might also be possible.

Monitoring levels of pests and diseases is an important part of orchard management. Monitoring allows the orchardist to know whether pest and diseases are approaching a level where some kind of intervention will be necessary. It also shows if beneficial species are present in sufficient numbers to control the pest.

Monitoring is especially important in organic production because early detection of potential problems allows time for the sometimes slower organic control strategies to take effect. The monitoring methods used can vary from the traditional crop walk, informally noting the levels of pest and disease, to the use of traps and data analysis to predicate intervention measures.

Diseases of summerfruit

For detailed descriptions and identification of diseases refer to the resources listed at the end of this chapter.

Brown rot caused by the fungus *Monilinia fructicola* is often the most difficult disease to manage in peaches, nectarines and apricots. It can be especially difficult in organic orchards because of the limited range of fungicides available to the grower. Growing resistant varieties (see Orchard Design) is the most important strategy in brown rot control.

Summary of brown rot management in the organic summerfruit orchard:

- Plant resistant varieties and replace highly susceptible varieties.
- Remove all thinned fruitlets, mummified fruits and prunings and burn
- Cut out infected laterals and destroy
- Avoid block planting of susceptible varieties – alternate rows with non-susceptible varieties or other types of fruit
- Avoid planting susceptible varieties in damp sites
- Prune to promote good air movement and rapid drying
- Manage shelter to ensure good air movement while avoiding wind damage
- Make use of available weather data (e.g. ONFIT) to ensure optimum timing for any sprays used either for prevention or control of infection.

Much of the initial infection comes from mummified fruits and fungal fruiting bodies on the orchard floor. These have been shown to collect in wheel ruts in the row centres where the more-often moist conditions foster the release of large numbers of spores. Piles of prunings were also found to be a significant source of spores[36]. As with many fungal diseases, it is the spore-load of the initial or primary infections that largely determines the severity of disease outbreaks. Therefore, measures that reduce the number of spores released from the over-wintering fruiting bodies will help to control brown rot. Brown rot infects flowers (blossom blight) and from these are produced further spores. Infections on fruitlets can remain latent or in a semi-dormant state until triggered into invasive growth by the smell of the ripening fruit. The most critical time to control brown rot is during flowering.

Heavy chain harrows, wind-rowers or light superficial cultivation will help to destroy (anecdotal evidence) the small fruiting structures (like cup-shaped mini-toadstools) that are on the soil surface, in leaf litter or shallowly buried. The sward should be mowed closely before winter or after pruning to pulverise leaf litter and fungal fruiting bodies and promote their decomposition before the following spring. In spring, the sward could be mowed short to promote soil surface dying and desiccation of the fruiting bodies. An alternative approach would be to have a long thick sward at flowering acting as a barrier to released spores[37]. This might need to be mowed after shuck fall to reduce humidity[38]. Further experimentation is needed to find the most effective approach.

Sulphur and copper sprays are the most effective chemical control methods presently available to the organic grower. Commercial preparations for the biological control of brown rot using antagonistic bacterial or fungal species are likely to become available in the near future. Organically acceptable calcium sprays may be useful to assist in prevention of skin cracking and also as post harvest treatment for reduction of infection in storage or in the market place (standards need to be checked to ensure product has been approved for use).

The common practice of applying copper fungicides at leaf fall may interfere with the rapid decomposition of the leaf litter. Compost tea or lime may be effective alternatives to promote leaf litter decomposition and destruction of the fruiting bodies – again experimentation is needed.

Leaf curl can be a serious disease of peaches, nectarines and apricots. The fungus (*Taphrina deformans*) appears to overwinter on the tree on infected buds, releasing spores in the spring as the new leaves emerge. Secondary infections can also occur during wet periods in spring.

Control consists of removing dead wood in winter and infected shoots as they appear in spring. Apply a copper spray just as buds begin to move but before they break in spring. Sulphur sprays during the same period may also give control. If left untreated a few infections in one year can quickly become widespread the following year. Badly infected trees can be seriously debilitated. Susceptibility varies between cultivars and, as with brown rot, resistance can be selected for in breeding programmes.

Bladder plum (*T.pruni*) and Cherry leaf curl (*T.weisneri*) have similar life cycles and control methods to *T.deformans*. They affect plums and cherries respectively. Bladder plum infects mainly fruits. As with leaf curl, symptoms appear early in the spring.

Silver leaf is a serious disease of summerfruit. It is caused by a wood rotting fungus (*Chondrostereum purpureum*) that has a wide host range. The greyish papery fruiting bodies can often be found on dead and rotting trees in adjacent hedgerows and shelterbelts. Summerfruit trees can die within two or three years of being infected. Peaches and nectarines are most likely to succumb. The fungus enters through wounds and spreads slowly down the tree. Pruning cuts are most vulnerable to infection during the first week. Spores are released in high numbers during cool wet conditions. The disease can be identified by scratching the epidermis of the silvered leaves: if it parts easily from the leaf tissue beneath it is likely to be silver leaf.

Control consists of limiting pruning to the late summer and autumn when the weather is dry and tree resistance high. The typical silvering of the foliage allows early detection and prompt pruning to remove the infected branch can often prevent the fungus from spreading further. If pruning is not to be done until after leaf fall, an infected branch should be marked with a coloured tie for easy recognition later. Large pruning cuts should be treated with an appropriate pruning paint, although natural colonisation of the wound by non-pathogenic fungi is likely to be a more effective barrier. Biological controls using the Trichoderma species are commercially available (TrichoDowels & TrichoJect), but the certifying body's approval should first be sought.

There is also variation between varieties in resistance to silver leaf. The particular susceptibility of many peach and nectarine cultivars may be another indication of how little disease resistance remains in modern cultivars of this group of summerfruit.

Bacterial spot is a disease of summerfruit caused by the bacterium *Xanthomonas campestris pv. pruni*. Symptoms include dark brown spots on fruits and leaves and cracked lesions on stems and branches. It is particularly damaging to fruit of Japanese plums. The bacteria multiply from infected lesions during warm wet periods in spring and early summer. Initial infections occur on leaf scars following leaf fall in autumn and at frost damaged flower nodes in spring.

Control consists of copper sprays at leaf fall and avoidance of frost damage during flowering (avoid planting in frost pockets). Plant only high quality disease-free trees. Some soil types predispose the trees to infection – light, sandy soils subjected drought or waterlogging. Improve drainage in rootzone, avoid overhead irrigation[38].

Stonefruit blast or bacterial canker is mainly caused by Pseudomonas syringae and affects all types of summerfruit. Symptoms include deep enlongated cankers on branches, shrivelled (blasted) shoots and young leaves, death of leaders, dark spots on fruits and dark spots and holes in older leaves. Cankers can produce an oozing gum; the disease is also known as gummosis. Infection occurs in autumn through fresh leaf scars following leaf fall. Autumn – winter pruning and planting on coarse textured soils can increase disease incidence.

Control with copper sprays at leaf fall and late dormancy.

Leaf rust, caused by the fungus *Tranzschelia discolor* can cause premature defoliation of trees in autumn. This lowers the tree's nutrient reserves needed to support fruit development the following spring. Wet, warm conditions promote this disease, specific strains of which infect different summerfruit types.

Control with sulphur sprays in spring and summer before wet periods. Sulphur is not effective once leaf spots have appeared.

Green fruit rot (caused by *Botrytis cinerea* and *Sclerotinia sclerotiorum*) can be a problem with apricots during wet conditions.

Control is by removing and destroying fallen fruit.

Insect pests

For detailed descriptions and identification of diseases refer to the resources listed at the end of this chapter.

Aphids damage the young shoots, fruits and leaves, causing distortion and blemish (sooty mould) on fruits. There are at least four species that can be troublesome: Green peach aphid (*Myzus persicae*), black cherry aphid (*Myzus cerasi*), black peach aphid (*Brachycaudas persicae*) and leafcurl plum aphid (*Brachycaudas helichrysi*).

Control: They are usually controlled in organic orchards by predators such as ladybirds, lacewings and predatory mites. If necessary, oil sprays just before bud break in spring will smother over-wintering aphid eggs. Infested shoots can be pruned and destroyed in October before the winged stage is reached. Encourage habitat for beneficial species. If materials like pyrethrum are used, apply with a handgun to 'spot spray' only infected shoots. Remove watershoots and consider reducing nitrogen inputs. Intervention may be necessary if more than 10% of trees are infested in late October[39].

Thrips Two main species are of concern – NZ flower thrips (*Thrips obscuratus*) and onion thrips (*Thrips tabaci*). They cause russetting and silvering of fruit and NZ flower thrips are a quarantine pest (affecting exports).

Control: They have several natural enemies including predatory bugs and mites. Oil sprays may help if numbers are high (check SummerGreen IFP manual for thresholds). Encourage habitat for beneficial species. Soil fauna and fungi can predate thrip pupae. Therefore organic practices that foster soil life may help to control thrips. Strains of fungi active against thrips pupae may become available in the future. They might be purchased like wine brewing yeasts are now and proliferated on the orchard in aerated brewing kits such as are being used by Soil FoodWeb practitioners[40] before being applied to the soil around the trees. Fish emulsion sprays might also deter thrips.

