Ensuring Market Access Through Quality Assurance

Ross Skinner
Almond Board of Australia (ABA)

Project Number: AL06006

AL06006

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the almond industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Almond Board of Australia (ABA).

ISBN 0 7341 2884 3

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399

Horticulture Australia

Ensuring Market Access
through Quality Assurance

Ross Skinner

Almond Board of Australia Inc

Project Number: AL06006

AL06006
Ensuring Market Access through Quality Assurance

Ross Skinner
Chief Executive Officer

Almond Board of Australia
PO Box 2246
9 William Street
Berri SA 5343
T: 08 8582 2055
F: 08 8582 3503
E: rskinner@australianalmonds.com.au
W: www.australianalmonds.com.au

Key Personnel

Ross Skinner
Julie Haslett
Ben Brown
Brett Rosenzweig
David Pocock (PIRSA)
Elizabeth Frankish
Graham McAlpine
Kevin Bodnaruk
Prue McMichael
Pat Barkley
Almond Industry Marketing Committee
Almond Industry Processing Committee
Almond Industry Production Committee
Almond Industry Plant Improvement Committee

Purpose of Report
This Final Report has been prepared following the conclusion of the final year of the Ensuring Market Access through Quality Assurance project (i.e. AL06006). The project report summarises the methodology and results of the field trials and other project activities in developing the knowledge, processes, documents, and industry adoption of quality assurance practices for the rapidly developing Australian almond industry.

Acknowledgements
This project has been funded by HAL using the Australian almond industry levy matched funds from the Federal Government.

Disclaimer
Any recommendations contained in this publication do not necessarily represent current HAL Limited policy. No person should act on the basis of the contents of this publication, whether as to matters of fact or opinion or other content, without first obtaining specific, independent professional advice in respect of the matters set out in this publication.

May 2012

Table of Contents

1 Media Summary

The Australian almond industry has grown rapidly during the past decade from producing less than 10,000 tonnes in 2002 to an expected crop of 60,000 tonnes in 2012 and nearly 90,000 tonnes by 2017. With the domestic market taking 15,000 tonnes the export of Australian almonds is a key to the industry's continuing profitability. The Australian almond is naturally a very good quality product but the industry is striving to develop a reputation for high product integrity. This requires a consistent product free from pest, physical, chemical and microbial contaminants. Effective quality assurance (QA) practices across the almond industry supply chain have been developed. Continuous improvement is being practiced as the QA systems are implemented or further developed.

In 2008, the Almond Board of Australia initiated an industry-wide pesticide residue monitoring program conducted annually with the National Residue Survey. The results are reported annually and the ABA has been able to demonstrate to export markets that Australian producers and processors are using good agricultural practices.

The project has reviewed the detection levels of known quality risks during production and processing and has alerted the industry to emerging threats. The project has also developed chemical use diaries, delivery dockets noting moisture contents, a network of calibrated moisture meters, and an industry agreed audit checklist.

The *Almond Industry Pest & Disease Control Guide* was first produced in 2007/08 and updated in 2009/10 and in 2010/11 to ensure the inclusion of accurate and up-to-date information.

The ABA in partnership with Plant Health Australia (PHA) has released an *Orchard Biosecurity Manual for the Almond Industry*. The manual is designed to assist growers protect their orchards from invasive pests using simple, yet effective, preventative strategies. Good biosecurity is essential to ensuring market access and the ABA has maintained a monitoring brief in this area and organised industry training to be better placed to manage a biosecurity incursion.

The project also undertook a review of factors involved in the commercial production of almond planting material from importation (seed, budwood and pollen) to distribution of budwood, seed and grafted trees. The project identified the strengths and weaknesses of propagule multiplication in the Australian almond industry that led to the development of product certification scheme for almonds planting material.

The project oversight has been undertaken by the ABA marketing, processing and production subcommittees and the uptake of the project outputs has been driven through the ABA industry development staff. The close involvement of the industry processors and marketers has enabled the early adoption of the project results.

Project AL06006

For more information contact:
Ross Skinner, Almond Board of Australia
T 08 8582 2055
E rskinner@australianalmonds.com.au

2 Technical Summary

The Australian almond industry has grown rapidly during the past decade from producing less than 10,000 tonnes in 2002 to an expected crop of 60,000 tonnes in 2012 and nearly 80,000 tonnes by 2014. With the domestic market taking 15,000 tonnes the export of Australian almonds is a key to the industry's continuing profitability. The Australian almond is naturally a high quality product but the industry is striving to develop a reputation for high product integrity. This requires a consistent product free from pest, physical, chemical and microbial contaminants. Effective quality assurance (QA) practices across the almond industry supply chain have been developed and are being implemented.

The project oversight was undertaken by the ABA marketing, processing and production subcommittees and the uptake of the project outputs has been driven through the ABA industry development staff. The close involvement of the industry processors and marketers has enabled the early adoption of the project results.

A range of interlinking activities were undertaken to support the continued development and implementation of effective QA practices across the almond industry supply chain.

2.1 Nursery Propagating Materials Standards and Standard Operating Procedures

The purpose of this review was to comprehensively investigate, review and document all factors involved in the commercial production of almond planting material from importation (seed, budwood and pollen) to distribution of budwood, seed and grafted trees. The report encompasses the results of consultation with a range of people involved in the almond and allied industries, review and comparison of other Australian and international perennial crop certification and accreditation schemes, and identification of the strengths, weaknesses, threats and opportunities relating to propagule multiplication presenting to the Australian almond industry. The case for development and introduction of an Australian nursery accreditation and product certification scheme for almonds is made.

There is an underlying assumption in this report, supported by industry members whom we consulted, that a high health status, industry-supported planting material improvement and supply scheme for clones of relevance to the industry has been, and will remain critical to industry development. The ABA pathway to healthy planting material is reliant as it stands today, on the Australian Quarantine and Inspection Service (AQIS), State government-based laboratories, Ausbuds, the University of Adelaide, and independent nurseries. The focus and critical component of the current pathway is the ABA operated scion multiplication block.

It is also acknowledged that the safeguards originally afforded by the very limited number of importers and strong quarantine regulations, are changing and that today's industry must identify and incorporate new safeguards in the industry that allow sustainability and security of the investment in orchards, while retaining the rights of individuals to make their own business decisions. This review discusses the potential benefits of, and need for, expansion of the pathway and all steps and alliances that contribute to the overall quality and supply of almond propagation material and industry biosecurity.

There are external influences likely to affect the industry, almond improvement generally, and more specifically the multiplication scheme. These include: water restrictions, increasing number of importations of proprietary lines of *Prunus* spp., inconsistent (and less predictable) demand for propagation material, increasing litigation about propagation material quality and performance, increasing influence of the competition policy on industry policy and structures, increasing awareness of biosecurity as a national issue, technological advancements in pathogen detection that outstrip field pathology, and the increasing dedication of resources to risk management. It is such issues that may prove to be the drivers for further almond industry development in the area of propagation material production, evaluation and management.

The report includes many recommendations and suggested tasks and authorities responsible for driving forward their consideration and implementation. In summary, we have concluded that the ABA should aim to:

- Remain the industry's first choice supplier of almond propagation material that is pathogen-tested and (in the future) certified, and true-to-type.
- Promote and pursue timely and secure access to new varieties and rootstocks through effective international collaboration and enhanced post-entry quarantine protocols.
- Deliver independent and objective variety and rootstock performance information to all parts of the Australian almond industry.
- Develop and promote high standards for almond management and propagation that are suitable for adoption by all providers of almond propagation material.

2.2 Guidelines for Food Safety Management in the Australian Almond Industry
Tree nuts are generally regarded as low risk produce. However, two significant contamination events originating from the almond industry in California caused the Australian industry to review its perception of the microbiological safety of almonds. In 2001, *Salmonella* Enteritidis PT30 was the cause of a food borne outbreak affecting 168 people in Canada. Again in 2004, around 29 people in the United States were infected with *Salmonella* Enteritidis from almonds. Whilst the origin of the *Salmonella* is unknown these events highlighted the need for increased knowledge of the food safety hazards associated with almond production and appropriate management of the risks.

The Australian industry recognised that in order to maintain its history of safety and the concomitant reputation it must take a whole of chain approach to managing food safety. Failure to control the risks in one sector would impact on the viability of the whole almond industry. In addition, maintaining and enhancing its good reputation is imperative to assisting growth in the industry and food safety is at the heart of that growth.

In 2002, Australian governments adopted a whole of chain approach to food safety regulation. This has resulted in the development and introduction of national primary production and processing standards for high risk food commodities. The almond industry is not currently regulated by specific commodity standards. By setting its own Guidelines the almond industry provides the framework for a practical approach to managing food safety risks. This should result in minimising future regulatory burden as the industry will be seen as taking the initiative and responsibility to control public health and safety with respect to consumption of almonds and almond products.

The Guidelines have been developed to identify potential hazards, assess the risks, apply controls and monitor outcomes of food safety controls in the industry. They are intended for use through the growing, hulling and shelling, and processing and marketing of Australian almonds. Chemical and physical risks are mentioned throughout the document, but the main focus of these Guidelines is the microbiological risks.

Each individual business must identify hazards specific to its operation. The Guidelines should be used in conjunction with other documents relevant to the industry. In particular, Codex Alimentarius documents outlining Good Agricultural Practices (GAP's), Good Hygienic Practices (GHP's) and Good Manufacturing Practices (GMP's) and codes of practice specific to tree nuts should be consulted. The processing and retail sector of the industry must also comply with the food safety requirements of the Australia New Zealand Food Standards Code.

The ABA in May 2011 conducted an industry workshop to look at the development of an advanced production system that would enable almond fruit to be placed into a controlled environment much earlier than is done in the current harvesting and post harvest processes. The industry is now investing in researching the technologies to enable the new system to be introduced into orchards.

2.3 Developing Chemical Residue Guidelines and MRL Testing Program:
In 2008, the ABA initiated an industry wide pesticide residue monitoring program with the National Residue Survey (NRS).

The NRS organises two sampling rounds each year in January and April. Almond samples are tested against a chemical screen which includes those chemicals known to be used in almond production, as well as those that may be important in terms of international trade.

Results are reported annually and demonstrate to export markets the Australian industry undertakes the appropriate use of agricultural chemicals in accordance with good agricultural practice. Maintaining compliance is of ultimate importance in protecting the industry's international reputation as a safe, quality almond supplier. The NRS almond results booklet has been produced for the period 2008 to 2011 and will continue in future.

The NRS in consultation with the ABA review and update the Almond MRL table to document the Maximum Residue Limit (MRL) requirements set by Australia's major almond export destinations, and consequently ensure that the MRL testing program is in line with these requirements. These tables are provided to the industry marketers annually.

The ABA established the Almond Industry Processing Committee in 2011 and this body oversees the chemical residue testing along with other food safety and quality assurance programs. Under the guidance of the Committee the chemical chlorantraniliprole was added to the 2012 screen as its use was undertaken in 2011 to control Carob Moth.

2.5 Almond Industry Pest & Disease Guide:
The "Almond Industry Pest & Disease Control Guide" was updated in 2009/10 and 2010/11 by the ABA and Scholefield Robinson Horticultural Services (SRHS) to ensure the inclusion of accurate and up-to-date information. The updated documents provide information on almond pests and diseases that can be managed and monitored by orchard managers. Fact sheets and field days were also provided on emerging pest threats such as mice and carob moth.

