Going Organic

Organic Vegetable Production
A guide to convert to organic production

RIRDC Shaping the future
Going Organic – Organic Vegetable Production – A conversion package

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Front cover: Organic farmers use a range of innovative techniques to manage weeds. Pictured is a tractor-mounted hot-air weed steamer. Photo: R Neeson.
Going Organic

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A guide to convert to organic production

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Foreword

Despite increased demand for organic products, particularly in export markets, farm conversion to organic agricultural systems in Australia is slow. An important impediment to conversion is lack of relevant information.

This document offers a comprehensive view of organic farming and the ‘paddock-to-plate’ requirements for successful organic vegetable production. It is one of three guides developed for organic agricultural systems—one each for vegetables, rice and soybeans, and rangeland livestock production. The guides arose as a result of a larger project that was coordinated by the NSW Department of Primary Industries and jointly sponsored by the Rural Industries Research and Development Corporation.

A series of workshops for NSW Department of Primary Industries staff and organic industry specialists underpinned the guides’ development. During these workshops the similarities and differences between conventional and organic systems were discussed and, where possible, ways of overcoming any perceived impediments to conversion were identified. This formed the framework for the draft publications. Stage two of the project involved presentation of the drafts to organic and conventional producers at additional workshops across regional New South Wales and a final review by organic certifying organisations.

This publication does not aim to be prescriptive; rather, it provides a framework for organic conversion and pathways towards conversion. In addition to general organic principles, each guide describes possible methods of organic production for the commodity in question, the market potential, possible marketing strategies, the economics of production, processing requirements, and quality assurance.

True evaluation of the publication lies with practitioners. The authors hope the information provided will help make the transition to organic production a smooth one.

The project was funded from RIRDC core funds, which are provided by the Australian Government.

This report, an addition to RIRDC’s diverse range of over 1700 research publications, forms part of the Organic Systems R&D Program, which aims to deliver R&D to facilitate the organic industry’s capacity to meet rapidly increasing demand—domestically and globally.

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Peter O’Brien
Managing Director
Rural Industries Research and Development Corporation
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Executive summary

Background
Market signals, both domestic and international, indicate significant demand for organically produced product. By the year 2015 it is predicted that the world trade in organic products will be US$100 billion. Australia has an opportunity to capture a proportion of this market. However, whilst demand for organic products is high, particularly in export markets, the rate of farm conversion to organic agricultural systems is relatively slow. Currently only about one percent of Australian producers are involved in organic production and the area devoted to such production is only about 0.8 percent of total area farmed.

What is the report about?
Fundamental to marketing an organic product is being able to prove to the consumer the organic integrity of the product ‘from paddock to plate’. The publication offers readers a step-by-step guide through the organic conversion and certification process for a vegetable enterprise. Topics such as farm selection and establishment; weed, pest and disease management; soil and crop nutrition; variety selection; rotation design; and irrigation management are discussed. Case studies provide information about organic production of processing tomatoes, asparagus and pumpkins, and economic gross margins are given for rockmelons, sweet corn and pumpkins.

Organic vegetables are marketed through supermarkets, direct to restaurants, through organic retailers and wholesalers, via home delivery services, at farmers markets, and as exports. Marketing methods, promotional activities, and packaging and labelling requirements are described, as are the central features of developing effective marketing alliances.

During these workshops the similarities and differences between conventional and organic systems were discussed and, where possible, ways of overcoming any perceived impediments to conversion were identified. This formed the framework for the draft publications. Stage two of the project involved presentation of the drafts to organic and conventional producers at additional workshops across regional New South Wales and a final review by organic certifying organisations.

Results and Recommendations
The report draws together the information gathered from the workshops and other sources into a guide for producers of organic vegetables. It identifies the principles of organic farming and the requirements a producer needs to gain certification, including the relevant industry bodies and organisations. It discusses the range of on-farm and post-production aspects which influence the ability of a producer to meet standards for organic production and allow the delivery of the product to the most appropriate markets. The case studies provide examples of the organic production requirements for three different vegetable crops.
This chapter provides an overview of the organic industry, the market potential for organic products, and the basic principles of organic production. Some of the production practices discussed here do not apply to rangeland producers, but the concept of creating and maintaining a holistic, dynamic farming system with emphasis on soil health and biological diversity does apply, no matter where the farm and what the products.

1.1 Industry size and structure

1.1.1 The world scene

Organic farming is practised in approximately 100 countries of the world. The total area of organically managed land worldwide is around 23 million hectares. Worldwide there are approximately 398,804 organic farms. (International Federation of Agriculture Movements 2003).

The retail value of the organic industry worldwide in 2005 was valued at US$30 billion. In 2005 organic retail sales accounted for US$13 billion in Europe, US$13 billion in the United States, and US$450 million in Japan. By the year 2015 it is predicted that the world trade in organic products will be US$100 billion. (International Federation of Agriculture Movements 2005).

The organic sector is reported to be growing at between 20 and 25 percent a year. If the growth rate experienced in Europe in the past 10 years continues, it is expected that, by 2010, 30 percent of food consumed will be organic. Some countries, such as the United Kingdom, have reported consistent growth in the consumption of organic foods (at 40 percent a year), with the increase in production (25 percent a year) failing to keep pace with demand.

The New Zealand organic industry has enjoyed spectacular growth in recent years: exports increased from $1.1 million in 1990 to over $60 million in 2003. Europe, Japan and the United States are important markets for New Zealand organic produce: exports to Europe amounted to $28.7 million in 2003 and are expected to grow to over $100 million by 2008.

The International Federation of Agriculture Movements, a private organisation, is the peak world body for organic agriculture. It has about 700 member organisations from around the world and runs an international accreditation program. The Codex Alimentarius Commission (created in 1963 by the UN Food and Agriculture Organization and the World Health Organization) works to encourage all countries to harmonise standards and import controls for organic produce. It has about 700 member organisations from around the world and runs an international accreditation program. The Codex Alimentarius Commission (created in 1963 by the UN Food and Agriculture Organization and the World Health Organization) works to encourage all countries to harmonise standards and import controls for organic produce. Australia has played a central role in Codex’s Organic Program, acting as chair for a number of years and regularly participating in negotiations to put forward the case for the Australian organic industry.

1.1.2 The Australian scene

It is estimated that there are about 2100 certified organic farming operations in Australia, farming about 10 million hectares. The number of organic farmers has increased by 10 to 15 percent in each of the past two years (Australian Certified Organic 2003). About 310 certified organic farms are located in New South Wales.

Estimates of the value of Australian organic produce vary. Australian Certified Organic’s 2003 Organic Food and Farming Report estimated the farm-gate value for such produce in 2002 at A$90 million and exports (possibly reduced as a result of drought) at A$40 million. Australia-wide, in 2002 there were an estimated 500 certified processors and manufacturers of organic produce, contributing to an industry worth about A$300 million annually at retail level; this represents an increase of A$222 million since 1990. The Commonwealth Department of Agriculture, Fisheries and Forestry estimates that retail sales of organic produce in Australia increased from A$28 million in 1990 to nearly A$200 million in 2003 (press release, 21 August 2003). Wynen (2003) reports the retail value of
Australian organic produce to be A$165 million. RIRDC (2007) estimates the retail value for organic produce is worth between A$250 - A$400 million. The Organic Food and Farming Report suggests that growth is continuing at between 10 and 30 percent a year, depending on the sector. Beef, milk and horticulture were of particular note.

Almost 20 years ago pioneers of the organic industry asked the Australian Quarantine and Inspection Service for assistance in developing an export program and a national standard for organic production. In 1992 AQIS, in conjunction with the Organic Producers Advisory Committee (now the Organic Industry Export Consultative Committee), released the National Standard for Organic and Biodynamic Produce, which sets out the minimum requirements for organic products exported from Australia.

AQIS is responsible for accrediting organic industry organisations seeking to become an AQIS-approved certifying organisation. An audit of the organisation and its documented system is conducted against the requirements of the National Standard for Organic and Biodynamic Produce, the Export Control (Organic Produce Certification) Orders 1997, and importing country requirements. Once the organisation is approved, AQIS issues a Quality Management Certificate. At the time of writing seven organic certifying organisations were operating in Australia:

- Australian Certified Organic
- AUS-QUAL
- the Bio-Dynamic Research Institute
- NASAA—the National Association of Sustainable Agriculture Australia Ltd
- Organic Food Chain
- Tasmanian Organic Dynamic Producers
- Safe Food Production Queensland.

Appendix A provides contact details for these organisations.

The role of the certifying organisations is to ensure that products marketed under their logo are produced according to specific standards. Each organisation has its own standards in addition to the national standard. Figure 1.1 describes the certification framework for the Australian organic industry.

NASAA and Australian Certified Organic are the only Australian certifiers accredited by International Federation of Organic Agriculture Movements (IFOAM). They are also accredited with the United States Department of Agriculture National Organic Program (USDA NOP); also the Japanese Agriculture Standards (JAS) administered by the Japan Ministry of Agriculture Forestry and Fisheries (MAFF), this recognition provides market access to these countries for Australian certified products, which have been accredited by these respective systems. Sections 3.3 and 6.1 provide more information about obtaining organic certification and the organic Export Control Program.

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**Figure 1.1 Certification framework for the Australian organic industry.**

*Source: May and Monk (2001)*
1.2 Market potential for organic vegetables

Horticultural produce leads the domestic market in terms of growth in organic products. In 1995 the Rural Industries Research and Development Corporation valued Australian organic vegetable and herb retail sales at $28.06 million. Wynen (2003) put the retail value of horticultural products at about A$48 million in 2000–01, with vegetables accounting for 13 percent of national organic production (see Table 1.1).

Target markets see Australia as having great potential to supply both fresh and processed vegetable products, largely to meet out-of-season needs. At present an undersupply of organic produce is limiting Australia’s ability to meet export demand, and temporary shortfalls have occurred in the domestic market as product is redirected to export markets. McCoy and Parlevliet (2000), from Agriculture WA, identified a range of organic products as having a high priority for further development (see Table 1.2).

Compared with the United States, Europe and Japan, in Australia the domestic market for organic vegetables is expanding slowly. Relatively few wholesalers, located in the larger cities, receive the majority of fresh vegetables, distributing to specialty and health food stores, home delivery services and, increasingly, the big supermarket chains Coles Myer and Woolworths. Producers supplying these outlets report mixed experiences. Oversupply seems to occur relatively easily for most lines during peak production times, suggesting that the market is in the main a small one.

Producers that can supply seasonal niches (early or late season), ‘novelty’ vegetables (such as mini-vegetables) or difficult-to-grow vegetables have little difficulty selling their products, usually for a significant premium. Wholesalers report mixed quality but say that product quality and presentation are generally improving. Excessive price premiums—averaging 30 percent but sometimes much greater—could be restricting sales and hampering the industry’s expansion.

Farmers’ markets are becoming an increasingly popular way for producers to sell their produce. Large farmers’ markets operate in the major capital cities on most weekends. Regional markets are also growing: some regional centres are using them as a way of promoting local produce and increasing tourism. Fresh and value-added produce such as chutneys and jams are the most commonly sold items.

Domestic processors are producing a range of organic vegetable products, among them canned asparagus and sweet corn, pasta sauces, potato crisps and baby food. Heinz Watties is producing frozen vegetable and baby food lines but is currently obtaining the ingredients from organic producers in New Zealand.

Table 1.1 National values of horticultural organic produce: farm-gate and retail prices, 2000–01

<table>
<thead>
<tr>
<th>Product</th>
<th>Farm-gate price</th>
<th>% of national organic production</th>
<th>Retail price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>11 509</td>
<td>13</td>
<td>25 148</td>
</tr>
<tr>
<td>Fruit</td>
<td>4 070</td>
<td>5</td>
<td>8 889</td>
</tr>
<tr>
<td>General</td>
<td>2 249</td>
<td>3</td>
<td>4 915</td>
</tr>
<tr>
<td>Citrus</td>
<td>3 416</td>
<td>4</td>
<td>7 464</td>
</tr>
<tr>
<td>Grapes</td>
<td>348</td>
<td>0</td>
<td>659</td>
</tr>
<tr>
<td>Dried fruit</td>
<td>544</td>
<td>1</td>
<td>999</td>
</tr>
<tr>
<td>Nuts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22 136</td>
<td>25</td>
<td>48 075</td>
</tr>
</tbody>
</table>

Source: Adapted from Wynen (2003).

Table 1.2 Organic products for further development

<table>
<thead>
<tr>
<th>Priority</th>
<th>Likely</th>
<th>Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>Apples</td>
<td>Broccoli</td>
</tr>
<tr>
<td>Carrots</td>
<td>Asparagus</td>
<td>Eggs</td>
</tr>
<tr>
<td>Citrus</td>
<td>Bananas</td>
<td>Fish</td>
</tr>
<tr>
<td>Wheat</td>
<td>Canola</td>
<td>Grapes</td>
</tr>
<tr>
<td>Wine</td>
<td>Dairy products</td>
<td>Herbs</td>
</tr>
<tr>
<td></td>
<td>Honey</td>
<td>Nectarines</td>
</tr>
<tr>
<td></td>
<td>Oats</td>
<td>Pears</td>
</tr>
<tr>
<td></td>
<td>Rice</td>
<td>Plums</td>
</tr>
<tr>
<td></td>
<td>Soybeans</td>
<td>Poultry</td>
</tr>
<tr>
<td></td>
<td>Safflower</td>
<td>Potatoes</td>
</tr>
<tr>
<td></td>
<td>Sugar</td>
<td>Sunflower</td>
</tr>
<tr>
<td></td>
<td>Onions</td>
<td></td>
</tr>
</tbody>
</table>

In 2003 Smith reported that Australian exported about 16,000 tonnes of organic product in 2002, about three-quarters of this being grain. The main destinations for the exports were the United Kingdom and Europe, and fruit and fruit products accounted for about 8 percent. Between 2000 and 2002 the main areas of growth were in exports of certified organic meats and in oils and fats; exports of certified organic vegetables fell sharply (Smith 2003).

Of the top 10 export destinations for Australian organic produce in 2001, six were in Europe—the United Kingdom, Italy, Switzerland, France, the Netherlands and Germany—and accounted for over 70 percent of all Australian organic exports. Other important markets in 2001 were Japan (12 percent), Singapore (5.5 percent), the United States (5 percent) and New Zealand (2 percent) (Smith 2003).

At present about 40 percent of Australian organic production is destined for the export market. There is a distinct and growing market for fresh and frozen organic vegetables in the United Kingdom, France, Germany and Japan. Among the factors promoting this demand are food safety, genetically modified organisms, and environmental concerns.

Estimates suggest that in the United Kingdom 70% of organic fruit and vegetables and 50 percent of organic cereal products are imported. In 1996 the market for organic vegetables in Europe was worth US$200 million a year, and it was predicted that this would reach US$510 million by 2003. Other destinations offering export potential are Japan, the United States, Singapore, Korea and Malaysia.

Holmes and Kreidl (2003) reported that market opportunities for Australian organic products would open up if phytosanitary restrictions to importing countries were relaxed. They referred specifically to opportunities for organic fruit and vegetables in Japan (lemons, limes, grapes, olives, cucumbers, marrow, pumpkin, squash, zucchini, beans and eggplant), South Korea (lemons and limes), Taiwan (lemons, limes, grapes, olives, cucumbers, rockmelons, honeydew melons, watermelons, pumpkin, squash, zucchini, beans and eggplant), the United States (lemons, limes, grapes, cucumbers, pumpkin, squash, zucchini, eggplant and blueberries), and the European Union (navel oranges, apples, pears and table grapes). They noted that development of alternative disinfection methods for asparagus was a high priority.

Import replacement is another market sector that warrants consideration. A large range of imported organic products are currently sold in supermarkets and health food outlets. Shepherd, Gunner, and Brown. (2003) reported that pureed vegetables for baby food offer import replacement opportunities in the Australian domestic market.

The estimated value of organic products imported into Australia in 2003 was A$13 million (Organic Monitor 2004, in DAFF 2004). In relation to imports, Department of Agriculture, Fisheries and Forestry reported:

Over half of imported organic products are processed foods, such as biscuits, breakfast cereals, muesli, chocolate, pasta, soups, coffee, tea and other beverages. Most global organic food processing occurs in North America and the European Union and it is these two regions that supply the majority of organic processed food imported into Australia.

Other organic imports include herbs, spices, grains, pulses, nuts, dried fruits, rice, honey, sunflower oil and olive oil. Organic fruit and vegetables are mainly imported from New Zealand to meet shortfalls in domestic supply. Apart from organic food and drinks, an increasing number of organic personal care products such as skin care products, hair care products, deodorants and soaps are imported into Australia.

... it is not clear whether imports are replacing shortfalls in Australian production or competing with domestic products. Certainly some products similar to those imported are produced in Australia and even exported. (DAFF 2004, pp. 32–3)

On this basis, it seems likely that there is the potential for an increase in the domestic production of certain organic products to replace similar imported products.

The current situation for organic products in Australia is perhaps best summarised by Hallam:

The market for organic food is still small and therefore susceptible to oversupply, at least at particular times and locations. While many countries report strong growth in demand for organic meat and dairy products, for example, a number of instances can be cited where supply has exceeded demand. This has resulted in either a severe reduction in the price difference between organic and conventional products or organic products being sold as conventional products. (2003, p. 17)
2. Organic production principles: an overview

Organic agriculture is defined worldwide as ‘farming without the addition of artificial chemicals’. An artificial chemical is one that has been manufactured or processed chemically. For example, rock phosphate is acceptable on an organic farm but superphosphate is not. The difference is that superphosphate is rock phosphate with a manufactured chemical (sulphuric acid) added to make more of the phosphate soluble. The definition includes the word ‘addition’ because organic farming is not necessarily chemical-free farming. The reason for this is that we live in a world where there are artificial chemicals in the soil, the water and the air.

Like many other words, ‘organic’ has several meanings. In the context of agriculture it refers to whole–farm management—the farm being treated as a living organism. Traditionally, organic farms aim for optimal production rather than yield maximisation. They seek to operate as closed systems, using renewable resources wherever possible and with, as far as practicable, reduced reliance on outside (off-farm) inputs. Organic farms can be managerially more complex, but they are less dependent on external inputs.

Organic systems are essentially 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. Management strategies based on an understanding of biological cycles and other interactions are the main tools for replacing reliance on synthetic inputs such as artificial herbicides, insecticides, fungicides, drenches, superphosphate and urea.

Biodynamic agriculture is a type of organic farming. It developed from a series of eight lectures on agriculture given in 1924 by Austrian Rudolf Steiner (1861–1925), founder of the spiritual system known as anthroposophy. The lectures were a response to farmers’ observations that soils were becoming depleted and there was a deterioration in the health and quality of crops and livestock following the introduction of chemical fertilisers at the turn of the century. Steiner believed a renewal in agriculture was necessary in order to find a way to re-invigorate the earth.

Biodynamic agriculture sees the farm as a living organism interacting with its environment to build healthy soil and nutritious food that sustains plants, animals and hence humankind. Emphasis is placed on the integration of crops and livestock, the recycling of nutrients, and the health and wellbeing of crops and animals. The farmer, too, is part of the whole. These interactions within the farm ecosystem lead to a range of management practices that take account of the environmental, social and financial aspects of the farm as a whole.

Although biodynamics parallels organic farming in many ways—especially in connection with cultural and biological farming practices—it stands apart from other organic agriculture systems by virtue of its association with the spiritual science of anthroposophy. Steiner identified energies working in nature and so proposed practices that would deploy those energies. He emphasised farming practices designed to achieve balance between the physical and higher, non-physical realms, that acknowledge the influence of cosmic and terrestrial forces, and that aim to imbue the farm, its products and its inhabitants with life energy.1

Biodynamic farmers aim to develop a soil rich in humus; this is facilitated by practices involving careful use of plants, animals, ...
machinery and special preparations. Humus—decomposed organic matter made up principally of water—assists in binding soil particles and holding on to soil nutrients. It binds with clay particles to form a clay–humus complex. Among biodynamic humus-building practices are the following:

- use of special preparations to stimulate biological activity
- application of composts containing special preparations
- use of cover crops and green manure
- crop rotations and companion planting
- appropriate tillage
- addition of rock dusts, lime and rock phosphate as required.

A distinguishing feature of biodynamic farming is the use of nine preparations designed to improve soil quality and stimulate plant life. The preparations consist of mineral, plant or animal manure extracts, usually fermented and applied in small proportions to compost, manures, the soil or plants after dilution and specialised stirring. The intention is to moderate and regulate biological processes as well as strengthen the life (etheric) forces on the farm. The preparations are used in homeopathic quantities—that is, in extremely diluted amounts. They are numbered BD 500 to BD 508.

### 2.1 Soil management and crop nutrition

There is worldwide agreement in organic standards that organic farming systems should maintain or increase soil fertility on a long-term basis. Australia’s organic standard, the *National Standard for Organic and BioDynamic Produce* states that the primary aims of organic agriculture are as follows:

- producing food of high nutritional value
- improving biological cycles in farming systems
- maintaining and increasing soil fertility
- working as far as practicable within a closed system
- avoiding pollution resulting from agriculture
- minimising the use of non-renewable resources
- co-existing with and protecting the environment (OIECC 2002).

This is achieved through: ‘management practices that create soils of enhanced biological activity … such that plants are fed through the soil ecosystem and not primarily through soluble fertilisers added to the soil … 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 … to maintain soil productivity and tilth and to supply plant nutrients …’ (AQIS 2002)

Initially, conversion from a conventional fertiliser regime to an organic soil-building process involves eliminating the use of artificial chemicals in the farming system. Fertilisers such as superphosphate and ammonium nitrate are thus excluded and are replaced by practices that foster the cyclic renewal of nutrients to maintain crop health. Organic matter content, microbial activity and general soil health are taken as measures of soil fertility. An analysis of organic farming systems in Europe (Stolze et al. 2000) found that organic farming increased microbial activity by 30 to 100 per cent and microbial biomass by 20 to 30 per cent.

A comparative study of organic, conventional and integrated apple production systems in Washington State from 1994 to 1999 found that the organic and integrated systems had higher soil quality and potentially lower negative environmental impacts than the conventional system. The data showed that the organic system ranked first in environmental and economic sustainability, the integrated system second and the conventional system last (Reganold et al. 2001).

Research into the sustainability of organic farming systems in Australia has been limited. The work that has been done has...
tended to focus on comparative studies in broad-acre, or extensive, cropping and livestock systems, which are characterised by their low use of external inputs. Rock phosphate, lime, dolomite, legume rotations, incorporation of green manures and crop refuse, manure application during livestock grazing, and the application of microbial preparations can be used for building soil fertility.

Studies by Penfold (1995), Derrick (1996), Deria et al. (1996) and Schwarz (1999) suggest a trend towards deficiencies in phosphorous, nitrogen and sometimes sulphur under current organic management regimes in broad-acre cropping and livestock systems.

The limited studies of intensive organic farming systems in Australia have generally shown an increase in soil health compared with conventional practice (Wells & Chan 1996; Huxley & Littlejohn 1997; Stevenson & Tabart 1998). This could largely be a reflection of the cost-effectiveness of larger applications of commercial organic fertilisers and compost and incorporation of green manures for high-value crops such as fruit, vegetables and herbs.

2.2 Livestock management

Livestock play an important part in organic farming systems, including those producing vegetables. In fact, some certifiers might demand that livestock (such as poultry) or livestock by-products (such as composted manures) be used as part of the organic vegetable rotation.

Nitrogen fixed by legumes and other nutrients consumed by livestock during grazing are returned to soil in manure and urine. Managed carefully, livestock manure can play an important role in nutrient cycling on an organic farm. Composting of livestock manure is generally required, particularly if sourced externally to the organic farm.

Livestock are used extensively for weed control on organic farms. For example, they can graze down weeds before a crop is sown or they can be used after crop establishment for weed control and to improve tillering. Crops can sometimes be chosen so that livestock selectively graze out weeds, leaving behind the less palatable crop. Chinese weeder geese are often used in organic vegetable and fruit production to selectively remove grasses and some broad-leaf weeds from crops.

Livestock can also help with preparing the ground for planting by grazing and trampling crop stubble and reducing the length of a pasture sward.

The pasture phase in a mixed cropping–livestock system builds critical fertility and structure into rotations and reduces potential for the build-up of insects and disease.

2.2.1 Livestock nutrition

In organic farming, animal husbandry aims to provide a diet that livestock are best adapted to; the aim is not to maximise weight gain at the expense of animal health and contentment. Although good nutrition seeks to produce adequate yields, it has an enormous effect on animal health and is therefore very important in disease prevention.

Dietary diversity is the key. A balanced diet helps to meet the animals’ physiological needs. Lampkin (1990) points out that cows with high production levels as a result of emphasis on concentrates in their diet have a shorter productive life. In organic systems crop rotation and a variety of plant species in the pasture help to achieve diet diversity. A mixture of deep-rooted and shallow-rooted species increases the potential for nutrients to be available and helps eliminate nutrient deficiencies. Herbs such as chicory, plantain, yarrow and caraway are often added. Deep-rooted native species can recycle and make available nutrients that otherwise remain unavailable, deep in the soil. Legumes such as lucerne can supply organic nitrogen to the grass component of pastures and help recycle deep nutrients.

Nutrient imbalances are less likely to occur in organically raised livestock when plant nutrients are provided through the balancing of soil fertility and the soil’s biological activity, rather than when water-soluble nutrients are provided.

The long-term aim of organic systems is to remedy soil deficiencies. Under the organic standards, any mineral supplements used should be from natural sources. For example, additives such as urea and synthetic amino acids are not permitted, whereas seaweed and seaweed extracts, which contain a range of minerals, are. Nutrients can...
also be provided in mineral licks and fodder mixes or by drenching. Exceptions are made for potassium-based fertilisers.

The National Standard for Organic and Biodynamic Produce requires that all food for organic livestock be produced organically—either as purchased input or, preferably, produced on the farm. Special conditions exist in relation to feeding supplements and rations and feeding during drought. The national standard and certifiers’ standards should be consulted in this regard.

2.2.2 Soil management for nutritious pastures
Slow, organic remediation of soils through improved biological activity provides balanced plant nutrition and growth and hence improved nutrition for livestock. The aim is to build soil fertility through practices such as incorporating green manure and cultivating in such a way as to improve soil aeration.

2.2.3 Breeding
In conventional livestock systems the genetic emphasis is on high production. The organic farmer selects livestock for a wider range of qualities, among them pest (parasite) and disease tolerance or resistance (for example, Brahman tick tolerance) and mothering ability. Breeding for lifetime yield is more commonly the practice in organic farming. While the aim of conventional livestock production is for high, early productivity, the aim with organic livestock is to increase the animals’ productive life, and this is often associated with resistance to disease (Boehncke 1990).

Developing longevity in the herd offers a number of advantages:

- A long growth period means a long youth, and a long immature stage has been shown to be a precondition for a longer life.
- The farmer has the opportunity to get to know the herd, which makes handling easier and allows for a thorough knowledge of the herd’s disease history.
- The herd establishes a stable social order and a stable health state.
- Stress factors become adapted to conditions over a longer period.
- The quality and quantity of colostrum in older cows is greater.

Breeding should be within the genetic capacity of the species concerned. For example, breeding for high feed conversion can lead to arthritis and breeding for large hindquarters can lead to birthing difficulties.

During conversion to organic production, livestock bought externally must be organic or, if conventional, placed in a quarantine area for three weeks. Once the farm is fully organic, external purchases are confined to breeding stock only: all other livestock should be bred on the property. Replacement breeders may be introduced at an annual rate of 10–20 per cent (depending on the certification organisation) of the existing breeding stock. A limited provision does, however, exist in the standards for taking on agisted stock.

Livestock produced by artificial insemination are allowed by most certification organisations if natural behaviour is not practical or new genetic material is required. Embryo transplant is not permitted since this technique usually necessitates hormone injection to synchronise breeding cycles and tends to lead to decreased diversity in the herd.

2.2.4 Livestock welfare
Organic farmers aim to minimise physical and psychological stress in their livestock in order to promote wellbeing and reduce the incidence of disease. Having non-stressed livestock also helps reduce veterinary bills and maintain meat tenderness.

The national standard states, ‘Livestock husbandry practices that reflect the behavioural needs and ethical treatment and welfare management of livestock are also of fundamental importance where animals are kept on the farm’ and, in relation to stress caused by practices such as castrating, marking and mulesing, ‘Pain inflicted by surgical treatments must be kept to a minimum level and duration’.

For example, NASAA prohibits practices such as de-tailing of cows, although de-horning and castration are allowed when carried out as humanely as possible and within specific age limits. Use of anaesthetics is permitted: it does
not result in loss of organic or biodynamic status.

Management aims to minimise stress during potentially stressful periods. After shearing, for example, stress can be reduced by providing good pasture with low or no parasitic infection. Reducing noise and not rushing stock through gateways can also help minimise stress during handling.

Animals experience added stress when being transported to market and during slaughter. The NASAA standards state, ‘Slaughter will be carried out quickly and without undue stress … animals may not be held or herded in an area where the killing of other livestock is visible’.

The benefits of shade and shelter for livestock are well documented. Organic animal husbandry requires that sufficient protection be provided against excessive sunlight, temperature, wind, rain and other harsh climatic conditions. This can be achieved through the provision of windbreaks and sheltered paddocks. Livestock such as geese should be protected from predators such as foxes and dogs.

2.2.5 Livestock health

The organic approach to animal health care focuses on prevention of disease through diet, shelter, breeding and husbandry practices, rather than treatment. It is not possible to eliminate all animal disease, but when disease does occur a healthy animal is in a better position to cope with it. For many organic farmers, good observation is an important part of disease management. A producer who keeps daily or frequent records will be in a better position to identify the possible origins of a disease or injury.

Organic standards exclude the routine use of veterinary drugs such as antibiotics and some vaccinations. Organic farmers rely instead on treatments such as herbs, vitamins and minerals, homoeopathy, acupuncture, and dietary additives such as pro-biotics. There is, however, not always a satisfactory ‘organic treatment’ for health problems, and when an organic treatment is not effective there is no doubt that conventional treatment must be used: the welfare of the animal is paramount.

Where an animal is treated with a non-permitted substance it: must be identified and quarantined from other stock from the time of treatment for at least three times the withholding period or three weeks, whichever is the greater, specified for the treatment under relevant laws … For a period of at least 12 months after quarantine, such areas shall only be used for livestock production. Crops labelled as organic or biodynamic intended for human consumption can be grown on the area after this period.

(AQIS 2002)

Therapeutic treatment with allopathic veterinary drugs or antibiotics is permitted. Following such treatment, however, livestock may not be sold as organic or biodynamic. Their products and/or progeny may be sold as organic or biodynamic after a minimum management period, as outlined in the standard. Where a law requires the treatment of diseases or pests, this overrules the organic standards.

Selection of stock on the basis of disease tolerance and resistance is an important tool of the organic farmer. Recurrent health problems point to something amiss in the system. If individual stock exhibit recurrent problems they should be culled.

Internal parasites

Organic farmers are not permitted to use conventional anti-worm preparations. Drenching is done only when necessary, as routine use is not permitted and could lead to the development of resistance. If permitted substances or practices do not satisfactorily treat an animal, the animal’s welfare takes priority over organic status.

Among the organic treatments used are drenches made from a mixture of natural products such as garlic, molasses, vegetable oil and cider vinegar. Copper sulphate in minute doses is also favoured by some organic farmers. Others use aloe vera, clay products, diatomaceous earth, other vegetable and tree products, and Nutrimol®. Homoeopathic remedies are widely

Grazing management is an important tool in managing parasites.
used, with reported excellent results.

Some substances listed as permissible are not registered as veterinary treatments, and the Organic Industry Export Consultative Committee, which is responsible for approving changes to the National Standard for Organic and Biodynamic Produce, has been asked to explore the legality of using these unregistered substances.

Alternative management practices aim to disrupt a parasite’s life cycle. Temperature and moisture favour the development of internal parasites, so after rainfall or irrigation livestock are moved to a clean pasture; alternatively, pastures can be harrowed following grazing to expose the eggs and larvae to sunlight and heat. The New Zealand Agroecology Program found pastures such as chicory and lucerne to be least conducive to parasite larvae intake.

Resistance to internal parasites increases with age because immunity develops through previous exposure. Sheep reach a higher level of resistance at about nine months, whereas cattle reach this stage at about 18 months. Late pregnancy, lambing and weaning are critical periods for infection because resistance drops with increased stress and as feed intake increases, so it is critical to provide clean pasture at these times. Good nutrition and grazing rotations assist in developing and maintaining resistance.

Grazing management is very important in managing parasites. Spelling paddocks can control worm populations, as can alternate grazing. This latter method can involve older, less susceptible stock grazing wormier pastures before young stock or having a higher number of less susceptible stock together with young stock. Another form of alternate grazing is to graze alternately with different species—for example, cattle before sheep because cross-infection does not occur to any great extent—or with different species together. This also offers benefits in terms of weeds: different grazing habits will prevent the domination of a particular weed species. Strip grazing involves back-fencing stock to match larvae development so that the stock do not contaminate their pasture. Most organic farmers prefer low stocking rates and relatively intensive rotations.

Cultivation and intermediate cropping allow for a break in the build-up of insects, parasites and disease and therefore a clean pasture. Sowing mustard and ploughing it in as a green manure has been shown to clean a pasture (Belstead & Belstead 1992).

In summary, maintaining good health and reducing the risk of parasites involves the following:

- maintaining a high plane of nutrition and minimum stress
- grazing management that reduces exposure to parasites
- eliminating herd drenching and drenching individual stock only when infection is sighted—close observation is crucial here
- after the system is established, culling of animals that show signs of heavy infestation.

2.3 Plant pest and disease management

Organic systems are designed to re-create natural systems, which support several competing species, so that no single species has a consistent advantage. This is contrary to the main objective of modern agricultural systems, where the enterprise must maintain permanent control in order to be viable. Organic producers also believe that, by maintaining a vigorous and healthy crop through the adoption of sound cultural practices, plants are better able to withstand attack from pests and disease. Predicting potential problems and developing strategies to prevent the problems from occurring is the key to successful organic pest and disease management. Organic farmers take an ‘integrated pest and disease management’ approach. Such an approach is sometimes called ‘ecological pest management’ in the case of organic farming, to differentiate it from integrated pest and disease management in conventional farming, which includes the use of pesticides. Pesticides are generally not available to organic farmers, although some substances that are derived naturally are allowed for restricted use—for example, natural pyrethrum and Bacillus thuringiensis).

In organic systems integrated pest and disease management makes use of a range of non-chemical techniques:

- cultural controls such as crop rotation, cultivation and crop manipulation—for example, varying the crop spacing and the planting time—and crop hygiene
- manipulation of species diversity—for example, increasing the number of plant species
species that act as a barrier to a pest or that provide an alternative (preferred) host
• crop resistance or other physical attributes of the crop—such as spines or hairs—that deter pests
• natural and biological controls—for example, encouraging the natural enemies (parasites, predators and disease organisms) of a pest species by providing a favourable habitat or food source
• mechanical controls to trap or kill pests or physically prevent them from gaining access to crops
• modification of the physical environment—for example, using light traps and sticky traps (to trap and monitor insect pests), laying down clear plastic to control weeds (solarisation), planting a crop such as canola that inhibits certain pest species (known as bio-fumigation), or planting antagonistic species (known as allelopathy) for weed control
• use of livestock—for example, using ducks and geese to reduce populations of snails and maintain hygiene by consuming crop refuse.

2.4 Weed management
Economic weed control—without the assistance of synthetic herbicides—remains one of the most difficult aspects of successful organic production.

A well-managed organic system should not develop a significant weed problem. A primary objective for organic farming is to change the composition of the weed community, so that the farming system gains maximum benefit. Sometimes, however, one weed species might dominate or a noxious weed (one that, by law, must be controlled) might be present and this situation must be managed.

Whereas most conventional farmers see a weed as something that grows where it is not wanted, organic farmers see it as a sign that something in the farming system needs attention. Weeds are also seen as having an important ecological role: for example, some deep-rooted species will recycle nutrients from deep down in the soil profile, making them available to shallow-rooted species.

In order to develop an integrated strategy for suppressing weeds without using chemicals, organic farmers need to have a good understanding of weeds’ behaviour, their growth characteristics, and the conditions that favour their use of livestock—for example, using ducks and geese to reduce populations of snails and maintain hygiene by consuming crop refuse.

