RURAL INDUSTRIES RESEARCH
& DEVELOPMENT CORPORATION

Organic Production Systems Guidelines

■ Beef ■ Wheat ■ Grapes and Wines
■ Oranges ■ Carrots

By S McCoy and G Parlevliet

Rural Industries Research and Development Corporation
Organic Produce Research and Development

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Foreword

Consumer interest in agricultural production methods regarding safety, health and the environment has increased in the highly developed affluent markets of the world. Agriculture Western Australia in conjunction with RIRDC recognise this as an opportunity to develop export markets based on 'organic' and 'clean' agricultural production systems.

In order to capture a share of these expanding markets, the Australian organic agriculture industry must develop supply capability matched to market demands.

Information on target markets and target products contained in the companion Stage One report 'The Export Market Potential for Clean and Organic Agriculture' is important to attract and focus investment in the industry. Five products; beef, wheat, wine, oranges and carrots were selected for priority development.

This publication forms Stage Two of the Organic Farming Project that aims to increase the export opportunity for clean and organic agriculture.

The report outlines organic production system guidelines for each of the five priority products. Details are provided of strategies and methods used by organic growers. The report aims to assist conventional growers with interest in developing agricultural production systems that can be certified organic or biodynamic in compliance with Australian 'National Standards for Organic and Biodynamic Agriculture' for export.

This project was funded from RIRDC Core Funds which are provided by the Federal Government and is an addition to RIRDC's diverse range of over 600 research publications. It forms part of our Organic Products R&D program, which aims to optimise the profitability of Australian organic production in domestic and overseas markets and to promote the utilisation of organic farming systems as a means of enhancing the sustainability of Australian agricultural systems.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirdc.gov.au/reports/Index.htm
- purchases at www.rirdc.gov.au/eshop

Peter Core
Managing Director
Rural Industries Research and Development Corporation

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Executive Summary

The five products covered in this report were identified in an earlier RIRDC report, “Export Market Potential for Clean and Organic Agricultural Products”, as target products for priority development by the Australian organic industry. The products are wheat, beef, citrus, wine and carrots.

The information presented aims to provide conventional growers, unfamiliar with organic farming and certification, sufficient detail to consider the various changes that may be required to their current farming practices when assessing the feasibility of conversion to an organic system. The term organic is used in a general sense to include biodynamic.

With the rapid expansion of markets for certified organic products, pressure is growing from competing suppliers to capture a share of these markets. Product distinction and quality assurance is becoming increasingly important for Australian organic producers in order to establish and maintain a strong position in premium export markets.

Claims made on a product label must be verifiable in order to gain consumer confidence that the product does in fact provide expected benefits and any price premium is justified. In addition to certification for organic production, a quality assurance program incorporating a HACCP system, can provide important food health and safety assurances, whilst ensuring other product quality requirements such as taste, appearance and presentation are maintained in every consignment.

For organic products to remain distinguished in consumer perceptions, the spectrum and integrity of benefits that the ‘organic’ label can simultaneously provide must be broadened and reinforced. Organic products must go beyond health, safety and environmental qualities, to satisfy the consumer need for convenience and finally the desire for enjoyable ‘sensory experiences’.

One major problem faced by many new growers is establishing premium markets for product during the transition years before full organic status. The commercial risk associated with this transition period may be minimised by; establishing markets for product ‘in conversion’ to organic; developing strong mutual commitment and support between farmers and buyers throughout the period of conversion; and developing production and marketing alliances with other growers.

The report provides a general coverage of the organic certification system operating within Australia and highlights important requirements related to organic production based on the Australian ‘National Standards for Organic and Biodynamic Produce’.

Production system guidelines for each of the five target products are presented in separate sections. Details covering general principles, strategies and techniques used by growers are presented. The principles of organic agriculture, encompassing an integrated whole system approach, is a common theme for all farms. A range of organic techniques relating to soil fertility, weeds, pests and disease management are described. Specific details should be amended to suit each circumstance and enterprise when planning and developing an organic system.

Collaboration between existing experienced organic growers and new entrants is essential if the Australian organic industry is to capture a share of rapidly expanding markets and provide a valuable direction for mainstream agriculture.

1. Introduction

This report aims to provide a general introduction to growers interested in the opportunity of developing organic agricultural production systems. The term organic is used in a general sense to include biodynamic.

The report forms Stage Two of an Organic Farming Project. Earlier work in Stage One of the project examined world trade and export opportunities for clean and organic agricultural products. Findings are presented in a companion report titled 'The Export market Potential for Clean and Organic Agricultural Products'. One outcome of the market report was identifying five target products for priority development. The target products were selected by an Australian wide industry panel and provide the focus of this report. The priority target products are:

- Beef
- Wheat
- Wine
- Oranges
- Carrots

The information presented in this report aims to provide conventional growers, unfamiliar with organic farming and certification, sufficient detail to consider the various changes that may be required to current farming practices when assessing the feasibility of conversion to an organic system.

The issue of product distinction and quality assurance is discussed as an important component if Australian organic products are to establish and maintain a strong position in premium export markets.

The report provides a general coverage of the organic certification system operating within Australia and highlights important requirements related to organic production based on the Australian 'National Standards for Organic and Biodynamic Produce'.

Production system guidelines for each of the five target products are presented in separate sections. Details covering general principles, strategies and techniques used by growers are presented for each target product. In general, the principles of organic agriculture are the same for all farms but the organic techniques used must be amended for each circumstance and enterprise.

The information presented comes from a wide but no means exhaustive range of sources. Many of the techniques and strategies reported come from discussions with experienced practical organic and biodynamic farmers from around Australia. A number of organic industry projects in various states have also provided valuable information.

For the organic agriculture industry to expand, additional conventional grower must convert to organic systems. Although the organic agriculture industry currently consists of only a small percentage of Australian agricultural production, considerable experience exists among practicing organic growers. Collaboration between existing experienced growers and new entrants is essential if the organic industry is to capture a share of rapidly expanding markets and provide a valuable direction for mainstream agriculture.

2. Product Distinction and Premium Markets

The market study 'Export Market Potential for Clean and Organic Agricultural Products' confirms that consumer demand, in the highly differentiated food markets of Europe, Asia and North America, is increasing for food and agricultural products that are perceived to be healthy and have low impact on the environment. A willingness to pay a premium for such products is apparent where products carry a verifiable assurance they are safe, nutritious and produced using systems with limited negative impact on the environment.

Many terms are used on product labels and advertising campaigns to convey the perception that a product has one or more of these desired attributes regarding safety, health and the environment. However, the terms 'organic' or 'organically produced' have become widely accepted by consumers in many major markets as providing all three attributes.

Organic products have become clearly differentiated in many markets to the point where mainstream supermarkets are now using organic to promote the overall quality and environmental image of the business. Products labelled as organic are being used as an 'image asset' to attract customers.

Consumers in the major world markets for organic products are generally well-educated, sophisticated and discerning people. Claims made on a product label must be verifiable in order to gain consumer confidence that the product does in fact provide expected benefits and any price premium is justified.

Standards and independent verification systems for organic production, processing and labelling of organic products are well established In Australia. Strict regulations control the trade in organic products throughout the European Union and national organic standards are being introduced in the USA and Japan.

The Australian 'National Standards for Organic and Biodynamic Produce' in conjunction with the 'Export Control Orders - Organic Produce' (that regulate export trade) have established a good international reputation. As a result Australia is one of very few countries pre-approved by the European Union for the purpose of organic food imports.

In addition to organic certification by a credible independent authority, developing long term successful markets for an organic product is likely to require that the product can also satisfy a range of other quality attributes. These are similar to the quality requirements for conventional products and typically these may include:

- visual appearance, including shape, colour and free of blemish;
- size and uniformity within size specifications;
- taste including flavour, aroma and texture;
- storage life;
- packaging and presentation.

All of the above quality criteria can apply to the grading of both conventional and organic products. Organic growers should endeavour to at least match the levels set by conventional growers.

However, product taste is one quality attribute where organic growers should aim to exceed conventional levels. Consumers tend to perceive organic products as better tasting. Organic growers should aim to reinforce this perception by ensuring that all stages of the production (from selecting delicious varieties or breeds, through to final packaging) maintain exceptional product aroma, flavour, texture and other eating characteristics.

One method of ensuring product quality attributes meet buyer expectations is through the use of a Quality Assurance (QA) system. The use of QA systems by growers and processors is becoming more widespread as buyers increasingly demand some form of assurance that all products will meet their specification requirements in every consignment throughout the year.

Organic growers should consider incorporating a QA program into operations. A suitable system such as the SQF 2000 quality assurance scheme (developed expressly for agriculture) in conjunction with organic certification, will allow growers to distinguish a product as 'quality assured & organic certified'.

Food safety has become an important issue of concern to consumers following periodic news of food scares involving harmful disease, micro-organisms or other contaminants. The safety of organically grown food has also come under question in recent years. Explicit food safety guarantees are becoming increasingly important and should be addressed by inclusion of a HACCP (Hazard Awareness Critical Control Point) system within the QA scheme.

Organic certification together with a HACCP based quality assurance scheme provides a strong basis to reinforce premium positioning in the market.

For organic markets to develop, the following criteria must be met:

- Product quality has to meet consumer expectations.
- Price premiums should not be excessive.
- Consumers must be sure that product sold as organic is authentic.
- The proclaimed benefits of organic products need to match the expected benefits that the consumer seeks.

One important part of satisfying the expected benefits that the consumer seeks, often overlooked by growers, is the 'story' of themselves and their farming system. Japanese consumers in particular are very interested to know who is the grower, the story of the production system and how this fits into their perception of food that is safe, healthy and produced in a sustainable way with respect for nature and the environment. Such a story can reduce consumer alienation and reinforce the positive benefits of purchasing products produced from an organic system. Growers should consider including a description of their farming story as part of the total image created by their product.

One major problem faced by many new growers is establishing premium markets for product certified as 'in conversion' to organic, i.e. during the transition years before full organic status. Buyers generally prefer full 'organic' product. Markets and premiums for 'in conversion' product can be less certain. It may be possible to establish markets for 'in conversion' product on the basis that the product is produced without chemicals, growth hormones and other substances of concern, in an environmentally sound way, with the intention of developing towards full organic certification.

Developing strong long-term relationships between farmers and buyers, with mutual commitment and support throughout the period of conversion to organic, is one way to minimise some of the risk associated with this transition. Another important risk reducing

strategy is to develop production and marketing alliances with other certified organic growers. A number of group have been formed where, as a group, growers are in a better position to offer reliable supply and larger volumes of product in order to establish new markets and maintain acceptable prices.

Working together in strategic alliances can also form the basis for capitalising on value added opportunities. As individuals, many farmers fail to appreciate the opportunities to enhance the value of their products.

The current consumer perception that organic products are unique in satisfying a spectrum of concerns (relating to food safety, health and the environment) may diminish in future. It is likely many new 'labels' or substitute products will emerge that provide assurances similar to those made on organic products. While this trend may in part reflect a positive direction for agriculture in general, the resultant proliferation of 'labels' may erode the distinction of the label 'organic'.

For organic products to remain distinguished in consumer perceptions, the spectrum and integrity of benefits that the 'organic' label can simultaneously provide must be broadened and reinforced. In addition organic products must go beyond health, safety and environmental qualities to satisfy the consumer need for convenience and finally the desire for enjoyable 'sensory experiences'.

3. Organic Standards and Certification

This section describes in general terms the requirements for organic or biodynamic certification within Australia.

3.1 Background - Organic/biodynamic certification and regulations in Australia

Internationally it is accepted that the veracity of claims on the labels of organic products must be underpinned by product and producer certification. The reputation and recognition of the organic certification system is often of great importance to importing countries.

Australia has a well-regulated system for organic and biodynamic production and processing that has gained a good international reputation. The 'National Standards for Organic and Biodynamic Produce', administered by Australian Quarantine Inspection service (AQIS) form the minimum mandatory requirements for export of products labelled as organic or biodynamic. These standards are implemented by seven independent AQIS accredited certification organisations, who conduct whole farming system inspections and ensure a comprehensive record keeping system is in place that allows trace back and verification of inputs used, management practices, yield and sales. Copies of the national standards are available through the certifying organisations, Australian Government Bookshops and the AQIS web site.

On the Australian domestic market no mandatory requirements exist regarding the labelling of products as organically grown. However, there is a trend across all markets for objective proof to support claims relating to product attributes. Most reputable retail outlets require independent organic certification by one of the above organisations for product labelled as organically grown.

Organic Production Standards aim to:

- protect consumers against deception and fraud in the market place and unsubstantiated product claims;
- protect producers of organic produce against misrepresentation of other agricultural produce as being organic;
- harmonise national provisions for the production, certification, identification and labelling of organically and bio-dynamically grown produce;
- ensure all stages of production, processing and marketing are subject to inspection and meet minimum requirements; and
- provide a guide to farmers contemplating conversion to organic farming.

Contact details of the seven AQIS accredited certification organisation are listed in Appendix 1.

3.2 General requirements - organic certification

The 'National Standards for Organic and Biodynamic Produce' (OPAC 1997) provide a general definition of organic farming as follows:

> "Organic farming means produced in soils of enhanced biological activity, determined by the humus level, crumb structure and feeder root development, such that plants are fed through the soil ecosystem and not primarily through soluble fertilisers added to the soil. Plants grown in organic systems take up nutrients that are released slowly from humus colloids, at a rate governed by warmth. In this system the metabolism of the plant and its ability to assimilate nutrients is not over stressed by excessive uptake of soluble salts in the soil water (such as nitrates).
>
> Organic farming systems rely to the maximum extent feasible upon crop rotations, crop residues, animal manures, legumes, green manures, mechanical cultivation, approved mineral bearing rocks and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests."

The principle aims of organic agriculture include:

- the production of food of high nutritional value;
- the enhancement of biological cycles in farming systems;
- maintaining and increasing fertility of soils;
- working as far a practicable within a closed system;
- the avoidance of pollution resulting from agriculture;
- minimising the use of non-renewable resources; and
- the coexistence with, and the protection of, the environment.

One essential feature of organic agriculture is the emphasis on biologically healthy, nutritionally balanced soil as the basis for healthy resilient (against pest and disease) plants.

Production avoids the use of synthetic fertilisers, pesticides, growth regulators and other chemical substances detrimental to nature. Genetically modified organisms are prohibited.

In practice organic certification takes into consideration the whole farming system and typically requires a whole farm plan, farm map and record keeping system. The grower must demonstrate and verify that a system is in place and operating in compliance with organic standards. This typically includes a sustainable crop rotation, and strategies to maintain soil fertility, control weeds, pests and disease, as well as water management and buffer zones.

High levels of chemical residues in soil from previous land use can disqualify land from organic certification as can excessive contamination in plant or animal tissues. Buffer zones and windbreaks can be required to protect certified areas from contamination by adjacent properties. Organic grower should seek cooperation from neighbours who use chemicals on adjacent properties.

Certification of all production, processing, handling, transport, storage, and sale of organic products is contingent on accurate up-to-date records of the enterprise concerned to allow scrutiny of the products and processes. Records required typically relate to:

- rotations, soil cultivations and other treatments;
- inputs - type, source, application and timing;
- outputs - production and sales details.

Provision can exist for part certification where part of a property is converted to an organic system while the remainder is farmed using existing conventional methods. Development plans for full (whole farm) conversion to an organic system within a defined period can be required.

The usual progress towards full organic certification is as follows:

Year 0-1 = 'pre-certification' (no certification status).
Year 1-2 = 'in conversion' to organic certified.
Year 2-3 = 'in conversion' to organic certified.
After 3 years = full 'organic' certified.

During the first year of compliance no organic certification is granted. In the second year of compliance, certification as organic 'in conversion' may be granted. A system certified as organic 'in conversion' typically should progress to full 'organic' after a minimum of three years verified compliance with standards.

Penalties may be imposed for failure to comply with organic standards or breach of rules of certification. This may involve cancellation of certification or reversion to an earlier stage in progress towards full organic certification.

3.3 Step involved in obtaining organic certification

The general procedure for obtaining organic certification is as follows:

1. Select an appropriate organic certification organisation.
2. Read and understand organic certification standards.
3. Implement and establish changes to the production system on farm.
4. Apply for certification and complete farm questionnaire.
5. Farm inspection undertaken and soil or tissue sample taken.
6. Inspection report reviewed, certification level and conditions determined.
7. Offer of contract to use 'organic certified' label.

1. Choosing an organic certifier

Interested growers or processors should contact the AQIS accredited certification organisations (Appendix 1) to discuss the following:

- The criteria for organic or biodynamic certification.
- Your certification needs.
- Export market destination requirements.
- The costs.

- Procedure and timing before certification can be granted; and
- Obtain a copy of the organic farming or processing standards to which your farming or processing system must comply.

Each organisation has slightly differing organic standards and other certification requirements, although all have been approved by AQIS as complying with the minimum national standards.

2. Understanding organic standards

Growers must demonstrate a good understanding of organic farming principles and knowledge of practices and inputs permitted as well as those prohibited according to the certifier's organic standards.

3. Modify the production system

Changes to the production system must be implemented. The grower must prove that an appropriate system is in place and successfully operates in compliance with the organic standards.

4. Apply for certification

When changes to the farming system are in place, application for organic certification of the system can be submitted. Upon receipt of an application the organic certifier organisation will issue a farm questionnaire seeking all relevant details describing the farming system. Information sought in the questionnaire typically include land use history, rotations, inputs used, details of farming practices and a map of the property and surrounding land use. The questionnaire forms a Statutory Declaration relating to farm practices and inputs used.

5. Farm inspection

A site inspection by an experienced organic farm inspector will follow soon after the questionnaire has been returned to the certification organisation. The purpose of the site inspection is to verify the details of the farming system as described in the questionnaire and to ensure the grower has a good understanding of the principles and methods of organic farming. Apart from discussing the farming system the inspector will view paddocks, crops and livestock as well as equipment, sheds and storage areas. The grower must also provide evidence of a complete documented audit trial covering all inputs used, output produced and sales details for all organic products. Soil samples or tissue samples may also be taken for testing.

6. Report of farm inspection

Following the farm inspection the inspector compiles a report confirming details of the farming system that has been established. This report, together with other relevant documents, is considered by the certifier to determine the appropriate level of organic certification. Specific conditions may be imposed where certain practices or circumstances require attention.

7. Organic certification contract

The certifier offers the grower a contract stating the land and crops to which the certification applies and any conditions that must be met. Acceptance of the contact and payment of fees

allows the grower to market relevant product labelled as certified ‘in conversion’ or ‘organic’ and bearing the logo of the certifier.

Organic certification contracts are generally subject to annual inspection of the site and to view farm records. The grower is required to complete a statutory declaration confirming compliance with the standards and detailing yields and sales figures for the year.

Growers may be subject to an unannounced random on site inspection as part of the obligations certifiers must fulfil to satisfy AQIS accreditation. In addition, some properties may be subject to inspection by AQIS representatives as part of the regulation of the certifying bodies.

4. Organic Beef Production Guidelines

By Steven McCoy
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4.1 Introduction

There are many areas within Australia that have the potential for organic beef production. Conversion from conventional to organic systems is likely to require fewer changes in the low input system of rangeland cattle production, compared to the more intensive pasture-based or feedlot cattle production systems. However, in most situations the management approach used in organic systems can be quite different and involve more than simply not using chemicals and synthetic fertilisers. In all cases a key requirement for success is motivation and commitment to the principles of organic farming - beyond the essential financial and market perspectives.

Conversion to an organic system takes time. Establishing biological systems and balanced soil is usually a gradual process. Normally, three years of compliance with organic standards is required to achieve full organic status. Careful planning and financial management is required during this conversion period. Growers often begin by converting a portion of their property to get a feel for the new system and build-up experience and confidence before converting greater portions of the farm.

As with conventional beef production, maintaining a reliable supply of consistent product that conforms to buyer quality criteria is essential for developing and retaining markets. Premium markets are expanding for beef products labelled and distinguished as organically or biodynamically grown in accordance with a recognised and verifiable organic production and processing standard. Development of a quality assurance system in addition to, or as part of, organic certification can be important to ensure the highest quality product in every consignment.

Organic farming systems are typically mixed operations involving a number of enterprises. Cattle production can often also include sheep and cropping as important integrated components of the whole farming system. Joining forces with other organic farmers, particularly where complementary seasonal or other conditions exist, can make resource usage more effective and enterprises more profitable for all involved. Such strategic alliances can also provide good marketing advantages particularly to ensure supply volumes, but also for brand development and promotional campaigns.

Due to the great variation in location and types of cattle production possible in Australia, only a general outline of organic beef production is possible in this report. The principles and techniques outlined usually apply to the more intensive types of production rather than low rainfall area rangeland types of production. However, evidence from the United Kingdom suggests that the more intensive types of organic beef production require a higher price premium to equal conventional returns, compared to low intensity types of production.

These guidelines aims to provide a general outline for conventional beef producers with an interest in investing in the production of cattle grown organically in compliance with the Australian 'National Standards for Organic and Biodynamic Produce' and certified by an accredited organic inspection organisation (see Appendix 1). The guide covers important

aspects of organic beef production as a basis for developing specific methods to suit individual farm locations and circumstances. Material presented comes from a wide, but by no means exhaustive, range of sources. A number of organic or biodynamic beef producers from NSW, VIC and WA have also provided information.

4.2 Market outlook for organic beef

Export markets

Organic meat exports from Australia have mainly been confined to beef exports to Japan. This includes certified biodynamic beef from Western Australia and certified organic beef from South East Queensland. There is also export of beef from Queensland produced with limited chemical inputs or as 'range grown'. However, this product is not organic certified and cannot be exported as such. The *Organic Beef Export* group in Queensland is progressively converting to Organic Standards whilst exporting chemical free beef to Japan in the interim. The buyers involved are happy to accept the product as 'chemical free' in the knowledge that it is a transitional phase to certified organic product.

Organically produced beef is reported to be a key product category of interest to Japanese consumers of organic products. Various companies are reported to want 'safe' beef without growth hormones. Interest has been expressed in biodynamic beef for export to Japan and also in developing some beef-based processed products including organic gourmet beef patties.

Some Japanese buyers are looking for specific cattle types with high marbling scores for the organic market. One report from Japan suggested that grass fed beef was considered less tender than feedlot beef and, maybe, more suitable for processing or restaurants rather than individual consumers. This perception may require attention if organic grass fed beef is to attract premium markets.

Austrade believes the greatest export potential for Australian organic foods to Japan lies in the processed foods and food ingredient sector. Identified products include beef and beef-based products.

Export competition

Competition on beef export markets can be expected from **USA** beef producers. Trade reports from Japan suggest USA organic grass fed beef has been considered better quality and lower priced than similar product from Australia. **Argentina** is reported to have 14 producers with 75,000 ha of land certified organic for beef production, with enormous potential to expand production.

Australian markets

Australian domestic demand for organic meat products remains subdued. However, renewed interest in organic products by the major supermarkets *Coles* and *Woolworths* may stimulate demand. *Coles Supermarkets* are reported to have trialed biodynamic beef in select stores and plans to introduce the product into other stores around Australia. Specialty butcher shops are increasingly offering organic meats as part of their range.

Several grower groups have developed supply lines and established markets to specialty butchers and supermarket retail outlets on the east coast of Australia.

Organic certified and quality assured

Many markets will only buy products certified as 'organic', i.e. products that can be labelled at point of sale as 'organic'. Markets for products certified as 'in conversion' to organic (i.e. less than 3 years since conversion) may be less certain and careful assessment can be required to verify demand volumes and price premiums. In order to maintain organic integrity throughout the supply chain all points must be in compliance with organic standards. Abattoirs and processing works must hold organic certification in order that meat products retain certified organic status.

While an 'organically grown' label is an important marketing tool, growers should also aim to promote the 'story' of their farm and farming production system. A 'product story' can provide valuable brand distinction, promote loyalty, and help reduce consumer alienation that is common among products of unknown background.

Quality assurance (in addition to organic certification), based on a well recognised QA scheme such as SQF 2000, can provide buyers with a higher degree of certainty that the product will conform to their specification criteria. A quality management system compatible with Hazard Analysis and Critical Control Points (HACCP) principles should be an integral part of an organic production system.

Market summary

Good prospects are apparent on export markets, particularly to Japan and possibly other East Asian destinations.

Markets within Australia seem to be at an early stage of development. However renewed interest by major retailers does provide an opportunity for reasonable volumes of trade.

Product quality must be maintained at a high level conforming to buyer requirements. Labelling a product as 'organically grown' is unlikely to establish a strong market unless the product also has excellent eating qualities. In addition to organic certification, some form of quality assurance system may be important to ensure organic beef is distinguished as a premium product.

4.3 General principles - organic beef production

This section outlines some important guiding principles and constraints that form the basis of planning and developing a successful organic beef production system. Aspects of organic certification standards specific to beef production are included. Many of the points covered can have practical implications for management plans to convert from conventional to organic beef production.

Closed systems

Like most organic farming enterprises, organic cattle production systems aim to operate within a closed system. All feed requirements and other inputs should be produced on-farm to the maximum extent feasible. In order to achieve this, organic farms are typically mixed enterprises involving a balance of pasture, crops and livestock. Integration of crops and livestock can be a key factor in making rotational grazing systems work and improving pasture management. Cattle can make profitable use of the pasture-based fertility building phase within a cropping rotation.

Animal health stems from the soil

Another primary underlying principle for organic animal production is based on the premise that: 'healthy animals grow from healthy plants and healthy plants grow from healthy soil'. W ell-balanced, biologically enhanced soil, as determined by adequate soil organic matter, humus level, crumb structure and feeder root development, forms the basis of organic beef production. Plants are fed through the soil ecosystem and not primarily through soluble fertilisers added to the soil.

Land degradation problems such as organic matter depletion, soil structure decline, compaction, erosion, and acidification must be avoided. Soil problems related to water imbalance, such as waterlogging and salinity, can also require specific remedial action. In general terms, well-managed soils with adequate organic matter and biological activity tend to be more resilient against most forms of land degradation.

Animals must feed to suit their physiology

Feeding should be suited to the physiology of the animal. Ruminants require a high proportion of forage in their diet in order for their digestive systems to function naturally. The preferred method of providing livestock nourishment is by choice feeding, whereby animals are free to select from a wide variety of foods natural to their diet.

Cattle must have access to pasture and must only eat certified organic feed. Feeding any portion of 'in conversion' feedstuffs to 'full organic' livestock will result in labelling of animal products as 'in conversion'.

Up to five per cent of all feed may be bought in as non-organic feed supplements, provided they are acceptable within organic standards. Feeding of mammalian material (excluding milk) to ruminants is prohibited, as is the use of growth promoters including hormones and antibiotics.

Stocking rates should be appropriate for the location, taking into account fodder production capacity, stock health, nutrient balance of both stock and soil, and environmental impact.

On non-arable land under less intensive management, organic cattle production requires careful matching of suitable breeds and class of animal with seasonal production patterns. Stocking levels must be closely monitored in order to optimise productivity while maintaining sustainable use of the lands' resources.

Husbandry systems must conform to the highest welfare standards

The welfare of animals is paramount. Maintenance of livestock must be guided by an attitude of care, responsibility and respect. The relationship between the health and vitality of an animal to the way in which an animal is kept, is important to organic producers. Stress is often a factor contributing to the development of disease and distressed animals are reported to be less able to adjust effectively to change.

Cattle were originally woodland animals, their natural habitat being woodland clearings and grassland at the edge of woodlands. Consideration must be given to their natural behaviour patterns. Living conditions should fulfil the natural needs of the animal for free movement, food, water, shelter and shade.

Shelter belts can be useful in providing protection from excessive sunlight, temperature, wind, rain and other climatic extremes.

Mutilations, such as castration and dehorning, shall only be carried out where benefits outweigh the consequences of non-treatment and there are no other acceptable management options. Stress, injury and pain inflicted by treatments must be kept to a minimum.

Animal health should be maintained through sound preventative husbandry, animal welfare and appropriate feeding systems

The aim in animal health should be to develop resistance through breeding and selection and to correct the cause of any disorder, rather than simply treating the symptoms.

Animal health results from a combination of good management practice and sound nutrition. Animal health management is based on the principles of good selection, feeding and nutritional balance for prevention of disease, resistance to infection, parasitic attack and metabolic disorders. Sound nutrition can be achieved by correct soil fertility providing balanced mineral and dietary input and through diversity in the diet.

Dietary intake should be based on balanced quality forage, and not reliant on supplements or concentrates. Feed-lotting is generally considered unnatural - especially for ruminants. Some producers consider grain fed organic beef as somewhat contradictory and should not be pursued. Organic standards prohibit highly intensive feed-lot production.

The use of prophylactic chemical treatments and vaccinations is avoided

Disease and parasite control should be by management practices rather than reliance on substances. In the event management efforts are insufficient, use of permissible products should be as an adjunct to, and not a substitute for, good management practices.

Where permissible treatments fail, producers must not withhold non-permitted medication where it would result in unnecessary suffering - although meat from treated cattle can no longer be sold as organic.

Animals given non-permitted treatments must be identified and quarantined from organic land and animals for at least three times the withholding period of the treatment. Their meat can no longer be marketed as organic. Their offspring can be sold as organic providing the non-permitted treatment was given prior to the last trimester of pregnancy. Product residue testing may be required.

Natural breeding and rearing

Livestock breeding should be by use of sires. Artificial insemination is not recommended although may be permitted. Embryo transfer, genetic engineering and routine use of reproductive hormones or synchronising drugs are not permitted.

Calves should be reared by their mothers in order to gain natural immunity to infection. Suckling or bucket rearing on organic whole milk for a minimum period after birth can be required.

Minimum qualifying period

Properties intending to raise cattle to be labelled as ‘organic’ must have reared cattle on land managed in accordance with organic standards for a minimum of one year in order to qualify for certification as ‘in conversion’ to organic. A minimum of 3 years compliance is required in order to qualify for certification as ‘organic’.

Limitations on introduced livestock

Livestock should be bred on the property. Animals introduced from other than certified organic sources can be limited to a certain percentage of the herd per year. Livestock introduced from other than certified organic sources may need to be quarantined from organic land and stock for a prescribed period. These introduced animals may never be sold as organic, although their progeny may be certified organic provided organic management begins from the last trimester. Residue testing meat products can be required.

Co-existence with, and protection of, the environment

Maintaining biological diversity on and around the farm is an important feature of organic systems. Biological diversity tends to allow ecological balance or equilibrium to establish, resulting in a more stable system with less dramatic biological fluctuations - both on the farm and in the surrounding natural environment. Shelter belts can be important in this regard. Areas of remnant vegetation should be protected. In addition, organic farms should ensure the avoidance of pollution and other forms of degradation resulting from agricultural practices. The use of non-renewable resources should be minimised.

Rangeland special criteria

Grazing of cattle in natural/rangeland areas can also be considered for certification as an organic production system. Additional conditions require that:

- grazing occurs within clearly defined areas;
- those areas have not received non-permitted substances for at least three years;
- monitoring must be undertaken to verify grazing does not disturb the re-establishment and/or maintenance of native species and stability of the natural habitat.

Yards

Holding paddocks and yards may require testing to ensure soil contamination levels are below maximum permitted residue levels. Excessive contamination may require yards to be relocated or top-dressed with acceptable material.

Yards and handling facilities should be designed and maintained to ensure animals are not stressed or injured.

Transport

Loading facilities and transport vehicles may require certification and should be designed and maintained to prevent injury, damage or bruising.

Organic quality feed and water may be required before and after transport. The duration of each transport leg can be restricted.

Slaughter

Slaughter must be carried out in a certified abattoir. A complete clean down and rinse after processing conventional livestock is required. Similar conditions apply to boning rooms.

An audit trail from receival to dispatch must be documented in full.

4.4 Production strategies and methods - organic beef

Conventional beef production systems are likely to require a number of modifications in order to meet the requirements for organic certification. Good management and balanced nutrition are essential features of both conventional and organic beef production. However, strategies adopted by organic beef producers can differ from conventional practice in a number of ways. While synthetic chemicals and fertilisers are not permitted, changes to management can go beyond simply not using these inputs. In their place a range of management strategies and techniques are used instead of routine reliance on substances.

This section outlines a range of alternatives used by organic producers for consideration by interested growers when planning conversion of their existing conventional production system.

Overall management strategies for organic beef production should be reconsidered in light of the following four key principles:

- Soil health is fundamentally related to animal health.
- Organic systems are intrinsically biological systems.
- Husbandry systems must conform to highest welfare standards; and
- Organic farms should operate as closed systems so far as possible.

Conversion from conventional to organic systems is likely to require changes to management strategies and techniques relating to the following aspects:

- Whole farm planning.
- Soil fertility management.
- Pasture and grazing management.
- Animal nutrition and supplementary feed.
- Selection, breeding and herd management.
- Pest/parasite and disease control.

The details provided are general outlines only. Specific strategies adopted by individual organic growers will vary according to their circumstances, location of the property and type of cattle enterprise intended.

4.5 Whole farm planning

Like other forms of organic farming, organic cattle production requires a whole farm approach. Increased reliance on management, rather than substances, demands careful planning. A well-designed whole farm plan, particularly during the conversion phase, can allow an organic system to be integrated within the whole farm activities. Financial risk can be managed during the conversion period. Integration of each operational component can improve management effectiveness and raise the overall efficiency of the operation. Good planning reduces management time. For example, adoption of a rotational grazing strategy to improve pasture utilisation, soil management and parasite control can require additional animal movements. Fencing layout modifications (using laneways, electric, or other means), may be designed to reduce the management time involved with the rotational movement of stock.

Planning on a whole-of-farm basis can be applied to various components of farm operations including:

- enterprise mix based on target markets and product requirements;
- financial plans, especially during conversion period;
- integration of enterprises and strategic alliances;
- farm layout and fencing to soil types;
- rotational plans, soil and pasture management;
- water management plans and contour tillage;
- shelter belts, biodiversity and remnant vegetation protection.

Organic farming systems are typically mixed enterprises; integrating different stock, or stock of the same species but for different purposes, or integrating stock with cropping. Although integration runs counter to conventional trends towards specialist beef herds as a way of gaining economies of scale, integration allows organic systems to gain flexibility and increase biological efficiency. For example, cropping can produce a paddock clean of parasites, ideal for parasite control in young calves.

Converting to an organic farming system can involve changes regarding the type and proportions of stock that should be carried, the most appropriate cropping program, or other activities. These decisions should be based on specific aims to work towards and may include:

- increase establishment and output from permanent or perennial pasture with a minimum of cultivation;
- re-seeding of land following cropping with grass/clover/herbal mixtures;
- minimise reliance on bought-in feeds; and
- avoid the use of drugs, chemical treatments and feed supplements for animal health.

A good farm plan should devote special attention to the first three years of transition from conventional to organic management - when markets for 'in conversion' product may be uncertain and practical experience is being developed. Details of the progressive changes intended to soils, pasture and animal husbandry will be helpful in order to develop a smooth conversion towards a profitable, productive and sustainable organic system.

Strategic alliances with other organic growers, processors or traders can be very important in defining enterprise mix and production levels. Working with other growers may allow a relatively closed sustainable system to develop between the properties involved. For example, aligning calving time or other operations with another property may extend supply capability and smooth quality variations due to seasonal differences and fluctuations.

4.6 Soil fertility management

Soil fertility (in addition to temperature, rainfall and pasture species) determines pasture productivity and quality and hence the number of cattle that can be carried. Organic farms aim to develop high humus, well-structured, biologically active soils as the source of plant nutrients. Increasing soil fertility, in conjunction with disciplined grazing management, can

also allow more desirable pasture species to out-compete weeds and improve the quality and nutritional value of pastures.

Rebuilding the biological activity and fertility balance of soil is a gradual process. Smaller applications of soil amendments that do not dramatically disturb the balance of the soil are preferable. Deep ripping has been used as part of a soil/pasture improvement program. In addition to correcting soil fertility and soil chemical imbalances, grazing is believed to stimulate new root growth. This combined with a sustainable grazing management system (such as high impact, short duration, rotational grazing) can provide time for soil structure to recover from stock traffic. Suitable soil amendments, together with appropriate cultivation that minimises soil structure damage and careful grazing management, can result in a steady improvement in soil fertility and hence the composition and vigour of pasture.

Pasture with improvements to soil biology and soil structure is reported to recover much faster after periods of weather extremes, hang on much longer in a drought and cope with a soggy winter much better. On biologically active and balanced soils, growers report that pasture growth extends further into those cold, wet and hot, dry conditions by as much as four to six weeks.

Soil testing can be important as an indicator of soil chemical imbalance and for monitoring longer term changes to soil conditions.

Some soils can be naturally deficient in essential elements (such as phosphorous, potassium, calcium, magnesium, sulfur, zinc, cobalt, copper, molybdenum, selenium, sodium, iodine and others) which may cause poor or imbalanced plant growth and lead to dietary deficiency. Amendments to soil using allowable forms of these elements may be necessary to correct a deficiency or imbalance. Deep rooted perennial plants can also draw on mineral reserves deeper in the soil.

Amending soils is preferred to feeding supplements direct to stock or via foliar spays on feed. However one system reported relies on making available a range of mineral supplements for free choice selection by stock. Animals vary their intake of supplements from paddock to paddock and according to feed and seasonal conditions. Over time, the amount of supplements consumed declines as deficient minerals begin to build up in the soil via residual in the dung. This system is also reported to show remarkable improvement in stock health and performance.

A range of different approaches to soil analysis have gained prominence among organic growers. These include interpretations based on Dr William Albrecht, Dr Carey Reams and Dr Rudolf Steiner - see Appendix 3 for a brief overview.

Organic growers are not permitted to use highly soluble fertilisers like superphosphate and ammonium nitrate.

Soil deficiencies and imbalance can be corrected by application of suitable amendments. A wide range of natural products are permitted for use as soil amendments - see Appendix 2 for a list of permitted and prohibited inputs. Amendments commonly used by organic growers include:

- **lime** - to increase pH; supply calcium.
- **dolomite** - to increase pH; supply calcium plus magnesium.