The review of chemical control practices has revealed the limitation spraying technology has in coping with large tree canopies and the industry has moved to address this through engaging Geoff Furness (formerly of SARDI) to optimise the performance of existing sprayers and guide the improvement of equipment. The ABA recognises that the satisfactory control of pest and diseases with chemicals will be limited if spray application technology and protocols are inadequate.

2.6 Almond Orchard Biosecurity Manual:
In October 2009, the ABA in partnership with Plant Health Australia (PHA) released an Orchard Biosecurity Manual for the Almond Industry.

Engaging the expertise of Plant Pathologist, Dr Prue McMichael of Scholefield Robinson Horticultural Services (SRHS) the manual has been developed to assist almond growers in protecting their orchards and the almond industry from new and invasive pests. By implementing the recommended measures in day-today operations, almond growers will enhance biosecurity and that of the region, while minimising productivity losses and unnecessary costs.

High priority exotic threats to Australia's almond growers are:

- Navel orange worm
- Almond leaf scorch
- Glassy-winged sharp shooter
- Hyperplasic canker
- Phomopsis canker
- Almond seed wasp
- Peach twig borer
- Ten-lined June beetle
- European stone fruit yellow
- Almond brownline
- Almond kernel shrivel, and
- Honey bee pests such as Varroa mite, due to their impact on the essential pollination services required for almond production.

Information on each of these pest threats is included in the fact sheets at the back of the manual.

In addition to including a wealth of information on the high priority pests of the almond industry, this manual is designed to assist growers protect their orchards from invasive pests using simple, yet effective preventative strategies. Regularly checking planting material, making workers aware of biosecurity measures, and cleaning vehicles and equipment, are just some techniques that can easily be incorporated into day-to-day orchard operations.

Good biosecurity is essential to ensuring market access, and the orchard biosecurity measures outlined in the manual are designed to help growers play a key role in protecting their own orchards and the Australian almond industry from the impacts of exotic pests.

2.7 Industry QA Review:
It is now nearly 12 years since a HACCP program was first developed for the Almond industry. During this period there have been several different programs available, and they have been widely adopted by the industry.

One of the reasons for the level of success in adoption has been the manner in which the systems have been developed, with an effective partnership and strong commitment operating between producers, processors and marketers with support for the process by the Almond Board of Australia. Each party has undertaken their role to establish control of the identified hazards in their area of operation.

Given the effectiveness of the approach in the past and the continued watching brief that is needed in food safety, a review was commissioned to review existing systems, look at detection levels of known risks and alert the industry to new or perceived risks.

To achieve these objectives the ABA engaged Rural Solutions SA (David Pocock) to provide a Gap Analysis of systems and on-farm practices and develop recommendations to the industry to meet the changing hazards and risks being faced in Quality Assurance of almonds.

These recommendations that have been implemented include:

- Spray diaries to ensure the use of registered chemicals, applied at the correct rates, and at the correct withholding period.
- Delivery dockets to aid traceability and record moisture measurement at delivery, a critical factor in limiting the development of moulds that can produce aflatoxin.
- A network of moisture meter to enable producers to assess moisture content of product prior to delivery.
- A calibration process to assess the accuracy of industry moisture meters.
- A method for sampling product for moisture testing.
- Guidelines for managing stockpiles affected by rain.

In addition to the above outputs, the project has heightened industry awareness of quality assurance and highlighted the need to fund research into food safety which has now been commissioned with DPI Victoria and CSIRO (AL11009).

The project has also been influential on the recent industry strategy to develop advanced production systems that will focus on providing a controlled environment from harvest through to packaging.

Funding has been allocated in the 2012-13 Annual Investment Plan to research shake and catch harvesting technologies, silo storage and dehydration that are seen to be keys to future contamination prevention.

The industry has also developed a close relationship with the School of Advanced Manufacturing and Mechanical Engineering located at the University of South Australia's Mawson Lakes Campus and will fund PhD’s under the guidance of Associate Professor John Fielke that will investigate physical contaminant removal and reduced mechanical damage to the kernel during hulling and shelling operations.

The Project has delivered on all the contacted outputs. These being:

1) A series of manuals dealing with the key areas required to support and resource the QA system
2) HACCP template documents based on the manuals
3) Annually updated Pest & Disease Guide, evolving into an Integrated Pest & Disease Management Manual
4) Annually updated MRL export tables for almonds
5) Annually updated chemical testing program for the Australian almond industry, together with an annual report of testing results
6) An Australian almond grower spray diary

3 Introduction

The Australian almond industry has increased its plantings more than five-fold from 2000. In 2011, the industry produced a record crop of 40,000 tonnes and this is expected to double by 2014 as the bulk of plantings reach full maturity and reach 90,000 tonnes by 2017.
This increase in production will make Australia the second largest producer of almonds in the world with approximately 9% of the world crop behind the USA which produces 80%. Almonds are California's largest agricultural crop and the USA's largest horticultural export crop. To find sales in export markets against such formidable competition the Australian industry needs to develop a reputation as a reliable supplier of almonds with a high level of product integrity.

To move towards this goal the industry recognised that developments were required to address contaminants of a physical, pest, disease, microbial, mycotoxin and chemical nature. With such varied hazard threats a number of aspects were addressed as separate tasks. Many of these tasks have been documented in detail in reports previously submitted and attached to this report as appendices.

4 Methodology

4.1 Nursery Propagating Materials Standards and Standard Operating Procedures

The ABA's intention is to develop and implement an Almond Nursery Accreditation Scheme for the use of high health status propagation material and best management practices as a mechanism for promoting commitment to best practices within that sector. This project will provide the industry with the technical foundation for such a scheme.

Contracting Scholefield Robinson Horticultural Services Pty Ltd (Scholefield Robinson) and sub-contracting the professional services and expertise of Mrs. Pat Barkley were sought to respond to ABA's brief. Scholefield Robinson is a specialist horticultural consulting company based in Adelaide.

The project methodology involved the following:

- Outline best nursery and planting material practices used in other leading perennial horticultural industries – e.g. citrus, apple/pears and grapevines.
- Define the key endemic phytosanitary concerns of relevance to nursery and propagation practices and therefore to Australian commercial almond orchard establishment and viability.
- Outline in brief those exotic pathogens that may directly impact on nursery operations and/or biosecurity measures, should their entry occur.
- Define the key genetic concerns for nursery and commercial almond production in Australia.
- Undertake a risk assessment of the issues identified in 2, 3 and 4 above.
- Prepare and document standards and guidelines for the management and control of the issues above, through the supply chain (point of entry to distribution).
- Prepare (or adapt as appropriate) a Standard Operating Procedures (SOP) Manual (based on points 2-5 above) for nursery implementation; and as the foundation of the ABA's Nursery Accreditation Scheme.
- Audit and evaluate processes implemented at the Monash Budwood Facility. Provide recommendations for improvement.
- Prepare (or adapt as appropriate) an SOP Manual (based on 8 above) for use at the Monash facility.

4.2 Guideline for Food Safety Management in the Australian Almond industry

Almond Microbiological Protocols: These were developed to cover all the microbiological issues from grower through to processor. They provide the basis for sampling and testing. Final development and fine tuning for each stakeholder's business situation was coordinated by Elizabeth Frankish.

4.3 Developing Chemical Residue Guidelines and MRL Testing Program

Guidelines, particularly for export markets, were required to ensure that the requirements of markets are known and met. This is linked to the National Residue Survey (NRS) with the major processor/marketers agreeing to voluntarily support the Government involvement in residue testing and performance reporting. A review of the industry's chemical residue screen and testing frequency was undertaken by the National Residue Survey (NRS). Kevin Bodnaruk updated the almond MRL export tables. The collection of the necessary information required discussions to be held with relevant government staff or via the APVMA, FSANZ, and MHLW websites and almond industry stakeholders.

The Almond Board of Australia (ABA) in conjunction with the three almond processor / marketers has participated from 2008 until 2012 and the program will be expanded to include Olam International in 2013. Annually, half the almond growers were tested for a broad range of insecticides, fungicides, herbicides, fumigants and metals. Approximately 1kg of kernel is collected by QA staff based at the plants in accordance with NRS procedures and protocols. Although the programs are fully designed and managed by the NRS, external contractors provide many of the operational functions including laboratory services, supply, and distribution of sampling materials and freight. Results are sent electronically from the NATA accredited laboratory to the NRS, where the data is collated and compiled for industry and government use.

If any sample shows a positive result for a chemical, further confirmatory testing is carried out. Any sample found to contravene the ANZFSC is referred to the relevant jurisdiction for trace back and appropriate advisory action taken. No legal action has been necessary.

4.4 Chemical Usage Permits and Registrations

The ABA is responsible for facilitating the review of the almond industry's agrichemical status in conjunction with the production committee. The production committee, ABA and other recommended experts review the industry's important pests, diseases and weeds; the availability and effectiveness of fungicides, insecticides and herbicides to control pests; determine any 'gaps' in the pest control strategy; and identify suitable new or alternative pesticides to address the 'gaps'.

The suitable pesticides to address the 'gaps' are then applied for use via the Minor or Emergency Use Permit program, or trialled for full registration.

Peter Dal Santo from AgAware Consulting is also actively engaged to assist the process of almond industry consultation (via the Strategic Agrichemical Review Process), chemical manufacturer consultation, trials, and applying and renewing Minor or Emergency Use Permits.

4.5 Almond Industry Pest & Disease Guide

With the Australian almond industry recently experiencing both significant growth and challenges, there was a need to produce an Almond Industry Pest & Disease Control Guide to assist new growers and investors with production information and chemical use advice, in markets where there is increasing compliance and regulatory pressures. This Guide was prepared and updated every two years (2006, 2008 and 2010) by Scholefield Robinson Horticultural Services, in consultation with industry and relevant expertise.

4.6 Almond Orchard Biosecurity Manual

Orchard Biosecurity is a set of measures designed to protect a property from the entry and spread of pests. Through Plant Health Australia, Scholefield Robinson Horticultural Services and the ABA, an orchard Biosecurity manual was designed and published to assist growers in protecting their orchards and the almond industry from new and invasive pests. By implementing the recommended measures, growers will enhance their Biosecurity and that of their region, while minimising productivity losses and unnecessary costs.

4.7 Industry Quality Assurance Review

The industry updated its QA systems based on a consultation process with stakeholders, including producer and processors which was completed to determine the existing QA systems in operation. Three meetings were conducted with representatives from Select Harvests, NPA/Riverland Almonds and Almondco to assist in defining the scope of the work. The items covered in the discussions were:

- Current systems in use
- Current adoption level and audit/verification process used
- Residue testing programs in place for chemicals and micro-organisms
- Detection levels
- Other hazards
- Current and anticipated customer specifications

The smaller private processors of almonds were also contacted to gain an appreciation of their QA systems.

A discussion paper was presented to the Almond Board of Australia and to the Annual Almond Conference in 2009.

A Gap Analysis using the HACCP process was then used to put the consultation, discussion and recommendation into a quality systems framework for action. This provided components for use in HACCP systems for the industry to bring it up-to-date and cover key risks for on-farm practices.

Furthermore, these HACCP templates encompassed new industry programs such as the almond industry's MRL testing program operated by the NRS, and the ABA's Aflatoxin Sampling Program.

5 Results

5.1 Nursery Propagating Materials Standards and Standard Operating Procedures

This section of the project developed the Nursery and Propagating Materials Standards and Standard Operating Procedures. Nursery practices for the ABA's budwood repository were reviewed and Standard Operating Procedures developed. This process was undertaken by Dr Prue McMichael from Scholefield Robinson Ltd and Dr Pat Barkley.