Organic farmers use a range of innovative techniques to manage weeds. Pictured is a tractor-mounted hot-air weed steamer. Photo: R Neeson.
3. Gaining organic certification

Conversion to organic farming is a dynamic process: it involves conceptualising, then action and observation, and finally reflection and refinement. It is a cyclical and continuous process. Figure 3.1 illustrates the concept.

Figure 3.1 An action learning model. Source: Kolb (1984)

Observation and reflection are particularly important because organic systems are, by their nature, holistic. A change to one component of the system will affect other components. Monitoring and recording the consequences of implementing a change are crucial to success.

Planning is an essential requirement of any business—not least an organic enterprise. To put it simply, if there is no planning the venture will almost undoubtedly fail.

3.1 A self-assessment test

Organic conversion starts with personal conversion—for you and your thinking. You must be committed to strictly following organic principles, yet be flexible enough to work with the ever-changing face of nature. Information is not readily available through conventional sources, so be prepared to spend many hours researching and testing new techniques. The self-assessment test shown in Figure 3.2 is designed to help aspiring organic farmers decide how far along the conversion pathway they are.

3.2 Beginning the conversion

John Melville, from Bioterm Consulting Pty Ltd, has a message for aspiring organic farmers: ‘A problem is a positive opportunity for development’. This is how the farm conversion process should be considered; failures should not be seen as problems but rather as a way of moving forward and developing and improving your organic system step by step.

Conversion begins by making small changes that will have the biggest impact on the farming system. It is best to change small aspects of management that can be implemented without excessive cost or loss of crop yield or quality. Avoid trying to change to total organic management immediately. Changes to soil fertility and soil management should be considered early in the process. This will involve conducting soil analyses, determining how to substitute non-organic fertiliser inputs with organic inputs and crop rotation practices (for example, green manuring) and assessing current cultivation practices. Locating organic inputs can be time-consuming and costly; some certification organisations do, however, provide a database of suppliers of certified organic inputs. Livestock can play an important role in the future soil fertility program, so it is also necessary to investigate how stock can be managed organically.

Paying increased attention to pest monitoring and determining ways of reducing pesticide applications form another area that should receive high priority during the early stages of conversion. It is worth considering employing a crop-check consultant to help with pest and predator identification and the development of strategies to predict and manage pest incursions.

Noxious weeds and other difficult-to-control weeds (such as perennials or weeds with rhizomes) should be targeted before organic practices are introduced. It is important to remember, though, that weeds are commonly an indication of a soil fertility imbalance or a structural problem in the soil: these problems must be remedied if their recurrence is to be prevented.

The first stage in the planning process involves information collection. Armed with as much information as possible, a farmer will be in a better position to make informed decisions and plan the conversion strategy. Information can be obtained from a variety of sources:

- successful organic (and conventional) farmers
- extension and research staff employed by government departments
- state organic organisations and the Organic Federation of Australia
Figure 3.2 How far away am I from being ready to apply for organic certification?

Note: HACCP denotes ‘hazard analysis critical control points’.
• certification organisations
• organic consultants
• organic (and conventional) producer groups
• books and other publications
• crop and market forecasts
• organic wholesalers, retailers and exporters
• short courses and workshops—for example, Integrated Pest Management courses run by the NSW Department of Primary Industries
• agricultural research and development organisations—for example, the Rural Industries Research and Development Corporation
• the internet
• universities, agriculture colleges and TAFE colleges—especially their libraries
• organic (and conventional) farmers’ newsletters—for example, NSW DPI’s VegiBites Newsletter and journals and papers such as Acres Australia and Good Fruit and Vegetables
• field days, agricultural trade shows, conferences and workshops.

This list is by no means conclusive, but it offers a good starting point.

When seeking information, people planning to convert to organics should not limit themselves to ‘organic’ networks. Much of the information available to conventional farmers is equally relevant to organic practitioners (and vice versa), particularly as conventional agriculture investigates ways of reducing reliance on chemicals.

Important information to have is a copy of the organic production standards. Each certifier has its own standard, which is available on-request. Some certifiers’ standards are on their website. The standard adopted will depend on the certifying organisation. The certifiers’ standards are based on the National Standard for Organic and Biodynamic Produce, which sets out the minimum requirements for production, processing and labelling of organic produce. The Australian Quarantine and Inspection Service administers the national standard and audits each approved certifying organisation to ensure it complies with the requirements of the national standard, the Export Control (Organic Produce Certification) Orders 1997 and importing countries’ requirements. The national standard can be viewed on the AQIS website.

### 3.3 Conversion and certification

‘Conversion’ refers to the physical and biological changes the farmer and the farming system must make in order to comply with organic standards. ‘Certification’ refers to the formal process of assessment designed to lead to accreditation of the farming system as compliant with organic standards. Before going down the conversion path, farmers should ask themselves the questions posed in Figure 3.2.

#### 3.3.1 Conversion planning

Converting to organic farming is not a short-term project, and there are no fixed methods for doing it. Each farm unit is a unique system, and successful conversion requires careful assessment of the resources available and the interactions between components of the system.

A degraded resource base and economic pressures resulting from previous land use can constitute the biggest constraints to successful conversion, and more specialised and intensive farms will generally take longer to convert. These systems require more time and effort to reintroduce diversity. The conversion process calls for a high level of commitment and often entails financial risk. Furthermore, there is little in the way of detailed information and advice about how to embark on the venture.

Basically, the conversion process begins with personal conversion—attitude and approach. It is then important to develop a planning framework. Often called an ‘organic management plan’, the framework accommodates changes in production methods and the potential financial consequences and outlines strategies for continued adherence to organic standards. It should also set out the steps to be followed during conversion and a time scale over which the conversion will occur. Preparation of such a plan is an essential pre-certification activity.

#### 3.3.2 Developing an organic management plan

When developing an organic
management plan, the following questions should be borne in mind:

- **How much, and over what time frame, will I convert?** It is a good idea to initially use only part of the farm to trial organic methods. A drawback is, however, that this might not allow for suitable rotations or provide the scale required for necessary adjustments in techniques and machinery. On the other hand, converting only part of the farm might allow for better financial stability if yields become depressed. Perhaps, too, it is worth trying organic production of just one commodity grown on the farm, although this could entail more work—for example, segregating organic and conventional produce.

Under organic standards, the growing of organic and conventional produce on the same farm is referred to as 'parallel production'. The standards prohibit production of the same crops (or livestock) organically and non-organically on the same farm where the crop (or livestock) products are not visibly different. For example, it is not permitted to grow an organic crop of Rosella wheat and a conventional crop of Janz wheat on the same farm, but it is permitted to grow organic Rosella and conventional oats, provided all sources of contamination have been considered.

- **What are the potential sources of contamination and how will I overcome them?** Organic standards require that the producers implement a process for documenting and monitoring the potential for contamination from substances and practices that are not permitted and that strategies be introduced to avoid these risks.

A system similar to HACCP—hazard analysis critical control points—should be considered. Any risk assessment requires asking, at each point in the production process, four further questions:

- What are the potential sources of contamination during the production, harvesting, storage, transporting and processing of the crop or livestock?
- Which of these contamination risks is significant and likely to occur if not properly managed?
- What must be done to keep these risks at an acceptable level?
- What records or evidence will I need to demonstrate that I have controlled the hazard?

If parallel production is practised then harvesting, sowing, transport and processing equipment must be thoroughly cleaned before organic produce is handled. Storages for organic and conventional produce must be separate, and there must be a strong system of traceability. Additionally, external sources of contamination—such as over-spray from adjoining properties and contamination of watercourses running through the organic land—should be identified. The use and sources of external inputs such as seed, fertiliser and livestock feed, even if they are organic, must also be recorded.

- **What rotations should I implement?** When making decisions about rotations, it is important to consider the implications of each crop for subsequent crops in the rotation. The potential for pests and diseases, weed management, fertility management and livestock requirements must also be taken into account and be balanced against what will be profitable for the farming business. Production decisions must be viewed against the goal of optimising the economic return. Rotations must be flexible, too. One organic producer has said he would select a crop for a rotation only if it offered at least three benefits—for example, an economic return, soil structure (or nutrition) improvement, and a pest and disease break (Whittaker, pers. comm., November 1997).

- **Is my farm layout suitable?** Now is the time to consider the appropriateness of the farm's layout and how it will facilitate organic conversion. Paddock size, fencing, irrigation layout, the location of watercourses and wetlands, the presence of windbreaks, topography and soil types are all relevant.

- **Do I have suitable equipment and farm structures?** Conversion to organic management could necessitate modification or replacement of existing farm equipment and structures. Specialised sowing and weed management equipment might be needed; sealed storages might have to be built to allow for carbon dioxide disinfestation of produce; refrigeration units could be required to control post-harvest insect pests and diseases.

- **Do I have a recording and monitoring system?** Keeping records of crop production, cropping history, soil tests, livestock movements, pest and disease management and crop sales will facilitate monitoring of the impact of management practices and the changes that have occurred during conversion. Certifiers will ask for some...
information—such as details of crop yields and sales—as part of the certification contract.

• *What financial factors should be considered?* The capital investment required for changes must be taken into account; this could include, for example, livestock housing, machinery, storage facilities such as coolrooms, and facilities for processing, packaging and marketing of produce. A viable marketing strategy should be established before proceeding with the organic management plan. Marketing options—including the availability of markets, the premiums offered (generally none for in-conversion produce) and marketing alliances—and value-adding potential all need to be assessed.

• *How do I start?* Start slowly. Gain experience with new crops and techniques and the potential output of the system. Start with a couple of paddocks entering the rotation for a couple of seasons. Then other paddocks can be brought in and the original paddocks can progress to later stages of the rotation. In this way the original paddocks are always a couple of years ahead, and mistakes learnt will not be repeated. Most importantly, record observations and redesign the conversion plan each year to take into account experiences with each paddock.

### 3.3.3 Certification

Consumers now recognise a certified organic product as their best guarantee that the product was in fact produced using organic practices. This is particularly important to consumers with health concerns.

Organic retailers and wholesalers generally will not buy uncertified produce.

The certification process involves having the farm and the farming methods examined in order to confirm that they meet the certifier’s standards for organic farming. The certifier’s standards cover all the requirements of the National Standard for Organic and Biodynamic Produce. Since January 1993 exports of organic produce have been required to meet the national standard, which sets out the minimum requirements for production, processing and labelling of organic produce and requires that all exporters, as well as producers and processors, be certified with an accredited industry organisation.

Seven organisations are currently accredited by the Australian Quarantine and Inspection Service to inspect and certify organic producers. (They are listed, along with their contact details, at the beginning of Appendix A.) Each certifier has standards that must be complied with in order to meet the requirements of the national standard.

Certification ensures the integrity of the organic product ‘from paddock to plate’, providing a guarantee to consumers. It also protects the interests of genuine organic producers in maintaining and increasing their market share. Trade practices law imposes severe penalties for passing off non-organic produce as organic.

There appears to be considerable potential for exporting Australian organic produce. Producers and exporters need to be aware that a certification program must cover any treatment, preparation and packaging of the organic product before export. All exporters must be approved for this purpose.

Domestically, the market for organic produce has expanded. The National Standard for Organic and Biodynamic Produce does not have legal standing within the Australian domestic market. Following a request from Australia’s organic industry peak body, the Organic Federation of Australia, Standards Australia, Australia’s peak standards body, has agreed to proceed with the development of a new Australian Standard for organic produce. The current National Organic (export) Standard is being considered as a basis for the development of the Australian Standard.

### Levels in the certification process

Full certification is generally granted following three consecutive years of organic management. Some certifiers’ standards refer to three levels in the certification process—‘pre-certification’ (also known as ‘pre-conversion’), ‘in-conversion’ and ‘organic’. Organic standards must be adhered to during all levels, each level usually being a reflection of the amount of time or degree to which an organic system has been implemented.

Producers must be involved in an accredited organic inspection system for a minimum of 12 months before receiving any formal acknowledgment that their product is produced using organic principles. The 12-month pre-certification period does not begin until a formal application to the certifier has been made and a statutory declaration and farm questionnaire have been completed and submitted.

Following the 12-month pre-certification period—provided organic standards are adhered to—the certifier will issue the producer with a contract and a certificate of certification. This allows the producer to label and market products as ‘in-conversion’. The in-conversion period generally lasts for a further two years, after which full organic status (with label) is issued.
No label is issued during the pre-certification period.

If the decision is made to proceed with certification, a completed application form, along with the required fee, should be sent to the certifying organisation. The certifier then asks for the completed statutory declaration and questionnaire describing the products for which certification is sought and the management practices currently used on the farm.

**Inspection**

Once the application has been made and the certifier determines that an organic system is possible—based on the information provided in the statutory declaration and questionnaire responses—an inspector contacts the applicant to arrange an inspection time.

The inspection usually takes two to four hours but can take longer, especially on larger properties. The inspector goes through the application and statutory declaration with the farmer and asks questions. Farmer and inspector together examine the farm, the machinery and the livestock. The inspector may take soil or product samples to test for chemical residues; problem areas could be old chemical storages or chemical disposal areas and old spray application equipment.

The inspector then makes an overall assessment of the property and its management. A certification review committee considers the inspector’s report and recommendation. The farmer might be asked for more information, or further inspections and tests for chemical residues might be called for. If successful, the farm will be approved for pre-certification, the phase that demonstrates to the certifier the farmer’s ability to manage the enterprise organically.

Following pre-certification, another inspection takes place, and if the requirements of the organic standard are met a certificate of certification is granted. The farmer is then required to enter into a licensing agreement with the certifier. From application to certification takes 12 months. At this point, the ‘in-conversion’ level is achieved, after which a further two years ‘in-conversion’ is generally required before ‘organic’ status is granted by the certifier.

Once a farm is certified, it will be re-inspected each year. Unscheduled inspections are also carried out as part of the certifier’s obligation to meet the Australian Quarantine and Inspection Service requirements.

**The cost of certification**

A number of fees are associated with becoming certified. The amount and type of fees imposed can depend on the certification organisation and on the sales turnover of the producer. In general, however, around $1300 should be allowed during the pre-certification period for the application fee, inspections (2 during pre-certification), and soil and produce residue tests.

Once certified for label use, ongoing annual fees are payable which includes the costs associated with annual reinspection. These are generally around $600. In addition, some certifiers place a levy (around 1%) on gross sale of organic produce when sales exceed a minimum amount.

Additional fees may be payable under certain circumstances such as for fast tracking applications, adding new acreage and / or new products, and for residue testing.

Some certifiers offer a scheme for small growers, where local producer groups can apply for certification at a reduced rate. The typical fee per producer is around $800 pre-certification, with annual fees of around $400 once label use is approved.

Some certifiers also employ multi-skilled auditors, who can carry out other audits such as HACCP (hazard analysis critical control points) for clients.

**How to stay certified**

To comply with and retain organic accreditation, farmers must uphold the national standard. Any breach of the standard—such as use of a prohibited substance—will result in temporary or, for continued non-compliance, permanent de-certification. Under the national standard inputs such as fertilisers and substances for pest and disease control are classified as ‘permitted’, ‘restricted’, or ‘non-allowable’.

Regardless of the type of input, its use must be recorded in the farm diary. If for any reason a non-allowable input is used, this use must be recorded and the certifier notified immediately. Only after the certifier is satisfied that organic management has been re-applied will it be possible to sell the produce in question as organic.

Continuing certification calls for good record-keeping. During inspections the inspector will want to see these records. This helps verify that management has been in accordance with the standard. Although it is not compulsory, adoption of a system for monitoring risk—such as HACCP—is recommended.
Formal application is made to the certification organisation for pre-certification inspection. Producers must be under an accredited certification system for a minimum of 12 months before receiving any certification level.

The producer completes a questionnaire and statutory declaration and returns them to the certifier. The 12-month pre-certification period begins when the certifier approves the application, receives the statutory declaration and questionnaire, and the fees are paid.

An organic management plan has been developed and is being implemented. The 12-month period is the time that the certifier has to approve the application, receive the statutory declaration and questionnaire, and the fees are paid.

The certifier evaluates the application and, if it is approved, notifies the producer of a date for inspection. The property inspection takes place. The inspection covers evaluation of organic management and pesticide and heavy metal residue tests of soils and/or plant tissue, as well as inspection of produce storage and processing areas.

The inspector prepares an inspection report and submits it to the certification organisation's certification review committee. From application to certification will take about 12 months.

The certification review committee evaluates the inspector's report and the application for pre-certification. A contract is offered, enabling use of the certifier's logo under strict guidelines and within an agreed organic management plan.

If there is no prior recognition for organic management the farm will remain at this level for two years. Organic status is usually offered following in-conversion level after three years of organic management.

Organic certification is ongoing and involves adherence to the organic management plan and annual re-inspections. In conversion is usually the stage following the pre-certification period. If there is no prior recognition for organic management the farm will remain at this level for two years.
4. Organic vegetable production

4.1 Farm selection and establishment

Successful production of organic vegetables can be very dependent on site selection. Apart from all the obvious reasons for choosing a site—suitable soils and climate, a plentiful supply of good-quality water, access to labour, transport and markets, and so on—the site should be relatively free of the pests and diseases of the crops the producer hopes to grow. For example, there may be greater risks associated with growing organic vegetables in an area where large monocultures of similar crops are grown or in higher rainfall areas, where pests and disease may be more prevalent. If processing is an option, then access to a certified processor would be a consideration.

Starting small is usually a good idea. This helps to minimise risks and allows for developing the requisite skills. Successful organic vegetable production relies on establishing a sound rotation plan; this might mean reducing the scale of the area under commercial production and putting land aside for green manure cropping. This land is then brought into production in a subsequent rotation. Rotation planning and design are discussed in Section 4.2

4.1.1 Soil and crop nutrition

Most vegetables prefer a well-drained loam or clay-loam soil with a pH of about 6.0 to 6.5. A thorough mapping of soils on the site should be done in order to determine if soil nutrition or the soil structure needs attention. Some adjustment will most probably be necessary before planting, in keeping with the crop’s nutritional requirements. The soil should also be tested for pesticide residues and heavy metal contamination: unacceptable levels could exclude produce from organic certification or could exclude the growing of particular crops, such as root vegetables. See Section 4.4 for information about optimising soil fertility for organic vegetable production.

Compost is an essential nutritional input for an organic vegetable farm, so it would be an advantage to have access to a local source of compostable material. This could include animal manures and crop waste from other agricultural enterprises, but these materials would have to be free of excessive pesticide and heavy metal residues. Most certifiers prefer that on-site composting facilities be developed. An area of the farm should be set aside for compost production—well away from watercourses and dams to avoid pollution.

4.1.2 Pests, diseases and weeds

Before planting, it is essential to carefully develop planting and crop rotation strategies in order to avoid or reduce the risk of losses resulting from pests, diseases or weeds.

If a crop is known to be susceptible, planting into a site that has a known pest or disease history should be avoided. Similarly, weedy areas near crops, which can act as reservoirs for disease-carrying pathogens and crop pests, should be managed or avoided. Other environmental factors, such as local climatic conditions, should be also considered; for example, a site a few kilometres inland may be at less risk of infection from fungal disease than one in a higher rainfall or more humid area.

Starting production with a relatively weed free site is a distinct advantage. Sites that are heavily infested with problem weeds—particularly perennials such as couch grass, kikuyu and nut grass—should be avoided or the weed thoroughly controlled before planting. Some weeds are indicators of soil problems such as poor drainage or an imbalance of nutrients and can be brought under control over time by modifying the soil condition.
Control of noxious weeds is a legal requirement. Local councils and state and territory agriculture departments can provide details of weeds that are declared noxious. Similarly, if a producer intends to grow vegetables in a fruit-fly exclusion zone, strategies must be developed for dealing with a possible fruit-fly outbreak.

4.1.3 Water
A large, reliable water supply must be available, and it is essential to ensure access to it by confirming this with the relevant authority. The water should be tested to determine its suitability for irrigation; it should also be tested for chemical contamination, particularly if the source comes via an adjoining (non-organic) property—for example, from a creek, river or irrigation channel.

4.1.4 Proximity to non-organic neighbours
Although proximity to non-organic neighbours is not the deciding factor when choosing the site of an organic vegetable growing enterprise, it is important to determine the potential for chemical contamination from those neighbours. It is advisable that organic producers approach their neighbours and explain that they are organic growers and that they risk de-certification if chemical contamination of their produce occurs. The New South Wales Pesticides Act 1999 offers some legal protection against pesticide contamination.

If there is potential for contamination, organic producers are required to incorporate non-certified buffer zones between the certified area and adjoining properties. Buffer zones can consist of windbreaks, wildlife and insectary corridors, or uncertified cropping areas. Properly selected and located, zones of vegetation add to the biodiversity on a farm and attract birds and other beneficial species that help control pests.

4.1.5 Transport
Access to reliable transport is essential for moving fresh produce to market. The transport might need to be refrigerated if highly perishable crops are grown, and transport operators should be made aware that the produce is organic and that it must be isolated from conventional produce to minimise the risk of contamination.

4.1.6 Labour
Vegetable production is usually a labour-intensive enterprise—and particularly so for an organic vegetable enterprise. Some estimates suggest that one person can efficiently operate a 1-hectare mixed organic vegetable enterprise. Access to additional labour should, however, be considered, especially during peak harvest periods and for any extensive hand-weeding operations. If on-farm value-adding is done, extra labour will almost certainly be needed.

4.1.7 Equipment
Many successful larger organic vegetable enterprises use a range of specialised equipment to help with farm operations. The equipment needed depends largely on individual situations. Most producers grow vegetables on raised beds (1.5-metre centres are common), so tractors require high clearance and a wheel spacing that suits the bed size. An extensive range of farm equipment is available to market gardeners, although some of it—particularly equipment used in weed management—is expensive or hard to obtain in Australia. The good news, however, is that more is being imported or manufactured locally by entrepreneurial dealers and growers. Although it might be possible to modify existing equipment, some purchases should nevertheless be budgeted for. Among the specialist equipment currently in use in Australia are flame and steam weeders and brush weeders.

Some of the most useful tools for organic farmers are hand operated. Such tools often allow for greater flexibility and accuracy under a greater range of conditions. For larger vegetable enterprises, an excellent reading resource is Steel in the Field: a farmer’s guide to weed management tools (Bowman 1997), which provides case studies of a number of organic vegetable producers and describes, among other things, their choice of equipment, the equipment’s uses, its compatibility with other equipment, and the suppliers. Appendix A lists a number of equipment suppliers.
4.1.8 Monitoring performance

Record keeping is essential and is a requirement of certification compliance. Ideally, all growing beds should be numbered, and records should be kept of crops grown, weed, pest and disease incidence and control measures used, successes and failures, soil analysis results, green manures, fertilisers and other inputs applied, and weather data. Information should be recorded immediately after an operation is completed.

4.2 Designing the rotation

Organic crop agronomy differs according to the growth cycle of the crop species in question. These species can be broadly classified into three production groups:

- perennial—permanent planting, often with a dormant ‘non-growth’ period. An example is asparagus
- broadacre annual—annual growth cycle; extensive longer rotation; may include legumes and/or green manures, cereals and livestock in the rotation. Examples are pumpkin, potatoes, beets, and carrots
- intensive annual—seasonal growth cycle; intensive rotation; usually includes planting of intermittent green manure crops. Examples are leaf vegetables (for example, lettuce and Chinese greens), tomatoes and brassicas (for example, broccoli).

Organic vegetable systems are by no means limited to these three systems. For example, perennial species such as asparagus can be interplanted with annual vegetables or herbs.

These systems are further influenced by the system design. A number of aspects of design need to be considered:

- the rotation sequence (temporal), where crop choice and the timing of operations are considered
- the layout within a rotation (spatial), where row spacing, sowing density and intercrop spacing are considered to afford optimum resilience to pests, diseases and weeds and to facilitate operations such as harvesting and cultivation.
- the relationship of the crop to other natural features on the farm. For example, location and design of shelter belts and insectaries to encourage the build-up of natural predators.

These design considerations greatly affect a producer’s ability to effectively manage pests, weeds and diseases organically.

4.2.1 The rotation sequence

Perhaps the most crucial management decision for an organic vegetable farmer is the design of the cropping rotation, which should meet the farmer’s production and financial needs while also implementing sustainable agricultural practices.

The choice of vegetable crops and their relationship with one another, with fertility building and with pest and disease-breaking crops such as pastures and green manures are all factors that must be considered when deciding on the rotation design. Other factors that should be taken into account are the market for the chosen crops, the available resources (for example, labour and equipment), the economics of the rotation and, if they are to be a part of the rotation, the role of livestock.

4.2.2 Rotation rules

Although there are a number of rules that should be followed when designing a rotation, flexibility is a central consideration; there is no point sticking to a planned rotation if, for example, the market for a particular crop has slumped. When choosing crops for a rotation it is a good idea to have a number of uses in mind—say, processed or fresh—and in such a situation careful choice of variety is crucial. Organic certifiers might stipulate that in any three-year period at least one year should include a green manure crop, leguminous crop or pasture phase. This might not be required if compost is regularly applied for primary fertility building or where livestock are incorporated in the system.

Generally, however, the following rules should be applied:

- Avoid repeat cropping with the same species. For crop rotation to be effective, vegetables belonging to the same plant family should not be planted in the same location for two or three years, or perhaps even longer if soil borne diseases are known to exist. This avoids the potential for pest and disease build-up. Knowledge of which insects, diseases and weeds may cause problems, their life cycles, and the conditions that favour their development is essential, to help plan the rotation and to develop management strategies to avoid or overcome problems.
- Crop rotation and weed control. Some crops and cropping conditions seem to encourage particular weed problems. These problems can occur in the current crop or in the next season’s crop. It is important to note and record these weeds, particularly during the early planning stages, so that it is possible to plan their control when those conditions recur in the rotation. Some crops and weeds can affect the growth of subsequent crops or
weeds by exuding a chemical, a phenomenon known as allelopathy. Allelopathic influences can be both an advantage (if they affect weeds) or a disadvantage (if they affect the crop).

- **Precede soil-depleting crops with soil-replenishing crops.** A rotation should generally consist of soil-depleting and soil-replenishing crops. Legumes can provide nitrogen for subsequent crops. Other crops, such as those with deep tap roots, have the ability to exploit a greater area of the soil nutritive reserve. Turning in refuse from these crops will help recycle deep nutrients for use by shallow-rooted crops. Crops with fibrous root systems are also important for nutrient exploration. Some crops are chosen on the basis of their ability to add to soil organic matter. With green manure crops, the aim should be to have a range of species that fulfil all of these requirements.

The composition and timing of incorporating a green manure crop can be designed either to supply essential nutrients (if ploughed under when young or, for legumes, at early flowering) or to boost organic matter and improve soil structure (if allowed to produce maximum crop biomass before being ploughed in). Table 4.1 shows two possible green manure mixes, their cost, and their biomass contribution. Crops having higher nitrogen requirements should follow green manure crops. These include crops such as lettuce and sweet corn, which have a shallow, fibrous root system. These would then be followed in the rotation by flowering crops such as broccoli and cauliflower, which have lower nutritional requirements, and then by a deeper rooted fruiting vegetable such as pumpkin. The final crop in the rotation would be a root vegetable: these have the greatest ability to exploit the soil profile for remaining nutrients. This could then be followed by two green manure crops—one to increase soil organic matter (for example, an oat-based crop) and the other legume based—to precede the start of the next vegetable rotation. Alternatively, a single green manure crop and compost could be applied. Incorporation of a green manure crop in the rotation does not preclude supplying additional nutrients before or during a vegetable crop’s growth. Soil and leaf analysis will help to determine these requirements. Section 4.4 discusses crops’ nutritional requirements in greater detail.

- **Use the root physiology of crops to help improve soil structure.** Some crop species—such as sunflowers—have extensive and penetrating root systems. These would then be followed in the rotation by flowering crops such as pumpkin. The final crop in the rotation by flowering crops such as pumpkin. The final crop in the rotation would be a root vegetable: these have the greatest ability to exploit the soil profile for remaining nutrients. This could then be followed by two green manure crops—one to increase soil organic matter (for example, an oat-based crop) and the other legume based—to precede the start of the next vegetable rotation. Alternatively, a single green manure crop and compost could be applied. Incorporation of a green manure crop in the rotation does not preclude supplying additional nutrients before or during a vegetable crop’s growth. Soil and leaf analysis will help to determine these requirements. Section 4.4 discusses crops’ nutritional requirements in greater detail.

### Table 4.1 Two possible green manure mixes: cost and biomass contribution

<table>
<thead>
<tr>
<th>Field pea mix</th>
<th>Vetch mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>50kg/ha field pea (Dundale)</td>
<td>38kg/ha vetch (Popany)</td>
</tr>
<tr>
<td>20kg/ha oats (echidna)</td>
<td>20kg/ha oats (echidna)</td>
</tr>
<tr>
<td>1.4kg/ha fodder mustard (Winfried)</td>
<td>1.4kg/ha fodder mustard</td>
</tr>
<tr>
<td>60kg/ha faba beans (mixed)</td>
<td>38kg/ha faba beans (mixed)</td>
</tr>
<tr>
<td>Sowing rate: 131.4kg/ha (total mix)</td>
<td>Sowing rate: 81.4kg/ha (total mix)</td>
</tr>
<tr>
<td>Cost of mix: $159.0/ha</td>
<td>Cost of mix: $94.3/ha</td>
</tr>
</tbody>
</table>

4.2.3 Spatial design considerations

Row and inter-row spacing, the number of crop rows per bed, and interplanting with other species to act as insectaries or trap crops are some of the spatial design considerations when planning a cropping phase.

**Weed management**

Weeds grow best where there is minimal competition—for example, where there are gaps in a crop stand. Because weeds are better competitors, they will occupy these sites rapidly. Several practices can reduce the potential for weeds to invade a site:

- decreasing the inter-row spacing—that is, increasing the crop sowing rate
- decreasing the distance between rows or beds
- increasing the number of crop rows on a bed
- growing a competitive crop or a crop that is readily cultivated—for example, pumpkin and potatoes.

The aim is to close the crop canopy as quickly as possible. In the case of crops that never establish a competitive canopy—such as onions and, to a lesser extent, carrots—other strategies are needed. Of course, any strategy that changes crop or row spacing must be compatible with the available machinery and equipment. Experimentation might be needed in order to determine the optimum spacing for each crop. Increasing the sowing rate can affect the total yield and the size of the product—for example, the head size of cauliflowers and the bulb size of onions.

**Pest management**

The crop spacing and its relationship with other crops
can influence the occurrence and dispersal of pests and their predators. Insectaries (to provide food sources and thus encourage beneficial predatory insects) and trap crops (to provide a preferred food source for the pest) are often interplanted in strips or planted as a border surrounding the main crop. Research in the United States has shown that substantial numbers of beneficial insects can move up to 113 metres from insectary hedgerows into adjacent vegetable crops. Research into spatial design for insectaries and trap crops is increasing, but there is as yet little information available about optimal design for the management of specific pest and predator species.

Understanding a pest’s ecology and dispersal characteristics will help when designing cropping layouts. For example, to limit the spread of aphid-transmitted virus, crops planted later can be planted upwind of fields planted beforehand. In New Zealand beetle banks have been successfully used around crops to prevent pests moving into the crops. Some planting layouts can also confuse pests and thus reduce egg laying or dispersal.

4.3 Variety and crop selection

Market suitability, physiological characteristics, pest and disease resistance, seed or seedling availability, and environmental suitability are all considerations when determining what variety of crop to plant. Since 31 December 2003 it has been a requirement of the National Standard for Organic and Biodynamic Produce that the chosen variety be obtained from organically certified seed or seedlings. The variety should also be popular in the marketplace, be high yielding, have good pest and disease resistance, and have good seedling vigour and canopy development in order to smother weeds. Some varieties have features—for example, hairs or a rough surface—that make them unattractive to pests.

**4.3.1 Market suitability**

Market research is essential for determining which vegetables are popular with consumers. Contact organic wholesalers, retailers and exporters and find out what is required and when it is required. Some types of vegetables might be undersupplied at particular times of the year, and it might be possible to fill that seasonal gap. Restaurants or caterers might want specialty vegetables—for example, ‘mini’ vegetables. Local markets or farm-gate sales might be a possibility, in which case growing a broad range of popular lines could be the best option. A vegetable processor is another possibility: organic baby food is being marketed by a number of processors in Australia and elsewhere. A study by the Queensland Department of Primary Industries found that there is an export market for frozen organic vegetables (Lakin & Shannon 1999).

*Generally, there are preferred cultivars for processing and for the fresh-food market; this should be researched. Processors will probably have their own requirements, which could include variety, timing and quantity of supply, shape, or specific composition requirements such as the percentage of soluble solids in the product.*

**4.3.2 Environmental suitability**

Once the decision has been made about what to grow, the next step is to choose a suitable cultivar. Do some ‘local’ research: contact the local agriculture department, producers and home gardeners to find out what performs well in the area. Soil type and seasonal characteristics such as day length and temperature range all influence what cultivars can be grown and when they can be grown. It may be possible to modify environmental factors to protect or change the maturity date of crops: crop (or row) covers and glasshouse production can achieve this.

**4.3.3 Pest, disease and weed resilience**

Among the variety features that will give an organic crop an advantage are inherited disease and pest
4.3.4 Seed and seedling availability

Organic certification standards require that first preference be given to planting organically raised seeds or seedlings.

Since 1 January 2004 this has been a requirement of the National Standard for Organic and Biodynamic Produce. An industry database of producers and suppliers of organic seed and seedlings is being developed.

Open-pollinated and non-hybrid varieties are also preferred but are not essential. Genetically modified (transgenic) cultivars are not permitted in organic systems.

Care should be taken to ensure that the seed has acceptable germination. A few seeds planted in a pot before sowing will give an indication of the germination percentage. Seed must not be treated with pre-sowing chemicals.

4.4 Soil fertility and crop nutrition

Organic farming starts with the soil. The organic farmer’s primary aim should be to provide crop and animal nutrition by implementing practices that nurture the soil, stimulate soil life, and conserve nutrients. This involves developing both long-term and short-term strategies to improve soil health and to supply crop nutrition.

4.4.1 Organic soil conversion

Organic conversion is not just about replacing a high-chemical input system with a no-input, or every ‘alternative’ input, system. The organic soil-building process goes through three critical stages, which can be referred to as the ‘adjustment phase’, the ‘comfort phase’ and the ‘maintenance phase’.

The adjustment phase

The adjustment phase involves developing a system that reduces the crop's reliance on artificial chemicals. This could be likened to going ‘cold turkey’ for farming systems that are heavily dependent on chemical inputs. During this phase some farmers have observed that crop yields can decline as the system converts from a chemical to a biological one and is starved of its regular ‘fix’ of readily available, chemical fertilisers.

The length of this preliminary soil-building process depends largely on the soil’s pre-existing condition and fertiliser history. The phase involves increasing biological activity by providing optimal soil conditions. The challenge for organic farmers is to develop and adopt a cost-effective strategy that encourages and builds biological processes in the soil while maintaining optimal plant nutrition. In addition to standard organic practices—such as planting legumes and green manure crops and applying compost and rock dusts—commercial organic fertilisers, seaweed, fish emulsion, sugar solutions and microbial preparations are applied to stimulate soil biological activity and supplement plant health.

The comfort phase

The comfort phase coincides with an increase in biological activity and a corresponding release of previously ‘locked-up’, or unavailable, nutrients. It is during this phase that optimal crop yields are reached. Organic farmers need to be careful not to over-fertilise during this phase. This is more likely to occur in intensive horticulture systems, where application of compost and green manuring are common practice. Over-fertilisation usually manifests itself through crop physiological problems and an increased incidence of pests and diseases.

Farmers should also be aware that a running down of the nutrient reserve can also occur if the soil system is not being monitored properly. Usually, organic farmers regularly monitor soil nutrient levels. Soil and plant tissue testing allows nutrient requirements to be tracked, thus avoiding ‘overfeeding’ or ‘underfeeding’ the soil system.
The maintenance phase

Research has shown that some organic systems have, over a relatively long period, experienced a decline in soil nutrient reserves (Small et al. 1994; Penfold et al. 1995). This could be attributed to long-term drawing down of nutrients during harvesting of crop or (less so) livestock products and through natural processes such as leaching. In Australia this has been particularly evident in broad-acre cropping and livestock enterprises where a phosphorous deficiency has been found. This has implications for cereal and legume crops: phosphorous deficiency in legumes adversely affects the plant’s ability to fix atmospheric nitrogen in root nodules; nitrogen fixed by legumes is an essential nutrient in subsequent crops in the cropping rotation.