- **gypsum** - to improve structure (especially salt affected); supply calcium plus sulfur.
- **rock phosphate** (various forms), **guano** - to supply phosphorous.
- **sulphate of potash** - to supply potassium and sulfur.
- **crushed mineral bearing rock** - to supply potassium plus other minerals; and increase 'paramagnetism' (refer Reams Appendix 3).
- **calcified seaweed** - to supply trace elements.
- **trace elements** including natural chelating agents.
- **various formulated fertilisers** - approved for use in organic systems.

Many of these inputs are typically made available to plants via the activity of soil organisms. Therefore immediate plant response (common with highly soluble synthetic fertilisers) may not be evident and must be observed over time. Several smaller applications may be preferable to a single large application, particularly on light soils with little buffering capacity. Economical and effective soil management can require a longer term view to build up soil fertility and balance.

Crops and pastures have been successfully established using composted pelletised manures, soil conditioners and fish emulsion fertilisers. A maintenance program reported by one grower involved using the rest period to fertilise pasture with rock phosphate and seaweed. Conservation farming techniques, such as green mulching, have been used to grow organic cereal crops for supplementary feeding.

Nitrogen

Generally organic growers do not apply additional nitrogen (N) fertiliser. Instead they rely on sufficient build up of soil N through the use of pasture legumes, organic matter accumulation and mineralisation, and to a lesser extent, legume crops. Ploughing in a legume-based green manure crop can contribute significant amounts of soil nitrogen.

A range of nitrogen sources permitted for organic systems are listed in Appendix 2.

Phosphorous

Phosphorous (P) levels and availability are considered an important issue for many growers. This is particularly so on alkaline soils where P release from rock phosphate can be very slow, resulting in yield declines and poor stands of legumes.

However, many organic growers have reported not applying additional P to paddocks for a number of years. In the short term, P availability to plants may be utilising residual soil P pools from past superphosphate applications. Availability of this P may be extended by improved soil biological activity and extracted by a larger root mass as a result of improved soil structure.

In the longer term, growers expect applications of some form of phosphorous may be required to maintain soil P levels. In contrast a few growers contend that P levels will be naturally maintained via a process referred to as 'transmutation of elements' whereby certain elements transform into other elements. However, research suggests that P levels on organic land tend to decline without addition of some P source.

Application of soluble P fertilisers, such as superphosphate or DAP, is not permitted. For organic production, less soluble forms of phosphorus such as reactive phosphate rock (RPR) or guano can be applied. The role of soil biological activity is particularly important in mineralising this phosphorus to plant available forms retained in the soil biomass. Other soil conditions such as pH and iron or aluminium binding can affect P release to plants. The effectiveness of RPR is enhanced by applying as a fine powder that is well distributed in the soil. The lag time for applied RPR to become available for plant uptake may require careful consideration.

A range of formulated organic fertilisers (incorporating various forms of naturally occurring P such as RPR, apatite, and guano) have differing levels of solubility. These fertilisers are permitted for use on a restricted basis. All sources of phosphorous must not contain high levels of cadmium. Typically rock phosphate contains negligible amounts of sulfur (unlike superphosphate) so in sulphur deficient soil a separate source of sulfur, possibly gypsum, may be required.

Potassium

Potassium leaches easily through sandy soils. On soils with high organic matter and humus content, less potassium may be lost through leaching. Sources of potassium permitted under organic production include rock dust, basic slag, wood ash, langbeinite and sulphate of potash.

Calcium

Conventional growers often satisfy calcium requirements via the use of superphosphate (contains about 20 per cent calcium) or lime. Calcium can be applied to raise soil pH.

Acceptable sources of calcium for organic production are limestone, dolomite and gypsum. Builders lime (quick lime) and calcium nitrate are not permitted.

The role of calcium, and its proportion to magnesium and other cations, is considered very important in soil biological processes and nutrient availability by an increasing number of organic growers. These claims are generally based on Albrect principles (see Appendix 3) of plant nutrition, where the ratio of major cations on sandy soils should be Ca 60 per cent to Mg 20 per cent or on heavy soils Ca 70 per cent to Mg 10 per cent.

Trace elements

Many Australian soils are naturally deficient in a number of important trace elements particularly Copper, Zinc, Manganese, Molybdenum and others. Deficiencies can be corrected using a trace element mix of permitted forms of the elements such as copper sulphate or zinc oxide. As mentioned previously, one system reported relies on making available a range of mineral supplements for free choice selection by stock. Animals vary their intake of supplements from paddock to paddock and according to feed and seasonal conditions. Over time, the amount of supplements consumed declines as deficient minerals begin to build up in the soil via residual in the dung.

Biological Agents

Biological inoculants have been used to bolster soil biological activity, increase nutrient availability, enhance soil structure and improve fertility. A wide range of different formulations of beneficial organisms are now available. Other products contain combinations

of different micro-organisms, hormones and enzymes. Sugar products are also used by some growers as source of energy to stimulate soil biological activity.

Microbial activity can improve soil structure, allowing plant roots to exploit a greater volume of soil. The performance of pastures, especially in dry years, is reported to improve. Pasture plants tend to 'hold on' longer in dry periods and 'come back' quickly following rain.

Pasture and grazing management

Pasture for cattle production can cover a range of types including native grass-based pasture, modified native pasture (to include fertilisers and legumes) or pasture based on introduced species sown on a prepared seed bed. On all pasture types good management requires an understanding of climate, soil type, enterprise needs and personal goals.

On organic farms pasture not only provides food for the livestock, it also contributes to the fertility of the soil. Pasture on organic farms is required to produce high quality forage by utilising and developing existing soil fertility, relying on legumes for nitrogen fixation and to minimise the need for bought in mineral and nutrient fertilisers.

Soil fertility balance is very important to maintain plant nutritional balance. When plant nutrition is imbalanced, nutrient deficiencies can arise in livestock. For example excess nitrogen in a crop or pasture can lower potassium and zinc content.

Pasture species

A typical pasture on an organic farm will consist of a mixture of different species and varieties of grasses, clovers (or other forage legumes), and other species generally referred to as herbs. Livestock production is highest when stock have access to green leaves all year round. This requires a species mix to suit seasonal climate change and land capability. The use of perennial species is very important in regions with an extended dry season.

Careful species selection can be used to extend the growing season and availability of green feed. Growers should aim to coincide peak feed requirements (for example, lactating or growth) to the natural highest growth period and match this with desired livestock targets.

An organic beef farm in France is reported to sow as many as 16 different grasses and herbs. These root to various depths and provide the animals with a diet which changes throughout the year, in line with the animals natural requirements. In addition, there is a belief that a greater variety of plants can lead to a greater variety of soil micro-organisms, assisting biological balance that aids nutrient balance.

Mixed pastures can be designed to suit specific paddocks or soil types, giving a range of different pastures to provide a suitable diet for the intended purpose within the seasonal pattern of the farming system. Certain paddocks can be developed to specialised pastures or forage for specific purposes. Examples could include: lucerne paddocks for finishing, drought tolerant perennials paddocks for summer green feed, selected mixed herb 'medicinal' paddock as a tonic for sick or weak animals as well as typical mixed grass/legume paddocks for more general grazing.

Selection of a suitable pasture species mixture requires careful consideration and may involve the following factors:

- Intended lifetime and purpose of the specific pasture.

- Climate and adaptability to soil and environmental factors.
- Compatibility between species.
- Growth cycles.
- Seasonal herbage quality.
- Palatability; and
- Cost of the seed.

Pastures consisting of a mix of ryegrasses, strawberry and white clover are reported to perform well, without the need for frequent renovations, in Victorian dairy land.

In contrast, on sandy soils of the mid-west coast of WA, pastures may comprise of dryland lucerne and Rhodes grass used with sub clover, rye and other grasses. WA Blue Lupins, NZ Blue Lupins (Fest) are also grown. Paspalum, kikuyu, strawberry clover are grown on summer moist areas.

In northern Victoria, a mix of short lived ryegrass, vetch and balansa clover - chosen for their vigour and ability to compete with an extensive Patterson curse problem - performed well and gave a yield of 11.5 t/ha silage with 23 per cent crude protein.

On an organic farm near Dubbo, NSW, pastures typically include lucerne, clover and grasses.

Table 1 provides a herbal ley pasture species mixture used on biodynamic farms in New Zealand.

Grasses

Modern grass selections, such as the aggressive and nitrogen demanding growth of highly productive ryegrasses, may not be most appropriate. They can out-compete other desirable species in the more complex organically managed pastures. While ryegrass is commonly used, selections may include both annual ryegrass varieties for fast early growth and perennial ryegrass varieties for good persistence - depending on rainfall.

Commonly used pasture grasses include perennial and short lived rye, tall fescue, cocksfoot and phalaris. Other grasses for consideration include Paspalum and Rhodes grass and native grasses such as Danthonia and Microlaena.

The grass component is considered to be very important. According to one grower, cattle kept metabolising efficiently can manufacture much of their own protein requirements. So ample roughage for energy every day is very important and protein feed becomes secondary, although also essential in the correct proportion.

Legumes

Improving pastures to include a good legume base can increase pasture feed quality. Protein and mineral content and total intake are increased with clover in the pasture. Cattle may be finished on clover-based grass pasture without the use of concentrate feed supplement. Clover selections, such as strawberry clover and white clover, are commonly used in high rainfall areas.

The performance of a clover variety depends on how it reacts with companion grass species, the nature of defoliation (grazing), climate, the Rhizobium strains present. Another important factor is the ability to fix nitrogen and transfer the nitrogen to grass production.

Commonly used pasture legumes include; subterranean clover, white clover, red clover, lucerne and annual medics. Other legumes that may be considered include; strawberry clover, balansa, serradella, bi-seradella, vetch and peas. According to location, some are used as forage, some as pasture.

Legume crops such as field peas and lupins can be grown for feed, cash or green manure as part of a mixed farming system.

Herbs

Herbs may contribute to the health of animals by enriching the diet, increasing the mineral content of the pasture and some herbs are believed to have medicinal properties. In addition, deep rooting herbs may improve soil structure and fertility. However, seed may be expensive and the establishment and persistence of herbs can be difficult in pasture. Generally herbal pastures are sown in a separate paddock reserved for the purpose, or sown as herbal strips within a paddock.

These pastures are not used as main grazing land. Instead they offer a health giving supplement to the diet for a few hours grazing occasionally (especially by pregnant cows just before calving), or are reserved for haymaking.

Possible herb species, depending on climate and soil, include; chicory (*Cichorium intybus*), plantain (*Plantago lanceloata*), yarrow (*Achillea millefolium*), burnet (*Sanguisorba officinalis*), caraway (*Carum carvi*), sage (*Salvia pratensis*), parsley (*Petroselium saxifraga*). One rule of thumb is to sow 0.5 kg/ha of each kind, except plantain which is sown at 4 kg/ha. Chicory is a particularly productive drought tolerant, deep-rooted perennial.

Perennial pastures

The use of perennial pasture plants is becoming increasingly important for improving feed quality and availability during the dry season. Perennials can help the sustainability of production in areas with rising water tables and salinity by providing greater annual water consumption. Deep-rooted perennial plants can also draw on mineral reserves deeper in the soil profile, improve soil structure and soil biology.

Callide Rhodes grass and paspalum are two important perennials that are reported to show promise on light soils in the medium rainfall central west coast. Tagasaste has been successful on very sandy soil.

A number of perennial native grasses such as Danthonia (wallaby grass) and Microlaena (weeping grass) are both tough and nutritious. They appear to offer good potential, for some areas, to improve productivity without the expensive inputs of sowing down improved pasture species. Rotational grazing can improve the condition and production from native pasture that has been heavily invaded by weeds.

Feed conservation

Good quality hay or silage is considered essential for some organic operations in order to maintain desired productivity and finish quality throughout the year, especially during feed gap periods. Some organic growers believe it prudent to retain 18 months supply of stored feed. Where significant quantities of hay or silage are removed, regular fertilising with acceptable forms of phosphate and potash may be required.

Silage containing legumes can give higher production than grass of similar digestibility. The use of some conventional additives may not be permitted in organic silage production. UK reports suggest the use of clover in pasture and silage can reduce the cost of organically produced feed supplements.

Improving pasture

Improving pasture productivity may be achieved by either changing the management of existing pastures or re-sowing a paddock to preferred species. Slashing old rank growth will encourage diversity and improve pasture quality. Sowing down improved pasture species to improve productivity can be an expensive and often fickle operation regarding success.

The need to upgrade or renovate may be required when paddock productivity starts to decline. Simply over-sowing a paddock, rather than ripping or working up, can be successful in some situations. Adding soil amendments to adjust pH and other imbalances, combined with deep ripping compacted soil, may assist establishment and persistence thereby increasing the benefit:cost ratio.

Sowing and establishment of pasture can generally take place either, during a cropping phase by under sowing a crop, or as a separate activity. Under-sowing requires a species mixture and sowing rate that will not compete excessively with the crop. Seed can be sown directly with the crop at rates sufficient to produce enough new seed for good pasture establishment in the following year.

Under-sowing is generally more suited to establishing clover in shorter term pastures, rather than perennials in longer term pastures. However, under-sowing cereals with lucerne, clover, rye and cocksfoot has been successful in some situations.

The alternative to under-sowing is direct seeding into a seedbed worked up for the purpose of renewing or renovating pasture. This can increase the chances of establishing a successful and productive pasture, particularly where perennial species are involved. Direct seeding into seedbed strips rather than the whole paddock, or seeding into heavily harrowed paddocks, are alternatives that can reduce the yield loss often associated with establishing a new pasture.

The persistence of clover in pasture can begin to decline after 2-3 years and grasses start to dominate. This effect is reported by some farmers to indicate that clovers have renewed soil N levels sufficient to favour grasses. On mixed cropping farms, this decline of clovers is viewed as a signal to bring the paddock under crop again, thus completing the pasture/cropping cycle.

Another approach following cropping is to turn in stubble together with oats, clovers and other feed species as a means of getting fast early growth (oats) and a good clover-based pasture. Timely grazing management is required to ensure good clover growth.

Management of pasture is important to gain optimal productivity. In addition to regular grazing and cutting regimes, topping can be used to control weeds and remove rank ungrazed material. Harrowing can be important for spreading dung pats. Soil compaction, particularly on heavy soil types, should be minimised by restricting stock and other traffic on waterlogged or excessively wet soil.

Grazing management

Sustainable management aims to match the number and class of animal with the characteristics of the land. One of the key factors in most types of cattle production management is flexibility to match available pasture types and quality with animal condition and purpose. This is not always easy given the natural fluctuations and other variables confronting the grower, and is particularly important on organic farms, where fertiliser cannot be relied upon to stimulate quick pasture growth.

Grazing management requires flexibility in order to make best use of the changing patterns of pasture composition, growth cycles and seasonal herbage quality and palatability. The general aim of cattle production is to fit animal requirements to pasture growth by purchasing or selling at the right time, or calving when pasture matches cow and calf nutritional requirements.

Some typical examples would be cattle for finishing get the best feed (possibly lucerne or a feed/pasture sown to oats/clover/grasses), followed by cows with calves. For maximum impact and highest concentration of metabolisable energy, crude protein and minerals, forage (and pasture) should be leafy and immature when grazed.

Grazing pressure, as indicted by pasture height, can be important in achieving optimal pasture production and affects the following:

- Leaf area available to trap sunlight, hence growth rates.
- Proportion of leaves which age and die without being utilised.
- The total amount of pasture available; and
- The amount which can be eaten, hence animal performance.

For finishing beef cattle while making best use of pasture or forage, one approach is to allow these stock to eat the best feed with a light grazing, followed by other stock with a lower requirement to utilise the remaining feed.

Managing grazing pressure, to ensure sufficient plant material or ‘litter’ is left behind by grazing animals, is important for maintaining soil organisms. This can result in improved nutrient release, soil structure, soil water infiltration and holding capacity.

Rotational grazing

Rotational grazing systems are generally preferred and can be designed to optimise pasture utilisation, maintain pasture composition and control parasites. In addition, rotational grazing can improve soil structure, fertility recovery, and is believed to allow pasture to develop to its full size so roots penetrate deep into the subsoil.

High intensity ‘mob’ grazing for short periods followed by long recovery can help prevent preferential grazing. This allows the pasture composition to remain mixed, particularly

perennial species including native grasses. A system known as cell grazing (also known as holistic grazing, crash grazing, time control grazing or high density short duration grazing), matches stocking rates/duration with rainfall/pasture productivity. Cell grazing creates a rotation system that aims to optimise pasture utilisation while managing pasture composition, growth recovery and soil fertility. The system aims to maximise the time available for the pasture or rangeland forage to regenerate. Within such a system, small paddock sizes can be required for effective intensive management and this is often achieved using portable or fixed electric fencing. Success requires close monitoring of pasture condition to determine optimum grazing pressure.

Stress involved with stock movements should be kept to a minimum. The use of noisy motorcycles, or hurrying animals through gates, should be avoided. One grower has trained the cattle to respond to a whistle when it is time to move.

Benefits of intensive cell grazing include improved pasture composition, quality and productivity, soil recovery/improvement and pest/disease control. Quick growing pasture typically requires a quick moving rotation. The duration of the recovery phase in the rotation is critical and can influence worm control, pasture quality and cattle condition. Pastures must be given adequate time to recover before next grazing. It is essential that paddocks not be grazed too soon after rain so the perennial pastures can be allowed to get a head start. Where there are distinct wet and dry seasons this can require disciplined management.

Weed management

The control of an undesirable 'weed' species in a pasture generally requires an understanding of its life cycle and the conditions present that favour the species.

Weeds can be seen as indicators of soil conditions, soil management and the environment. For example, dock is reported to thrive in compacted soil with abundant raw manure and wetter areas. Treatment to relieve compaction, together with prevention of seeding and repeated cultivation during summer, can help prevent severe dock build up. However can must be taken to reduce erosion risk.

A number of growers report that improvements to soil structure and soil fertility balance has reduced weed problems.

Constant monitoring and removal of any weed before it seeds is important to keep clean country clean. Any tactics to reduce seed set, such as slashing, can have a positive effect on weed burden. Hand hoeing spot weed incursions works to prevent weed establishment.

Sowing a vigorous annual pasture mix can be used to swamp-out emerging weed seedlings. Correct choice of species and careful management can give good weed control. A productive silage pasture of fast growing rye, vetch and balansa clover has been shown in Victoria to significantly reduce Patterson's curse numbers.

Perennial grass-dominant pasture can be a very effective control agent to reduce invasion by most weeds. Therefore, a management system designed to maintain perennial grass-based pastures with high ground cover, will not only provide maximum weed control but also reduce the risk of surface erosion. Spelling a perennial grass-based pasture just prior to the weed germinating period can reduce survival of weed seedlings through pasture competition.

Purchased stock can introduce unwanted weed species into clean paddocks and should be held in a small quarantine paddock to avoid spreading weeds. The same principle applies when shifting stock from dirty country to clean country.

Rotational grazing management is reported to improve the condition and the production from native pasture that has been heavily invaded by weeds.

Sheep are reported to be more effective than cattle in controlling dandelion, Cape weed and Patterson's curse. Mixed livestock operations can have more weed management options than single livestock farms.

Biological control agents are being developed for some weeds. These bioherbicides use a range of fungi, bacteria and other micro-organisms that result in death or reduced vigour of weedy plants. A number of commercial bioherbicides are available on international markets but as yet not available in Australia. Target weeds for developing bioherbicides in Australia include Bathurst Burr, Noogoora Burr, wild oats and other grass weeds of cereals. The Crown Boring weevil has been released for control of Patterson's curse.

Animal nutrition and feed supplements

Ideally, all livestock feed should be produced on-farm, allowing the development of a closed, self-sustaining system within the productive capacity of the land. However, some farms may not be capable of being totally self-sufficient for various reasons, including drought, and may have to buy in additional feed. Limits may be set on the proportion of bought in feed. Feed given to organic animals must be organic certified. A maximum five per cent of diet may be from non-organic sources.

Ruminants require a high volume of roughage for the proper functioning of their rumen. Emphasis should be placed on nurturing and maintaining the natural bacterial flora in the rumen through sound nutrition. The balance of this living symbiotic system within the rumen is critical to the health and vitality of the animal. Sudden changes in diet can disrupt vital fermentation in the rumen.

One report, referring to dairy cattle, suggests that to avoid health difficulties it is important to not start grazing too soon on young grass that has been heavily fertilised. When plants are a little older the ratio of substances they contain is more balanced. Young grass, particularly after heavy fertilising early in the season, contains a high proportion of nitrogen and little fibre or carbohydrates. Synthesis of this nitrogen into proteins in the leaves is thought to be incomplete, resulting in greater amounts of intermediary nitrogen compounds, like free amino acids, urea and nitrate. This can lead to rapid breakdown in the rumen and cause bloating. Liver problems can also arise. Straw or hay must be given if grazing is to start on young grass.

Fodder high in potassium can make it necessary to give salt. Mineral supplements with (in addition to salt) phosphate, ground lime, magnesium, kaolin and charcoal are suggested as being important. These can help avoid diarrhoea caused by salts intake from high water/low fibre content forage.

Diets with high levels of concentrates (especially protein) and low quantities of roughage can lower the rumen pH, resulting in problems such as rumen acidosis, fatty liver syndrome and foot problems.

Rumen modifiers/activators may be permitted on a restricted basis depending on rates of application, purpose of use and product purity. Growth hormones and other growth stimulants are not permitted.

Animals must have free access to pastures. Free choice feeding, where animals are allowed to follow their natural inclination, is the preferred method of feeding. However, low voluntary intake of feed is the nutritional factor that usually limits ruminant production, especially when forage is the only feed given. Voluntary intake is reduced by high fibre and low digestibility, or by deficiency of protein or minerals. Provision of a wide variety of food natural to their diet allows livestock to maintain an appropriate balance between fibrous roughage feeds and grain feed or supplements.

As a general principle, the feeding of valuable grain to ruminants may be considered inefficient use of resource. Where protein and energy supplements are required, organic standards can limit the quantity of off-farm feed supplement for organic stock.

Supplementary feeding to maintain weight gain is possible using organic grain or silage. Intensive finishing on high quantities of grain or feed concentrates is not permitted. Up to five per cent of all feed (on a daily basis) may be bought in as non-organic feed supplements, provided they are acceptable within organic standards. A range of supplementary feeds can be used (e.g. oats, barley and canola meal), however, organic standards may limit the quantity of supplementary feed. In the UK, during the feed gap, one organic producer finishes cattle on organic silage, supplemented with organic cereal and seaweed as a source of minerals.

In WA, one growers uses silage and pasture hay together with mineral and vitamin supplements to maintain productivity throughout the dry season when pasture feed quality is low. In addition, perennial pastures are being established to improve feed quality in the dry season.

Energy

Where an energy supplement is required oats are preferable to wheat and barley. The higher digestible fibre, higher fat and lower starch content causes fewer digestive upsets.

Protein

Natural protein sources may include grain legumes or canola, sunflower and linseed meal or dried lucerne. The use of artificial protein sources, such as urea, are prohibited. Protein balance in the whole diet can be a problem in high rainfall areas. Organic farms with good clover-based pastures may have excess protein and shortage of energy. Excess protein can lead to health problems similar to those in conventional farming with high nitrogen loads, such as excess ammonia production, liver and fertility problems. High protein levels can be compensated for by feeding straw or hay or other high energy fodder crops.

Minerals and vitamins

In general, mineral concentration in plants varies considerably and is influenced by concentrations of minerals in the soil, plant species, stage of growth and soil moisture. Dietary deficiencies of minerals and vitamins can result from a soil deficiency and poor management of fodder production.

Deficiency of minerals in the diet can lead to a wide range of problems including loss of appetite, reduced productivity and fertility.

Many soils in grazing areas of Australia are naturally deficient in one or more minerals such as copper, zinc, cobalt, selenium, iodine, magnesium, phosphorous, sulfur, calcium, sodium or others.

In the first instance, efforts should be made to rectify the underlying cause. Mineral and vitamin supplements are permitted where demonstrated deficiencies exist and where preferred remedies such as amending soil imbalances are ineffective. Amendments to soils may be required, however additional soil treatments may also be needed to correct other possible causes of a deficiency (for example, water logging or other factors locking up nutrients).

Minerals and vitamins derived from acceptable natural sources such as seaweed (calcified, meal or extracts), simple mineral salts, cod liver oil or yeast, can be added to feed supplements where other preferred management measures to correct the cause of the deficiency are ineffective and have been exhausted. Appendix 2 provides a list of permitted substances. Routine reliance on mineral salts and vitamin supplements in the diet is not acceptable, however a number of organic growers provide animals with access to permitted mineral licks. One grower reports having a mix of kelp, lime and copper always available for animals to freely choose. Free choice access allows animals to determine their own requirements as seasonal feed quality changes.

Careful consideration should be given to the balance of minerals, in particular the potassium to sodium ratio. In the UK it has been reported that in some situations the potassium content of forage can increase following the elimination of mineral fertilisers during the conversion period. Under low sodium conditions this increased potassium level can potentially lead to fertility and other problems.

Blood tests on several animals may be useful every year or two as a way of monitoring the effectiveness of soil amendments used to correct specific mineral deficiencies. However, when interpreting test results, bear in mind that cattle can deplete body reserves of some minerals (like phosphorous and possibly others) in order to maintain blood levels.

Feed supplements to improve digestibility of poor feed quality and generally improve metabolism and feed conversion have been used by some growers, although the cost of these inputs can be high.

Selection, breeding, rearing and herd management

Cattle breeds and selection for organic systems should aim for hardiness and resistance to pest and disease, as well as the more conventional measures of productivity and quality attributes. Unfavourable genetics are unlikely to do well even in the best environment. Hardier, more robust breeds suitable for organic production systems tends to be counter to current trends towards larger animals that can be slaughtered earlier when still immature and hence with less fat. Breeding for leanness and growth rates may not necessarily be the most appropriate for organic systems and limiting genetic diversity is undesirable. Breeding animals able to thrive with good growth rates on a predominantly roughage diet with a minimum of inputs, particularly protein rations, rather than growth rates dependent on large amounts of inputs, may be more suitable for organic production.

The general requirements of health and a strong constitution, high forage intake capacity, regular cycling/fertility and longevity, require close consideration by organic cattle producers when planning genetic selection.

Selection of appropriate cattle breeds must suit the specific environment and are likely to include factors such as; good maternal capabilities - a combination of fertility, fecundity, ease of calving and milk production; ability to thrive in the environment; good growth rates without too much fat and very efficient food conversion. For example, South Devon cows with Red Angus/South Devon bulls are used for biodynamic beef production from rangeland-bred cattle finished on the mid-west coast of WA.

Fertility in livestock is controlled by many factors including nutrition, stress and the presence of male animals. A well balanced diet of organic forage without high levels of feed concentrates is important in maintaining optimum fertility.

Careful consideration must be given to calving dates. Late spring calving may conform closely to the animal's natural nutritional and feeding cycle. In contrast, autumn calving can place additional stress on the animal at a time when its own system is trying to build up mineral reserves for the winter. If large numbers of calves are born during winter, problems such as pneumonia and scouring may be more severe. Spring born calves generally thrive, but cows may suffer excess milk production. Heifers rarely have this problem, so for these animals late spring calving may be best, with the cows calving 2-3 months later. This allows heifers an extra 2-3 months recovery after their calves have been weaned before joining the rest of the herd on a 365 day calving index.

However, calving policy may need to be designed to suit market requirements. If finished cattle are required all year round then two calving dates may be appropriate, e.g. Winter calving (July-August) and summer calving (Jan) if green feed or irrigation is available.

Feeding of colostrum to calves is essential for well being and early immunity. Calves should suckle within the first few hours after birth and for at least 2-3 days. As a minimum calves should receive organic whole milk for five weeks. The rumen should be trained to cope with high forage intake by feeding high quality forage or hay. Changes to diet should be gradual.

Natural weaning without forced removal of the cow from her calf should be considered, although this is not always possible with some production systems. Allowing cows to decide for themselves when to wean their calves can be very beneficial compared to forced weaning at nine months. Live weight gains can be considerable and calves have a high degree of finish, only requiring time to grow out to be fit for slaughter. However, forced weaning may be required as indicated by conditions and if a production target of a calf per cow per year is desired. In addition, cows may tend to feed right up until calving again, allowing no time to recover body reserves. This can have a detrimental effect on the new calf, especially if the first calf continues feeding.

Castration of male calves should be carried out as soon as possible after birth. Consideration may be given to leaving young meat animals entire, if the aim is to produce young carcass at less than 15 months with tender meat and little fat.

Cattle are gregarious animals with a herd instinct and develop social structuring within the herd. The herd instinct is important in maintaining the daily natural rhythms such as eating, ruminating and resting. These rhythms should be considered as part of the management system, for example; the highest feed intake typically occurs at sunrise and sunset so interference at these times should be avoided.

Cattle are often run as separate mobs according to age, sex, condition and purpose. As an example, one enterprise that aims to turn off 14 month old animals weighing 400-420 kg runs three separate mobs, consisting of steers plus heifers for fattening, old cows with calves and calving cows. The fattening steers/heifers mob get the best feed, the old cows with calves get the next best feed. Yearlings are weaned at 12 months and go onto pure lucerne to reach 400-420 kg at 14 months.

Pest/parasite and disease control

Regular and routine use of medication is not permitted in organic cattle production systems. The need for routine medication generally indicates action should be taken to correct an imbalance in the farming system. The underlying cause of the problem needs to be identified and modifications to the system made to prevent a re-occurrence. Many veterinary problems are believed to result from mineral or vitamin deficiencies caused by soil imbalances. Prevention of a disease rather than treatment is the preferred approach to animal health care.

Close observation and attention to individual animals is the key to early identification and treatment of pest or disease problems. Early treatment can be critical for the success of some natural remedies. Good record keeping may assist in assessing the origins of a problem.

The ability of an animal to fend off disease through its own defence mechanisms can be enhanced and nurtured by appropriate forms of good quality feeding and levels of production, and by creating the right environment so that stress and other factors do not impair natural resistance. Pastures that are too lush should be avoided.

The degree of immunity or resistance can vary depending on a range of factors. Detrimental effects on well-being and resistance may result from pregnancy and lactation, veterinary medication, vaccinations, contact with antigens, pesticide residues, contact with humans, nutrition, stress, shelter and weather conditions.

Young cattle can acquire a degree of resistance via colostrum and sucking. Colostrum is the starting point for building immunity and suckling can also stimulate immune response that can be passed from cow to calf.

A rigorous and ongoing culling program for susceptible and weak animals is very important for improving genetic traits related to pest and disease resistance.

A range of treatments including herbs, vitamins and minerals, homoeopathy, acupuncture and dietary additives are used by organic producers. However, routine use of such treatments is not permitted to mask poor preventative management.

Homoeopathic remedies are being used by a number of organic growers. Homoeopathy treats diseases with extreme dilutions of substances that aim to stimulate the level of resistance in order to overcome a disease rather than try to destroy the causative organism. Preparations called nodsodes are sometime used as preventative treatment similar to vaccines, however no antibodies are produced. The effectiveness of homoeopathic remedies is contentious and a high level of skill is required in deciding and administering treatment.

Mastitis

In general, mastitis is not as big a problem in low milk yielding beef breeds. Some growers (in the UK) have reported switching to homoeopathic treatments for Mastitis without any

adverse impact on their plate counts. A number of dietary supplements, such as dolomite and garlic, may have a positive effect on the control of mastitis.

Bloat

Bloat is usually not a problem when the general health of animals and pasture is improved according to one biodynamic dairy farmer. The risk of bloat can increase with cattle grazing very high clover (or other legume) content pasture. If bloat does occur one homoeopathic remedy reported is to put 5 mL of chamomile in the trough and this will settle a cows' digestive system. The use of vegetable oils may be permitted for occasional treatment.

Grass tetany

This was a major problem for one grower in south eastern Victoria when farming with high conventional inputs and high stocking rates to try and boost productivity. Changes to improve soil health and balance plant nutrition reduced the problem, which is now treated by administering magnesium salts. Grass tetany can also result from excess potassium in the diet which is believed to lower the absorption of magnesium.

Parasites

The preferred methods of parasite control relate to husbandry and environmental management such as good nutrition, rotational grazing and reduced stocking rates. The lower stocking rates adopted by many organic growers can benefit parasite control by providing a higher plane of nutrition and assists the ability to spell or rotate pastures. Bought in stock can also be a source of parasite introductions.

Internal parasites

Parasite control aims to reduce worm burden to a low, economically and physiologically acceptable level, not necessarily eliminate them. Young stock or stock subject to stresses, like weaning or marking, are likely to be most susceptible and can benefit from clean pasture. Good nutrition is important to maintain natural resistance. Adequate copper in the diet is believed by some growers to prevent worm infestations.

Control of internal parasites in cattle on organic farms can be achieved by rotational grazing management designed to achieve a clean grazing system. Clean grazing systems require a detailed understanding of the life cycle, seasonal cycle, and hosts, of the problem parasites. Paddocks are designated according to parasite burden. Clean paddocks are uncontaminated (usually after cropping or long period without host) and safe paddocks have low burden unlikely to affect production in susceptible animals. The availability of clean and safe pasture will vary over time and can be used strategically to prevent, evade or dilute parasite problems.

Safe or clean paddocks can be established by:

- Spelling a pasture - duration varies to suit parasite life cycle, season and local circumstances.
- Alternate grazing - grazing older resistant stock or different species first can reduce parasite numbers for following younger stock.
- Mixed grazing - different ages or species together can dilute worm burden compared to running susceptible age cattle together. Combining sheep with cattle has been used to control internal parasites in cattle.
- Strip grazing - prevents cattle feeding near their own recent faeces.

- Cropping - breaks parasite life cycle. A crop of mustard ploughed in as green manure is reported to clean up parasites.
- Hay making - provides a clean pasture after the paddock is spelled.

In dry summer areas the free living worm larvae tend to die faster (due to lack of moisture) so spelling a pasture during this period can be more effective in reducing an existing worm burden.

In summer rainfall areas, barber pole worm outbreaks can be sudden following heavy rains. Stock movements may need to be advanced to clean pasture to prevent expected worm burden.

Exposing worm eggs and larvae to sunlight, heat and drying by harrowing pasture after grazing may reduce worm burden.

Pasture herbage species are reported to influence worm numbers. Chicory and lucerne appear to be less conducive to roundworm larvae development, with lucerne perhaps offering an opportunity for reduced larvae intake.

Rotations and cell grazing techniques have been successful for internal worm control. Monitoring or testing parasite burdens is important to confirm the effectiveness of management strategies.

Close observation is a crucial factor. Despite the above management, drenching individual animals with permitted substances (see Appendix 2) may be required on occasions. However, any drenching program should be on a needs basis only, rather than as a prophylactic treatment over the whole herd.

External parasites

Management strategies should be directed at the cause of high parasite numbers. Bad infestations of external parasites such as lice and ticks are believed to be related to poor or imbalanced nutrition, particularly where sulfur is deficient. Feeding cattle sulfur, either through the feed or directly in licks, can help keep animals free of lice.

Purchased animals can be a source of parasite introductions. New animals may need to be placed in a quarantine area and remedies applied until the risk of introducing parasites to other stock is low. Good fences are important to prevent neighbouring stock from introducing parasites.

As a last resort, a range of acceptable treatments are available. Derris can be used to control lice. Neem oil extracts and cattle rugs have been used to overcome lice problems.

A soil fungus is being developed by Queensland Department of Primary Industries as a biopesticide for control of cattle tick.

4.7 Areas for future research

Research into the following areas would be useful:

- Mineral and feed supplements, effects on parasites and amending soil mineral deficiencies.

- Mobile slaughter facilities.
- Pastoral regions for breeding linked to higher rainfall properties for finishing.
- Details of input products for pest and disease control permitted for use when problems occur.
- Faith and patience - grower quote 'one of the biggest challenges is to trust in what you are doing and give natural agents time to work'.
- Phosphorus input sources and plant availability.
- Soil biological agents formulated to provide specific functions such as humus formation or phosphorous release.
- Bio-pesticides and bio-herbicides for pest and weed control.

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Table 1 - A herbal ley pasture seed mixture

(Taken from 'Grasp The Nettle - making biodynamic farming and gardening work', by Peter Proctor, Random House, New Zealand. 1997.)

Note: This mixture was developed by Grasslands, DSIR (now AgResearch) for New Zealand conditions (i.e. a temperate climate). Consult local agronomists for other species which will grow well in your district. This mixture contains legumes for nitrogen fixation; many deep-rooted species which tolerate drought, increase soil porosity, and access more minerals; several herbs with high mineral content and species which give a low risk of sheep facial eczema. Not all species will grow in all districts. Sow in early autumn or early spring.

Recommended sowing rate is 11.5 kg (25 lb.) per acre. The species in the mixture are in approximate balance on a seed-weight basis.