The ABA recognises the benefits of an accreditation scheme as broadly harmonising and raising standards to 'best practice' levels that might otherwise not be achieved.

Certification is assigned to a product that meets specific standards and has been produced and managed according to agreed guidelines and testing regimes. Implicit in the guidelines is full traceability of the plant components to foundation stock or mother trees at a minimum.

Certified almond budwood for example would be of a proven identity, have a prescribed high health status (i.e. free of detectable PNRSV, PDV etc), auditable to an official standard, and it might also meet specifications for budstick diameter and/or length etc. The traceability records would reveal its origin; the type and timing of virus tests and visual inspections; that maintenance procedures demonstrating the health status had been maintained; and the steps taken to minimise contamination or mixed identity etc. An almond tree could be certified only if produced from the union of a *certified* rootstock and *certified* scion budwood. The ABA has put in place the standard operating procedures at its Monash motherplanting site to allow full traceability including the materials health status and thereby can certify the material purchased by nurseries.

A grafted tree labelled as 'certified' comes with certain guarantees. The guarantees are specifically defined for each product. At a minimum, a locally-produced certified almond tree should have both rootstock and scion proven to be true-to-type, free of detectable levels of economically important viruses according to testing undertaken on mother trees in the season of cutting or seed production; documented evidence to show they have been maintained at that high health status, and traceability of each component to a foundation tree. Certification provides clear product distinction useful to growers in their attempts to actively manage risk.

Both Accreditation and Certification are not normally mandated and the industry has focused on putting its own house in order at Monash as the foundation for nursery accreditation and tree certification.

The ABA is now working to achieve nursery tree certification with a Trademark. The following is an outline of the scheme being worked on.

A candidate tree shall qualify as a Certified Tree if:

- It has been grown in and kept under specified conditions:
  - Registered growing area of fumigated pre-plant or virgin soil with 7m buffer.
  - Plants should be kept in fields isolated from potential sources of infection.
- Nursery stock has been propagated on rootstocks grown from seed of certified trees or imported from high health source with demonstrated freedom from seedborne viruses, i.e. certified budwood and certified seed.
- The label includes rootstock and scion source identification.
- There has been no re-working or budding of nursery stock.
- Off-types or infected material have been immediately removed and recorded.
- Plants have been inspected for symptoms of virus, virus-like diseases or other diseases and pests by the certifying organisation. Any plants showing symptoms to be removed and certification may be granted to the remainder.

Certified trees may be sold if they:

- Meet the minimum Certified Tree requirements.
- Have minimal damage from mechanical harvest or other operations.
- Have a minimum height measured from the ground.
- Have a minimum calliper size (trunk diameter) measured at 100 mm above the graft/bud union.
- Have been left with a root system following lifting that can adequately support the tree with, where possible.
- Are free of residual soil.
- Are bundled and transported in order to prevent damage; ensure tree roots remain damp.
- Have been treated for pests and diseases.
- Have no visual symptoms of pests and diseases.

The Plant Improvement Committee is overseeing the development of the certification scheme and it is proposed to have it operating for the 2012/13 propagation season.

5.2 Guideline for Food Safety Management in the Australian Almond industry

Almond Microbiological Protocols: These have already been substantially developed and cover all the microbiological issues through from grower to processor. They also provide the basis for sampling and testing and the addressing of the policies being put in place by our major competitor, California in regards to product pasteurisation. Final development and fine tuning for each stakeholder's business situation is required. To assist this Elizabeth Frankish developed the document Guidelines for Food Safety Management in the Australian Almond industry. They provide information on key areas of food safety control with practical guidance on how to minimise contamination, investigate food safety risks and monitor the controls in place.

5.3 Developing Chemical Residue Guidelines and MRL Testing Program

The report reviewing Australian almond export product MRL compliance examined the state of residue testing in the almond industry with regard to MRL compliance for export markets such as Japan. The report proposed possible options to address the identified areas of concern such as the residue testing within the industry as it stood lacking the necessary breadth and scientific rigour to provide certainty that nut kernels were MRL compliant. The industry accepted this criticism and acted to:

- Update information on pest management requirements,
- Develop in-field chemical management guidelines. The guidelines provide information on products approved for use in almonds and harvest intervals required to ensure compliance with MRLs in major export destinations,
- Implement an industry wide residue monitoring program.

To achieve the last of these the Almond Board of Australia (ABA) in conjunction with three almond processors initiated a pesticide residue monitoring program with the NRS in 2008. Annually, half the almond growers or about 60 almond samples are tested for a broad range of chemicals and metals.

The samples are collected from three processing plants and NRS organises sampling rounds in January and April each year. 1kg samples of kernel are collected by the processors' QA staff in accordance with NRS procedures and protocols and forwarded to Canberra. The NRS arranges for external laboratory services to analyse the samples against an agreed chemical screen that is developed in consultation with ABA. The chemicals included in the chemical screen are those that may be used in almond production in Australia, as well as those that may be important in terms of international trade.

The purpose of the random monitoring program is to confirm the residue status of the sampled produce, as specified by the maximum residue limits (MRLs) of the Australia New Zealand Food Standards Code (ANZFSC).

If any sample shows a positive result for a chemical, further confirmatory testing is carried out. Any sample found to contravene the ANZFSC is referred to the relevant jurisdiction for trace back and appropriate advisory or legal action may be taken.

In consultation with the Almond Board of Australia, NRS has maintained its international MRL tables for countries that are major export markets for Australian almonds. These tables can be found on the NRS website.

The results are sent electronically to the processors and a report on all results is prepared for the ABA.

5.4 Chemical Usage Permits and Registrations

Peter Del Santo of AgAware Consulting undertook the Strategic Agrichemical Review Process (SARP) which reviewed the industry's important pests, diseases and weeds; the availability and effectiveness of fungicides, insecticides and herbicides to control pests; determine any 'gaps' in the pest control strategy; and identify suitable new or alternative pesticides to address the 'gaps'.

The industry's Production Committee has continued to undertake the same process as the SARP and over the duration of the project the following chemical permits and registrations were obtained:

PERMIT / REGISTRATION	CHEMICAL	REGISTERED PEST
PER7161	Phosphorous Acid	Suppression of *Phytophthora spp*.
PER8061	Simazine	Broadleaf weeds & grasses
PER9200	Azoxystrobin	Anthracnose
PER9241	Pirimicarb	Green peach aphid
PER9244	Pymetrozine	Green peach aphid
PER9255	Propiconazole	Blossom blight & Anthracnose
PER9256	Captan	Blossom blight, Anthracnose, Shot Hole & Nut Scab
PER9764	Dicofol	Two-Spotted Mite & Brown Almond Mite
PER9914	Clofentezine	Two-Spotted Mite & Brown Almond Mite

PER10096	Bifenazate	Two-Spotted Mite & Brown Almond Mite
PER11003	Bromoxynil & Diflufenican	Broadleaf weeds
PER11121	Simazine	Broadleaf weeds & grasses
PER11124	Trifluralin	Prevent root intrusion in subterranean dripper systems
PER11941	Pirimicarb	Green peach aphid
PER12398	Bifenazate	Two-Spotted Mite & Brown Almond Mite
PER12989	Propiconazole	Blossom blight & Anthracnose
PER13199	Phosphorous Acid	Suppression of *Phytophthora spp*.
PER13233	Chlorantraniliprole	Carob moth
PER13266	Azoxystrobin	Anthracnose
PER13383	Pymetrozine	Green peach aphid
PER13384	Abamectin	Two-spotted mite & Brown almond mite
PER13387	Pirimicarb	Green peach aphid
PER13705	Chlorpyrifos & Maldison	Australian plague locust
58900	Pyraclostrobin	Rust
60244	Captan	Anthracnose
61529	Captan	Blossom blight, Anthracnose, Shot Hole & Nut Scab

5.5 Almond Industry Pest & Disease Guide

This Guide was prepared and updated every two years (2006, 2008 and 2010) by Scholefield Robinson Horticultural Services, in consultation with industry and relevant expertise. The Guide for the industry should be viewed as a living document. It is accurate and up-to-date at the date of publication but the rate of change in crop care technology (products, permits, registrations, chemistry, electronic support programs etc) is such that the Guide requires constant revision. Between reprints it was the responsibility of growers to access and implement the latest information and recommendations. Useful sources of such information are included in the Guide.

The Guide included technical information on the main almond pest and disease threats and products available for their control, it did not explicitly direct growers to specific crop protection products (or biological control organisms), application times or rates. Growers were required to make those choices in compliance with the product labels and when appropriate, export market requirements. Regional climates, varieties grown, disease pressure, pest populations, orchard history, previous product choices and tank mixes, resistance threats etc must be considered before designing and implementing your pest and disease control program. To finalise a program most growers will also look at the economics of the available product range.

The Guide provided information on almond pests and diseases that can be managed and monitored by orchard managers. The Guide did not include discussion of abiotic tree stresses (poor nutrition, soil problems, toxicities and deficiencies, irregular watering, water quality, heat, flooding, frost etc), but growers should recognise these factors may influence the onset or severity of the pests and diseases that are discussed. The Guide does did include information on viruses, viroids or phytoplasmas, or on disorders with unknown causes since the management of these is either undefined or is required before planting. Steps taken by growers before planting greatly influence the effectiveness of orchard management thereafter. Site selections, soil suitability, irrigation plans, choice of planting material, evaluation of planting material quality and health are critical steps in the establishment of good orchards.

5.6 Almond Orchard Biosecurity Manual

The Orchard Biosecurity Manual for the Almond Industry v1.0 was published in 2009. The manual assists growers in protecting their orchards and the almond industry from new and invasive pests.

The manual provides an overview of Biosecurity and provides information relating to the high priority exotic pest threats for the Australian almond industry and priority pests of pollination, all of which would have serious consequences should they be introduced.

The manual also provides information relating to pest surveillance, and the role of planting and propagation material, people, equipment and vehicles in Biosecurity. Checklists, useful contacts, registers and fact sheets were also provided in the manual.

5.7 Industry Quality Assurance Review

The development and provision of HACCP tables based on the manuals developed in the above steps. A gap analysis will be undertaken to identify the limitations of existing systems and these systems will then be brought up to standard by the incorporation of the new standards and recommendations. This final step of implementation will be ensured by QA training and facilitation provided by a specialist in this area. Training and system updating will be achieved by working with each of the three major processors and their grower suppliers in groups. David Pocock will undertake this final phase. Annual review of Australian almond grower spray diaries, in collaboration with Australian Almond processors. Review of spray diaries to be undertaken anonymously, for the sole purpose of assessing current chemical usage in the industry to inform decisions with respect to minor use permits, MRL testing program, rather than for any approval process. This information will then feed into the following two activities, in addition to highlighting chemicals for future registration / permitting as part of our ongoing SARP review process, HAL project: AL08003.

6 Discussion

The project has produced a number of very beneficial results that have achieved the projects aims.

The uptake of the individual project outputs has been achieved. However, it is an ongoing process to keep the guides, standards, protocols, programs current. The ABA has undertaken to maintain these. A recent example of this is the obtaining of an Emergency Use Permit for Alticor required to control Carob Moth which had dramatically increased in population as a result of the wet and mild summers. This also led to the modification of the National Residue Survey to include Chlorantraniliprole (Alticor) in the list of chemicals tested for in the program. Other examples are the trademarking of planting material that meets the industry standard; chemical use diaries; and training of industry personnel on the Emergency Plant Pest Response Deed (EPPRD).