Preparing a nutrient budget by reconciling inputs and outputs and correlating this with regular soil tests and crop performance can help organic producers track the performance of the annual soil nutrient cycle.

Increasing biological activity

Organic conversion begins with a process that encourages increased activity by microbes and arthropods in the soil. The elemental composition, structure and organic matter content of the soil need to be favourable if biological activity is to be increased.

Biological activity in the soil begins with the breakdown of organic matter. During the decomposition process the organic molecules in organic matter are either broken down into simpler organic molecules that require further decomposition or converted into mineralised nutrients. Organic farmers supply organic matter through incorporation of green manure crops and crop refuse and the addition of compost.

The use of bio-indicators is becoming increasingly important as a way of assessing soil health. Pankhurst et al. (1997) review how soil organisms and biotic processes can be used as indicators of soil health. A variety of techniques can be used for assessing biological activity, among them measurement of soil microbial activity based on the soil’s carbon dioxide respiration, DNA testing to determine the diversity and abundance of micro-organisms present, and an ‘in-situ’ technique based on measuring the tensile strength of a cotton strip that has been buried in the soil. Commercial laboratories offering services to assess soils for microbial status are now becoming more common in Australia.

Green manuring

Green manure crops are grown specifically for cultivation back into the soil in order to build up organic matter and nutrients and to stimulate biological activity. The type of green manure crop and the stage at which it is turned in determine the amount of organic matter or nutrients returned to the soil. A lush, actively growing legume sward (of vetch, faba beans or lupins, for example) contains large amounts of nitrogen (50–140 kilograms of nitrogen gain per hectare) that is released to the soil upon cultivation. The same crop, when allowed to mature, contributes more organic matter but less available nitrogen. If a soil is low in organic matter, a green manure crop that increases organic matter (for example, oats) is desirable.

Green manures can also act as ‘break crops’ to reduce the carryover of pests and diseases in subsequent crops in the rotation. They are an essential component in intensive organic annual cropping rotations.

Nitrate leaching following the incorporation of a green manure crop can occur when rainfall exceeds evaporation, resulting in net drainage. There is some evidence that nitrate leaching might be less under an organic system than under a conventional system (Lampkin 1990). Nitrate leached below the root zone is effectively lost from the system. Rotation design within the organic system must take into account the need to minimise large nitrogen losses following ploughing in of the green manure crop. Early establishment of a cereal crop immediately after incorporating the green manure has been shown to be one of the most effective ways of reducing nitrate leaching.
Some organic farmers apply foliar sprays of sugar, molasses or compost teas to green manure crops prior to turning the crop in. This is thought to provide additional energy for micro-organisms, enabling a more rapid breakdown of green matter prior to planting the next crop.

**Undersowing crops**
Undersowing crops—for example, barley with the grass or clover pasture that will follow in the rotation in the succeeding year or almost any leguminous crop—is central to organic systems. The practice has been shown to have beneficial effects on the diversity and abundance of insect species (Vickermann 1978). Other benefits are the potential for higher protein content in cereals undersown with a legume as a result of a small net nitrogen gain, improved weed suppression, improved pest and disease control, and establishment of that very important clover-based pasture (Lampkin 1990).

**Permanent swards and pastures**
In both livestock and cropping enterprises legume-based pastures provide the system’s main nitrogen input and livestock largely recycle other nutrients. In orchards, permanent swards, or sods, are sometimes planted between the rows and are the preferred method of inter-row management because the soil ecosystem remains undisturbed. This favours the development of plant roots, soil microfauna and flora, worms and mycorrhiza and helps retain good soil structure.

A mixture of deep-rooted and shallow-rooted species increases the potential for gaining access to soil nutrients; for example, in organic pastures herbs such as chicory, plantain, yarrow and caraway are often added. Ideally, an orchard soil consists of a range of perennial plant species. Grasses such as ryegrass and fescue are efficient in obtaining potassium from the soil and are able to make use of excess organic nitrogen. Legumes such as clover and lucerne can contribute 40–140 kilograms per hectare per year of nitrogen to the soil reservoir. Herbs such as plantain and chicory often have a higher mineral content and have deep roots capable of bringing up leached elements that would otherwise be unavailable to the crop.

**Compost**
Compost is a primary source of nutrients and organic matter in intensive organic farming systems and an invaluable food source for soil micro-organisms. Compost is not widely used in Australian broad-acre organic cropping systems because sources of compost material are limited and, when available, often costly. Animal manures and crop refuse are the main ingredients of compost. Organic standards require that imported manure intended for application be composted before use.

The primary benefits of compost are that it is a more stable form of organic matter than raw waste and weed seeds and diseases are destroyed during the composting process. When manure is composted, it is easier to spread, and losses to the environment are minimised. Rock dusts and clay added to compost in small quantities can help reduce nitrogen losses from the heap by absorbing ammonia (Lampkin 1990).

Many recipes and techniques are advocated for composting. The Australian Standard for Composts, Soil Conditioners and Mulches (AS 4454-1999) defines composting as ‘the process whereby organic materials are pasteurised and microbiologically transformed under aerobic and thermophilic conditions for a period of not less than 6 weeks’. The pasteurisation process is described as having ‘the whole mass of constantly moist material subject to at least three consecutive days at a minimum temperature of 55°C’.

The principal aim of composting is to produce a stable humic compound. This is achieved by mixing main ingredients together in quantities that achieve a suitable carbon–nitrogen ratio. The ideal ratio lies between 25:1 and 35:1 (Lampkin 1990). Moisture content is also important and ideally should be about 55 to 70 per cent. Compost heaps should be designed to allow sufficient air access. Microbial activity quickly raises the temperature of the heap to 55°C, where it stays for a
mounting bucket for loading and turning and a manure spreader for application.

**Rock dusts and re-mineralisation**

Many Australian soils are leached of elements essential for plant growth. Moreover, many years of farming with an emphasis on supplying a nitrogen–phosphorus–potassium fertiliser regime, at the expense of minor elements, might have resulted in further ‘mining’ of some trace elements. This theory has some support: evidence suggests a gradual decline in the elemental composition of fresh fruit and vegetables since the 1940s (McCance & Widdowson 1992).

Soils with higher biological activity play an important part in increasing the availability of micronutrients. Much research has been done into the symbiotic roles of arbuscular mycorrhiza fungi in increasing phosphorus availability in plants and rhizobium bacteria and their ability to fix atmospheric nitrogen for plant use. There has, however, been little research into the role of other soil micro-organisms in improving micronutrient uptake by plants.

The re-mineralisation of Australian farming soils is a strategy more recently proposed by some soil health experts. Various techniques for re-mineralisation are gaining an increased following among farmers; they are largely based on balancing soils’ cation exchange capacity and achieving a satisfactory calcium–magnesium ratio (Albrecht 1975). The effectiveness of the techniques is yet to be scientifically evaluated under Australian conditions.

Re-mineralisation involves the addition of various rock-based materials, among them reactive and colloidal rock phosphate, dolomite, limestone and rock dusts (from silicate rocks, including basalt and bentonite), as well as some commercial organic blends.

Rock dusts can be added directly to the soil or to compost heaps. Whatever the method of application, the release of nutrients from the rock dusts is accelerated by moist conditions, high temperatures and high biological activity—for example, during a green manure stage or composting. Finer particle size of the rock dust is preferred as this provides a greater surface area for micro-organisms to act on and hence a more rapid availability of nutrients to plants. Where soils have good biological activity and are subject to irrigation, the effectiveness of the mineral products can be further improved.

Rock phosphate becomes available more quickly under acidic soil conditions (a pH less than 5.5) and where rainfall exceeds 600 millimetres. Because the benefits of rock dusts are not available immediately to a crop, the dusts should be applied a few seasons before cropping. Consistent, small applications throughout the rotation should be considered.

For growers buying mineral rock dusts, it is important to note that unacceptably high levels of heavy metals have been found in some commercial products. Unlike other commercial fertilisers, rock dusts are at present not required to undergo testing or to be registered under the Fertiliser Act 1998. Each batch bought should be tested, or a written declaration should be obtained from the manufacturer or supplier, in order to determine whether impurities are present.

4.4.2 Improvements to soil structure

Improvements in the biological activity and cation exchange capacity of soils will generally lead to an improvement in soil structure, but this needs to be supported by
suitable cultural practices. Use of suitable machinery at the correct soil moisture, incorporation of soil organic matter, and improvement of soils using differing types of crop root physiology are techniques organic farmers use in order to develop soil structure.

Lampkin (1990) describes cultivation practices as having the greatest impact on the soil of any agricultural activity. He summarises the organic approach to soil cultivation as one that seeks to maintain soil structure and allow the soil to have vegetative cover for as long as possible within the rotation. Shallow cultivations, where only the surface layers of the soil are mixed, are an important element of this approach. Deep cultivation of dry soil is practised to loosen and aerate soil, avoiding inversion of the lower layers. Green manures or cereal crops are sown as soon as practicable following cultivation: their roots help stabilise loosened soil and minimise nitrate leaching.

4.4.3 Correcting deficiencies organically
Unseasonal weather, such as a prolonged dry spell or excessive moisture, or simply a miscalculation of crop nutrient requirements, can result in a nutrient deficiency in the crop. If this happens during a critical crop growth period, plant health can decline, predisposing the crop to pest and disease attack. A permanent yield loss could result, so it is necessary to correct any deficiency quickly. Leaf analysis is the most commonly used method of detecting deficiencies during the crop-growing period. Organic farmers use foliar sprays (such as fish and seaweed extracts) molasses, compost teas and trace elements to correct temporary deficiencies. Guidelines for foliar feeding of plants can be found on the website 'http://www.attra.org/attra-pub/PDF/foliar.pdf'.

4.4.4 Livestock and soil nutrition
Livestock play an important part in organic farming. Crop nutrition is improved when a pasture or grazing phase is incorporated in the cropping rotation. This is common practice in broad-acre systems and in some annual vegetable production systems. Among the nutritional benefits offered by a pasture phase are nitrogen fixation through the legume component and the recycling of organic matter and nutrients via livestock manure. The pasture phase can also help to suppress pests, disease and weeds by providing a break in the disease cycle.

If well managed, poultry such as chickens, geese and ducks can provide valuable nutrient inputs as well as contributing to pest, disease and weed control. Section 2.2 provides more information about managing livestock.

4.4.5 Determining crop nutrient requirements
The availability of nutrients in the soil and the growth stage of the crop will determine a crop's nutrient requirements. Augmentation of nutrients in the soil reservoir necessitates a long-term fertility building program. Increasing biological activity and organic matter (and thus humus formation) and balancing other essential elements (for example, the calcium–magnesium balance) should be based on site-specific information collected through regular soil analysis. Soil tests are the first step to planning a soil management program.

Soil tests should be conducted regularly—particularly during the early stages of conversion—to help track the effectiveness of soil improvement and crop nutrition programs. Soil samples should be collected from all representative soils on the farm, with care being taken to map out the location and depth of sampling. A good sampling procedure is described on the NSW Department of Primary Industries website ‘http://www.agric.nsw.gov.au/reader/6701’.

Ideally, samples should be taken in the same area and during the same environmental (temperature, soil moisture) conditions each time.

The samples should be sent to an independent, accredited soil laboratory. It is best to verify the sampling and packaging technique with the laboratory before dispatching the samples. Various levels of detail (and cost) are available with the analysis. A full analytical assessment (including an assessment of biological activity) costs from $80 to $150. Appendix A lists some accredited analytical laboratories.

4.4.6 Seasonal nutrient requirements
During conversion to organic production and during a crop’s growth period additional nutrients might need to be supplied. It is important that crop growth does not falter during the growing season, and in this instance sap or tissue tests on the crop offer a method of rapidly checking crop nutrient status. Nitrogen, phosphorous, potassium and calcium are the elements most often required by crops.

Nitrogen
Nitrogen is required in reasonable quantities by most vegetables. Unlike many elements, it is relatively mobile in the soil nutrient pool. As nitrate, nitrogen is water soluble and can be rapidly leached from the crop root zone. When large amounts of organic carbon are present—for example, when straw
or crops rich in organic matter are turned into the soil—nitrogen can become temporarily unavailable as soil microbes use the nitrogen to help them digest the carbon. Nitrogen can also be lost in gaseous form, through the processes of denitrification and volatilisation.

Before planting, nitrogen is supplied through incorporation in the soil of legume-based green manures, compost, blood and bone (usually applied as an ingredient during composting) and commercial organic fertilisers. Note that in the case of leeks, chives and shallots organic animal products such as blood and bone¹ should not be applied immediately before planting because they attract the corn seed fly whose larvae will attack the planted cloves or germinating seed.

Although nitrogen mineralisation can be high—up to 900 grams a day—this might be inadequate for a rapidly growing vegetable crop. Short-season crops such as radishes and beets will most probably be able to obtain all their nitrogen requirements from a green manure crop, compost or organic fertiliser that has been applied before planting. Crops with a growing season beyond six to eight weeks will probably need additional nitrogen, applied as a side-dressing or foliar spray or, if used, by means of drip irrigation. Commonly used substances are fish emulsion, worm juice and compost teas (made from stinging nettle, for example).

**Phosphorus**

Although soil tests might show there is sufficient phosphorus in the soil, the phosphorus might be in a form that is not readily available. Cold, wet soils, which can limit root growth, restrict phosphorus availability. In addition, organic sources of phosphorus are less soluble than conventional forms such as superphosphate, which is treated with sulphuric acid to increase its solubility, so there is a time lag before phosphorus becomes available for the crop. Increasing biological activity improves availability, but additional phosphorus applied in small, regular doses will ensure that a reliable supply is available for crop growth. Rock phosphate, guano, fish meal and bone meal¹ (usually added as an ingredient during composting) all contain moderate levels of phosphorus and are commonly applied in organic systems. Phosphorus should be applied at least a year before cropping.

**Potassium**

The element potassium is needed for flower and fruit development and to improve storage quality; it is particularly important for crops such as tomatoes. Among the organic sources of potassium are compost, seaweed, basic slag, wood ash, sulphate of potash, and green sand (langbeinite). Numerous commercial organic fertiliser blends containing potassium are available.

**Calcium**

Calcium is needed for plant cell strength, pest and disease resistance, and post-harvest quality. The Albrecht theory of plant nutrition holds that calcium and its relationship (ratio) with cations, particularly magnesium, are critical for soil-building processes and crop growth. Like phosphorus, calcium must be applied well before planting, with regular, small doses beneficial to sustain soil levels. Limestone (naturally mined), dolomite and gypsum are sources of calcium. Dolomite is also a source of magnesium, and gypsum also contains sulphur.

**Other elements**

Other minor elements essential for crop growth might be lacking in the soil. Commercial organic fertilisers, compost and foliar applications of seaweed, worm liquid and compost teas can be used to remedy deficiencies.

### 4.5.1 Ground preparation

**4.5 Soil preparation and planting**

Cultural management of soil in vegetable production systems is a matter of achieving a balance between the primary goal of maintaining or augmenting the level of organic matter and that of achieving an acceptable soil condition through the tillage that is required for crop growth and weed management.

Conventional intensive tillage systems generally have long-term negative effects on organic carbon levels in the soil. Conservation tillage techniques, while minimising soil disturbance and carbon loss, generally leave crop residues on the soil surface. This creates problems for organic producers who rely on tillage to manage weeds, incorporate crop residues, and aerate the soil.

Vegetables are generally grown in rows or beds, and ripping should follow this layout. Primary tillage usually involves developing a deep, friable soil, which is then formed into hills; if beds are to be used, a number of hills are combined into a bed. Further information on farming on raised beds can be obtained in the NSW Department of Agriculture.

Slowly available and soil-building substances such as compost, rock phosphate and lime are best applied before forming the beds. It is extremely important that the beds or rows be straight and the correct distance apart: otherwise, post-planting cultural operations such as inter-row weeding will be difficult. If well made, beds should last a couple of seasons before needing to be re-formed. If subsurface drip irrigation is to be used, it must be installed after bed-forming and before sowing the crop.

Green manure should be incorporated well before the crop is planted. Organic matter (in this case, the green manure crop) must first be digested by micro-organisms before any nutritional benefits become available to subsequent crops. Nitrogen is used by micro-organisms as they consume and break down organic matter, and if a vegetable crop is planted when undecomposed organic matter is still present a temporary nitrogen deficiency can occur. Some organic practitioners spray molasses, compost teas, sugar or microbial solutions on the green manure crop before incorporation, to facilitate its breakdown.

Incorporation of the green manure should be shallow, while still burying crop refuse. A bulky green manure might need to be slashed or mulched before incorporation, to facilitate breakdown. A rotary mulcher can be used very effectively to break up large amounts of crop refuse and can be adjusted to operate in the top 5 centimetres of soil.

The timing of incorporating green manures also needs careful consideration. Rapidly growing, immature green manures break down more rapidly than green manures that are allowed to mature. In legumes, once flowering begins, the vegetative growth slows, and nitrogen that has been fixed by the plant begins to be used for seed production. This is lost nitrogen in terms of the vegetable rotation, so incorporation should occur before or during early flowering of the green manure. If a mixture of species is used in the green manure, it might be necessary to forfeit some nitrogen benefit in order to ensure that there is sufficient time for the organic matter to decompose before the vegetable crop is planted. Low soil moisture can also slow the rate of decomposition. Green manures should never be allowed to go to seed (unless the seed is to be saved for future planting) since this can cause weed problems in subsequent crops.

Primary tillage can be very destructive of soil organic matter. The benefits of a green manure crop grown and incorporated before preliminary ground preparation and bed-forming can be quickly lost by excessive cultivation, or by cultivating at inappropriate soil moisture levels. Once the beds are formed, a green manure crop can be grown in situ, then mulched, and shallowly incorporated before the vegetable crop is planted. This cultivation can damage beds, so it is sometimes necessary to reshape the bed following incorporation of the green manure.

Another green manuring technique uses the residues of crops such as vetch grown in the previous season. The vegetable crop is planted into the residual surface mulch of the cover crop. The technique relies on the senescence of growth in the cover crop. The crop is then mulched down to form a surface mulch. The technique relies, however, on the cover crop dying off before the vegetable crop is planted. The growth cycle of the cover crop must be completed in time for that crop to be mowed before the vegetable crop is planted. Provided dry conditions prevail, this can be achieved for a winter-grown cover crop to be followed by late–spring planted vegetables. Late spring rains can, however, cause unacceptable delays to cover crop senescence and crop sowing. In addition, planting into the cover crop residue calls for specialist equipment. Despite these problems, researching suitable cover crops and their management as surface mulches in organic vegetable production systems is worthwhile.

### 4.5.2 Pre-irrigation

Pre-irrigation or rainfall before planting is advantageous: it helps germinate weed seedlings and provides a moist seedbed into which the crop can be sown. The weeds are usually cultivated out before sowing: in this case, the cultivation should be shallow and should avoid soil inversion since this would promote further germination of weeds. An effective implement is one that ‘slices’ under the soil, lifting and removing young weeds. It is important to avoid cultivating if rain is imminent because the weeds will be transplanted. Flame, steam and brush weeder can also be used to control young weeds. If pre-irrigation is not possible, planting should avoid soil disturbance as much as possible. Some post-planting weed control will nevertheless be required.

### 4.5.3 Planting

Before planting, soil tests should be done in order to determine whether additional fertiliser is needed, given the crop’s known requirements. Organic fertilisers or compost can be surface applied or
banded in the crop row. The time of planting should take into account the requirements of the variety to be grown, the market ‘window’ and if, by delaying planting or planting earlier, potential weed, pest or disease problems might be avoided.

Since 1 January 2004 it has been mandatory to use organically produced planting material. If such material is not available, formal application must be made to the certifier for an exemption. Exemptions are granted only if it can be demonstrated that the variety in question is not available or the quality is not acceptable. It should still be possible for a commercial organic nursery to supply transplants, provided it receives plenty of notice (about 15 weeks) in order to obtain the variety and prepare the order.

Germination tests should be carried out before seed is sown. This can be done by placing a few seeds in a pot or between damp (not wet) tissue paper for a few days and recording the germination percentage. The sowing rate can be increased to compensate for reduced germination. Some seed sources are very unreliable, so it is advisable to obtain a written guarantee of the seed germination percentage and the seeds’ freshness. Seed not used immediately should be placed in an airtight container and refrigerated.

Transplants should be checked for pests and any that are found should be removed before planting. A strong jet of water will physically dislodge some pests. Alternatively, they can be sprayed with an organically acceptable pesticide. The transplants should then be hardened off outdoors for a few days before being planted in the field.

Seeds or transplants?
Vegetables such as carrots do not transplant well, so seeds are the only option for planting. Transplanted (as opposed to direct-seeded) crops have an advantage in that they will be ahead of any weeds that germinate after planting and, if growing vigorously, will quickly shade out the weeds. Direct seeding tends to disturb the soil surface, encouraging weed germination. Irrigation can be crucial, especially for small-seeded species because they are not sown as deeply as large-seeded species. The soil surface must remain moist for longer to ensure good germination. Shallow-planted seeds are also more likely to be eaten by ants and birds.

Another consideration is seedling vigour. Some species—for example, onions—have extremely slow early growth, particularly in cold and wet conditions. Weeds, on the other hand, are better adapted to these conditions and will quickly smother struggling vegetable seedlings.

In general, small-seeded species are best transplanted—unless, like carrots, they do not like root disturbance—while larger seeded species such as pumpkin can be direct seeded.

When seeding or transplanting, it is important that rows are uniform and straight, so that inter-row operations such as weeding can be carried out accurately.

Plant spacing
The sowing rate between and within rows is generally higher in organic systems compared with conventional systems. Higher sowing rates mean that gaps between the crop plants will be quickly filled, which discourages weed competition. Care is needed, however, to avoid compromising crop quality. A higher sowing rate also increases inter-crop competition and can result in a reduced overall yield or smaller sizes for produce; for example, onion bulb size and cauliflower head size decrease with increased sowing density, although this can also be used to advantage if the aim is to produce ‘mini-vegetables’.

4.5.4 Post-planting operations
Post-planting cultural operations consist of weed and pest management and, if required, application of organic fertiliser. Accuracy when operating equipment and precision timing of operations are essential. Specially designed inter-row cultivators can remove young weeds from around the crop. One such implement is the WeedFix®, which consists of a series of rotating tines mounted either side of crop guards. The tines ‘stir’ the soil surface, dislodging weeds, while the guards prevent damage to the crop. The tines can be operated in two directions—either throwing soil towards the crop, thus smothering weeds in close proximity to the crop, or throwing soil away from the crop, removing the weeds.

Other types of equipment are also available for post-planting cultural operations, among them flame or hot-air weeder, brush weeder, rotating cultivator, and various toolbar attachments such as bean knives and Alabama sweeps. Highly recommended reading is Steel in the Field: a farmer’s guide to weed management tools (Bowman 1997), which documents farmers’ experiences in this regard. See: <http://www.sare.org/publications/steel/steel.pdf>
soil moisture in the root zone during the growing season. This requires a thorough knowledge of the crop’s water requirements and the soil’s water-holding capacity. Applying only the amount of water required by the crop leads to savings on pumping, fertigation (irrigation incorporating nutrients) and water costs and limits run-off problems. Information about good irrigation management practice is available on the NSW Department of Primary Industries website <http://www.agric.nsw.gov.au/reader/8054>. Also available from the department are publications providing guidelines for irrigation of processing tomatoes, onions and carrots, and melons.

Drip irrigation is the most efficient form of irrigation. It provides water directly to the plant, rather than wetting the entire soil surface, which can encourage additional weed growth. It has the further advantage that nutrients can be supplied by fertigation to the crop during the growing season. Cultural operations can, however, be made more difficult if the drip lines are laid on the bed’s surface.

Drip lines can be installed beneath the surface to facilitate cultural operations, although roots can grow into the lines and cause blockages. Most subsurface drip is impregnated with a herbicide to prevent root intrusion, so organic producers need to inform manufacturers that they require herbicide-free drip line. Most subsurface drip is impregnated with a herbicide to prevent root intrusion, so organic producers need to inform manufacturers that they require herbicide-free drip line. Most subsurface drip is impregnated with a herbicide to prevent root intrusion, so organic producers need to inform manufacturers that they require herbicide-free drip line.

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• Planning should aim to prevent weed outbreaks. Once there, weed problems are much harder to manage.
• Observe and record changes to weed populations in each field.
• Introduce changes to the lowest risk crops in the rotation.
• Identify the soil characteristics or management practices that favour specific weeds. The presence of a particular weed species might be an indication of a soil fertility or soil structural problem. A slight change in pH or improvements to irrigation management or drainage can change the conditions that were prompting growth and the spread of the weed.
• Build weed management strategies into whole-farm planning. For example, design a fence layout and paddock size that allow for strategic grazing (for example, with goats), grow less competitive crops in paddocks where weeds are not a problem, leave uncultivated areas to host potential biological control agents (for example, Patterson’s curse weevil), and choose crops that are able to compete effectively with weeds.

It is important to also remember that weeds can be beneficial. Among the possible benefits to the farming system are erosion control, habitats for insects, capturing soil nutrients and moisture at depth, and food or medicinal value for livestock (provided of course they are not toxic).

4.7.2 Reducing the bank of weed seed

Preventing weeds going to seed can greatly reduce weed pressure. Most soils contain a significant weed seed population, and each time soil is disturbed some of the seeds will germinate. It is possible, however, to gradually reduce this population by preventing weeds going to seed during the season and following up with off-season control measures.

Planting short-season crops such as lettuce provides more opportunities for weed suppression; competitive cover crops can smother weeds. Cultivation plus grazing and mowing weeds can prevent weed seed set. If the weeds do manage to set seed, baling the weeds into hay and removing them from the paddock before seed dispersal is an option. The hay could then be used in compost production. Proper composting makes seeds non-viable.

4.7.3 Management practices

Surveys of organic growers reveal that the most frequently used weed management tactics are manual and mechanical tillage, rotations including vigorous cover crops, slashing, and numerous cultural practices (Kristiansen et al. 2001). An integrated approach to weed management relies on planning long-term remediation strategies—such as soil improvements or the use of biological controls—backed up by short-term management practices.

Hand weeding

Perhaps the single most valuable tool in organic weed management is hand weeding, which can involve chipping or digging using a hand-held implement or pulling out weeds by hand. One weed allowed to seed could become an outbreak in a few seasons. Successful organic farmers never walk past a ‘potential’ weed problem. Hand weeding is often useful in inaccessible areas or for a final clean-up after relying on other methods.

Mulching

Organic farmers use mulches to help reduce weed competition, conserve soil moisture, lower soil temperatures, and prevent erosion. Among the organic materials used are hay, paper and cardboard, compost and sawdust. Organic standards prohibit the use of solid non-woven plastic or synthetic material sheets as mulches. Sometimes, woven plastic or synthetic materials are approved, provided they are completely removed from the paddock following harvest. To be effective, organic mulches should be applied and regularly maintained to a depth of 100 millimetres.

A green-manuring technique that uses the residues of crops (such as vetch) grown in the preceding season can also provide a mulch against weeds. The main crop is then planted into the residual surface mulch of the cover crop. The cover crop is also referred to as ‘living mulch’ or ‘smother crop’, and the technique relies on the senescence of growth in that crop, which is then broken down to form a surface mulch. Cowpeas and cold-sensitive clovers have been used with success.

Tillage

For tillage, Steel in the Field: a farmer’s guide to weed management tools (Bowman 1997) is essential reading.

Primary cultivation practices such as deep ripping can improve drainage and alter the weed species composition in a field. Primary cultivations, in combination with other control measures such as green manuring, should aim to reduce the weed burden before planting the crop. The final primary cultivation before planting should be carried out after optimum weed germination.

Secondary cultivations—those performed during seed-bed preparation or after planting—should be shallow and should aim to remove weed seedlings while minimising soil inversion or soil

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mixing, to prevent a 'new' weed seed bank from establishing at the soil surface.

Other techniques such as flaming avoid soil disturbance and, if properly timed, can be an effective alternative to cultivation. Such techniques are based on the idea that weed seeds require exposure to light to germinate. The seedbed is formed about two to three weeks before the crop is planted. After seven to ten days of good growing conditions (moist soil and warm temperatures), there is a flush of weeds, which can be killed with flame weeder or cultivation. Assuming all the weeds are killed and the soil on the bed is undisturbed (except for the minimal soil disturbance from seeding or transplanting the crop), fewer weeds should germinate during the season to compete with the crop. There is some evidence that, because of this need for exposure to light, night cultivation can also drastically reduce the germination of certain weed seeds.

In row-cropping situations, good weed control is facilitated by creating and maintaining evenly spaced, straight hills or beds. Mechanical weed control between crop rows, using implements such as rotary tillers (for example, the WeedFix®), should be carried out when the weeds are small and the crop is at the two- to three-leaf stage and, if necessary, again at the five-leaf stage or while it is still feasible without damaging the crop. Once the crop canopy has closed, competition from weeds should be minimal.

The most difficult place to manage weeds is within the crop row, and hand weeding is probably the most common method here. Having crop guards around tillage implements will allow weeding to be done as close as possible without damaging the crop.

To ensure a good weed kill, cultivations should be avoided if rain is imminent and should be timed for the earlier part of the day during hot, dry and windy conditions. Avoid cultivating wet soil: it will become compacted and drainage will be impeded.

The choice of tillage equipment depends on the job at hand, budget, and the equipment's commercial availability. Many vegetable growers use rolling cultivators because these allow shallow cultivation and can be adjusted for different row spacings and crop configurations. Mouldboard ploughing during primary tillage operations is the most effective way of reducing weed populations because it buries seeds deeply enough to reduce germination and establish. Mouldboard ploughing is, however, considered more destructive of soil structure than chisel ploughing.

Any form of prolonged tillage will affect the soil structure and increase compaction, as well as predisposing the paddock to erosion and fertility loss.

In summary, the following practices for mechanical cultivation should be adopted:

- Adjust equipment accurately for each cultivation.
- Establish straight rows and beds far enough apart to avoid injuring crop plants during between-row cultivations.
- Withhold irrigation after cultivation or avoid cultivating weeds if rain is imminent, to prevent the weeds from re-establishing.
- Establish 'traffic' rows to avoid compaction throughout the field.
- Hand-hoeing might also be practical on some crops. To avoid adverse effects from root damage to the crop, hoeing should be done before the crop and weeds are large.
- Narrow the row spacings or increase the planting density. Narrow row spacings will produce faster canopy cover, shading out weeds.

**Water management**

Effective water management is a central ingredient of weed management in organic production.

Pre-planting irrigation or rainfall stimulates weed emergence, after which weeds should be killed by shallow cultivation or by flaming. Planting of the main crop should occur shortly afterwards to avoid further weed germination as a result of rainfall.

Burying drip irrigation lines below the bed surface provides water to the crop but restricts the water's availability to weeds closer to the soil surface, particularly if rainfall does not occur. Post-planting operations are also be greatly facilitated if the drip line is buried.

**Crop physiology**

Vigorous crops often out-compete weeds. Fast-growing crops can quickly cover beds and fill gaps in the crop stand that weeds might otherwise occupy. Species with large leaves can shade out competing weeds.

**Biological weed control**

Various biological agents are available to facilitate weed management. Among them are insects (for example, crown root weevil for control of Patterson's curse), fungi and bacteria (for example, rusts formulated into biological herbicides known as myco-herbicides) and plant derivatives (for example, corn gluten meal, some vegetable oils and plant root exudates such as those from oilseed rape). Some of these agents have been formulated into commercial products known as bio-
herbicides. The certifier’s approval should be obtained before any treatment is used.

Some biological agents are effective over a longer period and rely on establishing and maintaining a colony of organisms. The organisms’ persistence—and hence long-term weed control—is dependent on the presence of a sustainable food source as well as suitable habitat, so it is desirable to set aside an area where there is a low level of the host weed or there is an alternative food source. These areas are usually uncultivated borders—for example, in windbreaks—adjacent to cropping areas.

Researchers often look for unsprayed or uncultivated sites in which to release biologicals, so an opportunity may arise to collaborate in trial work to evaluate the new control agents.

Of course, genetically modified organisms are not permitted as biological controls in organic systems.

Flame weeding
Flame weeding can be used to control weeds before and after germination of the crop. Effective pre-emergent flaming calls for good timing. The operation must be done after a flush of young weeds appears but ahead of significant crop emergence. The most effective time to kill weeds is before the three- to four-leaf stage. ‘Indicator’ seeds can be sown with the crop: they can be timed to emerge just before the crop in order to determine when it is safe to flame.

Post-emergent flaming is accomplished either by cross-flaming or by parallel-flaming. In cross-flaming, burners are set on either side of the crop row, in a staggered pattern, the burners being placed perpendicular to the row, so that the combined flames cover the entire drill area. In parallel-flaming, the burners are again set on either side of the row, but the flames are placed parallel to the row.

Ideally, beds should be smooth, with minimal clods: protruding clods or uneven terrain can shield small weeds or deflect the flame into the plant canopy.

For energy-efficient flaming it is desirable to travel as fast as possible, using the lowest gas pressure and thus the least fuel. Although there will be little immediate effect visible, the weeds will droop and wilt within a few hours. A quick way of testing whether the flaming has been effective is to firmly squeeze a plant leaf between thumb and forefinger, then let go. If there is a fingerprint where the leaf was squeezed, the heat has burst the cell walls and the leaf will wither.

Flaming has differing impacts on pests and their predators, so it is important to carefully monitor populations to see how they are being affected. For example, US researchers have found that ladybird beetles survive higher temperatures better than do tarnished plant bugs, a serious cotton pest. The ladybird preys on the pests in both their larval and adult stages; further, the tarnished plant bug appears at about the same time that cotton plants can first tolerate flaming.

Crops differ in their susceptibility to damage from flaming. Onions are flamed at around two weeks after the transplants are established. Corn, however, can be flamed at any time, although many flame users do not flame from the 12–25 centimetre growth stage, to avoid stressing the plants while their root system is developing.

Green beans, on the other hand, cannot handle exposure to the flame, so flaming is used only before emergence, to deal with the initial flush of weeds. With sensitive plants such as beans, plant parts can be protected from the flame by a wall of mist. Spraying a thin layer of water over the plants with flat-fan nozzles helps to protect them.

For some crops that send up early leaves before their growing point emerges, early post-emergence flaming can be used. Even if the young leaves are singed, the crops will recover provided the growing point survives. Once the growing point emerges, allow substantial growth before flaming the stalks.

Two types of flaming equipment are generally available. One is a hand-held propane flamer connected to a backpack-supported fuel tank. This manual method allows for greater selectivity and accuracy in applying the flame and is generally used in inaccessible areas or for small weed outbreaks. The other type of equipment involves propane burners that can be either individually mounted or attached to a two- or six-row, rear-mounted tractor-drawn cultivator. These can be four- or six-row flamers, depending on the size of the operation. This method is generally used for large areas and, if the burners are attached to a cultivator, allows flame weeding and mechanical cultivation to be done in one pass. The burners need to be adjusted in order to work efficiently with a cultivator because the soil the shovels throw can interfere with the flame hitting the target weeds.

For flaming between rows of emerged crops, accuracy and the safe use of equipment are essential. The following are considerations in this regard:

- The burners’ height and angle (vertical and horizontal) should be carefully adjusted, and fuel pressure, tractor speed and regulator setting checked frequently.
- Young crops should be carefully checked for flame damage to stems, buds or leaves.
- Flaming should be restricted to calm weather, and attention should be paid to the speed and direction of any air movement.
- The burners should be adjusted to a pilot setting when turning at the end of rows.
- Burner nozzles should be cleaned out each year to remove the carbon and rust that can flake off the inside of the steel pipe that leads to the burners. A bluish centre flame should be visible during peak operation.
- Operators need to be familiar with, and practise, the safety rules for proper inspection, filling and use of propane tanks and equipment.
- It is advisable to gain approval from local fire authorities before flaming. Never flame during a total fire ban.

Sanitation
Good sanitation can help to prevent new infestations and the spread of weeds. It involves the use of well-graded seed, removal of crop refuse, thoroughly composting manures and green waste, as well as cleaning down machinery between operations and before moving from one field to another. Livestock can act as weed carriers if they have been grazing on weed seed in infested pastures or have been hand fed on grain. Mulch applied to crops should be free of weed seeds. As noted, proper composting of crop refuse destroys weed seeds.