1. *Chicory* - 'Puna': a persistent deep tap-rooted pasture herb which is high-producing, high in minerals and has high-quality summer forage. Excellent animal performance has been recorded with this species. It is suited to free-drainage soils.
2. *Yarrow* - a mineral-rich forage herb, persistent, with an extensive rhizome system.
3. *Sheep's Burnet* - a fast-establishing perennial herb producing palatable summer forage. Performs well in dry, low-fertility sites and withstands cold winters.
4. *Plantain* - narrow-leaf plantain: deep-rooted summer-growing herb.
5. *Trefoil* - a deep-rooted legume, non-bloating, excellent summer growth, particularly suited to dry, acid, low-fertility soils.
6. *Lucerne* - 'Oranga': deep tap-rooted legume, very drought-tolerant, producing quality summer forage.
7. *Sulla* - 'Aokau': short-lived perennial legume, rapid establishment, very productive during winter. Produces non-bloating forage.
8. *Subterrranean Clover* - an annual legume, low-growing, with excellent winter growth, able to persist through vigorous reseeding, thus surviving dry summers.
9. *Pink Serradella* - 'Koha': a deep-rooted winter annual legume, tolerant of acid soils.
10. *White Clover* - 'Pitau': a persistent legume adapted to a wide range of environments. Creeping, prostrate habit with a network of spreading stolons.
11. *Red Clover* - 'Pawera' and 'Hamua': a tap-rooted perennial legume. Produces high-quality summer forage and is drought-tolerant. Early and late flowering types combined.
12. *Prairie Grass* - 'Matua': a perennial grass with a good winter growth. Best suited to higher-fertility sols that are free-draining. Growths well during winter and dry summers.
13. *Yorkshire Fog* - 'Massey Basin': a perennial grass, very palatable. Grows well on low-fertility and acid soils.
14. *Browntop* - 'Muster': pasture browntop suitable for low-fertility and acid soils. A perennial grass with a dense rhizomatous growth habit.
15. *Hybrid Ryegrass* - 'Greenstone': a persistent tetraploid hybrid ryegrass, very palatable. No endophyte, giving excellent winter/spring growth. Tillers strongly.
16. *Cocksfoot* - 'Wana': a perennial ryegrass with a deep root-system, well adapted to dry, low-fertility soils. Active over the summer.
17. *Phalarus* - 'Maru': perennial grass with active cool-season growth. Tolerant of dry, harsh environments and of insect pests, including grass-grub.
18. *Timothy* - 'Kahu': high forage-quality grass, especially good on moist sites.

5. Wheat - Organic Production Guidelines

By Steven McCoy
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5.1 Introduction

Many people believe organic agriculture systems can only work in high rainfall regions. However, perhaps some of Australia's most successful organic farmers are the pool of experienced practical organic wheatbelt farmers. They are producing a range of cereal, pulse and oilseed crops in different regions and soil types across the country. The major crop is wheat, particularly noodle wheats and bread making wheats, grown predominantly for export markets.

Farming systems developed by modern organic wheat growers in Australia may differ quite significantly in concept, strategies and techniques from those used by their conventional counterparts. Successful conversion to an organic wheat production system requires careful planning and integration of the whole farming system over several years. In addition, conversion from a conventional to an organic system often involves a significant change in attitude and approach to the farm. Many growers report that making this mental change can be the most difficult aspect of developing a sound organic system.

Most farms are mixed operations, incorporating animals into the system as an integral part of the whole farm management. A number of different crops are grown in rotations designed to minimise pest, disease and weed problems while maintaining sustainable yields. Biological diversity is an important factor in establishing beneficial ecological balances across the farm.

Close attention should be given to planting appropriate varieties and managing soil and other conditions to ensure grain qualities meet buyer specifications; particularly those relating to protein levels and other end use qualities.

A number of grower groups have been formed to not only coordinate supply capacity and develop markets, but also to develop best practices in production methods and assist new growers through the conversion period when establishing an organic system.

A key requirement for success is motivation and commitment to the principles of organic farming - beyond the essential financial and market perspective.

These guidelines aims to provide a general outline for conventional producers with an interest in investing in the production of wheat grown organically in compliance with the Australian 'National Standards for Organic and Biodynamic Produce' and certified by an accredited organic inspection organisation (see Appendix 1).

The underlying principles outlined are similar for all farms, however the organic techniques and methods should be amended to suit individual farm enterprises and circumstances. It is likely that growers will also need to consider organic methods applicable to other crops or livestock also produced on the farm if whole farm certification is envisaged. Much of the material presented comes from organic or biodynamic wheat producers from NSW, Vic and WA.

The report does not cover important aspects relating to farm economic outcomes and financial considerations, nor changes to capital plant and equipment.

5.2 Market outlook for organic wheat

Markets for organic wheat have fluctuated over the past years. Markets for higher protein wheat appear quite strong at present, whereas some growers have had difficulty finding organic markets for lower protein noodle varieties. Some growers aim to have contracts in place before planting crops, however in a developing market this is not always possible.

Export markets

Australian exports of organic and biodynamic wheat have grown steadily over the past few years, although volumes remain relatively small. The main markets are Japan, Europe and North America.

Production of medium protein wheat varieties, such as Rosella or Cadoux for noodle making, has become well established. The majority of this wheat is for manufacture into Udon noodles for export to Japan. Product is exported from Australia either as wheat, flour, Udon noodle premix or finished retail ready packs of frozen Udon noodles.

High protein wheat varieties for bread making are exported to a number of Northern European countries including the UK, Holland, Austria, Norway, Sweden, Switzerland and also Japan. Some South East Asian destinations such as Singapore, Malaysia and Hong Kong are emerging as potential markets.

Biodynamic Durum wheat and flour is exported to Italy for pasta manufacture. The Italian manufacturers are reported to consider this product as being of exceptional quality.

Export trading of organic and biodynamic wheat into European markets is reported to be very competitive, with considerable price fluctuations from year to year based on seasonal supply factors. Exporting organic wheat to Europe can be difficult following seasons when European organic wheat producers have good crops. The main competitive suppliers onto world organic wheat markets are USA, Canada, Argentina and several European countries.

The strong growth within the processed food sector of the organic food industry suggests considerable opportunities exist for value adding. Wheat-based manufactured products such as breakfast cereals, biscuits, pies, cakes, pastries and ingredient products may all have export potential.

Australian Markets

Within Australia, major supermarkets are showing renewed interest in offering a range of organic products. For example, three brands of organic wheat breakfast cereal biscuit are made in Australia. This development follows mainstream supermarket trends in the major organic export markets. In Europe and particularly the UK, major food retailers consider organic products as an ‘image asset’ in line with consumer demand.

By way of example, *Weston Milling* are a major company in Australia with active interest in developing organic wheat markets. Export markets account for 85 per cent of organic sales, predominantly to Japan and more affluent South East Asian countries.

The following table shows organic sales for *Weston Milling* for 1998-99.

Product		Amount (tonne)	Wheat quality
Organic 1 kg packet flour sales	(domestic)	1,000	ASW/APW
Organic bread mix	(domestic)	500	APW/AH1
Organic bread mix	(export)	2,000	APW/AH1/PH
Organic noodle mix	(export)	3,000 (WA)	Noodle varieties
Organic Noodle varieties	(export)	3,000 (NSW)	Noodle varieties
Organic durum	(export)	1,000 (Qld)	Durum
Total		10,500	

(From: Opportunities in Organics, 1999, Agriculture Victoria.)

Weston Milling report that sales have been growing by 10 per cent or 1000 tonne of wheat per annum. Opportunities have been available to push this growth faster based on current demand, however guarantee of supply and continuity are considered more important in the development of a long term sustainable organic market.

5.3 General principles - organic wheat production

This section outlines the general principles which underlie organic wheat production systems. Aspects of organic certification standards specific to wheat production are highlighted.

Whole farm approach

Production of organic wheat must be considered as only one component of a whole farm system. Continuous wheat cropping, or short rotations with another crop and no pasture phase, are unlikely to be acceptable as a sustainable organic farming system. Consequently, organic wheat production will typically also involve organic production of other cereal, pulse or oil seed crops in rotation with wheat; as well as soil regenerating pasture phases. Rotating or inter-planting crops with different growth habits and varieties of crops suited to specific geological location can add diversity to the whole farm and favour the establishment of a more balanced ecology.

Closed systems

Organic farms tend to operate as closed systems, using renewable resources wherever possible and minimising reliance on outside (off-farm) inputs as far as practical. Management strategies based on an understanding of biological cycles and other interactions are the main tools that replace dependence on synthetic chemical inputs. Organic farms can be managerially more complex, but less reliance on external inputs means costs can be reduced.

Plant health stems from soil health

Well-balanced, biologically enhanced soil, as determined by adequate soil organic matter, humus level, crumb structure and feeder root development, are an essential component of good organic wheat production. Plants are fed through the soil ecosystem and not primarily through soluble fertilisers added to the soil.

Synthetic fertilisers and chemical pesticides and herbicides are not permitted and can be detrimental to active healthy soil.

Land degradation problems such as organic matter depletion, soil structure decline, compaction, erosion, and acidification must be avoided. Soil problems related to water imbalance, such as waterlogging and salinity, can also require specific remedial action. In general terms well managed soils, having adequate organic matter and biological activity, tend to be more resilient against most forms of land degradation.

Part certification

Growers typically convert part of a property to organic methods while continuing to use conventional methods on the remainder. However, to establish a functioning organic system, sufficient paddocks must be converted to organic methods in order to establish a feasible crop rotation. One paddock is insufficient and generally it is not possible to certify just one crop. Moving into and out of organic certification is also unacceptable. Development plans generally must indicate the intention to achieve whole farm organic certification within a defined period.

Spray drift

Potential sources of contamination from spray drift or other means can require careful consideration. Buffer zones are likely to be required between organic wheat crops and conventional crops. Neighbours must be informed of the change to an organic system and their cooperation sort to avoid contamination risks. Soil tests may be required to check for chemical residues in soil from previous land use.

Animals

Animals such as sheep or cattle are often involved as an integral part of the whole farm system. Animals can be important by contributing to: soil fertility maintenance, carbon cycling, managing pastures, controlling weeds and diversifying the biology of the farm. Animals run on organic land ideally should be treated only with permissible organic inputs. Animals given chemical treatments require a quarantine period before release onto organic land.

Minimum qualifying period

The transition from a conventional system to a balanced biologically active organic system is a gradual process. For organic wheat production the land must be managed in accordance with organic standards for a minimum of three years. However, growers can obtain certification as ‘in conversion’ to organic after one year (pre-certification) of compliance with organic standards. Markets for ‘in conversion’ status may require careful assessment as premiums can be lower than for full ‘organic’ certification.

Coexistence with, and protection of the environment

Maintaining biological diversity on and around the farm is an important feature of organic systems. Biological diversity tends to allow ecological balance or equilibrium to establish, resulting in a more stable system with less dramatic biological fluctuations - both on the farm and in the surrounding natural environment. Areas of remnant vegetation should be protected. In addition, organic farms should ensure the avoidance of pollution and other forms of degradation resulting from agricultural practices. The use of non-renewable resources should be minimised.

Storage and processed products

To prevent contamination of grain on-farm, clean down procedures may be required for contractors' equipment such as harvesters, trucks and storage silos. Sealed steel silo gassed with CO_2 is the most common method of grain storage.

Where growers intend to value add or process wheat into flour, premix or a finished product, compliance with organic processing standards is require if the final product is to be labelled certified organic.

5.4 Production strategies and methods - organic wheat

This section provides a general outline of the various management strategies and techniques used by organic wheat growers. Conversion from a conventional system to an organic system is likely to involve changes to existing management and the adoption of some of the following strategies and techniques.

Wheat production using conventional methods tends to rely upon the use of external inputs in the form of artificial fertilisers and synthetic herbicides, pesticides and fungicides to achieve acceptable productivity. In contrast, organic wheat production attempts to farm within a closed system, relying more on management techniques, biological processes and renewable resources to maintain acceptable productivity.

The thought of producing a crop of wheat without the use of herbicides or fertilisers often seems completely unrealistic to conventional growers. Many organic growers can confirm the difficulty they had in convincing themselves to put in a wheat crop without the use of conventional inputs. Yet over time, most organic growers establish a production system that allows them to produce reliable crops of organic wheat with acceptable yields as part of their whole farming system.

The major changes conventional farmers may need to consider when converting to an organic production system relate to the following general areas:

- Whole farm planning
- Rotations
- Soil fertility and nutrient inputs
- Animals
- Weed management
- Pest and disease control

Whole farm planning

Good organic farming, like any other good farming, requires a whole-farm approach. Management of soil fertility, weeds, pests, cropping and animals are not considered in isolation but rather as interrelated aspects of the whole farm, where each decision can benefit or harm other management strategies.

Whole farm planning can involve the physical layout and resources of the property as well as the management system to be used. For example, weed control to prepare a paddock for cropping may require intensive grazing pressure. Effective grazing pressure may not be possible on large paddocks. Additional fencing, realignment, or electric fencing, may be required. Realignment can be designed to follow soil types thereby improving land usage. Smaller paddocks may allow rotational grazing which can be used to control internal parasites

and improve pasture use and soil structure. With whole farm planning, a weed control strategy may be designed to improve pasture utilisation, parasite control, soil structure and land usage.

Other aspect of whole farm planning can involve water management and the use of contour banks to direct or store surface water.

A well thought out whole farm plan that projects 5-10 years into the future is an important first step towards establishing an organic wheat production system. Aspects for consideration can include the following:

- Enterprise activities.
- Financial projections, especially during conversion period.
- Organic conversion progression plans.
- Farm layout and fencing.
- Water management plans and contour tillage.
- Shelter belts, biodiversity and remnant vegetation protection.
- Cropping rotational plans.
- Capital equipment changes.
- Integration of operations and strategic alliances.

Many successful organic farms adopt a gradual conversion approach, as a risk management strategy. As experience and management expertise develops, more of the property can be converted to an organic system.

A good farm plan should devote special attention to the first 3 years of transition from conventional to organic management - when markets for 'in conversion' product may be uncertain and practical experience is being developed. Details of the progressive changes intended to soils, pasture and animal husbandry will be helpful in order to develop a smooth conversion towards a profitable, productive and sustainable organic system.

Strategic alliances with other organic growers, processors or traders can be very important in defining enterprise mix and production levels.

Rotations

A well designed crop rotational system is critical to the success of organic wheat production. Good crop rotations can serve many functions including:

- maintenance of soil physical, chemical and biological condition;
- assist weed, pest and disease control;
- management of soil moisture levels;
- allow pasture improvement;
- diversify income sources.

Organic standards may limit crop rotation to no crop of the same species, family or characteristics to be planted more than two years out of five in a given paddock. The rotation

typically should include at least a 12 month ley pasture phase that contains at least one legume species.

Actual rotations used by organic growers vary from farm to farm. Growers typically may crop on average around one third of the property each season depending on seasonal conditions, soil conditions, weed burden, markets and other considerations. The simplest rotation for wheat production often follows the cycle:

Pasture>Pasture>Wheat>Pasture> Pasture>Wheat

On occasions and depending on soil condition, two or more crops may be grown in succession following the pasture phase, giving a rotation as follows:

Pasture>Pasture>Wheat>Barley>Pasture> Pasture>

or

Pasture>Pasture (green manure)>Wheat>Oats>Pasture>Pasture

or, a more complex rotation may be:

Pasture(vetch or medic hay)>pasture>wheat>chickpeas>fallow>wheat>

The duration of the pasture phase may be longer on light soil where rebuilding soil fertility can be slower. Some growers follow pasture species as an indicator of soil fertility conditions. Declining legumes in pasture and a build up of grasses indicates time for cropping. Some growers aim to turn in a pasture as a green manure at least once every five to seven years.

Growers can remain very flexible in deciding what rotational crops (in addition to wheat) are to be planted, with the final decision based on markets, seasonal conditions, soil or land suitability and other circumstantial factors. Flexibility in cropping ability allows growers to take advantage of opportunities as they arise.

Soil fertility and nutrient inputs

Optimal management of soil resources in organic farming requires a balance of not only the chemical (nutrient) status of a soil, but equally importantly, its biological and physical condition. Maintenance of soil fertility over the long term is a key management objective of sustainable organic wheat production. Soil fertility in organic systems is based on nurturing and maintaining active soil biological activity during the growing season.

Adequate levels of soil organic matter provide the energy for soil biology to perform the essential functions of decomposition, transformation and mineralisation necessary for soil structural development and nutrient availability. Soil chemical imbalance and mineral nutrient deficiency are corrected by applying permitted nutrient inputs. These generally require microbial mineralisation to become available for plant use.

The development and maintenance of good soil structure is critical in allowing plant roots to extend deep into the soil and exploit a large volume of soil for moisture and nutrients.

Soil fertility status typically follows a cycle of progressive improvement during a pasture phase then decline at cropping. Sustainable organic management requires the improvement

phase to at least raise fertility sufficient for the next crop such that over time the average fertility does not decline.

Methods used by organic growers to maintain soil fertility include the following:

- Crop rotation
- Pasture phases with legume species
- Rotational grazing
- Pasture topping
- Green manuring
- Deep ripping
- Minimal cultivation
- Biological inoculation
- Soil amendments; and
- Nutrient inputs

Crop rotations

Crop rotations that involve a pasture ley phase are used to allow soil to recover lost fertility from previous cropping activities, particularly relating to organic matter levels and soil structure decline. A well planned crop rotation may also involve successive crops that have different root structure and nutrient requirements, thereby exploiting soil resources still remaining after the first crop. A strong legume-based pasture is usually very important to rebuild soil nitrogen levels. The use of legume crops in the rotation such as lupins, field peas, faba beans or chickpeas can be useful in managing soil fertility, particularly nitrogen levels.

Pasture phase

Under-sowing a wheat crop with a legume can be used to give the pasture phase a head start in order to establish a good nitrogen fixing pasture the following year. Excessive shading of the under-sown species can be a problem with some wheat varieties, but establishment can be good under oats, triticale or barley. Alternatively, a mixed sowing of clovers, oats and other feed species after cropping can provide quality feed while establishing a good clover-based pasture the following years. Clover stands are reported to often last only 2-3 years before grasses begin to dominate, indicating sufficient soil nitrogen build-up for crop production.

Grazing

Animal grazing can be used to manage pasture development. Controlling grasses is important to allow less vigorous and low growing legumes to dominate. Well controlled grazing events can stimulate fresh pasture growth and root development, thereby increasing soil organic matter and soil structure. Animal manure can improve soil fertility and maintains the natural cycling of carbon and nutrients.

Pasture topping and green manuring

Mechanical pasture topping (mowing) is primarily used for weed control, however green pasture residue contains quantities of nitrogen and other nutrients. Green pasture cut while

soils remain moist enough to support biological activity, can be decomposed rapidly thereby adding organic matter, nitrogen and other nutrients to the soil.

Ploughing in a pasture or cover crop as a green manure is another important method of improving soil organic matter and nutrient status. Green manure crops can include a range of species designed to perform specific functions; for example, legumes for nitrogen fixation and grasses for biomass (organic matter) accumulation. Late germinating weeds such as radish, wireweed and capeweed can be ploughed in towards the end of winter. Over-sowing at the same time with oats or barley can protect the soil from summer exposure and prevent wind or water erosion. Two principal green manure crops used by some growers in summer rainfall areas are fenugreek in winter and celera mung beans in summer. The fast growing fenugreek is reported to yield 95 kg/ha of nitrogen when ploughed back into the soil.

Cultivation

Soil cultivation requires extremely careful management. Disturbing the soil, either with a disc plough, scarifier, harrows or even a deep ripper, can have a dramatic stimulating effect on soil biological activity. The resulting flush of soil biological activity consumes soil organic matter as its main source of energy. Repeated cultivation or soil disturbance can rapidly deplete soil organic matter levels resulting in biological decline, nutrient depletion and poor soil structure. Excessive cultivation can also physically destroy soil structure, particularly if soil conditions are too wet or cultivation speed is too fast.

Wherever possible, especially on sites prone to water erosion, cultivation should follow the contour - preferably in conjunction with appropriate contour banks.

Deep ripping

The formation of hard pans below plough depth is a common problem in conventional wheat production. Hard pans restrict plant root depth and the volume of soil plant roots can exploit. Organic growers cannot use highly soluble fertilisers that are necessary to compensate for a small root mass exploiting a small volume of soil. Deep ripping at progressively deeper settings, in accordance with the depth of soil biological development, can be used to remedy hard pan problems and increase the depth of biological activity and soil structure. Application of gypsum in conjunction with deep ripping can assist soil structure development particularly where deflocculated clays are a problem.

Balanced soil chemistry

Organic wheat producers require a good understanding of a soil's chemical condition and remedies that may be applied. Soil tests are used to monitor changes to soil chemistry and confirm suspected imbalances. Many soils may be naturally deficient in major elements or trace elements particularly copper, zinc, manganese and molybdenum. Apart from consideration of the major nutrients, N, P and K, the elements Ca and Mg are often given great importance for their influence on nutrient availability and soil biological activity.

Nutrient inputs

A wide range of soil input materials are now available for use by organic wheat growers. Various naturally occurring soil amendments commonly used by conventional farmers such as lime, dolomite, gypsum and other minerals, are also used by organic growers to balance deficient soils. In addition, a number of biological preparations can be used to inoculate soils with beneficial soil organisms. Various sources of major nutrients; such as formulations

containing acceptable forms of reactive phosphate rock, potassium, magnesium and trace elements; can be used where a demonstrated deficiency exists. Other inputs can include fish emulsion, rock dust, seaweed and humate type organic fertilisers. However, organic standards in general do not permit reliance on large quantities of applied nutrients to compensate for a poorly managed soil fertility system.

Soil tests can be important to monitor soil fertility balance over time and assess any corrective amendments required. A range of different approaches to soil analysis have gained prominence among organic growers. These include interpretations based on Dr William Albrecht, Dr Carey Reams and Dr Rudolf Steiner - see Appendix 3 for a brief overview.

Total nutrient removed for every 2 t/ha of wheat are approximately as follows:

42 kg Nitrogen

9 kg Phosphorus

10 kg Potassium

2.5 kg Sulphur

Nitrogen and organic matter

Organic farms rely mainly on legume nitrogen fixation as their main nitrogen (N) input. Maximising nitrogen fixation in legumes and minimising losses of nitrogen by leaching is crucial.

The majority of nitrogen in the soil is in organic form, which is not available to the plant until it is mineralised to produce inorganic forms; that is, as ammonium and nitrate. Organic matter varies in its N content and its ease of mineralisation. Recent crop or pasture residues are readily mineralised, whereas older more stable organic matter is mineralised slowly. Mineralisation continues throughout the growing season at a rate which varies with temperature and soil moisture. Soil cultivation stimulates N mineralisation.

The N released from five per cent soil organic matter can provide about 110 kg/ha of nitrogen.

Organic production prohibits the use of conventional sources of applied N such as Urea, ammonium nitrate or Agran, ammonium sulphate, Agras No. 1, Agras No. 2 and Di-ammonium phosphate or DAP.

Generally organic growers do not apply additional N fertiliser. Instead they rely on sufficient build up of soil N through the use of pasture legumes, organic matter accumulation and, to a lesser extent, legume crops. Several years of pasture with a strong base of nitrogen fixing legume pasture species - such as clovers, medics, serradella or lucerne - is the main method of raising soil nitrogen levels sufficient for successful wheat production. Ploughing in a legume-based green manure crop can contribute significant amounts of soil nitrogen.

Nitrogen accumulation is greatest in soils with initially low nitrate levels. As soils become more fertile, N increase becomes progressively less. Some growers report that as soil N levels increase grass species begin to dominate the pasture, indicating the paddock is ready for cropping again.

A range of nitrogen sources permitted for organic systems are listed in Appendix 2.

Phosphorous

Phosphorous (P) supply and plant availability are very important in early plant growth. A deficieny reduces head and grain numbers, which are established early in the crop.

The movement of P tends to be fairly limited within the soil (although can leach through sandy soil), so plant uptake generally requires root growth to intercept pockets of available P. Improvements to soil structure that allow greater penetration of root mass through larger volumes of soil may assist P uptake.

Phosphorous levels and availability are considered important issues for many growers, particularly on alkaline soils where P release from rock phosphate can be very slow (resulting in yield declines and poor stands of legumes).

Many organic growers have reported not applying additional P to paddocks for a number of years. In the short term, P availability to plants may be utilising residual soil P pools from past superphosphate applications, mineralised by improved soil biological activity and extracted by a larger root mass resulting from improved soil structure.

In the longer term, growers expect applications of some form of phosphorous may be required to maintain soil P levels. In contrast, a few growers contend that P levels will be naturally maintained via a process referred to as 'transmutation of elements' whereby certain elements transform into other elements. However, research suggests that P levels on organic land tend to decline without addition of some P source.

For organic growers, application of soluble P fertilisers such as superphosphate or DAP is not permitted. For organic production, less soluble forms of phosphorus such as reactive phosphate rock (RPR) or guano can be applied pre-planting. The role of soil biological activity is particularly important in mineralising this phosphorus to plant available forms retained in the soil biomass. The effectiveness of RPR is enhanced by applying as a fine powder that is well distributed in the soil. The lag time for applied RPR to become available for plant uptake may require application well before cropping.

A range of formulated organic fertilisers, incorporating various forms of naturally occurring P such as RPR, apatite, and guano, have differing levels of solubility. However, other soil conditions such as pH and Iron or Aluminium binding can affect P release to plants. These fertilisers are permitted for use on a restricted basis. All sources of phosphorous must not contain high levels of cadmium. Typically rock phosphate contains negligible amounts of sulfur (unlike superphosphate), so in sulphur deficient soil a separate source of sulfur, possibly gypsum, may be required.

Potassium

Potassium leaches easily through sandy soils. On soils with high organic matter and humus content less potass0ium may be lost through leaching. Sources of potassium permitted under organic production include rock dust, basic slag, wood ash, sulphate of potash and langbeinite.

Calcium

Conventional growers often satisfy calcium requirements via the use of superphosphate (contains about 20 per cent calcium) or lime. Calcium can be applied to raise soil pH.

Acceptable sources of calcium for organic production are limestone, dolomite and gypsum. Builders lime (quick lime) and calcium nitrate are not permitted.

The role of calcium, and its proportion to magnesium and other cations, is considered very important in soil biological processes and nutrient availability by an increasing number of organic growers. These claims are generally based on Albrect principles (see Appendix 3) of plant nutrition, where the ratio of major cations on sandy soils should be Ca 60 per cent to Mg 20 per cent or on heavy soils Ca 70 per cent to Mg 10 per cent.

Trace elements

Soils for wheat production can be naturally deficient in a number of important trace elements particularly Copper, Zinc, Manganese and Molybdenum. Deficiencies can be corrected using a trace element mix with permitted forms of the elements such as copper sulphate or zinc oxide.

Animals

The role of animals is often seen as fundamental in a sustainable organic farming system. For wheat production, livestock (usually sheep) are commonly viewed as a vital part of the management system. Animals are typically integrated into the whole farming system not only as an enterprise in their own right, but also used as an important management tool for soil fertility building, pasture management and weed control. Animals are also considered as having an important function in energy, carbon and nutrient cycling, particularly during the dry season when soil biological activity is dormant.

Animal grazing is managed by some growers using a high intensity/short duration rotational grazing strategy based on reduced paddock size. Close management of grazing pressure can give good weed control at critical periods when preparing a paddock for cropping.

Weed management

Weed control without herbicides often seems an impossible achievement to conventional growers with farming systems reliant on herbicide use. However, organic wheat growers can successfully control weeds by means of an integrated approach followed over several years, involving some of the following strategies:

- Soil improvement
- Crop rotation
- Pasture topping, hay making
- Green manure
- Animal grazing
- Flame or steam
- Cultivation
- Varieties and seeding rates
- Harrows

Soil improvement is often cited as one of the most important influences on weed problems. The spectrum of weeds is reported to change as soil conditions change. Where problem soils

exist, not only can weeds flourish, but preferred pasture species or crops often do poorly, unable to compete with weed growth. Specific weeds are reported to be indicators of certain soil conditions. For example, cape weed problems are often associated with acid soils; onion grass can be found on hard tight soil; and sea barley grass may indicate slightly saline soil.

Another belief is that, soils low in a certain element attract weeds that accumulate that element. For example, legumes may do better than grasses in low N soils but as N levels rise grasses tend to dominate.

Typical soil improvements include the use of amendments such as lime to adjust soil pH and gypsum to assist soil structural improvement with resulting impact on pasture composition.

A pasture phase in the **rotation plan** for a paddock provides various opportunities for weed control activities prior to cropping. Improving pasture species, by under-sowing crops or pasture seeding after cropping, can be used to compete with weeds or change the dominance of certain problem weeds. In addition, certain crops may provide a beneficial impact on control of certain weeds in the following crop; for example, barley or canola can be suppressive.

Pasture topping with a mower can be used to prevent seed formation and thus reduce the build-up of weed seeds in soil. Pasture topping becomes useful when excess pasture growth cannot be controlled by grazing or used for hay making.

One grower reports that **cutting hay** is the most effective weed control. If a pasture is a good clean stand of legumes, then many cropping options are possible. However, if there are a lot of grasses in a pasture, hay is cut to get control of the weeds again. Cutting hay ensures that no weed seed is set that year, so the most weed susceptible crop is sown following hay as the starting point in a rotation.

Green manure crops are ploughed into the soil just prior to flowering, thereby preventing seed formation. Subsequent new weed germination is typically late in the season when soil conditions are drying and growth can be more easily controlled with grazing.

Animal grazing can play an integral part in weed control. Controlled grazing pressure can be used to manage pasture species dominance before cropping. For example, low growing clovers give better coverage when taller growing species are grazed down. Animals can be used to graze down pastures prior to flowering as a means of reducing weed seed set. Several seasons of good grazing management can reduce weed burdens. If a paddock is to go into cropping next season, heavy grazing pressure can be applied to clean out weeds, leaving the paddock with just enough cover to protect the soil from erosion. Sheep have also been used to graze within a crop to reduce weed burden and are reported to enhance stooling. Higher density planting and grazing just before tillering, to prevent crop plants being pulled from the soil, are considered important factors in addition to careful management of grazing pressure.

Hand pulling and flame weeders are used for small patches or spot weed control to prevent weed spread. **Thermal weed control** methods are being investigated as a possible alternative for broadacre application. Gas powered flame systems may provide economical control, however such systems are still being developed.

Soil cultivation is one of the last weed control methods used after the above weed prevention and reduction strategies have been applied. Soil cultivation must be kept to a minimum. The

number and frequency of cultivations can have a direct and immediate impact on reducing gains in soil organic matter, nutrient status and soil structure. Weed growth from summer rains may be controlled using wide point scarifiers if fallowing to conserve moisture is required. Disc plough cultivation is often used to 'work up' land following opening rains to kill first germination. The second germination is killed by the cultivation involved with seeding. A well managed weed control system may require only two cultivations. However, timing of operations is critical for effective weed kill. Sunny, windy days when disturbed roots and soil dry quickly give best results.

Additional cultivations may be required where weed control is poor - but at the expense of deteriorating soil fertility. Prickle harrows have been used within a young wheat crop where post-emergent weeds are an economic problem. Another alternative used is to run sheep in a young crop to clean out weeds such as wild radish. Close management and careful timing are required for good results.

Selection of suitable **wheat varieties** can also assist in reducing the impact of weeds. The main factors appear to be differences in shoot and root growth and crop ground cover. South Australian trials showed Halberd and Excalibur did best, and in Western Australia, Gutha and Eradu were most effective. Choosing a competitive variety is most likely to be useful when combined with other techniques such as increased crop density and delayed sowing to reduce early weed competition. Short season varieties may be useful if weed management requires a late planting. Fast growing varieties that have an early spreading habit may help out-compete weed growth.

Seeding rate may need to be increased for organic production to ensure good early coverage. Organically grown wheat can exhibit slightly slower early growth rates than conventionally grown wheat. If prickle harrows are to be used over a young crop then higher seeding rates may be required to compensate for harrow losses. Seeding rates as high as 150-200 plants/m^2 have been shown in conventional crops to be about the upper limit before yield declines. One grower reported using seeding rates at twice the district average, with narrow tine spacing and the seeding boot modified with deflector plates to spread the seed across the furrow. The aim is to get an even spread of seed across the paddock and help out-compete weeds.

Preventative removal of weed seeds at harvest will also successfully reduce weed populations in future years.

A range of bioherbicides involving fungi, bacteria and other micro-organisms are being developed as a means of controlling weed plants.

Overall, weed control in organic production requires long term management based on an integrated approach that uses a range of strategies and techniques. Good timing of operations is critical for effectiveness. Cultivation as a means of controlling weeds depletes soil fertility and should be kept to a minimum. The aim is not to achieve a completely weed free wheat crop but to manage weeds within an economic threshold.

Pest and disease control

Many growers report few pest or disease problems in organic wheat production. Incidence of common pests and disease may be found in organic wheat crops but at levels that generally do not concern growers and that do not warrant expenditure on specific treatment.

The generally low importance organic wheat producers give to pest and disease problems may derive from a number of management strategies that combine to contribute to the prevention of pest and disease problems. These include the following:

- Resistant varieties.
- Soil fertility balance.
- Crop rotation and Bio-fumigant crops.
- Ecological cycles and beneficial predators.
- Biological control agents and other acceptable substances.

Wheat **varieties** known to be resistant to pest or disease problems are an obvious first choice as a preventative measure. The susceptibility or resistance of different wheat varieties is generally well known when grown under conventional farming systems, however their performance has not been well studied under organic farming systems.

The effect of **soil conditions** on plant growth is considered a crucial factor in plant susceptibility or resilience to pest and disease attack. Poor plant growth or imbalanced growth (due to soil conditions) can make plants less resilient and more susceptible to pest and disease attack. In addition, soil with good biological activity can provide a level of biological control over soil borne pests or disease. The organic farmers' dictum - 'healthy soil produces healthy plants'- may explain why organic wheat growers tend to report very few serious pest or disease problems.

Crop rotation is used by organic and conventional growers alike to provide a break in disease cycles. Certain crops or green manure species known to suppress target pests or disease can be included in the rotation. For example, brassica crops such as canola can decrease the severity of some wheat diseases like Take-all. Pasture management to control tall grass species and encourage legumes can also reduce some pests and diseases of wheat. For example, cut worm problems can be more severe with excessive pasture residue prior to cropping.

The avoidance of herbicides, pesticides and some fertilisers may also contribute to **biological diversity** and better **ecological balance** of pests and diseases. Understanding of the biological cycles for specific pests or diseases, as well as their place in the general ecological cycles of the farm and surrounding district, is essential knowledge when considering control measures. Organic farms typically become biologically very diverse, allowing a range of natural biological control cycles to develop thereby maintaining many pests or diseases at acceptably low levels.

Biological diversity can be enhanced by use of shelter belts, mixed species in pastures (including attractant species) and maintaining habitats for beneficial populations to persist. The non-use of pesticides, particularly wide spectrum substances that kill a range of non-target creatures, also enhances biodiversity and allows beneficial insects, spiders and other creatures to proliferate.

Outbreaks of major pest or disease problems usually indicate an imbalance exists and efforts should be directed at correcting the imbalance. However, an increasing range of biological control agents and other acceptable substances are being developed that may be applied where preventative strategies fail to provide economic control.

For example *RLEM (Redlegged Earth Mites)* can be a problem in leguminous pastures. Predatory mites are available and can be introduced - although their rate of spread is slow so introductions may need to be over a wide area. Applying lime to raise the pH in acid soil is reported to reduce RLEM severity. Neem oil based product with pyrethrum has been reported to control RLEM in horticultural situations - however growers must ensure products are registered for use.

Cut worm damage is reported to be related to pasture management problems. Excessive grass pasture coverage prior to cropping is believed to benefit the pest, causing a more severe problem in the following cropping year. Close management of pasture grasses prior to cropping can minimise cutworm problems.

The major wheat leaf diseases including *septoria nodorum blotch*, *yellow spot* and *septoria tritici blotch* typically cause few problems for organic growers. Later sowing and less luxurious plant growth may account for the low impact of the diseases. Likewise the reported low incidence of *take-all* root disease may be due to long rotations and good host grass management in pastures.

Preventative measures for control of cereal rusts such as *Stripe rust*, *Leaf rust* and *Stem rust* include; good pasture management and close grazing to minimise host plants providing a 'green bridge' to carry the fungus over summer; use resistant varieties especially following wet summers and high carry over of fungal spores; and avoid early sown crops that can carry rust through winter allowing rapid development in spring.

Grain storage

On-farm grain storage may need to be considered, particularly given that organic grain is often sold outside of the storage and distribution systems used for conventional grain and separate storage for organic grain may not be available.

The preferred method of storage is in sealed silos gassed with carbon dioxide.

5.5 Organic wheat production system

This section gives a general example of an organic wheat production system for consideration. Variations should be applied to suit individual farm conditions and circumstances.

Preparing the land

Establishing soil conditions with a balanced nutrient status, adequate organic matter, extensive biological activity and good deep structure, is the most important task for good organic wheat production. Badly degraded soils can take some time to transform sufficiently to produce acceptable yields and quality. Generally, lighter soils are slower to recover than heavier soils.

Preparing a paddock for organic wheat production can be considered as a cycle of events beginning with the last wheat crop. Under-sowing the last wheat crop with clover can be considered as the first step in preparing for the next wheat crop. The under-sown clover is used to provide sufficient seed for a good clover-based pasture to establish the next season. Over several years a good legume-based pasture should accumulate sufficient soil nitrogen for the next wheat crop. At least 2 years of strong clover-based pasture (or other nitrogen fixing

legume) is likely to be required. A longer pasture phase is likely to be required on light soils in order to maintain long term sustainable soil fertility levels.

The pasture phase can be used for the following purposes:

- Build-up the biological, physical and chemical components of soil fertility.
- Control weeds; and
- Control pest and disease.

If clover regeneration in pasture is likely to be poor after cropping, then clover may be directly sown at the start of the first pasture season. The cost:benefit of sowing clover seed as a separate operation may be improved by adding other desirable pasture species to the seed mix to increase pasture feed quality or gain other benefits. For example, oats, peas and vetch for feed; or possibly lucerne or other perennials if water balance requires management.

Pasture management becomes very important over the years prior to cropping if weed control benefits are to be effective. Animal grazing is an obvious way of managing pasture growth. Fencing to soil type or productive unit is very important to enable heavy grazing on better soils without exposing poorer soils to erosion risk. Electric fencing to reduce paddock size can allow intensive grazing; using high stocking rates for a short duration. Newly shorn sheep quickly learn to avoid the electric fences. Mobs in the order of 3000 head in a 50 acre strip for several days have been used with good effect. The extra management required to move stock frequently can be reduced by fencing to a laneway system. One grower reported using three pet leader sheep that would come when called, to lead a big mob into a new paddock.