The maintenance the information and programs is crucial to them continuing to deliver valuable outcomes for industry. It is planned to achieve this through incorporating this task into the ABA's industry development project which will act under the guidance of the industry's supply chain committees: Plant Improvement, Production, Processing and Marketing.

7 Technology Transfer

The Almond Board of Australia has distributed the following publications to levy payers and broader industry membership.

1. Nursery Propagating Materials Standards and Standard Operating Procedures
2. Guidelines for Food Safety Management in the Australian Almond industry
3. Developing Chemical Residue Guidelines and Annual National Residue Results (2008 -2011)
4. Advice on Chemical Usage Permits and Registrations (Ongoing)
5. Almond Industry Pest & Disease Guide 2009
6. Almond Industry Pest & Disease Guide 2011
7. Almond Orchard Biosecurity Manual
8. Industry Quality Assurance Review and the following documents:
   - 8.1 Delivery Booklet
   - 8.2 Chemical Use Diary
   - 8.3 Moisture Meter Calibration Report
   - 8.4 Sampling Process for Moisture Testing

During the project the ABA informed levy payers and industry members of the projects progress by the following communications in the industry magazine "In a Nutsell"; at the annual Almond Conference; by email and mailouts. The list of the communication activities follows formatted as a timeline:

2007

August - In a Nutshell Articles

- Chemical Permits List
- Request for feedback on Almond Industry Pest & Disease Guide
- Almond Industry Food Safety Guidelines

Australian Almond Industry Conference November 1st & 2nd (Mildura VIC)

- Nursery & Propagation Review - Prue McMichael

2008

February - In a Nutshell Article

- Strategic Agrochemical Review Process for Almonds (AgAware)
- See It early, Stop it Fast (PHA Biosecurity)

May - In a Nutshell Articles

- Expanding our Chemical Armoury (AgAware)
- What are the top pest risks for the Almond industry, and who decided (PHA article)
- Biosecurity Awareness Workshop Notification (PHA)

November - In a Nutshell Articles

- Almonds Adopt Industry Residue Testing Program (NRS)
- Almond Chemical Screen 2009 (Listing of current chemicals)

Australian Almond Industry Conference October 29th to 31st (Rowland Flat SA)

- Biosecurity - Impact of Varroa - Dr Mark Goodwin, HortResearch NZ

Email Contact & Website Upload

- Email - 2 June - DAFFs Sentinel Hive Program Response
- Email - 11 June - Varroa mite incursion in PNG
- Email - 18 June - Biosecurity Training Workshop Notice - Loxton, SA
- Email & Website - 21 August- New Permit - Acramite (Bifenazate)
- Email & Website - 19 September - New Permit - Acramite (Two-spotted & Bryobia mite)
- Email & Website - 22 September - New Permit - Captan

2009

August - In a Nutshell Articles

- Quality Assurance - HACCP Commencement
- Bees Biosecurity & Best Practice (PHA)

November - In a Nutshell Articles

- 100% Compliance - National Residue Survey Results
- EU Increases Aflatoxin Levels
- Protecting Our Orchards - Almond Biosecurity Manual Released
- 2009-10 Almond Pest & Disease Guide Released

Australian Almond Industry Conference October 28th to 30th (Rowland Flat SA)

- Almond Industry Residue Testing Program - Alastair James, NRS
- Poisons, Toxins & Pathogens - David Pocock, Rural Solutions SA
- Managing a Crisis: Could we have one, and what could we do about it? - Richard Bennett, HAL Almonds, Bees & Biosecurity - Rodney Turner, PHA

Media Releases

- October 29 - Shield against Sharpshooters (Joint release ABA & PHA)

Mailouts

- September - Almond Industry Pest & Disease Guide 2009/10
- November - Almond Orchard Biosecurity Manual
- November - Almond Industry National Residue Survey Results 2008 – 2009

Email Contact & Website Upload

- Email & Website - April 7 - New Permit - ER11003 - Bromoxynil -Diflufenican (e.g. Jaguar)
- Email & Website - December 22 - New Permit - PER11769 - Phosphorus Acid (e.g. Foli-r-Fos)
- Email & Website - January 7 - New Permit - PER11124 - Trifluralin (e.g. Treflan)
- Email & Website - July 30 - New Permit - Abamectin (e.g. Vertimec)

2010

November - In A Nutshell Articles

- Don’t be a Drifter (Chemical Application Workshop)

Australian Almond Industry Conference October 27th to 29th (Mildura VIC)

- Food Safety - Dr Prue McMichael, SRHS

Mailouts

- November - Almond Industry National Residue Survey Results 2009 - 2010

Email Contact & Website Upload

- Email & Post - September 3 - Spring Almond Pest and Disease Workshops
- Email & Website - April 7 - New Permit - PER11941 Pirimicarb
- Email & Website - September 24 - New Permit - PER12332, Chlorpyrifos and Maldison for control of APL
- Email & Website - September 8 - New Registration - Cabrio
  Email - August 30 - Bee Disease Article - Nosema
- Email - January 4 - Information - Weather for Pesticide Spraying
- Email - June 30 - Farm Biosecurity Producer Survey (PHA)
- Email - November 12 - Non-Chemical and Minimum Chemical Use Options for Managing Varroa
- Email - November 4 - Almond Field Day - Don't be a drifter - Chemical Application Workshop
- Email - October 7 - Information - Summerfruit Integrated Pest & Disease Manual
- Email - September 13 - Notice of Almond Field Day - Rust, Pest & Diseases, Infield Monitoring

- Email - September 7 - Almond Diseases

2011

December - In a Nutshell Articles

- Don't Be a Drifter (2nd round of Chemical Application Workshops)

Australian Almond Industry Conference October 26th to 28th (Victor Harbor SA)

- Food Safety - Supply Chain Issues - Dr Chin Gouk, DPI VIC

Media Releases

- March 3 - Almond Board of Australia Supports campaign to eradicate Asian bee

Email Contact & Website Upload

- Email - April 27 - Carob Moth - Literature Review
- Email - August 1 - Almonds & Mice
- Email & Website - September 2 - New permit - Propiconazole
- Email - November 1 - CropLife Australia - Resistance Management Strategies Update
- Email & Website - December 13 - New permit - Phosphorus Acid (eg Foli-R-Fos)
- Email & Website - December 22 - New Emergency Use Permit: Carob Moth Control - Chlorantraniliprole (Altacor)

8 Recommendations

8.1 Nursery Propagating Materials Standards and Operating Procedures

The Review of Almond Budwood and Seed Multiplication and Recommendations for Accreditation Scheme by Prue McMichael and Pat Barkley provided a host of recommendations (see below) but provided the following summary:

- The ABA to remain the industry's "first choice" supplier of almond propagation material that is pathogen-tested and (in the future) certified, and true-to-type
- The ABA promote and further enhance timely and secure access to new varieties and rootstocks through effective international collaboration and efficient PEQ protocols;
- The ABA deliver independent and objective variety and rootstock performance information to all parts of the Australian almond industry;
- The ABA develop and promote high standards for almond management and propagation, that are suitable for adoption by all providers of almond propagation material.

Prue McMichael and Pat Barkley also recommended that a not-for-profit association or company be formed to oversee the multiplication and improvement (evaluation and breeding programmes) for almonds. This association/company, representing almond production and nursery industries, should be an affiliate of the Almond Board of Australia (ABA), but should act independently enabling the ABA Board to be the overriding and official body which grants certification.

Recommendations on Budwood Multiplication at Monash

- Budwood source trees of relevant varieties/clones be increased so that budwood supply exceeds future demand.
- All trees supplying budwood are tested annually for PNRSV and PDV.
- Any infected trees be removed following validation of the molecular indexing result.
- The location of infected trees be mapped/analysed periodically to assess whether or not root-grafting may be involved in any virus transmission.
- In re-development, isolation and tree-spacing distances should reflect the known presence of other related hosts, potential for root-grafting, vector movement and pollen spread.
- An isolated site may be required to accommodate incompletely-indexed material released from PEQ or submitted from local sources, but ideally all material would be fully indexed by AQIS prior to entry to any industry scheme.

- The ABA maintain two original plants (rootstocks and scions) released from PEQ (or local breeding programmes) as potted, foundation trees in a secure, insect-proof screenhouse, hereafter. A field repository should also be considered.
- A biosecurity plan should be developed for Monash.
- The almond industry support the process of protocol validation on almonds (i.e. indexing methodologies for budwood, rootstocks and pollen) and also peer scientific review of the protocols.
- The industry should seek AQIS endorsement for post-entry quarantine indexing for endemic as well as exotic diseases.
- The ABA to consider the eligibility criteria in terms of defined health status and documented origin and identity, for both local and imported material entering the almond budwood multiplication facilities.

Recommendations on Rootstock Supply

- The benefits of an ABA-controlled source of Nemaguard at Monash to be evaluated. Consultation with the stone fruit industry and Ausbuds is advised.
- The status of GF677 as “ABA-approved” or other, needs resolution, particularly for those in Managed Investment Schemes (MIS) that have Product Development Statements (PDS) defining very specifically the accepted source and status of planting material.
- The industry is encouraged to ensure that seed is imported only from direct suppliers of certified seed from identified sources and that approved labelling and/or documentation allows traceability of such material, and validation of information provided on permit applications.
- The ABA consider and document the eligibility criteria in terms of defined health status and documented origin and identity, for both local and imported material entering the almond rootstock multiplication facilities.

Recommendations on Post Entry Quarantine (PEQ)

- There are PEQ arrangements relevant to the Australian almond industry that need further development.
- The almond industry should engage PHA and HAL in dialogue that leads to strong representation to AQIS directly, and through PEPICC25. Matters of interest to the industry are: auditing of overseas suppliers; verification of sources and pest-free status; private QAP facility and PEQ activity audits; testing/indexing standards; closing/moving of AQIS facilities at Knoxfield and Eastern Creek.
- The ABA formally acknowledge their desire for the draft Prunus PEQ Manual and the recommendations included within it, to be approved by BA and implemented for Prunus spp. in PEQ.
- The almond industry support the process of protocol validation on almonds and peer review of the protocols.
- The ABA is encouraged to discuss a requirement for freedom from PNRSV and PDV of all almond relevant material released from PEQ.
- It is incumbent on the industry and especially private importers, to ensure that endemic pathogens do not enter the multiplication chain with newly imported clones/varieties, seed or pollen.
- The industry is encouraged to ensure that seed is imported only from direct suppliers of certified seed from identified auditable sources.
- The ABA, on behalf of the almond industry, is encouraged to build a database of importers and relevant planting material entering the country through PEQ as best they can, and prior to the expected and potentially rapid growth in the number and type of private importations.
- Representation on PEPICC is recommended.

Recommendations on Engagement of Private Importers of Almond Propagating Material & Variety Managers of Proprietary Lines

- Since most entries of imported almond material now originate from non-approved sources, it is recommended that engagement of private importers be increased.
- ABA leadership in developing a secure (physically and legally) and mutually-beneficial environment for private proprietary material to be included in the multiplication scheme and in industry-driven independent evaluation trials, is encouraged.
- Determine if variety managers, at the least have an intention to provide propagation material of defined, high health status to the industry.

Recommendations on Industry Development Tasks.