Solarisation
Solarisation, a technique used to kill weeds (as well as some pathogens and nematodes), involves placing clear plastic film over moist soil. The plastic is applied during the hottest part of the year for four to six weeks. The soil temperature should reach 60°C at a depth of 5.08 centimetres and 39°C at a depth of 45.7 centimetres. The main difficulty with soil solarisation is finding a time between crops when temperatures under the plastic are high enough for long enough to be effective. Once solarisation is completed, the plastic film used can be recycled for future use or disposed of in an environmentally acceptable manner.

Weeds vary in their susceptibility to solarisation. Winter annual grasses, barnyard grass, black nightshade, chickweed, field bindweed seedlings, hairy nightshade, prickly lettuce, red-root pigweed, and shepherd’s purse have been reported to be controlled by solarisation. In contrast, Johnson grass, nut grass, purslane and established field bindweed are only slightly affected.

Experience in the United States suggests the following general guidelines when applying soil solarisation:

- Solarisation is most likely to be effective during long days of high temperatures and no wind.
- Clear 1-millimetre-thick plastic should be adequate and is not expensive, but in windy areas thicker (1.5 to 2 millimetres) plastic might be necessary to prevent tearing. If the plastic is to be used as a mulch with the following crop, it must have UV inhibitors. Otherwise, sunlight and high temperatures will start to break the plastic down after four to six weeks.
- The soil–plastic contact should be as tight as possible in order to raise the soil temperature as much as possible and as deep as possible. Thus, the area to be solarised must be levelled and free of weeds and large clods of soil that could lift the plastic off the ground.
- Moist heat is more damaging to pathogens than dry heat. Irrigating with drip lines placed under the plastic is usually the most effective method.
- Plastic must completely cover the soil surface. There is an edge effect of up to 60 centimetres in which temperatures will be cooler and solarisation less effective.
effective, so solarisation in narrow strips is not likely to be effective.

- The plastic must be left in situ for four to six weeks.
- Deep cultivation should be avoided before planting the next crop, to avoid bringing non-solarised weed seeds to the surface.

**Organic sprays**

A number of organic sprays are approved for weed control under the National Standard for Organic and Biodynamic Produce. Among them are essential oil sprays, homeopathic products and biodynamic peppering. The efficacy of these substances is yet to be scientifically evaluated. A pine oil derivative is approved for use by some certifiers; some preliminary trials with this product have shown minimal efficacy.

Scientists from the US Department of Agriculture’s Agricultural Research Service in Beltsville, Maryland, have demonstrated effective control of a common range of broadleaf weeds by spraying vinegar on plants. Five and 10 per cent concentrations killed the weeds during their first two weeks after emergence; at higher concentrations, the vinegar had an 85 to 100 per cent kill rate at all growth stages. The vinegar used was made from fruit or grains, to conform to organic farming standards.

**Grazing animals and birds**

Goats, pigs, sheep, and other animals will eat weeds but will also root out or graze any crop plants present in the field. Pigs are sometimes useful to root out tubers of nut grass and Johnson grass before a crop is planted. Sheep can be used to ‘crash’ graze paddocks to prevent seed set. Goats and some breeds of sheep (such as dorpers) are foragers and will often eat plants that are less palatable to other species. Grazing by goats is a very useful weed control strategy, but owners need to be aware of potential toxicity risks. The RIRDC publication *The Palatability and Potential Toxicity of Australian Weeds to Goats* (Simmonds et al. 2000) provides suggestions for control strategies and outlines the health and production problems that may result.

Geese are one of the few animals that can be used once the vegetable crop emerges. In 1960, 175,000 geese were used as weeders in the United States, mainly to remove grasses from broadleaf crops such as cotton. Geese eat Johnson grass, sedge and nut grass, clover, chickweed and many other weeds. White Chinese weeder geese at least six weeks old are the best feeders. Because of their light body weight, they do little damage to crops if they step on them. If a larger goose for processing is required, Toulouse or Embden would be suitable. Some consider African weeder geese to be even better than the Chinese breed.

The geese should be grazed at rates of seven to twelve geese per hectare, depending on the weed population. In some crops and climates where weed growth is extreme in the early spring, more geese may be needed. It is crucial to start with enough geese and then remove (or sell) them as weed growth permits (usually when 75 to 90 per cent of their preferred food is gone); otherwise, they might begin eating the crop.

Geese generally prefer the tender young shoots of grasses and sedges over broadleaf vegetables. They need a constant supply of fresh water, so placing their water near weedier areas can help with weed management. When an area is weeded the water containers can then be moved into an area that is weedier. When checking on the geese, it is a good idea to carry a hoe to remove the weeds the geese find unpalatable.

Geese must have access to shade and be fenced in and protected from predators. Movable shelters...
can be useful. Strip-grazing geese concentrates their efforts on areas most in need of attention. This can be done using electric net fencing. Electric netting is available from Gundaroo Tiller in New South Wales (see Appendix A).

Geese can be ‘conditioned’ to eat weeds they normally do not eat if the undesirable weeds are fed to them when they are goslings. Geese and sheep can be grazed together. The sheep eat many of the broadleaf weeds the geese find unpalatable.

Since geese are vegetarian, a small number of ducks (such as Khaki Campbells) can be kept with the geese to help control insects, slugs and snails.


4.7.4 Managing problematic weeds
Weeds that organic growers commonly report as problematic—examples are couch, dock, kikuyu and sorrel—tend to have underground parts that are less vulnerable to the usual forms of non-chemical weed control such as tillage and mulch or are heavily seeding annuals (Kristiansen et al. 2001). Some annual weeds have very long-lived seeds and can survive for more than 40 years before germinating.

The primary approach to controlling perennials with cultivation is to separate the above-ground and underground parts and then exhaust the food reserves in the underground part. Tap-rooted and shallow-creeping perennials are generally easier to control; the deep-creeping and tuber, corm and bulb types are often the most problematic. Difficult-to-manage annuals are controlled by preventing the conditions that encourage seed germination and by stopping further seed set. Merfield (2000) provides some useful management strategies for weeds of this kind.

Noxious weeds
Farming organically does not exclude anyone from adhering to laws imposed by the Commonwealth or the states and territories. Under the New South Wales Noxious Weeds Act 1993, for example, producers are required to control certain weeds. The Act does not specify chemical control, but it does specify that the noxious weed be either fully and continuously suppressed and destroyed (for W1 and W2 category weeds) or be prevented from spreading and its numbers and distribution reduced (W3 category weeds). For a W4 noxious weed, the action specified in the declaration must be taken. The Act can be viewed online <http://www.legislation.nsw.gov.au/viewtop/inforce/act+11+1993+FIRST+0+N> and details of weeds declared in New South Wales can be viewed online at <http://www.dpi.nsw.gov.au/agriculture/noxweed>.

4.8 Managing pests
Organic standards prohibit the use of synthetic insecticides and discourage a pest management strategy that substitutes reliance on synthetic insecticides with allowable organic insecticides. Under the standards a more holistic approach needs to be adopted, which essentially comes down to an ‘integrated’ pest management strategy. Integrated pest management uses all suitable (and allowable) techniques to manage pest populations below levels that cause economic damage. It is now best practice in conventional agriculture. An organic grower has fewer tools and techniques available, but the approach is the same. It is possible to produce high-quality, relatively blemish free food, but to do so without resorting to agricultural chemicals calls for a higher level of management and a greater understanding of the whole system.

4.8.1 Planning an organic pest management program
Instead of using synthetic pesticides, organic farmers adopt cultural practices that encourage healthy plant growth and other practices that encourage predators of pests.

Three conditions must pertain if a pest problem is to develop:

- The pest must be present.
- The crop must be a suitable and susceptible host.
- The environmental conditions must be favourable.

These conditions can be thought of as the ‘pest triangle’.
The first step in an integrated pest management system lies in knowing what pests are likely to, or might possibly, attack the crop, the pests' life cycles, what conditions favour their survival, and what conditions or natural enemies might control the populations. The second step is to pre-plan the cropping system to minimise the potential for pests to become a problem. The third step is to monitor the conditions that might favour a pest outbreak. If all the conditions of the pest triangle are favourable to a pest outbreak, the fourth step is to intervene, to modify those conditions in order to reduce the risk or severity of damage. Figure 4.1 illustrates this.

**Step 1: Knowledge**

**Key pests**
Less than 1 per cent of all insects are ‘pests’. But agricultural production creates conditions that favour the build-up of a small number of insects to pest levels. ‘Key’ pests tend to be insects that are likely to cause serious damage if left unmanaged. They can be regular pests, as *Heliothis* is on tomatoes and many agricultural crops, or they can be irregular but potentially devastating, such as russet mite on tomatoes or pumpkin beetle on cucurbits. Lists of likely or possible pests and a number of crop guides for most agricultural crops are readily available from state departments of agriculture. In many cases the types of pests—for example, aphids, leafhoppers and *Heliothis* caterpillars—attacking a particular crop are similar species and, in some cases, the same species across different regions and countries, which is helpful when seeking information about potential management strategies.

**Pest biology and life cycles**
Knowledge of a pest’s biology and life cycle is essential for finding out where it is most vulnerable and how it is most likely to be managed. The more one knows about them the more likely it is one will find ways to thwart their successful development.

The native *Heliothis* (*Helicoverpa armigera*) is a good example. The moths emerge from over-wintering in late spring; they are active from early evening and need to mate before the females can deposit single eggs. Male moths find females by tracking (smelling) a sex pheromone the females emit. The females deposit up to 1000 eggs in their lifetime. The moths live primarily on the fat stored since they were caterpillars and only need to drink water or, if possible, nectar. Depending on temperatures, the eggs can take from four to 30 days to hatch. The warmer the temperature, the sooner the eggs hatch; for example, over a fairly typical temperature cycle in a temperate summer, when daytime temperatures are in the mid-30s and night temperatures drop down below 20°C, a *Heliothis* egg can take seven days to hatch. After the egg has hatched the newly emerged larvae immediately start feeding, initially just grazing the leaf or fruit surface. *Heliothis* caterpillars like to be in protected situations, so they will also seek shelter inside developing fruit or in the heart of leafy plants such as lettuce. The larvae or caterpillars are feeding machines, and as they grow too big for their skins they moult into the...
next instar, or larval, stage. *Heliothis* have six instars. At the completion of the sixth instar, the caterpillar burrows into the soil to pupate. Most pupae are found in the top 10 centimetres of soil. If pupation takes place during summer, the moth will develop, then crawl to the surface along the tunnel the caterpillar dug and, once emerged, repeat the cycle. In much of temperate Australia *Heliothis* have three to four generations a year. As autumn progresses an increasing proportion of the pupae will enter a winter diapause and will not complete development until the following spring.

There are several things to note from this life cycle:

- The moths are not active in the day or are not readily observed, but male moths can be caught in pheromone traps.
- Eggs are exposed from four to 30 days, depending on temperatures.
- Newly emerged larvae often feed in exposed situations, but later instars tend to be protected.
- The larvae cause the damage to the crop, and the later instars feed the most.
- Moths cannot burrow, so any damage to the exit tunnel will prevent moths emerging.

The resulting management options are as follows:

- monitoring moth flights with pheromones
- monitoring egg numbers and, if intervention is required, targeting treatment to egg hatch
- if larvae are missed, the next opportunity for management is to cultivate the soil after pupation to destroy the exit tunnels—known as ‘pupae busting’.

**Natural enemies**

In natural environments most organisms’ populations are kept in check by a range of ‘natural enemies’, among them bacterial, viral and microsporidium diseases, nematode infections, parasites or parasitoids, and predators. These natural enemies are called ‘beneficials’. Most insect pests have a range of specific and generalist natural enemies that either kill them or limit their ability to cause damage or reproduce. In most agricultural systems—and particularly those that use few, if any, insecticides—there are a range of generalist predators. Davidson and Davidson (1992) give the example of 1000 ibis consuming nearly one-quarter of a million pests during a day.

Populations of specific natural enemies can build up in the presence of the pest. If natural enemies are to thrive they need the ‘beneficial’ equivalent of the ‘pest triangle’:

- The beneficial must be present.
- There must be suitable hosts and, in some cases, a nectar or pollen source.

The environmental conditions must be favourable.

Shelter, breeding grounds and year-round food sources encourage predators. Nectar-producing species incorporated in pastures and windbreaks attract parasitic wasps, which parasitise scarab species in pastures. On-farm wetlands encourage predatory waders and, if correctly located and properly designed, provide a filter for nutrients in drainage before it leaves the farm. Ideally, there are suitable non-pest hosts for the beneficial populations to increase, so that if a pest arrives it finds itself in a hostile environment.

**Step 2: Prevention**

Within a pest management system, it is wise to prevent or limit the likelihood of pest populations causing serious damage. A variety of cultural control methods can be used to reduce the likelihood of pest outbreaks.
Site selection
Some sites will be more prone to pests than others. For example, growing organic tomatoes next to large plantings of sweet corn or other Heliothis host crops will increase problems with Heliothis. Choose sites that are isolated from sources of pests.

Choice of crop
Choose a crop that is optimal for the location: a strong, vigorous plant is less susceptible to attack. When growing organically, it is often better not to grow crops that are already grown extensively in the area, unless there are natural barriers that reduce the flow of pests onto the organic land.

Cultivar selection
Some cultivars are resistant to, repel or are less palatable to pests than other cultivars. In sweet corn, for example, the H15 variety has a tighter ‘throat’ to the cob, reducing Heliothis caterpillars’ access.

Crop rotations
To reduce soil-borne pests and diseases, rotate host with non-host crops. Rotations can also break insect pests’ life cycles and help control weeds.

Material from off-site
If using transplants or bringing any materials to the site, assess the risk of bringing pests with them. Insects, and particularly diseases, can easily come from off-site contamination.

Timing of planting
If possible, choose planting times when pest pressure is likely to be lowest. Early planted crops of processing tomatoes experience less Heliothis pressure than later planted crops.

Crop health
Plants growing with optimum water and nutrition tend to be less susceptible to pest attack and might better compensate for damage. Over- or under-provision of water or nutrients will stress the plant and increase its vulnerability.

Sanitation
Many key pests have many host plants. If those host plants are weeds or old harvested but uncultivated crops, they can contribute to supporting the pest population on the property. Controlling weeds—particularly flowering weeds—is crucial for the successful management of, for example, western flower thrips. Mites are often spread through properties or from crop to crop by machinery or on the clothes of people walking through the paddocks.

Natural habitats
Natural habitats provide a source of beneficials to colonise the farming system.

Trap crops
In some instances other crops might be the preferred habitat for a particular pest, and if some of the preferred crop is grown it might draw the pest away from the main crop. For example, pigeon peas have been used successfully as a trap crop for Heliothis in soybean production. In some cases a particular crop stage is preferred by the pests, so a small sacrificial planting can be used as a trap crop.

Insectary crops
Many beneficial insects require nectar or pollen as food sources, and a nearby flowering crop can act as an insectary crop and help increase the number of beneficials working the main crop. Other insectary crops can be crops that host a related non-pest species—for example, a species of aphid that can then support the establishment of aphid parasitoids and predators that might move into the main crop if aphids become established there.

Inter-cropping
Alternating rows of different crops has been used as a means of reducing pest pressure. Of itself, inter-cropping does not reduce pest pressure, but some combinations of crops work well together and result in less pest pressure. Inter-cropping is not widely used in highly mechanised or extensive agricultural systems: it is most typically used in labour intensive systems such as market or home gardens.

Step 3: Observation
Once the basic system for reducing pest incursions and build-ups and maximising the effects of beneficials is in effect, the next step is monitoring. Agricultural environments are complex systems, and changes in weather or the arrival of a key pest can rapidly change a pest situation. Regular observation of the factors in the pest and beneficial triangles can warn of a potential problem while there is still time to respond.

Crop monitoring
Systematically checking crops for the key pest stages (for example, eggs for Heliothis) and using available traps (for example, pheromone traps or sticky traps) to help monitoring are fundamental to developing an ability to respond to an emerging problem. Weekly checks are recommended for most crops, with more frequent checking during periods of high vulnerability or high pressure. In some areas commercial scouts monitor crops for a fee.

Pest identification
Whilst in the process of learning about the pests and beneficials that visit crops, it is important to have insects or diseased plants identified by an expert. Most state agricultural departments offer diagnostic services. Some insects, such as thrips, are hard to identify in the field and, although many different
species of thrips often visit a single crop, the presence of western flower thrips can radically alter a pest management strategy. Thrips are often most easily monitored by using sticky traps, which can be sent to the NSW Department of Primary Industries Insect Diagnostic Laboratory (take them to the nearest department office or send them to Orange Agricultural Institute, Forest Road, Orange NSW 2800), the Beneficial Bug Company, or another commercial group to check for the presence of western flower thrips.

Pest prediction models
Insects and diseases tend to respond predictably to temperature and/or moisture levels, so models can be developed. In some cases the models can be developed into prediction models, and for some cropping systems, such as cotton, there is crop management software that can help predict pest problems with the input of a range of data. At present there are no such models for vegetable crops in Australia. A Heliothis development model can be downloaded from the web <http://www.uq.edu.au/~uqwoche/gentime/> and, with the input of temperature information or using historical records for the area, it can predict the period of each life stage.

Step 4: Intervention
If observations of the crop or cropping situation suggest a need for action to reduce a likely or current pest build-up, the available tools fall into three categories—mechanical, biological and chemical controls.

Mechanical control
Mechanical controls are methods that can physically remove pests or physically prevent them moving into the crop.

- Light or bait traps. Moths and some beetles are attracted to black light and so can be caught in a 'light trap'. These traps are not very selective, which means that a large number of non-pest, and possibly beneficial, insects might also be trapped. In Western Australia some lettuce growers use large light traps to help manage Heliothis. Some insects such as fruit fly are attracted to fermenting yeast or other 'baits' and can be trapped this way. Pest-specific pheromones can greatly increase a trap's attractiveness to the target pest.

- Bug vacs or suction devices. In the United States large vacuum cleaner–like machines are used to suck up all the bugs in a crop. Strawberry growers have been the most successful users of this technique. It is not very specific, however, and beneficials are as likely, if not more likely, to be sucked up. In some cases a modified leaf-blower is used to collect beneficials from insectary crops or areas where their numbers are plentiful; they are then released in a crop where their numbers need to be increased.

- Covers and barriers. For high-value crops, row covers or fully enclosed net houses can prevent pests reaching the crop. The size of the holes in the covers or net determines which insects can be excluded. Smaller holes usually mean less water penetration. The disadvantage is that, once a pest has found a way into the plants, its numbers might increase more rapidly in the absence of predators or it might be more difficult to physically control. Row covers and net houses do, however, offer other potential benefits such as providing a warmer environment and increasing the rate of plant growth; on the other hand, they can also increase humidity and the likelihood of fungal diseases developing. Row cover materials can be purchased from various horticultural suppliers, including Gundaroo Tiller (see Appendix A).

- Soil solarisation. Soil pests and some soil-borne diseases can be controlled by soil solarisation, which involves using sealed or overlapping clear plastic to heat the soil beneath to high temperatures, thus sterilising the top few centimetres of soil. Proper laying of the plastic and enough sun exposure to raise the soil temperature to a lethal level to the required depth are crucial. This technique has the advantage of sterilising the soil without fumigants but, like fumigation, it kills most living things (including beneficial soil organisms) and leaves the now-sterile soil open to colonisation by invasive and often pestiferous species.

- Pupae busting. ‘Pupae busting’ means cultivating the soil to destroy the exit holes for Heliothis (Helicoverpa armigera) moths after pupation. Normally it is done after harvest and before the over-wintering larvae or pupae are due to emerge as moths. Cultivation to a depth of 10 centimetres is sufficient. Although some pupae can be physically destroyed, the main purpose is to destroy the exit tunnels. Pupae busting is essential to keep the number of spring-emerging Heliothis to a minimum. Populations of Heliothis—particularly the tomato budworm or sweet corn earworm—grow exponentially with each subsequent generation, so reducing the initial numbers can make a big difference to the pressure in late summer or early autumn.

- Removal of pests. Sometimes only a small number of pests are in the crop and the crop area is relatively small. In this situation hand removal of pests is an option. Hosing plants down with water can also dislodge some pests and, if they are not very
Biocidal control

Biocidal control involves using mass-reared pest insects that are released after having been sterilised by radiation or chemosterilants. When the sterilised males mate with ‘wild’ females no progeny is produced. The success of this strategy is dependent on releasing enough sterile males into the natural population to outcompete or outnumber the natural or wild males and prevent the females reproducing. This is a tool being used in fruit fly control.

Semiochemical control

Semiochemical control uses synthetically produced chemicals that imitate sex or aggregation (grouping) pheromones to disrupt the pest’s behaviour. Both sex and aggregation pheromones can lure pests into a sticky or pesticide trap. Sex pheromones are also used to disrupt or prevent mating and reduce the number of pest offspring. This technique is commonly used in orchards and is more effective as a preventative method.

Biotic control

Biocidal control uses natural products or organisms that have a toxic or lethal effect on the target pest. Among such agents are products derived from plants (such as neem and natural pyrethrum), pathogens, bacteria, viruses, protozoa, fungi, nematodes and animals. In general, biocidal control can be used only as a direct control method once pest numbers have reached damaging levels since the kill rate is usually high but the carryover effect is low.

Chemical control

Chemical control is usually associated with synthetically derived poisons, which are not allowed under organic standards. Some chemicals are, however, permitted under organic standards, and these tend to be biologically derived or inorganic products or minerals. Some of the new generation insecticides are not clearly biologicals or synthetics and might be accepted under organic standards in the future.

It should be noted that even if the product is acceptable under organic standards it may not be legal to use it. As just noted, any insecticide, biologically based or not, is regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and each pest-crop-insecticide combination must be approved. Approved uses are clearly written on the insecticide label and any use contrary to those instructions is illegal. Table 4.2 lists examples of the common insecticide groups.

### Table 4.2 Common insecticide groups: some examples

| Inorganics | Common synthetics | Organochlorines | Neem | Petroleum spray oils
|------------|-------------------|-----------------|------|---------------------|
| Copper sulphate | Organophosphates | Pyrethrum | Vegetable spray oils—for example, Eco Oil®
| Arsenicals | Carbamates | Natural pyrethrum (non-selective) | Soapa |
| Pyrethrods | Neema | Diatomaceous earth |
| Insect growth regulators | Bacillus thuringiensis | Transgenics |
| Insect viruses (non-GM) | | |

a. Permitted in organic standards.

b. Some permitted in organic standards. Petroleum oils are not permitted for use on organic products exported to Japan.

c. Available from Organic Crop Protectants Pty Ltd (see Appendix A).

4.9 Disease management

4.9.1 Causes of plant disease

Various members of the four major biological groups—fungi, bacteria, viruses and nematodes—cause plant diseases. The pest triangle (see Section 4.8) also relates to diseases. The pathogen, environment and host interact in disease expression. It is worth remembering, however, that symptoms resembling disease are often expressed but are the result of other factors such as nutrient effects.

Viruses

Viruses are micro-organisms that can infect plants and animals. Many viruses affect plants, and all of them need external agents, or vectors, for their transmission. Examples of vectors are insects, mites, nematodes and fungi; examples of insect vectors are thrips, aphids and leafhoppers. Some viruses have specific vectors—perhaps a certain type of aphid or fungus. There are no chemical treatments for viruses, which means the vector must be controlled if possible. Identifying viruses from plant symptoms is quite difficult, so if there are serious problems it is important that the virus be identified at a diagnostic laboratory.

Fungi

Fungi are microscopic organisms but have structures that can be seen with the naked eye. They produce hyphae, or strands, that can be seen on plant material. Their fruiting structures are visible with a hand lens or microscope, and their spores can be carried by wind or spread through water. These spores usually require moisture—rain, dew or high humidity—to germinate and infect plants. Some fungi have a narrow host range; others have a wide host range. Downy mildew is the collective term for a disease that affects a wide variety of plants, but separate species infect different plant groups. The downy mildew that affects grapes does not affect lettuce, for example. Many soil-borne fungi are important in breaking down plant material and are an important part of soil biology.

Bacteria

The bacteria that cause diseases in lettuce are single-celled organisms and do not form more complex structures such as those developed by fungi. There are no multi-celled hyphae or hard-walled resting spores (sclerotia), so the bacteria need other entry points. Bacteria can be secondary invaders of plant tissue when they invade damaged tissue. The initial damage can be caused by insects, other pathogens, frost, herbicide or hail. Other entry points for bacteria are stomates and lenticels, natural openings found on the leaf surface. Unlike fungi, which have spores that can be spread by the wind, bacteria must be transported by other means—for example rain, insects, pruning and cutting implements, machinery, moving soil and water. In lettuce production bacteria can be spread from one head to another during harvest.

Nematodes

Nematodes are very small worm-like animals, too small to be seen with the naked eye. Some types are pathogenic; others are beneficial and consume pathogenic fungi; yet others contribute to soil biological activity. Pathogenic-type nematodes have a mouthpart that pierces plant cells for feeding. As a consequence of this feeding, the plants can become stunted and die. Nematodes are usually associated with plant roots, but some species affect other plant parts. Nematodes tend to be more of a problem in light-textured soils such as sand.

4.9.2 Diagnosis

Different diseases require different treatments. Publications on plant diseases might help with diagnosis; otherwise, there are plant disease diagnostic services in each state (see Appendix A). Control recommendations cannot be made unless the problem has been accurately diagnosed. Disease control will not be successful if the disease has not been correctly identified.

The various diagnostic services available might charge a fee, but using them can save time and money: unnecessary sprays will be avoided and the right spray for the disease can be chosen.

4.9.3 Reducing plant diseases organically

It is important to have a complete picture of what diseases occur in a particular region. Some regions may not have a serious disease: for example, white rot of onions does not occur in the Murrumbidgee Irrigation Area, whereas it is a serious disease in other growing areas.

The proposed cropping site should not have a history of any serious soil-borne diseases. Ask the district horticulturist what diseases could cause trouble for the proposed crop.

Variety selection

When choosing the correct variety for the area, account should be taken not only of optimising yield but also of maximising disease control. There are two ways a variety can help disease management:

- varietal resistance and tolerance
- the physical shape or habit of the plant.

A variety can have genetic resistance to a disease; that is, it has been bred to be resistant to the disease. For example, resistance to downy mildew has been bred into some
lettuce varieties. Varieties can also show reduced or increased disease levels as a result of their physical characteristics. Plants might not be completely resistant to a disease but can be tolerant.

**Pathogen-free seed or vegetative propagation material**

Many viruses are seed borne. Potatoes are a good example of vegetative material capable of carrying pathogens. Make sure any planting material is free of diseases. Always keep a small amount of the material for reference in case problems are found after planting.

**Climate**

Many plant diseases are affected by environmental conditions. High rainfall—or, more specifically, high leaf wetness—can promote infection with many of the fungal diseases, such as downy mildews and rusts. Reducing the plant density can increase the air flow through the crop, although this could compromise weed management.

**Weed control**

Weed control is important for many plant diseases because often the weeds are also the hosts of the diseases. Many weeds and ornamental plants are hosts of tomato spotted wilt, which is a virus affecting tomatoes. The virus is transmitted by thrips.

**Crop rotation**

Changing the crops grown has long been a way of reducing diseases. It can be important in controlling many soil-borne diseases, but it will not have an effect on soil-borne diseases that produce inoculum that can survive in the soil for many years. Fungi that produce sclerotia (hard-bodied survival structures of some soil-borne fungi) are an example of this.

Rotation will be successful if the disease in question survives only on host material and does not survive when all residue of that host is absent. For example, in a rotation with lettuce it is important not to have a crop that is also a host of *Sclerotinia minor*.

**Roguing**

‘Roguing’ means physical removal of any diseased plants. The practice can reduce both the spread of the disease and the carryover of the disease. It can be labour intensive, though, so might be of benefit only in high-value crops. Using lettuce as an example, removing plants that sclerotia have developed on will help to reduce the overall amount of sclerotia that could end up in the soil for future infection.

**Removal of crop residue**

Removal of crop residue is very important if overlapping of plantings occurs. In lettuce production, lettuce is planted in overlapping plantings so that a continual supply is available. Once a block is harvested, plant material should be ploughed in. As a last resort, burning the plant material—something not favoured in organic standards—can help reduce the carryover of disease. Grazing livestock such as poultry can help to remove crop residue.

**Irrigation management**

Overhead irrigation can contribute to plant foliar diseases. If it is used, make sure that plants dry out as quickly as possible—for example, by avoiding watering in the evening, so that foliage does not remain wet overnight.

Trickle irrigation is the best option for reducing plant disease. Flooding can, however, be used to limit some diseases (such as sclerotia) before planting a susceptible crop.

Over-irrigation can cause serious problems by favouring soil-borne diseases.

**Soil solarisation**

Solarisation is discussed in Section 4.7.

**Soil management**

Improving soil health through increasing biological activity can reduce the chance of soil-borne pathogens being a problem. Addition of compost and incorporation of green manure crops can help reduce soil-borne diseases by increasing the biological activity of beneficial species in the soil. Careful selection of the green manure is important, to ensure that it, too, is not a host to the pathogen.

**Ploughing**

Ploughing can be useful for burying sclerotia and subsequently increasing the biological breakdown of the survival structures.

**Biological control**

Research into biological control is expanding rapidly, and growing numbers of micro-organisms for biological control of soil-borne diseases are being developed. *Trichoderma* (a common soil-borne genus of fungi) species have been developed to control soil-borne plant diseases.

**Fungicides**

A number of organically acceptable chemicals are available if disease control is necessary.
(see Appendix B). Among them are copper, lime sulphur, sodium bicarbonate, sulphur and vegetable oils. These products are effective only against foliar plant pathogens. Copper is useful against downy mildews and bacterial diseases; sulphur is effective against powdery mildews. Note that both copper and sulphur are currently under review for use in organic systems, and using alternatives to them might become necessary. A review of alternatives to copper for disease control in organic systems has been undertaken by Van Zwieten et al. (2004).

Other organic sprays
Among other possibilities for disease control are products still under evaluation, such as compost teas and milk. Evidence suggests that both these products are efficacious for certain diseases. Milk has shown some effectiveness against powdery mildew. Many organic farmers believe that, by stimulating the natural defence mechanisms in plants and animals, resistance to disease can be strengthened. Some commercial products are marketed on this principle; examples are seaweed extracts such as Acadian SSE®, a product of Organic Crop Protectants Pty Ltd (see Appendix A).

4.10 Economics
When determining the economics of organic vegetable production it is necessary to take into account not only the profitability of growing the particular crop but also the profitability of the entire rotation. As a result of trials conducted at the NSW Department of Primary Industries organic demonstration site at Yanco, some indicative gross margin budgets have been developed; these are shown in Tables 4.3 to 4.6.

When interpreting these budgets, several important points need to be taken into consideration:

- The data are site specific. The yields obtained and management practices used are appropriate only for the Yanco organic demonstration site; data should be modified to reflect different management regimes and sites.
- Returns for produce are those quoted by an organic wholesaler for certified organic produce at the time of sale. Prices will vary from season to season and will generally depend on supply at that particular time and in that particular market.
- Gross margin budgets are only an indication of potential costs and returns for an enterprise in any particular year. Factors such as climactic variability, management expertise and market fluctuations will vary the budget.
### Table 4.3 Indicative gross margin budget: organic rockmelons

<table>
<thead>
<tr>
<th>Standard budget ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Income</strong></td>
</tr>
<tr>
<td>Yield 1600 cartons @ $13/carton</td>
</tr>
<tr>
<td>Total income</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
</tr>
<tr>
<td>Land preparation</td>
</tr>
<tr>
<td>Rip</td>
</tr>
<tr>
<td>Disc (2)</td>
</tr>
<tr>
<td>Grade</td>
</tr>
<tr>
<td>Broadcast</td>
</tr>
<tr>
<td>Bed form</td>
</tr>
<tr>
<td>Incorporate</td>
</tr>
<tr>
<td>Fertiliser</td>
</tr>
<tr>
<td>Compost (8 t/ha)</td>
</tr>
<tr>
<td>Rock phosphate</td>
</tr>
<tr>
<td>Green manure (grow and incorporate)</td>
</tr>
<tr>
<td><strong>Planting</strong></td>
</tr>
<tr>
<td>Sowing</td>
</tr>
<tr>
<td>Seed</td>
</tr>
<tr>
<td><strong>Growing</strong></td>
</tr>
<tr>
<td>Mechanical cultivation (2)</td>
</tr>
<tr>
<td>Boomspray (foliar 4)</td>
</tr>
<tr>
<td>Fertiliser</td>
</tr>
<tr>
<td>BD500</td>
</tr>
<tr>
<td>Foliar biological spray (3)</td>
</tr>
<tr>
<td>Weed control</td>
</tr>
<tr>
<td>Casual labour (hot) 35 hrs</td>
</tr>
<tr>
<td>Irrigation (deep)</td>
</tr>
<tr>
<td><strong>Harvesting</strong></td>
</tr>
<tr>
<td>Contract pick, sort and load</td>
</tr>
<tr>
<td>Trailer use</td>
</tr>
<tr>
<td>Casual labour</td>
</tr>
<tr>
<td>Bins hire</td>
</tr>
<tr>
<td>Grade, pack</td>
</tr>
<tr>
<td>Cartons</td>
</tr>
<tr>
<td>Machine operation</td>
</tr>
<tr>
<td><strong>Total variable costs</strong></td>
</tr>
<tr>
<td>Gross margin/ha</td>
</tr>
<tr>
<td>Gross margin/mL</td>
</tr>
</tbody>
</table>

Source: NSW Department of Primary Industries

### Table 4.4 Indicative gross margin budget: organic sweet corn

<table>
<thead>
<tr>
<th>Standard budget ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Income</strong></td>
</tr>
<tr>
<td>Yield 11.3 tonnes/ha @ $143/tonne</td>
</tr>
<tr>
<td>Total income</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
</tr>
<tr>
<td>Land preparation</td>
</tr>
<tr>
<td>Incorporate green manure</td>
</tr>
<tr>
<td>Deep rip</td>
</tr>
<tr>
<td>Scarify (2)</td>
</tr>
<tr>
<td>Hill up</td>
</tr>
<tr>
<td>Bed form</td>
</tr>
<tr>
<td>Fertiliser</td>
</tr>
<tr>
<td>Apply and spread compost</td>
</tr>
<tr>
<td>Gypsum</td>
</tr>
<tr>
<td>Lime</td>
</tr>
<tr>
<td>PPR</td>
</tr>
<tr>
<td>Spreading</td>
</tr>
<tr>
<td>BD500</td>
</tr>
<tr>
<td>Foliar (3)</td>
</tr>
<tr>
<td>Biological spray</td>
</tr>
<tr>
<td><strong>Planting</strong></td>
</tr>
<tr>
<td>Seed</td>
</tr>
<tr>
<td>Sowing</td>
</tr>
<tr>
<td>Seed treatment</td>
</tr>
<tr>
<td><strong>Pest control</strong></td>
</tr>
<tr>
<td>Interrow cultivation * 2</td>
</tr>
<tr>
<td>Pest control</td>
</tr>
<tr>
<td>Gemstar® (permit required)</td>
</tr>
<tr>
<td>Aerial spray (Gemstar®)</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
</tr>
<tr>
<td>8 mL/ha @ 17.36/mL</td>
</tr>
<tr>
<td><strong>Total variable costs</strong></td>
</tr>
<tr>
<td>Gross margin/ha</td>
</tr>
</tbody>
</table>

Source: NSW Department of Primary Industries
### Table 4.5 Indicative gross margin budget: organic pumpkin, Jarrahdale

<table>
<thead>
<tr>
<th>Income</th>
<th>Standard budget ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>30 tonnes/ha @ $400/tonne</td>
</tr>
<tr>
<td>Total income</td>
<td></td>
</tr>
</tbody>
</table>

**Operation**

| Land preparation | Rip | 27.50 |
| Disc (2) | Rip | 27.50 |
| Grade | 12.14 |
| Direct drill | 6.88 |
| Bed form | 20.63 |
| Fertiliser | Compost | 120.00 |
| Rock phosphate | 45.50 |
| Green manure (grow and incorporate) | 283.50 |
| Planting | Sowing | 20.63 |
| Seed | 60.00 |
| Growing | Mechanical cultivation (WeedFix 2) | 61.88 |
| Rehill | 13.75 |
| Boomspray (3 foliar) | 20.63 |
| Fertiliser | B500 | 2.00 |
| Foliar biological spray (3) | 39.42 |
| Weed control | Casual labour (hoe) | 35hrs | 420.00 |
| Irrigation | 77.52 |
| Harvesting | Contract pick, sort and load | 1,375.00 |
| Bins (large) | 900.00 |
| Freight (Sydney) | 2,420.00 |
| Total variable costs | 6 044.48 |
| Gross margin/ha | 5 955.52 |
| Gross margin/mL | 992.58 |

**Source:** NSW Department of Primary Industries.

### Table 4.6 Indicative gross margin budget: organic pumpkin, butternut

<table>
<thead>
<tr>
<th>Income</th>
<th>Standard budget ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>1050 cartons/ha @ $16 /carton</td>
</tr>
<tr>
<td>Total income</td>
<td></td>
</tr>
</tbody>
</table>

**Operation**

| Land preparation | Rip | 27.50 |
| Disc (2) | Rip | 27.50 |
| Grade | 11.00 |
| Direct drill | 7.00 |
| Bed form | 20.63 |
| Fertiliser | Compost | 120.00 |
| Rock phosphate | 45.50 |
| Green manure (grow and incorporate) | 283.50 |
| Planting | Sowing | 20.63 |
| Seed | 150.00 |
| Growing | Mechanical cultivation (WeedFix 2) | 82.50 |
| Rehill | 20.63 |
| Boomspray (4 foliar) | 27.50 |
| Fertiliser | B500 | 2.00 |
| Foliar biological spray (3) | 39.42 |
| Weed control | Casual labour (hoe) | 35 hrs | 420.00 |
| Irrigation | 90.44 |
| Harvesting | Contract picking | 1 666.75 |
| Wash, grade, pack | 1 440.00 |
| Cartons | 1 995.00 |
| Freight (Sydney) | 1 155.00 |
| Total variable costs | 7 652.50 |
| Gross margin/ha (A – B) | 9 147.50 |
| Gross margin/mL | 1 306.79 |

**Source:** NSW Department of Primary Industries.
5. Organic vegetable case studies

The case studies that follow have previously been published as part of the NSW Agriculture Agfact series. They provide examples of the organic production requirements for a range of vegetables. The crops chosen reflect the growth patterns of three production systems—perennial (asparagus), broadacre annual (pumpkin) and intensive annual (tomatoes). Many of the organic practices used in the production of these crops are applicable to other vegetable and herb crops.
5.1 Organic production of asparagus

Introduction
Asparagus has few pest or disease problems and can be grown without artificial pesticides, making it a relatively easy crop to grow organically. Good weed management, particularly during establishment, is essential to promote healthy growth and satisfactory yield and quality.