A high impact/short duration rotational grazing system can offer the following benefits:

- Provide more effective grazing pressure.
- Achieve better pasture and weed control.
- Leave a paddock maximum time for soil to recover from grazing and compaction pressure; and
- Allow stock parasite cycles to be broken.

Grazing pressure is often insufficient to manage pastures over an entire property, particularly during the spring flush. Mechanical pasture topping can be used just prior to flowering as a means of reducing weed seed set and contributing to soil organic matter accumulation.

The first pasture year can be used to establish a strong clover (or other nitrogen fixing legumes) base and generate biomass to replenish soil organic matter reserves. Pasture should be used to maximise pasture legume growth and reduce grass and weed growth and seed set. Grazing and pasture topping can be used to manage pasture species and prevent weed seed set.

Soil tests may be taken to monitor changes in soil conditions and guide decisions regarding the fertility status of the soil and the need for **soil amendments**. A number of alternative approaches are being used to interpret soil test results. Appendix 3 outlines several of these concepts for consideration.

Additional years of pasture may be required if soil fertility remains low, weed control is poor or disease control is inadequate. Minimising weed seed set is extremely important.

The final pasture year can be used to apply soil amendments and bring soil fertility into balance. Where hard pans exist or soil structure and biological activity is shallow, **deep ripping** (at a depth of about 10-15 cm below existing activity) can accelerate the development of deeper fertility. The depth of ripping can be progressively increased over time in accordance with the depth of soil biological development. Deep ripping is likely to be most effective when soil is still dry enough to cause cracking or fracturing to extend between tines, thereby allow biological activity to penetrate. Ripping when soil is too wet can cause smearing and must be avoided. Prior to ripping, soil amendments such as lime, dolomite, gypsum, reactive phosphate rock and other minerals may be spread to get some soil penetration benefit from the ripping operation. Application of soil biological inoculants is used by some growers to assist soil biological activity. Application is often early in the season when soils are moist but while some soil warmth remains. Examples include formulations such as SC27 or Bio 3/20 microbes (sometimes applied with sugar as an energy source) or stimulants such as biodynamic preparation 500.

Good **weed management** is very important in the final pasture year. Intensive short duration grazing pressure, pasture topping and possibly ploughing-in pasture as a green manure can be used to control weeds. Turning in a pasture just prior to flowering stage can provide additional organic matter, nitrogen and other nutrients to the soil. This cultivation can also be used as an alternative opportunity to incorporate various soil amendments at a time when the decomposition of the **green manure** can assist in mineralising the applied amendments.

Alternatively, at the end of the pasture phase, the stand can be cut for hay or grazed very hard or sometimes both, then left until there is a germination of seed before cultivating with a scarifier.

Grazing management can be used to control weed re-growth due to late spring or summer rains. The benefits of summer scarifying for weed control or fallowing for water conservation must be carefully considered against the cost of reductions in soil organic matter levels and increased risk of soil erosion.

Longer pasture phases and less cultivation increases soil root mass and lowers the erosion risk associated with leaving soils bare, compared to short pasture phases and more cultivation. Importantly, once land has been grazed down for cropping, animals must be removed to prevent surface powdering from stock traffic (which increases erosion risk).

Paddocks well prepared for cropping should have a low weed burden with minimal cover sufficient to protect the soil from erosion. Soil amendments will have begun mineralising and nutrient build-up should have reached adequate levels. Soil biological activity should have rebuilt good soil structure to greater depth. Pest and disease cycles should have been broken.

Sowing a wheat crop

Wheat varieties that will perform well under organic production require consideration. New wheat varieties are often selected to perform with high input of chemicals and fertilisers. Older varieties, bred to perform with less chemicals and fertilisers, may have better root systems with more feeder roots and generally more vigour and stronger emergence.

Apart from market requirements, varieties with good vigour under organically prepared soil conditions, pest and disease resistance, quick growth, good coverage and are well equipped to handle a degree of weed competition are best. Due to the reliance on cultivation for pre-planting weed control, medium to short season varieties are likely to be more suitable to achieve optimal flowering time.

Optimal seeding rates for organic wheat are not known. The relatively low cost of seed and generally little impact of high seeding rates (up to 150-200 plants/m^2) on reducing yield, suggests that dense plantings may be useful to give better weed competition. However, very high plant populations may cause small grain and high screenings in very dry years especially for small grain varieties; although low rainfall at grain filling and potassium deficiency are the more likely causes of small grain screenings.

Following the opening rains and a good weed germination, under ideal conditions where previous weed control has been good, some growers report the crop can be sown without working up by using a combine set-up to give a good weed kill. Timing is the key for effective weed kill. However, more often a paddock may first be worked up with disc ploughs or scarifiers following the opening rains and good weed germination. Effective weed control is far more likely if weather conditions are dry and windy.

Very wet soils compact easily so cultivation at the correct soil moisture level is very important to avoid compaction. Excessive cultivation speed can pulverise soil structure and must be avoided.

A good second germination generally signals the time for sowing, provided adequate earlier weed control has been achieved. The seeder should be set-up to give an effective weed kill. A prickle harrow chain can be run behind the seeder to give additional weed kill and flatten any ridges left by the cultivator or seeder. This helps reduce evaporation by minimising the soil surface area. If required, the crop can be under-sown to clover. Where soil nutrient deficiencies remain, acceptable nutrient inputs such as pelletised or granular formulations may be drilled at seeding. Press wheels or rollers can be used to assist good crop germination and have been reported to possibly limit some weed germination. An additional pass with heavy harrows or prickle harrows after seeding, but before crop emergence, can be used to kill weeds that survive the sowing pass or have newly germinated.

Crop development may progress at a different rate than under a conventional system. Early growth can be slower, although the difference becomes less noticeable over time. As soil structure improves growers report that crops are ‘holding better in dry spells and finishing later, which means they continue growing longer before maturing’. The crop is unlikely to be weed free, but if effective weed control was achieved prior to seeding the weed burden is not likely to be an economic problem. Excessive weeds in young crops have been controlled with the use of prickle harrows or carefully managed grazing with sheep.

Pest and disease problems are generally reported to be minor and growers generally report that treatment is rarely justified. In some instances a pest outbreak such as mites will appear, but often farmers allow these to run their course without noticeable impact on the crop. In extreme events a range of allowable pest or disease control substances are available for use.

5.6 Areas for future research

Research into the following areas would be useful:

Weed control - strategies and methods

- Soil conditions related to specific weed spread or control.
- Optimal economics for pasture topping or green manuring.
- Rotational effects on weeds.
- Pasture species mix for weed management, smother crops.
- Antagonistic allopathic plants for specific weed repression.
- Duration of pasture - effect on weed burden and changes to weed species and populations.
- Optimal timing for cultivation operations, weed density and climate conditions.
- Effects of minimal disturbance, shallow cultivation, night cultivation.
- Harrows, pre-emergence.
- Harrows or grazing, post-emergence.
- Rollers and weed emergence.
- Flame and thermal weeding.
- Bioherbicides.
- Specific problem weeds, e.g. double gees.

Soil fertility maintenance

- Optimal levels for soil energy/carbon, humus, nutrient balance.
- Ways to enhance fertility building phase via pastures, pasture mixes, crop mixes. Plant species for accumulating specific elements especially N, P and K and improving soil structure, biomass accumulation and pH change.
- Application, rates and timing of soil amendments, green manure, cultivation/incorporation, deep ripping for optimal effectiveness.
- Green manure species and cost:benefits.
- Rotational effects of different species on soil conditions, weeds and pest and disease.
- Soil biological processes, enhancement and management - inoculants, biomass fluxes and nutrient flows and plant availability.
- Crop Nutrition; use of organic fertilisers, especially P, to obtain yields comparable to conventional. Phosphorous supply and availability especially in alkaline soils.

Wheat varieties

- For early growth and spreading habit for weed suppression.
- Short season, late sown for optimal flowering time and yield.
- High yields under organic conditions - nutrient pools and availability or release rates.

Seeding rates

- Optimal rates for yield, weed control and pest/disease management
- When harrow/scarifying or grazing after emergence.
- Moisture, soil nutrient status and other seasonal conditions.

Other areas identified by growers include:

- lice control in sheep using Neem based products;
- high protein yields under organic systems;
- strip cropping or mixed cropping possibilities;
- RLEM control in legume pastures.

5.7 Selected references

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6. Grapes and Wine - Organic Production Guidelines

By Gerry Parlevliet,
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This report is based on personal interviews with organic grape growers and industry people, particularly Lyn Serventy, Leigh Verral, David Bruer, Wendy Allen, Alex Sas, John Elliott and Stewart Learmonth. It also relies on articles published in Acres Australia by various authors but in particular Tim Marshall. There are also many references from other journals and web-sites. The comments by the many participants in a series of seminars around Australia also contributed. Thank you all.

6.1 Overview

This report outlines the market trends in the organic wine industry. It goes on to discuss and define organic and biodynamic production. It also highlights the National Standards adopted by the organic industry.

Several ways of achieving organic status are illustrated. They include:

- starting from a conventional existing vineyard and converting;
- starting a new vineyard using conventional means to help with early establishment; and
- the main preference of using organic principles from the beginning of establishment.

Location and establishment are discussed, based on grower experience. Selection of low vigour sites in dry climates is suggested. Choice of trellis and pruning styles to ensure exposure to sunlight and to enable good airflow is stressed.

Nutrient management is complex and relies on compost, cover crops and natural compounds.

Disease control revolves around location, exposure to light, good air-flow and the use of copper and sulphur.

Yields reported range from 3 tonne/hectare to 18 tonne/hectare. Yield depends on age, location, production system and variety and can compare favourably with conventional production systems. However, yields are generally lower for organic producers.

6.2 Introduction - Australia as a source of organic wine

Australia is well suited to organic viticulture and organic wine production.

Many of our viticulture districts are in areas where grapes grow and ripen in a dry climate and disease control is relatively easy. We do not have some of the diseases and pests that plague grape production in other countries.

Our horticultural products already have a ‘clean, green’ image overseas and we have a well established export wine industry. Australian wines are highly regarded throughout the world. Organic wines should be able to share this reputation.

Organic wine producers are located in most major wine making areas. Several larger wine companies have their own organic brands or are testing organic systems on parts of their vineyards.

There is a core of experienced organic growers who are willing to share their knowledge and experience and we have several organisations which advise on organic production and can certify vineyards and wine as organically produced.

For export purposes the certification is backed-up by the Australian Quarantine and Inspection Service (AQIS). AQIS provides Australian Government audit of the certifiers.

The Organic Vignerons Association of Australia Inc reported in August 1999 that it had 20 certified producers on 24 properties, with a total of 124 hectares of vines. The 1999 vintage included 432 tonnes of grapes certified and 33,108 litres of wine certified.

Other organic certifiers have also certified grape and wine production. Significant amounts of wine made from organic certified grapes are not sold as certified wine.

6.3 Market trends

World interest in organic agricultural products

Rapidly growing numbers of people, especially in the developed world, are seeking organically grown foods, and organic products have become well established in many markets.

World trade in organic products is estimated at US$11 billion (1997) and growing at the rate of 20 per cent a year. It is projected to reach US$100 billion by the year 2006.

Major markets are the USA, Europe and Japan. The Australian market for organic products is also growing rapidly. The industry is valued at $200-250 million with exports of $30-50 million. Annual growth is estimated as 10-20 per cent.

The world market has been analysed in a report by Agriculture Western Australia for the Rural Industry Research and Development Corporation. The report, 'The Export Market Potential for Clean and Organic Agricultural Products' by Steven McCoy and Gerry Parlevliet, looks at the reasons for the demand, the driving forces and sources of products, and it profiles a range of commodities and countries.

Much of the interest is sparked by concern about the effects of synthetic chemical pesticides, fertilisers and food additives on human health and the environment. Illness and deaths from contaminated products, such as salmonella and *E. coli* in food, are fuelling the interest in organic products.

At the same time excessive or un-informed use of pesticides and some chemical fertilisers has led to problems such as:

- development of resistance to pesticides by insects, weeds and disease organisms;
- damage to useful organisms, which help plants resist disease or aid in biological control of pests; and
- loss of structure and general 'health' of soils resulting from destruction of soil-borne flora and fauna, ranging from beneficial microbes and fungi to earthworms.

These and other concerns about the direction taken by modern agriculture and horticulture have led to the worldwide growth of organic farming systems. Organic farming systems aim to assure food is produced free from harmful substances. At the same time maintaining soil health and fertility by using materials which enhance microbial activity in the soil. Organic systems aim to eliminate the use of chemical fertilisers and of pesticides to control weeds, pests and diseases.

Organically grown grapes, dried fruit, organic wine and even vinegar made from organic wine are part of this growing market.

World interest in organic wine

The interest in organic products is mainly by consumers with high disposable incomes. Many eat out frequently and have an interest in quality food. They are likely to consume wine.

The increasing interest in Japan for Mediterranean food has increased demand for wines. Japan is also showing real interest in organic products and Japanese buyers are looking for organic wine.

Wine buyers in Europe, the United States and Japan now seek wine made from organic grapes. However the messages coming from the industry do indicate a variable demand and a real requirement for quality.

Statistics for the organic wine industry worldwide are limited. It is unclear what level of premium exists. Quality wine, whether organic or conventional, will sell for a reasonable price. The lower end of the organic market is facing competition from France, Spain and South America.

Increasing interest by supermarkets in United Kingdom started as early as 1992 with Safeway stocking 15 lines. A specialist company, Vintage Roots, stocked 130 wines from around the world.

Jerry Lockspeiser, in Thorsons Organic Wine Guide (1991), estimated that France had 200 organic wine producers, Germany 130, Italy 40, Spain 2, England 2, with Portugal, New Zealand, Australia, California, Hungary one each. There are no clear indications on the number of producers in 1999. However, considering that the number of Australian producers selling organic wine or wine from organic grapes is more like 10 in 1999, with similar growth in the USA, numbers are likely to be about 400-450 world wide.

Organic wine and wine made from organically grown grapes

Organic wine is produced from organically grown grapes and then made into organic wine under strict standards. This wine can then be certified and labelled accordingly.

However, in many cases wine producers do not take that last step - labelling as certified organic - preferring to market their wine without organic certification. This wine is often described as ‘made from organically grown grapes’. It is still able to be certified but this is not done. This appeals to many consumers and avoids some market perception of organic wine being of inferior quality.

Some growers produce wine by conventional techniques from their organically certified grapes. These are also mostly labelled as ‘made from organically grown grapes’.

Some companies target the low sulphite market by producing and marketing wine as being made with no preservatives.

The demand for all categories can be expected to grow as more organic wine becomes available and markets become increasingly aware of the product.

However, makers of organic wine emphasise that 'organic' must also mean high quality wine that can compete with other wines at the top end of the market.

Marketing your wine

Plan your vineyard project to include an outlet for the grapes or wine. If you do not plan to include a winery on the property make sure you secure a market for the grapes. Such markets may mean a contract with local wine making facilities. If available, an advance contract may be desirable.

An established organic winery within easy reach of the vineyard would be a major advantage, ensuring almost certain sales for high quality, certified organic grapes.

When the vineyard plan includes a winery, the marketing plan for selling the wine needs to be focused on obtaining maximum value.

A West Germany study by Dabbert and Oberhofer (1999) showed that direct marketing was the only way to get the full premium for quality and organic wine,

6.4 Organic standards, requirements and certification

This section describes in general terms the requirements for organic certification relating to viticulture.

The organic farming industry maintains a certification system to protect both consumers and producers from spurious claims that products are 'organic'. The certification system verifies that products are organic. Importing countries place great importance on the credibility of the certification system.

Grower-supported bodies carry out certification. The Australian Quarantine Inspection Service (AQIS) accredits these certifiers for export purposes. Contact details of the AQIS-accredited certification organisation are provided in Appendix 1. Not all of these certifiers are involved in certifying grape production or wine making. Discuss with them your needs and determine which is most appropriate for your requirements.

Organic viticulture defined

The Procedural Manual of the Organic Vignerons Association of Australia states that 'When applied to grape growing and winemaking the term organic refers to the production of grapes of high quality, with an emphasis on nurturing and maintaining the land for future generations without the use of synthetic chemicals.'

'There is an emphasis on the use of renewable resources, clonal and rootstock selection, pest control through integrated pest management techniques, the need for conservation of energy, soil and water resources and the maintenance of environmental quality, with the utmost restrictions on external inputs, especially fertilisers and chemicals. The production cycle is as closed as possible.'

Zuur (1989) described organic viticulture as a form of production considering vines as part of a complete ecosystem, with emphasis on:

- Quality rather than maximum yield.
- Maintenance of an ecologically diverse environment including plants, fungi, microorganisms and animals.
- Caring for the soil using sod and cover crops, mowing and mulching. No herbicides are used and many weed species are regarded as useful for nutrient cycling and supporting a diversity of soil activity.
- Preventing pest and disease problems using such things as beneficial insects and training systems to improve canopy aeration. In emergency situations insecticides and fungicides with the least impact may be applied.
- Careful planning of vineyards to reduce potential problems, considering site, rootstock, variety, training system and soils.
- The reduction of pollution by not using synthetic chemicals.
- The strengthening of vines using various herbal preparations.

Certification for vineyards

Organic certification requires that comprehensive records are kept, and regular inspections are carried out to ensure that the standards for certification are met.

Organic certification takes into consideration the whole farming system of the property. It requires a farm plan, map and an approved record keeping system. The growers must demonstrate that they understand organic farming principles and prove that an appropriate system is in place and operates in compliance with organic standards. Sustainable crop rotation and strategies to maintain soil fertility, control weeds, pests and diseases and provide water management are required.

Certification as ‘organic in conversion’ may be achieved in one year, following inspection and verification of compliance with organic standards. Full certification as ‘organic’ may follow after a minimum of three years of verified, full compliance with standards. It may take considerably longer than this to meet the strict standards laid down by certifying bodies.

High levels of chemical residues in soils from previous land use can disqualify land from organic certification, as can excessive contaminant residues in plant tissues.

Buffer zones and windbreaks installed to an approved standard can be required to protect certified areas if there is a risk of contamination from adjacent properties. Organic farmers are advised to seek the cooperation of neighbours who use chemicals on adjacent properties.

Part certification may be possible where part of a property is converted to an organic system while the remainder is farmed by conventional methods.

There are penalties for failure to maintain organic standards or breach of rules of certification. This may involve cancellation of certification or reversion to an earlier stage in the progress towards certification.

Sequence for certification

A new organic grower may need to follow a generalised sequence of steps to achieve certification.

Practices questionnaire: Following application to the selected organisation the grower receives a vineyard practices questionnaire seeking details of practices followed over the previous three years. Varieties, blocks and details of vines on each block are required. A sketch map of the property is required as an aid to inspection. Map features must be able to be related to the producer's records and the map may be required to indicate use of adjacent holdings. The questionnaire is up-dated each year to provide an annual record.

Site inspection: A site inspection is then carried out during the year, preferably in December/January. A professional viticulturist normally carries out inspection and samples are taken for tissue testing. The purpose of the inspection is to verify claims made in the questionnaire and to ensure that the applicant understands the principles of organic viticulture. The inspector may recommend further testing or analysis. At subsequent annual inspections the operator must be able to demonstrate that organic systems are being used.

Third party inspections: Some properties may be subject to inspection by AQIS representatives as part of the regulation of certifying bodies. The inspections ensure that Australian and international standards of organic products are being met.

Statutory declaration: The grower must complete a statutory declaration for each vintage, stating that the grapes have been organically grown. The declaration is made before vintage and includes details of the area of grapes and an estimate of yield for the vintage. The yield estimate is required, in part, to guarantee to winemakers that they receive only organically certified grapes.

Checklist: A check list and approval form attached to the annual questionnaire becomes the covering document for subsequent action and approval or otherwise for the coming vintage. Certification as 'organic' or 'organic in conversion' is then issued.

Record of practices: A record of vineyard practices for each financial year is required and provides the annual update for the vineyard This is the basis of the organic farm plan, which must be adhered to.

Random testing: Certified products are subject to random testing for chemical or heavy metal residues.

Certification for organic wine

There are two possible approaches to making wine from organic grapes:

- Wine made from organically certified grapes and made in accordance with the Australian Food Standards P4 winemaking standard.
- Wine made from organically certified grapes in accordance with a code of winemaking practice endorsed by the OVAA and the OPEC. This is true organic wine.

At present the first is the most common alternative. This wine is generally made with minimum use of chemicals and additives and is sold as 'made from organically grown grapes', not 'organic wine'.

For certification of wine as 'organic' the Organic Vignerons' Association requires:

Annual Statutory Declaration: A declaration must be completed for each batch by the winemaker when seeking approval to use the term 'organic'. The declaration relates to the batch of wine, grape supply details and name of growers who produced the grapes, as well as information on production methods. The certification number for the organic grapes and details of accreditation must be included.

Wine processing agreement: The winemaker and bottler agree to comply with procedures and practices required for organic wine.

Delivery declaration: Provides the winemaker and bottler with proof that the grapes or wine delivered were sourced from an organically certified vineyard/winery.

Winery inspection check list: A qualified person, usually a professional winemaker, inspects the winery to ensure that the approved practices are being followed.

Certification checklist and approval form: This ensures that the winemaker's statutory declaration has been cross-checked to the vineyard and that the grapes have been grown according to organic principles.

Certificate of compliance: Certifies that the wine has been made in accordance with organic production regulations.

Two bottles of finished, labelled wine from each certified batch must be submitted to the certifying body. One bottle may be tested for residues and the other stored for reference.

Penalties for breaches of the standards are similar to those applied to grape growers. For winemakers, if the breach is accidental, accreditation for the batch of wine is revoked and stocks must be withdrawn from sale until claims of organic certification are removed. If the breach by the winemaker is intentional membership is revoked for two years and any certified wine must be removed from sale until claims of certification are removed.

6.5 Starting an organic vineyard

An aspiring organic grape grower has three possible avenues for establishing an organic vineyard:

- Convert an existing vineyard from to conventional to organic operation
- Start a new vineyard

Establish the vineyard by conventional means and, once established, convert to organic operation

Start a new vineyard, using organic principles from the beginning

In each case a sound knowledge of the principles and requirements of organic production would be a pre-requisite to any formal action.

6.6 Converting existing vineyards

Converting existing conventional vineyards may have some advantages. The vines are likely to be mature, the infrastructure is in place and most of the start-up difficulties will have been

overcome. Existing soil nutrient levels are also likely to be adequate. More importantly some of the insect problems of establishing vines will not be an issue.

It is also possible to have parallel production systems. This allows the producer to convert part of the vineyard to organic while continuing to use conventional techniques in the rest of the vineyard.

However there may also be some disadvantages. The vines may be near other conventional vines, which can lead to contamination from spray drift. Past chemical sprays may have left a residue in the soil at levels unacceptable to certifiers. The trellis system may not be the best for organic production techniques. There may also be residues in the soil (such as cadmium) from past fertiliser applications.

The prospective organic grower would need to have the vineyard soils tested for residues and should consult the selected certifying body before becoming committed to this course.

However, many vineyards have been managed for many years with minimum inputs of chemical fertilisers and pesticides, so residues may not pose a problem. In such cases the conversion may be relatively simple and for some this could be the easiest way to move into organic production.

In the initial change, the grower should switch to practices that improve soil biological activity such as using compost and reducing chemicals.

6.7 Starting a new vineyard

Starting by conventional methods then converting to organic

It is easier and more economical to establish vines by conventional means than under an organic system. Initial weed control is vital to survival of the young vine and treatment of the planting lines with a non-residual knockdown herbicide before planting is the most effective way of reducing weed competition.

Relatively ‘soft’ insecticides can be used to control pests such as garden weevil and various caterpillars that may otherwise destroy the early growth. Materials acceptable to organic systems are available to control diseases likely to affect young vines, so these may not pose a problem.

Fertilisers such as superphosphate and calcium nitrate are a more readily available source of nutrients for young vines than most organic sources and could help early establishment.

Limited use of these materials would get the vineyard off to a good start with least cost and effort and without leaving residues that could preclude organic certification in the future. Careful use of tissue and soil testing should ensure that excessive rates of application would not be used.

However it is vital to incorporate all the requirements and principles of organic production in the planning and operation of the vineyard during this time.

One organic grower described his establishment system:

- "Establishment using cross ripping North/South and East/West shatters to 600 mm, spreads gypsum as it is needed also grape marc and chicken manure. Spread before ripping (South African technique).
- The offset disc plough is used to chop up soil blocks brought up.
- The planting lines are then line-ripped down row using winged tine 30 cm wing at 15-degree angle. Gets to 900-1200 mm.
- Posts, drip system installed.
- Roundup used in early stages.
- Example: Grapes planted in September 97, picked 7 tonne per hectare in March 99; at third year can harvest 13 tonne per hectare and can go into conversion.
- Top soil moved from inter-row to under vine row; vine grows better when top soil deeper.
- If the vine gets a good start in early growth it retains that rate over more years."

The specific establishment details are similar to those described in the section below 'Establishing a new vineyard', which describes site selection, varieties, trellis design, irrigation, nutrient management, pruning and harvesting.

Starting by organic or biodynamic principles

All organic and biodynamic certifying bodies would prefer establishment of a new vineyard was carried out using full organic techniques and subject to all certifying requirements from day one. This ensures the producer is committed to the principles of organic/biodynamic production.

However, starting a new vineyard using purely organic methods may be more difficult, costly and time-consuming than starting by conventional means. Establishment and early growth of the vines may be slower.

A greater number of cultivations may be needed for initial weed control and considerable hand weeding would be necessary for control of weeds around the cuttings or rootlings. Use of black plastic strips, weed mats or straw mulch to suppress weeds along the rows may be an option.

Greater risks and higher costs are involved in controlling insects if chemical insecticides cannot be used, although some organic materials are claimed to give adequate pest control.

Use of guinea fowl or chickens is a recognised way of controlling some insects. Caution should be exercised in the first year or two because of the increased risk of damage by the birds to young plants.

Approved organic fertilisers do not provide nutrient elements as quickly as do those in highly soluble form, such as chemical fertilisers. The principles require approved fertilisers to be used to improve organic matter levels in the soil and ensure healthy biological activity in the soil, which will provide nutrients in a slow release fashion. Fertigation with acceptable substances can be used but not as a routine practice.

Establishing a new vineyard

District and site selection

If you have the luxury of acquiring a new site for the organic vineyard a number of considerations will need to be taken into account. These are likely to include:

- type of wine to be produced;
- the grape varieties preferred;
- grape growing conditions - climate;
- availability of good quality water;
- proximity of wineries and/or tourist roads;
- isolation from sources of contamination;
- disease, pest and weed burdens;
- amount of sunlight;
- suitability of soil;
- air drainage.

Many of the decisions an organic grower must make are the same as those conventional viticulturists need to make. If possible, draw upon local knowledge and experience to help with basic decision-making.

The most **suitable climate** is warm and relatively dry during the growing season, with low humidity when grapes are ripening.

Water for irrigation is important in most wine producing areas. Ensure there are bore license, pumping license or dam sites available.

Consider the proximity of crushing and winemaking facilities when choosing the location of the vineyard. If you are intending to sell part of the wine vintage via cellar door sales, **a tourist** town or road should be nearby.

Soil will also have a major impact on the venture. Find out as much as you can about the suitability of soil types on a property for vines before considering purchase. A block to be used for vines should not be too steep. If the vines are to be pruned and harvested mechanically the shape of the block must accommodate long rows to allow economical operations.

It is important to select a suitable district and location when planning an organic vineyard. Weed, pest and disease control are the major difficulties of organic viticulture and should be minimised by selection of a suitable location.

If possible the district should be one of **low pest and disease status** and the property selected should not have heavy **weed** infestations.

The possibility of **contamination** from chemicals used on adjacent properties must be considered; a degree of **isolation** from other vineyards is an advantage. Pesticide residues

from earlier use of the land are more likely if the district is prone to fungus diseases and/or insect and weed infestations. Old vineyard districts in high rainfall areas are best avoided.

The chosen site should have **good air 'drainage'**, with enough breeze from prevailing winds to keep vines well ventilated and so reduce fungal growth and germination of fungal spores. The valley floor in a small valley may not have adequate air movement.

Light is important both to produce sugar for ripening the berries but also to ensure good drying conditions around bunches. Morning sunlight can be important. If possible the land should have the capacity to allow the vines to be lined up approximately north-south. This may be less important for early ripening types.

Producing organic grapes is difficult enough without losing the benefits pre planning and consideration of the above points can bring.

Soils and fertilisers

Soils and plant vigour

Soil type is important in that deep, fertile soils with high water holding capacity may encourage excessive vegetative growth, leading to shading of bunches and an environment favouring disease organisms. As well, vigorous vines may produce large, thin-skinned berries, in tightly packed bunches. These are prone to diseases, especially Botrytis bunch rot. Winemakers, in any situation, generally favour small berries, because they tend to provide more flavour and colour. This can be an advantage of organic production.

Low vigour sites (from a disease management point-of-view) tend to be most suitable for organic vineyards. Duplex soils with a relatively shallow root zone may be recommended if excess vigour is likely to be a problem. However this may also slow down early growth of vines.

Vigour control is important in organic vineyards. To avoid excess vigour:

- develop the organic vineyard in a low vigour environment with medium fertility, and manipulate irrigation to control vine growth; or
- go to sites where there is no summer rain on deeper soils and only irrigate if needed;
- avoid higher vigour sites. In particular, avoid deep soils with good water holding capacity, where there is unlimited access to water and you cannot control vigour.

Soil fertiliser history

If possible, the fertiliser history and nutrient status of the soil should be known, as well as previous pesticide use. The soil should also be submitted to chemical and pesticide analysis. High pesticide or heavy metal. residues may prevent organic certification.

More importantly, soil testing will allow determination of those nutrients that should be applied in an approved form and allow the grower to monitor them over time. Test for nitrogen, phosphorus, potassium, iron, calcium, magnesium, pH, etc. The soil test will ensure the adequate nutrients are available.

Depending on the materials used, fertiliser may be banded on the planting line, drilled below the plants or broadcast. Compost and mulch may be concentrated around the young vines -

for example, one small grower spreads composted chicken litter at about 2-3 shovels over 0.5 metre by a metre to encourage root spread. For large-scale operations side delivery systems have been used.

Vineyard layout and trellis design

Organic principles encourage planting vines on the contour to improve infiltration and avoid run-off and erosion, leading to healthier soil conditions.

The layout should be designed to maximise air drainage and light interception by the canopy. Close planting of vines should be avoided if it is likely to lead to greater shading and reduced air movement through the vines.

The type of trellis selected is critical, as this will have possibly the greatest influence on air movement and interception of sunlight. An open system such as the lyre trellis or Smart-Dyson is favoured in most situations, although it is costly to erect. The various vertical-positioning systems can also be effective and usually suited to organic systems where vigour tends to be lower than in similar conventional vineyards. However, in high vigour sites shading of basal buds in vertical positioning may reduce fruit set for the following year, leading to a cycle of decreasing fruitfulness.

District practice and experience is often the best guide because the importance of light penetration varies from district to district.

Trellis design is less significant in hot, dry climates than in higher rainfall areas where vigorous growth accompanied by high humidity may encourage fungus diseases.

Training the vines to suit the chosen trellis system is identical to that in conventional vineyards and usually begins in the second year of growth. Heavy rates of fertiliser and irrigation may necessitate earlier attention in conventional establishments but this would be rare in an organic situation.

An essential reference is *Sunlight into Wine*, by Richard Smart and Mike Robinson.

Spacing

Vine spacing may be varied according to rainfall of the district and proposed irrigation system. The vigour, the site and different varieties may also influence spacing - it should be closer for low vigour but should avoid crowding.

Irrigation

Irrigation design is an essential part of vineyard layout and generally involves installation of a trickle system by the time the rootlings or cuttings are planted. Irrigation is generally essential for rapid establishment and early growth, and a suitable trickle system can also be used for fertigation.

The irrigation system is commonly used to apply nitrogen from synthetic fertilisers, often in the form of urea. This is not acceptable in organic vineyards, but organically derived substances such as fish emulsion may be used.

Water use must be regulated to avoid waste of water, leaching of nutrients and possible increases in salinity of the groundwater or raising of the water-table. A soil moisture

monitoring system should be installed so that the future irrigation regime will provide for the vines' minimum needs on each soil type in the vineyard.

Cape Mentelle Vineyards is developing an organic vineyard at Witchcliffe, WA, using black plastic for weed control along the vine rows. Vineyard manager Brenton Air made the following points at a seminar in Margaret River:

- *"Irrigation for white grapes is different to red.*
- Drip tape will be laid out under the plastic. Once the plastic wears out we will remove what is remaining, and the tape, and install micro sprinklers, not drippers.
- I believe that **drip irrigation is not the best irrigation method** in vineyards. You just have to look at the influence of natural rainfall on vine growth. I believe that watering and vine feeding over the whole vineyard floor will be much more effective.
- The micro sprinklers should also help in establishing early winter cover crop growth and to ensure that our spring/summer cover crops flower."

Soil preparation for planting

Soil preparation should start in the year before planting vines to thoroughly prepare and fertilise the ground and ensure good weed control. This may also include establishment of cover crops.

Initial weed control on the site is by cultivation. Then soils being prepared for planting vines are usually deep-ripped in two directions to remove debris and break up hardpans. This applies to both conventional and organic situations.

Ripping along the planting lines is also recommended, with deep placement of phosphorus fertiliser below the vines. Heavy rates of superphosphate are applied in this way in conventional situations but this is not acceptable for organic vineyards. Superphosphate could be replaced by untreated rock phosphate for an organic vineyard but rock phosphate takes much longer to release phosphorus available to plants, especially in alkaline soils.

Lime is required to raise the pH of acid soils in many grape-growing districts. It is usually topdressed at heavy rates and this is acceptable in organic vineyards if untreated lime from a natural source is used.

Planting stock

Premium varieties are favoured because quality is paramount in organic grapes and wine; the extra effort of operating an organic vineyard should not be wasted on lesser varieties.

Varieties and clones should be selected for superior disease or insect resistance or tolerance as well as likely demand for each variety when the time comes to market the grapes.

Vines on rootstocks that regulate vigour and resist disease or insect attack are favoured for organic growing because this reduces the need for later control measures. Use of resistant rootstocks is particularly important if there is any risk of phylloxera being introduced.

The planting material must come from organic nursery sources unless otherwise approved by the certifying organisation.

Planting stock should be free of diseases such as downy and powdery mildew, crown gall and phomopsis and not harbour mites or other pests. These are likely to be difficult to eliminate or control at a later stage. The 'virus status' of the planting stock should be known.

The insect/disease susceptibility or otherwise and the quality characteristics of premium varieties within each district are well known. Established growers or consultants should be consulted. Generally, varieties or clones with open bunches and smaller berries are less susceptible to disease than those with large berries in tight bunches.

6.8 Management of an established organic vineyard

While general management of organic vineyards is basically the same as that for conventional vineyards in the same environment, it requires much more attention to detail and closer monitoring of the vines.

There is little scope to use fertilisers or chemicals for rapid response in nutrient deficiency correction or weed, pest and disease control. Pruning systems may also have to be modified, mainly to allow for organic viticulture's necessarily different approach to pest and disease control.

Soil management and fertiliser application

Management of the vineyard soil is the basis of organic viticulture. It provides for nutrition of the grapevine, maintains good soil structure and has an important influence on pest and disease control. The use of chemical fertilisers is not permitted and in most cases material (such as animal manure) to be applied must first be composted. Cultivation is acceptable but should be limited to the minimum necessary for any particular purpose to avoid soil structure decline and loss of organic matter.

Soil management in an organic vineyard encourages the soil flora and fauna to develop a balanced, living soil environment free from chemicals. Organic growers believe dependence on chemical fertilisers eventually produces 'dead' soil in which the vines depend on readily available chemical elements applied to the soil, rather than slow release nutrients produced by soil microorganisms as they break down organic matter.

The organic viticulturist aims to develop the soil in the vineyard by concentrating on increasing organic matter, increasing biological activity, reducing compaction and improving soil structure.

Cover crops

Organic matter in various forms is the preferred fertiliser and soil conditioner. Cover crops and in some cases a permanent sod provide a cheap and effective means of building up the soil organic matter and soil structure, encouraging the development of soil microorganisms and earthworms.

Cover crops can serve a range of functions. These include:

- reduced soil erosion;
- suppression of weed growth through 'smothering' of unwanted plants;
- provision of soil nitrogen, if legumes make up a large proportion of the cover;

- maintenance of beneficial organisms which provide nutrients to the vine by breaking down mineral and organic matter;
- development and maintenance of good soil structure, leading to further benefits such as improved trafficability;
- breaking up of sub-surface hardpans, if deep-rooted plants are included in the crop;
- attraction of beneficial birds and insects, especially if the crop is allowed to flower;
- the possibility of suppression of nematodes or other unwanted organisms through the use of selected species.

Selection of species sown in a cover crop will depend on the main requirements of the vineyard and the soil and water available.

In most organic vineyards provision of soil nitrogen is a priority and legumes are sown to 'fix' nitrogen from the atmosphere. Brassica crops such as radish may be sown as possible soil 'fumigants' to discourage nematodes; they also have strong taproots that can penetrate hardpans. Grass species may be preferred in areas where light brown apple moth is a problem because some broad-leafed species favour this pest. The strong fibrous root system of grass species is good for soil structure.

Different species are sometimes grown in alternate rows and rotated to provide the required benefits. Species may also be sown as a mixture, especially in permanent swards.

Availability of irrigation water may influence the choice of species because cover crops growing into summer may reduce moisture available to the vines. In some situations this can be an advantage if it is necessary to reduce vigour in the vines to avoid excessive vegetative growth. Annual species that set seed early and die off in summer may be favoured where competition with the vines for moisture must be avoided.

Species selected should be resistant to or tolerant of insect pests because spraying them for pest control is not an option.