- The industry drive (via an independent, approved affiliate) comparative evaluation trials, carried out with due prior consideration of exactly how the industry will value and use, disseminate and respond to, the resultant information.
- DNA finger-printing of all submitted material is recommended.
- The ABA (or appropriate affiliate) prepare diagrams of agreed almond nursery tree specifications and standards.
- A Newsletter for nurserymen and growers be developed and made available on-line to provide information on budwood and seed supply, results of horticultural evaluations, presentations etc.
- The ABA in consultation with IP Australia consider the requirement for defined health status of propagation material intended for inclusion in comparative evaluation PBR trials for almonds or almond relevant planting material (rootstocks).
- The ABA commitment to breeding should be maintained.
- The ABA should determine the relative financial and IP benefits of maintaining non-commercialiser status; and its alternative, i.e. becoming a commercialiser (variety manager) competing with major nurseries and importers.
- ABA should be central manager of head agreements, testing agreements of ABA-imported material and a manager of IP, where required.

8.2 Guidelines for Food Safety Management in the Australian Almond industry

This aspect of the project developed the Guidelines that provided specific direction on managing food safety on farm and at the processing facilities, it did not offer other recommendations.

8.3 Developing Chemical Residue Guidelines and MRL Testing Program

The recommendation for this aspect of the project is the continuation of the program with the co-ordinated support of the processor marketers managed by the ABA.

8.4 Chemical Usage Permits and Registrations

The recommendation for this aspect of the project is the continuation of the work in this area by the ABA's Industry Development Manager.

8.5 Almond Industry Pest & Disease Guide

The recommendations for this aspect of the project are the continued updating of the Pest and Disease Guide, the development and implementation of training programs specific to the use of airblast sprayers and herbicide units in almond orchards.

8.6 Almond Orchard Biosecurity Manual

The recommendations for this aspect of the project are the continued updating of the Almond Orchard Biosecurity Manual and the training of industry personnel in incursion management to be adequately prepared for a biosecurity incident.

8.7 Industry Quality Assurance Review

The reports prepared by David Pocock contained the following recommendations:

- Increase the availability of moisture meters to growers to improve the compliance at delivery with Huller specifications. The use of testing equipment needs to be promoted by industry.
- A fact sheet for the storage of almonds to better enable storage would benefit industry. Issues covered in the fact sheet should include;
    - locating the pad,
    - materials used for the base,
    - construction of bunker walls,
    - covering the stockpile and moisture management and
    - pest control in and around the stockpile.
- Biological contamination is an emerging risk and more work needs to be conducted in the infection, presence and predisposing factors of alflatoxin and *Salmonella spp*. on-farm.
- Acceptance of second party audits is recommended in the report due to the level of control of hazards that can be demonstrated and the level of cooperation achieved by various sections of the production quality chain.
- Adjustment in weights post hulling and shelling to 4.5% kernel moisture. The aim of this recommendation is to remove any incentive to deliver high moisture almonds. Balancing kernel moisture to 4.5% is an ideal processing percentage and will remove the temptation to maximise moisture content whilst not disadvantaging growers who deliver low moisture kernels. Low moisture almonds are also not desired as these kernels are more likely to scratch.
- Charges based on receival quantity. Charges for hulling and shelling of almonds have been based on the out-turn quantity. As a result, there is little incentive for growers to improve the delivery quality of almonds, as the imperative is to complete harvest as quickly as possible. High levels of sand (from higher speed harvesting and sandy blocks), sticks (older or younger orchards), and rocks (from shallow soils) can result in waste levels well above the current, average foreign material amount being delivered to the plant of 6%.
- Non acceptance of badly out of specification material. Some growers may still deliver small quantities of badly out of specification material in the hope of retrieving some value. This material should be rejected in the main part of the season as growers are well aware of the nature of the material. It effectively becomes material for rework with high waste, slow throughput and significant potential for high levels of contaminants.

9 Acknowledgements

The ABA acknowledges the guidance and critical review of the almond industry subcommittee members and those industry producers and processors that provided knowledge and access to their orchards, hulling and shelling facilities and storage sites. This assistance has underpinned the successful outputs of AL06006.

Special thanks to Dr Prue McMichael (Scholefield Robinson), K Delaporte, S Kane, Pat Barkley, Elizabeth Frankish (Silliker Microtech Pty Ltd) Kevin Bodnaruk (AKC Consulting Pty Ltd) Peter Del Santo AgAware and David Pocock (PIRSA) who undertook key elements of this project.
The staff of DAFF's National Residue Survey, APVMA and Plant Health Australia who continue to assist the industry are acknowledged for their valued contribution.

We also acknowledge the assistance of the HAL project manager, Richard Bennett whose knowledge and experience in this area is highly regarded and valued by the almond industry.

The ABA acknowledges the financial assistance of the Australian Federal Government provided through Horticulture Australia Limited (HAL).

10 References

The individual reports appended contain the References if used.

11 Bibliography

The individual reports appended contain the bibliographies if required.

12 Appendices

12.1 Appendix 1 - Review of almond budwood and seed multiplication and recommendations for accreditation scheme - Final Report

12.2 Appendix 2 - Almond budwood standard operating procedures

12.3 Appendix 3 - Guidelines for food safety management in the Australian almond industry

12.4 Appendix 4 - Australian almond export product MRL compliance review

12.5 Appendix 5 - National Residue Survey 2008-09

12.6 Appendix 6 - National Residue Survey 2009-10

12.7 Appendix 7 - Pest and disease control guide 2007-08

12.8 Appendix 8 - Pest and disease control guide 2008-09

12.9 Appendix 9 - Orchard Biosecurity Manual for the Almond Industry

12.10 Appendix 10 - A Review of Almond Industry Quality Assurance

12.11 Appendix 11 - Almond Spray Diary

12.12 Appendix 12 - Almond Delivery Docket

FINAL REPORT

Review of Almond Budwood and Seed Multiplication and Recommendations for Accreditation Scheme

AL06006

Prepared for	**:**	**Horticulture Australia Ltd**
HAL Project No.		**AL06006**
Prepared by	**:**	**Prue McMichael & Pat Barkley**
Completion Date	**:**	**February 2008**

SCHOLEFIELD ROBINSON HORTICULTURAL SERVICES PTY LTD

118A Glen Osmond Road, Parkside SA 5063 Australia
Ph: (08) 8373 2488
Email: srhs@srhs.com.au

ACN 008 199 737
ABN 63 008 199 737

PO Box 650, Fullarton SA 5063
Fax: (08) 8373 2442
Web Site: www.srhs.com.au

Offices in Adelaide and Mildura

HAL Project No. AL06006

PROJECT LEADER

Dr Prue McMichael
Senior Consultant/Plant Pathologist
Scholefield Robinson Horticultural Services Pty Ltd
PO Box 650
Fullarton SA 5063

PURPOSE OF REPORT

This Final Report has been prepared to document information acquired, analysed and considered during the review undertaken for the ABA and HAL, into all aspects of propagation material in the almond industry. The Final Report includes recommendations for industry, research partners and government authorities who together influence the almond industry's progress.

ACKNOWLEDGMENTS

This research has been supported by HAL and levy contributions from the Almond Board Australia. Many industry members have provided significant time and input to the project and we acknowledge the importance of their contributions.

FEBRUARY 2008

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS

AAIS	Australian Almond Improvement Society
ABA	Almond Board Australia
ANFIC	Australian Nursery Fruit Improvement Company
APFIP	Australian Pome Fruit Improvement Program
AQIS	Australian Quarantine Inspection Service
ARC	Australian Research Council
AVIA	Australian Vine Improvement Association
ACG	Australian Citrus Growers' Inc.
BA	Biosecurity Australia
DAFF	Department of Agriculture Fisheries and Forestry
DPI	Department of Primary Industries
EMAI	Elizabeth Macarthur Agricultural Institute
EPPO	European and Mediterranean Plant Protection Organisation
HAL	Horticulture Australia Limited
HRDC	Horticultural Research and Development Corporation
ICON	AQIS's Import Conditions
IDO	Industry Development Officer
IP	Intellectual property
MIS	Managed Investment Scheme
NBF	Non-infectious bud failure
NGIA	Nursery and Garden Industry Association
NIASA	Nursery Industry Accreditation Scheme Australia
NAPPO	North American Plant Protection Organisation
PBR	Plant Breeder's Rights
PEPICC	Post-Entry Plant Industry Consultative Committee
PEQ	Post-Entry Quarantine
PHA	Plant Health Australia
PISA	Primary Industries South Australia
PIRSA	Primary Industries and Resources of South Australia
PQA	Pest Quarantine Area
QAP	Quarantine Approved Premises
RSPM	Regional Standards for Phytosanitary Measures
SARDI	South Australian Research and Development Institute
SRHS	Scholefield Robinson Horticultural Services Pty Ltd (Scholefield Robinson)
SRM	Scholefield Robinson Mildura Pty Ltd
STG	Shoot Tip Grafting
VINA	Vine Industry Nursery Association
VINAS	Vine Industry Nursery Accreditation Scheme

GLOSSARY

Wherever available, definitions are those of the International Plant Protection Convention as detailed in the International Standards for Phytosanitary Measures, Publication No. 5 (2007): *Glossary of Phytosanitary Terms*. Other definitions are from EPPO PM 4/31 *Schemes for the production of healthy plants for planting*

Approved source:	A source of budwood or seed approved by AQIS (or other certifying body) for the provision of high health status material.
Basic material:	Propagation stock material from all but the last stage of propagation stock, satisfying the recommended certification standards and certified for sale. According to the number of stages of propagation stock, there may be several grades of basic material (EPPO)
Candidate nuclear stock:	Any plant that may become or may be propagated to produce nuclear stock. Testing for specified pests is required before the plant can be accepted as nuclear stock. Until testing is complete and negative, the plant remains candidate nuclear stock (EPPO).
Certification scheme:	System for the production of vegetatively-propagated plants for planting, intended for further propagation or for sale, obtained from selected candidate material after several propagation stages under conditions ensuring that stated health standards are met. The traceability (line of descent from a defined parent plant) of the material is considered throughout the scheme. (EPPO definition).
Certified stock:	Material which is produced from propagation stock under appropriate conditions. (EPPO definition)
Exotic:	Not native to a particular country, ecosystem, or eco-area (applied to organisms intentionally or accidentally introduced as a result of human activities).
Foundation or Nuclear stock:	Material individually tested by the most rigorous procedure in the scheme. Material propagated from nuclear stock may remain nuclear stock under appropriate conditions. All such material must be maintained at all times under strict conditions ensuring freedom from infection. (EPPO definition).
Germplasm:	Plants intended for use in breeding or conservation programmes [FAO, 1990].
Growing season:	Period or periods of the year when plants actively grow in an area, place of production or production site [FAO, 1990; revised ICPM, 2003].
Host pest list:	List of pests that infest a plant species, globally or in an area [CEPM, 1996; revised CEPM, 1999].
Host range:	Species capable, under natural conditions, of sustaining a specific pest or other organism [FAO, 1990; revised ISPM No. 3, 2005].
ICON	AQIS's import conditions database http://www.aqis.gov.au/icon32/asp/homecontent.asp

Indexing	Indexing is the term used to encompass the methods available for determining the presence/absence of a pathogen. It includes visual (naked eye, light and electron microscopy), biological (woody and herbaceous hosts), molecular and serological testing of seed or plants for the presence of graft-transmissible pathogens.
Nuclear (or Foundation) stock:	Material individually tested by the most rigorous procedure in the scheme. Material propagated from nuclear stock may remain nuclear stock under appropriate conditions. All such material must be maintained at all times under strict conditions ensuring freedom from infection. (EPPO definition).
Nuclear stock material:	Propagating material derived from nuclear stock, which may be further propagated without change of ownership, or certified for sale as pre-basic material (EPPO).
Non-approved source:	A source of budwood or seed not approved by AQIS (or other certifying body) for the provision of high health status material.
Pathogen:	Micro-organism causing disease [ISPM No. 3, 1996].
Pathogen-tested (AQIS):	Plant material that has been indexed by AQIS in PEQ and found to be free of detectable levels of quarantineable pathogens.
Pathogen-tested (schemes):	Plant material available to industry or scheme that has been tested and found free of detectable levels of economically-important, endemic pathogens in the year of testing.
PCR (polymerase chain reaction):	Conserved nucleotide sequences are replicated to levels detectable by gel electrophoresis.
Pre-basic material:	Nuclear stock material, satisfying the recommended certification standards and certified for sale (EPPO).
Propagation stock:	Material derived from the multiplication of nuclear stock, under conditions ensuring freedom from infection. Pathogen freedom is checked by an appropriate procedure. Material derived from propagation stock under the same conditions remains propagation stock, but, according to the plant species concerned, a maximum number of generations of propagation may be fixed at this stage. (EPPO definition).
Pathway:	Any means that allows the entry or spread of a pest [FAO, 1990; revised FAO, 1995].
Pest:	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products. This includes insects, mites, fungi, bacteria, nematodes, and viruses.
Pest diagnosis:	The process of detection and identification of a pest [ISPM No. 27, 2006].
Place of production:	Any premises or collection of fields operated as a single production or farming unit. This may include production sites which are separately managed for phytosanitary purposes [FAO, 1990; revised CEPM, 1999].