Leafrollers There are three main species causing damage to summerfruit: Greenheaded leafroller (*Planotortrix octo*), light brown apple moth (*Epiphyas postvittana*) and brownheaded leafroller (*Ctenopseutis obliquana*). Leafrollers prefer sheltered sites as are provided by touching fruit and leaves. Within these sites they make webbing and chew the plant surfaces. Damaged fruit will be mostly unsaleable.


LEAFROLLER MOTH

Control: Leafrollers have many natural enemies including wasps, spiders, bugs and birds. Encourage habitat for beneficial species. Pheromone traps can be used to monitor for the emergence of the moths. Pheromones dispensers can also be used for mating disruption. Poultry and other birds prey on grubs as they emerge from the soil in spring. For export fruit, consult SummerGreen IFP manual for thresholds and quarantine regulations. If spraying is necessary use *Bacillius thuriengensis* (Bt) or possibly, neem oil.

Mites are usually well controlled by natural enemies, including predatory mites, where broad-spectrum insecticides are not used. Some mites do not damage the crop but might still be quarantine pests. Mites can debilitate the tree and reduce fruit set.

Control: Oil and sulphur sprays can control mites but are also toxic to beneficial insect species. Encourage habitat for beneficial species.

Cherry Slug (*Caliroa cerasi L.*) Also known as pear slug or sawfly. This pest appears as a smelly black or dark olive slug on the leaves of plums and cherries. Hawthorn is also a host. There can be multiple generations in warm areas, with populations rapidly building up and causing severe defoliation of the trees. The pest pupates in the soil beneath the trees.

Control: A natural disease is known to sometimes control populations of cherry slug, but as yet has not been commercially developed. Although pyrethrum very effectively kills the slugs, it is likely to return in even greater numbers, probably because natural predators have also been killed off by the spray. Birds will predate the slug, especially the shining cuckoo, and chooks may be useful to predate the pupae. Dusting with wood ashes, hydrated lime or dolomite, washing off with a strong stream of water and insecticidal soaps are all possible control methods.


LONG TAILED MEALY BUG

Mealy Bugs Several species may cause damage mainly by the excretion of honey dew.

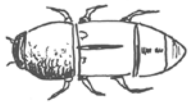
Control: Natural predators and parasites are probably numerous, including the Tasmanian lacewing and eleven spotted ladybird. Preserve habitat for beneficial species. If necessary, oil (1%), neem or insecticidal soap spray in early spring before the adults have developed waxy coats.

Oriental Fruit Moth (*Grapholita molesta*). A newly arrived pest of summerfruit and pipfruit that has not yet reached the South Island. The caterpillar burrows into fruit and shoots. Adults overwinter as mature caterpillars in silken cocoons in protected crevices in the tree or on the ground.

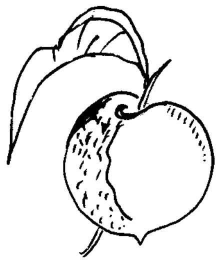

ORIENTAL FRUIT MOTH

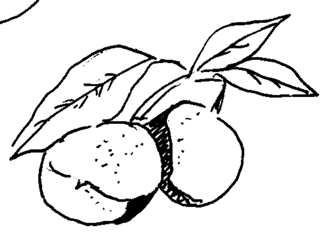
Control: Natural biological control occurs by parasitic wasps, slugs, beetles and spiders. Silver eyes might predate the cocoons in winter. Pheromone dispensers are available and can be used for monitoring moth activity and for mating disruption. Mating disruption works best in sheltered larger sized blocks, while Bt could be used in conjunction with pheromone trap monitoring.

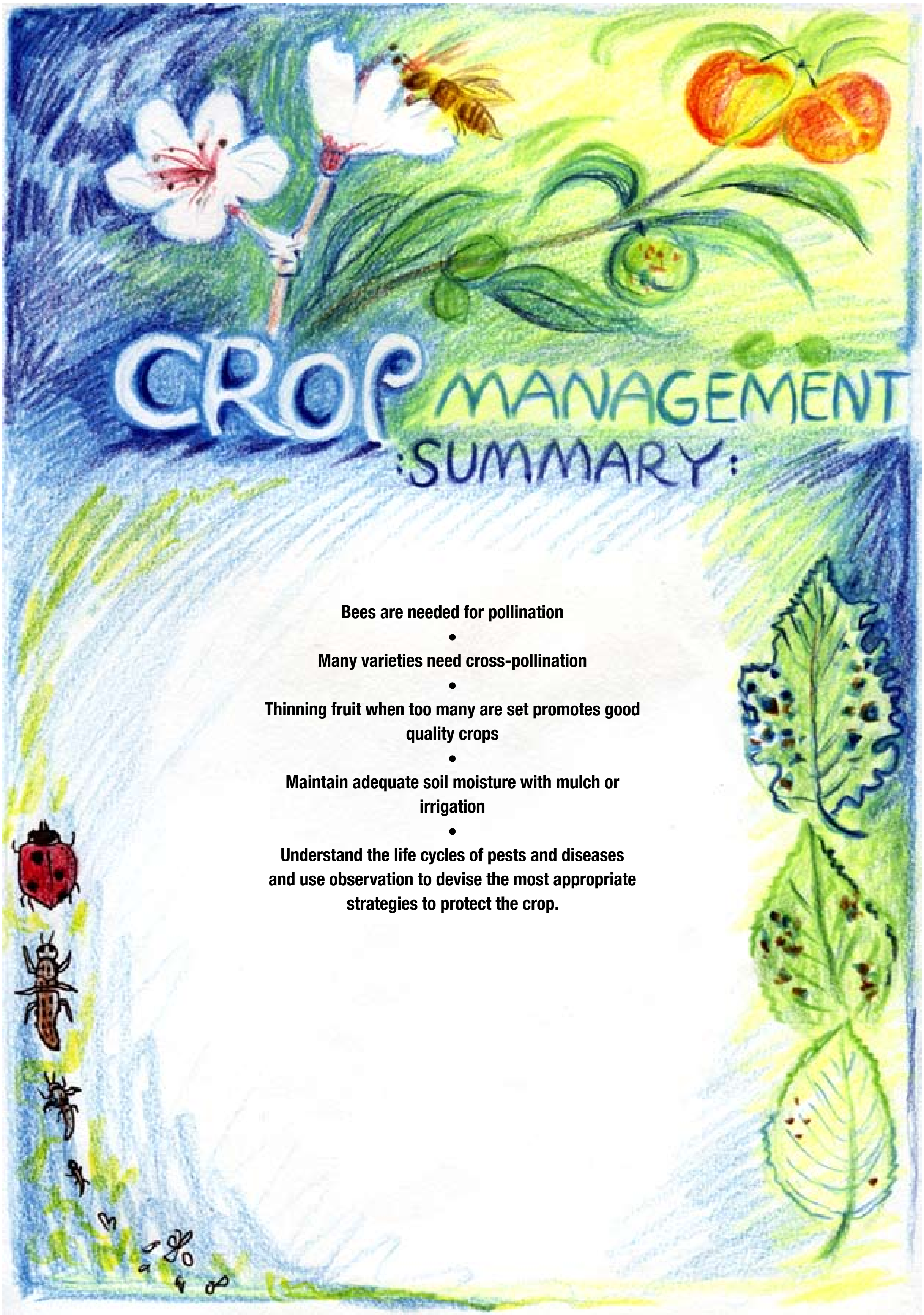
Carpophilus beetle (*Carpophilus spp.*). Another North Island pest, these small dark beetles (2–3mm) attack the ripening fruit by making a small hole and then feeding under the skin or they can enter through existing points of damage (e.g. leafroller tunnels). Numbers can increase rapidly near harvest. They are a vector of brown rot, spreading the disease through the tree and crop.


CARPOPHILUS DAVIDSONI

Control: Remove rotting fruit from the orchard, including thinned fruitlets early in the season. Natural predators such as soil nemotodes may play a role in controlling the beetle. The beetle can be attracted to a trap baited with fermenting fruit juice (see SummerGreen manual).







Bees are needed for pollination

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Many varieties need cross-pollination

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Thinning fruit when too many are set promotes good quality crops

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Maintain adequate soil moisture with mulch or irrigation

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Understand the life cycles of pests and diseases and use observation to devise the most appropriate strategies to protect the crop.

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Further information on pests and diseases:

Books

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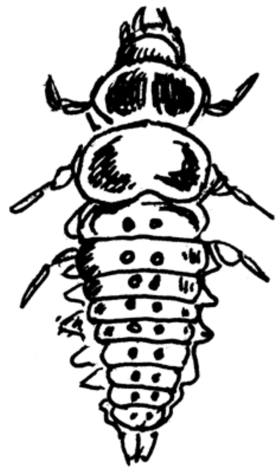
Lucas, R. (1998). *What's that pest – identify and control NZ garden pests and diseases.* NZ.

McLaren, G.F., Grandison, G., Wood, G.A., Tate, G. & Horner, I. (1999). *Summerfruit in New Zealand: management of pests & diseases.* Dunedin: HortResearch/ AGMARDT/Summerfruit New Zealand Inc./University of Otago Press.

Detailed information for summerfruit pest monitoring is provided in the SummerGreen IFP manual produced by Summerfruit New Zealand.