Regular mowing of the cover crop (or permanent sward) may be desirable to maintain species composition and density, to provide organic matter to the soil and to reduce moisture uptake. The crop may be slashed, with the cut material thrown under the vines as mulch to suppress weeds and reduce moisture evaporation.

Fertiliser for cover crops in organic vineyards must meet the requirements of the national standard for organic agriculture (Appendix 2).

An excellent general guide to cover crop selection and management is *Cover crops - A guide to species selection and sward management*, published by the South Australian Seedgrowers Co-operative (SEEDCO) and the Grape and Wine Research and Development Corporation. It is available from SEEDCO phone (08) 8234 9333, fax (08) 8234 6133.

Fertilisers

Fertiliser applications from sources external to the vineyard for organically grown grapevines are acceptable provided the materials are approved by the certifier and meet the 'National Standard for Organic and Biodynamic Produce'.

The certified property must operate within a closed system as far as possible, with inputs from outside kept to a minimum and used only where no other alternative is available. There may be limits placed on the amount of manure or compost that can be brought in.

The standard requires that enough organic material should be returned to the soil to maintain or increase the soil's humus content. Conservation and recycling of nutrients is a major feature of any organic farming system, with the use of mineral fertilisers (from natural sources only) regarded as a supplement to recycling and not as a replacement.

Biological material added to the soil should generally be composted by natural means; composting is essential for animal manure and for materials brought onto the property from non-certified sources. Mulching materials applied to the soil surface do not have to be composted but their use must be documented.

Soil and petiole analysis should be used as a guide to fertiliser application in the vineyard and the source of materials added determined accordingly.

In practice most organic vineyards depend on green manure or leguminous cover crops to supply nitrogen and also use compost made from material harvested on the property as a major source of nutrients and organic matter. Animal manure (including pelleted poultry manure), fish by-products, rock phosphate, wood ash, gypsum, lime and various forms of seaweed may be added. See Appendix 2 for list of permitted substances.

In some cases foliar sprays of fish emulsion may be applied direct to the vines. Ground natural rock powder may be used as a source of trace elements, potassium and magnesium.

Use of any material should if possible be based on chemical analysis to ensure value for money and avoid excess use of any element.

Growers need to appreciate that nutrition of vines under an organic system needs a long-term approach, as it depends on the gradual breakdown of natural products by soil organisms rather than the usually rapid supply of nutrients from synthetic fertilisers.

The materials selected generally depend on what is readily available in the district concerned. Importing bulky material from elsewhere is not likely to be economically viable.

Organic growers regularly apply trace elements as required. These include Copper, Zinc and Manganese mostly as the sulphates. The practices range from mixing in compost to one to three applications by foliar spray. Sprays may include oils. Timing coincides with anticipated needs, such as the first flush of growth.

Nitrogen is supplied by both the use of cover crops and extensive application of compost. Compost on young vines is often applied around the vine whereas on older vines the compost is broadcast. The compost is used to feed the cover-crops as well as the soil and the vine. Growers generally consider compost an essential input. It may, in some cases, be supplemented by specialised proprietary products such as ' Complete Organic Fertiliser', fish emulsions, rock dust, dried blood, bone meal and the equivalents. Some of the blood/bone products have been applied to other horticultural crops to get quick responses when deficiency of nitrogen has been detected; rates of up to 150 or 200 kg/ha have been used.
Organic growers are utilising any available approved input for compost making, including local animal manure, grape marc, pig manure, chicken farm waste, cattle feedlot manure, saw dust and orange waste. Additives include reactive rock phosphate as a phosphorus source,

brown coal dust as a carbon source. Growers on some light river soils in Victoria apply mixtures of compost and grey flood plain clay to improve soil water holding capacity. Grape marc is seen as a good potassium source.

Material	N kg/tonne	P kg/tonne	K kg/tonne
Winery marc	16	3	28
Fowl manure deep litter	25	12	15
Fowl manure (cage)	40	30	16
Blood and bone	40	40	-

These materials are variable - test in the laboratory before relying on it (Coombe and Dry 1992).

Varying rates of compost are used, often triggered by cost considerations rather than nutrient content. However the amount that can be applied is also determined by the certification organisations.

Many producers make their own compost from locally sourced inputs. Others buy in commercially produced compost; some in pellet form. In either case producers need to understand the composition and the likely effect on the soil and the vine. Soil tests, compost analysis and a good nutrient balance for the farm, which recognises the amount of nutrient exported from the property, is essential. Low nitrogen compost may cause poor fruit quality.

Growers who have found reduced levels of phosphorus in plant leaf samples are using reactive rock phosphate as a way of creating long term replacement Phosphorous.

Biodynamic producers use their preparations to stimulate soil as well as compost.

Some soils need adjustment of pH, either because it is too high or too low. Soil tests will indicate this and local knowledge will indicate the rates of lime or organic matter required to bring pH into a reasonable range. Some example prices in 1998.

Material	Location	Approximate cost/t
Pig manure compost	South Australia	$70
Cattle manure	NSW	$15
Chicken manure	Victoria	$40
Dried blood	South Australia	$750
Bone meal	South Australia	$400
Complete organic fertiliser	Victoria	$300

Some growers use parts of the property to grow material for compost production and run animals on the property to complete the nutrient cycles. This is generally in line with the intent of the organic certification requirements.

Using compost in horticulture

This section is modified from a paper by Aileen Reid and Bob Paulin both Development Officers at Agriculture Western Australia.

What is compost?

Compost is a friable dark brown product that has a characteristic earthy smell. The term compost tends to be used to describe several products that may or may not be composted, but it should only be used where the product has been through a controlled process of microbiological degradation. Simply leaving a heap of material in a corner for weeks or months does not constitute composting.

Composts suitable for soil incorporation are usually fine. The coarser grades of compost, often those made from green waste or other woody materials, are more suitable for applying to the soil surface in a layer (i.e. use as mulch) and may provide additional benefits to mulch, which has not been composted.

A wide range of ingredients can be used to make compost. Carbon is provided by materials such as straw, green waste (tree and garden prunings), paper and wood. Nitrogen is usually provided by animal manure (pig, chicken), as well as vegetable and food wastes. These are blended to produce a carbon to nitrogen ratio of between 20 and 40 to one.

There are many ways to make compost from relatively simple and low cost mechanically turned windrows to much more capital intense invessel systems. Regardless of the process, composting requires the materials to be uniformly mixed, moisture content maintained in the range of 50 to 60 per cent, adequate oxygen levels and temperatures between 50 to 70^{o}C in the centre of the pile.

What are the benefits from using compost?

Composts supply organic matter to the soil. Over time, both during the composting process and after addition of the composted organic matter to the soil, micro-organisms work to transform this organic matter into humus. These materials improve soil structure, soil aeration and water retention. They also provide a source of nutrients that is both slowly released and readily available to the plant, unlike artificial fertilisers that can be easily leached into the groundwater.

Soil microbial populations also change and numbers of beneficial bacteria and fungi increase, allowing plants to better withstand attack from pests and diseases. These changes allow crops to be produced with less fertiliser, pesticides and irrigation and have the potential to help address growing worldwide food health and safety concerns. By helping toward ‘cleaner, greener’ food production, the use of compost has the potential to increase exports as well.

Continuing horticultural development also needs continued access to soil and water resources that are becoming increasingly scarce, particularly in areas of large population and/or increasing environmental concerns. Compost may help maintain this access by reducing contamination of these resources.

Finally, by transforming large quantities of waste material into compost that can be used in crop production, horticulture will contribute to achieving landfill reduction targets.

Using compost

Compost has application to all crops and the extent of its use will be will be a matter of cost considerations. Based on typical fertiliser pesticide and irrigation costs for vegetable crops on the Swan Coastal Plain in Western Australia, a one third reduction in these costs will pay for a 20 t/ha application at current prices of around $40/tonne delivered. However this is a simplistic view. Many of the benefits from compost are indirect, developing over time and with repeat applications and so it may take several years for the full economic benefits to be realised. We currently believe that in vegetable production, cost savings for 20 tonne/ha applications should be readily achieved within four to five consecutive compost applications.

Application rates

For vegetable crops, 20 t/ha incorporated before planting each crop seems to produce good results, although beneficial results have been found with applications as low as 12 t/ha.

Rates are normally quoted as 'wet' rates. Most well made compost is about 50 per cent moisture, which allows for maximum biological activity. Australian compost standards require compost to have moisture contents above 30 per cent.

Early work also indicates that 5 to 10 litres of mature compost incorporated in the planting hole of tree crops will improve establishment and tree growth.

Mulches, 30-50 mm thick around the base of perennial tree and vine crops will help to conserve soil moisture and reduce soil temperature and weed growth, thus contributing to improved crop growth and yield. Results, largely from work by John Buckerfield in South Australia, have demonstrated that these improvements are significantly greater if the mulch is composted.

Application frequency

The best principle is to apply smaller amounts on a more frequent basis. Many of the benefits of compost are long term and develop over several years with repeated applications.

For vegetable crops, apply pre plant before seeding or planting each crop, at least in the first three to four years. This can be before incorporating a cover crop where one is used, or the residual crop after harvest, providing the establishment of the next crop is imminent.

Apply as mulch to perennial crops every three to five years or depending on the rate of breakdown.

Possible problems

Overseas reports indicate concerns when compost is made from highly mixed urban wastes. They may not perform as well as composts from source separated wastes sources. Non-separated compost can contain various contaminants such as:

- heavy metals - from industrial wastes, batteries, etc;
- chemicals and compounds that do not break down or that degrade to plant toxins during the composting process

Compost maturity will affect crops and, as a rule, only matured compost either made from predominantly non woody sources or that have been screened to remove woody material that has not been degraded by the compost process, should be incorporated in the soil before crop

establishment. This applies equally to planting of tree and annual crops. There are two reasons for this. Large woody particles will continue to degrade in the soil and potentially use nitrogen that would otherwise be available to the crop. Secondly, large particles of wood (or other materials) may adversely affect seed germination or root growth of the crop.

Coarse immature compost that contains a high proportion of woody materials should only be applied as mulch to established perennial crops.

Compost quality

There is an Australian standard (AS 4454-1997) which has been designed to ensure that compost meets certain minimum requirements. This is to ensure it is not contaminated or harmful to plant growth. The standard, however, is voluntary and does not aim to make statements concerning the product's contribution to plant growth.

Growers should ask the supplier for evidence that the batch of compost being purchased complies with the Australian standard. Organic growers must also ensure the compost is approved for use by their organic certifier. Growers should also feel free to ask for additional information such as:

- what has the compost been made from; and
- the nutrient (nitrogen, phosphorus and potassium) content of the compost, however it should be realised that compost is not a replacement for fertiliser and does have other benefits, as stated earlier.

Changes to management practices

Before applying compost, carry out a soil test. If you have high levels of available phosphorus and potassium, reduce these components of your fertiliser program to allow for the contribution that compost will make. At this point in time, you should assume that both phosphorus and potassium availability from compost will be similar to that from the common fertiliser types used.

If lime is required to raise the soil pH, then this can be safely applied with the compost and the manufacturer may be able to mix them before delivery, saving on spreading costs.

More information about compost

There are numerous sources of written information - the Internet, consultants working with compost products and manufacturing technologies, and compost manufacturers. Be on the lookout for bias and seek information from more than one source. Use your own peer network (e.g. other growers) to cross reference information sources.

Some common nutrient management practises by grape growers and other horticulturists

Organic growers have used colloidal phosphate and brown coal dust in composted form as a nutrient source.

They have also used other products to promote biological activity. Some of these consist of blends of fish emulsion, protein, bacteria and fungi. They generally require brewing up and then application to the soil. Several organic viticulturists have indicated they have seen benefits from this material.

One grower's nutrient inputs:

Compost - With young vines apply Compost at 1 tonne/hectare around vines when 3 years old - 8 tonne/hectare inter-row.

Rockdust - Commercial material at recommended rates. They use local basalt dust at higher rates.

For pH management use dolomite.

Rock phosphate - Pre - establishment and in three to five year rotation, after five years soils change.

Blood and Bone - To young vines to help promote growth of vines not when mature, some available locally adjust rate if blood content changes. Blood and bone 500 g/vine, 760 vines per acre.

Fish Fertiliser - Local fisherman makes fish fertiliser, apply through drip and as foliar spray.

Seaweed - as for fish, use for disease control.

Earthworm castings.

Weeds, pests and diseases

Control of weeds, pests and diseases is more complex in organic than conventional vineyards because the usual range of pesticides is not available to organic growers.

Susceptibility to pest and disease attack is reduced if the vines are healthy and grown in a balanced environment. This is the first defence against these problems in an organic vineyard.

Regular and detailed monitoring of the vines is paramount in maintaining vine health and gaining early warning of potential pest or disease attack. While monitoring is an essential aspect of vine management in any vineyard it is doubly important for organic growers.

Weed control

As herbicides cannot be used in organic vineyards, weed control depends mainly on cultural means. This may involve:

- Cultivation. Limited cultivation gives control of weeds in many situations. However, frequent working of the soil is not acceptable because it destroys soil structure, burns up organic matter and destroys earthworms and other soil dwellers. A cutting blade that severs weeds just below the soil surface is sometimes used for under-vine control.
- Mowing or slashing between the vines keeps weed growth in check. Slashed material from cover crops or other growth may be propelled from mid-row to smother weed growth near the vines.
- Thermal control, using a flame or hot water. This is expensive and not generally successful.
- Smothering weeds by growing a dense and vigorous cover crop. This is an effective approach where climate and soils allow suitable cover crops to be grown - and where it is possible to grow them without unduly depleting moisture needed by the vines.
- Application of straw mulch along the vine rows may also be used to smother weeds. The origin of the straw and its freedom from weeds and chemical residues should be checked.

- Use of ‘weedmat’ or black plastic strips along the vine rows to prevent germination or smother germinated weeds.

The management of one organic wine producer in Adelaide Hills includes:

“Main issue is weed control - have tried hot water but was expensive.

Mature vines do not need bare ground, ignores few weeds that come under drips

Young vines - weeds more competitive for water and young vines can handle less competition.

Has not considered cover crops, i.e. for insect control/companion planting as he has no problems.

Weed control - in September ploughs out green weed between rows and by dodge out plough then rotary hoes at slow speed to level out and incorporate (uses rotary speed same as tractor speed for gentle action.

In November rotary hoes summer weeds, rotary hoes again even under vines, has grader blade to move soil back under vines (some weed burial)

After that lets weeds go - little competition under dry conditions. They get little summer rain.

Big issue is weed control, dodge out is fine but needs skilled operator, tiring bit hard in large vineyards.”

Another grower in the Clare region suggested:

Difficult to control weeds on the vineyard floor - in past slashed to short height. Has used straw mulch under vines, 40 round bales per hectare, problem with mineralisation (uses up nitrogen).

Used one cultivation to keep ground bare during summer.”

In the Margaret River area one manager indicated his weed management plans:

“The results were encouraging. We controlled weeds by mechanical means and fertilised our vines by composts. The mechanised control of weeds was not new to me as when I started working in vineyards in South Australia there were no good herbicides which could be used (e.g. there was no Roundup® there was no Spray.Seed®).”

“We intend to plant some of the vines under a heavier than normal black plastic for a trial. We hope that the plastic will last for 4-5 years. The plastic is 75 microns whereby the normal black plastic is 50 microns. It is about 1 m wide. The reason for the use of the plastic is that our German made under vine weeders require quite a large trunk on the vine to work without destroying vines. We hope that the black plastic will suppress the weeds until the trunks are sufficiently large to cope with the machinery we intend to use.”

A second organic producer in Margaret River area suggested:

“Use mulch as much as possible - straw mulch, shredded paper and peat.

“Clemens undervine weeder, hydraulic cuts just below surface, used just after emergence - has trigger mechanism for operation to avoid cutting vines. Also use Woofers (volunteers - Willing Workers on Organic farms) for hand weeding.”

Insect pests

Insect control in organic vineyards must depend on natural means. Growers have access to a range of approaches, including use of extracts from natural materials, release or encouragement of insect predators or parasites, biological controls such as insect-attacking bacteria or viruses, pheromones, use of flowering cover crops to attract birds, and poultry running in the vineyard. This allows a well-developed integrated pest management program that does not use synthetic chemicals.

Extracts: Pyrethrum (extracted from chrysanthemum, rotenone (from derris), garlic and seaweed extracts are among the substances permitted for insect control. A full list is in the Appendix 2.

Predators and parasites: Wasps or mites that attack or parasitise pests, usually at the caterpillar stage, are preferred treatments. For example, *Trichogramma* wasps can be imported as eggs on cards to control caterpillars. In general, beneficial insects are encouraged by not spraying with broad-spectrum insecticides and by growing plants that provide food and shelter for them, either in cover crops or elsewhere near the vines.

Biological controls. *Bacillus thuringiensis* is a well-known control for caterpillar pests such as the light brown apple moth. It must be sprayed thoroughly to coincide with peak pest egg hatching and before the pests reach sheltered positions. The spray cannot work unless caterpillars are present. The predatory mite, *Typhlodromus doreenae* has been used to control bunch mite. It appears to have resistance to sulphur sprays.

Pheromones (sexual attractants) are commonly used to attract flying male moths and disrupt the breeding cycles of pest insects. They are also used as an aid to monitoring pest numbers.

Poultry, usually guinea fowls, turkeys and chickens, are used against insect pests and snails in conventional as well as organic vineyards. They appear to be effective in control of the garden weevil. The weevil is a major pest of vines, especially newly established vines. In most districts special efforts are necessary to protect poultry from foxes and/or dogs.

Black beetle

There are no proven ways of controlling black beetle, which can be a major problem for new vines, especially. However, site preparation techniques that starve out resident populations can be effective. Physical barriers can prevent adults from accessing the stem where the feeding damage occurs; these could include aluminium foil or grow-guards. Black plastic along the rows has been suggested as a possible deterrent. Some of the plant extracts may also have a control benefit.

Grower comments on insect management:

Considers light brown apple moth (LBAM) grubs are eaten by spiders in vineyard.

He does however clear cultivate in September to reduce competition but this also removes host broad leaf weeds which can harbour the insect-this reduces hatching which occurs in October/November. It is the October-November hatching that can cause a lot of damage in other vineyards. Tolerates some small amount of insects, they do limited damage. - Has some scale but sulphur and oil has some effect on scale."

"Insects no problem in Clare - scale occasionally but oil is having impact, the organic vineyard has lot spiders, winged grass hoppers have threatened but no need to spray.

Bacillus Thuringiensis hasn't worked for them - Mimic ok - could have LBAM every few years; pheromone tags keep them away but also keep broadleaf weeds down from October/November."

"Very effective control of LBAM using B. thuringiensis targeted at peak egg hatch" - Jenkins.

"Lots of wasps spiders, etc. parasitise LBAM. Need to ensure the adult has nectar plants to live on as only larvae are parasitic. Some such as Trichogramma sp. can be introduced."

"In 1981 we had 25 acres of conventional vines. In 1988 we bought some new land, which we planted only to be eaten by grasshoppers. In that season we spent a lot of money on chemicals. Thus, we invested in guinea fowl to eat the grasshoppers. We had a few problems with the guinea fowl to begin with as foxes ate the first lot. However, we now have over 200 guinea fowl roaming over about 100 acres of vines. The grasshoppers are controlled and we do not have any weevil problems. Whether the small weevil numbers are due to the presence of the guinea fowl or not we are unsure but we are not complaining."

Bunch-mite has been controlled with *Typhlodromus doreenae* at Loxton.

Diseases of grapevines

Disease control in organic vineyards depends on management techniques and use of a limited number of materials sprayed on the vines.

Healthy vines grown in an environment that is not favourable to fungal pathogens are less likely to suffer severe damage than vines in conventional vineyards in disease prone areas - particularly vineyards with heavy leaf cover in high moisture growing season environments.

In the long term fungus-resistant varieties which produce loose bunches will provide the best means of disease control. Meanwhile varieties appropriate to each district and soil type, planted in situations with good air 'drainage' and open, well-exposed canopies, will give good results. Local experience is a good guide to the most suitable varieties for each district.

Irrigation and moisture control management techniques, combined with well-balanced fertiliser programs, should be used to avoid excessive vigour, which favours fungus infection.

Substances permitted for disease control include wettable or dry sulphur, and copper in forms such as Bordeaux and Burgundy mixture. The organic industry is facing some concern in the future with the possibility of application rates of copper, sulphur and zinc being limited under European regulations.

A full list of materials permitted under the national standards is given in Appendix 2.

Major diseases

Downy mildew

Open canopy management, careful monitoring of weather conditions (the fungus needs 10°C temperature, 10 mm rainfall and 24 hours wet foliage for spores to move to foliage) and spraying with Bordeaux mix as a protective treatment is recommended.

Bordeaux sprays may be applied pre and post-flowering and three weeks later - but more frequent applications may be needed, such as before forecast wet weather and before

overhead irrigation. Timing and good coverage is important and Bordeaux mixture has several problems, including the possibility of copper accumulation, so must be used with care.

There is no approved eradicant spray. The only effective one the organic industry used was phosphoric acid but it has had its approval withdrawn.

There is some possibility of mites being available to control downy mildew.

Report by Liz Riley from Europe indicated acidified clay products being useful in cool climates - Myco-San® and Ulmasud®. They are not yet available in Australia.

Several Bio-fungicides are being tested and imported; these may have some use in a well-integrated disease management program.

Powdery mildew (oidium)

An open canopy that admits plenty of sunlight reduces spore germination and spread of powdery mildew and this is the first defence against the disease. Sulphur is a permitted material for organic vineyards and generally gives reasonable control. Lime sulphur may be sprayed during dormancy and just before budburst to kill over-wintering spores, followed by wettable sulphur sprays starting several weeks after budburst and continuing at two to three-week intervals.

A successful traditional treatment is the application of dusting sulphur during summer growth: it needs temperatures between 25-30°C for best results. Application in temperatures above 32°C can result in burning of foliage. (Details in IPM manual from AgVic.)

Some NZ work indicates that a plant extract from *Reynoutria sachalinensis* (Knot weed) gave control of powdery mildew (Tassie, E., 1990).

Research on vines has indicated that milk products have useful powdery mildew control properties.

Botrytis

Botrytis, which causes bunch rot, is a major problem for organic growers because there are no effective specific fungicides permitted for control of this disease.

An open canopy, possibly accompanied by leaf removal around the fruiting area, is a defence against botrytis. However, exposure to sun may lead to sunburn on fruit.

Loose bunches are desirable because berries in tight bunches are likely to split when damp and provide entry to the fungus, which then spreads rapidly. In extreme cases bunch and berry thinning may be used.

Excess vigour produces lush vegetative growth which shades the bunches and encourages the fungus. In some cases such vigour can be avoided by limiting nitrogen available to the vines. Hard pruning also stimulates vegetative growth.

The fungus is more likely to attack berries damaged by birds or larvae of pests such as the light brown apple moth and these should be controlled where possible. In the South West of Western Australia light brown apple moth may not be a major problem.

High levels of nitrogen can produce thinner skins on berries, which makes them more susceptible. Thicker skins inhibit Botrytis.

Some success has been claimed for sprays derived from seaweed and fish waste, (Jenkins, 1991).

Potassium metabisulphite applied as a spray can delay the development of botrytis in berries approaching harvest and is used as a 'last resort' against the disease.

Some growers have tried Tricodex; an Israeli-made biological control for botrytis.

Some grower disease management strategies:

"Needs to spray young vines for powdery mildew - they are very susceptible - uses Sulphur and canola oil (wettable powder sulphur any commercial line).

Some leaf plucking around bunches on older vines.

Powdery mildew only disease.

Sprays on average every fortnight till hot and dry but may come back to 10 days in cool wet longer interval in hot dry condition.

Starts spraying at first shoot, i.e. 100 mm just after bud burst. The first two sprays are a copper hydroxide/sulphur/oil mix (100 mm than again at 3-400 mm) then reverts to copper hydroxide. (Copper oxychloride is allowed but is discouraged due to Cl and Bordeaux mix too hard to use.

He uses pruning to get air and light into bunch, which reduces conditions for disease.

All sprays are preventative there is no apparent control spraying."

Other comments include:

Use copper/sulphur preventative sprays 4-5 times some years 6-7 time.s

Copper hardens tissue, sulphur for powdery mildew at 1-8 kg wettable powder and copper hydroxide at 1-2 kg/hectare.

Could model and monitor disease but is labour intensive. Prefer preventative treatment.

Birds not an issue, large areas of grapes dilute effect, small vineyards may have problem.

A spray program on an example organic vineyard:

Spray program	***Vififer***	***Cambourge***
After prune		*Tree spray with seaweed*
Budwood to 10 cm		
10 cm to begin flowering	*501, copper hydroxide every 10 days*	
	ZN/Mn	
Flower to fruit set	*Copper Hydroxide, Trichodex (cucumber fungi)*	
Pea size to Bunch		
Sprays		
Powdery mildew	*Lime-sulphur spray prior to bud burst, wettable S with Canola oil, seaweed and fish emulsion used as foliar spray to bunch closure.*	
	Calcium spray from 10 cm shoot to begin flowering, compost tea.	
Downy mildew	*Copper Hydroxide*	
Botyrtis	*Casuarina Tea, tricodex, potassium, fish emulsion use early.*	
Tree spray	*Silicate, sulphur, seaweed, fish emulsion pre bud burst.*	
Light brown apple moth	*Bt, pheromone treatment, trigogramma. Eggs with light oil.*	

Pruning

Pruning is commonly carried out by machine and there is generally only one pruning during vine dormancy. There may also be some trimming or hedging during the growing season.

There are different ideas about the level of pruning that should be carried out. The level used relates to vine vigour, fruit quantity and resulting yield, and bud numbers required.

High vigour which may result from heavy pruning leads to shading and therefore less fruit in the following year; more shading and even less fruit, with yield on a spiral down over the years - for example, from 10 kg to 5 kg fruit per vine.

Minimum pruning is often advocated as a way to reduce vigour in high rainfall areas. In those high vigour environments heavy pruning leads to dense vegetation and tight bunches, ideal for Botrytis so minimum pruning may be needed to reduce vigour. There may be a need to remove leaves from around bunches under minimum pruning.

In minimum pruning old wood is retained, which may lead to some increase in phomopsis inoculum carryover because diseased wood is not removed. With minimum pruning have self-terminating tips and shoots are not much more than 20 cm in length.

6.9 Making wine from organic grapes

'What makes an organic wine different is much more the method of growing the grapes than the way in which the wine is made.'

'Let us also kill a myth by stating that making organic wine does not mean refusing the help of modern technology in the form of cold fermentation, conservation by inert gas blanketing, cartridge filtration and so on.'

'One may ask whether the organic method is an appropriate one for wines of the year 2000? My answer would be yes. The organic method is not an archaic one, but a modern, quality-conscious one, which takes into account the environment, the health of the consumer and last but certainly not least the enjoyment of men and women who appreciate good wine.'

Guidelines for winemaking from organically grown grapes are detailed in the Organic Vignerons Association of Australia's *Procedural Manual Governing the Certification and Control of Organic Grapes and Wine.*

The organic grapes must be grown in compliance with the national standard for organic and biodynamic produce and the fruit must be certified by an organisation accredited by the Australian Quarantine Inspection Service.

The wine can then be produced and labelled either as 'Wine Made from Organically Grown Grapes' or as 'Organic Wine'.

Wine from organically grown grapes

Producers of wine made from organically grown grapes must be able to demonstrate an 'audit trail' linking the finished product to organically grown grapes. The wine can, however, contain up to five per cent of material derived from non-organic grapes for the purposes of generating cultures of microorganisms or for topping up.

It must be made according to standard winemaking procedures complying with Australian Food Standards Code Section P4.

At present 'wine made from organically grown grapes' is probably the main use of organically grown grapes; the market for organic wine is not generally considered to justify the extra effort involved in producing fully organic wine.

Producing organic wine

Organic wine is made from grapes certified Level A organically grown, made in compliance with Australian Food Standards Code P4. An 'audit trail' is required linking the wine to organically grown grapes.

The grapes must be certified organic by an accredited organisation.

Harvesting

If the grapes are machine harvested the harvester must be washed out with water before harvesting the organic grapes.

The grapes must be harvested in a manner that prevents contamination with undesirable metals, plastics, chemicals or dust. The time of the day that grapes are harvested will also

influence the quality. White wine grapes are often harvested in the cool of the night to prevent oxidation. Red wine grapes may be allowed to warm up to allow full flavour to be developed.

Transport

Transport must be in inert containers that will prevent contamination. If containers are also used for conventional grape growing they must be thoroughly cleaned out to avoid possible contamination before they are used for organic grapes. At the same time the grapes, if they are being transported any distance, may need protection by the use of potassium metasulphide.

Winemaking

Because organic winemakers do not have access to the full range of materials available for conventional winemaking, attention to hygiene and careful handling in the winery is paramount. However, winemaking techniques are much the same as those used for conventional winemaking.

At the winery, the grapes must be crushed without delay to prevent spoilage. Crushing equipment must be made of inert material. Inert equipment must also be used to drain and press the grapes. Washing of the crusher by water is carried out before crushing the organic batch. Pectolytic enzymes may be used. Juice can be clarified by chilling and settling in the usual manner.

Additives and processing/processing aids allowable for organic winemaking are listed in the table. Importantly, sulphur dioxide is acceptable as a preserving and anti-oxidation agent but free sulphur dioxide must not exceed 30 mg/L and total sulphur dioxide must not exceed 125 mg/L. It is allowed only in the gaseous form or as a solution of the gas. Ascorbic acid may also be used as an antioxidant

Yeast for fermentation may be obtained from commercial sources. However, some makers prefer the yeast naturally present on the grapes. Larger populations of yeast are likely to be present on organically grown grapes than on grapes grown in a conventional vineyard that has been sprayed to control pests and diseases.

After fermentation the wine may be clarified using most of the normal processes. Bentonite, egg white, isinglas, skim milk and gelatine are among fining materials that may be used to help clear and stabilise the wine. Use of inert gas - carbon dioxide or nitrogen - is encouraged to prevent contact with air at all stages of winemaking.

All handling and bottling equipment and procedures must be designed to minimise contamination or modification of the wine. Barrels may be cleaned only with water, and sulphur dioxide should only be added to empty barrels in gaseous form.

Organic wines must be free of residues of materials not allowed in the regulations governing grape growing and winemaking for organic wine and the wine must also meet the relevant Australian food standards.

The winemaker must keep detailed records of all winemaking activities, transfers and additions, and details of storage vessels used.

Winery and bottling facilities must be inspected and certified by an accredited organisation before being used to produce organic wine and the winery or section of a larger winery used for organic wine should not be used for conventional wine production. Organic wines should be kept separate from other wines. Inspectors are likely to be needed on-site when organic wine is bottled. Unfortunately this can add to the cost, making the certifying of organic wine more expensive.

Winemakers must be prepared to also submit to subsequent inspections to ensure compliance with regulations and provide samples of wine for analysis as required.

Quality

The quality of the grapes determines the ultimate quality of the wine. There are many factors that influence both grape quality and the wine making process.

Simply described, the grape contains sugar, most of which is converted to alcohol during fermentation. The rest provides sweetness and balance. The grape also contains tannin, and a range of compounds in the skin that determine colour, taste and smell. Many of these are an interaction between variety and the way the plant is grown.

Winemakers have specific requirements for sugar content (baume), acid level, damage to berries and other characteristics of the grapes they accept. Growers need to be aware of the requirements of makers, which may be more stringent for organic wines, where quality of the fruit is considered paramount.

High levels of irrigation can produce high yields, but quality may suffer - premium wines tend to be made from low-yielding vines. Small berries with a high proportion of skins, which may be produced in unirrigated vineyards, are often favoured for quality wine production.

High soil nitrogen levels lead to high yields but too much nitrogen may be undesirable because nitrogen increases vegetative growth and possible problems of excessive shading. However, low nitrogen in grape juice can lead to ‘stuck’ ferments, difficult to overcome in organic winemaking.

Labelling of organic wine

If wine is labelled as ‘organic’ it must have been produced under approved conditions as specified by the certifying body referred to on the label. This implies that the organisation concerned has inspected the vineyard and winery and certified them as Organic Level A. In many cases the wine making process is not certified and wine is labelled only as ‘made from organically grown grapes’.

The standard wine industry conditions apply to organic wine. The Australian Wine and Brandy Corporation can conduct audits to ensure that wine meets these standards and is true to label.

6.10 Yields and Costs

Yields

Growers entering the industry will benefit from some indication of relative yields obtained under organic conditions. Only limited data is available. The material presented here is derived from several people and may give an indication. The actual yield you can or should obtain depends on growing conditions, varieties and use. It is also very much determined by the amount of light the vines and grapes are exposed to.

The table below compares yields from organic and other grapes grown at Clare in South Australia.

Comparison of organic and conventional yields (1992-98)

	Organic t/ha	Conventional t/ha
Cabernet Sauvignon	8.8	8.30
Chardonnay	10.7	11.4
Merlot	8.9	10.7
Shiraz	7.7	8.3

From Allen, Wendy (1998). Southcorp, Clare, SA.

The table indicates a small reduction in yield for the organic grapes, except for Cabernet Sauvignon

Costs

Costs will also be important to new grape growers. The information presented is a limited indication; this document is not designed to develop financial plans and has not gone into detail.

There is an increased cost in organic viticulture because of increased labour inputs as a result of the organic status.

Results reported from Southcorp indicate the following:

Cost comparisons	E Block organic	F Block organic	A and C Blocks conventional
Total costs per ha	$7,801	$6,407	$5,124
Total cost per tonne	$998	$892	$490

Costs taken from the 1996-97 financial year. Materials and labour 65 per cent, overheads 35 per cent of costs.

Zuur (1989) indicated five per cent extra labour and yield 15-20 per cent lower for organic compared to conventional vineyards.

Dabbert and Oberhofer (1990) indicated labour cost to harvest was about the same for conventional and organic, but higher for hand harvest compared to machine harvested conventional.

6.11 Research needs

The project collated research needs as identified by organic growers. In addition the following summary of research needs identified by Kerry Ward of the Organic Vignerons Association of Australia are listed.

- The use of rootstocks to reduce chloride and potassium residues in export wine.
- Development of methods for the control of vine vigour and water use optimisation based on the concept of heterogeneous rootzone hydration.
- Sustainable viticultural production optimising soil resources.
- The role of inter-row ground covers to improve the management and sustainability of Australian vineyard soils. (Being done.)
- Integrated management of Botrytis bunch rot and Light Brown Apple Moth.
- Screening of cruciferous crops for glucosinolate (nematicide) levels by HPLC chemical analysis and field assessment in Semillon plantings (CSIRO).
- Non-conventional control of powdery mildew (work by Trevor Wicks *et al*.).
- Optimisation of vineyard spray application technology through integrated testing and evaluation (work by Keiran Murphy *et al.*).
- Review of Integrated Pest Management adoption.
- Biological and chemical control of Eutypa.
- IPM from research to practice (workshops in last few years).
- Restricted deficit irrigation demonstration project.(some work in WA).

The same needs were listed during this project. Others raised include:

- Poultry for insect control (some trials in WA).
- African black beetle control (some trials in WA).
- Nutrient sources.
- Disease tolerant varieties.

Jason Alexandra and Rod May have been carrying out an investigation on research needs in a range of agricultural commodities. One of those is Wine Grapes. The RIRDC report derived from that work should be consulted for a more detailed look at this aspect of the industry.

6.12 Conclusion

The report 'Organic Grape and Wine - Production Guidelines' indicates that it is possible to successfully produce organic grapes and wine in most wine growing parts of Australia.

However, attention must be paid to location to help make the management of disease, insects and weeds effective.

Growers should aim to produce premium wine to ensure good returns at reasonable prices. Variety selection will be a major factor.

The type of trellis and pruning management needs to ensure excellent sun penetration and air flow.

Diseases can be managed adequately by a small range of products but supported by a holistic management system.

Nutrient management is based on composted and naturally occurring material.

All winemaking requires good hygiene and limited contact with air but this is especially important for organic wines.

Yields can be as high as in conventional production systems, but are generally lower.

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Table 1. Organic winemakers and viticulturists

There are a number of organic wine grape producers and winemakers in Australia. This list has been derived from publicly available information and is not claimed to be complete.

Southcorp - Penfolds Clare Valley, NASAA

Glenara - Adelaide Hills, South Australia, White and Red, OVAA

Settlers Ridge - Margaret River, Western Australia, White and Red, NASAA

Robinvale Wines - Robinvale Victoria - Demeter

Martins Hill Wines - Mudgee, New South Wales, OVAA

Cassegrain Vineyards - Port Macquarie, NSW (Chambourcin), BDRI, Demeter

Temple Bruer - Langhorne Creek, South Australia, OVAA

Botobolar - Mudgee, New South Wales, (no longer certified)

Jeanneret - Clare, South Australia

Serventy Wines - Margaret River, Western Australia, NASAA

Rosnay Organic Vineyard - Lachlan Valley, New South Wales (OVAA in Conversion)

Highbank - Coonawarra, South Australia (organic grown)

Eden Ridge- Mountadam wines, Eden Valley, South Australia

Wilkie Estate - Penfield, South Australia OVAA

Wynns Wines - Various States, OVAA

Table 2. Approved winemaking substances

The following tables have been reproduced from The Organic Vignerons Association of Australia Manual.

Allowed additives and processing aids for the production of organic wine in Australia.