Plant quarantine:	All activities designed to prevent the introduction and/or spread of quarantine pests or to ensure their official control [FAO, 1990; revised FAO, 1995].
Protocol:	A detailed procedure for undertaking an activity.
Specimen Report:	Specimen reports are completed whenever suspect plant samples are collected for diagnosis. The report will provide location details and other important information that will assist in managing the outbreak.
Spread:	Expansion of the geographical distribution of a pest within an area [FAO, 1995].
Technically justified:	Justified on the basis of conclusions reached by using an appropriate pest risk analysis or, where applicable, another comparable examination and evaluation of available scientific information [IPPC, 1997].
Virus free:	Tested by accepted indexing methods and found free of (detectable levels) viruses under those test conditions. Often incorrectly used to mean free of other graft-transmissible pathogens including phytoplasmas, viroids etc.
Virus tested:	Tested by accepted indexing methods. Often incorrectly applied also to other graft-transmissible pathogens including phytoplasmas, viroids etc.

MEDIA SUMMARY

This review was commissioned by the Almond Board of Australia (ABA) to form part of a larger project called Ensuring Market Access through Quality Assurance (Project AL 06006). The ABA saw the opportunity and necessity for the almond industry, in the early phases of a rapid expansion, to chart its course with an industry-endorsed structure that protects its genetic resources.

The purpose of this report was to comprehensively investigate, review and document all factors involved in the commercial production of almond propagation material from importation (seed, budwood and pollen) to distribution of budwood, seed and grafted trees. The review provides the background and technical information necessary for the industry in partnership with other authorities, to prioritise strategic options and resource needs for future development in almond improvement and management.

The review investigated industry structures and technology relevant to the industry's genetic resources - their introduction, production, health status, management, traceability and distribution; the case for accreditation and product certification; and the future steps in the supply chain - from import conditions and quarantine to tree distribution - necessary for enhancement of the industry's capabilities and preparedness in propagation material supply, biosecurity and genetic stability.

The report includes recommendations for industry, research partners and government authorities who together influence the almond industry's future development. There are opportunities identified for the almond industry to assume significant leadership within the perennial horticultural industries.

TECHNICAL SUMMARY

The purpose of this review was to comprehensively investigate, review and document all factors involved in the commercial production of almond planting material from importation (seed, budwood and pollen) to distribution of budwood, seed and grafted trees. The report encompasses the results of consultation with a range of people involved in the almond and allied industries, review and comparison of other Australian and international perennial crop certification and accreditation schemes, and identification of the strengths, weaknesses, threats and opportunities relating to propagule multiplication presenting to the Australian almond industry. The case for development and introduction of an Australian nursery accreditation and product certification scheme for almonds, is made.

There is an underlying assumption in this report, supported by industry members whom we consulted, that a high health status, industry-supported planting material improvement and supply scheme for clones of relevance to the industry has been, and will remain critical to industry development. The ABA pathway to healthy planting material is reliant as it stands today, on the Australian Quarantine and Inspection Service (AQIS), State government-based laboratories, Ausbuds, the University of Adelaide, and independent nurseries. The focus and critical component of the current pathway is the Monash scion multiplication block (Monash).

It is also acknowledged that the safeguards originally afforded by the very limited number of importers and strong quarantine regulations, are changing and that today's industry must identify, debate and incorporate new safeguards in their industry that allow sustainability and security of the investment in orchards, while retaining the rights of individuals to make their own business decisions. This review discusses the potential benefits of, and need for, expansion of the pathway and all steps and alliances that contribute to the overall quality and supply of almond propagation material and industry biosecurity.

There are external influences likely to affect the industry, almond improvement generally, and more specifically the multiplication scheme. These include: water restrictions, increasing number of importations of proprietary lines of *Prunus* spp., inconsistent (and less predictable) demand for propagation material, increasing litigation about propagation material quality and performance, increasing influence of the competition policy on industry policy and structures, increasing awareness of biosecurity as a national issue, technological advancements in pathogen detection that outstrip field pathology, and the increasing dedication of resources to risk management. It is such issues that may prove to be the drivers for further almond industry development in the area of propagation material production, evaluation and management.

The report includes many recommendations and suggested tasks and authorities responsible for driving forward their consideration and implementation. In summary, we have concluded that the ABA should aim to:

- remain the industry's 'first choice' supplier of almond propagation material that is pathogen-tested and (in the future) certified, and true-to-type.
- promote and pursue timely and secure access to new varieties and rootstocks through effective international collaboration and enhanced post-entry quarantine protocols.
- deliver independent and objective variety and rootstock performance information to all parts of the Australian almond industry.
- develop and promote high standards for almond management and propagation, that are suitable for adoption by all providers of almond propagation material.

1 PURPOSE OF REVIEW

This review was commissioned by the Almond Board of Australia (ABA) to form part of a larger project referred to as *Ensuring Market Access through Quality Assurance (Project AL 06006)*. The ABA saw the opportunity and necessity for the almond industry, in the early phases of a rapid expansion, to chart its course with an industry-endorsed structure that protects its genetic resources. This is reflected in the Australian Almond Industry STRATEGIC PLAN (2006-2011)[1]:

Industry propagation material backed by nursery or tree accreditation process including agreed nursery standards	• Develop standards for budded trees • Identify and implement accreditation process • Execution of accreditation process
Development and maintenance of the ABA budwood program	• Review sustainability existing plantings to support expansion • Maintain annual virus testing • Increase ABA budwood program by 50% from 2005 plantings • Maintain all accredited budwood sales and marketing activities under ABA control

The review has been timely in that the almond industry has not yet experienced the influx of private importations experienced by the grape, citrus and stone fruit industries. When this occurs in the almond industry, as it inevitably will, it is hoped the almond industry will be well-prepared with structures and systems in place for inclusion of such imports into the industry scion and rootstock multiplication scheme, with adequate resources and expertise devoted to development, improvement and protection of all propagation material in the interests of the national industry.

The purpose of this report was to comprehensively investigate, review and document all factors involved in the commercial production of almond planting material from importation (seed, budwood and pollen) to distribution of budwood, seed and grafted trees. The review has allowed development of a comprehensive framework suitable for further development into a nursery accreditation/certification scheme. The review has assessed the suitability and consistency of terminology, technology, methodology and traceability for points along the production and supply chains.

The report encompasses the results of consultation with a range of people involved in the almond and allied industries (Appendix 1), review and comparison of other Australian and international perennial crop certification and accreditation schemes, and identification of the strengths, weaknesses, threats and opportunities relating to propagule multiplication presenting to the Australian almond industry.

In reviewing the status of the almond industry's planting material, it has been necessary to consider the whole pathway from importation to dispatch of nursery trees. The components and steps of a high health planting material multiplication scheme in horticultural perennial crops are simplified as:

1) Sources (imported or local, budwood, rootstock seed);
2) Health status determination;
3) Repository for high health status material;
4) Evaluation site/s of relevant, clean material;
5) Multiplication (rootstocks, scion budwood);
6) Maintenance of health status and identity;

[1] http://www.aussiealmonds.com

7) Dispatch of planting material from scheme;
8) Production of nursery trees

Components of the planting material pathway may involve Commonwealth and State governments, the industry peak bodies, nurserymen and almond growers, independent providers (i.e. diagnostics, auditing etc) or a combination of all. The ABA pathway to healthy planting material is reliant as it stands today, on the Australian Quarantine and Inspection Service (AQIS), State government-based laboratories, Ausbuds, the University of Adelaide, and independent nurseries. The focus and critical component of the current pathway is the Monash scion multiplication block (Monash). Its success is affected by other components and gaps in the scheme. This review discusses the potential benefits of, and need for, expansion of the pathway and all steps that contribute to the overall quality and supply of almond planting material.

There is an underlying assumption in this report, supported by industry members whom we consulted, that a high health status, industry-supported planting material improvement and supply scheme for material of relevance to the industry has been, and will remain, critical to industry development. It is also acknowledged that the safeguards originally afforded by the very limited number of importers and strong quarantine regulations, are changing and that today's industry must identify, debate and incorporate new safeguards in their industry that allow sustainability and security of the investment in orchards, while retaining the rights of individuals to make their own business decisions.

There are external influences likely to affect the industry, almond improvement generally, and more specifically the multiplication scheme. These include: water restrictions, increasing number of importations of proprietary lines, inconsistent (and less predictable) demand for planting material, increasing willingness to litigate, increasing influence of the competition policy on industry policy and structures, increasing awareness of biosecurity as a national issue, technological advancements in pathogen detection that outstrip field pathology, and the increasing dedication of resources to risk management. It is such issues that may prove to be the drivers for further almond industry development in the area of propagation material and its management.

2 REVIEW OF AUSTRALIAN ALMOND BUDWOOD AND SEED MULTIPLICATION AND IMPROVEMENT SCHEME

2.1 The Status of Australia's Almond Industry

The Australian almond industry has dramatically expanded over the past four decades, with production growing from 790 tonnes in 1960 to approximately 16,000 tonnes in 2006 (http://www.aussiealmonds.com) and 26,000 tonnes (kernel) in 2007 (ABA, 2007). The acreage has increased seven-fold since 1999. Production is expected to almost treble over the course of the next decade as strong planting activity and productivity gains continue to take effect. It is predicted that the productive capacity by 2015 will be 77,000 tonnes.

Total Australian almond plantings as of 2006/07 are estimated at 25,900 hectares (64,000 acres), with more than half (55%) of the plantings at this stage, being non-bearing. Less than 15% of the plantings have reached full maturity (ABA, 2007). Nonpareil is the predominant variety, comprising just over half of total plantings, followed by Carmel and Price varieties (Table 1). More than 80% of 2006 plantings took place in the state of Victoria. It should be noted that these data do not account for plantings in previous years that have since been removed[2] .