Organic asparagus production, like other vegetable production systems, involves developing a functional system that provides adequate fertility while maintaining effective weed management. A well managed asparagus stand may stay productive for 15 years or more.

An understanding of the annual growth habit will help in planning an organic management program.

Growth habit
Asparagus is a perennial plant. It produces dark green fern-like foliage during summer and in cooler climates becomes dormant over winter months.

Asparagus spears begin as leaf buds below the soil surface, elongating to form the spears above ground as temperatures warm in the spring. These are then cut during harvest, making way for new spears to initiate from buds on the crown below the soil. Harvesting of the spears continues until spear quality deteriorates (during hot weather) or market prices fall.

When harvesting ceases, the spear is allowed to develop into its fully expanded leaf, or fern. During this stage the plant photosynthesises and replenishes its nutrient reserves in the crown for the next year’s harvest. In colder districts, the asparagus fern will ‘die off’ during winter in similar fashion to a deciduous tree.

The fern is then mulched into the soil or removed in preparation for harvest of the new asparagus spears in spring. The fern is not removed until completely ‘dead’ so that the asparagus root or crown is replenished as nutrients are reabsorbed from the stem and foliage. This step is followed by a shallow cultivation prior to spear emergence to incorporate the trash, clean up weeds and provide a clear surface for harvesting.

Variety selection
Potential growers will need to source an asparagus variety that has market acceptability, is suited to your local climate and, ideally, and if possible, is raised organically (this is a requirement of the National Standard for Organic and Bio-Dynamic Produce).

Select varieties that have been bred for disease resistance, specifically *Fusarium* sp. and *Phytophthora* sp. resistance.

Pre-planting and establishment
Establishment is the critical growth stage for asparagus. Seedling transplants are common, although these are relatively slow to establish and full production can not be expected for at least three years. Crowns are more reliable and may yield earlier depending on crown size. The young crowns are usually planted in a shallow trench which is gradually filled in as the crown matures. This leaves the asparagus growing on a low mound (the mound is higher for white asparagus).

Crop nutrition and soil management
Asparagus grows in a wide variety of soils but grows best in a light well-drained soil with a high nutrient content. Deep alluvial soils provide optimum conditions for growth. However, these soils can be prone to erosion, low in organic matter and may be leached of essential nutrients.
The soil should be analysed for its nutrient status well before planting to determine pre-planting nutrient requirements and a fertility program should be implemented at least 2 years before planting.

If a green manure crop is to be grown as part of the fertility program it will require incorporation well before planting so that organic residues are properly decomposed. Compost is an excellent soil amendment and should be considered an essential addition pre-planting, with annual applications for the established asparagus stand.

Fertiliser recommendations vary with soils and growing conditions, but as a general guide NSW asparagus producers apply 150 kg actual nitrogen (N), 50 kg actual phosphorus (P) and 50 kg actual potassium (K) per hectare per year to asparagus.

An incorporated green manure crop can supply from 80 to 150 kg actual N per year, while composted cow manure (analysed at 2% N on a non-dry weight basis), applied at 6 tonne / hectare / annum, could supply 120 kg actual N. Because of variability between batches of compost each should be separately analysed for nutrient content. If externally sourced, you should also test for heavy metals.

Phosphorus should be applied as Reactive Phosphate Rock (RPR) a season prior to planting as well as under the plants at planting and in each year of production. RPR should be checked for cadmium. Levels should not exceed 20 ppm – mg/kg in fertilisers or manures.

Potassium can be supplied organically through composts and seaweed extracts.

Commercial organic fertilisers that can supply most nutrients are available, but these must be carefully evaluated for cost and effectiveness. Some organic certification organisations have approved a range of commercial organic fertilisers. Reliance on these, as opposed to good soil management practices (green manuring and use of compost) is discouraged.

Annual fertiliser applications should be applied prior to the pre-harvest cultivation.

Research has shown that N, P, and K extraction by crops is in the vicinity of 34, 6 and 18 kg/Ha, respectively, so you should aim to replace these amounts annually. Allowances should also be made for other losses to the system such as those from leaching, surface run-off and volatilisation evaporation) of nutrients.

Research has also shown that asparagus seedlings are particularly sensitive to deficiencies in magnesium, calcium, copper and sulfur.

A nutrient budget can help you to assess your crop’s nutritional requirements a couple of seasons in advance, and helps to identify potential losses and gains of nutrients to the system. Table 1 gives an example of a possible budget for nitrogen inputs in asparagus production.

Table 1. Estimated annual nitrogen budget for 1 Ha asparagus, green manured and fertilised with composted cow manure

<table>
<thead>
<tr>
<th>Input / Losses</th>
<th>kg actual N / ha / year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Inputs</strong></td>
<td></td>
</tr>
<tr>
<td>a) Gains that remain in the soil and in crop residues:</td>
<td></td>
</tr>
<tr>
<td>N in green manure crop (clover/vetch)</td>
<td>140 b</td>
</tr>
<tr>
<td>N in rain</td>
<td>8 c</td>
</tr>
<tr>
<td>N2 fixation (non-symbiotic)</td>
<td>5 c</td>
</tr>
<tr>
<td>subtotal 153</td>
<td></td>
</tr>
<tr>
<td>b) Gains in composted cow manure applied @ 6 tonnes / ha (analysed at 2% N on dry weight basis)</td>
<td>120 d</td>
</tr>
<tr>
<td>subtotal 120</td>
<td></td>
</tr>
<tr>
<td><strong>Total input</strong></td>
<td>Total gains 273</td>
</tr>
<tr>
<td><strong>II. Losses in the field</strong></td>
<td></td>
</tr>
<tr>
<td>sale of spears (42 t/ha, untrimmed)</td>
<td>34 e</td>
</tr>
<tr>
<td>fern removal</td>
<td>negligible as most nutrients returned to crown</td>
</tr>
<tr>
<td>composted manure</td>
<td></td>
</tr>
<tr>
<td>leaching, surface run-off and volatilisation</td>
<td>200 c</td>
</tr>
<tr>
<td><strong>Total Losses</strong></td>
<td>Total losses 236</td>
</tr>
<tr>
<td><strong>III. Net accumulation of N in soil</strong></td>
<td></td>
</tr>
<tr>
<td>Net +37 kg N / Ha</td>
<td></td>
</tr>
</tbody>
</table>

Weed management

Weed control is critical during asparagus establishment and is best started well before planting. This involves selecting an area with few weeds and using cultivation and sowing activities to encourage pre-planting germination of weed seeds. Green manure and cereal crops planted prior to asparagus will help to out-compete weeds as well as adding to soil organic matter and fertility levels. Difficult to control weeds may need to be removed by hand.

Weed management following planting can be difficult as the young asparagus plant lacks vigour and the competitiveness of a mature stand.

Mulch can be applied around seedlings. Research has shown that mulches such as straw, sawdust and bark spread at 100mm depth can provide adequate to good control of weeds. In cooler districts, mulching may delay the emergence of spears in spring and prolong harvest later in the season due to its cooling effect on the soil. This may be advantageous if a later harvest gives you a market niche, or disadvantageous if there is a market glut. Mulch may also increase the risk of frost damage to emerging spears.

Weed control during harvest (particularly self-sown asparagus) needs to be achieved.

Flaming weeds is an option prior to spear emergence. A clean-up during harvest could also be achieved by removing all spears protruding above the ground and then flaming the weeds. Note that flamers are most effective on newly emerged weeds.

Grazing animals while the asparagus is dormant will also help to control weeds and provide additional nutrient benefits in the form of manure. Sheep and weeder geese can be used effectively, while ducks – as well as eating weeds – will also consume snails and insects.

Intercropping

An asparagus crop will not reach full productivity for at least three years, so returns will be relatively low during the establishment years. The delay in economic return could be partially offset by intercropping between the asparagus rows with other vegetables or herbs. Planting an intercrop also helps reduce weed problems in the inter-row area.

Any intercrop requires good nutrition and water management to reduce competition with the asparagus, and care is needed to ensure the crop does not host pests or diseases of asparagus.

Intercropping of asparagus with a low-growing leguminous cover crop can be effective in reducing inter-row weeds, providing nutrition to the asparagus and improving soil structure. Research has shown that there may be a competitive effect from cover crops during the establishment year and the first few years following transplanting the asparagus. Supplying ample nutrition and water to the cover crop may reduce this impact.

Two potential cover cropping systems could be adopted. The first type involves planting a low-growing perennial cover crop, such as clover, that is mulched or slashed regularly for optimum benefit. A side-throw mulcher, slasher, or alternatively a forage harvester could be used, with the cuttings directed around the asparagus plants. This provides a nutrition and mulch benefit to the asparagus plants.

If using this system, sufficient distance must be retained between the asparagus rows to allow for machinery operations such as slashing of the asparagus fern in winter, cultivation of weeds and harvest preparations. Cultivation over the crop row should be shallow or avoided altogether to avoid damaging the crowns. Soil may need to be hilled up over rows to increase depth.
An alternative cover cropping system involves sowing an annual cover crop following removal of the fern in winter and incorporating it as a green manure or slashing / mulching it prior to spear emergence in the spring.

Regardless of the system decided upon, it is imperative to have the cutting zone free of weeds and trash during harvest.

**Pests and diseases**

Asparagus has few pest and disease problems.

The most significant insect pests are thrips and Rutherglen bug (*Nysius viator*, Lygaeidae). Both are difficult to predict and control, usually appearing ‘overnight’ in swarms.

Thrips are very tiny, slender insects that may feed on developing spears, causing distortion. The onion thrips (*Thrips tabaci*) is the most common. Thrips are most likely to migrate to asparagus when plants they have been feeding on have matured or dried out. A large number of weeds and ornamentals (particularly perennials) are known to host thrips, and whilst removal of host weeds will reduce the chance that thrips may become a problem, this may not be a practical solution. Anecdotal evidence suggests basil may help to repel thrips.

Releasing predatory insects may reduce thrips numbers. Effective predators include predatory mites (*Amblyseius*) and green lacewing (*Mallada signata*). Releases should begin early in the season and may need to be made several times. Pest and predator populations should be monitored regularly.

A number of organic sprays can be used successfully to control thrips including soap, natural pyrethrum (will also kill beneficial species) and horticultural mineral oils.

The Rutherglen bug usually breeds in the seed heads of weeds and from here they move to agricultural crops. In some years they may reach plague numbers in spring and summer. Management is best achieved by removing host weeds such as Paterson’s curse from areas surrounding the crop.

Minor damage due to red legged earth mite and two-spotted mite has been reported. Removing or slashing green manures prior to harvest may worsen mite problems as they could migrate onto the asparagus.

Snails and slugs can occasionally damage spears. Ducks introduced into the system consume these and some weeds, but are less likely to eat the asparagus.

*Fusarium* sp. and *Phytophthora* sp. are two fungal diseases commonly reported in conventional asparagus production. With good soil and irrigation management, the use of resistant varieties and the use of well-grown nursery stock, these are less likely to be a problem.

*Stemphylium* sp is the fungus that causes fern spot of asparagus. It commonly occurs in showery weather or where overhead irrigation is used. Symptoms include purple spots on ferns and spears. Removing old ferns will help to reduce the level of this disease.

Three new diseases have recently been recorded on asparagus in Australia. Asparagus stem blight (*Phomopsis asparagi*) has been found in Queensland and Victoria. Stem blight causes defoliation and loss of production and is a very difficult disease to manage. Asparagus rust (*Puccinia asparagi*) has only been found in Queensland. The rust weakens plants and reduces marketable yield. Anthracnose (*Colletotrichum gloeosporioides*) can be a devastating disease and has been found in Queensland and the Northern Territory. Anthracnose produces large lesions on the fern stems.

**Harvesting**

The harvest season for asparagus extends from August in warmer districts through to December in cooler districts. Harvesting has been extended using crop manipulation techniques such as 'mother fern culture'. In this system, one spear is permitted to proceed to fern, while other spears in the crown continue to be harvested. The ‘mother fern’ provides some supplementary nutrition, slightly prolonging the harvest. This method of extending the harvest, however, may affect crown longevity and, thus, the total productive potential of the asparagus stand.

Harvesting is performed during the early morning when it is cool. Spears are cut just below the ground when 200mm or greater of the spear is protruding above the soil surface. Spears are later trimmed to 180mm. Spears are then collected and kept in the shade until removed from the field.

**Post-harvest management**

Asparagus spears deteriorate rapidly and must be cooled as soon as possible after harvest. Once in the packing shed, field heat should be removed. This should occur immediately if the spears are not being graded and packed straight away.

*Bio-dynamic asparagus packaged for market.* Photo: R. Neeson

Hydro-cooling is the usual method used to pre-cool spears to remove...
field heat. This involves spraying, flooding or immersing the spears in chilled water (3°C-5°C). The spears are then placed directly into a cool room. Length of time to leave the spears in the hydro-cooler depends on the temperature and flow rate of the cooling water, the initial temperature of the spears and whether the spears are loose or packaged.

Hydro-cooling usually involves recirculation of water and this may cause an accumulation of micro-organisms. In conventional production systems active chlorine at a rate of 200 – 400 mg.l⁻¹ is usually added to the holding tank. However, organic standards do not permit the use of chlorine above 5ppm. Hydrogen peroxide (H₂O₂), another effective disinfectant, is permitted in organic standards. Research has shown that 5% H₂O₂ is a reasonably effective antimicrobial agent. However, further research is necessary to determine the usefulness of H₂O₂ treatment.

If spears are dirty they should be washed, preferably with chilled water, prior to packing. Spears will need to be trimmed, graded and bundled according to the requirements of your markets. Conventionally, it is common practice to dip the butts immediately after cutting and bundling into a solution of calcium hypochlorite to prevent bacterial soft rot, but this is not permitted in organic production systems. The use of hydrogen peroxide should be investigated as an organically acceptable alternative to calcium hypochlorite.

Bundled spears should be packed in fully waxed, paper-lined cartons. If already pre-cooled, spears should be packed as quickly as possible and cartons placed into a coolroom set at 2°C.

Refrigerated transport should be used to ship asparagus to market. Transport operators should be made aware that your produce is organic and to avoid the possibility of contamination.

**Marketing**

The market possibilities for asparagus producers include fresh or processed, local or export, white or green, spears or tips. Quality and continuity of supply are the keys to success.

Fresh asparagus is most likely to fall victim to oversupply. While the harvest period can be extended or manipulated through various cutting strategies, the only other opportunity to avoid peak supply times arises if your particular climate favours slightly out-of-season production.

Check with wholesalers to determine when periods of undersupply and oversupply occur. New Zealand organic asparagus is available from October through to January.

**Contacts**

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**Vegetable pathology**

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Yanco Agricultural Institute
Phone (02) 6951 2611

**Further reading**


Diver, S., Compost Teas for Plant Disease Control, pest management technical note, Appropriate Technology Transfer for Rural Areas (ATTRA) http://www.attra.org/attra-pub/comptea.html


5.2 Organic production of pumpkin

Introduction
Pumpkins are a good choice for the grower who is considering organic vegetable production, as they may be included early in rotations or in a conversion plan. Other vegetables in this category include squash, gourds, cucumbers, rockmelons and watermelons.

Given favourable growing conditions, organic pumpkins will yield around 40 tonnes to the hectare, are relatively easy to store, handle and transport and, if markets are not over-supplied, can provide a good return for producers. The organic market should be well researched as oversupply is a danger.

Variety selection
Markets should be assessed prior to planting to determine consumer preference. Butternuts, Jarrahdale and Jap pumpkins are commonly grown. Organic markets may prefer some of the older varieties, while processors may be quite specific in their requirements. If over-supply occurs, you may have to sell your produce on the conventional market. With this in mind, you may wish to consider growing varieties such as Japanese hybrids that sell well in conventional markets.

Varieties will differ in their yielding ability, vigour and pest and disease resistance so it is advisable to investigate how the variety selected performs in your region. The growth characteristics of the variety will also determine cultural aspects such as planting distance.

Production of pumpkins is usually from seed sown directly in the field. The National Standard for Organic and Bio-Dynamic Produce requires seed to be organically produced, unless suitable quantity and quality is unavailable, so a reputable supplier will need to be found. Records proving that an effort has been made to source organic seed must be provided to the organic certifier. If an open-pollinated variety is grown it will produce seed that will breed true to type provided cross-pollination with other pumpkin or squash varieties does not occur) so, alternatively, you could raise and collect your own seed.

Rotation design
Pumpkins prefer a high nutrition regime that would generally follow a green manure (legumes and grasses) or an intensive composting program. Pumpkins' spreading growth habit and leaf size gives it a competitive advantage over weeds, and provides an opportunity as a 'cleaning' crop to precede a less competitive vegetable such as onions in the rotation. Potatoes are another excellent cleaning crop and if grown back-to-back with pumpkins in a rotation can provide a good preceding rotation for root crops, which are among the most difficult of vegetables to keep weed free.

To minimise the risk of disease carryover, pumpkins ideally should not be grown where another member of the cucurbit family e.g., watermelons, cucumber, zucchini, has been grown in the previous year.

Organic standards require that no annual crop of the same species, family, or similar characteristic be planted for more than 2 years out of 5 within the rotation. Furthermore, the standards require that a green manure, annual legume or pasture ley phase be grown at least one year in three, except where soil fertility and structural characteristics are entirely met by the importation of composted manures or other permitted varieties of organic matter.

Ground preparation and planting
Like other vegetables, good seedbed preparation is essential for pumpkin production. The seedbed should be weed free and reasonably clod free.

Pumpkins are generally grown on well-formed beds. Following green manure incorporation and scarifying, the field is hilled and, if compost is to be applied, it is deposited between a series of hills, which are later combined to form a bed. This places the compost directly below the planting row, allowing the pumpkin immediate access to the compost as it grows into it.

Alternatively, compost application could be split, with half applied and incorporated during primary tillage, thus facilitating decomposition of the green manure, and the remainder applied during bed forming or surface-applied following planting.
Seed is normally sown direct, when the risk of late frosts is well past and when soil temperatures have warmed (a minimum of 15°C). In inland New South Wales sowing begins in early October.

When planted in continuous rows the seeds are sown rather thickly, and when the pumpkin plants are at the 3 to 4 leaf stage, they are thinned to 0.8 – 1.3 metres apart within the row.

Crop nutrition

Achieving good yields of a quality product will depend on achieving a balance of soil elements, good organic matter and a biologically active soil.

Pumpkins will tolerate slightly acid conditions but prefer soils that are high in organic matter. Compost applications of around 10 tonnes / ha are commonly incorporated with green manure prior to cropping.

A soil test should be carried out following green manure incorporation and prior to planting to determine the crop requirements. Pumpkins are relatively heavy nitrogen feeders and since N in compost is slowly available, an additional application of a commercial organic fertiliser may be required at planting.

Foliar applications or fertigation (applied through a micro-drip irrigation system) with approved organic products can be used to correct temporary nutritional deficiencies. A foliar application of fish emulsion, seaweed or garlic extract may also help to repel certain pests.

Weed management

The most critical period for effective weed management is prior to crop establishment.

Pre-irrigation or rainfall will germinate weeds, after which a shallow cultivation or flaming will remove weeds prior to sowing.

Weeds need to be kept in check until the pumpkin vines have covered the beds. This can be achieved either by removing weeds by tillage with an implement such as the WeedFix® (see photo) hand weeding or mulching the entire bed. Mulching can provide additional benefits including moisture retention and can provide a ‘clean’ barrier between fruit and the bare soil, thus preventing staining of the underside of the pumpkin.

Hand weeding during early crop establishment is the usual method of intercrop (between plants within a row) weed management, since weeds are difficult to control with cultivating implements without damaging the crop. Thinning time provides an opportunity to remove weeds that have grown within the crop row.

Pests and diseases

Pests

Significant pests of pumpkin include the 28-spotted ladybird (Epilachna spp.) and the pumpkin beetle (Aulacophora hilarus). Both these pests have a migratory habit, often flying in to a crop in large numbers from weeds or other nearby crops. They are most likely to be a problem during establishment when plants are small (during this stage they may skeletonise a young plant) and during flowering when fruit set may be affected. Older plants can generally tolerate a larger pest load.

Crops attractive to pests should not be grown adjacent to the pumpkin crop and should be avoided prior to the pumpkin crop being planted. Removing host weeds also helps to reduce problems. Alternatively, some plants may be more attractive to these pests and these may be strategically planted to act as a trap crop to draw the pests from the commercial crop.

Established organic producers often suggest that plants that are attacked by pests are suffering some form of stress. This could be moisture stress or a nutritional deficiency. Irrigation should be monitored to avoid moisture stress, while a leaf sap or tissue analysis can determine the nutritional status of the growing crop.

Some naturally derived pesticides are permitted for use in organic standards. However, this use should not be the primary form of control. Care should be taken when using these products as some may be toxic to non-target species and may also affect human health.

Diseases

Powdery mildew

The most common disease affecting pumpkins in inland areas is powdery mildew (Oidium sp.). Powdery mildew generally does not require moist conditions to establish and grow, and normally does well under warm conditions; thus they are more prevalent than many other leaf-infecting diseases in the dry summer conditions of inland NSW.
Powdery mildew first appears as white powdery spots that may form on both surfaces of leaves, on shoots and sometimes on flowers and fruit. These spots gradually spread over a large area of the leaves and stems. Leaves infected with powdery mildew may gradually turn completely yellow, die and fall off, exposing fruit to sunburn. Severely infected plants may have reduced yields, shortened production and fruit with little flavour.

An oat crop that has been slashed to form a mulch over beds prior to sowing at Yanco. Photo: R. Neeson

Planting varieties that are least susceptible to powdery mildew is the primary method of control. Varieties differ in their susceptibility and seed companies should be able to provide you with a resistance rating for your chosen variety.

Old crops that are infected should be ploughed under as soon as possible following harvest. Crops should be rotated every 3 to 4 years and growers should avoid planting a new crop right next to an older, diseased crop.

Seed should only be saved from healthy fruit.

**Downy mildew**

In coastal districts downy mildew (*Pseudoperonospora cubensis*) is more common and is favoured by cool, wet weather. Symptoms are yellow leaf spots that soon turn brown. Faint purple spore growth develops on the lower leaf surface and if the spots are numerous, the leaf shrivels and dies. Control is usually achieved organically with copper sprays (note that under the national organic standards this is restricted use).


An oat crop that has been slashed to form a mulch over beds prior to sowing at Yanco. Photo: R. Neeson

**Other problems**

Failure of pumpkins to set fruit is usually as a result of inadequate pollination and / or excessive amounts of nitrogen in the soil. Bee hives can be hired for the season from bee keepers: 2 – 3 hives /ha is needed to ensure good pollination.

**Harvesting and marketing**

Following hand removal (cutting) of the vines, pumpkins may be field cured or cut from the vines and cured in well-aerated bins in storage. A light frost will kill off vines and facilitate harvest by exposing the fruit. There is some anecdotal evidence to suggest that allowing the vines to be frosted may also improve the flavour of the fruit. Heavy frost, on the other hand, may damage the pumpkin skin, especially thin types such as butternuts, leading to fruit breakdown.

Pollination is needed to set the pumpkin fruit
A field elevator will assist in lifting fruit from the field and into field bins.

Bins should allow for adequate aeration and should be removed to the packing shed as soon as possible.

**Packing and storage**

Once cured, the pumpkins should be graded and packed according to market requirements. Wholesalers usually prefer fruit packed into bulk cardboard bins.

Boxes or cartons should be labelled with your name, certification number, the certifier’s logo, date packed, batch number (if selling in batches), variety and grade.

Pumpkins will store up to three months, depending on variety and storage conditions. Only sound fruit should be stored and these should be checked regularly and any rotting fruit removed. Butternuts should not be stored under cold conditions.

**Marketing considerations**

Storage will allow marketing over a period of time. This may help to avoid market oversupply. If other growers are supplying the market at the same time, it may be worthwhile coming to an agreement whereby supplies of produce into the market are alternated between growers. By doing this, all growers may receive better market prices.

Pumpkins are also processed into frozen, pureed for baby food and pie fillings, made into jams and used in dried products. Value-adding pumpkins could be done on-farm (facilities will need to be inspected by the certifier and will need to meet health standards) or by a certified processor. If supplying a processor, their requirements (such as variety, size and maturity at delivery) should be determined prior to planting.

The economics of organic pumpkin production will depend on costs of inputs (labour, fertiliser) the yield, quality, the type of market you target (fresh or processed) and supply and demand for your product.

**Contacts and further reading**

**Vegetable Agronomy**

District Horticulturist
NSW Department of Primary Industries
Yanco Agricultural Institute
YANCO NSW 2703

**Vegetable Entomology**

Technical Specialist Vegetables, Yanco

**Vegetable Pathology**

Research Pathologist Vegetables, Yanco

**Further Reading**

Organic Produce Export Committee (OPEC), now known as Organic Industry Export Consultative Committee (OIECC), 2002, The National Standard for Organic and Bio-Dynamic Produce, c/o AQIS. See also the web site www.aqis.gov.au/organic


Diver, S. Compost Teas for Plant Disease Control, Pest Management Technical Note, Appropriate Technology Transfer for Rural Areas (ATTRA), see http://www.attra.org/attra-pub/comptea.html


5.3 Organic production of processing tomatoes

Introduction
Processing tomatoes differ from those grown for the fresh market. They tend to be thicker skinned and less acidic and have a lower water content and higher pulp content than fresh market types. They are grown un-staked on beds, often in double rows.

Large-scale monoculture production is a feature of conventional processing tomato operations.

Processing tomatoes are mechanically harvested and transported in bulk carriers to processors.

Organic production on the same scale is unlikely to be successful. However, careful field layout involving intercropping with other species or staggering plantings could increase the scale of operations and extend the harvest period.

Organic producers sell directly to wholesalers or processors or carry out some form of on-farm value-adding.

A large range of processed organic tomato products is produced. This includes pasta sauces, salsas, juices, ketchup, baby food, tinned whole and pieces, dried tomatoes and pastes.

Most of the organic processed tomato products currently on the Australian market are imported.

Rotation design
Tomatoes belong to the botanical family Solanaceae. Other members in the family include eggplant, capsicum and potatoes. Rotation design should avoid preceding tomatoes with other solanaceous species, thus reducing the potential for pest, disease and weed carryover. Rotation to non-solanaceous crops for three years is usually recommended to avoid pest problems common to this group of vegetables.

If an intensive market garden regime is practised or where long rotations are impractical, green manuring should be implemented. This practice will help to increase organic matter, biological activity and nutrient reserves prior to cropping and will also favour the suppression of soil-borne diseases. A green manure grown prior to planting should be well incorporated, with minimal crop residue apparent before planting the tomatoes.

Ideally, a green manure should consist of a range of deep and shallow rooted herb, legume and grass species. Sod crops preceding tomatoes—such as grass pasture and small grains crops—may result in heavy cutworm and/or wireworm damage to tomatoes.

Some producers practice long rotations where the tomato crop is preceded by a 3-year legume-based pasture or lucerne crop. In this instance, nitrogen requirements of the tomato crop should be met by ploughing down the pasture or lucerne well before planting, allowing adequate time for decomposition and ground preparation.

Tomatoes have a relatively shallow root system, extending down to around 30cm. It may be good practice to follow the rotation with a deeper-rooted species able to extract nutrients from deeper in the soil profile.

Paddock layout could include tomatoes inter-planted with insectary species. This practice involves

Inter-planting the main crop with species they are more attractive to pests than the main crop (also known as trap cropping) or that provides a food source (such as nectar) for beneficial species, which migrate into the main crop and predate on pests.

Trials in cotton have shown pest control benefits from inter-planting cotton with 20m x 1m rows of lucerne (totalling 4% of the area planted). Research investigating layout of chickpeas as a trap crop for Heliothis armigera in cotton has shown that blocks of chickpeas are more effective than strips or patches.

More research needs to be undertaken on suitable species for inter-planting in tomatoes and on the ratio of main crop to insectary crop for optimum benefit.
Variety selection
Choice of variety will depend on market demand, regional adaptability, disease resistance and the end use of the product. For example, the Roma type is the market preference for drying, while tomato paste processors require a product with high total soluble solids (TSS).

The crux of successful organic production of processing tomatoes can often be resistance or tolerance to disease. Some diseases may be more of a problem than others in your district, so you should ensure that the variety you choose has been bred for tolerance or resistance to these diseases. Seed supply companies will be able to provide this information.

Crop nutrition
Nutritional requirements of processing tomatoes are met organically by a range of practices such as green manuring, cover crops, livestock manures and composts, lime, mineral rock dusts, commercial organic fertilisers and foliar sprays.

Many organic sources of nutrients may take a number of seasons to become fully available, so soils should be assessed for their nutrient status a few seasons before planting the tomatoes. This is particularly the case with rock phosphate and mineral dusts. These can be added to composts.

Tomatoes prefer a soil with a pH of 6.0 – 6.8. Soil pH below this can be adjusted by adding natural lime to green manures or pastures before they are incorporated. If magnesium is found to be lacking, dolomitic lime should be applied.

Tomatoes require moderate to high levels of phosphorus and potassium. Advanced applications of rock phosphate should be made based on soil test results. The availability of rock phosphate in less acidic soils (>5.5 pH) in low rainfall areas can be improved by applying the colloidal form. The addition of elemental sulfur has also been shown to improve solubility; although this will also cause a moderate increase in soil acidity.

The crop's potassium and sulfur requirements can be met with applications of mined sulfate potash. Compost and seaweed fertilisers are other organic sources of potassium.

Ground preparation and planting
Primary cultivation should aim to turn under green manures or cover crops well before planting to allow for adequate decomposition.

Initially, soils should be worked deeply to ensure adequate soil depth for bed forming. Deep-ripping is advised if beds are being formed for the first time. If soils are poorly drained, adding naturally mined gypsum prior to ripping may be beneficial.

Follow-up cultivations should be slow and shallow, and should avoid bringing subsoil to the surface. This will minimise the germination of weeds.

The aim should be to produce straight, evenly spaced beds to facilitate cultural (particularly weed management) and harvest operations. Bed width will most likely be determined by machinery wheel spacing.

Once formed, beds should be irrigated if rainfall is insufficient prior to sowing to stimulate weed emergence. A final slow and shallow cultivation to remove weed seedlings usually then precedes planting.

Transplants are the most common method of planting. Transplants are preferred over seeds as they have a competitive advantage over weeds. Transplants should be raised organically. This is a requirement of the National Standard for Organic and Bio-Dynamic Produce.

If organic seedlings are not available you must provide evidence to your certifier that you have made every effort to source organic material. These should be pre-ordered (if

Organic fertiliser

Selecting crops to include in a green manure it is important to use a range of root systems that can explore, work and enrich the soil. Shown here, from left, are oats, faba beans and fodder rape. Source: NSW Department of Primary Industries
not growing your own) at least 6 months prior to planting to ensure that suppliers can supply the variety and quantities you require.

Check transplants upon arrival to ensure they are pest and disease free. If pests or disease are present, treat with an organically acceptable pesticide prior to planting.

Transplants should be hardened-off after delivery and pre-watered prior to planting.

Transplants are generally planted by machine, although hand planting may be considered for smaller areas.

To avoid stimulating weed germination, aim for minimum soil disturbance during planting.

Plants should be placed 40cm apart in straight, evenly spaced double rows. Tomatoes should be watered-in as soon as possible after planting.

Planting in double rows makes efficient use of soil nutrients and encourages rapid coverage of the bed surface thus providing competition (shade, moisture and nutrients) against potential weed invasion. However, weed control can be more difficult between the two rows.

Alternatively, the tomatoes could be planted in single rows and undersown with a leguminous green manure crop. Suitable species could include dwarf red and white clover.

Undersowing is best done 4 weeks after planting tomatoes to ensure they are well established.

You will need to flame or cultivate any weeds that emerge in this intervening period. The clover should be sown in a weed-free seedbed.

Careful water and nutrient management will be needed to ensure competition between the cover crop and tomatoes does not occur.

Weed management

Weed management begins well before planting. If planting in a previously uncropped field, you should select one that is relatively weed-free. This is particularly important with difficult to manage weeds such as nightshade or weeds with persistent seed banks such as Bathurst burr.

If the tomatoes are part of an ongoing rotation, weed ‘cleaning’ crops such as short season vegetables or green manures should precede the tomato crop.

Weeds in areas bordering the field should be controlled, particularly if they are hosts for thrips or aphids as these may transmit diseases to the crop.

Irrigation as a weed control method

Beds should be pre-irrigated or have received rainfall prior to planting to stimulate weed germination. Germinating weeds are then controlled by shallow cultivation or flaming prior to planting.

Sub-surface drip irrigation can minimise weed competition. The drip line should be buried at, or just below, rooting depth.

You may need to compromise slightly with the depth as the drip line will remain in the soil for a number of seasons and crops following tomatoes in the rotation may have a different root depth.

Soil type will also dictate the depth at which the drip line should be laid. Crop type and soil type will also dictate the distance between in-line emitters in the drip line. If unsure, you should seek advice from the drip line supplier or a NSW Department of Primary Industries Irrigation Officer. NOTE: Some drip line is impregnated with herbicide, so be sure to specify when purchasing that this is not required.

Post-planting weed control

The critical period for weed management occurs during crop establishment and until the tomato crop canopy closes over the bed. Following planting, emerging weeds can be flamed or interrow cultivated.

Weeds emerging within the plant row may require hand removal (chipping) at least until the crop canopy closes.

Once the crop canopy closes over the bed, little—if any—weed management is usually required. Weeds in the furrows between beds may be mechanically cultivated or flamed.

The application of surface mulch may also be considered to suppress weeds and to conserve moisture. Non-synthetic woven or processed materials or organic mulches such as straw, hay, sawdust and rice hulls are suitable. Equipment is available to mechanically lay some commercial mulch. These should be laid prior to transplanting.