Activated carbon	Malic acid
Argon	Membrane filters
Ascorbic acid	Milk - skim
Bentonite	Milk - whole
Calcium alginate	Mistelle (fortified organic grape juice)
Calcium carbonate	Nitrogen
Cane sugar (for sparkling wine and vermouth)	Oxygen
Carbon dioxide	Oak pieces
Casein	Pectolytic enzymes
Citric acid	Potassium caseinate
Concentrated grape juice (organic)	Potassium carbonate
Copper sulphate	Potassium hydrogen carbonate
Diammonium phosphate	Potassium metabisulphite
Diatomaceous earth	Potassium tartrate
Egg white	PVPP
Evaporated milk	Silicon dioxide
Gelatine	Sulphur dioxide - gas
Grape alcohol	Sulphur dioxide - aqueous
Grape juice - organic	Tannic acid
Ion exchange resins (inert)	Tartaric acid
Isinglass	Thiamine and other vitamin supplements
Kaolin	Water (to a maximum limit of 3 per cent for mixing additives
Lactic acid	Yeast
Lactic acid bacteria	

Allowed processes for the production of organic wine in Australia

Setting	Heating
Centrifugation	Filtration with approved media
Chilling	Treatment with inert gas (blanketing, sparging)

7. Oranges - A Production Guide to Growing Organic Oranges in Australia

Gerry Parlevliet
Organic Farming Project, Agriculture Western Australia

Thanks to the many growers and industry development officers who have given their time to discuss their ideas and operations. In particular Murray and Dianne Mutton at Cadall SA, Humphrey and Michelle Howie, Renmark, South Australia, Peter Matthews, Murray Valley, Victoria, Peter Neaves, Supply Manager, Mildura Juice, Mildura, Glen Chislett, Boundary Bend Victoria, David Madge at Sunraysia Horticultural Institute Mildura Vic, Jan Denham and Robert Ridgewell in NSW and Gavin Fround, Development Officer, Agriculture Western Australia, Midland, WA, Mike Perkins, Planet Sales, Perth, WA. I also acknowledge the contribution from participants at workshops around Australia.

7.1 Background

Organic oranges have been identified as a potential commodity that can be produced in Australia.

Agriculture Western Australia and RIRDC have conducted an assessment of world markets during which a series of commodities were identified as having potential in Australia. The reference panel assisting the project specifically gave organic oranges a high priority. The project has therefore developed this report on production of organic oranges to help new and existing producers. The document is not able to provide detail for each and every farm in Australia but is designed to provide growers with some basic information from which to start. New growers are encouraged to talk to consultants and other organic citrus growers when planning their own operations. Growers are also encouraged to take advantage of the vast amount of knowledge on many issues held by conventional growers and consultants.

7.2 Introduction

Citrus has its origins in the warmer areas of Southern China and other parts of South East Asia. Traditionally citrus is grown in the Mediterranean, USA, etc.

Oranges and other citrus are currently grown commercially in a limited number of areas in Australia. Citrus generally prefers warmer frost-free areas. However, availability of water has encouraged citrus production in inland areas such as the Riverland in South Australia and Sunraysia on the Murray in Victoria. Other areas are on the west coast of Western Australia, northern NSW and southern Queensland.

7.3 Markets and market trends

World production

World production of conventional oranges is dominated by the USA, which in 1994 had over 7 million tonne annual production. The Mediterranean counties (including Israel, Italy, Greece, Spain, Turkey, Morocco and Egypt) produce a combined 11 million tonne. Other big producers are Mexico (2.5 million Tonne), Chine (4.7 million tonne), Brazil (1.3 million tonne). Other producers include Argentina, Venezuela, South Africa and Australia.

Markets

The market for Australian organic oranges is strongly influenced by international supply trends and prices. Oranges grown in Australia are supplied to domestic and export markets as fresh fruit and as juice.

For the future expansion and development of the organic orange industry, the industry needs to recognise the driving forces behind the market and be demand led to survive. Growers or their agents need to plan for trends, both in the organic industry and also the conventional market.

In 1999 the prices for juicing fruit was influenced by the increased impact of citrus canker in the Brazil crop; and by the fact that growers in the Murray Valley have been replacing Valencia trees with grapevines.

Fresh fruit, particularly Navels but also some Valencia, has been exported to Europe predominantly by 'Organic Connections'. Experience has indicated that the European market is not as reliable as the USA market for price.

Organic citrus growers in some localities have been grouping together to get quantity for export. There are also benefits in working with wholesalers/exporters to get volume and range. This has occurred in both Riverland and Murray Valley.

The major supermarkets influenced the domestic market during 1999 by their interest in organic fresh and processed product. They have directly or through agents canvassed growers to supply product. However, volume is limited and growers have been keen to maintain loyalty with previous buyers. There appears to be demand in various markets but supply is limited.

Both juicing companies and bottlers have found it difficult to get adequate supply of oranges for juicing. Concentrate is imported from other counties such as USA for converting to orange juice in bottles.

7.4 Organic standards, requirements and certification

This section describes in general terms the requirements for organic certification relating to orange production.

The organic farming industry maintains a certification system to protect both consumers and producers from spurious claims that products are 'organic'. The certification system verifies that products are organic. Importing countries place great importance on the credibility of the certification system.

Grower supported bodies carry out certification. The Australian Quarantine Inspection Service (AQIS) accredits these certifiers for export purposes. Contact details of the AQIS-accredited certification organisation are provided in Appendix 1. Not all of these certifiers are involved in certifying citrus production or processing. Discuss with them your needs to determine which is most appropriate.

Certification for orchards

Comprehensive record keeping is required and regular inspections are carried out to ensure that the standards for certification are met.

Organic certification takes into consideration the whole farming system of the property. It requires a farm plan, map and an approved record keeping system. The grower must demonstrate that he or she understands organic farming principles and prove that an appropriate system is in place and operates in compliance with organic standards. Sustainable crop rotation and strategies to maintain soil fertility, control weeds, pests and diseases and provide water management are typically required.

Certification as 'organic in conversion' may be achieved in one year, following inspection and verification of compliance with organic standards. Full certification as 'organic' may follow after a minimum of three years of verified, full compliance with standards. It may take considerably longer than this to meet the strict standards laid down by certifying bodies.

High levels of chemical residues in soils from previous land use can disqualify land from organic certification, as can excessive contaminant residues in plant tissues.

Buffer zones and windbreaks installed to an approved standard can be required to protect certified areas if there is a risk of contamination from adjacent properties. Organic farmers are advised to seek the cooperation of neighbours who use chemicals on adjacent properties.

Part certification may be possible where part of a property is converted to an organic system while the remainder is farmed by conventional methods.

There are penalties for failure to maintain organic standards or breach of rules of certification. This may involve cancellation of certification or reversion to an earlier stage in progress towards certification.

Sequence for certification

A new organic grower may need to follow this generalised sequence of steps to achieve certification.

Practices questionnaire: Following application to the selected organisation the grower receives a farm practices questionnaire seeking details of practices followed over the previous three years. Varieties, blocks and details of trees on each block are required. A sketch map of the property is required as an aid to inspection; map features must be able to be related to the producer's records and the map may be required to indicate use of adjacent holdings. The questionnaire is up-dated each year to provide an annual record.

Site inspection: A site inspection is then carried out during the year. An inspector normally takes samples for soil and tissue testing. The purpose of the inspection is to verify claims made in the questionnaire and to ensure that the applicant understands the principles of organic farming. The inspector may recommend further testing or analysis. At subsequent annual inspections the operator must be able to demonstrate that organic systems are being used.

Third party inspections: Some properties may be subject to inspection by AQIS representatives as part of the regulation of certifying bodies. The inspections ensure that Australian and international standards for organic products are being met.

Statutory declaration: The grower may need to complete a statutory declaration stating that the oranges have been organically grown.

Checklist: A check list and approval form attached to the annual questionnaire becomes the covering document for subsequent action and approval. Certification as 'organic' or 'organic in conversion' is then issued.

Record of practices: A record of farm practices for each financial year is required and provides the annual update for the orchard. This is the basis of the organic farm plan, which must be adhered to.

Random testing: Certified products are subject to random testing for chemical or heavy metal residues.

7.5 Starting an organic orchard

There are a number of ways to start an organic orchard. The choice depends on the grower's specific circumstances. Generally however, it either involves starting with an existing orchard and converting it from conventional management systems, or establishing a new orchard on organic principles.

Conversion of existing conventional orchards to organic

Existing citrus growers intending to convert to organic production need to analyse their current practices against the certification standards. Then develop a low risk conversion process. However keep in mind some of the comments made by people who have converted.

Quotes from grower who has converted:

"Go into conversion slowly; be prepared for soul destroying moments when things get too much, e.g. weeds".

> *"Started organic in 1990 - I was already using low levels of inputs. It has been stressful - biggest problem is setting up changes. Need to build up organic matter, this is slow part".*

The system will depend on local requirements and risks but it is likely to include making sure there is a cover crop established containing legumes to provide nitrogen for the trees.

If the existing orchard cover crop is in poor condition then the area between the tree lines needs to be cultivated to control grass and weeds. Applications of organic nutrients need to be applied; these could include compost, dynamic lifter, blood and bone or guano.

The grower also needs to do a risk assessment plan for pest, disease and weed threats on their orchard. This will then enable the grower to monitor for potential outbreaks and formulate preventative strategies. It is important to learn about the life-cycles of the likely insects and disease; the possible biological or organically acceptable sprays available; and the cultural ways to prevent these problems. Growers may need to invest in specific cultivating, mowing or slashing equipment.

Water quality is important in all orchards. The grower may need to ensure that he is aware when water quality deteriorates to unacceptable levels. This particularly applies to some South Australian growers with access to the Murray River. Water quality may become too saline for safe use. Improving application efficiency, by use of drippers or low throw sprinklers during all or part of the growing season, can reduce costs significantly and make the organic enterprise more viable.

Growers converting to organic should also ensure they have an adequate buffer around the block to prevent spray drift from neighbours. Their neighbours should also be advised of the change to organic status.

There are many more considerations but these will be discussed in following sections.

Establishing a new organic citrus orchard

There is more flexibility if you have not yet purchased land for the new organic citrus orchard. If there is a farm with suitable sites and already has organic certification, that may reduce the time needed to become certified. However since full production of the orchard will take several years the normal certification process is not likely to reduce income. Alternatively, if the site needs to be treated to kill hard to manage weeds using conventional chemicals this may also be appropriate. However keep in touch with your certification organisation when making these decisions.

Selecting orchard sites

Look for warm areas that have good water supplies. Soils need to be well drained and generally of high capability. Citrus is not going to do well on poor soils, especially if nutrient inputs are limited. Existing citrus orchards in an area are a good indicator of an area's capability for the industry. Where there is a risk of frost, ensure the site has good airflow to remove cold air.

Isolated sites may be an advantage for prevention of spray drift or movement of weeds and insects. A buffer between conventionally managed properties and the new organic orchard is desirable. Existing windbreaks may help in frost or wind susceptible locations.

Varieties

There is no suggestion that specific varieties are more or less appropriate under organic systems. Existing organic orange producers consider that the right variety and rootstock for new plantings need to be decided on factors such as location, market, profitability, soil, water quality, previous history, likely soil disease and insect problems and management needs.

Choice of rootstock can influence yield. New growers should obtain local guidance for variety and rootstock decisions. Local advice on all these issues should be obtained before committing to your planting or reworking of trees.

The range of varieties and types of citrus that could be planted on any one property depends also on the intended scale of the operation and markets for the product. Many growers like to establish a wide range to reduce peak workloads and to satisfy the needs of their buyers. Others specialise in one or two varieties or types.

Replanting orchards in old citrus land

Citrange rootstock provides some benefits and tolerance to citrus nematodes - this is present in Sunraysia.

Establishment

It is important initially to remove any hard to manage weeds. Mostly this involves cultivation with discs and rotary cultivators. In some cases growers have resorted to products like glyphosate to control weeds before entering the organic certification process.

Temporary or permanent wind-breaks are planted if required. Ensure they are high enough to protect the young plant from wind damage. Rows of tall Bamboo, Banyan Grass or Elephant grass, as well as a range of other species, are used. These are then removed after four to five years.

Tree lines are mostly ripped before planting.

The grafted plants are planted in well-prepared holes that can contain compost, blood and bone or other nutrients.

Mostly the young plants are protected from sun, frost and insects by painting with white paint and or have foil wrapped around the stem.

Compost can be placed around the young tree to provide nutrients and act as mulch for weed control. Additional lucerne mulch is also used.

Repeat application of nutrients often to ensure the young plant grows actively and is not stunted.

Irrigation systems vary in different locations but there is a growing trend to in-line trickle systems attached to a wire running 15 cm or so above the ground down the tree line. Trickle provides young plants with sufficient water and avoids the high capital cost of overhead sprinklers. Low throw sprinklers are also often used. They have some advantages in watering the inter-row cover crops. In many areas, especially where frost occurs, overhead sprinklers are considered essential (for frost control, also for some disease control) and are added at a later stage when trees are bigger.

Inter-row cover crops are planted in most new orchards. Lucerne is commonly used. This also makes good mulch under the tree when it is slashed.

Some hand weeding is carried out under the young plants to prevent competition.

Spacing

Organic orange growers have similar choices to make about tree spacing when they plant new areas as do conventional growers. The decision is generally made for them in old established orchards. There are no organic specific issues.

Old orchards are generally about 24'x24', with some suggestion that this is too wide for sprinklers. Other growers have suggested 24'x12' is a good spacing. Others suggest that with navels 12'x6' is okay. For Valencia, which is more vigorous, this is too close. Generally the closer the planting the more hedging and pruning required in future years. Nutrients need to be kept up to the trees at close spacing.

7.6 Management guidelines for organic oranges

Nutrient management

Management principles for organic production focus on developing the soil organic matter content and the microbial activity in the soil. However from time to time it may also be necessary to correct deficiencies.

Soil monitoring for nutrients; petiole or leaf analysis

Good nutrient management in orchards relies on the grower knowing what the status of nutrients is in soil and plants. This suggests regular soil and plant testing.

Trace elements

Organic orange growers regularly apply trace elements as required. These include Copper, Zinc, Manganese and Magnesium, mostly as sulphates. Practices range from mixing in compost to 1-3 applications by foliar spray. Sprays may include oils. Timing coincides with anticipated needs, e.g. first flush.

Macro-nutrients

Nitrogen is important to organic citrus growers and they obtain this by both use of cover crops and extensive use of compost. Compost is often applied directly around young trees, whereas on older trees the compost is broadcast. The compost feeds the cover-crops as well as the soil and trees. Growers generally consider compost an essential input. It may, in some cases, be supplemented by specialised proprietary products such as 'Complete Organic Fertiliser', fish emulsions, rock dust, dried blood, bone meal and their equivalents. Some of the Blood/Bone products have been applied to get quick responses when nitrogen deficiency has been detected. Rates of up to 150-200 kg/ha have been used.

Organic growers are utilising any available approved input for compost making. These include: local animal manure, grape marc, pig manure, chicken farm waste, cattle feedlot manure, saw dust, orange waste. Additives include reactive rock phosphate as a P source and brown coal dust as a carbon source. Growers on some light river soils in Victoria apply mixtures of compost and grey flood plain clay to improve soil water holding capacity. Grape marc is seen as a good K source.

Material	N kg/tonne	P kg/tonne	K kg/tonne
Winery Marc	16	3	28
Fowl manure deep litter	25	12	15
Fowl manure (cage)	40	30	16
Blood and bone	40	40	-

These materials are variable - lab test before relying on it (Coombe and Dry 1992).

Varying rates of compost are used, often triggered by cost considerations rather than nutrient content. Ranges are from 250 kg/ha every 2 months through 12 t/ha to 20 tonne/ha. Source and composition of inputs will somewhat determine the rate. Timing ranges from frequent to one application in July.

Many producers make their own compost from locally sourced inputs. Others buy in commercially produced compost, some of which is in pellet form. In either case the producer needs to understand its composition and likely effects on the soil and the citrus tree. Soil tests, compost analysis and a good nutrient budget for the farm, which recognises the amount of nutrient exported from the property, are essential. Low nitrogen compost may cause poor fruit quality.

Growers have been finding reduced levels of P in plant leaf samples and are using reactive rock phosphate as a way of creating long term replacement P.

Biodynamic producers use special preparations to stimulate soil as well as compost.

Some soils need adjustment of pH either because they are too high or too low. Soil tests will indicate this and local knowledge will indicate the rates of lime or organic matter required to bring it into a reasonable range. Citrus like a soil pH of around 6-7 (in water).

Some example prices:

Material	Location	Approximate cost/tonne
Pig manure compost	South Australia	$70
Cattle manure	New South Wales	$15
Chicken manure	Victoria	$40
Dried blood	South Australia	$750
Bone meal	South Australia	$400
Complete organic fertiliser	Victoria	$300

Some suggestions for a closed production system included using parts of the property to grow material for compost production and running animals to complete the nutrient cycles. This is generally in line with the intent of the organic certification requirements.

Using compost in horticulture

(Contributed by Aileen Reid and Bob Paulin, Agriculture Western Australia. 1999.)

What is compost?

Compost is a friable dark brown product that has a characteristic earthy smell. The term compost tends to be used to describe several products that may or may not be composted, but should only be used where the product has been through a controlled process of microbiological degradation. Simply leaving a heap of material in a corner for weeks or months does not constitute composting.

Composts suitable for soil incorporation are usually fine. The coarser grades of compost, often those made from greenwaste or other woody materials are more suitable for applying to the soil surface in a layer (i.e. use as mulch) and may provide additional benefits to mulch, which has not been composted.

A wide range of ingredients can be used to make compost. Carbon is provided by materials such as straw, greenwaste (tree and garden prunings), paper and wood. Nitrogen is usually provided by animal manure (pig, chicken), as well as vegetable and food wastes. These are blended to produce a carbon to nitrogen ratio of between 20 and 40 to one.

There are many ways to make compost, from relatively simple and low cost mechanically turned windrows to much more capital intense in-vessel systems. Regardless of the process, composting requires the materials to be uniformly mixed, moisture content maintained in the range of 50 to 60 per cent, adequate oxygen levels and temperatures between 50 to 70^{o}C in the centre of the pile.

What are the benefits from using compost?

Composts supply organic matter to the soil. Over time, both during the composting process and after addition of the composted organic matter to the soil, micro-organisms work to transform this organic matter into humus. These materials improve soil structure, soil aeration and water retention. They also provide a source of nutrients that is both slowly released and readily available to the plant, unlike artificial fertilisers that can be easily leached into the groundwater.

Soil microbial populations also change and numbers of beneficial bacteria and fungi increase allowing plants to better withstand attack from pests and diseases. These changes allow crops to be produced with less fertiliser, pesticides and irrigation; and have the potential to help address growing world-wide food health and safety concerns. By helping toward 'cleaner, greener' food production, the use of compost has the potential to increase exports as well.

Continuing horticultural development also needs continued access to soil and water resources that are becoming increasingly scarce, particularly in areas of large population and or increasing environmental concerns. Compost may help maintain this access by reducing contamination of these resources.

Finally, by transforming large quantities of waste material into compost that can be used in crop production, horticulture will contribute to achieving landfill reduction targets.

Using compost

Compost has application to all crops and the extent of its use will be a matter of cost considerations. Based on typical fertiliser pesticide and irrigation costs for vegetable crops on the Swan Coastal Plain, a one third reduction in these costs will pay for a 20 t/ha application at current prices of around $40/tonne delivered. However this is a simplistic view. Many of the benefits from compost are indirect, developing over time and with repeat applications and so it may take several years for the full economic benefits to be realised. We currently believe that in vegetable production, cost savings for a 20 tonne/ha applications should be readily achieved within four to five consecutive compost applications.

Application rates

For vegetable crops, 20 t/ha incorporated before planting each crop seems to produce good results although beneficial results have been found with applications as low as 12 t/ha. Rates are normally quoted as 'wet' rates. Most well made compost is about 50 per cent moisture, which allows for maximum biological activity. Australian compost standards require compost to have moisture contents above 30 per cent.

Early work also indicates that 5 to 10 litres of mature compost incorporated in the planting hole of tree crops will improve establishment and tree growth.

Mulches, 30-50 mm thick around the base of perennial tree and vine crops will help to conserve soil moisture and reduce soil temperature and weed growth thus contributing to improved crop growth and yield. Results, largely from work by John Buckerfield in South Australia have demonstrated that these improvements are significantly greater if the mulch is composted.

Application frequency

The best principle is to apply smaller amounts on a more frequent basis. Many of the benefits of compost are long term and develop over several years with repeated applications.

For vegetable crops, apply pre plant before seeding or planting each crop, at least in the first 3 to 4 years. This can be before incorporating a cover crop where one is used, or the residual crop after harvest, providing the establishment of the next crop is imminent.

Apply as mulch to perennial crops every three to five years or depending on the rate of breakdown.

Possible problems

Overseas reports indicate concerns regarding compost that is made from highly mixed urban wastes. They may not perform as well as composts from separated wastes sources. They can contain various contaminants, such as: heavy metals - from industrial wastes, batteries, etc. and chemicals and compounds that do not breakdown or that degrade to plant toxins during the composting process.

Compost maturity will affect crops and as a rule only matured compost, either made from predominantly non-woody sources or that have been screened to remove woody material that has not been degraded by the compost process, should be incorporated in the soil prior to crop establishment. This applies equally to planting of tree and annual crops. There are two reasons for this. Large woody particles will continue to degrade in the soil and potentially use nitrogen that would otherwise be available to the crop. Secondly, large particles of wood (or other materials) may adversely affect seed germination or root growth of the crop.

Coarse immature compost that contains a high proportion of woody materials should only be applied as mulch to established perennial crops.

Compost quality

There is an Australian standard (AS 4454-1997) which has been designed to ensure that compost meets certain minimum requirements. This is to ensure it is not contaminated or is harmful to plant growth. The standard, however, is voluntary and does not aim to make statements concerning the products contribution to plant growth.

Growers should ask the supplier for evidence that the batch of compost being purchased complies with the standard. Growers should also feel free to ask for additional information such as: what has the compost been made from, and the nutrient (nitrogen, phosphorus and potassium) content of the compost, however it should be realised that compost is not a replacement for all fertiliser and does have other benefits as stated earlier.

Changes to management practices

If fumigation is involved, ensure that it is completed and that excess fumigant has had time to escape, before applying compost. Failing to do this will result in the beneficial micro-organisms in the compost also being killed. Apart from that there are no additional operations required when using compost.

Before applying compost, carry out a soil test. If you have high levels of available phosphorus and potassium, reduce these components of your fertiliser program to allow for the contribution that compost will make. At this point in time, you should assume that both

phosphorus and potassium availability from compost will be similar to that from the common fertiliser types used.

If lime is required to raise the soil pH, then this can be safely applied with the compost and the manufacturer may be able to mix them prior to delivery, saving on spreading costs.

As you re apply compost to subsequent crops you can and should experiment with reducing your overall fertiliser program, probably by around 10 to 15 per cent after the first application and by similar amounts following continued, repeat compost applications until you have reduced the overall rates to around 40 per cent of your original fertiliser rates. Agriculture Western Australia's developing research program aims to further define these limits.

More information on compost?

There are numerous sources of written information - the internet, consultants working with compost products and manufacturing technologies, and compost manufacturers. Be on the lookout for bias and try to seek information from more than one source. Use your own peer network (e.g. other growers) to cross reference information sources.

Organic growers should confirm that the product purchased is approved for use by their organic certifier.

Cover crops

Existing organic citrus producers generally use sod culture or cover crops as part of their management. The continuous vegetative growth between trees functions as an important part of their biologically active system. This system is made easier by the availability of good supplies of water.

However there is a vast array of individual systems in place with no single system being the most appropriate. There are some essential features that new and existing citrus growers can benefit from. The increasing interest by the conventional horticultural industry is resulting in research and development work on this topic. Knowledge can often be transferred to organic citrus production.

The design of the cover crop composition and management should incorporate the many elements growers need to influence in their orchard.

Cover crops are used to provide organic matter, nitrogen, bulk for mulch, erosion control, feed for stock, dust management, weed management, cooling, water absorption, as well as host habitat and pollen for beneficials.

However cover crops can also host unwanted insects, compete for moisture, reduce frost mitigation and require increased labour for irrigation and control.

To balance these requirements and benefits means organic citrus producers need to understand their environment and the properties of the species they introduce into the orchard.

Organic citrus producers in SA, Victoria and NSW have had some experience with this complexity.

Lucerne has been used on a number of properties to provide nitrogen, bulk and weed control with variable results. Stands have not survived for some growers as well as they would have

liked, others have noticed an impact from high water use on the trees. Lucerne may need regular resowing to retain densities. Over time, weeds and undesirable grasses may invade. This may require a program of resowing on a three to four year cycle.

All growers recognised the need to use legumes for nitrogen; they obtained this in different ways. Some sow annual clovers or a local mix of seed. Others use a summer active mix - 'white clover, strawberry clover, lucerne, medics, oats for bulk and feed for geese - soil is high pH'; or, 'a mix of langudoc vetch, harbinger, paradosa, snail clover, Haifa white, barley (barley for disease control)'; or, 'use lucerne, balansa, Vic/NZ White, Palestine and Strawberry (is hardy)'.

Maintaining the cover crop is equally important as planting it in the first instance. The different mixes and varieties will have different water, nutrient and mowing needs. Slashing lucerne hard to the ground to maximise bare soil for frost control may damage its survival. The slashing may not be necessary if an automatic overhead sprinkler system is set to turn on. Mowing clovers at flowering is likely to reduce seed set and require more frequent resowing.

In severe frost prone areas without overhead sprinklers, growers may find it necessary to grow annual green manure crops which are cultivated in and rolled prior to frost occurrence. This helps to maximise heat in the system.

A balance is therefore necessary between keeping the cover crop down and ensuring survival and soil development.

To get good growth adequate nutrients need to be supplied to the cover crop. This is discussed in the section on nutrition. It normally includes compost applied to the cover crop.

Good weed management is important prior to sowing or resowing cover crops. This may mean some fallow period, or repeat cultivation to remove hard to control weeds such as couch.

Sowing should occur during the time most appropriate for the mix. This may be early winter for annuals or in spring for summer active varieties. The seeding operation should be done in such a way as to ensure successful emergence. Monitoring of germination would help determine success. Selection of insect tolerant species may be useful.

Organic systems rely on the soil improvements and other benefits provided by cover crops. This will necessitate buying in the right varieties in adequate quantity as required. Inadequate nitrogen will generally hold citrus back.

The Grape and Wine Research and Development Corporation and SeedCo in South Australia have produced a useful leaflet 'Cover crops - A guide to species selection and sward management'. This is customised for various States and may provide citrus producers with some guidance.

Wind breaks

Growers and specialists agreed that shelter belts or windbreaks are important - fruit exposed to wind can get blemished and its value in the fresh fruit market drops.

Windbreaks can have multiple functions including providing a haven for insect eating birds and a source of pollen for beneficials. In dry areas drainage water can be used to irrigate the

trees. Some management such as root pruning the windbreak may be necessary. In new orchards planting the windbreak ahead of time is important to protect young plants. Some growers use tall grass (e.g. Banyan) in the first few years.

Frost management

Frost is a major issue for citrus growers in some inland areas such as the Murray Valley in Victoria. Growers have different ways of managing the impact. However the preferred method is to use overhead sprinklers to apply water. Some systems are fully automated; temperature is monitored and uses sprays automatically by controllers. Others need to do this manually. In many cases growers have both overhead and drip systems. They use drip for water efficiency and the overhead purely for frost control or cover crop watering.

Generally growers also try to keep the grass or cover crop slashed down hard and the soil kept moist to improve the orchards chances. The bare moist soil retains heat in the orchard.

In areas where it is possible, selecting sites that allow good air drainage will help reduce frost risk. In some situations shelter-belts can also help.

Insect management

Organic citrus production by its very nature relies heavily on biological control to manage insect problems.

Organic production systems are managed to maximise the development of naturally occurring predators and parasites. Careful observation and monitoring of insect and predator numbers is important to minimise intervention with other control products.

Many organic citrus growers find that, with the establishment of an organic system, problem insects are kept in check by encouraging spiders, ladybirds and other predators. Production factors that encourage this include the retention of flowering plants, to act as reservoirs, for holding predators over from one season to the next. In some systems alternate rows of cover crops are mowed to ensure predator populations are not reduced significantly. Retaining pollen-producing grass like Rhodes has been shown to help some beneficials. The absence of chemicals allows spiders and other predators to build-up in number.

The professional organic citrus grower also introduces large numbers of specific predators to ensure populations are adequate. These may be re-introduced from time to time depending on seasonal conditions or other needs.

Specialised consultants are used in some states to monitor numbers and advise on predator releases. Knowledge of insect and predator life cycles allows management options to be predicted but the monitoring ensures actual situations can be managed.

However, if some insects get out of balance controls such as oils, soaps and Bt, are used.

Growers in the Riverland and Murray Valley have generally not reported significant insect problems. This appears to be partly due to the organic system and releases of predators. Comments about local conventional growers also not spraying suggests that some of these areas have low insect pressure.

An issue for organic growers is the regulatory requirement for fruit fly, i.e. bait spraying they need alternatives (fibre board with bait solution hung up). Growers need to plan for fruit fly.

Specific insects reported and management options used include:

- Light Brown Apple Moth - Dipel (Bt).
- Aphids - ladybirds control - oil and detergent have been used.
- Red Scale - parasite released (*Aphystis melinus*) wasp.
- Thrips - attracted by mildew bug honeydew - one grower uses overhead sprinklers to wash trees in November (main problem is downgrading of navel oranges into juice).
- Mealy bug - Wasp release.
- Ants, weevil - trim tree skirt.
- Snail - control has been carried out using ducks, with the usual need to manage duck predators. Copper has also been used to manage snails. Pruning of tree skirt has also been suggested as a way of managing snails. (Enclosed meta dehylde baits are permitted under certification standards.)

Red Scale (*Aonidiella aurantii*) causes blemish of fruit but can in large numbers damage the tree. Generally control is by biological means. Infestations of large numbers are reduced by oil sprays before releasing the parasite *Aphytis melinus*. High temperatures can reduce numbers of parasites and lead to damaging red scale numbers. The parasite is particularly effective in spring and autumn. This may mean that some varieties are more affected than others (those that ripen late when it is hot do so in presence of more red scale). The parasite works its magic at stages of the red scale development, which means washing operations will clear most light blemish.?? The parasite is available from commercial breeders. Ants can interfere with the parasite and measures to manage ants are desirable. Dust may also interfere with the parasites.

Light Brown Apple Moth (*Austrotortrix postvittana*) can attack oranges in spring. Damage includes fruit drop, scaring and providing entry for insects and fruit rotting organisms. Control is by the use of *Bacillus thuringiensis* (Bt), available in a number of brand names. Controlling weed hosts early will reduce numbers.

There are inter-relationships between many management operations, e.g. skirting reduces snail and ant access to trees, reduced ant numbers reduces impact of honeydew producing scale and improves the effectiveness of parasites against red scale.

Native birds were not mentioned as beneficial in insect control, however windbreaks with native flowering plants may contribute to insect management.

Products such as Bt are useful but need careful targeting at the insects that are to be controlled and should only be used as a last resort. Similar considerations apply to the release of predators. Routine reliance on such control measures may indicate some fundamental imbalance in the organic production system that requires correction.

'The National Standards for Organic and Biodynamic Produce' indicate the range of other insect control products permitted (Appendix 2), these include:

Pyrethrum extract, Rotenone (Derris), Quassia, Neem oil, Ryania, garlic extracts, etc., white oil, vegetable oil, Fruit fly baits, Meta-aldehyde baits (but conditions apply).

Weed management

Organic citrus growers suggested two categories of weeds frustrate them. Firstly, problem weeds such as spiny emex, caltrop, gentle annie and spiny burr grass, most growers find relatively easy to control with labour and time. Emphasis is on physical removal and destruction to prevent build-up of numbers. Other weeds mentioned include feather top and ryegrass.

Secondly, control of the ground cover, sod, and general weeds in inter-row and under-tree strips, tend to drive most growers to distraction. This particularly focuses on the growth of weeds around pop-up and low throw sprinklers. There is a continual (weekly) need to keep them clear. Different techniques have been tried including steam and hot water but as most sprinklers are plastic this is limited. Most control is by the hand use of whipper-snippers. Pop-up sprinklers are usually inserted into the ground through some larger diameter plastic pipe to provide some clearance.

In old established orchards with healthy trees, weeds are generally not a major problem due to shading out. However weak trees allow light in and hence weeds to grow, which further weakens the trees.

The majority of weed/cover crop control is by slashing or mowing, with plant material and pruning used as mulch in situ or under tree lines. Multiple types of equipment are used to achieve this. The frequency of mowing or slashing operations is directly linked to the rate of plant growth, other control measures and impact of the plants on tree vigour.

In the Riverland and Murray Valley, control is generally at 2-4 week intervals (mostly 3-4) in summer and out to a 6-week interval in winter.

There is some need to consider establishing a system that allows mowing of alternate rows at each time to ensure pollen producing plants are retained to help maintain predator habitat.

Techniques for mowing or cultivation depend also on the position of irrigation equipment. Overhead sprinklers are mostly in the tree line but low throw sprinklers are off-set.

Combinations include:

- Side mow around young trees - conventional slasher.
- Flay mulcher includes mulching, disk mower under skirt every 3-4 weeks.
- Now use rotary hoe right next to the tree (shallow), his other equipment is then just in and out of the tree line.
- Uses rotary hoe for couch, constant working through summer, clean up as best as can.
- Mows up middle of row - slasher type drops in situ as mulch. Uses a cut down Layly mower, slides under tree skirt.
- Has three slashing techniques. Sprinklers offset from tree line and alternate, uses big slasher in middle of row, smaller between butt and sprinkler, whipper-snipper between butts.
- Side slash once a month, two runs before and after sprinkler, whipper-snip every 3 weeks.
- Under tree rotary hoe 3 feet to keep clear, finds it easier to cultivate, no damage if 50-75 mm top scratched, leaves 1 foot wide strip on which he uses a Tosari weeder (touch sensitive), throw soil and weed on centre and use blade to pull back. Has Mac weeder disc on hydraulic arm for some jobs.

Animals for weed management

Geese are used in some situations for weed management. The orchard is split into smaller units and large numbers of geese are allowed to roam free (e.g. 60 geese on 1.6 hectares for 4 weeks in one case in Riverland). They eat weeds. They are then moved to a new area. Fox control is a problem as is moving fences (Electro Mesh in one case). Permanent infrastructure in paddocks, e.g. troughs, makes the moving of temporary fences easier.

Geese have been found to be hardy and don't require supplementary feed when year round green feed is available. They won't damage trees but their use is still experimental.

Geese do not control some weed species. Growers have found that geese leave wire weed, doublegee (spiny emex), innocent weed, buffalo grass and couch. Species like medic (a legume pasture species) are also not preferred by geese and this provides some potential scope to retain groundcover for nitrogen production.

Growers have thought of using other species such as chickens and ducks (for snail control). However, the need to fence orchards into sections (both to retain the chickens, and to exclude foxes) has prevented adoption. Some research in Western Australia has indicated good insect management as well as weed control by using chickens. On smaller scale operations there have been examples of mobile chicken runs (fully enclosed wire structures of varying size on a solid frame fitted with wheels or skids). These are moved as the chickens do their job. Chickens can be very efficient and can scratch the ground bare. There is a possibility that they may expose and damage roots of young plants. Sheep have also been considered but growers have some concerns about tree damage and there were no examples provided that suggested it was practical.

It is likely that, with additional research on the use of animals, combinations of species will control a broader range of weed species. This combined with mowing can give good control.

Alternative weed control measures

On large scale operations technology such as flame, steam, and hot air weeders will be available. Hot water and steam have been used to control couch in some orchards but the cost is generally too great to use in any other than high need situations. New products derived from natural fungal cultures may also become more readily available.

On small areas of hard to control weeds solarisation has been suggested. This uses black plastic placed over the weeds, heat from the sun is accumulated under the plastic and the plants tops are killed. Sub-surface rhizomes may not be affected nor are buried seed.

Couch has been managed in some organic orchards by use of rotary hoe. Repeated cultivation during summer reduced plant density and weakened rhizomes to tolerable levels, enabling replanting of cover crops. This operation would need to be carried out every 3-4 years.

Mulch is used in new orchards on the tree line and around sprinklers. However where couch is a problem growers have had limited success with mulching.

Weed management in organic citrus orchards in the future will benefit from a growing interest in non-chemical work being carried out by research bodies. Management will, in most cases, use combinations of control mechanisms; with greater reliance on animals, use of legumes and other species that smother or have allopathic effects, with appropriate mowing.

Selecting a site for orchard planting that is free of weeds will avoid the need for chemicals at time of establishment.

Disease

There have been few comments by organic citrus growers about disease issues. A number of growers use a copper spray (Bordeaux) in autumn for septoria spot (grey spot). One grower reported he had over watered in the past and got collar rot.

Collar Rot (*Phytophthora* sp.) The fungi involved move in free water so it is more likely to occur in waterlogged, poorly drained or over watered soils. Some rootstock is particularly susceptible, e.g. rough lemon and sweet orange. Management of existing trees includes keeping weeds, compost and mulch away from the trunk. New orchards can be grown using trifoliata or Citrange rootstock as they have some resistance to Collar Rot.

Septoria Spot (*Septoria* sp.) can appear on fruit in late spring and summer particularly under overhead irrigation. The infection occurs in late autumn or early winter under light rain or dew. It then remains dormant until cold driving rain and frost cause it to grow, damage is often worst on the weather side. Removal of weak and dead wood will reduce the source. A copper spray in mid-March can help prevent the disease. In wet summers an earlier spray may be necessary. A later spray may be useful if the disease persists. Hail and frost damaged fruit could also be sprayed.

Pruning and tree management

Pruning of citrus is generally limited in both organic and conventional systems. Trimming is used to ensure sufficient space for equipment movement through the orchard, but this is generally done on alternate rows to reduce impact on income. There is some pruning to remove dead and unproductive wood. Pruning by some organic growers has been used as a crop regulator (thinning) straight after fruit-pick to ensure larger fruit size in the next crop.

The techniques used depend on scale of operation and can include handwork, but generally involve some mechanical process. Some machines imported for vine work have been used in orchards. Machinery includes: Israeli rotary 4 blade and cross arm units, bar hedgers, vine toppers.