[2] http://www.investsmart.com.au/distributions/documents/Timbercorp_AdviserEdge_Almond_Research_2006.pdf

Australian food manufacturers and consumers remain the largest market for Australian almonds. The current farm gate value is estimated at $150 million. The industry however is gaining a greater export focus with the value of exports now estimated at more than $50 million (ABA, 2007). The industry today has a total estimated value of $600 million with expectations this will rise to $2 billion when full production is achieved in 2015 (ABA, 2007).

The Australian almond industry has been based entirely on the selection of chance seedlings or imported material. Imported material was generally commercial or in the advanced testing stage in California and was often prioritised by the Australian Almond Improvement Society (AAIS), after consideration of input from retired University of California Co-operative Extension, Farm Advisor, Mr Don Rough and from published data on varietal traits in California. Still today the Australian industry is based on Californian cultivars with half the trees planted being Nonpareil. The orchards are planted also with pollinators chosen for their flowering time. The currently favoured pollinators are Carmel, Peerless and Price, with growing interest in Monterey.

Until recently the Australian almond industry had relied entirely on three rootstocks: almond seedling, Nemaguard peach, and Bright's hybrid (peach x almond). Bright's hybrid is, within the Australian almond context, generally referred to as 'hybrid'. The focus is now on GF677, a French peach x almond hybrid.

Table 1: Almond planting composition by variety in 2006

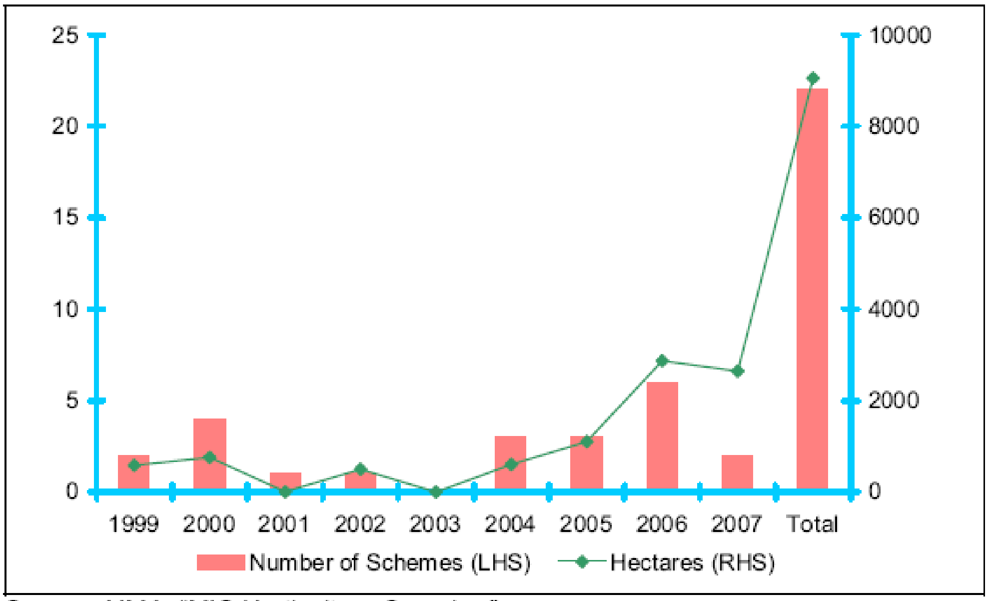
Variety	Tonnage (Kernel Equivalents)	
	2006	% of total
Baxendale	163.22	1.0%
Carmel	4,245.83	26.7%
Chellaston	59.48	0.4%
Davey	0.00	0.0%
Fritz	248.53	1.6%
Johnston	30.30	0.2%
Keene	112.06	0.7%
Mission	272.69	1.7%
Monterey	5.40	0.0%
Ne Plus	594.42	3.7%
Nonpareil	7,988.84	50.2%
Peerless	491.44	3.1%
Price	902.51	5.7%
Somerton	6.00	0.0%
Other	795.83	5.0%
TOTAL	**15,916.61**	**100.0%**

Source: Extract from Australian Almond Production (Document Date: 1 September 2006)

An independent report on the status of Managed Investment Schemes (MIS) in horticulture by consultants, Econtech Pty Ltd., commissioned by Agriculture Investment Managers of Australia and Horticulture Australia Limited (HAL) (project number HG06115) and entitled, *Independent Review of Managed Investment Schemes Involvement in Horticulture* states that although Australia contributes only around 2-3 per cent of the world supply, producing 11,775 tonnes of almonds in 2004/05, the Australian almond industry has been growing at an annual compound rate of approximately 11 per cent since 1960 and it is currently undergoing a period of accelerated growth. The report conservatively predicts almond production will increase threefold to approximately 50,000 tonnes in 2012[3] and that there are approximately 9,055 hectares of land dedicated to MIS almond orchards and around 22 schemes (Figure 1). Victoria accounts for the majority of the MIS almond plantations, with 94 per cent of total MIS plantations by area.

[3] Great Southern, *"2007 Almond Income Project. Product Disclosure Statement"*

Figure 1 : Number of MIS and Hectares of Land Dedicated to MIS in the Almond Industry



Source: AIMA, "MIS Horticulture Overview".

Through visual observation alone, it is fair to conclude that most almond trees planted in Australian orchards establish well, grow as expected, and produce above average yields of good quality nuts. It is our view that the current health status of almonds is the result of significant contributions from those who planned and established Monash, those who have been committed to establishing orchards with propagation material from Monash, and a significant amount of good fortune.

There are many almond pests and diseases that on introduction would threaten the multiplication programme, nurseries and orchards. It is the role of AQIS to minimise the chance of their introduction, but illegal introductions of infected budwood are always a possibility. There are also local threats that could have enhanced economic consequences for the almond scheme and commercial production, in the future. These include more severe strains of some endemic organisms, genetic disorders like non-infectious bud failure (NBF), mixed identity material, poor management and resourcing of the multiplication scheme, and the inclusion of almonds in an eradication campaign for an emergency plant pest (i.e. Plum Pox Virus (PPV) or *Xylella fastidiosa*) for which almonds are not a preferred host. Each of these is discussed in greater detail below.

2.2 History of the ABA Multiplication Block at Monash, SA

The Australian almond industry has a valuable resource in its budwood multiplication block at Monash. It is also the site of primary evaluation of the progeny of the breeding programme.

The development of the Monash site and facility 20 years ago resulted from significant collaboration between the SA Vine Improvement Committee, SA Pome Fruit Improvement Committee, SA Citrus Improvement Society, the AAIS (from 1997), and the Horticultural Research and Development Corporation (HRDC - forerunner of HAL). Most of these bodies no longer exist and with their decline, much 'corporate' history has been lost. The site is still leased from the Riverland Vine Improvement Committee.

Although it is inferred in various reports that the Monash mother trees were originally propagated from, and traceable to, foundation material, the location of some of the foundation trees today, is unknown. Original trees from quarantine are highlighted in the following Monash map (Figure 2). The collection includes foundation trees in row 1A on Okinawa rootstock, which was the rootstock of choice for indexing in AQIS Post-Entry Quarantine (PEQ) at Knoxfield. Almonds on Okinawa are generally identifiable because of their tendency for scion ‘overgrowth’. This knowledge may allow other foundation trees within the collection to be identified.

Other ‘original’ trees were propagated specifically for the Monash collection (by Neil Grant, SARDI) onto Nemaguard. The complete map of Monash is included in Appendix 2. Gathercole (2001) noted that releases of foundation material from Knoxfield were directed to Loxton, but it is also known that some went to Northfield in SA and later to the University of Adelaide’s Waite precinct. The consolidation of the *Prunus* repository in NSW to Victoria, the move of the Victorian foundation collection from the Department of Agriculture Burnley to Frankston and then to Ausbuds, also contributed independently and collectively to the loss of historical knowledge of Monash’s foundation trees.

Figure 2 : Monash map indicating foundation trees

MONASH FIELD PLAN - V2.0

CITRUS PLANTINGS | CITRUS PLANTINGS

	Rows	A19	A18	A17	A16	A15	A14	A13	A12	A11	Rows	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	
	Variety	PeerlessNFC	CARMEL	FRITZ	PeerlessHRU	Mission128/1	PRICE	Nonpareil 15-1	Nonpareil 15-1	Neplus Ultra	Variety	Nonpareil 12	Nonpareil 11	Nonpareil 10	Nonpareil 9	Nonpareil 8	Nonpareil 7	Nonpareil 6	Nonpareil 5	Nonpareil 4	Mixed	
	Tree No.										Tree No.											
	1	A19-1	A18-1		A16-1	A15-1	A14-1	A13-1	A12-1	A11-1	1	A10-1	A9-1	A8-1	A7-1	A6-1	A5-1	A4-1	A3-1	A2-1		
	2	A19-2	A18-2		A16-2	A15-2	A14-2	A13-2	A12-2	A11-2	2	A10-2	A9-2	A8-2	A7-2	A6-2	A5-2	A4-2	A3-2	A2-2		
	3	A19-3	A18-3		A16-3	A15-3	A14-3	A13-3	A12-3	A11-3	3	A10-3	A9-3	A8-3	A7-3	A6-3	A5-3	A4-3	A3-3			
A	4	A19-4	A18-4		A16-4	A15-4	A14-4	A13-4	A12-4	A11-4	4	A10-4	A9-4	A8-4	A7-4	A6-4	A5-4	A4-4	A3-4	A2-4		
P	5	A19-5	A18-5		A16-5	A15-5	A14-5	A13-5	A12-5	A11-5	5	A10-5	A9-5	A8-5	A7-5	A6-5	A5-5	A4-5	A3-5	A2-5		
P	6	A19-6	A18-6		A16-6		A14-6	A13-6	A12-6	A11-6	6	A10-6	A9-6	A8-6	A7-6	A6-6	A5-6	A4-6	A3-6	A2-6	210 (Wood Colony)	
L	7	A19-7	A18-7			A15-7	A14-7	A13-7	A12-7	A11-7	7	A10-7	A9-7	A8-7	A7-7	A6-7	A5-7	A4-7	A3-7	A2-7	211 (Wood Colony)	
E	8	A19-8	A18-8		A16-8		A14-8	A13-8	A12-8	A11-8	8	A10-8	A9-8	A8-8	A7-8	A6-8	A5-8	A4-8	A3-8	A2-8	212 (Livingston)	
S	9	A19-9	A18-9		A16-9	A15-9	A14-9	A13-9	A12-9		9	A10-9	A9-9	A8-9	A7-9	A6-9	A5-9	A4-9	A3-9	A2-9	213 (Livingston)	
	10	A19-10	A18-10		A16-10		A14-10	A13-10	A12-10	A11-10	10	A10-10	A9-10	A8-10	A7-10	A6-10	A5-10	A4-10	A3-10	A2-10	214 (Ne Plus Ultra)	S
	11	A19-11	A18-11		A16-11		A14-11	A13-11	A12-11	A11-11	11	A10-11	A9-11	A8-11	A7-11	A6-11	A5-11	A4-11	A3-11	A2-11	215 (Ne Plus Ultra)	C
	12	A19-12	A18-12		A16-12	A15-12	A14-12	A13-12	A12-12	A11-12	12	A10-12	A9-12	A8-12	A7-12	A6-12	A5-12	A4-12	A3-12	A2-12	216 (Butte 1)	R
	13	A19-13	A18-13		A16-13	A15-13	A14-13	A13-13	A12-13	A11-13	13	A10-13	A9-13	A8-13	A7-13	A6-13	A5-13	A4-13		A2-13	217 (Butte 1)	U
	14	A19-14	A18-14		A16-14	A15-14	A14-14	A13-14	A12-14	A11-14	14	A10-14	A9-14	A8-14	A7-14	A6-14	A5-14	A4-14	A3-14	A2-14	218 (Butte 2)	B
	15	A19-15	A18-15		A16-15	A15-15	A14-15	A13-15	A12-15	A11-15	15	A10-15	A9-15	A8-15	A7-15	A6-15	A5-15	A4-15	A3-15	A2-15	219 (Butte 2)	
	16	A19-16	A18-16			A15-16	A14-16	A13-16	A12-16		16	A10-16	A9-16	A8-16	A7-16	A6-16	A5-16	A4-16	A3-16	A2-16	220 (Padre)	
	17	A19-17	A18-17				A14-17	A13-17	A12-17		17	A10-17	A9-17	A8-17	A7-17	A6-17	A5-17	A4-17	A3-17	A2-17	221 (Padre)	
	18		A18-18		A16-18	A15-18	A14-18	A13-18	A12-18		18	A10-18	A9-18	A8-18	A7-18	A6-18	A5-18	A4-18	A3-18	A2-18	222 (Sonora)	
	19	A19-19	A18-19		A16-19	A15-19	A14-19	A13-19	A12-19	A11-19	19	A10-19	A9-19	A8-19	A7-19	A6-19	A5-19	A4-19	A3-19	A2-19	223 (Sonora)	
	20	A19-20	A18-20			A15-20	A14-20	A13-20	A12-20		20	A10-20	A9-20	A8-20	A7-20	A6-20	A5-20	A4-20	A3-20	A2-20	224 (Monterey)	
	21	A19-21	A18-21		A16-21			A13-21	A12-21	A11-21	21	A10-21	A9-21	A8-21	A7-21	A6-21	A5-21		A3-21	A2-21	225 (Monterey)	
	22	A19-22			A16-22	A15-22		A13-22	A12-22	A11-22	22	A10-22	A9-22	A8-22	A7-22	A6-22	A5-22	A4-22	A3-22	A2-22	226 (Monterey)	
	23	A19-23	A18-23		A16-23	A15-23		A13-23	A12-23	A11-23	23	A10-23	A9-23	A8-23	A7-23	A6-23	A5-23	A4-23	A3-23	A2-23		
	24	A19-24	A18-24					A13-24	A12-24	A11-24	24	A10-24		A8-24	A7-24	A6-24	A5-24	A4-24	A3-24	A2-24		
	25	A19-25	A18-25					A13-25		A11-25	25	A10-25	A9-25	A8-25	A7-25	A6-25	A5-25	A4-25	A3-25	A2-25		
	26		A18-26					A13-26		A11-26	26	A10-26		A8-26	A7-26	A6-26	A5-26	A4-26	A3-26	A2-26		