On line

Current Research on the control of pests and diseases of organic stonefruit: http: //www.hortnet.co.nz/publications/proceedings/ifoam/ifoam29.htm

Images ppvbooklet.cas.psu.edu/

www.ianr.unl.edu/pubs/PlantDisease/g1011.htm

Organic/low spray peach production:

attra.ncat.org/attra-pub/peach.html

www.gov.on.ca/OMAFRA/english/crops/facts/88-114.htm

Some brand names of common organic spray materials

Baccillus thuriengensis (Bt) – Dipel, Delfin, Foray, Agree

Pyrethrum – Yates Pyrethrum, BettaCrop Garlic & Pyrethrum

Neem oil – Nemesis

Mineral oil – Sunspray, D-C-Tron

Vegetable oil – Codacide Oil

Clay powder - Surround

Copper hydroxide – Kocide, Champ Flowable, Blue Shield

Insecticidal soaps – Defender

Pheromone traps – DeSIRe SEX

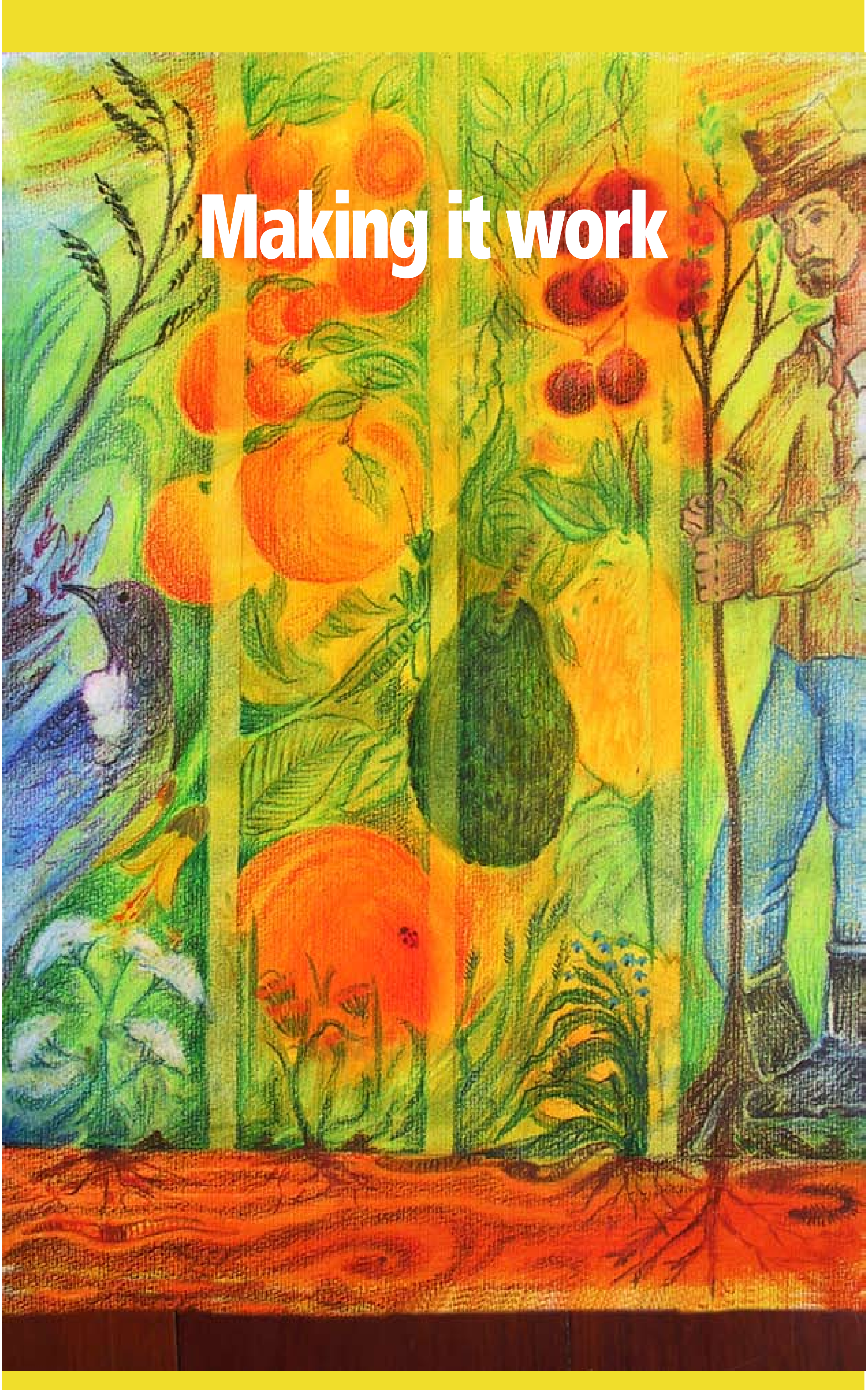
Herbicides – Interceptor, IT 1

A wide range of organic products available from:

Eco Store, Fruitfed, Town & Country, Wrightsons, Farmlands, Pacific Growers Supplies (Auckland)

Pest Management Services (Kapiti) - bird scaring devices

Earthwise Direct (Hamilton) – Garlic & Pyrethrum, and other natural pesticides


Making it work

Harvest and marketing

Timing of the harvest is much more critical for summerfruit than for many other fruits (e.g. apples or pears). Fruit must be firm enough to withstand handling and transport to market but ripe enough to attain satisfactory eating quality by the time of consumption. Harvesting up to 4 days before fully ripe is preferred. Harvest peaches and apricots when background colour has changed from green to yellow. For varieties that are red before ripe, harvest when fruit has just started to soften. This can be measured by penetrometer with a 8mm tip (UC Davis). Ripeness is likely to trigger rapid development of brown rot in susceptible varieties. Apricots, white skinned peaches and brown rot resistant cultivars are particularly prone to bruising when ripe. Plums are harvested according to colour development, which differs between varieties. They are generally more resistant to bruising than peaches and nectarines. Some varieties, such as Hawera, are firmer and therefore better suit more distant markets. Varieties, such as Sultan, can be harvested partially green and will still ripen satisfactorily. Sweet cherries are harvested according to colour, the degree varying between cultivars.

Early morning or evening harvest is best because the fruit is then cooler. Where possible, fruit should be picked directly into trays (3.5kg capacity), ready for despatch to help minimise handling damage. Apart from trays, 10kg cartons are commonly used for summerfruit.

Biodynamic growers tend to observe cosmic events and/or planetary constellations to achieve the best possible results. Therefore fruit that needs an extended shelf-life may be picked at a favourable time, weather permitting. Rain will swell fruit (possibly leading to splitting in cherries) and increase the chances for bruising, diluted sugars and a shorter shelf-life. The time of harvest and of course postharvest handling, will set the quality aspects of the harvested fruit.

Santitation during harvesting and all subsequent handling stages is very important to minimise the risk of postharvest fruit rots. The fruit should be cooled as soon as possible after harvest. Fruit can be stored at 0°C for 1 to 3 weeks and for shorter periods at 5°C. Possible postharvest treatments for organic summerfruit to reduce brown rot include dips in a solution of calcium salts (e.g. hydrated lime)[41] or possibly neem oil[42]; fumigation with vinegar[43,44]; or heat treatment[45]. Postharvest treatment with hot water has been proved to be effective for disinfestation of stonefruit, however at this stage the cost of equipment is prohibitive and the process is unlikely to be developed further unless international pressure forces the withdrawal of preharvest insecticides for conventionally grown stonefruit.[46]. Hot water treatment offers excellent possibilities for organic growers as it does not damage the fruit and reduces brown rot levels (G.McLaren, personal comment).

The most important points in postharvest management of summerfruit are:

- Maintain cool conditions
- Minimise handling
- Market quickly.

Successful marketing of summerfruit depends on efficient systems to harvest and move the fruit to the consumer. Many organic retail outlets have relatively slow turnover rates and this can easily lead to fruit being kept longer than it should. Allowing poor quality fruit to be displayed for sale reduces the likelihood of increasing demand and return sales. It must be remembered that as IPM systems are developed for summerfruit, there will be an alternative low-chemical-residue product. Matching the volumes of fruit sent to outlets to demand, ensuring that the fruit is handled properly at all stages to the consumer and matching the storage period to the fruit's postharvest characteristics will help ensure a successful operation. Summerfruit marketing suits local 'farmers markets' (or flea markets) or the use of couriers to get fruit rapidly to retail outlets in a tree-ripened state. Personal relationships with couriers, retailers and others involved in the supply chain, also helps to ensure fruit is handled efficiently.

Export

Note: **information in this section correct as of 2002.**

Global Organics – Russell Faulkner reports that

- *They export 15–20 tonnes plums and 3-4 tonnes nectarines to USA*
- *Their product comes from Hawke's Bay, Hamilton and Central Otago*
- *Peaches are considered too difficult to export (because of shelf life issues)*
- *Australia's product is absorbed by the domestic market*
- *Australia grows mostly organic plums and nectarines in the Melbourne area*
- *Competition for NZ exports comes from Chile – they are able to get their product onto the market more cheaply (proximity, sea freight/air freight, labour etc.)*
- *Windows are available pre-Christmas and at the end of February*
- *Still some room for more exported fruit but margins are tight, as is the appropriate time as from Christmas to mid-February the market is too saturated with product from Chile.*

Freshco – John Mangan reports that

- *At this time they do not export any organic stonefruit*

- *There are markets there but they require:*
  - *Sufficient guaranteed product supply*
  - *Quality to be at least as good as conventional*
  - *Product to have reasonable shelf life*
  - *Grower expectation of margins to be within reasonable bounds*
- *They expect (hope) to become involved in the market once some of these issues are ironed out.*

Local market

- Existing suppliers have commented that, although many of the local markets for fresh organic stonefruit are currently close to capacity, consumer demand (as a result of greater awareness) may increase in the future.
- Growers have also expressed concern that if too many new growers begin to put fruit into the local market at the moment they may create a surplus, reducing prices to below a point where it is viable.
- There is also concern that substandard fruit potentially coming onto this market could act as a deterrent to wholesalers and consumers who may already be cautious because of problems with shelf life of organic stonefruit.