Tree tops have been shaped but this in some cases means overhead sprinklers need to be lowered to avoid damage.

Cuttings are usually mulched during a slashing or mowing operation.

Some growers suggested that regularly hedging using a bar hedger could give a good response without damage to young fruit (bar pushes fruit out of the way).

One grower thinks he can increase yield by hedging light more frequently - but may need to use more compost. New growth has stronger flowering and fruit on young growth (but this can get some extra frosting). He has hedged Navels more than Valencia (Navel more healthy).

Some growers trim the tree skirt, for sprinkler efficiency and disease/insect management, and also fruit maturity and colour.

Skirting involves removing up to 900 mm from the bottom of the leaf canopy.

Leng and Washington Navels should be skirted between May and July before flowering. Trees compensate during spring for leaf loss. Skirting during flowering and fruit set can reduce yield by 50 per cent.

Late maturing cultivars such as Lane's Late Navel and Valencia should be skirted over two years to reduce fruit loss - half each year (Thornton and El-Zeftawi 1983).

Irrigation

Organic citrus growers need to ensure their irrigation system is using best practice. This means applying water efficiently to meet plant needs without waste. It should involve a good knowledge of the soil's capacity to hold water. In some areas, obtaining a water license for irrigation requires assessment of soil profile using pits to ensure efficient use of irrigation water.

Monitoring water application and soil status is important, as is scheduling of water replacement. Several organic orchards are on fully automated irrigation systems that include frost controls. These can be computerised and use gopher probes to monitor soil moisture, with the data being downloaded to the computer controlling the irrigation. The majority are using semi-manual systems that require manual setting of times or turn-on of irrigation lines. Both can take advantage of low cost night time electricity supplies.

Generally low throw sprinklers (pop-up and Waterbird) are used, but in many cases drip is also installed for the first few years.

In frost prone areas many growers like to retain or even install overhead sprinklers to manage the effect of frost. Overhead sprinklers are also used to wash honeydew from fruit.

Irrigation system choice is influenced by the water quality and quantity available and the need to manage frost and hot temperatures.

In areas of relatively cheap good quality water with frost risk, the preference is for overhead sprinklers. These are often established initially with low throw or trickle systems for young trees to gain some water savings.

Many growers also dislike the way they need to continually remove weeds from around low throw sprinklers. Pop-up sprinklers are often hard to find. However poor water quality, or limited water supplies, or lack of justification for frost control, forces many growers to stay with low throw systems.

Available water quality can vary dramatically depending on source. Once around 300 TDS ppm (500 EC - microseimens per cm) trees can be damaged. This particularly applies if watering during the day or in windy periods.

Growers have reported getting small mussels in irrigation pipes, requiring the use of filters in each sprinkler head and flushing of pipe-lines.

Water application rates included 40 mm per week during hot periods, and 1100 mm per year.

7.7 Economics

Scale of operation and labour needs

The organic orange producer has a lot of operations that require labour. Labour is one of the biggest costs. It is also important that the labour employed is interested in what they do. This may require some training on the part of individual growers. Time management is important. Many of the Quality Assurance and Hazard Analysis and Critical Control Points (HACCP) systems being introduced to the organic industry emphasise the need to train labour for safety, quality and efficiency.

Organic citrus growers have indicated that they can handle up to 20 hectares of organic citrus on an owner/operator basis.

Yield

Some organic growers are benchmarking against conventional growers and suggest they achieve 'no lower yield'.

Organic growers have provided a range of yields. They include:

- 40-60 tonne/ha for **conventional** growers;
- 14-45 tonne/ha (yield 55t on 4 ha, 180 tonne on balance);
- 47 tonne/ha (yields about 250 kg/tree, spacing 24'x24');
- 25-50 tonne/ha, average 35 tonne/ha;
- 30-40 tonne/ha (3/4 acre navel giving 20 bins (each 600 kg) at best. Now is giving about 15 bins);
- 28 tonne/ha (Valencia getting 30 bins from 1.5-1.7 acres);
- 8-15 tonne/ha (one batch of trees 18 yo 1.5 acres 2/3 Washington gets 10-15 bins (or 8-10 in light years (bin is about 600 kg);
- 7000 cases from 15 acres (10 acres mature);
- Valencia tougher, less variable;
- Navel flowers heavily - drags energy out of tree.

The range of yield reported suggests that there is great scope to improve production on most organic citrus orchards. Tree age, variety and vigour were some of the variables. Nutrient management would appear to be a significant factor.

Choice of rootstock can influence yield and new growers should obtain local guidance for variety and rootstock decisions.

The fruit must be clean with no mud. They can handle some waxed fruit.

Prices

Fresh

During 1998 one packer sent 23,000 cases to the USA and Europe. It was a light year in the USA, top price was $30 at shed door, and in UK was $22 at shed door. Packing cost for USA was $7 and for UK it was $6. The exporter provided growers with an agreed price for the season.

Growers also reported organic oranges getting about $20 per carton, but $5 goes to packing and carton costs.

Big Navels to USA get good prices and that results in most organic Navels going for export. Local demand is also strong, with a limited supply of Navels, and late Valencia also do well in the fresh market at good prices.

There is little market development or promotion of organic citrus.

Juice

The conventional juice market is very price sensitive. Competition comes from USA, Israel and South America - who have economics of scale and advantages with transport costs.

Locally, there is not a big market-unless hooked into large cooperative - and it is very price sensitive. There is a lot of resistance to any price increase by buyers supplying export markets. Loss of export juice markets could lead to over-supply and impact on domestic prices.

Future trends include a push for Navel fruit in fresh orange juice. Other products that can be developed include frozen product and aseptic packs.

Suppliers of organic juice report getting many enquiries, but most do not result in orders.

Export of organic juice or concentrate is relatively new. In 1996/7 Mildura Juice put out feelers to bottlers and users to build up market, successfully. This year there will not be enough fruit for the export market. Buyers have had to be put off (including 2 containers or 500 tonne fruit equivalent). For concentrate, export need is 1200 tonne fruit (mainly into Europe - Denmark and UK). The Denmark long-term market is coming unstuck because of limited supply availability. Other exports on year to year basis include to Japan.

With tonnage of fruit available for juicing dropping, the market is shrinking and it will be hard to regain.

The domestic organic orange juice market also needs over 700 tonne fruit. There are no long-term arrangements in place to ensure this supply.

The organic orange juice market is not very sophisticated. Pricing in the conventional sector tends to be related to TSS, with bonus for high TSS; however organic growers tend to be paid a flat rate, usually at a premium to conventional prices. This seems to be related to the end product price and certification rather than inherent quality. Although there is some belief that organic juice is inherently sweeter most growers and processors discount this.

Mildura Juice at Mildura, Victoria has indicated that they will continue to take fruit for juice. Quality at this time is not an issue. They contract juice for other companies. Prices in 1999 were high at about $300 per tonne (in previous years it was around $60 per tonne).

In South Australia, Nippy's have been juicing fruit for Japanese markets in long life packs and some one-litre containers.

Quality assurance and HACCP

There is some interest in adopting QA (Quality Assurance) or SQF 2000 (Safe Quality Food 2000) schemes to help guarantee fruit quality, pest control, training, quality control of on-site practices and ability to target selected markets. However with whole sections of the conventional citrus industry adopting QA and specifically SQF, organic growers will eventually be expected to provide the same level of assurance. Organic certification may not be sufficient unless it also incorporates QA and HACCP.

Many of these systems can improve returns for product and thereby pay for QA costs.

Fresh fruit quality

Growers must ensure exported material is good quality - they have had no problems (but no clear direction from market). There is some quantitative testing for Brix/Acid ratios but there are no specific organic quality parameters.

Most fruit is for the fresh market but a small amount of poor material is going to juice - about 15 per cent for some growers.

Washington Navels have been suggested as storing better.

Some growers check quality for brix and acid using industry standards. There is some debate about whether organic oranges are better than conventional fruit. There is some thought that flavour is deeper and better but many growers do not detect inherent quality differences nor see any difference in appearance.

Fruit maturity is related to location, fruit position on tree, tree age, nutrition, rootstock and weather conditions.

There are maturity standards in place in most States for domestic and export markets and will vary for Navels and Valencia. The minimum ratio of TSS (Total Soluble Solids):TTA (Total Titratable Acidity) is likely to be about 5.5 for Valencia and 7 for Navels; and minimum TSS per cent of 8 for both. These are provided for guidance only. Check you local season and State specifically.

Retaining quality in transport is important; wax is used where permitted to reduce drying in the six-week trip to Europe or USA. NASAA allows the use of Britex 701. However emulsifiers are not allowed.

There is scope for looking at reducing temperature settings in shipments to improve shelf life.

Fruit for juice - quality

The market determines the quality of the juice it requires. Generally the market has looked for juice with a Brix/acid ratio of 15+. There are some moves to widen the specification to increase the quantity of juice available from organic oranges.

Juicing plants need fruit of good sound condition. They will take almost anything except fruit that has been affected by frost. However juicers prefer high yielding fruit and pay a flat tonne rate, but prefer TSS or Brix 10. Juicing yields about 500 litre juice/tonne of fruit at about 10 Brix (finished-no floating fibre). All fruit is tested, but organic fruit is paid for on weight or volume not TSS. A price premium is paid.

Packing sheds

Packing of fruit for both domestic and export market is carried out. There are a number of certified facilities in the large citrus growing areas. Some producers pack their own fruit. To supply the export market in USA they will need to invest in wash and wax facilities.

The market will provide the parameters for the product. For the domestic market, organic fruit is often only dry brushed then packed and placed in coldstore. Smaller producers may pick only when orders are received. Maintaining a clean, dust-free property will reduce the amount of brushing required and maintain keeping quality.

For export, organic citrus can be washed and waxed. This is asked for in the USA market and in some European markets. There are other European markets that prefer the citrus unwaxed. Defining the market is therefore essential for producers as is complying with export needs. Good presentation is also important.

Cooling after packing is important to increase storage life.

When there are transport delays fruit can ripen before it gets to the market, especially if freighted long distances.

Citrus by-products

The organic citrus producers have predominantly grown oranges for fruit and juice. Waste material is an issue for packing sheds and juicers. Some waste is being used in compost.

The literature does suggest some alternatives. These are listed for illustrative purposes only. The viability of such activities have not been examined.

- Essential oils for flavouring and perfume.
- Alcohol production from waste - gin and vodka.
- Stock feed.
- Fruit flakes.
- Pectin extraction.
- Pigment from rind is reported to have termite insecticidal properties.
- Oil from seed of oranges - up to 250 kg oil per tonne of seed - suggested it can be used in margarine industry if large enough supply.

7.8 Research needs

Growers indicated several areas they would like to see work carried out on:

- Organic industry needs to find easiest way - no support activity.
- Research nutrient recycling, soil development, weed management, (California puncture weed), fruit fly options.

- Want respect from agencies, links.
- Want soil management research - systems research - species compatible, companion crops - grazing animals.
- Research - worm numbers - would like to increase - more worms with vetch.
- Research option hedge vs. wide spacing, bar vs. saw.
- Research to get soil carbon levels up.
- Look at alternatives to Copper and Zinc for disease control.
- Research in irrigation - lot of work by Agriculture Departments on water patterns and soil types, confusing thing is moisture monitoring.

Investigations by Jason Alexandra and Rod May have identified research needs for a number of agricultural commodities. These form the basis of a report from RIRDC.

Extension support and needs

Organic citrus growers indicated that they do need access to more and better information on technical and management matters. However there was also an indication that many exiting organic producers are not accessing some of the available conventional sources. This appears to be partly due to not having the time (or not allocating the time), and partly because they do not recognise those sources as being applicable or creditable. Some of this applies to the alternative of sharing information amongst other organic growers.

The increasing interest in organic products in world trade has triggered action in many State Agricultural Agencies; this is likely to lead to tailored information becoming available. The presence of the Organic Federation of Australia (OFA) is also encouraging this process particularly in the electronic media, e.g. Website development.

There are several projects, supported by RIRDC, developing organic information packages (Kondinin Farm Improvement Group, Agriculture Western Australia, Jason Alexandra and Rod May). These and others in related fields such as IPM are becoming available and will be of use to new and existing growers.

Organic growers provided some indication of their needs in the extension and information services area; comments included:

- Like to see a database for organic technical information.
- Found David Madge useful Victoria.
- Uses all other traditional sources but most organic growers don't.
- Need to spend a lot of time getting information.
- Would like to have Agriculture Departments provide service - particularly if they are interested in organic (credibility).
- Growers have problems getting together to talk to other growers.
- Some growers do not want to provide their information or are too busy.
- Extension and development - tailor information and get out to growers.
- How to get people to do Best Management Practice.
- Don't need to do a lot more but need to encourage adoption and tailoring of information.
- Information on input choice and selection.

- Information on compost.
- Collate research of organic.
- Discussion groups.
- DOOR group driven? (Do Our Own Research).
- All farmers need risk management training - develop action plans could be worth tailoring for organic.

7.9 References and further reading

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8. Carrots - Organic Production Guidelines

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8.1 Introduction

There appears to be considerable opportunity for the development of organic carrot production in Australia for either fresh or processed product. While a number of relatively small growers are successfully producing organic carrots for both domestic and export markets, large scale commercial growers have yet to realise this opportunity.

Conversion from a conventional carrot operation to an organic system may require significant change in management approach, techniques and inputs used. These changes usually take several seasons to establish and involve more than simply not using synthetic chemicals and fertilisers. Managing an organic system can require close attention to detail, and possibly more time and effort monitoring different indicators of the systems' balance. To optimise management effectiveness, organic growers tend to adopt a holistic approach when evaluating and trying to predict the consequences of any decision, especially with respect to pest, disease and weed management.

Growers may find that setting aside a small area for developing organic production is a practical way to minimise commercial risk during the transitional phase, while gaining experience and confidence in an organic management system. Motivation and commitment to the principles of organic farming - beyond the essential financial and market perspective - are regarded as key requirements for success.

Developing an organic system for carrot production is likely to also require organic production of other vegetable crops to be grown in rotation with carrots. Selection of other crops to grow in rotation with carrots can have important management implications. In addition, these other rotational crops must also have reliable organic markets if returns from developing an organic system are to be optimised.

As with conventional carrot production, maintaining a reliable supply of consistent product that conforms to buyer quality criteria is essential for developing and retaining markets. Producing carrots with superior flavour, colour and other eating qualities would be very valuable in distinguishing organic carrots from other carrots in the market. Incorporating a quality assurance system as part of the organic operation may be necessary to ensure product quality is maintained in every consignment.

Given the current small number of organic carrot growers in Australia, consistent year round supply is lacking. As a consequence, establishing new markets, both domestic or export, has been seriously hampered. There may be considerable benefit for new organic growers in forming strategic alliances with other organic growers, as a way of extending supply capability in order to capture new markets, and as a means of sharing knowledge and resources to improve management systems.

This guide aims to provide a general outline for conventional carrot growers with an interest in investing in the production of carrots grown organically in compliance with the Australian 'National Standards for Organic and Biodynamic Produce' and certified by an accredited organic inspection organisation (see Appendix 1). The material presented comes from a wide, but by no means exhaustive, range of sources including a number of experienced organic carrot producers in Vic and WA.

8.2 Market outlook for organic carrots

Opportunities exist in a number of different markets for either fresh, juice or processed carrot products certified as organically grown.

Australian market

Within Australia, most organic retail sales are through specialty health food stores and home delivery services. Demand from these existing organic retail outlets remains strong although volumes can be relatively small. As a consequence, periodic over-supply of organic carrots can occur from March to August - the main growing season in Victoria. In contrast, Australian supply can be virtually non-existent during the summer December to February period, with some product imported from New Zealand.

Renewed interest by major supermarkets to stock a range of organic products, including carrots and other vegetables, suggests an opportunity for large scale organic production. Typically, supermarkets have indicated organic carrots may best be presented in a pre-packed form, allowing easy identification by check-out operators. Establishing a good market with the major supermarkets is likely to require a reliable supply of consistent product that conforms to rigorous quality specifications. An appropriate quality assurance program may also be required.

Growers or grower groups that can provide year-round supply of organic carrots are more likely to succeed in establishing large volume markets through supermarket chains or other vegetable retailers.

Export markets

Export demand for organic carrots is evident from Japan for fresh product and a range of processed products, including juice and frozen carrot. At least one Australian grower currently exports organic carrots to Japan. Other export destinations seeking organic carrots, either fresh or processed, include several Southeast Asian countries such as Singapore, Malaysia, Taiwan and Hong Kong.

Strong demand has been reported from the United Kingdom for organic carrot and other vegetable juices. In addition, Queensland Department of Primary Industry research identifies the UK, Germany, France and Japan as target export markets for organic frozen vegetables, including carrots.

The main competitive suppliers onto world organic carrot markets include USA, New Zealand, China and the Netherlands.

The current supply of organic carrots from Australia is generally inadequate and too unreliable to capture a share of the rapidly expanding export markets.

8.3 General principles - Organic vegetable production

This section outlines the general principles that underlie organic vegetable production systems. Aspects of organic standards specific to vegetable production are highlighted.

Whole system approach

Production of organic carrots must be considered as only one component of the whole farm system. Continuous carrot cropping, or short rotations with another crop, is unlikely to be acceptable as a sustainable organic farming system. Consequently, organic carrot production will typically also involve organic production of other vegetables (like potatoes, onions, brassicas and others), as well as soil regenerating pasture or green manure phases.

Closed systems

Organic farms tend to operate as closed systems, using renewable resources wherever possible and reduced reliance on outside (off-farm) inputs as far as practical. Management strategies based on an understanding of biological cycles and other interactions are the main tools that replace reliance on synthetic chemical inputs. Organic farms can be managerially more complex, but can be less dependent on external inputs.

Sustainable cropping rotations

The intensive (land use) nature of vegetable production requires mixed and diverse cropping regimes and rotations in order to maintain and develop soil structure, optimise the use of soil nutrient pools, and minimise pests, diseases and weeds.

Within the rotation no crop of the same or similar species, family or characteristic should be planted more than twice within a five crop rotation.

In any three year period, at least one year shall include either a green manure crop, leguminous crop or a pasture ley phase. An exception to this requirement is where soil fertility and structural characteristics are entirely met by importation of composted manures. However the application of such inputs can be limited to 20 t/ha/year.

In addition, there is a preference (where practical) to include the use of livestock in the rotation cycle, for soil conditioning during fallow periods and for the supply of manures.

Plant health stems from soil health

Well-balanced, biologically enhanced soil, as determined by adequate soil organic matter, humus level, crumb structure and feeder root development, are essential components of good organic vegetable production. Plants are fed through the soil ecosystem and not primarily through soluble fertilisers added to the soil.

Conservation and recycling of nutrients is a major feature of any organic farming system. The use of mineral fertilisers should be regarded as a supplement to recycling, not as a replacement. Synthetic fertilisers, chemical pesticides and herbicides are not permitted.

Land degradation problems such as organic matter depletion, soil structure decline, compaction, erosion, and nutrient leaching must be avoided. In general, well managed soils with adequate organic matter and biological activity tend to be more resilient against most forms of land degradation.

Biological processes

Organic systems are primarily biological systems, both above and below the soil. Pest, disease, and weed control must, in the first instance, encourage and maintain natural biological processes so as to balance disease and pest problems. Preventative control measures can include:

- choice of species and varieties of crops;
- appropriate rotational program;
- mixed cropping regimes;
- mechanical cultivation;
- mulching and mowing;
- flame weeding;
- biological control and maintenance of beneficial predator habitats;
- mechanical controls such as traps, barriers, light, sound and pheromones.

Where available, the producer should use open-pollinated (non-hybrid) organically grown plant varieties, using seed not treated with synthetic fungicide.

Part certification

Growers typically convert part of a property to organic methods while continuing to use conventional methods on the remainder. However, to establish a functioning organic system, sufficient area must be converted to organic methods in order to establish a feasible organic system. Generally it is not possible to certify just one crop. Moving into and out of organic certification is also unacceptable.

Conversion

Existing conventional growers may convert part of their property to an organic system while maintaining conventional production on the remainder. Typically, this involves selecting a location with low risk of spray drift or contamination from adjacent land. Buffer zones may be required to ensure adequate separation from conventional cropping. Sufficient area must be allocated to allow for a sustainable crop rotation to be established. Some organic certifiers may require a development plan that aims to convert the whole property to an organic system within a defined period.

Spray drift

Potential sources of contamination, from spray drift or other means, can require careful consideration. Buffer zones are likely to be required between organic crops and conventional crops. Neighbours must be informed of contamination risk. Soil tests may be required to check for chemical residues in soil from previous land use.

Minimum qualifying period

The transition from a conventional system to a balanced, biologically active organic system is a gradual process. For fully certified organic vegetable production, the land must be managed in accordance with organic standards for a minimum of three years. However, growers can obtain certification as 'in conversion' to organic following one year of compliance with organic standards.

Irrigation management

Irrigation methods must be adequately managed, scheduled and monitored to reduce problems with water table, leaching of nutrients and salinity inducement. Irrigation management must minimise disturbance to the environment and natural ecosystems, including wetlands, river flow regimes and wildlife habitat.

Coexistence with, and protection of the environment

Maintaining biological diversity on and around the farm, is an important feature of organic systems. Biological diversity tends to allow ecological balance or equilibrium to establish, resulting in a more stable system with less dramatic biological fluctuations - both on the farm and in the surrounding natural environment. Areas of remnant vegetation should be protected. In addition, organic farms should ensure the avoidance of pollution and other forms of degradation resulting from agricultural practices. The use of non-renewable resources should be minimised.

Post-harvest, storage and processed products

To prevent contamination of vegetables on farm, organic product must be kept in a dedicated storage area separate from conventional product. Post harvest treatments and packaging materials must comply with organic standards.

Where growers intend to value add or process vegetables, compliance with organic processing standards is required if the final product is to be labelled certified organic.

8.4 Organic carrot production strategies and methods

This section provide a general outline of the various management strategies and techniques used by organic carrot growers. Conversion from a conventional system to an organic system is likely to involve changes to existing management and adoption of some of the following strategies and techniques.

Many of the best management practices developed for conventional carrot production are likely to also be applicable for organic systems. Efficient irrigation management, windbreaks, erosion control, and aspects of integrated pest management or integrated weed management may be adapted to suit an organic production system. In addition, quality control management systems, preferably incorporating a HACCP (Hazard Analysis and Critical Control Point) system - for example the SQF 2000 system, are likely to be beneficial.

Selecting a location isolated from potential sources of pest, disease or weed introductions is obviously desirable. Sites that are away from conventional production areas can avoid problems of spray drift and chemical contamination. On windy sites windbreaks may be required, not only to control spray drift problems but also to protect crops from wind effect and damage.

Carrots generally require free draining soils. In Western Australia carrots are almost exclusively grown on sandy soils. The sandy soil gives good straight smooth skinned root quality. However these soils have relatively low capacity to hold nutrients and water thus presenting special management problems in nutrition and irrigation management. In eastern Australia, carrots are also grown on heavier loam soils and are believed to have superior flavour compared to those grown on sandy soils, although varietal selection and soil management also likely to effect eating qualities. Heat and moisture stress reduces the sweetness of carrots.

Water requirements for vegetable production on sandy soils can be in the order of 15,000 - 18,000 m^3/ha/year. Consideration should be given to possible sources of unacceptable contamination in irrigation water. For example, nitrate nutrients in the water supply may exceed permitted levels.

Carrot production using conventional methods can require considerable modification in order to comply with organic certification standards. The major changes are likely to relate to the following aspects of production:

- Rotations.
- Soil fertility and nutrient inputs.
- Weed control.
- Pest and disease control.

Rotations

Deciding on a suitable rotation for an organic system is possibly one of the most important considerations. The selected rotation must attempt to satisfy a number of criteria such as:

- Suit market demand, particularly in terms of seasonal timing and prices.
- Make efficient use of machinery, land, water and other inputs.
- Provide whole farm year-in year-out profitability.
- Minimise pest, disease and weed problems.
- Remain sustainable in terms of soil conditions and fertility.
- Be practical and relatively simple in terms of day-to-day management.
- Comply with organic standards.

Organic vegetable production rotations, ideally, are designed to involve different plant types, not only for pest and disease control but also to optimise the use of each soil fertility building phase. As a general concept, such a cycle may begin with a green manure crop or applied compost incorporated into the soil. The soil then has highest fertility, so crops requiring rapid growth or having high nitrogen demand should be grown. Typically, these may be leaf crops such as lettuce or sweet corn with fibrous root systems. The next crop would be a flowering crop with less fertility requirement and different root system, such as broccoli or cauliflower. The third crop would be a fruiting vegetable with more extensive roots, such as tomatoes. The final crop should have the lowest relative fertility requirements, typically these are root vegetables such as carrots. Thus the general cycle - leaf > flower > fruit > root - is considered ideal for optimising the use of soil fertility resources. However, in practice compromise is often required in order to balance practicality with profitability and sustainability.

Carrots have traditionally been grown in rotation following heavily fertilised crops, such as cauliflowers or potatoes, making use of the residual nutrients and decomposed residues from these crops, often with little additional fertilising. Development of carrot production for export markets to south-east Asia has led to continuous cropping systems without rotation, or more frequent cropping with a relatively simple rotation involving only one or two other crops, e.g. carrots > cauliflower > carrots, or, carrots > potatoes > carrots. These rotations are unacceptable for organic certification and require modification.

Acceptable rotations depend on individual circumstance, particularly relating to personal preferred crops, experience and expertise, existing equipment or capital to change equipment, crop suitability to the farm location and risk or reliability of successful crops.

Every crop in the rotation must be grown according to organic methods in order to retain organic certification over the land. Each crop should have a ready organic market if premium prices are to be obtained.

Clearly, there are many reasons not to include a crop in the rotation, however some compromise will need to be made - bearing in mind that the whole farming system year-in year-out profitability must be considered, rather than just individual crop gross margins. For example, growing a green manure crop may not in itself be profitable, but contributes to the value of subsequent crops in the form of soil fertility, weed control and possibly pest or disease control.

Disease organisms affecting carrots can survive in crop trash and soil for several years. As wide a rotation as possible should be practiced to minimise the risk of disease build-up. Vegetables commonly grown by conventional growers immediately before carrots (apart from another carrot crop) include potatoes, lettuce, onions or brassicas.

Wherever possible, at least one year in any three year period should include either a green manure crop, leguminous crop or a pasture ley phase. Continuous cropping rotations without a pasture ley or green manure phase are generally not preferred, but may be acceptable only where soil fertility and structural characteristics are entirely met by importation of composted manures. However, the application of such inputs may be limited by some certification organisations to 20 t/ha/year and/or the potential capacity of the land to produce such volumes of inputs.

Soil fertility and nutrient inputs

The management of soil conditions and fertility is considered the most fundamental aspect of organic farming systems, and is believed to underlie most other aspects of the production system including pest and disease control. Optimal soil fertility, soil structure and soil biology are the fundamental aims of organic soil management.

Conventional growers typically approach plant nutrition from an N, P and K dominant perspective, with additional amendments for minor nutrients. While this approach cannot be ignored, organic growers tend to adopt a different approach to plant nutrition - based on a living soil system. Soil health relates to an equilibrium or balance between biological, chemical, and physical aspects of soil conditions. Adequate soil organic matter, especially humus, forms the basis of this approach.

The primary concept is to feed the soil (biology), and via biological transformations and humus formation plant nutrients are made available in a slow release form, allowing plants to selectively assimilate nutrients according to their requirements. This approach is believed to maintain balanced plant growth. Soluble nutrients in the free soil water are avoided, hence the use of highly soluble conventional synthetic fertilisers such as normal bag fertiliser is not permitted.

A combination of management techniques can be used according to soil type. These may include:

- green manuring;
- application of compost;
- legume crops for nitrogen fixation;
- crop rotations;
- biological inoculants;
- approved soil amendments;
- approved nutrient inputs, mineral fertilisers;
- animal use; and
- appropriate cultivation practices and deep rooting plants.

Excessive cultivation, and cultivation implements that rapidly destroy soil structure, must be avoided.

A **green manure** crop generally consists of a mix of annual plants incorporated into the soil while green to improve soil properties and fertility. Green manures are an essential component of good soil management and can provide the following benefits:

Conserve nutrients - especially grasses which scavenge nitrogen to be recycled when incorporated and made available for use by the next crop.

Maintain soil structure - particularly when fibrous root systems permeate the soil. Deep, strong root systems like lupins help break up hard pan and compaction.

Organic matter maintenance - particularly where repeated cultivation occurs.

Erosion control - reduces the impact of raindrops and crusting, allows better infiltration and limits surface water run-off.

Disease control - especially through the use of non-host species to break pest and disease cycles, and the use of biofumigant plants.

Weed control - can be effective with fast growing species that smother weeds. Weed seed burden is reduced if weed plants are turned in prior to seed set.

The effective use of green manure crops form an integral part of organic management. Green manure crops usually include some legume for nitrogen addition, and can be used to return nutrients and organic matter to the soil. A dense, well established green manure crop can add organic matter, improve soil structure, soil fertility and give good weed control. Good growth of a well-inoculated legume based green manure can add 100-200 kg nitrogen per ha to the soil.

A mixed green manure planting combines the benefits of several species and can provide better weed suppression. Factors that determine the suitability of a plant as a green manure include; availability and cost of seed, rate and quantity of top growth, type and size of root system, length of growing season, ability to compete successfully with weeds and ease of incorporation into the soil. Sowing rates for green manure are generally 30-60 kg/ha, the higher rate for better soils. A typical mixed green manure crop may include:

- legume species, such as vetch and field peas, for nitrogen build-up;
- grass species, such as rye, barley or oats (saia oats for nematode control), to improve soil structure, biomass and humus build up;
- brassica species, for biofumigation, such as table mustard.

Grass species, such as cereals, can make legumes more efficient at nitrogen fixation, but can also out-compete legumes if sown too heavily, thereby reducing nitrogen fixation. Careful species selection and management is important to prevent green manure plants from becoming a weed problem. For example, some clovers can become a weed problem. Hard seeded brassicas can create a near permanent source of weeds, but varieties developed as annual seed crops (e.g. table mustard) can minimise this problem).

When incorporating a green manure, shredded material breaks down faster than coarse material and cultivation of the soil will be easier. Adequate moisture is required for the breakdown of organic matter.

The preferred means of supplying nutrients is via the use of **compost**. Compost suitable for organic production must be free from unacceptable contamination. Compost must have correct carbon: nitrogen balance, aeration, water and temperature conditions to undergo

proper decomposition and humus formation. The use of compost, particularly on sandy soils commonly used for carrot production, can provide significant improvements in soil physical, chemical and biological conditions. Good quality compost can increase soil nutrient retention and availability to plants, increase soil water retention, increase beneficial soil biological activity and improve soil structure.

The value of compost must be considered over time and from a number of aspects, including its ability to improve plant nutrient uptake, support healthy vigorous growth and suppress plant diseases. Since materials in compost are in a stable form and their immediate availability can be low, timing of applications is important and may occur several weeks prior to cropping or during the green manure phase. Generally, compost does not provide a large source of immediately available nitrogen.

The application of compost can range from 5-20 t/ha according to soil type and soil conditions. Commercial quantities of compost suitable for vegetable production are now becoming available in various locations. Specific formulations may be required to suit individual conditions. Wet compost can be difficult to spread.

Fresh undecomposed organic matter, must be avoided to prevent forked or hairy roots. Carrots thrive in soils that have good residual fertility from previous crops, however residual nitrogen in sandy soil can be low.

Supplementary nutrients based on demonstrated deficiency can be applied in organic farming. The use of supplementary nutrients is generally restricted to situations where nutritional corrections are not available using a more favourable product or methods. Excessive application of nutrient supplements, such as pelletised composted chicken manure, should be avoided.

A wide range of allowable products involved with soil fertility are now available. These include:

- a range of composted and formulated manures;
- various rock mineral including reactive phosphate rock (RPR);
- blood/meat/bone meal;
- fish products;
- seaweed products;
- microbial preparations;
- various vitamins, humates; and
- various liquid formulations or teas.

Supplementary nutrients reported for use on organic carrot crops include, RPR, lime, gypsum, dolomite, dried blood, bone meal, general purpose organic fertiliser, fish emulsion, seaweed spray and pelletised chicken manure.

The acceptability of any nutrient input should be approved by the relevant organic certifying organisation prior to use. A list of permitted nutrient inputs is provided in Appendix 2.

Management of soil conditions involves maintenance of optimal soil organic matter levels as well as balancing nutrient levels. Soil testing at regular intervals is important to monitor changes in soil conditions.

Interpretation of soil testing, and management of soil fertility for biological systems, has attracted a number of alternative approaches to understanding soil conditions and plant growth. An outline of several alternative concepts used by organic growers for consideration is provided in Appendix 3.

Various approaches and analyses relating soil conditions and plant growth continue to be developed, and a vast array of alternative input products are available. Scientific verification of many of these contentions and products has yet to be established. As a consequence, the decision to adopt particular approaches tends to rely on anecdotal information and experience rather than rigorous scientific testing.

Weed control

The use of synthetic herbicides is prohibited under organic certification. Economic weed control remains one of the most important aspects of a successful organic vegetable production system.

Organic growers do not aim for total weed control. In certain situations weeds can be managed to provide beneficial effects, for example; by encouraging beneficial insects, soil fungi, and overall species diversity, and in light soil help reduce nutrient leaching, particularly nitrogen in wet conditions. However, weed management is often the most difficult aspect of organic carrot production. The aim is a balance between the level of weeds and the growth and yield of the crop.

Like many other aspects of organic production systems, weed control requires an integrated approach. Preparing the land to reduce weed burden prior to cropping is very important to minimise weed problems. Growing carrots on a weedy site should be avoided.

A combination of weed control measures commonly used can include:

- amendment of soil conditions;
- cover crops and green manure crops;
- crop rotation;
- crop varietal selection;
- biological controls;
- mechanical cultivation, plough, scarifier, hoe, harrows;
- flame and steam weeders;
- smother crops and mulches;
- brush and rotary weeders;
- hand weeding.

Soil conditions are considered by many organic farmers to influence problem weeds. Corrections to soil pH, soil nutrient imbalance and soil structure have been reported to affect different weed species and their control.

Previous land use can have a significant impact on weed burden. Designing a **crop rotation** that creates a low weed burden will benefit a subsequent carrot crop. Weed control is more difficult in summer sown crops than one sown in winter. Pasture leys when well managed to prevent seed set, or **green manure** crops turned in at the optimal time, can be used to reduce weed burden. Crops such as potatoes can achieve good weed control, but can create a problem of volunteer potato plants as weeds in a following carrot crop. Brassicas, such as broccoli or cauliflower, may leave a weedy paddock, as can longer term crops such as onions.

Carrot varietal characteristics likely to minimise the impact of weeds may include the following features:

- High yielding - to compensate for weed competition.
- Fast growing and large tops - to smother weeds.

Weed control methods prior to seeding typically begin with **cultivations** during soil preparation and bed-forming. Allowing a subsequent good weed germination, followed by a final shallow cultivation or **flame weeding** prior to sowing the crop, is very important. Flame weeding this flush of weeds can give effective control without disturbing the soil surface. This approach may reduce further weed germination by minimising the stimulating effect soil disturbance can have on new weed germination. Well-timed pre-emergent flame weeding can considerably lower subsequent weed control cost. After sowing and just prior to carrot emergence, a flame weeder can be used again to give a weed free bed.

In non-competitive crops like carrots, the optimal weeding time (after emergence) occurs over a very narrow time period, so post emergence weeding must be carefully timed. For non-competitive crops, yields may be reduced by five per cent each day the crop remains weedy outside the optimal weeding time window. Research has shown that vegetable crops can tolerate weeds for much of the time between sowing and harvest, and that a short weed free period, or a single weeding at optimal time, may be sufficient to prevent yield loss. Weeds have little effect up to the onset of competition. However, if the crop remains weedy beyond this critical point, crop yields will suffer. Conversely, weeds that emerge after this optimal weed free period suffer from crop competition and can remain without affecting yield.

Mechanical weed control between rows using a **rotary brush hoe** or rotary scarifier may be used at about the two to three week stage and again at the four to five week stage depending on weed competition.

Timing of weed control is critical for good results. Effective weed control by mechanical means is more likely on small weeds early in the day, with hot, dry, windy conditions to ensure a good kill with few transplants.

Follow up **hand weeding** is often required to clean out problem weeds, especially within carrot rows. The amount of hand weeding required depends to a large extend on effectiveness of other weed control measures, particularly optimal timing in relation to weed size and weather conditions.

Within row weeds are reported to be the most difficult to control. Smother crops, that emerge with the carrot seedlings then die-off, are a possible solution. One grower in Victoria has used cold sensitive clover varieties in this manner with good results.

The use of **mulches and smother crops** is being investigated in California with promising results. Cowpeas as a cover crops, cut at the soil line leaving a mulch over the bed, have been shown to provide season long weed control for transplanted peppers (capsicum). Adaptation of this technique, using fast growing cover crops mulched down between carrot rows, may provide adequate weed control with additional benefits of wind protection, moisture conservation and enhanced soil biological activity.

Biological weed control agents, so called **bioherbicides**, are being developed and are likely to be available in the future. In addition, some plants, for example oil seed rape, are know to release chemicals which repress the germination of other plants. Weed suppression by this means may be incorporated into green manure crop mix.

Research is also being conducted into the use of various vegetable oil and starch based products for use in weed control.

Completely weed free crops are unlikely to be achieved in an organic system. However, minimising weed seed set within a crop is important for reducing the weed burden in future crops. Weed control sufficient to allow mechanical harvesting is likely to be required. Economic control of weeds must be determined on the basis of economic thresholds, i.e. deciding what level of weed control expenditure will give optimal return.

Pest and disease control

Organic standards prohibit the use of synthetic pesticides including insecticides, fungicides, miticides and nematiscides and other synthetic chemicals. However, a range of naturally derived products are allowable for use as a last resort where preferred management practices have been exhausted.