Organic mulches should be maintained in a layer 10cm or deeper, and are generally applied after planting so not to interfere with equipment. If surface mulch is applied, drip irrigation can be placed under the mulch on the bed surface.

Insect pest management

Effective pest management can only be achieved through monitoring and correct identification of the pest and predatory species. An understanding of the pest’s (and predator’s) lifecycle will help you to plan and design an integrated pest management strategy.

Monitoring for the presence of pests and predators should start before planting—in surrounding fields, on weeds and in the soil.

The presence of pests that live in the soil (such as wireworms) can
be determined by soil sampling. Sticky traps, baits and light traps located around the field will help to monitor the presence of flying insects. Crop monitoring should be done at least weekly.

Beneficial insects are very susceptible to insecticides, so care must be taken to reduce drift from neighbouring properties. Some organic farmers plant windbreaks or arrange with their neighbours to sow crop buffers such as sorghum along the boundary. *Casuarina* spp. is very effective at reducing spray drift by trapping spray droplets.

Windbreaks also add to the biodiversity of the farm by providing shelter for smaller birds and other potential pest predators.

**Major insect pests of tomatoes**

**Caterpillars**

*Heliothis* spp (Heliocoverpa), *H. punctigera*, and *H. armigera* are the two most common species that damage tomatoes.

While *Heliothis* larva will feed on buds and flowers of tomato plants and may also bore into the stems, it prefers fruit. Fruits that are damaged when young are most likely to rot before harvest.

**Monitoring for Heliothis**

All processing tomato producers monitor crops on a twice-weekly basis from planting until about two weeks before harvest. Regular monitoring for pest presence will let you know if the beneficial insects are present and if they are keeping *Heliothis* at a satisfactory level of control. Pheromone and light traps are used to monitor moth numbers, species and flight patterns.

Monitoring pest/predator build-up involves collecting random leaf samples to determine the level of *Heliothis* eggs present. The eggs are then collected and inspected 4–6 days later to determine the level of parasitism from wasps such as *Trichogramma* or *Telenomis*. If the eggs turn black, they have been parasitised by the wasp. This enables you to determine if an organically acceptable spray is required to further reduce pest numbers. The threshold for spraying *Heliothis* in tomatoes is five viable eggs on 30 leaves or 2 larvae on 30 leaves. See Table 1 for beneficial insect and spider ratings as reported by the Department of Primary Industries, Queensland.¹

**Biological control**

Mass-reared beneficial insects including *Trichogramma* wasps are available for biological control of *Heliothis*. These wasps are egg parasites of *Heliothis*. Commercially reared *Heliothis* eggs parasitised by *Trichogramma pretiosum* may be released to control *Heliothis* and loopers, although this is an expensive operation, costing around $100 per ha.

Eggs can be released in a water solution through a backpack at a rate of 8 ha / hour or over larger areas with a specially built machine, or on egg cards that are placed throughout the field. The most important consideration with *Trichogramma* release is timing. Farmers have found it is normally necessary to make two releases approximately 5–7 days apart. Monitoring is essential to determine the best time for release.

**Cultural controls**

It is possible to reduce the risk of *Heliothis* damage through a number of cultural practices.

**Plant early.** Early season crops (harvest late January / early March) are generally less prone to damage from *Heliothis*. Avoid planting late season crops in NSW.

**Cultivar selection.** Different tomato varieties may be able to tolerate different levels of insect damage. More research is required in this area.

**Crop sanitation.** Thoroughly cultivating the field after harvest will destroy pupation chambers (this known as ‘pupae busting’). This will reduce the population of the next generation of *Heliothis*.

**Insectaries and strip cropping**

Strip or trap cropping is ‘growing two or more crops simultaneously in different strips, wide enough to permit independent cultivation, but narrow enough for the crops to interact agronomically’ (Francis,
C.A., *Multiple cropping systems*, 1986, MacMillan). Strip crops, or insectaries, can be the breeding grounds for beneficial insects that migrate, are forced (for example, by cutting) or transferred (by D-Vac™ suction collection) to nearby commercial crops.

In trials conducted at NSW Department of Primary Industries Yanco Agricultural Institute's organic demonstration site, pigeon pea has been shown to be a very effective trap crop for *Heliothis* when planted in soybeans.

Sweet corn has also shown some effectiveness as a trap crop. The egg-laying moths prefer corn to beans, tomatoes and other crops, so borders or strips of corn planted around or within the crop may reduce *Heliothis armigera* densities on the less-preferred crops. This approach is likely to only be effective if the corn is silking at the same time as the tomatoes, or other crops are setting pods or fruit. Staggered plantings would be required to ensure silking is continuous.

**Organically acceptable pesticides**

These include naturally occurring bacterial and viral insecticides. They can provide significant control of *Heliothis* in tomatoes if applications are well timed and frequent. Note: All products must be registered for their designated use. Minor use 'off-label' permits may be obtained by contacting the Australian Pesticide and Veterinary Medicine Authority.

**The sap-suckers**

Aphids, leafhoppers and thrips are sap-suckers that reduce crop vigour, fruit quality and yield. Some may act as vectors, or carriers, of viral diseases in tomatoes and other plants.

**Thrips**

Thrips are very tiny, slender insects that feed primarily in flowers and developing fruit. Thrips transmit the tomato spotted wilt virus (TSWV), causing tomato spotted wilt. Not all species of thrips are capable of transmitting the virus. The onion thrips (*Thrips tabaci*) is the most common vector of TSWV in Australia.

The thrips acquire the virus as they feed on tomatoes and other host plants, including weeds. Thrips are most likely to migrate to tomatoes when plants they have been feeding on have matured or dried out.

A large number of weeds and ornamentals (particularly perennials) are known to host thrips, and while removal of host weeds or those known to be susceptible to spotted wilt will reduce the risk of disease transmission, this may not be a practical solution.

Anecdotal evidence suggests basil interplanted in tomatoes may help to repel thrips.

When monitoring for thrips, sampling should be done at the same time as *Heliothis* sampling.

Select one tomato flower from each of the plants sampled (5 plants per location in the field). The flowers are then placed in jar with alcohol and after a few minutes the thrips will sink to bottom of the jar where they can be counted. Tapping flowers into the palm of the hand is another quicker method.

**Table 1. Beneficial insect and spider ratings (sweet corn)**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Beneficial rating*</th>
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<tr>
<td><strong>W asps and ants:</strong></td>
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| Trichogramma | Hymenoptera: | ++++
| Black ants | Trichogrammatidae | ++++
| Microplitis | Iridomyrmex sp. | +++
| Telinomus | Microplitis demolitor | ++
| **Bugs:** | Telinominae | ++
| Black mirid | Hemiptera: | ++++
| Pirate bug | Tythhus chinensis | ++++
| Apple dimpling bug | Orius sp. | ++++
| Brown smudge bug | Campylomma liebknechti | ++
| Bigeyed bug | Deracoris signatus | ++
| Damsel bug | Geocoris lubra | +
| **Spiders:** | Nabvis kinbergii | +
| Foliage dwellers (e.g., jumping spider) | Araneae: | ++++
| Soil dwellers (e.g., wolf spider) | Salticidae | +++
| Web builders (e.g., orb weaver) | Lynxidae | +++
| **Beetles:** | Araneidae | ++
| Ladybirds | Coleoptera: | +++
| Carab beetle | Coccinellidae | ++
| Red and blue beetle | Carabidae | ++
| Green soldier beetle | Dicranolaius bellilus | ++
| **Lacewings:** | Chauiognathus pulchellus | +
| Green Lacewing | Neuroptera: | ++
| Brown Lacewing | Mallada sp. | ++
| **Flies:** | Micromus tasmaniae | ++
| Tachinid flies | Diptera: | ++
| Hover flies | Tachinidae | ++
| | Syrphidae | +

* Level of pest management in sweet corn = Low (+); Moderate (+++); High (++++).
An organic spray is recommended if an average of one thrips per flower is found (5 thrips in a jar with 5 flowers). Soap, natural pyrethrum and horticultural mineral oils can be used successfully.

**The common brown leafhopper (Orosius arenatus)**

This is a brown speckled insect about 3mm long that is responsible for the spread of the mycoplasmic disease Big Bud.

Host weeds in and around the crop should be destroyed. High tomato plant populations can reduce losses due to the disease within the crop.

**Aphids**

These feed on the underside of leaves, causing curling and reduced growth potential. The feeding of large numbers of aphids results in excretion of honeydew that supports the growth of secondary fungal diseases. Aphids may also act as vectors of certain virus diseases of tomato. Virus transmission has been observed when lucerne is interplanted to attract beneficials.

Research has shown that reflective polyethylene mulch placed on beds before transplanting significantly reduces the rate of colonisation by winged aphids and whiteflies, and can delay the build-up of damaging numbers of aphids by 4 to 6 weeks.

**Control of aphids**

Common natural predators of aphids are lady beetles and their larvae, lacewing larvae, and syrphid fly larvae. Aphid parasitoids, *Aphidius* spp, can occur naturally in the field, but often only when aphids are in large numbers. *Aphidius* spp are commercially reared in New Zealand, while green lacewings *Mallada signata* are commercially available in Australia.

Organically acceptable pesticides to control aphids are sprays of insecticidal soap or natural pyrethrum. Pyrethrum is harmful to beneficials so treatment should aim to avoid their peak activity, but still contact aphids.

Organic farmers have reported good control of aphids with spray applications of garlic oil, when it is combined with mineral oil and pure soap.

**Green vegetable bug (Nezara viridula)**

The green vegetable bug (*Nezara viridula*), or GVB, also damages fruit through the sucking and piercing feeding action, although there are no reports of disease transmission through this activity. Tomato fruit that is attacked develops mottled areas.

**Organic control** of GVB is difficult. Release of predatory wasps and natural predation are the common control methods relied upon by organic producers. A parasitoid wasp (*Trissolcus* spp) and parasitic fly (*Trichopoda* spp) are two predators of GVB.

The CSIRO has conducted trials aimed at establishing the South American parasitoid, *Trichopoda giaoceumelli*, at sites in south-eastern QLD and northern NSW. Results indicate that *T. giaoceumelli* has successfully established in these regions and is now impacting on the abundance of GVB at sites in northern NSW. Ants are also known to be effective predators of GVB.

**Crop nutrition.** Some organic farmers apply foliar sprays when the plant is under insect attack, believing this improves plant health and renders the crop less attractive to pests.

Two of the most common foliar sprays are kelp and fish emulsion.
Organically acceptable insecticides. Natural pyrethrum is a pesticide used by organic farmers to limit GVB damage. However, in trials conducted at Yanco organic demonstration site, pyrethrum did not give a satisfactory level of control against GVB.

Trap cropping. It may be possible to plant species that are more attractive than tomatoes to GVB.

This attracts the GVB away from the crop, where they can be destroyed eg by cultivation, rolling or mulching. Suitable crops include sunflowers, soybeans and *Amaranthus*.

Cultural control. Some of the crops that are effective trap crops can also host GVB, for example, *Amaranthus*. You will need to weigh up whether your aim is to use these plants in a trap situation or to control them in the area instead.

If you do not wish to use trap cropping, then plants and weeds in areas immediately surrounding the tomato crop that are known to host GVB should be controlled.

Weeds known to support development of GVB include castor oil, yellow-vine (caltrop), privet and *Amaranthus*. GVB has also been observed on silver leaf nightshade.

Mite pests

Two-spotted mite (*Tetranychus urticae*) and tomato russet mite (*Aculops lycopersici*) feed on the underside of leaves. Tomato russet mite also feed on the stems and on fruit. Damage is usually greater in hot, dry weather. Both mites are extremely small, best seen with a hand lens or magnifying glass.

Biological control. The predatory mites, *Phytoseiulus persimilis* and *Typhlodromus occidentalis*, and the fungus gnat, *Hypoaspis* spp are commercially available to control two-spotted mite. A small, shiny black ladybird (*Stethorus* spp.), often occurs naturally in the field and is also an effective predator.

Predators that are commercially reared and released in the crop will require a non-crop plant on which to overwinter once the commercial crop is harvested. Otherwise, annual releases will be required. Windbreaks containing a variety of species and weedy borders (that don’t host pests or diseases) act as suitable overwintering sites.

Monitoring of pest and predator populations is essential to track their movement into the crop, their numbers and hence effectiveness.

Chemical control. Wettable sulfur and sulfur dusts are organically acceptable compounds are available that will control mite pests. Horticultural mineral oils can also be used successfully at rates between 0.5 – 1.0% volume of oil / vol water. Sprays should not be applied when temperatures are above 35°C and caution should be taken to avoid spraying when predators are most active.

(Note that Japanese organic standards have recently been amended to disallow use of these, so producers intending to supply this market need to be aware of this when considering this type of control).

Diseases and nutritional disorders

Organic producers should aim to select tomato varieties that are bred for resistance to disease.

Long rotations with non-related crops and improving soil biological activity through incorporation of green manures and compost will have a positive impact on reducing the incidence of soil borne diseases. Crop sanitation, by removal and composting or ploughing under of crop residues, will help to prevent disease carryover.

Compost teas could prove beneficial in control of certain bacterial and fungal diseases.

Viral and mycoplasmic diseases

*Big bud*

*Big bud* is a mycoplasmic disease that may not develop until six weeks after infection by the brown leaf-hopper (*Orosius argentatus*). It is more common in dry inland regions from October, particularly after hot weather forces leafhoppers from weeds and on to crops.

Symptoms appear as a thickening of stems, and a proliferation of small stiff shoots with short internodes. Roots may develop high on the stem and splitting may occur. Flower buds are greatly enlarged and do not develop properly.

Control. Weeds in and around the crop that host the brown leaf-hopper should be destroyed. Increasing tomato plant populations can help to reduce losses.

*Spotted wilt*

Spotted wilt is a viral disease that can cause heavy losses in spring and early summer crops. The disease is spread by the onion thrips (*Thrips tabaci*), a small yellowish brown / grey flying insect about 1mm long, and by Western Flower Thrips (*Frankliniella occidentalis*).

It breeds on weeds and migrates on to tomatoes as weeds dry out. Dandelion, lamb’s tongue, nightshade and thornapple are favoured weed hosts. Many ornamental plants also host spotted wilt.

Symptoms first appear 7 to 20 days after infection. Small areas of bronzing appear on the upper side of young leaves in top growth, and on older leaves as bronze spots or rings between the veins. As the disease develops the spots blacken and shrivel.
Affected fruit show irregular or circular blotches as they ripen, often shrivelling and falling off.

**Control.** Weeds and ornamentals that may host thrips near the crop should be destroyed. Tomatoes should not be planted near flower crops.

Increasing tomato plant populations can help to reduce losses. Soap, natural pyrethrum and horticultural mineral oils can be used successfully to control thrips.

**Bacterial diseases**

Bacterial diseases commonly affecting processing tomatoes include bacterial canker (*Corynebacterium michiganense*), bacterial speck (*Pseudomonas syringae* pv. *tomato*) and bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*).

Sources of infection include seeds, contaminated soil (can survive in soil for up to 3 years and, in the case of bacterial speck, on plant debris for 30 weeks), and weeds (particularly blackberry nightshade, *Solanum nigrum* and thornapples, *Datura* spp.).

**Control.** A 4–5 year rotation between tomato crops is desirable. Seeds saved from healthy plants should be planted. If the disease status of seed is unknown it should be treated in hot water.

Host weeds in and around the crop should be destroyed. Sanitation should involve removing and burning diseased plants as they appear.

Hands and tools should be washed in warm soapy water after touching diseased plants. Overhead irrigation should be avoided.

Crop refuse should be deeply buried or removed for composting.

At the time of writing, use of copper hydroxide is an organically acceptable chemical control method. However, the use of copper as an allowed organic treatment for disease is currently under review.

The National Standard for Organic and Biodynamic Produce (2003) states that the annual application of copper should not exceed 8 kg/ha/annum and that producers should have a staged reduction strategy in place.


**Fungal diseases**

Fungal diseases commonly affecting processing tomatoes include anthracnose (*Colletotrichum* spp.) and *Phytophthora* spp.

Spread of anthracnose is favoured by warm, humid conditions with temperatures above 26°C and relative humidity above 93%. *Phytophthora* commonly occurs where extremes in soil moisture occur and where drainage is poor.

**Control.** Anthracnose is controlled by hot water treatment of seeds, crop rotation and sanitation measures. Anthracnose is principally a disease of ripening fruit, so harvesting mature green fruit can reduce incidence.

Copper hydroxide sprays may (at the time of writing) be used when fruit begins to ripen. However, producers should check before use to ensure this is still permitted.

*Phytophthora* incidence can be minimised by good irrigation management and adequate drainage.

Maintaining high organic matter and biological activity in the soil will also assist in control of *Phytophthora*.

**Nutritional Disorders**

**Blossom End Rot**

Blossom-end rot appears as brown to black spots on the underside (blossom-end) of the fruit of tomatoes. As the fruit grows, half or more of the fruit may be affected — the fruits ripen earlier and may be prone to secondary infections.

**Causes.** This is primarily a nutritional disorder caused by a deficiency in calcium, a water-soluble element. Any factors affecting water and calcium availability, or movement, into the plant will therefore contribute to the problem.

Environmental and cultural factors that contribute to the occurrence of blossom end rot include:

- poorly drained soil
- improper soil preparation and planting
- inadequate or excessive watering
- soil pH levels below 5.5
- inadequate calcium in the soil
- applying too much nitrogen
- excessive root disturbance
- use of plastic mulch instead of an organic mulch, high soil and air temperatures and low humidity.

**Control.** Contrary to past belief the direct application of calcium as a spray is ineffective.

A soil test should be conducted to help determine nutrient levels. Excess levels of ammonium, magnesium, potassium and sodium have been reported to reduce the availability of calcium.

The addition of limestone, gypsum or dolomite to the soil well before transplanting is recommended to overcome the soil calcium deficiency. Liming is recommended in areas with low pH (below 5.5) soils.
Maintaining the proper balance of potassium, phosphorus and other soil nutrients and avoiding excessive growth due to over-fertilisation with nitrogen is recommended.

Having a uniform and adequate soil moisture content is critical to preventing blossom-end rot. Irrigation scheduling with the aid of soil moisture probes and mulching can help to maintain optimum soil moisture for plant growth.

**Harvesting and marketing**

Conventional processing tomatoes are harvested mechanically to supply large processors. Vines are lifted from the field, the fruit removed mechanically and then conveyed along a sorting platform, where it is graded by field workers.

Fruit is graded according to whether it is rotten or badly blemished (rejects), mature green and red ripe. The degree of acceptable blemish will depend on your end market. For example, a higher degree of blemish will be acceptable for fruit that is to be pulped than for whole peel or dried tomato products. Some tomato growers invite hand picking for the local market prior to machine harvesting.

**Markets**

A large range of processed organic tomato products is currently produced. These include pasta sauces, salsa, juices, ketchup, baby food, tinned whole and pieces, dried and pastes. Most of these lines are currently imported into Australia.

Contracts for processing tomatoes are difficult to obtain unless you are an established producer. Contracts are issued before the season begins.

Organic processed tomatoes are a niche product, not yet being sourced in Australia by the larger tomato processors. However, there appears to be potential for import replacement of processed tomato products.

Heinz Watties currently contracts New Zealand organic producers to produce processing tomatoes for their organic baby food lines. Cedenco Foods Ltd, New Zealand, is developing a number of processed organic vegetable lines. Australia has a climate more suitable for processing tomato production, so potential exists for Australian organic producers to become the preferred supplier should reliable supplies become available. Growers should investigate these opportunities.

Smaller producers could consider on-farm value-adding or supplying unprocessed product to farmers’ markets, health food and restaurant outlets. Consumers often prefer the egg or Roma type processing variety. The Sydney based wholesaler and exporter, Eco Farms, has indicated interest in receiving processing tomatoes to supply smaller clients.

If processing is carried out on-farm you will need to have these operations inspected by your certifier. Your processing operation must also comply with State and Territory health regulations. The development and implementation of a Hazard Analysis Critical Control Point (HACCP) plan will help you to achieve compliance with organic standards and health regulations.

**Economics**

The economics of organic processing tomato production will largely depend on the market you are targeting. On-farm value-added products will return more than unprocessed tomatoes sold to a processor. However, the labour and infrastructure requirements for on-farm value-adding will be significantly greater. So, returns will largely depend on how much effort, time and initial resources you are prepared to outlay.

Returns will also depend on costs of inputs (labour, fertiliser), yield, quality, the type of market you target (fresh or processed) and supply and demand for your product.

Organic whole peeled canned tomatoes – one of the processed tomato product opportunities available to Australian organic producers. Source: [http://www.goodnessdirect.co.uk/detail/340456b.jpg](http://www.goodnessdirect.co.uk/detail/340456b.jpg)

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Further reading

A useful information source on pest management for processing tomato growers is the ‘UC pest management guidelines — tomato’, published on the web by the University of California.


6. Post-harvest management and marketing

Post-harvest management must ensure that the quality and the organic integrity of the product are retained—from paddock to plate.

Vegetable producers must ensure that harvested product does not become contaminated after it leaves the paddock. Harvest bins and transport—particularly if provided by contractors—need to be thoroughly cleaned to remove potential contaminants. Since few chemicals for prolonging post-harvest storage of the product are permitted, optimum hygiene and storage conditions must be provided. Certifiers will require that freight transporters be inspected or that information about post-harvest storage and disinfection procedures be provided. Storage and packaging facilities will probably also have to be inspected. Any processing of organic vegetables must be certified. Certification is sometimes a deterrent to processors, particularly if only a small quantity of organic produce is to be processed. Producers could consider forming processing cooperatives.

6.1 Quality assurance

Quality assurance of products entering the marketplace is becoming increasingly important. Consumers of agricultural produce need to be assured that the products they buy meet their expectations for safe and wholesome food. Large supermarket chains and export markets are starting to demand that goods be produced in conjunction with a system that offers full traceability. As Australia develops new export markets, it must be remembered that many of the countries that import our produce now enforce quality specifications more rigidly than ever before, and failure to meet specifications may see the loss of these markets. This is just as relevant for organic produce as it is for conventional produce.

Consumers demand quality—particularly for fresh fruit and vegetables—and, since most people ‘buy with their eyes’, farmers should be rigorous throughout the grading process. Supplying blemished or damaged produce is not acceptable. Poor quality reflects on the industry as a whole. Damaged (provided it is not breaking down) or blemished produce need not be discarded, however. Consider value-adding to second-grade product by processing it into purees or juices or packing it as pieces.

Organic producers wishing to receive training in quality management can do an accredited quality management course. Two such courses are the regularly conducted National Organic Auditor Training workshops and the Independent Organic Inspector Association Organic Training workshops.

Quality assurance of organic products is crucial to ensure that there is no contamination by products excluded from the standard. Among the potential risks are pesticide and microbial contamination and contamination with genetically modified or conventional product. An important aim of any quality assurance program is to eliminate problems before they occur and, if possible, to reduce reliance on end-point inspection (quality control).

6.1.2 Quality

[This section is reproduced from Marketing Organic and Biodynamic Products: conference proceedings (NSW Agriculture 1997). Joseph Ekman, Extension Horticulturist, Quality Assurance, NSW Department of Primary Industries, contributed what follows.]
Quality is no accident. Climatic conditions may vary from season to season but product quality is essentially the end result of investment of money, time and labour. Quality can only be achieved consistently and efficiently through managing the activities and inputs that affect quality from the field through to the customer. Consistently achieving the 'right result' requires planning and implementing a quality system. 'Quality assurance' can be defined as 'all the planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality'. Quality assurance requires the planning and implementation of a quality management system.

Every producer has some kind of informal quality system in place. More often than not this information is stored 'in the manager's head'. A formal, auditable quality system requires production and post-harvest operations to be planned, documented, implemented, verified and certified to a recognised standard. Management to satisfy a standard is familiar territory for organic and biodynamic producers certified to the National Standard for Organic and Biodynamic Produce or respective group standards. However, there are numerous other quality system standards in operation, all of which are based on similar principles. Figure 6.1 illustrates the principles generic to most quality systems.

**Why develop a quality system?**

Agriculture in Australia has been changing rapidly in recent years and the pace of change continues to accelerate. These changes include:

- changes in consumer preferences for products
- increased production and geographical spread of many crops
- government retreat from enforcing product quality standards and the push to market self-determination on quality
- increased competition from imports.

These forces are changing the way Australian producers market their crop. Many of the problems facing producers can be tracked down to a failure to research and understand what their customers really wanted. Australia has earned a poor reputation in overseas markets because of variations in product quality, poor or patchy market service history, and a poor understanding of market-specific requirements.

Changes on the domestic marketing scene are also putting greater pressure on producers to supply products of consistent quality. Chain stores (supermarkets) continue to capture market share in fresh produce retailing, and they prefer to supply of long lines of consistent quality product. As their market share grows, chain stores are demanding rigid standards for the products they buy. They want to know that the products they sell meet their consumers' expectations, in order to gain consumer loyalty and repeat purchases.

Purchasing long lines of consistent quality products can also simplify their handling and distribution logistics, reduce wastage and reduce operating costs.

Rising production costs are also putting pressure on growers to improve their quality consistency to remain competitive. The threat of an industry collapse from oversupply is forcing producers in many industries to look overseas for new markets. There is no doubt that successful penetration of export markets will require close attention to the needs and expectations of customers.

The major challenge for the future of Australian producers is being able to supply consistent quality products and service to markets.
Forces driving change in agricultural industries

Group marketing:
- strength in group marketing
- demand for long lines and continuous supply
- brand establishment—product differentiation

Retailing
- consumers and health authorities demanding safe, quality foods
- less consumer time to shop around—one-stop shopping
- direct sourcing of produce from farms—contract growing/alliances
- use of product specifications

International trade
- decreasing tariff and trade barriers (WTO)
- opening of new markets
- competition (domestic and international) and declining global market share

Business environment
- need for profitability/efficiency gains
- increases in production and market saturation
- quality replacing price as the competitive advantage
- government deregulation of industries

Figure 6.1 The quality system cycle. Source: Adapted from Ekman 1997
Quality costs

Quality costs! However, the costs of quality and getting it right must be assessed relative to the costs of quality failure.

All quality systems are a balance between the cost of getting it right and quality failure. The three categories of quality costs are:

• prevention costs—the costs of preventing quality failure, including the planning and maintenance of a quality management system and certification
• appraisal costs—the quality control costs of ongoing monitoring of products and services such as product testing and inspection from production to marketing
• failure costs—the cost of final products or services that do not satisfy customer requirements. Failures detected before the product reaches the consumer are termed ‘internal failure costs’. Failures that result in dissatisfied customers are ‘external failure costs’.

Quality costing provides a basis to assess the value of a quality system to an organisation and to assist management to identify opportunities for efficiency gains and cost reductions.

The key to improving quality and profitability is failure prevention.

A quality management system increases the prevention costs in a business but, when the system is implemented effectively, the cost is more than compensated for by reduced failure costs, operational efficiency gains and increased competitive potential in the market.

Quality system benefits

The following are some of the main benefits of failure prevention achieved through quality management:

• improvement in product consistency
• improved competitiveness and ability to adjust to market change
• enhanced reputation in the market
• reduction in liability risks
• reduced wastage and rework of products
• process efficiency gains
• decrease in labour and material costs
• improved employee involvement and morale
• improved return on investment.

Quality systems are a tool businesses can use to provide the assurance customers want. By focusing on managing activities that affect safety and quality, the quality system helps organise the way things are done and provides organisational confidence in the ability to consistently provide the goods and services customers require.

Elements of quality management systems

Quality plans. A quality plan (manual) sets out the policies, resources, practices and responsibilities for the business to meet its customers’ requirements for products and service. Appropriate quality system plans can make the difference between an easy-to-use system and one that sits on the shelf.

Product specifications. Specifications are a tool for improving customer–supplier relationships. The important feature of specifications is that they objectively define the requirements of a product, thereby avoiding confusion. They also provide a means of objectively monitoring performance in meeting the specifications.

Management and staff

Improvements can be achieved only if management and staff are working toward similar goals. A successful business—with a reputation for quality—provides better job security and job satisfaction for employees. When the whole organisation runs smoothly and everyone is involved the success helps build confidence and teamwork. Management must ensure staff have a clear understanding of what is required of them. Many managers often underestimate the contribution staff can make to the business when given the opportunity. Being part of the quality system from the beginning lowers staff resistance to any improvements or changes to be made and often improves morale.

Customers and suppliers

Customers and suppliers are other links in the production, delivery and marketing ‘supply chain’. It is important that suppliers know what their customers want if they are to reliably supply products of the quality expected. Often it is the supplier who must ask the customers what they require and seek feedback on how well the requirements are being met. Most unhappy customers don’t complain—they simply don’t come back. In the same way that a business needs to understand what its customers’ requirements are, the business must also define the qualities of products it uses and
communicate its expectations of quality to its suppliers via specifications.

**Documentation.** Documentation can help make decisions, assist in running the business, and help staff do their job. More paperwork does not, however, mean better systems. One of the aims of a quality system is to reduce wastage, so it is important not to create excessive paperwork. People drive a quality system—not paperwork. One of the main functions of documentation is to help improve communication. This overcomes problems of poor verbal communication and memory failures. Documents are valuable tools in that they record what has to be done and what has been done.

**Quality system standards**

There are a number of quality, food safety and environmental management systems that affect Australian agricultural industries. Key established and emerging standards and codes of practice include:

- ISO 9000:2000 and ISO14001
- Safe Quality Food 2000 and 1000
- Woolworths Vendor Quality Management Standard
- CATTLEcare/FlockCare, Freshcare, Graincare, and so on—HACCP-based codes of practice
- EUREPGAP—for suppliers to European retailers
- many other industry-specific standards and approved supplier programs.

The systems implemented by a business will need to satisfy the requirements of its customers. Businesses need to expand their definition of 'satisfied customers' to include regulatory authorities in regard to food safety and phytosanitary requirements. Food Standards Australia New Zealand (previously known as the Australian and New Zealand Food Authority) is implementing new national food standards in the food service and processing sectors. It is also developing a framework for the establishment of ‘Primary Production Standards’.

**HACCP**

Food safety plans are conventionally developed in food industries using the HACCP technique. HACCP stands for the Hazard Analysis and Critical Control Point method of food safety management. It is a step-by-step risk analysis and control technique used in food industries worldwide to analyse processes and so identify food safety risks. It is a pro-active management technique for preventing hazards from occurring and reaching consumers, rather than reactive (fire-fighting) management methods of damage control. HACCP requires an objective assessment of all biological, chemical and physical hazards to human health throughout a business’s operations and the development of appropriate control, monitoring and data recording strategies. As a risk management tool, HACCP can also be used to assess risks to product quality and environmental risks. The HACCP technique applies the following seven principles:

- Conduct a hazard analysis—identify all biological, chemical, physical and quality hazards.
- Determine the critical control points—the points in the process where risks are likely to occur.
- Establish critical limits—boundaries/tolerances for safe operation at the critical control points.
- Establish a system to monitor control of the critical control points.
- Establish the corrective action(s) to be taken when monitoring indicates that a particular critical control point is not under control.
- Establish procedures for verification to confirm that the HACCP system is working effectively.
- Establish documentation concerning all procedures and records appropriate to these principles and their application.
A HACCP plan essentially requires asking at each point in the process:

- What safety or quality hazards are associated with this process?
- Which of these hazards are significant and likely to occur if not controlled?
- What must be done to control these hazards to an acceptable level?
- What records or evidence are needed to demonstrate that the hazards have been controlled?

Implementation of HACCP is guided by scientific evidence of the risks.

The intent of HACCP is to focus control at critical control points. The individual operations within a business are identified, and HACCP principles are applied to each specific operation separately.

Consideration must also be given to raw material inputs such as water, fertilisers, packaging materials, and so on, which may be the source of problems. Hazard control measures may potentially introduce new hazards of their own and must also be considered.

When a significant hazard is identified in a specific operation, control measures must be established that prevent, eliminate or reduce the hazard to an acceptable level.

The critical limits (tolerances or safe operating limits) for that operation must be established to maintain control of the hazard, and an appropriate monitoring and recording procedure must be developed to confirm that hazard control is achieved.

Sometimes the monitoring may indicate that hazard control was not effective—that is, the operation exceeded critical limits for safety or quality—and corrective actions are required. Corrective actions are planned responses to a breach of safety or quality limits and the response must:

- identify the affected product
- determine what is to be done with affected product after assessing the severity of the problem
- determine the origin of the problem
- take the necessary action to prevent the problem from occurring again.

The intent of HACCP is to systematically build safety and quality into a food operation to minimise the chances of unsafe product entering the market. HACCP plans are fully compatible with quality management standards in food businesses for control of production requirements. HACCP plans can work in combination with other support programs such as:

- good manufacturing practices
- pest control programs
- staff training
- cleaning and sanitation procedures
- calibration programs
- preventative maintenance programs
- document and record control

They can also constitute a business's Food Safety Plan.

Development of a HACCP plan will identify the requirements of a business to implement these support programs. The food standards will require all food production and handling businesses to develop an auditable food safety plan. The degree of complexity required in a food safety plan will reflect the complexity of business operations and the type of product and its associated risks; that is, the food safety plan for a small grower may be far simpler than that for a larger, more complex operation, although the same principles apply.
In summary, changes in the expectations and buying behaviour of consumers are affecting agricultural producers. Globalisation of the food supply and the changing structure of fresh produce retailing in response to consumer trends are creating new challenges and dilemmas throughout the food supply chain. Research indicates that buyers are becoming more discerning about quality from the health and eating perspectives, and food safety is increasingly the primary concern.

Opportunities exist for organic and biodynamic producers to capitalise on these market trends through their ‘clean and green’ image with consumers. But close attention to customer requirements for quality and consistency, coupled with the need to satisfy food regulatory authorities in relation to food safety management, is required to realise this potential. Quality systems cost time and money, but these costs must be weighed against the substantial financial and potential legal costs of getting it wrong. Quality management is pro-active. Use of HACCP-based quality systems can accommodate food safety, quality and environmental business objectives.

The pace of implementation of quality management systems for quality assurance in agricultural industries is rapidly increasing. Quality assurance does not guarantee market premiums, but it will increasingly determine market accessibility. Quality management is rapidly becoming an essential management tool for producers in all food industries who want to do business better and remain competitive.

6.2 Environmental management systems

[This section is reproduced from *Marketing Organic and Biodynamic Products: conference proceedings* (NSW Agriculture, 1997). Genevieve Carruthers, Environmental Management Systems Specialist, NSW Department of Primary Industries, contributed what follows.]

Environmental management systems (EMSs) are based (in general) on the principles of total quality management (Netherwood 1996). The British Standards Institute (1994, cited in Netherwood 1996) defines an environmental management system as ‘the organisational structure, responsibilities, practices, procedures, processes and resources for determining and implementing environmental policy’.

This definition, describing British Standard 7750 (which has now been withdrawn with the ratification of ISO 14000), is similar to that which could be applied to the Eco-Management and Audit Scheme (EMAS) and to Canadian and Irish environmental management standards and guidelines. All these schemes follow the total quality management loop approach—that of plan, do, check and act. A feature of the ISO 14000 standards is the requirement to achieve continual improvement of the system and therefore in the environmental management overall.

Whereas quality control and assurance programs have focused mainly on the production of consistent goods and services, environmental management schemes have a broader focus—that of examination of the whole process of production of goods and services and the effect of that production on the environment. That is, not only will goods be produced according to the same set of standard procedures, but the effects of producing that product, be they pollution, use of resources, or transport of the completed object or delivery of the service, are also taken into account.

In agriculture, the growing of beef cattle is an example. Not only does (or should) the farmer want to be able to produce a consistently high quality...
product, but s/he should also consider the way in which the cattle are treated during the production period, the effect they have on the soil, water and air quality on and off the farm, ways in which the cattle are transported, the potential impact other farm activities might have on the cattle (use of pesticides, for example), packing of beef produced, and so on.

In their development, environmental management systems all follow much the same path. In the case of ISO 14000, there are five steps to developing and using an EMS:

- **Commitment and policy.** Here commitment is developed at all levels of the business or enterprise, from management down to the most junior levels. The policy is defined and developed.

- **Planning.** This is where the policy is translated into things to be done. A number of steps are usually involved, from a review of the environmental aspects and impacts of the business, the identification of legal requirements for compliance and the setting of objectives and targets through to establishing the environmental management program.