Process fruit

Heinz–Wattie has been working for the past 4 years with a Hawke's Bay grower and Greg Tate (Crop Health Services) in an attempt to find an effective and viable method of growing Golden Queens organically for the process market. They abandoned the programme this year as the grower felt that it was not economically viable. Heinz–Wattie have indicated that they are prepared to make information on these research results available to growers on request.

There are a number of smaller processors who are seeking a range of organic stonefruit for processing into baby food, juices and other food additives, etc.. However these are niche markets and tend to have been obtained as a result of the extensive effort of individual growers. As a result these growers are understandably reluctant to share information and it is up to others to seek out their own markets.

Biodynamics

"Biodynamics is a human service to the earth and its creatures, not just a method for increasing production or for providing healthy food" (47).

Biodynamic practice is an ever-evolving system of landuse-pactices, which was originally introduced by Dr Rudolf Steiner, who delivered his Agriculture Course in 1924 in Koberwitz, Silesia (Poland today). Dr Steiner contributed profound insights into a deeper understanding of man, our condition, our civilisation and, relevant to this context, the so-called natural world.

In general terms, the biodynamic method is one way of organic farming, which integrates human existence into primary production without destroying our habitat.

Based on a foundation of sound practice and good husbandry, biodynamics (please note the 'dynamics' or process orientation) focuses on the whole, the farm as an organism, the bigger picture and seeks positive integration of all constituent parts. Soil-fertility is considered of primary importance. Any problems in terms of crop- or animal-health are more likely addressed by searching for long-term solutions on a causal rather than a symptomatic level. The judicious use of the biodynamic field- and compost-preparations is an essential tool for balancing and guiding processes which ultimately determine good health and sustained production.

Man, in this case the grower or farmer, is seen as an integral part of the farm-organism and ideally much more than a mere manager of inputs and outputs.

Cosmic and planetary aspects:

In contrast to healthy soil, the less visible sphere of planetary aspects is viewed as a necessary counterbalance for healthy growth. These forces influence plant and animal growth and the biodynamic practitioner endeavours to harness the forces to best effect. This will naturally lead to specific timing of activities and interventions. Good seed-germination, improved disease-resistance, extended shelf-life can all be enhanced by balancing the factors that are responsible for growth. There are calendars that list the important planetary aspects and lunar cycles. The Bio Dynamic Farming and Gardening Calendar of New Zealand does not specify any particular activities at set times but is more designed to school users in improved understanding of rhythms and cycles, while listing events and aspects of importance extensively. As with all outdoor growing, the weather and possibly other factors may take precedence over any one particular desirable planetary aspect.

Biodynamic practice includes the use of a number of special preparations *(Table 11)*. These are prepared and used according to detailed procedures[27].

Table 11. **The composition, preparation and use of the biodynamic preparations**.

Preparation	Composition	Use
500	Cow dung Horn Manure Preparation	Applied to the land at least twice a year to increase soil fertility (vitality).
501	Ground silica Horn Silica Preparation	Sprayed on growing crops at least once a year to provide structure to growth and to increase disease resistance
502	Yarrow flowers	Compost preparation
503	Chamomile flowers	Compost preparation
504	Stinging nettle – whole flowering plant	Compost preparation
505	Oak bark shaved outer bark	Compost preparation
506	Dandelion flowers	Compost preparation
507	Valerian flowers	Compost preparation
508	Equisetum herb	Spray for protection against fungal diseases

The biodynamic preparations are used to guide the natural forces, which are at work in growth and fermentation processes and to balance cosmic and terrestrial forces. Biodynamic growers acknowledge that growth cannot be looked at as a mere physical–chemical phenomenon, but that healthy balanced growth is reliant upon forces, which we can work with through biodynamic practice. Biodynamic preparations may be seen as quality- and vitality-enhancing catalysts.

Certification

Organic growers may wish to have their properties certified. Certifying organisations codify the rules for managing an organic property (e.g., input audits, on farm inspection and report, wider environmental impacts, compost quality and diversity levels). Certifiers charge for these services.

Copies of organic production standards are available from certifying organisations which outline the above procedures, practices and materials

In New Zealand there are three bodies that register organic growers; the Bio Dynamic Farming & Gardening Association that own the Demeter trademark, the NZ Biological Producers and Consumers Council Inc that owns the Bio-Gro Trademark, trading as Bio-Gro New Zealand and thirdly, AgriQuality trading as Certenz (please note that the trading name Certenz is going to be phased out and AgriQuality will be used in future). All three are members of the International Federation of Organic Agricultural Movements (IFOAM), which is the governing international body. Bio-Gro and AgriQuality are also accredited by IFOAM, Demeter NZ by Demeter International.

The three certifying bodies lay down a strict set of standards relating to management strategies and farm inputs that must be adhered to if certification of a property under a particular trademark is to occur. The farmer/grower contractually agrees each year to abide by the certifiers written standards. These regulations are based on such factors as the environmental impact caused by the manufacture or use of many herbicides, insecticides and fungicides, the effect on soil fertility by synthetic fertilisers and the fostering of ecosystem diversity on various levels within the farming environment. The organisations charge for inspection services and administration of the standards.

Demeter trademark

The Demeter certification trademark denotes agricultural products produced using the biodynamic agricultural techniques detailed by Rudolf Steiner in a course of lectures given in 1924 to a group of landowners in Germany. The methods have been amplified by practitioners around the globe since that time (including NZ in the late 1920's). The Demeter trademark first appeared in Germany in 1928. Biodynamic farmers look towards the living processes that comprise the farm – soil, water, plants, animals, humans, air and wider influences, such as sun, moon and planets.

Bio-Gro New Zealand

Bio-Gro New Zealand was founded in 1984, as an independent, non-profit Incorporated Society, to promote the interest of organic production in New Zealand. Activities include the setting of organic production standards; inspection and verification of Bio-Gro licenses and License Applicants; research and education. Bio-Gro New Zealand is funded entirely by membership and inspection fees, licensing levies, donations and grants.

AgriQuality

AgriQuality New Zealand Organic standards are based on internationally recognised standards, which were developed to allow market access to the USA, EU, Australia, Southeast Asia, UK and Japan. The standards introduction quotes 'this standard has been prepared for the purpose of providing minimum requirements to be complied with to gain certification for the production of, and the labelling and claims for, organically produced foods.'

OrganicFarmNZ

In 2002 a small growers certification scheme was launched, which is administered by the Soil and Health Association based on Bio-Gro standards. Small regional groups of growers (pods) meet for mutual inspections. An independent auditor oversees. Strictly for domestic marketing.

Far North Organic Growers & Producers Association

This group was founded in 1989 by a group of growers, home gardeners & customers who were interested in organic methods of growing fruit & vegetables. A certification scheme was worked out, standards established and the scheme was running by 1991. Far North Organic Growers & Producers (FNOG) Association has since become a certifying body under OrganicFarmNZ. However the original FNOG certification still operates independently for growers marketing locally where this established logo is recognised. Strictly for domestic marketing.

Information and certification sources:

Bio–Gro

P O Box 9693
Marion Square
Wellington.
Ph: 04 801 9241
Fax: 04 801 9242
Email: info@bio–gro.co.nz
Web: www.bio–gro.co.nz

Bio Dynamic Farming and Gardening Association in NZ Inc.

PO Box 39 045
Wellington Mail Centre
Tel: 04 589 5366
Fax: 04 589 5365
Email: info@biodynamic.org.nz
Web: www.biodynamic.org.nz

AgriQuality Ltd

David Brown, Organic Service Manager
P O Box 307
Pukekohe
Auckland
Ph: 09 237 1807
Fax: 09 238 3757
Email: brownd@AgriQuality.co.nz
Web: www.AgriQuality.com

Organic Farm NZ (small growers domestic certification scheme)

Soil and Health Association of NZ Inc.
P O Box 36–170
Northcote
Auckland
Ph: 09 419 4536
Fax: 09 419 4556
Email: info@organicnz.pl.net
Web: www.organicnz.org

Far North Organic Growers & producers Association

PO Box 157, Kaitaia
Web: www.farnorthorganics.org.nz

Going organic – the conversion period

Converting a conventional orchard to an organic management system can create a new set of problems for the grower. When synthetic fertilisers and pesticides are withdrawn it may take some years for new equilibriums to establish. Difficulties often encountered during conversion include nutrient deficiencies and pest outbreaks. Organic management demands more of the grower than simply substituting conventional chemicals with organic alternatives. It might be necessary for the grower to learn new skills, such as observational skills. In fact, going organic often demands new attitudes and perspectives both from growers and consumers. For example, the minimal intervention approach to growing often requires a suppression of the immediate urge to intervene and solve a problem, in order to allow time for natural processes to take effect. This 'hands off' approach can be difficult for growers accustomed to taking more direct control of the farm environment. Additionally, the stand down and transitional period necessary before full organic certification is gained, means the premium often received for organic produce is not immediately available to the grower. It is this premium that can compensate for the reduction in yield that sometimes occurs after organic conversion.