As with other aspects of organic carrot production, pest and disease control requires an integrated approach. Background management measures to prevent pest and disease problems can include a combination of the following:

- Select low risk location for potential pest or disease.
- Schedule crop timing to avoid high incidence periods.
- Use resistant varieties.
- Design crop rotations to minimise pest and disease build up.
- Ensure soil conditions (chemical, physical or biological) do not favour pest or disease.
- Develop and maintain natural processes that balance pest and disease problems, e.g. establish habitat and food source for beneficial organisms. Avoid inputs and treatments that have a negative impact on predator: prey proportions or harm soil beneficial organisms.
- Use mixed cropping regimes, appropriate species and avoid monocultures.
- Maintain balanced, healthy plant growth.
- Use cultural methods to minimise the opportunity for pest and disease outbreak.

In general, organic growers indicate that most of the main pest and disease problems tend to diminish below economic damage thresholds by using the above preventative measures. Wherever possible, close monitoring of pests and disease and their control agents, should be used to determine the need for additional control measures.

As a last resort, difficult to control pest and disease problems can be treated using a wide and expanding range of allowable products. These include a range of target specific and non-target specific products. Non-target specific products are generally avoided, and must be used with due regard to their potential negative impact on beneficial organisms and disrupting other predator/prey (pest) balances.

Target specific products can include:

- pheromone traps;
- mating disrupters;
- biological control agents;
- various allowable natural substances.

Non-target specific methods can include:

- sticky traps, light traps;
- barriers - natural or manufactured;
- repellent or catch crops - grown around an area;
- vacuum suction;
- solarisation - for soil pathogens;
- a range of natural substances - toxins, repellents and antifeedants.

A range of permitted materials for plant pest and disease control is listed in Appendix 2.

8.5 Organic carrot production system

This section gives a general outline of an organic carrot production system for consideration. Variations should be applied to suit individual farm conditions and circumstances.

Target markets

Initial production should possibly target local and/or interstate markets with the aim of using these market opportunities to establish a reputation for excellent quality, flavoursome, and reliable supply of certified organic carrots. Packaging to suit supermarkets may require pre-packed labelled bags. Investment in processed products and export market development can follow when reliable supply capability has been established.

Varieties - market requirements

Western Red types are the traditional and main variety sold. Specialty fruit and vegetable retailers and some supermarkets indicate a preference for Western Red type varieties, primarily due to colour, shape, size, weight and flavour characteristics.

Nantes carrot varieties, in contrast, appear to be preferred by some WA Supermarkets and some eastern states markets. The blunt-end shape of Nantes varieties is more suitable for pre-packaging. Characteristics required include sweet flavour, good colour, smooth skin and non-woody core. Export markets also have a preference for Nantes varieties. Japanese consumers prefer the Kuroda varieties such as Koyo2.

Nantes type carrots appear to offer the best potential for both domestic and export markets. Distinctive, delicious flavour should be the major promotional focus, with the organically grown status an additional bonus. Pre-packaging into retail ready bags avoids mixing or confusion with conventionally grown carrots and may suit large volume supermarket sales. Bags can be labelled certified organic and carry appropriate consumer information regarding organic production and related benefits.

Varieties - production requirements

The selected variety must grow well under an organic soil management regime, where luxurious levels of nutrients are unlikely and nutrients may be available in a slower release form than applied soluble fertilisers.

Ideally, a preferred variety will be open pollinated, high yielding, have excellent pest and disease resistance, with fast top growth to smother weeds. Good yields throughout the growing season with a high proportion of uniform roots of the desired size and shape is important. Strong tops to minimise collapse and allow mechanical harvesting may also be important.

Western Red is an open pollinated variety that fits the above description and is commonly used in organic production.

In WA, preferred Nantes varieties for organic production may be Ivor, Nandor or Murdoch. All three varieties are sweet flavoured but tend to be suseptible to diseases such as leaf blight and cavity spot. More disease tolerant varieties include Stefano, Havana and Navarre. Most commercially available Nantes carrot varieties are F1 hybrids.

Crop rotation

A well-designed crop rotation can provide many benefits and minimise many problems. A wide range of rotations can be suitable under organic production systems, depending on a variety of factors including location, season, available equipment, markets, soil conditions and many other factors previously mentioned.

Green manure crops are commonly used and can provide a useful starting point in any rotation. The green manure crop is designed to perform a number of function relating to soil fertility and pest, disease and weed control.

The following rotations are for consideration:

green manure > potatoes > carrots> …..

or

green manure > onions > green manure > potatoes > carrots > …..

or

green manure > brassica > potatoes > green manure > carrots > …..

For year-round carrot production, crop rotation will have to be carefully scheduled. Alternatively, a group of growers could work together to schedule production according to season and location to ensure year-round supply of the required volumes.

Location

Choose soils with some inherent fertility where possible. Soils with some clay content are likely to have superior nutrient and moisture holding properties, thus requiring less inputs than pure sand soils. However, on heavy soils consideration must be given to drainage, as carrots are prone to root disease if drainage is poor.

Background pest and disease pressure should also be considered. Where possible, avoid locations renowned for serious infestations of problem pests and diseases.

Soil likely to be contaminated with chemical residue from previous cropping should be avoided. Organic standards can limit residue levels to 10 per cent of the normal MRL for specific chemicals. Old orchards or potato growing areas may be unacceptably contaminated with residues from historical use of organichloride pesticides. Heavy metal. contamination, especially cadmium, can also disqualify land from organic certification. Cadmium levels in soil up to 100 per cent of the maximum permitted concentration (in food) may be permitted subject to conditions.

Soil preparation

Soil testing should be conducted to establish the chemical status of the soil. A thorough soil analysis should test for the following:

- pH.
- Electrical conductivity (EC).
- Total cation exchange capacity (CEC).
- Organic matter (OM).
- Amount and availability of major and minor nutrients and trace elements.
- Base saturation or cation exchange percentage of Ca, Mg and K.

The results of a soil analysis can be used as a guide for soil amendment recommendations, and should be used to monitor changes to soil conditions over time.

Soil for carrot production should ideally be free draining, low in salts (total salts less than 80 mS/m), pH 6.0-7.5 (in water), total CEC of 12, and have about 5% organic matter. However on very sandy soils, CEC and organic matter levels are normally very low and these levels would be difficult to reach. According to Albrect principles (see Appendix 2), cation exchange ratios (for sandy soil) should be Ca 60%, Mg 20%, K 4%, H 13%, other cations 3%. A deep, friable structure, without compaction, stones or other physical barriers, is important to allow long, straight, root growth.

Soil preparation for cropping begins well before seeding and typically involves management relating to:

- soil biological stimulation and humus formation;
- soil structural improvement;
- soil chemical/nutrient balance;
- weed control; and
- pest and disease control.

Green manure crops often provide a good starting point in preparing a soil for cropping. Green manure crops typically include a mix of species and can be designed to suit a range of purposes such as:

- produce bulk biomass for incorporation to raise soil organic matter levels;
- stimulate biological activity and mineralisation;
- nitrogen fixation;
- root activity to develop soil structure and depth;
- smother and control weeds;
- pest and disease break; and
- biofumigation.

A suitable green manure crop will typically include a mix of species as follows:

- Legumes for N fixation and biomass - vetch, field peas or clover.
- Grasses for pest control, biomass and soil structure - oats, barley or rye.
- Crucifers for biofumigation - mustard or canola.

Preferred varieties must be selected that will produce the greatest growth in the particular location and the allotted time.

Green manure crops are ideally turned in at the first sign of flowering. Soil amendments such as lime, dolomite, gypsum, sulfur, RPR, trace elements, compost and biological inoculants can be applied prior to green manure crops being incorporated into the soil. If possible, flail mowing the green manure crop will reduce particle size and assist rapid decomposition when incorporated. Allow sufficient time for organic matter to decompose adequately, otherwise forked or hairy carrot roots may result.

The crop following a green manure incorporation should be planted immediately after adequate decomposition has occurred, in order to optimise the use of released nutrients and minimise any leaching losses. However, planting a crop too soon may result in stunted growth, as the flush of soil microbes stimulated by the incorporated green manure can temporarily tie-up nutrients (especially nitrogen) during the decomposition phase.

In warm soil conditions, wait at least 2 weeks after incorporating a succulent green manure crop. For coarse green manure in cool conditions at least 4 weeks may be necessary. Nutrient amendments may be required to compensate for temporary microbial tie-up if early sowing cannot be avoided.

Nutritional requirements

Compost is the preferred method for supplying plant nutrients and is likely to form the basis of nutritional requirements for organic production on sandy soils. Compost can increase soil organic matter, raise CEC, retain moisture and enhance soil biological activity thereby assisting the availability of other applied nutrients. A well-made compost, with high proportion of humus, can prevent leaching and provide a slow release supply of nutrients.

Compost should be formulated to provide most of the nutrients deficient in the soil. A number of commercial compost producers can provide large quantities of compost formulated

to suit specific needs. However, research indicates that compost typically cannot supply large amounts of readily available nitrogen, but can be an effective source of potassium and phosphorous. Nutrient release rates from WA composts have yet to be fully determined. Release rates vary according to soil characteristics, drainage, microclimate and crop type. One standard assumption in UK trials is that (in the growing period after compost application) 10 per cent of total nitrogen, 15 per cent of total phosphorous and as much as 50 per cent of total potassium are released.

Applied pre-planting, compost can be broad-cast or applied in bands to suit crop spacing, then lightly turned into the soil. Rates may vary from 5-20 t/ha according to soil conditions and history. Preliminary compost trials on sandy soils by AGWEST suggest rates of 12-20 t/ha pre-plant before seeding can produce beneficial results, at least in the first 3-4 years.

Additional nutrients may be required based on soil testing and tissue tests. Permitted fertilisers should be assimilated into the soil by soil organisms and the nutrients slowly released to the plants. Application of raw animal manure is not permitted. Foliar sprays, such as seaweed or fish emulsion, are permitted where corrective action is required for a demonstrated deficiency and other preferred soil amendments are ineffectual. Soil testing and tissue testing at regular intervals may be required to monitor changes in nutrient levels over time.

Care must be taken to ensure the type and form of nutrients applied do not have a detrimental impact on beneficial soil biology. For example, trials have shown where 80 kg/ha of conventional nitrogen fertiliser was applied, microbial population fell by 25 per cent - believed to be due to a drop in soil pH.

For conventional production, approximate total nutrients (N, P and K) needed by a carrot crop over its whole life are shown in the following table:

Crop type and nutrient **Summer crop**	**Western Red (large top) kg element/ha**	**Nanco, Tip Top, Nandor (small top) kg element/ha**
Nitrogen, N	101	168
Phosphorus, P	145	138
Potassium, K	182	162
Winter crop		
Nitrogen, N	130	197
Phosphorus, P	160	145
Potassium, K	220	163

(From Phillips, D. 1990. Carrot nutrition and irrigation.)

Actual amounts of N, P and K nutrients applied by conventional carrot growers on sandy soils can exceed the above requirements due to leaching and other losses.

Nitrogen

Nitrogen is the most important plant nutrient for high yield, but is readily leached from sandy soils. In WA, maximum yields for conventional growers on sandy soils are obtained with 215-280 kg/ha N, however growers commonly apply 100-150 kg/ha N to control excessive

top growth in Western Red varieties. Although lower N reduces yield and delays maturity, lodging (tops fall over) is minimised so harvesting is easier. Nantes varieties have smaller tops so higher N quantities can be applied. In general, rates may be lower on heavier, more fertile soils and in summer compared to winter.

For organic production, calculation of N requirements prior to cropping needs to take into account residual soil N from green manure and nitrogen fixation, and nitrogen available from soil organic matter. Nitrogen release from 5.1 per cent soil organic matter may provide 112 kg/ha N, although on sandy soil organic matter is generally well below this level.

Organic production prohibits the use of conventional sources of applied N such as ammonium nitrate, potassium nitrate, NPK red, NPK blue, Nitrophoska and Komplete Blau.

Acceptable sources of nitrogen include compost, dried blood, and a range of proprietary organic fertiliser brands such as Complete Organic, Organic 2000, Dynamic lifter, Blood and Bone, Fish emulsion, and other protein sources. A number of these products can have a slower rate of soil mineralisation (plant availability) than many conventional sources of N, so during periods of rapid growth ensure sufficient N is available for balanced growth without limiting growth or causing excessive uptake.

Phosphorus

For conventional growers on sandy soils, phosphorus level above 60 ppm (Colwell) is considered adequate. Where additional phosphorus is required, one pre-planting application of super phosphate of 100-140 kg/ha is often used.

For organic production, less soluble forms of phosphorus, such as reactive phosphate rock (RPR) or guano, can be applied pre-planting. The role of soil biological activity is particularly important in mineralising this phosphorus to plant available forms retained in the soil biomass. The effectiveness of RPR is enhanced by applying as a fine powder that is well distributed in the soil. The lag time for applied RPR to become available for plant uptake may require application well before cropping.

A range of formulated organic fertilisers incorporating RPR or guano are permitted for use on a restricted basis. All sources of phosphorous must not contain high levels of cadmium. Typically rock phosphate contains negligible amounts of sulfur (unlike superphosphate), so in sulphur deficient soil a separate source of sulfur may be required.

Potassium

Although carrots are not heavy feeders, they do take up fair quantities of potassium. Potassium improves root quality and storage.

Potassium leaches easily through sandy soils. As a consequence, conventional growers (on WA coastal sands) typically apply a total of about 200 kg/ha potassium fertiliser throughout the life of a crop. In sands around 40 ppm K is considered adequate for one crop of carrots without yield loss. Carrot plants can buffer fluctuations in potassium supply to some degree, by storing potassium when readily available then redistributing around the plant when supply is deficient.

Sources of potassium permitted under organic production include rock dust, basic slag, wood ash, langbeinite and sulphate of potash. A range of permitted organic fertiliser blends

containing K are available. On soils with high organic matter and humus content, less potassium will be lost through leaching.

Calcium

Conventional growers often satisfy calcium requirements via the use of superphosphate (contains about 20 per cent calcium). Calcium in the form of lime or dolomite can be applied to raise soil pH into the 6.2-6.8 range. Irrigation water can also be a source of calcium.

Acceptable sources of calcium for organic production are limestone, dolomite and gypsum. Builders lime (quick lime) and calcium nitrate are not permitted.

The role of calcium, and its proportion to magnesium and other cations, is considered very important in soil biological processes and nutrient availability by an increasing number of organic growers. These claims are generally based on Albrect principles (see Appendix 3) of plant nutrition, where the ratio of major cations on sandy soils should be Ca 60 per cent to Mg 20 per cent or on heavy soils Ca 70 per cent to Mg 10 per cent.

Magnesium

Magnesium is often a deficiency in carrots, especially on acid sands.

Dolomite is a commonly used source of magnesium (and calcium) for organic growers. Langbeinite is also an acceptable source of magnesium.

Supplementary nutrients

Conventional production typically applies side dressings of nutrients periodically throughout the crop life.

Organic production standards permit a range of acceptable supplementary nutrients such as those listed in Appendix 2, and various others, including foliar sprays, may be applied during the life of a crop. Application should be on the basis of demonstrated deficiency where nutritional correction is not available using a more favourable product or method. Routine use or reliance on supplementary nutrients may not be permitted. Soil and leaf analysis may be useful in confirming nutrient imbalance or deficiency.

Weed control

Weed control is possibly the most critical aspect of organic carrot production, particularly with mechanical harvesting. Early land preparation to reduce weed burden and good timing of weed control operations is crucial for effective weed control.

Starting with a relatively weed free site is very important. Weed reduction begins with a well-planned crop rotation. Planting a green manure crop, prior to carrots, provides the opportunity for good weed germination and kill when the green manure crop is turned in. Green manure species for weed suppression in the warm season can include lablab, cowpea, lucerne, sudan grass and buckwheat. Cool season species include lupins, oats, fenugreek, rape, subclover and vetch. In addition, the inclusion of weed repressive species in the green manure, such as Indian Mustard and Fodder Radish varieties, may contribute to weed control.

Growing a relatively weed free crop, such as potatoes, prior to the green manure may also assist in reducing weeds. Canadian research indicates weed populations increase when onions

are part of the rotation production cycle and decrease with barley. Barley has been shown to release allelochemicals that can reduce weed growth.

Shallow scarifiers can be used to kill young residual weeds after the green manure has been incorporated. Bed formation provides another opportunity for mechanical weed control. After bed formation, weed germination should be encouraged then killed using a flame weeder. To further assist weed reduction, sow a small row of carrot seed 2 days prior to sowing the main crop. When the earlier sown carrots emerge, flame weed the bed again to provide a weed free bed for the main crop to emerge 2 days later.

After emergence a range of mechanical implements, such as brush weeders and rotary weeders, can be used to control weeds between rows until sufficient canopy cover can suppress weed competition. Hand weeding at about 2-3 weeks may be required to remove weeds from within rows.

Within row weeds are considered a major problem, typically requiring at least one hand weeding. One alternative reported is the use of smother crops to out-compete weeds within rows. For Autumn sown carrots, certain clover species emerge with the crop and smother weeds only to die off when temperatures drop during winter, leaving the crop with a low weed burden. Smother species that can be easily controlled or die with seasonal climate change may be selected to suit local conditions.

Seeding

In carrot production, precision seeding is important to obtain optimal plant densities. Plant densities can affect yield, quality, time to maturity and weed control. Having the best plant population is critical to achieving high yields in the preferred root size range and avoiding top lodging (collapse of tops). The optimal population varies with time of sowing, time of harvest, nutrition, variety and the size grade of carrot demanded by the market.

Row spacing and layout must suit weed control equipment and allow effective weed control. Single rows may be preferable to assist within-row hand weeding. In warm, moist conditions, single rows may help reduce the incidence of humidity related pest or disease problems, compared to a more dense planting. However, double or triple rows on multi row beds may provide better inter-row weed competition. On heavier soils, single or double rows on raised hills have been used.

Sowing a nursery crop, such as cereal rye, to prevent wind damage and erosion may be useful. The position of the nursery crop must allow easy removal or mulching once carrots are established.

Sowing depth is influenced by surface tilth, seedbed moisture, soil type and prevailing temperature and wind, but is normally about 12 mm deep at a rate of 1-3 kg/ha.

Thinning is not economical, so seeding rate must be adjusted to provide the required plant population - usually (for conventional production) at about 14-18 plants/30 cm. The following table indicates combinations of plant populations and times of harvest for given size grades on WA sandy soils.

Harvest time and plant populations giving high marketable yield and a 50:50 mix of carrots in 25-40 mm and 40-50 mm size grades for Western reds.			
Month sown	**Plant population plants/sqm**	**Plants/m of row (4 row bed in 1.5 m track)**	**Days to harvest**
January/February	80	30	130-160
March/April/May	73	27	160-170
June/July	85	32	170-140
August/December	100	38	140-125

(From Phillips, D. (1990 (b)). Planting and harvesting carrots).

Irrigation

When preparing ground for organic carrot production, pre-irrigation can be required to wet the soil down and stimulate a good weed germination prior to sowing the crop. Care must be taken to avoid over-watering at this stage when soil nutrient levels are high and may easily be lost by leaching.

After sowing, light watering at frequent intervals may be required to maintain surface moisture until seedlings are established.

Thereafter, sufficient water is required to maintain continuous growth. Large fluctuations in soil moisture encourage root cracking and misshapen roots. Excessive water can leach nutrients or cause root rots, particularly in the late growing stage.

On sandy soils in WA, recommended irrigation rate for conventional production is to replace daily evaporation plus 50 per cent. Irrigation rates may be reduced where improvements to soil organic matter levels and humus content has increased the soil water holding capacity.

Irrigation practices must ensure leaching of nutrients and induced salinity are minimised.

Pest and disease

Pest and disease control in organic carrot production begins with healthy soil. The underlying concept is that healthy soil grows healthy plants, with low vulnerability to pest and disease problems. Where pest and disease problems persist, life cycle and ecological opportunities are used in designing control measures. Cultural and management techniques can also minimise the risk of excessive losses.

As a last resort, a range of naturally derived products are permitted (see Appendix 2) where other more preferred methods of pest and disease control have shown to be unsuccessful. A number of permitted substances are non-specific in their action and must be used with due regard to possible detrimental impact on non-target and beneficial organisms.

The major pest and disease problems reported for conventional carrots are:

- cavity spot;
- scab;
- leaf blights;
- nematodes.

Cavity spot

Cavity spot disease of carrots is caused by soil borne *Pythium* fungi. Visible symptoms often develop in the month before harvest maturity. Cavity spot can develop rapidly if conditions are favourable and can be difficult to control.

Cavity spot in conventional production has been reported to be more severe under the following conditions:

- More intensive (repeated) carrot cropping. Extending the rotation between carrot crops reduces the severity of cavity spot.
- Soil pH less than 7.0. Raising pH greater than 7.2 reduces severity.
- Nantes and Imperator types may be more susceptible than Western Red types.
- Autumn harvested crops. Late summer and autumn harvested crops have higher losses.

Control of cavity spot for organic production may include preventative management measures as follows:

- Reduce build up of cavity spot fungus by well-designed crop rotation, green manure crops and soil biological balance.
- Adjust soil pH to greater than pH 7.2.
- Use resistant varieties - for Nantes types, Crusader.
- Only plant crops for late summer-early autumn harvest into soil with low risk of cavity spot.
- Harvest carrots as soon as they reach marketable size. Over mature carrots develop more cavity spot.

Bio-fungicides treatments for cavity spot are being developed that may be acceptable under organic standards. *Streptomycetes* and *non-streptomycetes actinomycetes* fungi are reported to significantly reduce the incidence of cavity spot.

Scab

Scab refers to thin black corky lesions where secondary roots arise on the carrot and may be caused by seed borne *Alternaria* fungus or severe leaf blight (usually *Alternaria dauci*) outbreak in the field. In conventional crops, incidence of scab appear more severe under the following conditions:

- More intensive carrot cropping. Extending the rotation between carrot crops reduces the severity of scab.
- Western Red types appear more susceptible according to seed source.

For organic production, control of scab will require:

- Reduce build up of scab by well-designed crop rotation, green manure crops and soil biological balance.
- Use resistant varieties.

Leaf blight fungal disease

Alternaria leaf spot - causes dark grey to brown angular spots on the leaves. Surrounding tissue becomes yellow. Older leaves are attacked first.

Cercospora leaf spot - more severe on young leaves causing circular, tan or grey spots.

These fungi survive on underground crop residue and may be introduced on carrot seed. Leaf spot diseases can be serious in wet conditions. Water is essential for spreading leaf blight fungi. Control by rotating carrots with other crops. Nantes varieties vary in their susceptibility to *Alternaria* blight. New Zealand organic growers are reported to mow tops to allow more light and air within the crop.

Nematodes

The root knot nematode (*Meloidogyne* spp.) causes growth of lumpy galls on roots and results in slower growth, misshapen roots and tops wilt on warm days.

The severity of nematode problems under conventional production appears more severe under continuous cropping with host crops. Nematodes prefer warmer temperatures so summer grown crops may be more affected. Nematodes can be more severe on sandy alkaline soils.

Conventional growers control nematodes with soil fumigants and nematicides not permitted in organic systems. Deep ploughing to place infected soil 45 cm deep also aids control. Good sanitation is essential.

Nematode control for organic production may require the following management methods:

- Reduce build up of nematodes by well designed (non-host) crop rotation.
- Non-host green manure crops.
- Enhance soil ecological balance - by maintaining adequate soil organic matter and incorporating green manure.
- Biological controls.
- Biofumigants, mustard, Neem oil cake.
- Solarisation - clear plastic over soil for 3-4 weeks during hot conditions.
- Wash machinery to avoid introducing nematodes.

Canadian research showed a dramatic reduction in root knot nematode populations when barley was included in the rotation. Onions are an intermediate host upon which nematodes can feed, but their reproduction is limited so proliferation is diminished.

8.6 Areas for future research

Research into the following areas would be useful:

- Weed control, especially within row weed control.
- Nutrient inputs, allowable sources, rates, placement and timing.
- Detailed agronomic aspects of organic production.
- Yields, costs and returns.
- Risks involved in conversion from conventional to organic and transitional strategies.

- Rotation design and implications, costs and benefits, mixed cropping, inter-cropping regimes.
- Soil chemical balance, relative proportions of ions.
- Soil biological manipulation and nutrient release fluxes.
- Organic matter maintenance and humus formation.
- Compost characteristics, application rates, timing, nutrient release patterns.
- Possible/potential inputs for pest, disease and weed control.
- Carrot variety selections suitable for organic management.
- New innovations/science - biol controls, soil microbes, green manures, machinery, intercropping, strategic planting.
- Grower attitude and willingness to invest in experimental research and development.

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9. Appendices

9.1 Appendix 1. Organic industry certification organisations accredited by AQIS as of January 2000

Bio-Dynamic Research Institute POWELLTOWN VIC 3797	Phone: (03) 5966 7333 Fax: (03) 5966 7433
Biological Farmers of Australia Co-Operative Ltd PO Box 3404 TOOWOOMBA VILLAGE FAIR QLD 4350	Phone: (07) 4639 3299 Fax: (07) 4639 3755 E-mail: bfa@icr.com.au
National Association for Sustainable Agriculture (Australia) Ltd PO Box 768 STIRLING SA 5152	Phone: (08) 8370 8455 Fax: (08) 8370 8381 E-mail: nasaa@dove.mtx.net.au
Organic Herb Growers of Australia Inc. PO Box 6171 SOUTH LISMORE NSW 2480	Phone: (02) 6622 0100 Fax: (02) 6622 0900 E-mail: herbs@lis.net.au
Organic Vignerons Association of Australia Inc. 1 Gawler Street (PO Box 503) NURIOOTPA SA 5355	Phone: (08) 8562 2122 Fax: (08) 8562 3034 E-mail: boss@dove.net.au
Organic Food Chain PO Box 2390 TOOWOOMBA QLD 4350	Phone: (07) 4637 2600 Fax: (07) 4696 7689 E-mail: organicfoodchain@hotmail.com
Tasmanian Organic-Dynamic Producers PO Box 434 MOWBRAY HEIGHTS TAS 7248	Phone: (03) 6383 4039 Fax: (03) 6383 4594 E-mail: plowe@vision.net.au

For more information on the production and marketing of Australian organic produce, contact the Organic Federation of Australia at the address below:

Organic Federation of Australia C/- 452 Lyton Street EAST BRUNSWICK VIC 3057	Phone: (03) 9386 6600 Fax: (03) 9384 1322 E-mail: ofa@netspace.net.au
Organic Retailers and Growers Association PO Box 12852 MELBOURNE VIC 3000	Phone: (03) 9737 9799 Fax: (03) 9737 9499 Toll Free: 1800 356 299 E-mail: oas@alphalink.com.au

9.2 Appendix 2. Input products for use in organic production (From: National Standards for Organic and Biodynamic Produce)

Appendix 2.1 Permitted materials for use in soil fertilising and soil conditioning

A. Materials permitted for use in organic and biodynamic farming

Substances	Specific conditions
Slurry from certified sources	-
Aerobic compost	Compost is the conversion of organic materials into humus colloids
Anaerobic compost	-
Straw	-
Mined carbon-based products such as peat, or coal	-
Blood and bone, fish meal, hoof and horn meal, or other waste products from fish or animal processing	-
Seaweed or seaweed meal	-
Plant and animal derived by-products of the food and textile industries	-
Sawdust, bark and wood waste	From untreated sources
Basic slag only	Only after residue testing for heavy metals
Dolomite and lime	From natural sources
Gypsum (calcium sulphate)	From natural sources
Calcined or rock phosphate and other crushed mineral bearing rocks	Excluding those minerals which are more than 20 per cent soluble
Phosphoric guano	-
Rock potash and sulphate potash	-
Wood ash	From untreated sources
Sulphur	-
Clay, bentonite	-
Attapulgite	-
Perlite	-
Trace elements includes materials such as borax. Natural chelates are acceptable, e.g. ligno sulphonates and those using the natural chelating agents such as citric, malic, tartaric and other di- and tri- acids	Not synthetically chelated elements
Homeopathic preparations	-
Approved microbiological and biological preparations	-
Naturally occurring biological organisms (e.g. worms and worm castings)	Excluding products derived from genetic modification technology
Fish products	-
Zeolites	-
Vermiculite	-
Potassium glauconite	-

Appendix 2.2 Permitted materials for plant pest and disease control

Substances	Specific conditions
Pyrethrum extracted from *Chrysanthemum cinerariaefolium*	Without piperonyl butoxide
Rotenone extracted from *Derris elliptica*	-
Quassia extracted from *Quassia armara*	-
Neem oil and extracts	-
Ryania extracted from *Ryania speciosa*	-
Propolis	-
Diatomaceous earth	In non-heat treated form
Stone meal	-
Metal dehyde baits	In traps or enclosed from the environment
Baits for fruit fly	Substances as required by statutory regulation and must be fully enclosed within traps
Copper, in forms such as Bordeaux mixture and Burgundy mixture	Hydroxide is the preferred form except for Bordeaux on dormant tissue
Sulphur in a wettable or dry form	-
Sodium silicate (waterglass)	-
Sodium bicarbonate	-
Potassium soap (soft soap)	-
Biological controls	Naturally occurring organisms and approved cultured organisms such as Bacillus thuringiensis
Pheromones	-
Granulose virus preparations	-
Essential oils	-
Vegetable oils	-
Light mineral oils (white oil)	-
Seaweed, seaweed meal, seaweed extracts, sea salts and salty water	-
Homeopathic preparations	-
Natural plant extracts, excluding tobacco, such as garlic extract, etc. and used as a repellent, antifeedant or pest/disease control	Obtained by infusion and made by the farmer without additional concentration
Potassium permanganate	-
Carbon dioxide and nitrogen gas	-
Vinegar	-
Wetting agents	Caution needs to be exercised with product which may be contained in some commercial formulations of the above products. Acceptable wetting agents include some seaweed products and plant products

Appendix 2.3 Permitted material for animal pest and disease control

Substances	Specific conditions
Pyrethrum extracted from *Chrysanthemum cinerariaefolium*	Without piperonyl butoxide
Rotenone extracted from *Derris elliptica*	-
Quassia extracted from *Quassia armara*	-
Neem oil and extracts	-
Garlic oil, garlic extract or crushed garlic	-
Seaweed, seaweed meal, seaweed extracts, sea salts and salty water	-
Sulphur	-
Potassium permanganate	-
Homeopathic preparations	-
Natural plant extracts obtained by infusion	Excluding tobacco
Essential oils	-
Methylated spirits	-
Tallow	-
Cider vinegar	Certified organic
Nettle	-
Diatomaceous earth	Non heat-treated form
Selenium and other trace elements	To correct identified deficiencies only
Zinc sulphate	-
Copper sulphate	-
Vitamins	-
Biological controls	-
Charcoal	-
Clay	-
Vaccines	May be used only for a specific disease which is known to exist on the organic farm or neighbouring farms and which threatens livestock health and which cannot be effectively controlled by other management practices
Wetting agents	Caution needs to be exercised with product which may be contained in some commercial formulations of the above products. Acceptable wetting agents include some seaweed products and plant products

Appendix 2.4 Substances permitted as post-harvest/storage treatments

Treatments	Substances/means
Controlled atmosphere	Carbon dioxide oxygen nitrogen
Ripening agents	Ethylene gas
Pest control	Physical barriers; temperature control; diatomaceous earth; rodenticides; sticky boards.
* **Rodenticides must be in enclosed traps outside of food processing and/or storage areas and only where harbour reduction and physical barriers have proved ineffective. Traps should be checked regularly and the baits changed.**	

2.5 Substances permitted as food additives, including carriers

B1. Food additives, including carriers

INS	Name	Specific conditions
170	Calcium carbonates	-
220	Sulphur dioxide	For wine only
224	Potassium metabisulphite	For wine only
270	Lactic acid	-
290	Carbon dioxide	-
296	Malic acid	-
300	Ascorbic acid	-
306	Tocopherols (antioxidant)	-
322	Lecithin	-
330	Citric acid	-
331	Sodium citrate (canned meat products)	Acidity regulator, emulsifier, sequestrant, stabiliser
332	Potassium citrate (meat products)	-
333	Calcium citrate (meat products)	Acidity regulator, filming agent, sequestrant
334	Tartaric acid (for wine)	-
335	Sodium tartrate	-
336	Potassium tartrate	-
341	Mono calcium phosphate	Only for raising flour
342	Ammonium phosphate	Yeast improver
400	Alginic acid	-
401	Sodium alginate	-
402	Potassium alginate	-
406	Agar	-
410	Locust bean gum	-
412	Guar gum	-
413	Tragacanth gum	-
414	Arabic gum	-
415	Xanthium gum	Thickener, stabiliser
416	Karaga gum	-
440	Pectins (unmodified)	-
450	Disodium diphosphate	Sequestrant, acidity regulator, texturiser
500	Sodium carbonates	-
501	Potassium carbonates	-
503	Ammonium carbonates	-

B1. Food additives, including carriers (continued)

INS	Name	Specific conditions
504	Magnesium carbonates	-
508	Potassium chloride	Gelling agent
509	Calcium chloride	Firming agent
511	Magnesium chloride	Firming agent
516	Calcium sulfate	Carrier
517	Ammonium sulphate	Flour treatment stabiliser
524	Sodium hydroxide	Acidity regulator
938	Argon	-
941	Nitrogen	-
948	Oxygen	-

B2. Flavourings

Substances and products labelled as natural flavouring substances or natural flavouring preparations as defined in the Australian/New Zealand Food Standards Code.

B3. Water and salts

Drinking water

Salts (with sodium chloride or potassium chloride as basic components generally used in food processing).

B4. Preparations of micro-organisms

Any preparations of micro-organisms normally used in food processing, with the exception of micro-organisms genetically modified.

B5. Minerals (including trace elements) and vitamins

Only approved in-so-far as their use is legally required in the food products in which they are incorporated.

C. Substances permitted as processing aids

Names	Specific conditions
Calcium chloride	Coagulation agent
Calcium carbonate	-
Calcium hydroxide	-
Calcium sulphate	Coagulation agent
Sulphur dioxide	For wine making only
Copper Sulphate	For wine making only
Magnesium chloride (or nigari)	Coagulation agent
Potassium carbonate	Drying of raisins
Carbon dioxide	-
Lethicin	Greasing agent
Nitrogen	-
Citric acid	Unrestricted
Ethanol	Solvent
Lactic acid	For meat products stabiliser
Tannic acid	Filtration aid
Egg white albumin	-
Casein	-
Gelatine	-
Isinglass	-
Vegetable oils	Greasing or releasing agent
Silicon dioxide (gel) or colloidal solution	-
Activated carbon	-
Talc	-
Bentonite	-
Kaolin	-
Diatomaceous earth	-
Perlite	-
Hazelnut shells	-
Beeswax	Releasing agent
Carnauba wax	Releasing agent
Sodium carbonate (flour industry)	Anti-caking agent
Tartaric acid and salts (wine industry)	Stabilisers, sequestrants
Gelatine (fruit and vegetable products)	-
Water (unrestricted)	-
Oak Chips (untreated)	For wine making only
Preparations of micro-organisms and enzymes	Any preparations of micro-organisms and enzymes normally used as processing aids in food processing, with the exception of genetically modified organisms and enzymes.

9.3 Appendix 3. Understanding soil conditions: Alternative concepts

Management of soil fertility for biological systems has attracted a number of alternative approaches to understanding soil conditions and plant growth. The following outlines indicate several concepts for consideration.

- Dr Rudolf Steiner - was the initiator of the concepts that form the basis of biodynamic agriculture. Biodynamic farming is a method designed biologically to activate the life of soil and plants. Plants are fed naturally through the soil ecosystem and not primarily via soluble salts in the soil water. Essential features relate to the use of special preparations and other techniques that enhanced soil biological activity, humus formation and soil structural development as the basis for allowing plants to selectively assimilate nutrients as dictated by sun warmth and light.

- Dr William Albrecht - was primarily concerned with a soil fertility approach based on nutrient balance (or ratios) as the foundation for achieving proper fertility relevant to optimal plant growth. The nutrient balance equations he developed are related to soil total exchange capacity. Ideal ratios or percentages of cations and anions are defined for different soil types, with the total availability of these nutrients generally increasing (except magnesium and manganese) with their percentage saturation. The optimal base saturation (cation exchange) ratios are 60 per cent Ca, 20 per cent Mg on sandy soil and 70 per cent Ca, 10 per cent Mg on heavy soil, 3-5 per cent K, 10-15 per cent H and 2-4 per cent for other bases. The relative values and relationship between nutrients, especially Ca and Mg is considered of great importance.

- Dr Carey Reams and Dr Phil Callaghan - this work is based on the concept of defining the potential for plant growth and fertiliser performance in terms of energy release and energy exchange. The contention is that fertilisers in themselves did not stimulate plant growth. It was the energy released (electromagnetic influence or paramagnetic energy fields) from these fertilisers that enhanced production. A distinction is made between fertilisers (nutrients) that produce growth energy, i.e. calcium, potash, chlorine, and nitrate nitrogen, to those that produce reproductive (fruiting energy), i.e. ammonium nitrogen, sulphate sulfur, manganese and phosphate. The approach also involves a proposition that the nutrient energy potential was dependent on microbial activity, and that energy availability is determined by nutrient balance. The approach also argues that phosphate is the primary catalyst in photosynthesis and subsequent plant sugar production. Increasing sap sugar levels (brix) is believed to reduce susceptibility to pest and disease attack and that plant sap sugar levels is directly related to plant pest and disease susceptibility.

Various approaches and analyses relating soil conditions and plant growth continue to be developed and a vast array of alternative input products are available. Scientific verification of many of these contentions and products has yet to be established. As a consequence the decision to adopt particular approaches tends to rely on anecdotal information and experience rather than rigorous scientific testing and understanding.