- **Implementation.** This is the ‘doing’ of the plan. This phase requires the provision of resources and support mechanisms to ensure that the environmental management plan is achieved and may include staff training programs to ensure that the objectives of the policy and plan can be met.

- **Measuring and evaluation.** This phase checks to see if the objectives and targets previously established are being met. Such methods as environmental performance evaluation, laboratory analyses of emissions, financial records examination and staff understanding of training programs may be used to assess whether the environmental plan is being met.

- **Review and improvement.** Here the data gathered in the previous phase are put to use. Were targets met? If not, why not? What can be improved? What worked well and why?

ISO 14000 specifies that continuous improvement of the management system—note: not the environmental performance—is required.

The various environmental management systems differ in how prescriptive they are with regard to the ways to achieve improved environmental management. ISO 14000 does not specify particular environmental targets; these are set by the person/company/business setting up the EMS. However, all schemes do require that the EMS developed must use as minimum standards legislated requirements and/or (if available) industry codes of practice or best management practice.

In the case of an organic farmer, the required specifications would be one of the AQIS-accredited organic certifying organisations’ standards, in addition to any current legislation (federal or state), as well as industry codes of practices to suit the particular enterprise.

**Use of EMSs and organic farming to achieve environmental health**

The use of EMSs is one tool in a range of methods designed to facilitate the management of agricultural land, using a system-based approach rather than focusing on crisis management. Organic farming is also a way of examining the whole system of farm operations, starting with soil health and its overall effects on farm components through to all facets of production.

The difference really is one of degree: use of an EMS is not prescriptive in terms of what can be used on the farm but does specify that all operations and processes used on the farm need to be considered in the light of their potential impact on the environment—the so-called cradle-to-grave approach.

Organic farming may look at
all those elements but, to gain organic certification, there are a number of products and farming practices that cannot be used. This does not mean that use of an EMS cannot be made effective on an organic farm, but it does mean that using ISO 14000 as a guide will not result in an organic approach, unless that is the stated intention of the system in the first place and actions are matched to the chosen organic standard.

Author’s note
A Rural Industries Research and Development Corporation report, Green Marketing and EMS (RIRDC publication number 04/175), states:

A key finding is that the meaning of the labels ‘sustainably produced’ and, to a lesser extent, ‘environmentally friendly’ are confused and, in contrast to ‘organic’, not widely agreed by the industry or consumers. This confusion, and the assessment that currently there is relatively insignificant demand for sustainably produced food, will result in considerable delay in the eco-labelling of food products …

The findings of this study concur with international experience that there is little clarity regarding what green, sustainable, or environmentally friendly production systems mean and what benefits these systems deliver to the consumer. This suggests a necessary, but not sufficient, condition for progress in green food marketing is that clear protocols, guidelines and accreditation processes must be established if generic labelling is to be adopted to communicate the benefits to consumers and facilitate the market development for sustainably produced food products. (Cary et al. 2004, p. vii).

It is clear from these comments that organically certified products are well accepted in the marketplace and that the market advantages of adopting an environmental management system are yet to be recognised.

6.3 Marketing
Organic producers use a variety of marketing techniques. The market destinations are domestic (local and interstate) and export sales. The following are among the domestic distribution channels for organic produce:

• direct farm sales
• local, regional and city farmers’ markets
• wholesale and retail
• processors
• home delivery
• internet sales
• mail order.

Some producers add value to their farm produce on the farm. Others tend to do little on-farm value-adding. Some farmers cooperatively sell their produce to processors, who then add value by processing (snap freezing, for example) and packaging the product.

Quality, continuity of supply, product range and service are central concerns for purchasers of organic products. Many consumers bemoan the fact that a regular, year-round supply of consistent-quality product is often unobtainable.

Gibson (1995) puts forward 50 farm marketing tips that should be compulsory reading for marketers. They can be found at the Australian New Crops website: <http://www.newcrops.uq.edu.au/newslett/necn1112.htm>.

6.3.1 Marketing alliances
Producers can benefit from developing marketing alliances. Such alliances allow producers to work together to research, locate and gain access to markets.

Production alliances give purchasers of organic products access to a range of products through one avenue and the potential for a year-round supply.

Two types of marketing alliances appear to dominate organic production:

• Diverse product alliances. This involves producers in forming regional alliances based on promoting the regionality of specialty products. These alliances are characterised by production of diverse commodities and may entail a high degree of value-adding. Such groups generally target local, gourmet and specialty markets.

• Parallel product alliances. This involves producers who produce like products (for example, potatoes and carrots) in marketing to a central distributor or processor. These alliances might involve minimal on-farm value-adding of a bulk commodity.

One example of a parallel product alliance is Heinz Wattie's Australasia, which pioneered large-scale commercial organic vegetable cropping in New Zealand and is acclaimed as an industry leader.

At present, the organisation processes organic peas, carrots, sweet corn, green beans, broad beans, potatoes, squash and onions. Its organic products are marketed in New Zealand, Australia, Japan, South Africa, Europe, Canada and the United States.
All suppliers and processing facilities are certified as meeting the production standards of BIO-GRO NZ, an independent certifying agency, and the organic products carry the BIO-GRO trademark. Heinz Wattie’s Australasia supplies technical advice and assistance. New growers are helped through the BIO-GRO certification process. Newsletters, field days and discussion groups keep growers up to date with the latest information.

Heinz Wattie’s Australasia started its organic program in 1990, with a 7-hectare crop of peas in Canterbury, New Zealand, and production has been growing steadily ever since. The company now has about 60 BIO-GRO-certified suppliers in New Zealand, most of whom have converted from conventional cropping practices.

Now over 2500 hectares are available for organic crops. The organisation expected to process about 6000 tonnes of various organic crops in the 2000–01 season.

The first step in successful marketing is for producers to define their production and supply pathways; then they must introduce effective supply chain management.

**6.3.2 Defining production and supply pathways**

Producers considering selling any product first need to define who the consumer is, what product is to be sold, where the consumers are, and how the product will be transported and processed.

What follows is from a presentation by Barry MacDonald, formerly Market Development Officer, NSW Department of Primary Industries, to the Organic Production Workshop (Rangeland Livestock), Hay, September 2002:

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**Focus on pathways**

Consumers are the focus of production pathways. Consumer protection is paramount. Pathways need to be defined. This includes on-farm practices. The direction of pathways needs to be determined, and guidelines and specifications need to be developed to meet these requirements.

**Communications**

Communications/documentation must be developed to facilitate the marketing process. The origin of the product needs to be verifiable, so a system of full traceability is essential. Organic producers need to be able to prove the organic history of the product in order for consumers to have confidence in the product. Accreditation and certification will achieve this. Marketing and promotion of the product should be undertaken by the producer or supplier. Use personalised logos on labelling; tell ‘your story’.

**Substitution**

Substitution is occurring in the marketplace—non-organic meat being sold as organic, mislabelling of cuts, and so on. Producers must have confidence they can prove their accreditation and the authenticity of their product. Truth in labelling and the correct naming of the product are essential.

**Processing specifications**

Processing specifications for a product involve establishing guidelines at key points in the production pathway. These include the farm, transport, slaughter, boning room, during any further processing, packaging, distribution, at the retailer or purchaser, and during the display of your product. Feedback sheets provide an opportunity to gauge consumers’ response to the product but can also be included at other key points in the pathway. Maintaining awareness of how the product is performing at all key points is essential.
**Further processing (value-adding)**

As a producer, you need to determine if you will produce traditional market cuts and/or value-add to product cuts. Value-added products include prepared meals, heat-and-serve cuts, pan-ready cuts, and oven-prepared and gourmet (for example, pate) products. If the product contains other ingredients, such as herbs, and is being marketed as organic, proof of the other ingredients’ organic certification is also required.

**The consumer**

Consumers must be willing to pay for the organic product. This will tend to limit markets to health-conscious, middle and upper class consumers. It is important to identify where the greatest demand is—for example, affluent city suburbs—and what type of product will be in demand. The product needs to have purchasing appeal (good presentation, and so on) and it is important to instil in purchasers confidence in the product. Information such as cooking methods can accompany the product. A consumer who is happy with your product will come back for more.

In summary, pathways between the producer and consumer need to be defined. Market specifications, codes of practice and quality assurance need to be implemented. Credibility in the marketplace must be gained. Marketing alliances allow for supplying year-round, but will only be successful if participants work together to develop the market pathway, become involved, and stay aware of the program. Communication is essential throughout all the supply chain.

**6.3.3 Supply chain management: the key to successful marketing**

The key to successful marketing, whether as an individual or as a group, is effective supply chain management. The individual or group must be active and maintain communications and interest in the entire marketing process. Successful producer alliances follow their product throughout the marketing pathway to track its performance—all the way to the consumer—and are prepared to diversify. Figure 6.2 illustrates a supply chain model for organic products.

Supply chain management can be defined as ‘a business strategy that sees the whole chain as the competitive unit, not the individual firms within that chain. This strategy depends on the firms within the chain learning to work together. Working together builds better relationships between firms and is a way of creating more value for others in the chain, especially consumers’ (AFFA 2003, p. 3).

The following are important considerations for organic producer alliances seeking to export:

- organic credibility
- year-round supply
- selection of a processor sympathetic to their aims
- selection of suitable trading partners.

**Organic credibility**

Producers must understand and implement an organic certification scheme that meets their requirements as well as those of their customers. Ideally, a single certifier should certify each property in the producer alliance. Not all importing countries or customers recognise the standards of each Australian certification organisation, so it is important to choose a certifier whose standards are recognised by the country where or the customer to whom the product will be sold.

Clear and precise documentation will assist with marketing the product, and the group will be able to demonstrate to potential customers full traceability of the organic product. Specific standards might need to be developed for transporting and handling, these then being endorsed by the organic certifier. It is advisable to conduct trial runs with the product in order to expose any potential problems that could call its organic status into question. Full documentation that clearly alerts produce handlers to the organic status of the product is also necessary.

**Year-round supply**

Consumers are unlikely to be interested in a product for which year-round supply cannot be guaranteed.

Cooperation between members in a producer alliance is the key to obtaining a year-round supply of quality product. Harvesting and marketing of crops needs to be scheduled within the capacity of each individual property: people will manage their operations to grow and finish within the capability of their resource base. This might, however, vary from season to season and locality to locality.

In order to have a year-round supply, year-round production data for each property should be thoroughly assessed and all options should be investigated.

**Choosing a processor**

The processor chosen must understand the requirements of the group and the product. They need to be innovative and accept that the producers want to be involved throughout the entire supply chain. They also need to agree to...
Specific organic production and individual property management plan

Organic producer

Organic producer

Certifier

Organic producer

Organic producer

Customer (for example, exporters, retailer)

Single processor with high technology, enabling full traceback to property

Extent of organic producer group alliance involvement

Source: Adapted from Pahl (2000).

Figure 6.2 The supply chain model concept for organic products

be certified to process the organic product and have the requisite export clearances for the markets the group is targeting.

If not already certified to process organic products, the processor should establish procedures and standards that ensure the segregation of the organic product throughout the processing plant, including packaging and storage for shipment. Full traceability to each farm, and even paddock, will need to be demonstrated.

6.4 Product promotion, packaging and presentation

[This section is reproduced from Marketing Organic and Biodynamic Products: conference proceedings (NSW Agriculture 1997). Catriona Macmillan, Heaven & Earth Systems P/L, contributed what follows.]

Key elements in selling organic products are promotion, packaging and presentation. Organic products generally command a premium in the marketplace. Consumers paying a premium price expect a quality product that looks well packaged and presented. Further, the consumer needs to be educated about why they are buying a premium product—promotion. Consider a number of promotional ideas:

- **The product being sold is organic, so put the word 'organic' on the label.** Research has shown that 12 per cent of Australian consumers are interested in organics. It is up to you to harness that interest into profitability. The competition is tough, a world of multinational companies who can and do spend millions trying to convince the consumer their product is what our product really is—environmentally responsible, natural, clean and green. Organic is unique product and needs to be promoted as such.

- **Participate in joint promotional opportunities.** Organic farmers have regularly participated in and promoted their produce at the Royal Easter Show in Sydney, which over 1.7 million people visit each
year. Your participation not only gives your products and produce exposure but educates the consumer.

- **Tell your story; this is what makes your product interesting.** Consumers love to hear your story. The consumer wants to be able to say, ‘I made this little dish out of organic rice. The rice farmer doesn’t burn the stubble, just allows it to build soil fertility’, and so on. Remember you are selling your product/produce to processors, exporters, wholesalers and the consumer, whether it is a brochure, a label or your letterhead, the consumer wants a story. Why do you grow? Why do you care? How do you grow? You don’t have to reveal all. A graphic and a few words can say a lot.

- **Promote your farm using farm tours, open days and school tours.** Excellent examples of farm tours are Montrose farms, Kiwi Down Under and Glenbye. Montrose farms offers ‘pick up your own berries in picking season’, ‘tour of the charming 1860s homestead’ and ‘bed and breakfast’; they also offer ‘afternoon teas, with hot country-style scones and homemade berry jam’ and you can hold your ‘wedding reception on the lawns’. Kiwi Down Under has won numerous tourist awards, and 12 000 people go through a year. It has a tea house, organic food market, informative farm tours, animal feeding and nature walks. Another highly innovative farm, Glenbye offers ‘Glenbye Getaway Tours’, a package including air fares for parties of ten. Riverina organic rice farms regularly host tours for Japanese farmers and overseas trade delegations.

- **Promote your farm and produce.** Send brochures or newsletters to your local library, schools and tourist office. Advertise with your state tourist board and holiday magazines. Develop a mailing list, including everyone who has visited your farm in the past, and post a newsletter … to inform people of new products or dates for the next ‘pick-your-own weekend’. You could include some other local events or sights in your area. Investigate any ecotourism projects in your area. Do you have any features that the Eco Tourism Association of Australia would endorse? Hold open days and field days: organise your own or look for opportunities, for example, in 2001 ABC open farm schemes held their annual farm open day with four Victorian organic farms. Let the local paper know of any special events, attach a brochure or newsletter to a very brief and simple press release. Start a school farming project to encourage visits.

- **Mail order delivery.** In the United States and the United Kingdom a great deal of trading in organics is done by mail order. Producers advertise in the major health and gourmet magazines. If you have a website, you could include your web address on your label. In Australia some trading and information sites are being developed.

**What product?**

Identify the trends, choose the market for your product, and package and present your product in a way that will sell it. In other words, are you planning the right product, and are you growing produce that will sell next season?

Note what organic products Australia is importing—for example, organic cornflakes from the United States and the United Kingdom. We also import tomato sauces salsas, olive oil and Californian dates, and we pay a premium for them. Note how these products are presented. Why will a consumer pay $6.50 for imported organic cornflakes? The packaging and quality account for a lot.

Remember, fads and fashions change. Investigate, look at conventional models: pasta sauces hardly existed on supermarket shelves in the early 1990s, but look in the supermarket now. Chilled, and particularly prepared, dishes are filling the shelves. Consumers even want to buy salad dressing ready to pour. As Reg Clairs, CEO of Woolworths, said, ‘Meal solutions will be the single most important revolution for supermarkets over the next five years’. People want dinner on the plate, not the ingredients in the shop. As organic producers, are you investigating organic meal solutions, frozen meals, frozen vegetables, salad mixes, dips, desserts, pasta meals, chilled vegeburers, as well as the more traditional deli ranges of chutneys, jams, sauces and pickles? What about frozen juices, fruit juices, muesli bars and cornflakes?
If you are investing in labour and machinery, invest in research and advice too. Include packaging and marketing in your costing.

Farmer and consumer need to get together: look for every opportunity to find out what the consumer buys. Ask your friends, everyone you meet; ask them why they buy. Visit the city.

**What supermarkets need**

Recently a spokesman for Coles Myer Ltd said they were now working closely with smaller food companies in a bid to offer a wider range of products, particularly at the gourmet fresh food end of the market. Unlike the big brand names, which offer special marketing deals to the supermarkets to claim the best shelf positions for their products, organic businesses have not spent millions on advertising and promotion. Some supermarkets will expect you to give in-store demonstrations and food tastings.

Supermarkets usually trial a line for a season to see if it sells; if not, it is out. They also have specific packaging needs—for example, barcodes and particular sizes and shapes for stacking.

**A reliable and regular supply**

In Britain the success of fresh organic fruit and vegetables in supermarket chains was the result of a wholesaler checking what the supermarkets needed. The wholesaler packaged the produce so that it could be easily identified as organic and stacked easily and also provided efficient and reliable delivery system. Sainsburys, a UK supermarket chain, has sponsored major organic industry events and has a program in operation to encourage conventional farmers to convert.

When Sainsburys advertises nationally it simply lets consumers know it sells organic as part of its range. It also sponsors the organic industry to promote and educate the public on the value of organics.

**What department stores need**

Packaging, shelf life and presentation are just as important to department stores. David Jones is very interested in a line of organic flour that comes in calico bags. It thought the ‘calico’ look outweighed the problem of stacking and shop soiling—that is, the bag looking grubby from dust—although the top-stitching has to be sewn straight and parallel to the edge.

The buyers for David Jones have said they would order more organic products if the labelling and packaging were improved.

Grace Bros’ preferred packaging for Glenbye’s organic wool quilts is a firm, transparent plastic case rather than a calico case. Why? Plastic will not become shop soiled, it can be dusted, it can stay neatly stacked, and it can be handled and still look bright and shiny over time. Using plastic rather than calico may seem an environmental contradiction, but shop soiled means selling at a discount.

**What small shops need**

Customers like variety. They come in to be entertained: a fruit and vegetable shop is like a theatre with live daily performances—the display. What is needed is a constant supply of quality staples plus something new and seasonal. Find ways to have your produce tasted.

**Brochures, newsletters and logos**

Prepare a simple but professional-looking brochure explaining what your farm sells, plus ‘your story’ and who you are certified by. Use it like a business card. Or send a leaflet providing recipes out with consignments.

Newsletters could be posted, perhaps quarterly. Tell readers about the harvest, any new products, what is in season,
field days, and so on. Select dates for farm tours, explain why you dug in your lettuces, as opposed to spraying after a bug invasion; and why there were no carrots last month. Do you do mail order? Include your latest product list with your newsletter. Macro Wholefoods is a large Sydney wholefood store; its newsletter acted as a brochure and contained a recipe, some Christmas shopping ideas, the business’s mission statement, and a map showing the business’s location. A newsletter can cost less than a glossy brochure, especially if printed in one colour, and can be more readable, with new ideas presented in each issue.

Logos can be a powerful tool for recognition. Note that, when selling to different cultures, a healthy green image or name could translate into an inauspicious image. It is also possible to label individual pieces of fruit, to distinguish them from conventional produce.

**The environmental predicament**

When it comes to packaging and presentation, there are conflicts between organic principals and retail demands.

- Consumers have high expectations and unrealistically want perfect-looking produce.
- Consumers assume that if it looks hygienic it must be healthy that sterility equates with goodness, and that soil on potatoes and lettuces means germs and work to clean. Fear of food contamination is also a great concern for retailers and consumers.
- Organic broccoli travels better in ice and polystyrene, but what does the polystyrene do for the environment? The consumer wants fresh-tasting and -looking broccoli.
- Some consumers want ‘environmentally friendly’ claims—such as ‘dolphin safe’, ‘chemical free’, ‘phosphate free’ and ‘recycled paper’—because these claims inundate retailers’ shelves already.

We need to find ways of responsibly managing these conflicts when labelling and packaging.

**Seasonality**

Some organic food is not available year round. In both Europe and the US ‘being in season’ has become a selling point. Extending supply could include processing the product or specialised storage.

The Earth Food store in Sydney sells an organic apple pie. As soon as the new apples are in season the regular customers start anticipating the arrival of these freshly baked pies. Consumers need to understand why product is not always available, so it is important to communicate with the retailer.

**Labelling**

Labelling is an important component of packaging. Labelling should be informative and legally correct. Following are a few pointers:

- Often the label is built into the packaging, as opposed to being stuck on.
- Always identify your certified ingredients as certified organic.
- Labels need to be attractive: bring in a designer.
- Sell the positives, not the negatives—for example, ‘we build soil fertility’.
- Every label tells a story: let your label tell your story.
- Include ‘free range’ when applicable. The customer often assumes that free range is as good as organic, so explain what your organic poultry and livestock are fed—for example, organic grain on an organic farm. Another misconception is that ‘tree ripened’ and ‘sun-dried’ mean organic-type harvesting and no chemical preservatives.
- Take pride in your product. Label and box your produce, and...
and each time your name and product are displayed check the standard.

- Try out a label and package and gauge the responses in the real market—in Bondi, not Bourke. Ask your friends in the city.
- Check packaging and labelling laws in your state. The New South Wales Department of Fair Trading can direct you to the relevant government departments and statutory bodies.

Legally you are required to provide certain details on the label. State or territory and federal laws, as well as the laws of importing countries if you intend to export your product, apply. In New South Wales, the New South Wales Food Authority can provide information on correct labelling (see Appendix A). The National Standard for Organic and Biodynamic Produce describes the requirements for labelling organic products destined for export and those for imported organic products.

The following is a basic checklist for labelling packaged food:

- name of the food
- the ingredients, in order of volume
- the name and address of the maker, packer, vendor or importer
- the country of origin
- the batch code
- the sell-by date or a date stamp
- sugar-free, low-fat, and so on, nutritional content—keep claims and information simple, realistic and relevant
- claims that can be verified
- a notice to refrigerate after opening where relevant

If you are exporting, some countries might require additional nutritional information, and the label might need to be in a language other than English.

**Promotion and the media**

If a story about your organic produce and how healthy it is is published nationally, suddenly consumers want organic. When promoting nationally, promote realistically.

Australia has a small population spread over a large land, so how can we promote a relatively small industry nationally when it is spread over such an expanse? Industry promotion such as an ‘organic harvest’ provides an opportunity to promote locally and nationally. Its main purpose is to educate consumers. The organic harvest is a national event where the focus is on promotional events at the local level. Activities are held over a month and can include everyone, no matter how small. Publicity for such events can be generated through networking, coordinated media releases, using celebrities and linking with other promotions.

**6.5 Export help**

[This section is reproduced from Marketing Organic and Biodynamic Products: conference proceedings, (NSW Agriculture 1997). Jim Murison, Previously Manager, Agsell¹, NSW Agriculture, contributed what follows.]

When thinking about export, the first step is to examine the reason for exporting. What are you going to achieve by exporting rather than selling in Australia? Do you have goals you wish to achieve, and within what timeframe do you plan to achieve them? Do you have the funds and time to devote to this project and, importantly, enough product to satisfy the market if you become successful? Can you obtain more product from others if you are not able to meet the requirements yourself? These questions must be part of your evaluation.

Having evaluated your position and decided to proceed, the next step is to select the markets you are interested in and find out if they are interested in you and your product. There may be no demand for what you produce if it is not part of that nation’s culture. You also need to determine if the importing country recognises your certifier’s logo or if it requires you to carry its logo, in which case there will need to be an agreed equivalence with your certification organisation.

Austrade can provide general information—for example, information on price, packaging, suitability and trends—on the market in locations throughout the world. The information is provided on a fee-for-service basis … If you have difficulty in meeting this initial cost, exporting is most likely out of your range of options.

Once the market needs are known it is time to inspect the chosen market personally. Taking samples of your product is suggested if it is possible. Business cards and a brochure in the local language are needed. Introductions to businesses that are interested in your product can be made by Austrade and, in some areas, by the Department of State and Regional Development, as well as Agsell.

Another way of meeting people who could be interested in buying your product is to exhibit at a trade fair. Many

¹Agsell is now known as Primex
are held throughout the world each year. There are often state-organised displays at these fairs, and this can offset the costs involved in mounting a display by yourself. Agsell has organised such displays at selected trade fairs in Japan and Korea, with success for the participants.

Once the contacts have been made the difficult part begins. It involves trial shipments, altering the packaging, changing the size and a number of ingredients, and many other incidentals. A freight forwarder conversant with the rules of your chosen market is essential for forwarding samples and product to your overseas representative. It will be invaluable in handling problems of customs, quarantine and officials involved in gaining entry to a market. The fee is well worth the service provided. Before agreeing on final orders, a number of trips by both parties to each other’s business is essential. Then the real price of each unit can be negotiated.

Often Australians give a price on a take-it, leave-it basis, while Asians will ask for alterations on the assumption that the price offered will cover the alterations. It is also important to keep your brand on a product for as long as possible, so there is no confusion about the product’s origins. Follow-up information is highly recommended to keep final sellers informed that it is your product they are selling.

Vital for any producer is a quality assurance scheme that will guarantee to the purchaser of your product that it is safe and of the best quality. It also assures the buyer that what they are buying is the same as the last purchase, since success is based on people returning to buy more.

New exporters often fear not being paid. Your bank can help in this regard by nominating a number of ways to ensure that you get your money. There is a charge involved, but it is one way to be confident about being paid when you first start exporting. Methods of guaranteeing payment range from letters of credit secured against your consignment to cash transfers, insurance coverage, and even banks paying you the agreed price and then recovering the money from the buyer. Being paid is not usually a problem in most Asian markets.

Agsell is the marketing arm of the NSW Department of Primary Industries. Agsell’s role in the export business is to assist exporters and buyers. It can introduce an Asian buyer to a producer of a product such as organic pasta and assist in overcoming problems with exporting that product. Many overseas groups like to deal with government agencies as a first step in contacting suppliers. Agsell is that first port of call for intending buyers of New South Wales produce.

The same conditions apply to organic products for export as for any other product for export. There must be a market for the product and the price must be high enough for the exporter to make a profit from the sale.

To avoid health problems with a range of foods, consumers in Europe and Japan are buying organic food in the belief that it will overcome food contamination. But organic production cannot guarantee that protection. A quality assurance scheme is required.

Display of organic products in an Asian supermarket
The Japanese market is going through an ‘organic’ phase. Japanese purchasers will want only certified organic products. Suppliers in Japan do not meet the high standards set in Australia. The price offered will often not reflect the fact that the product is certified organic by a recognised Australian organisation. Japan is the largest market for organic produce. There is a limited market in Singapore and Hong Kong, but the rest of Asia is still coming to terms with supermarkets and year-round fresh food.

European markets are large and, because of the wealth and number of consumers, there is demand for organic products during the northern winter. Competitors would be Mediterranean and African countries that are close to the cities of Germany, Holland and the United Kingdom. Many of these producing countries have preferred entry to the European Union, so competing on an equal basis might not be possible.

Agsell is often asked to seek a source of product that is not grown in New South Wales. There could be a need to import planting material and work closely with research staff to develop the product to meet the buyer’s requirement. The intending buyer might also contribute to the research work to help speed up the process of developing a crop.

Export is not for everyone, and a strong domestic base is almost essential before moving to export. Most exporters use the export market for their top-grade product, seeking a higher price than the domestic market. Export can also be used to reduce an oversupply on the home market and establish price stability in the home market. Sending product to export markets on an infrequent, or ‘spot’, basis rarely pays in the long term, and it does very little to develop a long-term profitable business domestically or overseas.

### 6.6 Processing requirements

The processing, packaging and labelling of organic product must conform to organic standards. Commonwealth and state or territory health and food safety laws must also be adhered to.

The national standard states that, in order to be sold as organic, products produced organically ‘… must be handled in a manner which would prevent contamination or substitution with substances or products not compatible with this Standard’. This means that processing facilities must be pre-cleaned of substances not compatible with the standard prior to processing of organic products and that storage areas for organic and non-organic products must be segregated.

Careful identification is also required to ensure that mixing of organic and non-organic products does not occur. To assist with this, the national standard states, ‘An operator should have in place a quality management system as an integral part of the organic production system … and … this should be compatible with Hazard Analysis Critical Control Point (HACCP) principles’.

The national standard requires that off-farm processing facilities be inspected and certified. Processors must apply for and undergo an inspection before processing an organic product. On-farm processors of organic products must be inspected and are required to provide a quality management manual for the operation.

Processing and food preservation techniques must comply with organic standards. The use of additives and processing aids is restricted to situations of demonstrated technological need, where food safety might be compromised or where the aids are essential in order to prepare, preserve, or minimise physical or mechanical effects to a product. Sometimes Commonwealth and state or territory law requires the use of such additives.
7. Regulatory considerations

7.1 Export requirements

[This section is reproduced from Marketing Organic and Biodynamic Products, Conference proceedings (NSW Agriculture 1997). It was contributed by Ruth Lovisolo, then Manager, Food Standards Policy, Australian Quarantine and Inspection Service.]

The potential for exports of organic produce has increased from a niche market in Europe to wide interest from consumers among a number of Australia’s trading partners. To ensure that the integrity of organic produce is not compromised and to meet the requirements of importing countries, the Australian Quarantine and Inspection Service requires that all organic certification organisations be accredited for the purpose. A national standard and legislation underpin the third-party accreditation program and provide the mechanism for approved certification organisations to issue certificates to accompany organic produce to importing countries.

The stimulus for introducing an export facilitation program in Australia was created by the increasing world demand for organic produce and the need to provide assurances about the integrity of the product. European Commission regulations for the import of organic produce into countries of the European Union require the competent authority in the exporting country to oversee the organic industry.

By 1990 Australia had gained a niche market in the European Union for organic produce. While this market has continued to grow, since then other markets have also opened up for organic produce. Among them are Switzerland, Japan, the United States, Singapore and Hong Kong. All countries are being encouraged to harmonise their respective import controls for organic produce through the work of the FAO–WHO Codex Alimentarius Commission.

Any producer intending to export food or fibre that claims to be organic or biodynamic needs to know the following.

The National Standard for Organic and Biodynamic Produce

The Federal Minister for Primary Industries introduced the National Standard for Organic and Biodynamic Produce on 10 February 1992. The 3rd edition of the standard is currently available in draft form.

The standard sets out the minimum requirements for production, processing and labelling of organic produce. It also establishes the minimum requirements for inspection of individuals producing organic products and the minimum requirements for certifying such operators. Any producer or processor who wants to export produce that is labelled organic or biodynamic must demonstrate compliance with at least the requirements of the standard. This is achieved by being certified by one of the AQIS-accredited organisations.

AQIS accreditation

The national standard sets out requirements for industry organisations seeking to become ‘approved certifying organisations’. This is achieved through a system of third-party accreditation. The basic approach to the audit program has been developed by AQIS in conjunction with the industry.]
Arrangements describe how certifying organisations apply to AQIS for accreditation.

Each certifying organisation is audited annually, as required by the European Union. The audit process involves a number of steps to ensure that the organisation and its members meet the requirements of the national standard. Individuals may be involved in one of these steps when AQIS verifies the inspection reports of an organisation on the farm or in the processing plant. By 2004 AQIS had accredited seven organisations to provide inspection and certification services for a range of organic or biodynamic commodities and production practices. Certifying organisations that are accredited by AQIS are listed in Appendix A.

Cost recovery
Government policy requires that AQIS fully recover its operational costs. These costs are met by the certifying organisations. AQIS recognises the impact of such charges on the industry and has undertaken to minimise such costs wherever possible.

More information
Further information about the export facilitation program for organic produce can be obtained from AQIS (phone 02 6271 6638).

7.2 Permitted inputs
Although organic production standards promote non-reliance on external inputs, they do acknowledge that some intervention might be required at certain times during production. This could particularly occur during the conversion phase.

The national standard provides lists of permissible substances for correcting soil fertility, for combating pests and diseases, for sanitation, storage and handling, and as processing aids.

Requirements for use of inputs are defined in the standard. Inputs are classified as permitted without restrictions on use or permitted providing specific conditions of use are met. Appendix B lists the permitted inputs.

Various commercial products containing the permitted substances have been developed, and certifying organisations have approved the use of some of these substances. All inputs must be recorded in the farm diary, and it is advisable to have any input approved in writing by the certifying organisation before using it.

7.3 Other regulatory considerations
As is to be expected, organic farmers are subject to the same legal requirements as other farmers.

State, territory and federal laws relating to things such as health and food safety, noxious weed control, fruit fly, feral animal control, exotic pest and disease outbreaks, and pesticide use must all be obeyed.

In some instances the use of chemical controls might be the only option for an organic producer.

If a non-permitted chemical must be applied, the certifier must be notified immediately and, although certification will be withdrawn, it might occur for a limited time only or apply only to a specific part of the farm.

In some instances the certifier might be able to negotiate with the statutory body responsible for administering the law to find a solution to the problem. Sometimes a non-chemical solution is possible. This needs to be clearly explained to the responsible statutory body, and a ‘win–win’ outcome will have to be demonstrated.

7.3.1 Chemical application permits
All chemicals used for pest and disease control must be assessed and registered by the Australian Pesticides and Veterinary Medicines Authority (formerly the National Registration Authority).

The authority evaluates all agricultural and veterinary chemical products and registers them for sale in Australia. Registered products can be used only in accordance with the instructions on the label.
All chemicals used for pest and disease control must be assessed and registered by the Australian Pesticides and Veterinary Medicines Authority.

Off-label and minor use permits

Many minor crops, although significant in total value, are too small for agrochemical companies to accept the high cost of registering crop protection products. At times it also becomes necessary to use agricultural chemicals for a use not specified on the label. To use registered or unregistered products in an off-label manner, an off-label permit must be obtained. The Australian Pesticides and Veterinary Medicines Authority recognises two categories of justification for off-label permits:

- **Minor use.** This refers to one or more of the following:
  - a specialty crop produced only on a small scale—that is, production of less than 500 hectares or $500 000 a year
  - a small percentage of a major crop—that is, less than 2 per cent of such a crop
  - a minor or infrequent pest or disease on either a minor or a major crop
  - when the method of application differs from what is described on the label because of unique local circumstances—that is, aerial application of a chemical registered only for ground application because local wet conditions do not allow ground application.
- **Emergency use.** This refers to a situation calling for a rapid response. The most common example is when it is necessary to control a new or exotic pest or disease for which there are no registered control products.

Applying for a permit

The Office of Minor Use, under a company called Crop Protection Approvals Ltd, has been set up to process and assemble off-label and emergency-use permit applications on behalf of AUSVEG-levied crops such as lettuce. CPA can be contacted by phone (03 8371 0001), fax (03 8375 7552) or email (Cpa@cpaltd.com.au).

Otherwise, applications for off-label permits can be made directly on the approved application form and submitted to the Australian Pesticides and Veterinary Medicines Authority. General information and application forms can be obtained from the APVMA website or by contacting the permit evaluator.

The majority of off-label permits take between three and 12 months to be assessed by the APVMA. Genuine emergency uses are usually assessed in five to 10 days. No fee is charged for any applications received from primary producers.

7.3.2 Phytosanitary requirements

Access to export markets depends on a product’s ability to meet the importing country’s often stringent phytosanitary (quarantine), sanitary (for example, microbial contamination) and non-quarantine (for example, quota and tariff) requirements. Phytosanitary barriers relate to the possible presence of insects that are absent or of restricted occurrence in the importing country (Holmes & Kriedl 2003). Among the specified control measures are monitoring to establish area freedom status, pesticide programs, pre-shipment treatment with chemical and non-chemical agents, in-transit cold treatment, inspection, and/or fumigation on arrival.

Chemical treatments are becoming less common, but they are still relied on in order to gain access to some markets for some products. Chemical disinfestation of an organic product destined for export nullifies the organic status of the product, and this has limited the ability to export many Australian organic products, particularly fruit and vegetables.

A report published by Victoria’s Department of Primary Industries collates the phytosanitary requirements for Japan, South Korea, Taiwan and the United States, identifies export market opportunities for organic fruit and vegetables, and recommends disinfestation methods and other phytosanitary controls that could satisfy export markets while maintaining the organic integrity of products (Holmes & Kriedl 2003).

The report recommends further investigation of a range of organic export market opportunities based on current market signals, market size and ease of access. These include navels oranges, apples, pears and table grapes to the European Union. Furthermore, the report encourages discussion between Australian and overseas authorities on the Queensland fruit fly host status of many products. Negotiation on these could realise opportunities in a number of areas.
• Japan—for lemons, limes, grapes, olives, cucumbers, marrow, pumpkin, squash, zucchini, beans and eggplant
• Taiwan—for lemons, limes, grapes, olives, cucumbers, rockmelons, honeydew melons, watermelons, pumpkin, squash, zucchini, beans and eggplant
• Korea—for lemons and limes
• the United States—for lemons, limes, grapes, cucumbers, pumpkin, squash, zucchini, eggplant and blueberries.