Generally the greatest difficulty experienced during conversion will be pest and disease outbreaks. It will take several seasons before populations of beneficial insects become established. Increasing the orchard's biodiversity by introducing new sward and hedgerow species and avoiding broad-spectrum insecticides can promote this process.

The soil in a conventional orchard may have a depleted level of organic matter, especially in the tree row where herbicides have been used. This, along with a degraded soil structure, reduces the soil's ability to supply the trees with sufficient nutrients and to support the high levels of biological activity necessary for efficient nutrient recycling. Nitrogen in particular can be in short supply. Therefore, during the first years it will be necessary to apply larger amounts of compost and mulch as remedies. Also, more use can be made of the concentrated organic fertilisers, such as fishmeal.

Weeds can also be a problem during the conversion period. As soil biological activity increases, weed seeds may become less virulent. Sometimes weed problems will be due to the need for new weed control strategies such as different mowing equipment and mulch, or it might be another case where new attitudes and perspectives will reveal that the villain is in fact an ally.

Many of the problems associated with conversion to organics can be minimised if the orchard has already adopted IFP (Integrated Fruit Production) -type practices beforehand. For example, practices such as spraying to pest thresholds rather than calendar spraying and changes such as substituting broad-spectrum insecticides with pest-specific ones, using mulch and mowing rather than herbicides can be implemented several years before applying for certification.

Integrated fruit production

Integrated fruit production (IFP) has been defined as 'the economical production of high quality fruit giving priority to ecologically safer methods, minimising the undesirable side effects and use of agrochemicals, to enhance the safeguards to the environment and human health'[48]. It is an extension of the integrated pest management (IPM) systems that were developed to reduce pesticide use in many crops. IPM reduces pesticide use by integrating a range of control methods to manage pests. It aims to protect and enhance populations of natural predators by using low toxicity and pest-specific pesticides. It achieves this by monitoring pest levels in the orchard and setting critical threshold levels at which point pesticides are applied to coincide with the vulnerable developmental stages of pests. IFP, however, includes more than just pest and disease management. It recognises that the control of pests and diseases involves a wide range factors such as soil, fertiliser and water management, pruning and training systems, sward management and scion/rootstock selection. It also recognises that the production of high quality fruit involves issues of food safety, quality assurance, occupational health and safetyand other agronomic and economic factors. It uses whole farm planning so that consideration is given to the preservation of native vegetation, the siting of buildings, roads, dams and windbreaks in order to minimise adverse environmental impacts. Pest complexes are considered rather than just individual pests. Whereas IPM emphasises pest management, IFP emphasises crop production. IPM is a component of IFP[49].

In New Zealand an IFP programme for summerfruit, the SummerGreen programme, has been developed and implemented by growers. Research into pest lifecyles, biological controls, sward management and many other areas is being done both here and internationally for IFP and IPM programmes and will directly benefit organic growers. There is a full description of life cycles, monitoring methods and timing in the SummerGreen IFP manual. This is currently available free to all Summerfruit NZ levy payers who agree to participate in the SummerGreen programme which involves attending regular technical update meetings and providing monitoring and spray records to HortResearch for research purposes. HortResearch in return give feedback to the growers about the latest trends and research results.

The development of IFP programmes might reduce the ability of organic produce to be differentiated in the market place unless organic growing systems also maintain a 'continuous improvement' approach and move into the redesign phase as described by Stuart Hill[3].

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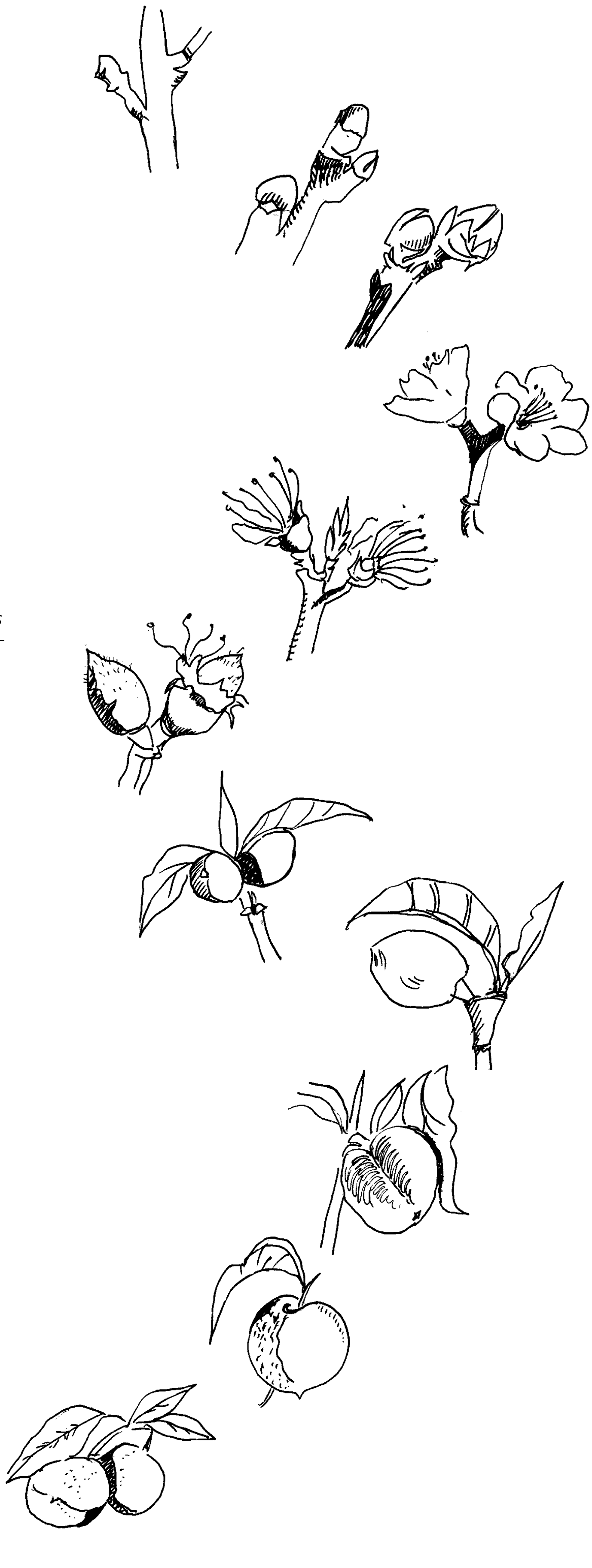

Further information postharvest:

Postharvest produce facts
http://postharvest.ucdavis.edu/Produce/Producefacts/index.shtml

Further information on biodynamics:

Anon. (1989). *Biodynamics: new directions for farming and gardening in New Zealand.* Auckland: Random House.

Proctor, P. (1997). *Grasp the nettle: making biodynamic farming and gardening work.* Auckland: Random House.

Steiner, R. (1974). *Agriculture*. London: Biodynamic Agricultural Association.

Biodynamic Association Website: www.biodynamic.org.nz/
Biodynamic preparations available: www.bdmax.co.nz

Biodynamic Advisory/Consultancy:

All advisory work requests are now referred to the Biodynamic Consultancy Society (c/o B. Gillatt (secretary) Redhill, R.D.1, Dargaville), which is an incorporated collegiate of consultants who offer a spectrum of expertise. Depending on the type of operation advice is sought for a number of consultants may be recommended to the client. The consultant is then chosen by the grower / farmer.

Appendix A
Consultation with growers

A number of New Zealand organic growers when faced with the question of whether growing organic stonefruit is sustainable or commercially viable have commented that in their experience:

- Stonefruit, grown organically, produces reduced crops because there is greater loss from disease such as brown rot and it is harder to keep up with the heavy nutritional demands of the trees under an organic regime
- In many areas there is a limited local market demand for their fruit (as opposed to stonefruit which has been grown with conventional methods.)
- This is not the case in all parts of the country and in some areas the local market is growing well
- Shelf life is not as good for organically grown stonefruit. This reduces marketing options
- Price margins are not yet sufficient compensation for the losses incurred
- The main competition in the export market , which is mainly to the United States, is Chile. Because Chile is able to get their fruit to the market faster and more cheaply and because their labour costs are lower, they are able to sell their fruit at prices which New Zealand is unable to compete with
- While the local market for fresh organic stonefruit is currently close to capacity, consumer demand (as a result of greater awareness) may increase in the future
- Some of the processing companies are still interested in obtaining more organic stonefruit (particularly the smaller companies)
- Exporters are still keen to procure fruit for the export market provided growers are able to provide a consistent supply of quality fruit in reliable quantities at realistic prices.

Wider consultation with other stonefruit growers, some of whom have grown organically in the past, considered growing organically or others who are growing stonefruit under a conventional programme, have made the following observations:

- All expressed keen interest and support for the project
- Most think that there is definitely a place for this manual (once it is edited) and believe it should be used as a living document-being continually updated as new information becomes available
- Some think that a network for organic summerfruit growers should be interwoven with the SummerGreen growers and definitely not a "them and us" scenario
- Some believe that under-storey management with appropriate plants and herbs (e.g. oregano or lavender) can assist with soil health and pest management
- Many believe that the manual must not be prescriptive but should offer a range of options for growers to follow up for themselves to decide whether they are appropriate for their area and varieties of fruit
- Some believe that the only premiums available for organic stonefruit are offshore and shelf life is too much of a problem for most varieties to make this viable
- Some believe that there is already a glut of stonefruit (conventional) grown for local market and that this will get worse before it gets better
- Some think that there is possibly potential for organic cherries and plums on the overseas market but are not interested in getting involved themselves
- Some think It may be worth considering 10 years down the track when there is/are:
  - A viable market
  - More grower and consumer education
  - Local consumers are prepared to pay a premium for the organic fruit
  - Organic methods for controlling brown rot
- One grower thinks anyone who is trying to grow stonefruit organically must either be mad or able to afford to lose a whole crop about every second year
- He would grow his stonefruit organically tomorrow if a way was found to manage brown rot and blast
- He thinks most people would happily "Go Organic" if these problems were sorted and it was sustainable
- He does not believe it is possible to grow stonefruit without copper
- He believes that lack of shelf life means that organic growers are unable to put fruit onto the market which is anywhere near up to standard
- He does not think it is advisable to encourage new growers to go organic until some of the issues have been solved
- One grower believes that issues such as brown rot will eventually be solved with soil management rather than substitute spraying
- He will not be trying to grow stonefruit again until some of these issues are solved as he thinks it is too risky and can be financially disastrous
- He believes organic growing would only be possible with a small block of fruit in an area where weather conditions are conducive
- He thinks economic margins for organic fruit need to improve to make it a worthwhile exercise
- One grower believes that the way ahead is for pest and disease resistant varieties even if they have to be genetically modified
- He thinks that the local stonefruit market (including conventionally grown fruit) is shrinking because there is too much competition from other types of fruit and imported fruit.
- He thinks that there are also difficulties because of the way the supermarkets control the markets and prices are reducing
- He says that even for conventional growers it is also becoming more difficult because of the lack of promised replacement chemicals for the ones which the market no longer accepts or is about to withdraw
- Another grower believes growers need to recognise that getting it right one season will not necessarily mean that they've got it sussed as different seasons present different types of problems – particularly related to the weather.

Appendix B
Case studies

The following case studies have been kindly supplied by people who are currently growing their stonefruit organically and are intended to give the reader an insight into some of the current practises, successes and issues occurring in New Zealand. The range of the case studies reflects some of the differences between growing organically in different climates (e.g. Hawke's Bay compared to Central Otago).

Case study 1

Alister and Carolyn O'Brien

Orchard description: We have a 5ha block near Alexandra in Central Otago. When we bought the land in 1996 it had about 4ha planted in various Moorpark apricots on Tatura trellis. Some of the strains of Moorpark were poor quality conventionally and did not fare any better when we put them under organic management. These have been removed leaving about 2ha apricots, which we run as a part time orchard. It has been Full Bio-Gro for 2 years. Soils are mainly shallow clay loans, which have been ridged.

The Central Otago climate is usually relatively dry except for large dollops of rain at cherry harvest! The low rainfall and humidity mean reduced pressure of brown rot infections compared to other parts of the country. Frost is often a problem in spring and the orchard has overhead sprinklers for frost control/irrigation.

Background – Why Organic? Because we live on the orchard with our 5 children we decided to manage it organically. If it had been our main source of income, however, our choice may have been different, because of the difficulties involved in growing organic apricots, particularly brown rot control. Because this disease can often cause a severe reduction in the storage-ability and shelf life of apricots, we decided supplying processors was our best option with some fresh sales. This has proved to be a good system with our varieties of apricots and our current knowledge on brown rot control. However significant change in the latter could lead to potentially large export opportunities.

Spray programme: see warning note below

Date	Material (g/100 litres)
11/9/01	Kocide 50g, Lime 100g Zinc sulphate 200g Solubor 100g, Kumulus 180g
18/9/01	Kocide 30g Kumulus 190g
28/9/01	Kocide 25g Kumulus 180g
17/10/01	Kocide 25g Zinc Sulphate 150g Lime 100g Boron 100g
1/11/01	Kocide 25g
10/12/01	Bt (Delfin) 50g Summer Oil 1%
23/12/01	Bt (Delfin) 50g Summer Oil 1%
2/1/02	Kumulus 100g

Fertiliser programme: Leaf tests have shown we are low in the micronutrients zinc, boron and manganese. Bio-Gro has given us permission to use foliar sprays of:

- ZincSulphate (always mix with Lime)
- Solubor and
- Manganese Sulphate

Most of these we apply pre- or postharvest. We are also low in nitrogen and have had permission from Bio-Gro to use some meat and bone meal. As we change to a mow/mulch groundcover management system, I think this will supply most of our nitrogen. Other nutrients appear to be fine. Potassium has increased significantly as 'weeds' have invaded the old weed spray strip.

Problems and issues

1. I'm not sure whether our biggest problem is brown rot or the sulphur we put on to control it.
2. Nutritional sustainability/tree health over time.
3. Very difficult to find markets for conversion fruit.

Successes Still working on this one.

I suppose harvesting the majority of our fruit this year in a season which was a brown rot nightmare even for conventional growers, was something of a success.

Plans/Opportunities We are working on tree health and improving our yields. Aiming to maintain our supply to processors as our core business.

We desperately need an alternative organic brown rot control both pre and/or postharvest. This would open export opportunities.

Warning Note: Apricots do not like sulphur products (e.g. Kumulus and maybe lime sulphur) although some seem to tolerate it more than others do (e.g. Sundrop). It would appear that older varieties like our Moorparks are very sulphur shy with symptoms including stunted growth, yellowing of leaves, delayed harvest, taste/texture changes, inhibition of bud formation for the following season. Consequently on our block we will not be using sulphur next season, but will rely on some copper, removal of diseased wood and mummified fruitsand prayer.

Case study 2:

HortResearch, Clyde Research Orchard. Orchard Manager, Alister O'Brien

Orchard description: The Clyde Research Orchard in Central Otago has been researching organic stonefruit production since 1991. The orchard has 0.2ha of Noir de Guben cherries (similar to Dawson). The soil is a shallow light gravelly loam over gravel. Climate is generally low rainfall, low humidity, warm/hot in summer and cold in winter. Spring frosts can be a problem. The block has overhead sprinklers for frost control and undertree microsprinklers for irrigation. (These are raised off the ground on a wire so as not to hinder the swing arm mower).

Background: Dr. Jill McLaren (HortResearch) has been trialling various methods of controlling brown rot and black cherry aphid on the block. Fruit not used in the trials is sold.

In the 2000/2001 season, we sent a trial lot of 6kg to Taiwan to check buyers comments. Feedback was positive. It was planned to send more in 2001/2002, however because of bad brown rot in a very wet season, we decided not to. We intend to try again in 2002/2003.

Cherries seem to be more tolerant of brown rot than peaches and apricots. They also do not seem to be affected by the use of sulphur sprays. These two factors combined with a reasonable season seem to offer hopeful prospects for exporting.

Spray programme:

Mid August	Oil 2%
Bud movement	Kocide 100g
Bloom to petal fall	Kumulus 100g x 3 Depending on weather
Pre-harvest	Kumulus 100g
Post-harvest	Kocide 100g
Full leaf drop	Kocide 100g

Fertiliser: Depends on soil test/leaf test

Have used:
- Reactive phosphate rock (RPR)
- Lime
- Gypsum
- Elemental sulphur
- Meat and bone meal

Mow/mulch – herb lay transfer

Problems/Issues

1. Rain splitting at harvest. Our cherries do not seem to split as badly as some conventional blocks. There are many variables affecting this but I suspect the use of Gibberellic acid (GA) on conventional cherries makes them more prone to splitting. It also makes them firmer and later. BioGro indicated that organic growers could possibly use GA (a natural plant hormone) if a commercial source could be found without unnatural additives.

2. Brown rot is a problem. However sulphur seems to do a reasonable job at control, if used immediately pre-infection (pre-rain).

3. Black Cherry aphid. Research is continuing on control methods. Pruning out infected shoots in spring just as the aphids are making the leaves curl is a useful control.

Successes: Positive market responses both nationally (Auckland) and internationally (Taiwan).

Plans/Opportunities: The future of this cherry block and the research conducted on it depends on continued funding from both Government and industry. While the block remains in the ground, we will continue to use any fruit not required for research to test export market opportunities.

Case study 3:

Summerfruit Orchards Central Otago. Stonefruit Manager, Ian Nichols

Summerfruit Orchards Ltd is involved in the conventional production of 60 hectares of summerfruit based at Earnscleugh, near Alexandra. The company is also producing organic apples and stonefruit. Their own 6ha block of apples is entering C2 while a leased block of 5ha is entering its fourth year of full certification. Also in the leased block is 1ha of fully certified stonefruit, being predominantly nectarines.