Approved organic disinfestation methods include heat and cold treatments and controlled atmosphere.

Market access for Australian horticultural produce is negotiated by the Horticultural Market Access Committee, made up of representatives of Horticulture Australia Limited (which manages the group), Biosecurity Australia, the Australian Quarantine and Inspection Service, the Department of Foreign Affairs and Trade, the Australian Horticultural Exporters Association, the Horticultural Export Consultative Committee, and the National Horticultural Research Network. The Horticultural Market Access Committee assesses identified horticultural products for their market access priority status into an identified market. Growers or other members of the supply chain can make applications for market access consideration. Applicants should complete a market access proposal form, available on the Horticulture Australia website <http://www.horticulture.com.au> or from the National Horticultural Market Access Coordinator.
Appendices

Appendix A Sources of information and other contacts

A.1 AQIS-approved certifying organisations

Australian Certified Organic
Post Office Box 530
L1 766 Gympie Rd
Chermside QLD 4032
Phone: 07 3350 5716
Fax: 07 3350 5996
Email: info@bfa.com.au

AUS-QUAL
Post Office Box 3175
9 Buchanan Street
South Brisbane QLD 4101
Phone: 07 3361 9200
Free Call: 1800 300 815
Fax: 07 3361 9222
Email: ausqual@ausqual.com.au
Web: http://www.ausqual.com.au

Bio-Dynamic Research Institute
Post Office
Powelltown VIC 3797
Phone: 03 5966 7333
Fax: 03 5966 7433

National Association for Sustainable Agriculture (Australia) Ltd
PO Box 768
Stirling SA 5152
Phone: 08 8370 8455
Fax: 08 8370 8381
Email: enquiries@nasaa.com.au
Web: http://www.nasaa.com.au

Organic Food Chain
PO Box 2390
Toowoomba QLD 4350
Phone: 07 4637 2600
Fax: 07 4696 7689
Email: organicfoodchain@hotmail.com
Web: http://www.organicfoodchain.com.au

Safe Food Production Queensland
Spring Hill QLD 4004
55 McLachlan St
Fortitude Valley QLD 4004
Contact: Phil Pond
Phone: 07 3253 9800
Free Call: 1800 300 815
Fax: 07 3253 9824
Email: info@safefood.qld.gov.au

A.2 Australian organic industry

Organic Federation of Australia
PO Box 369,
Bellingen NSW 2454
Andre Leu, Chair
Phone: 07 4098 7610
Mobile: 0400 075 869
Email: chair@ofa.org.au
Website: http://www.ofa.org.au/

A.3 Export requirements

Australian Quarantine and Inspection Service
Program Management and Operations
Phone: 02 6271 6638
Policy and Market Access
Phone: 02 6272 3509
Fax: 02 6272 3238
Email: organic@aqis.gov.au

A.4 NSW and ACT organic and bio-dynamic groups

Henry Doubleday Research Association of Australia
PO Box 442
Richmond NSW 2753
Phone: 02 4567 8424

Bio-Dynamic Agriculture Australia
PO Box 54
Bellingen NSW 2454
Phone: 02 6655 0566

Natural Produce Network
c/- Sam Statham
Rosny Organic Farms
Canowindra NSW 2804
Phone: 02 6344 3215

Tweed Richmond Organic Producers Organisation
PO Box 5076
East Lismore NSW 2480
Phone: 02 6663 5224

Northern Rivers Biodynamic Group
Ambrosia Farm
Lot 6 English’s Road
Upper Coopers Creek NSW 2480
Phone: 02 6698 2003

Sapphire Coast Producers Association
PO Box 1054
Bega NSW 2550
Phone: 02 6492 0161

Riverina Organic Farmers Organisation
c/- Judy Brennan
Clifton
Brocklesby NSW 2642
Phone: 02 6029 4237

Floodplains Organic Growers Group
c/- Frank Old
Balranald NSW 2715
Phone: 03 5020 1770

Hunter Organic Growers Group and the Hunter Biodynamic Group
39 A Dunks Creek Rd
Dunks Creek NSW 2320
Phone: 02 4938 5308
Canberra Organic Growers Society Inc.
Elizabeth Palmer
PO Box 347
Dickson ACT 2602
Phone: 02 6248 8004

Coffs Regional Organic Producers Organisation
PO Box 363
Coffs Harbour NSW 2450
(02) 6651 1770

Regional groups in other States and Territories are listed on the Web at:

A.5 Diagnostic and analytical services
NSW Department of Primary Industries diagnostic and analytical laboratories are located at Lismore, Wollongbar, Menangle, Orange and Wagga Wagga, supporting the department's research and extension programs. The laboratories also provide commercial services to industry and the public, including tests for agricultural water, animal disease, soil fertility, plant nutrition, chemical residues, and insect and plant pathogen identification. For further details, see <http://www.agric.nsw.gov.au/reader/das-laboratory>.

For soil biological assessment, the following organisation also provides services:
Soil Foodweb Institute Pty Ltd
1 Crawford Rd
East Lismore NSW 2480
Phone: 02 6622 5150
Fax: 02 6622 5170
Email: info@soilfoodweb.com
Web: http://www.soilfoodweb.com

A.6 Consultants
Tim Marshall
PO Box 207
Stirling SA 5152
Phone/fax: 08 83391250
Mobile: 0412473230
Email: timmar@box.net.au

John Melville
Bioterm
Mobile: 0417 662 709
Email: johnwm@bigpond.net.au

Adam Willson
Soil Systems
267 Oxley Road
Graceville Qld 4075
Phone: 07 3716 0688
Fax: 07 3716 0677

Janie McClure
Organics for Rural Australia
Phone: 03 9819 2224
Website: http://www.ruralorg.com.au

NASAA consultants
Steven David
Organic Farming Systems
PO Box 419
Cottesloe WA 6911
Phone: 08 9384 3789
Fax: 08 9384 3379
Email: admin@organicfarming.com.au
Web: http://www.organicfarming.com.au

Kenneth Scott
Piber Pastoral Company
Piber
Roma Qld 4455
Phone/Fax: 07 4623 0213
Email: piber@ripmet.com.au
Web: http://www.maranoa.org.au/kenscott

A.7 Institutional support
Universities, colleges and TAFE offering courses relevant to organic agriculture
Charles Sturt University
Leeds Parade
PO Box 883
Orange NSW 2800
Phone: 1800 334 733
Email: inquiry@csu.edu.au
Website: www.csu.edu.au/campus/orange

Relevant courses offered:
• Master of Sustainable Agriculture
• Graduate Diploma in Sustainable Agriculture
• Graduate Certificate in Sustainable Agriculture
• Bachelor of Land Management (Ecological Agriculture)
• Advanced Diploma of Land Management (Ecological Agriculture)

Murrumbidgee Rural Studies Centre
Yanco Agricultural Institute
Yanco NSW 2703
Phone: 02 6951 2696

and

CB Alexander Agricultural College
Tocal
Paterson NSW 2421
Phone: 02 4939 8888

Relevant courses offered:
• organic and biodynamic courses in conjunction with local groups

TAFE NSW
Web: http://www.tafensw.edu.au

Relevant courses offered:
• Organic Farming nos. 652 and 653

Government
• NSW Department of Primary Industries:
  Robyn Neeson, Yanco Agricultural Institute
  Phone: 02 6951 2611

Karen O'Malley, Bathurst Agricultural Research Station
Phone: 02 6330 1200

Scott Seaman, Bathurst Agricultural Research Station
Phone: 02 6330 1209
Primex

Primex is the international export marketing arm of NSW Department of Primary Industries, providing international access to the highest quality commodities of New South Wales. Primex works closely with local producers and international buyers to encourage partnerships in a broad range of commodities.

Primex, NSW Department of Primary Industries
PO Box K220
Haymarket NSW 1240
Phone: 02 8289 3999
Email: agsell@agric.nsw.gov.au

Federal government assistance

The New Industries Development Program and Agribiz

The New Industries Development Program helps people in the agricultural, processed food, fisheries and forestry industries turn innovative business ideas into competitive, profitable and sustainable commercial ventures. Agribiz encourages and supports Australian agribusinesses as they commercialise new products, services and technologies. For more information check the website <http://www.daff.gov.au/agriculture-food/nidp-agribiz>.

Austrade and TradeStart

Austrade and TradeStart offer a package of free services designed to help small and medium-sized Australian companies develop their business overseas and make their first export sale. The TradeStart program gives Australian businesses the best possible start to exporting, providing a wide range of free services to new exporters, including advice and information about getting into exporting, export coaching, and assistance on the ground in foreign markets.

To find out more about TradeStart and what the export advisors and Austrade's international network offer, go to <http://www.austrade.gov.au/Home3618/default.aspx>.

Farmer information group

Kondinin Group
8 Fitzhardinge St
Wagga Wagga NSW 2650
Phone: 02 6921 4047
Web: http://www.kondinin.com.au

A.8 Journals and newsletters


Acres USA®. Subscribe by email <info@acresusa.com>. Web: <http://www.acresusa.com/magazines/magazine.htm>


Canberra Organic. Quarterly publication of the Canberra Organic Growers Society. Phone: 02 6258 2811


Australian Organic Journal. Produced by Biological Farmers of Australia. Contact BFA—07 3350 5716.

The Producer. Official journal of the Sapphire Coast Producers Association (bi-monthly)—02 6492 0161.
A.9 Useful websites
http://www.attra.org
http://www.goodbugs.org.au
http://www.anbp.org
http://ipmwww.ncsu.edu/biocontrol/biocontrol.html
http://www.biocontrol.ucr.edu/
http://www.nysaes.cornell.edu/ent/biocontrol/
http://www.nysaes.cornell.edu/recommends/
http://www.bioresources.com.au
http://www.bugsforbugs.com.au
http://www.ipm.iastate.edu/
http://www.IPM.ucdavis.edu
http://ipmworld.umn.edu
http://www.nysipm.cornell.edu
http://vegedge.umn.edu/

Australian government websites
Agriculture Western Australia—http://www.agric.wa.gov.au/
Northern Territory Department of Primary Industries and Fisheries—http://www.nt.gov.au/dpifm/Primary_Industry/
South Australian Department of Primary Industries and Resources—http://www.pir.sa.gov.au/agwine


Other websites
Agriculture Network Information Centre (US site)—http://www.agnic.org/
Avcare, National Association for Crop Protection & Animal Health—http://www.avcare.org.au
Horticulture Australia—http://www.horticulture.com.au
Vegetable Research and Information, University of California—http://www.vric.ucdavis.edu/
http://www.fao.org/organicag/
http://www.organic-research.com/
http://www.ofa.org.au
http://www.bfa.com.au
http://www.nasaa.com.au
http://www.soilfoodweb.com/
http://www.ofrf.org/
http://www.farmerfred.com/plants_that_attract_benefi.html
http://www.organic-europe.net/
http://www.ams.usda.gov/nop/indexIE.htm
http://www.organicherbs.org/Main.html
http://www.mda.state.mn.us/esap/organic/default.htm
http://www.organicstandard.com/
http://www.co.sas.oh.us/
http://www.nal.usda.gov/afsic/AFSIC_pubs/findinfo.htm

A.10 Other contacts
Integrated pest management
Australian Entomological Supplies
Supplier of hand lenses, sticky traps, and other equipment
Phone: 02 6684 7650
Web: http://www.entosupplies.com.au

Commercial insectaries
Australasian Biological Control (Association of Commercial Insectaries)
http://www.goodbugs.org.au

Beneficial Bug Co.
PO Box 436
Richmond NSW 2753
Phone: 02 4570 1331
Fax: 02 4578 3979
Email: Info@beneficialbugs.com.au
Web: http://www.beneficialbugs.com.au

(preatory mites, Phytoseiulus persimilis)

Bugs for Bugs
Bowen St
Mundubbera Qld 4626
Phone: 07 4165 4663
Fax: 07 4165 4626
Email: info@bugsforbugs.com.au
Web: http://www.bugsforbugs.com.au

(Aphidius spp., Chilioerus beetles,
Cryptolemus beetles, green lacewings, trichogramma wasps)

Bio-Protection
PO Box 384
Kilmore Vic 3764
Phone: 03 5781 0033  
Fax: 03 5781 0044  
Email: royc@hyperlink.com.au  
(predatory mites—Phytoseiulus persimillis)

BioResources  
PO Box 578  
Samford Qld 4520  
Phone: 07 3289 4919  
Fax: 07 3289 4918  
Email: richard@bioresources.com.au  
Web: http://www.bioresources.com.au  
(Orgilus lepidus and trichogramma)

Biological Services  
PO Box 501  
Loxton SA 5333  
Phone: 08 8584 6977  
Fax: 08 8584 5057  
Email: fruitdrs@sa.ozland.net.au  
(Aphytis spp., Encarsia formosa, Hypoaspis miles, Typhlodromus occidentalis)

BioWorks Pty Ltd  
PO Box 203  
Nambucca Heads NSW 2448  
Phone: (02) 6568 3555  
E-mail: bioworks@optusnet.com.au  
(Phytoseiulus persimiliis)

Ecogrow Australia Pty Ltd  
P.O. Box 7657  
Bondi Beach NSW 2026  
Phone: 0417 242 222  
Fax: 02 9327 4610  
Email: info@ecogrow.com.au  
Web: http://www.ecogrow.com.au  
(entomopathogenic nematodes)

Horticultural Crop Monitoring  
P.O. Box 3725  
Caloundra Qld 4662.  
Phone: (07) 5439 6077  
Fax: (07) 5439 6088  
Email: pjones@hotkey.net.au  
Web: http://www.biomites.com.au  
(predatory mites—Phytoseiulus persimillii)

IPM Technologies  
PO Box 560  
Hurstbridge Vic. 3099  
Phone: 03 9710 1554  
Fax: 03 9710 1354  
Email: ipmtechnologies@bigpond.com  
Web: http://www.ipmtechnologies.com.au  
(Orgilus lepidus)

Manchil IPM Services  
1/17 Batavia Place Kallaroo  
Western Australia 6025  
Mobile: 0403 727 252  
email: lachlanchilman@hotmail.com  
web: http://www.manchilipmservices.com.au  
(Phytoseiulus persimillis)

BioForce Ltd  
PO Box 81  
Pukekohe, NZ  
Phone: 64 9 294 8973  
Fax: 64 9 294 8978  
Email: john.thompson@xtra.co.nz  
(Phytoseiulus persimillis)

Pheromones  
Dunluce International  
Michael MacQuillan  
PO Box 922  
St Ives NSW 2075  
Phone/Fax: 02 9983 1776  
(Helicoverpa armigera and H. punctigera lures and Agrisense® funnel traps)

Pesticide registration information  
Australian Pesticides and Veterinary Medicines Authority—http://www.APVMA.gov.au

INFO Pest CD  
Animal and Plant Health Service  
Department of Primary Industries and Fisheries  
GPO Box 46  
Brisbane Qld 4001  
Phone: 07 3239 3967  
Fax: 07 3211 3293  
Email: infopest@dpi.qld.gov.au  

PestChem manuals  
Centre for Pesticide and Application Safety  
University of Queensland  
Gatton College  
Gatton Qld 4343  
Phone: 07 5460 1293

Crop Protection Approvals Ltd  
Suite 5, Moonee Ponds Business Centre  
5 Everage Street  
Moonee Ponds Vic 3039  
Phone: 03 8371 0001  
Fax: 03 8375 7552  
Email: Cpa@cpaltd.com.au

Input and equipment suppliers  
Organically certified pest and disease control products  
Organic Crop Protectants  
42 Halloran St  
Lillyfield NSW 2040  
Contact: Gary Leeson  
Free Call: 1800 634 204  
Web: http://www.ocp.com.au

Composted cow manure  
Rivcow Environmental Pty Ltd  
PO Box 135  
Yanco NSW 2703  
Phone: 02 6953 5985  
Mobile: 0419 748 269  
Fax: 02 6953 5986  
Email: sales@rivcow.com.au  

Small farm band tools and electric net (livestock and poultry) fencing  
Gundaroo Tiller  
Joyce Wilkie and Michael Plane  
Allsun Farm  
Gundaroo NSW 2620  
Phone: 02 6236 8173  
Fax: 02 9383 8894  
Email: GT@allsun.com.au  
Weed cultivation and soil management equipment

WeedFix® cultivator
Fix Engineering
Whees Hill Rd
RMB 4801
Daylesford Vic 3460
Phone: 03 5348 2669
Mobile: 0418 508 573

Sustainable Agricultural Machinery Developments Pty. Ltd
3 Bradford Street, Wodonga,
Victoria 3690. Australia.
Phone: (02) 6056 2844
Fax: (02) 6056 2994
Email: samsales@samd.com.au
Postal: PO. BOX 1321 Wodonga,
Victoria 3689.

A.11 Other contacts, by chapter

Chapter 6
Murrumbidgee Rural Studies Centre
Yanco NSW 2703
Phone: 02 6951 2611

National Organic Auditor training workshops
Biological Farmers of Australia
Phone: 07 3350 5716
Fax: 07 3350 5996
Email: info@bfa.com.au

Independent Organic Inspector Association Organic Training workshops
Contact NASAA office
Phone: 08 8370 8455

Genevieve Carruthers
Environmental Management Systems Specialist
NSW Department of Primary Industries
Wollongbar Agricultural Institute
Wollongbar NSW 2477
Phone: 02 6626 1237

Joseph Ekman
Extension Horticulturist, Quality Assurance
NSW Department of Primary Industries

Marketing advice and promotions

Primex
Level 6, 201 Elizabeth Street
Sydney NSW 2000
Phone: 02 8289 3999

Catriona Macmillan
Heaven & Earth Systems Pty Ltd
PO Box 3335
Tamarama NSW 2026
Phone: 02 9365 7668
Fax: 02 9365 7828

Packaging and labelling laws

NSW Office of Fair Trading
PO Box 972
Parramatta 2124
Local Call: 13 32 20
Fax: 02 9758 2691

NSW Food Authority
PO Box 6682
Silverwater NSW 1811
Local Call: 1300 552 406
Fax: 02 9647 0026
Email: contact@foodauthority.nsw.gov.au
Web: http://www.foodauthority.nsw.gov.au

Trade Marks Office
PO Box 200
Woden ACT 2606
Phone: 1300 651 010
Appendix B Farming inputs

The following information comes from the National Standard for Organic and Biodynamic Produce (Edition 3.3, 1 July 2007. AQIS, Canberra.)

Requirements for use

General principles

i. Where inputs are required they should be used with care and with the knowledge that even permitted inputs can be subject to misuse and may alter the soil and/or water ecosystems or the farming environment.

ii. Use of any product has the potential to introduce unwanted residues and contaminants.

Standards

1. A developed organic or biodynamic farm must operate within a closed input system to the maximum extent possible.

2. External farming inputs must be kept to a minimum and applied only on an ‘as needs’ basis.

3. Inputs must not be used as a permanent measure to support a poorly designed or badly managed system. Non-essential use of inputs is counter to organic and biodynamic farming principles. The approved certifying organisation must give approval for their ongoing use.

4. The following lists are subject to review, and inclusion of a material does not imply that it is safe in all circumstances. Any additions or changes to the lists will be made where it can be demonstrated that they satisfy the requirements of this Standard.

5. Liquid preparations, including products of the sea must be used with care as some preparations can be easily applied in concentrated forms and in high quantities.

6. The use of trace elements must be on the basis of a demonstrated deficiency.

7. Use of any input must be based on an assessment of need and with knowledge of the origin and/or analyses of the material for contaminants.

8. The use of any materials/inputs will be recorded in the farm diary or logbook and repeated use must be justifiable.

9. Federal, state/territory and local laws must be adhered to at all times …
## Permitted materials for soil fertilising and conditioning

<table>
<thead>
<tr>
<th>Substances</th>
<th>Specific conditions/ restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal manures</td>
<td>Application must be composted or followed by at least two green manure crops in cropping system.</td>
</tr>
<tr>
<td>Blood and bone, fish meal, hoof and horn meal, or other waste products from livestock processing</td>
<td>Following application, uptake of such products by livestock does not form part of the animal’s diet.</td>
</tr>
<tr>
<td>Compost</td>
<td>Should be produced in accordance with Australian Standard 4454-1999 or recognised equivalent system.</td>
</tr>
<tr>
<td>Minerals and trace elements from natural sources, including:</td>
<td>Must not be chemically treated to promote water solubility</td>
</tr>
<tr>
<td>- calcium (dolomite, gypsum, lime)</td>
<td></td>
</tr>
<tr>
<td>- clay (bentonite, kaolin, attapulgite)</td>
<td></td>
</tr>
<tr>
<td>- magnesium</td>
<td></td>
</tr>
<tr>
<td>- phosphate (rock phosphate, phosphatic guaro)</td>
<td></td>
</tr>
<tr>
<td>- potash (rock and sulphate potash)</td>
<td></td>
</tr>
<tr>
<td>- elemental sulphur</td>
<td></td>
</tr>
<tr>
<td>Epson salt—magnesium sulphate</td>
<td>None</td>
</tr>
<tr>
<td>Microbiological, biological and botanical preparations</td>
<td>Products derived from genetic modification technology are prohibited</td>
</tr>
<tr>
<td>Mined carbon-based products</td>
<td>Must to be used for plant propagation only</td>
</tr>
<tr>
<td>Naturally occurring biological organisms (e.g., worms) and their by-products</td>
<td>None</td>
</tr>
<tr>
<td>Plant by-products</td>
<td>From chemically untreated sources only</td>
</tr>
<tr>
<td>Perlite</td>
<td>For potting/seedling mixes only</td>
</tr>
<tr>
<td>Sawdust, bark and wood waste</td>
<td>From chemically untreated sources only</td>
</tr>
<tr>
<td>Seaweed or algae preparations</td>
<td>None</td>
</tr>
<tr>
<td>Straw</td>
<td>From chemically untreated sources only</td>
</tr>
<tr>
<td>Trace elements and natural chelates, (e.g., ligno) sulphonates and those using the natural chelating agents (e.g., citric, maleic and other di-/tri-acids)</td>
<td>Not synthetically chelated elements</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>For use in potting/seedling mixes only</td>
</tr>
<tr>
<td>Wood ash</td>
<td>From chemically untreated sources only</td>
</tr>
<tr>
<td>Zeolites</td>
<td>None</td>
</tr>
</tbody>
</table>

## Permitted materials for plant pest and disease control

Where wetting agents are required, caution needs to be exercised with commercial formulations as these may contain substances prohibited under this Standard. Acceptable wetting agents include some seaweed products, plant products (including oils) and natural soaps.

### Plant pest control

<table>
<thead>
<tr>
<th>Substances</th>
<th>Specific conditions/ restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayurvedic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Baits for fruit fly</td>
<td>Substances as required by regulation. Baits must be fully enclosed within traps.</td>
</tr>
<tr>
<td>Boric acid</td>
<td>None</td>
</tr>
<tr>
<td>Biological controls</td>
<td>Naturally occurring cultured organisms (e.g., Bacillus thuringiensis)</td>
</tr>
<tr>
<td>Diatomaceous earth and naturally occurring chitin products</td>
<td>None</td>
</tr>
<tr>
<td>Essential oils, plant oils and extracts</td>
<td>None</td>
</tr>
<tr>
<td>Homeopathic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>None</td>
</tr>
<tr>
<td>Iron (II) phosphate</td>
<td>None</td>
</tr>
<tr>
<td>Light mineral oils, such as paraffin</td>
<td>None</td>
</tr>
<tr>
<td>Lime</td>
<td>None</td>
</tr>
<tr>
<td>Natural acids (e.g., vinegar)</td>
<td>None</td>
</tr>
<tr>
<td>Natural plant extracts excluding tobacco</td>
<td>Obtained by infusion and made by the farmer without additional concentration</td>
</tr>
<tr>
<td>Pheromones</td>
<td>None</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>None</td>
</tr>
<tr>
<td>Pyrethrum</td>
<td>Extracted from Chrysanthemum cinerariaefolium</td>
</tr>
<tr>
<td>Quassia</td>
<td>Extracted from Quassia amara</td>
</tr>
<tr>
<td>Rotenone</td>
<td>Extracted from Derris elliptica</td>
</tr>
<tr>
<td>Ryana</td>
<td>Extracted from Ryana speciosa</td>
</tr>
<tr>
<td>Seaweed, seaweed meal, seaweed extracts</td>
<td>None</td>
</tr>
<tr>
<td>Sea salts and salty water</td>
<td>None</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>None</td>
</tr>
<tr>
<td>Sterilised insect males</td>
<td>Need recognised by certification organisation where other controls are not available</td>
</tr>
<tr>
<td>Stone meal</td>
<td>None</td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>None</td>
</tr>
</tbody>
</table>
### Plant disease control

<table>
<thead>
<tr>
<th>Substances</th>
<th>Specific conditions/restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayurvedic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Biological controls</td>
<td>Naturally occurring cultured organisms only</td>
</tr>
<tr>
<td>Copper (e.g. Bordeaux and Burgundy mixture)</td>
<td>Hydrate is the preferred form, Bordeaux only on dormant tissue. Annual copper application must be less than 8kg/ha.</td>
</tr>
<tr>
<td>Essential oils, plant oils and extracts</td>
<td>None</td>
</tr>
<tr>
<td>Granulose virus preparations</td>
<td>Need recognised by certification organisation.</td>
</tr>
<tr>
<td>Homeopathic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Lime</td>
<td>None</td>
</tr>
<tr>
<td>Lime-sulphur</td>
<td>None</td>
</tr>
<tr>
<td>Natural plant extracts excluding tobacco</td>
<td>Obtained by infusion and/or made by the farmer without additional concentration</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>None</td>
</tr>
<tr>
<td>Potassium soap (soft soap)</td>
<td>None</td>
</tr>
<tr>
<td>Propolis</td>
<td>None</td>
</tr>
<tr>
<td>Seaweed, seaweed meal, seaweed extracts</td>
<td>None</td>
</tr>
<tr>
<td>Sea salts and salty water</td>
<td>None</td>
</tr>
<tr>
<td>Skim milk or skim milk powder</td>
<td>None</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>None</td>
</tr>
<tr>
<td>Sodium silicate (water-glass)</td>
<td>None</td>
</tr>
<tr>
<td>Sulphur</td>
<td>In wettable or dry form only</td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>None</td>
</tr>
<tr>
<td>Vinegar</td>
<td>None</td>
</tr>
</tbody>
</table>

### Permitted materials for livestock pest and disease control

Where wetting agents are required, caution needs to be exercised with commercial formulations as these may contain substances prohibited under this Standard. Acceptable wetting agents include some seaweed products, plant products (including oils) and natural soaps.

### Livestock pest control

<table>
<thead>
<tr>
<th>Substances</th>
<th>Specific conditions/restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayurvedic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Biological controls</td>
<td>Naturally occurring organisms and cultured organisms</td>
</tr>
<tr>
<td>Boric acid</td>
<td>None</td>
</tr>
<tr>
<td>Clay</td>
<td>None</td>
</tr>
<tr>
<td>Diatomaceous earth</td>
<td>None</td>
</tr>
<tr>
<td>Essential oils, plant oils and extracts</td>
<td>None</td>
</tr>
<tr>
<td>Garlic oil, garlic extract or crushed garlic</td>
<td>None</td>
</tr>
<tr>
<td>Homeopathic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>None</td>
</tr>
<tr>
<td>Natural plant extracts obtained by infusion excluding tobacco</td>
<td>None</td>
</tr>
<tr>
<td>Magnesium sulphate (Epsom salts)</td>
<td>None</td>
</tr>
<tr>
<td>Methylated spirits</td>
<td>None</td>
</tr>
<tr>
<td>Mentho-menthol compound</td>
<td>None</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>None</td>
</tr>
<tr>
<td>Peppermint from Chrysanthemum cinerariaefolium</td>
<td>None</td>
</tr>
<tr>
<td>Quassia being from Quassia armara</td>
<td>None</td>
</tr>
<tr>
<td>Retene being from Derris elliptica</td>
<td>None</td>
</tr>
<tr>
<td>Sea salts and salty water</td>
<td>None</td>
</tr>
<tr>
<td>Seaweed, seaweed meal, seaweed extracts</td>
<td>None</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>None</td>
</tr>
<tr>
<td>Sulphur</td>
<td>None</td>
</tr>
<tr>
<td>Vinegar (e.g. cider)</td>
<td>None</td>
</tr>
</tbody>
</table>
Livestock disease control

<table>
<thead>
<tr>
<th>Substances</th>
<th>Specific conditions/ restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayurvedic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Calcium salts</td>
<td>None</td>
</tr>
<tr>
<td>Charcoal</td>
<td>None</td>
</tr>
<tr>
<td>Clay</td>
<td>None</td>
</tr>
<tr>
<td>Copper sulphate</td>
<td>None</td>
</tr>
<tr>
<td>Diatomaceous earth and naturally occurring chitin products</td>
<td>None</td>
</tr>
<tr>
<td>Essential oils, plant oils and extracts</td>
<td>None</td>
</tr>
<tr>
<td>Homoeopathic preparations</td>
<td>None</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>None</td>
</tr>
<tr>
<td>Natural plant extracts obtained by infusion</td>
<td>None</td>
</tr>
<tr>
<td>Magnesium sulphate (Epsom salts)</td>
<td>None</td>
</tr>
<tr>
<td>Methylated spirits</td>
<td>None</td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>None</td>
</tr>
<tr>
<td>Sea salts and salty water</td>
<td>None</td>
</tr>
<tr>
<td>Seaweed, seaweed meal, seaweed extracts</td>
<td>None</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>None</td>
</tr>
<tr>
<td>Trace elements</td>
<td>To correct identified deficiencies only</td>
</tr>
</tbody>
</table>

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. Vaccines must not contain genetically modified ingredients or by-products.

Trace elements
- To correct identified deficiencies only

Vitamins
- Natural sources only

Vinegar (e.g. cider)
- None

Zinc sulphate
- None

Substances permitted for sanitation, storage and handling

1. Operators will select cleaners, sanitisers, and disinfectants based on avoidance of residual contamination, rapid biodegradability, low toxicity, worker safety, and a life-cycle impact of their manufacture, use, and disposal.

2. Endocrine disrupting, ozone depleting, and trihalomethane-forming compounds used in sanitation chemicals are prohibited.

3. Substances Permitted as Sanitation treatments include:
   - Alkali carbonates
   - Bleach (not to exceed 10% solution)
   - Biodegradable detergents (e.g., low in phosphate and rapidly degradable)
   - Caustic potash and caustic soda
   - Ethyl alcohol
   - Hydrogen peroxide
   - Iodine (non-elemental, not to exceed 5% solution e.g., iodophors)
   - Lime
   - Lye
   - Natural acids (e.g., vinegar, lactic, phosphoric)
   - Potassium permanganate (not to exceed 1% solution)
   - Soaps
   - Sodium bicarbonate
   - Sodium borate
   - Isopropyl alcohol

4. The use of any of the above substances will be followed by a thorough rinse of the area/equipment using potable water.

5. Cleaning and sanitising chemicals will be used and stored in such a manner so as to avoid cross-contamination to organic and bio-dynamic produce.

Substances permitted as post-harvest/storage treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Substances/conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled atmosphere</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
</tr>
<tr>
<td></td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Peroxide acid</td>
<td>Approval for use required</td>
</tr>
<tr>
<td>Ethylene gas</td>
<td>Ripening of bananas only</td>
</tr>
<tr>
<td>Pest control</td>
<td>Physical barriers</td>
</tr>
<tr>
<td></td>
<td>Temperature control</td>
</tr>
<tr>
<td></td>
<td>Diatomaceous earth</td>
</tr>
<tr>
<td></td>
<td>Rodenticides*</td>
</tr>
<tr>
<td></td>
<td>Sticky boards</td>
</tr>
<tr>
<td></td>
<td>Biological controls</td>
</tr>
<tr>
<td></td>
<td>Electric barriers or grids</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
</tr>
<tr>
<td></td>
<td>Light</td>
</tr>
</tbody>
</table>

Waxing of citrus fruit: Export only—using natural wax

* Must be enclosed outside processing area and used only where other methods have proved ineffective. Containers must be positioned so that there is no potential for contamination with products complying with this standard. Containers must be inspected regularly and dead rodents removed. The operator must maintain records on volume and use of rodenticides.
Bibliography


Andersen, A 1992, *Science in Agriculture*, Acres USA, Raytown, MO.


Beecher, HG, Thompson, JA, McCaffery, DW & Muir, JS 1997, ‘Cropping on raised beds in southern NSW’, Agfact P1.2.1, NSW Agriculture, Paterson, NSW.


Broadley, R & Thomas, M (eds) 1995, *The Good Bug Book: beneficial insects and mites commercially available in Australia for biological pest control*, Australasian Biological Control, Richmond, NSW.

Brough, E, Elder, R & Beavis, C 1994, *Managing Insects and Mites in Horticultural Crops*, Department of Primary Industries and Fisheries, Brisbane.


Darwin, C 1881 (repr. 1945), *The Formation of Vegetable Mould through the Action of Worms, with Observations on Their Habits*, Faber and Faber, London.


Department of Primary Industries and Energy 1998, *Chains of Success: case studies on international and Australian food businesses, co-operating to compete in the global market*, DPIE, Canberra.


Ekman, J 1997, in *Marketing Organic and Biodynamic Products: conference proceedings*, NSW Agriculture, Orange, NSW.


Goodwin, S 2001, *Pests, Diseases, Disorders and Beneficials in Ornamentals: field identification guide*, NSW Agriculture, Orange, NSW.


Hely, PC, Pasfield, G & Gellatley, JG 1982, Insect Pests of Fruit and Vegetables in NSW, NSW Agriculture, Orange, NSW.


Hilgard, EW 1906, Soils: their formation, properties, composition, and relations to climate and plant growth in the humid and arid regions, Macmillan, New York.


Hopkins, CG 1910, Soil Fertility and Permanent Agriculture, Ginn, Boston.


Hulme, J, Hickey, M, Hoogers, R & Kelly, G 2001, Best Management Guidelines for Irrigation of Melons, NSW Agriculture, Paterson, NSW.


King, FH 1911 (repr. 1973), Farmers of Forty Centuries: or permanent agriculture in China, Korea and Japan, Rodale Press, Emmaus, PA.


Kolb, DA 1984, Experiential Learning: experience as the source of learning and development, Prentice-Hall, Englewood Cliffs, NJ.


NASAA 1993, *Standards for Organic Agricultural Production*, National Association for Sustainable Agriculture Australia, Stirling, South Australia.


Persley, D 1994, *Diseases of Vegetable Crops*, Department of Primary Industries and Fisheries, Brisbane.
van Zwieten, M, Stovol, G & van Zwieten, L 2004, Literature Review and Inventory of Alternatives to Copper: for disease control in the Australian organic industry, Report to the Rural Industries Research and Development Corporation, NSW Agriculture, Orange, NSW.


Waksman, SA 1936, Humus: origin, chemical composition, and importance in nature, Williams & Wilkins, Baltimore.


Walters, C 1996, Eco-Farm, Acres USA, Raytown, Missouri.


White, D & Eamens, R 2000, Chemical Application Reference Manual, NSW Agriculture, Orange, NSW.


Wynen, E 2003, Organic Agriculture in Australia—levies and expenditures, Rural Industries Research and Development Corporation, Canberra.

Zimmer, G 2003, The Biological Farmer, Acres USA, Raytown, Missouri.
This information is for producers wishing to convert to organic production and for producers already involved in organic production but keen to diversify their production. It provides a framework for organic conversion and diversification and suggests possible strategies and pathways for moving forward.

This valuable information will help make the transition to organic production or to diversified organic production a smooth one.

Organic products are the fastest growing food sector worldwide. Growth of new farms, products and consumers has been steadily increasing over the last 20 years. In the last 10 years the rate of growth has consistently increased in all of the advanced economies.

Market analysts forecast annual growth rates between 10% and 30% around the world. The United States Department of Agriculture expects the organic industry to be worth US$100 billion by 2010 in America, Europe and Japan.

Major international food corporations are developing organic product lines.

The Australian organic sector is worth between $250 - $400 million per annum at retail level and demand outstrips supply. Domestic production is increasing at between 6-15% per annum and consumption is growing at between 25-40%—the balance is imported. Australia is one of the world’s leading grain exporters but organic grain is imported to meet the shortfall in production. Rising domestic and overseas demand for Australian organic products is prompting more conventional farmers and processors to consider and adopt organic systems.

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