The move into organic production was seen as a way of adding value to the apple crop at a time when prices were particularly low and the foreseeable future did not look a lot better. Although a change in philosophical approach was not the main driver, it is fair to say that it was a consideration. The company has been involved in both summerfruit and pipfruit IFP programmes since their inception and is committed to safe food production. The experiences gained from this background made the consideration of an organic approach seem less far daunting.

The stonefruit block was inherited as part of the leased apple block and is seen as an opportunity to gain experience with organic summerfruit. The major disease threat of brown rot, along with a lack of vigour, meant the block was not a high performing one in economic terms. The site itself has heavy silt loam soils with good water holding capacity and good fertility levels. The land has been used for growing fruit for over 70 years, but is quite a cold site that is somewhat marginal for stonefruit production.

The main variety is Fantasia nectarines with smaller amounts of Maygrand and Early Red 2 nectarines plus the odd Flamecrest peach tree and a few Louisa plums. The focus of production is for fresh consumption with the Fantasia being exported while the rest are sent to local markets throughout New Zealand.

Our company is beginning the third season of production on this block and still the 2 main issues are brown rot and vigour. In the past season Fantasia was exported to the USA and returned $15 per tray (around $4.00 per kg). Repacks were necessary on arrival overseas due to brown rot but not in a way that damaged the market acceptance. In a year when the district suffered high brown rot incidence, even on conventional blocks, this result gives some confidence that brown rot may be manageable.

Our spray programme consists of 2 coppers over bud burst (one combined with an oil) then a programme of Kumulus at 180g reducing down to 80g close to harvest. Six sulphur sprays were applied last year timed as protectants before forecast infection periods. Any brown rot seen throughout the growing season is removed or pruned out and we attempt to remove all brown rot on the first light harvest pick. As this programme has been moderately successful we will continue with it although a lime sulphur will be added at bud burst and perhaps over bloom. Brown rot will always be an issue but we feel a combination of sprays and cultural practices can reduce the risk significantly.

Leafroller is also a problem and prevented export in the previous season. Two Bt and oil sprays in early December help address this but don't eradicate it. The practice of removing damaged fruit as soon as possible and at first harvest is also used. It appears that keeping the sward lower may also help so that will be looked at this season. Only one generation is usual down here so damage is reasonably obvious at harvest.

The summerfruit block was planted about 17 years ago and so is at the end of its economic life. This means lack of vigour will reduce yields and in an organic system is not so easy to address. We have used a foliar programme (Millennium 3 from Fluid Fert) with about 3 or 4 applications during the season. Last season we also applied meat and bone meal at 500 kg/ha, which seemed to be beneficial. It was not applied this year and the trees suffered a bit – so will our crop this year as a result.

We have no set policy for under tree sward management. All prunings are mulched but the clippings are not thrown under the tree. Swing arm mowing occurs during the growing season while grazing by sheep over winter is also a cleanup process. The plant species under the trees are all naturally occurring with no planned planting undertaken. We are keeping an eye on the results of the understorey management project being carried out in the Hawke's Bay with particular interest in nutrition effects.

The use of composts or mulches is not occurring at present because of the difficulty and expense of obtaining certified material down here. It is becoming a necessity for weed suppression in some young apple trees so a more concerted effort will be made this coming season to source something.

Overall we are reasonably happy with growing organic stonefruit. As mentioned above it is a useful learning block. We would not be comfortable recommending the exercise to others but believe that in the right site with certain varieties potential is high. More work on brown rot is vital as is a change in thinking about postharvest handling. Being able to move the product quickly through the supply chain and expanding the local demand will make organic growing more attractive.

The high cost of certification and compliance prohibit the trialling of small blocks and needs to be addressed. A very undeveloped and small domestic market is a worry and makes it difficult to receive the premium necessary. This reflects an overall lack of infrastructure for any type of organic production in this region. If this is not addressed then it is difficult to see summerfruit as a viable organic option in the long term. We are still in wait and see mode at the moment.

Case study 4

Bruce Ellingham; Woodstock Growers, 750 Ohiti Road, RD 9, Hastings

Orchard description

- Irongate Block is a 17ha mixed orchard situated on the corner of Irongate and Stock Roads, Flaxmere, Hawke's Bay.
- The property was purchased in 1999 with the intention of converting it to organic apple production.
- Soils are fertile silt loam mainly Type 17 (Hastings silt loam on sand).

Background

- Due to the success of previously growing apples organically, the decision was made to convert the pipfruit to organic management immediately. The stonefruit was to remain conventionally managed except for a 20 metre spray buffer bounding the organic pipfruit to prevent conventional spray drift affecting the organic apples.
- The organically managed 'buffer' zone was not registered under Bio-Gro but was seen as a trial area to test the success or otherwise of organic stonefruit in Hawke's Bay
- Initially the writer converted their Ohiti orchard for philosophical reasons coupled with a promising future for organic apple exports. The decision to grow stonefruit organically was primarily because existing trees bounded the pipfruit. It was reluctantly done due to the apparent difficulties with organic stonefruit.

Spray programme.

- The organic spray programme is based on a copper and sulphur/lime sulphur programme with a big emphasis on foliar seaweed/fish sprays.
- Early season – Leaf curl- Lime sulphur/copper
- Flowering – Blossom blight – Lime sulphur/sulphur
- Post flowering – Harvest - Rust/Brown rot – Lime sulphur/sulphur
- Organic 100 used for leaf and soil health/nutrition throughout season
- Calcium chloride to be used as a restricted input next year to reduce apricot splitting

Fertiliser

- Compost was applied at 8m3/ha in spring
- Foliar seaweed/fish throughout season for soil and leaf health
- Manganese as Mn sulphate as a restricted input if required

Problems/Issues

- Brown rot: Last season (2001/02) was a particularly difficult season for stonefruit growing conventionally let alone organically. Brown rot is the greatest challenge in growing stonefruit organically. The sulphur based programmes we use have limited success in controlling brown rot especially in a season with high disease pressure due to high rainfall.
- Nutrition: Due to stonefruit's quite high demand for nutrition, our experience is that high crop levels are not possible in an organic situation. The last year has given us false results due to the particularly poor (wet) season.
- OFM (Oriental fruit moth) has been controlled reasonably successfully by using pheromone mating disruption ties at 500/ha.
- Thrips can be a problem in some varieties of nectarines (Spring Red) and a method of control could be using reflective foil.

Future

- As our pipfruit orchard turns full organic in January 2003 the decision was made to manage the entire stonefruit crop organically so preharvest 2002 all the stonefruit was registered with Bio-Gro as 'in registration' and the 2002/03 crop will be C1 conversion fruit (with the exception of the apricots which have been grown organically since the pipfruit was converted.)
- As varieties prove too difficult or uneconomic to grow they will be replaced with either apples or varieties that suit organics. In winter 2002 Elegant Lady peaches and Firebright nectarines are to replaced with Fortune plums.
- Markets are being investigated. However I see the New Zealand markets as being quite small, but growing. Exports may be possible with plum varieties that do not suffer from brown rot problems. Other than that, an increase in production of organic peaches and nectarines will depend on the industry finding better methods of controlling brown rot.

Case study 5

Jane and Brett Dewar; Meeanee, Awatoto Road, RD3, Napier

Orchard overview We have a 6.3ha mixed orchard with pip fruit, kiwi fruit and stonefruit. The stonefruit varieties are Springcrest and Golden Queen Peaches. The plums are Omega and Black Doris.

The soil type is t23-24 Pakowhai silt loam and is generally sandy with slight grey 'pug' at 600-800mm depth. As the orchard has limited elevation above sea level and was subject to partial formation by the 1931 Hawke's Bay earthquake, the soil tends to be saline with a pH of approximately 6.8. The block is fairly exposed on the south and east sides as the adjoining land is used for cropping and livestock farming. Consequently this tends to make parts of it cooler than desired. The present organic matter level is 4.2%. Previously it was 3.5% and the pH was 7.1.

Spray programmes

Peaches Disease control in past seasons was based on lime sulphur (including over bloom) and also sulphur. Bordeaux type copper sprays were used at bud movement and Kocide copper at leaf abscission. For leafroller caterpillar control Delfin BT was sprayed on average twice per season. Reasonable control of disease and good control of pests were achieved. A change to straight sulphur-based brown rot control, while still using Bordeaux and BTs, in the past season has seen poor results. Leaf curl has increased to become an area of concern.

The lime sulphur appeared to prevent the brown rot becoming established over bloom along with better leaf curl control.

Plums Less problems to date with very little disease present except for bacterial blast associated, I think, with the low copper use for leaf abcision sprays.

Fertilisers Have used 'Vitec Seabase'(85% fish protein, 15% kelp seaweed) at 2x 60 l/ha at early leaf growth as a ground application. Also used 'Seagro' seaweed as a liquid brew for foliar sprays throughout the growing season for leaf conditioning and trace elements . 'Agrich' compost banding down tree lines at 20c/mts/ha to increase organic matter levels.

Problems Trace element deficiencies in block have led to use of magnesium and manganese sulphates in foliar sprayed form and phosphorous in the form of Ben Guerir RPR being used and probably used for some years. Magnesium oxide was ground applied at 200kg/ha to attempt to correct a high potassium affecting magnesium availability.

Have a problem with citrus lemon tree borer which is entering trees through pruning cuts and broken branches. Stockholm tar was used for pruning cut protection from silver leaf disease. Acrylic paint blended with Kocide has also been tried. Both these treatments have now been stopped. The Stockholm tar soaked into the trees requiring repeat applications and did not repel the borer. It was also very messy to use but did appear to prevent silver leaf. Acrylic paint/copper was effective as a skinning agent but the copper addition appeared to cause weeping wounds for some years. Now use Smiths grafting wax on all saw cuts and straight acrylic paint on small cuts.

Some lateral die back in plum trees required branch removal. Suspect this was due to low amounts of copper used at leaf abcision sprays.

Pear slug is starting to defoliate plum trees to the extent that some control is needed in future. Possible remedies include Pyrethrum Plus or Diatomaceous Earth at an early season time.

Successes The Omega and Black Doris plums have had fairly good results in all seasons so far, bearing in mind the seasonal crop load fluctuation. The trees are growing well with replacement wood developing. The crop load has been satisfactory but fruit size could be bigger and russet less.

The Spring Crest peaches have been successful in most areas (except in the past season). The crop load is less than wanted due to the thinning effect of lime sulphur over bloom. Will continue to use L/S as fruit shelf life is good.

The Golden Queen peaches have okay tree health but brown rot poses a great challenge due to a large percentage of crop loss at harvest. There is potential for a good crop load if it can last to market stage.

Plans and opportunities Every year we have considered Golden Queen removal but have stuck with them due to the potential from good crop load and better tree health compared to Spring Crest. Will compost heavily and hope to reduce pH to make manganese more available. Will retain Spring Crest and endeavour to establish a bloom period spray programme which is effective but does not thin blossom (see spray programme below).

With the plums the young Omega trees are slow to come into cropping due to the competition with the grass growth. Feel that a bare earth policy might be good for the first couple of years or heavy mulching around trees with straw etc.. Plums appear to have a good natural immunity to disease with reasonable replacement growth. They also crop well.

We intend to use compost teas as foliar sprays, with seaweed added, to improve the trees' ability to resist brown rot spores by hopefully not leaving space on the fruit for them to establish.

Markets Local market for Spring Crest peaches is satisfactory due to their early maturity prior to Christmas. The Golden Queen market is difficult as it is viewed as a process variety hence of lower price structure. If the price cannot be raised by 25% then it probably won't be economic to continue growing them.

At present the process plum market requires more supply. We presently grade Omega and Black Doris for export to USA with the small and russet affected fruit being bulk packed for local process. The USA market, long term, is uncertain due to Chilean fruit on the market in the same time span.

Summary Stonefruit on this block appears to have better vigour than apples and kiwifruit. The stonefruit provide early income and spread our risk. All stonefruit is packed and cool stored on site which keeps packing costs economical, always an issue with stonefruit.

We feel that into the future the use of high percentage nitrogen-containing fertilisers and poisonous pesticides cannot be continued as the owners of land are really only temporary occupiers and as such have no right to ruin the soil for long term use. This underpins our choice of going into organic production leaving the soil in good condition and hopefully, also earning an income.

Spray programme (all applied at 2000 L/ha)

Growth stage	Variety	Product rate /100 L	Rate	Comments
Leaf fall	All peaches	Kocide	100g	(2 sprays) 20% & 80% leaf fall
		Copper sulphate	200g	Mix bordeaux (80% leaf fall)
		Hydrated lime	400g	
Bud movement	All peaches	Copper sulphate	200g	Bordeaux , followed when dry by oil
		Hydrated lime	400g	
		DC Tron oil	2%	
Late pink to first flower	All peaches	Lime sulphur	2%	14 days min. since oil. Add 150g Kumulus if needed
Plus 5-7 days	All peaches	Lime sulphur	0.75%	Add 150g/100 L sulphur if disease pressure
Plus 5-7 days	All peaches	Lime sulphur	0.75%	As above
P/Fall-shuck fall	All peaches	Lime sulphur	0.75%	As above
Dec-preharvest	All Peaches	Delfin BT	50g	Monitor and spray for leafroller (2 x poss.)
Nov- preharvest	All peaches	Kumulus	200g	In advance of rain if possible
Alternative to above		Lime sulphur	0.75%	
		Kumulus	150 g	
Preharvest/harvest	All peaches	Kumulus	100/200g	High rate if brown rot present
				Total active copper use 2.6kg max
Bud movement	Plums	Copper sulphate	200g	Bordeaux followed by oil when dry
		Hydrated lime	400g	
		DC Tron Oil	2%	
Dec –preharvest	Plums	Delfin BT	50g	Monitor traps and spray for Leafroller
Nov-Dec	Plums	Diatomaceous	1kg	Min 2 sprays 1 week apart
Leaf fall	Plums	Kocide	100g	2 sprays 20% - 80% leaf fall
Throughout season	All stonefruit	Seagro	1L	Seaweed kelp brewed in vat for 3 months 12.5kg in 400 L water. Stir frequently to introduce oxygen.

Appendix C
Further information

Recommended reading:

Balfour, E. (1975). *The living soil and the Haughley experiment.* New York: Universe Books.

Fukuoka, M. (1978). *The one-straw revolution: an introduction to natural farming.* Emmaus: Rodale Press. 181p.

Howard, A. (1943). *An agricultural testament.* Oxford: University Press.

Innis, D. (1997). *Intercropping and the scientific basis of traditional agriculture.* London: Intermediate Technology.

Jackson, D.I. & Looney.N.E. (eds.) (1999). *Temperate and subtropical fruit production,* 2nd Edition. New York: CABI Publishing.

King, F.H. (1927). *Farmers of forty centuries.* London: Jonathon Cape Ltd.

Lampkin, N. (1990). *Organic farming.* Ipswich: Farming Press Books.

Senn, T.L. (1987). *Seaweed and plant growth.* Clemson: Senn.

Periodicals – Organic NZ, Growing Today, Horticulture News, The Orchardist

Nutritional value of organic foods:

Lundegardh, B. & Martensson, A. (2003). Organically produced plant foods – evidence of health benefits. *Acta Agriculturae Scandinavica, Section B, Soil and Plant Science,* 53: 3-15.

Worthington, V. (2001). Nutritional quality of organic versus conventional fruits, vegetables and grains. *Journal of Alternative and Complementary Medicine,* 7(2): 161-173.

Suppliers of books on organic and biodynamics:

www.ceresbooks.co.nz/

www.touchwoodbooks.co.nz/

www.organicnz.org

www.biodynamic.org.nz

Web sites of interest:

htttp://www.attra.ncat.org/ National Sustainable Agricultural Information Service

www.sare.org/ The Sustainable Agriculture Network

www.rodaleinstitute.org/ The Rodale Institute

www.organic-research.com/ Organic Research.com

www.permaculture.org.au/ The Permaculture Research Institute

Gold, M.V. (1999). *Sustainable agriculture: definitions and terms.* Special Reference Briefs Series no. SRB 99 – 02 . www.nalusda.gov/afsic/AFSIC_pubs/srb9902.htm#term1

www.bio-gro.co.nz BIO-GRO NZ Ltd

www.biodynamic.org.nz Bio Dynamic Farming and Gardening Association

www.hri.ac.uk/site2/research/eastmall/organics.home/htm European Organic Fruit and Nursery Stock Research Centre

www.hdra.org.uk Henry Doubleday Research Association

www.ifoam.org IFOAM (The International Federation of Organic Agricultural Movements)

www.landcare.cri.nz Landcare Research NZ Ltd

www.maf.govt.nz MAF

www.organicsnewzealand.org.nz OPEGNZ The New Zealand Organic Products Exporters Group

www.postharvest.tfrec.wsu.edu/pgDisplay.php?article=PC98U Postharvest Information Network-Handling Organic Fruit

www.summerfruitnz.co.nz SummerFruit NZ

www.soilassociation.org/sa/saWeb.nsf/!Open The Soil Association, UK

www.swcs.org USA Soil and Water Conservation Society

Bio-Gro registered products:

organicpathways.co.nz

www.rd2.co.nz/pages/bio-gro_reg.html

The biodynamic preparations can be obtained at a cost from the Bio Dynamic Farming and Gardening Association and from Garuda Biodynamics Ltd (Te Puke).

Other Publications

Ames,G. (2000) *Organic/Low-Spray Peach Production.* ATTRA National Centre for Appropriate Technology, University of Arkansas, United States.

Certified Organic Association of British Columbia (1998). *Organic Tree Fruit Management.*

Chapman, B. & Penman, D. (1986). *Natural pest Control.* Reed Methuen Publishers Ltd.

French, J. (1990). *Organic Control of Common Weeds.* Aird Books Pty Ltd.

Heinz-Watties New Zealand (1997) *New Zealand Processing Peach Integrated Fruit Production Manual.*

Moreton, B.D. (1969). *Beneficial Insects and Mites.* Her Majesty's Stationary Office, London

Proctor, P. & Cole, G. (1997).*Grasp the Nettle.* Random House New Zealand Ltd.

Ingham, E., Moldenke, A.R. & Edwards, C.A. (2000). *Soil Biology Primer.* Soil and Water Conservation Society, USA.

Te Whakapau Taru. *The Biological Control of Weeds Book: A New Zealand Guide.* Manaaki Whenua Landcare Research New Zealand Ltd.

The Orchardist—Journal of the New Zealand Fruitgrowers Federation

Further information on marketing:

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