HEADLAND | HEADLAND

Rows	19B	18B	17B	16B	15B	14B	13B	12B	11B	Rows	10B	9B	8B	7B	6B	5B	4B	3B	2B	1B
Tree No.	CARMEL p'05	CARMEL p'99	CARMEL p'99	CARMEL p'05		PRICE p'99	onpareil 15-1 p(	onpareil 15-1 p(	Nonpareil 15-1 p05	Tree No.	Nonpareil 4 p05	Nonpareil 4 p05	Nonpareil 12 p05	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
1	B19-1 /hybrid		B17-1	B16-1 /hybrid	GF677 (p05)	B14-1	B13-1	B12-1		1		B9-1								
2	B19-2 /hybrid	B18-2		B16-2 /hybrid	GF677 (p05)	B14-2	B13-2	B12-2		2	B10-2	B9-2		22-120 (pl04)	Tardy NP (t/t)(pl03	R486 Ferragnes(pl(	Alnem88 mutant	Sonora (pl 01)	H184 (pl2001)	R916 Lauranne (pl 01)
3	B19-3 /hybrid		B17-3	B16-3 hybrid	GF677 (p05)	B14-3				3	B10-3			22-120 (pl04)	Tardy NP (t/t)(pl03	R486 Ferragnes(pl(	Ferrastar (pl03)	Sonora (pl 01)	H184 (pl2001)	R916 Lauranne (pl 01)
4	B19-4 /hybrid	B18-4	B17-4	B16-4 /hybrid	GF677 (p05)	B14-4	B13-4	B12-4	B11-4	4	B10-4	B9-4	B8-4	155 (pl04)	Tardy NP (t/t)(pl03	GF749 PxA	Ferrastar (pl03)	Sonora (pl 01)	AI27-18 PxA (pl0	R916 Lauranne (pl 01)
5	B19-5 /hybrid		B17-5	B16-5 /hybrid	GF677 (p05)	B14-5	B13-5			5	B10-5	B9-5		155 (pl04)	Parkinson (t/t)(pl03	GF749 PxA	Ferrastar (pl03)	Sonora (pl 01)	GF677 PxA (pl03	R916 Lauranne (pl 01)
6	B19-6 /hybrid	B18-6	B17-6	B16-6 /hybrid	GF677 (p05)	B14-6	B13-6			6	B10-6	B9-6		12-350 (pl04)	Parkinson (t/t)(pl0	GF749 PxA	Ferrastar (pl03)	Sonora (pl 01)	GF557 PxA (pl03	R916 Lauranne (pl 01)
7	B19-7 /hybrid	B18-7	B17-7	B16-7 /hybrid	GF677 (p05)	B14-7	B13-7	B12-7	B11-7	7	B10-7	B9-7	B8-7	12-350 (pl04)	Parkinson (t/t)(pl0	R1049 (pl03)	Guara (pl03)	Butte#1 (pl01)	Alnem88 mutant	R916 Lauranne (pl 01)
8	B19-8 /hybrid	B18-8	B17-8	B16-8 /hybrid	GF677 (p05)	B14-8	B13-8	B12-8	B11-8	8	B10-8	B9-8	B8-8	21-169 (pl04)	Chellaston (t/t)(pl0	R1049 (pl03)	Guara (pl03)	Butte#1 (pl01)	R1146 (pl03)	Avalon (pl 01)
9	B19-9 hybrid	B18-9	B17-9	B16-9 hybrid	GF677 (p05)	B14-9	B13-9	B12-9	B11-9	9		B9-9	B8-9	21-169 (pl04)	Chellaston (t/t)(pl0	R1049 (pl03)	Guara (pl03)	Butte#1 (pl01)	R1146 (pl03)	Avalon (pl 01)
10	B19-10 hybrid	B18-10	B17-10	B16-10 /hybrid	GF677 (p05)	B14-10	B13-10	B12-10	B11-10	10	B10-10	B9-10	B8-10	Marta (pl04)	Chellaston (t/t)(pl0	R1049 (pl03)	Guara (pl03)	Butte#1 (pl01)	R1146 (pl03)	Avalon (pl 01)
11	B19-11 hybrid	B18-11	B17-11	B16-11 /hybrid	GF677 (p05)	B14-11	B13-11	B12-11	B11-11	11	B10-11	B9-11	B8-11	Marta (pl04)	Somerton (t/t)(pl03	R887 (t/t)(pl03)	Supernova ('03)	Butte#1 (pl01)	R1146 (pl03)	R937 Moncayo (pl 01)
12	B19-12 /hybrid	B18-12	B17-12	B16-12 /hybrid	GF677 (p05)	B14-12	B13-12	B12-12	B11-12	12	B10-12	B9-12	B8-12	Glorieta (pl04)	Somerton (t/t)(pl03	R887 (t/t)(pl03)	Supernova ('03)	Monterey (pl01)	Mandaline (pl03)	R937 Moncayo (pl 01)
13	B19-13 /hybrid	B18-13	B17-13	B16-13 /hybrid	GF677 (p05)	B14-13	B13-13	B12-13	B11-13	13	B10-13	B9-13	B8-13	Glorieta (pl04)	Somerton (t/t)(pl03	R887 (t/t)(pl03)	Supernova ('03)	Monterey (pl01)	Mandaline (pl03)	R932 Francoli (pl03)
14	B19-14 hybrid	B18-14	B17-14	B16-14 hybrid	GF677 (p05)	B14-14	B13-14		B11-14	14	B10-14	B9-14	B8-14	Supernova (pl04	Fritz (t/t)(pl03)	R887 (t/t)(pl03)	Supernova ('03)	Monterey (pl01)	Mandaline (pl03)	R928 Masbovera (pl03)
15	B19-15 /hybrid	B18-15	B17-15	B16-15 hybrid	GF677 (p05)	B14-15	B13-15	B12-15	B11-15	15	B10-15	B9-15	B8-15	Supernova (pl04	Fritz (t/t)(pl03)	Ferragnes (pl03)	Steliette (pl03)	Monterey (pl01)	Mandaline (pl03)	R185 Marcona (pl03)
16	B19-16	B18-16	B17-16	B16-16 hybrid	GF677 (p05)	B14-16	B13-16	B12-16	B11-16	16	B10-16	B9-16	B8-16	Ferralise (pl04)	Fritz (t/t)(pl03)	Ferragnes (pl03)	Steliette (pl03)	Monterey (pl01)	Butte#2 (pl '01)	R998 Mandaline (pl03)
17	B19-17	B18-17	B17-17	B16-17 hybrid	GF677 (p05)	B14-17	B13-17	B12-17	B11-17	17	B10-17	B9-17	B8-17	Ferralise (pl04)	Sauret #1 (t/t)(pl03	Ferragnes (pl03)	Steliette (pl03)	Padre (pl 01)	Butte#2 (pl '01)	R1146 (pl03)
18	B19-18	B18-18	B17-18	B16-18 hybrid	GF677 (p05)	B14-18	B13-18		B11-18	18	B10-18	B9-18	B8-18	Francoli (pl04)	Sauret #1 (t/t)(pl03	Ferragnes (pl03)	Steliette (pl03)	Padre (pl 01)	Butte#2 (pl '01)	R943 Supernova (pl03)
19	B19-19	B18-19	B17-19	B16-19 hybrid	GF677 (p05)	B14-19		B12-19	B11-19	19	B10-19	B9-19	B8-19	Francoli (pl04)	Keanes (t/t)(pl03)	Ferraduel (pl03)	R1148 (pl03)	Padre (pl 01)	Butte#2 (pl '01)	R975 Steliette (pl03)
20	B19-20	B18-20	B17-20	B16-20 hybrid	GF677 (p05)	B14-20	B13-20	B12-20	B11-20	20	B10-20	B9-20	B8-20	Masbovera (pl04	Keanes (t/t)(pl03)	Ferraduel (pl03)	R1148 (pl03)	Padre (pl 01)	Butte#2 (pl '01)	R269 Ai (pl03)
21	B19-21	B18-21	B17-21	B16-21 hybrid	GF677 (p05)	B14-21	B13-21	B12-21	B11-21	21	B10-21	B9-21	B8-21	Masbovera (pl04	Keanes (t/t)(pl03)	Ferraduel (pl03)	R1148 (pl03)	Padre (pl 01)	Livingston (pl 01)	R934 Guara (pl03)
22	B19-22	B18-22	B17-22	B16-22 hybrid	GF677 (p05)	B14-22	B13-22	B12-22	B11-22	22	B10-22	B9-22	B8-22	Antoneta (pl04)	21-323 (pl05)	Ferraduel (pl03)	R1148 (pl03)	Wood Colony(01	Livingston (pl 01)	R800 Ferrastar (pl03)
23	B19-23	B18-23	B17-23	B16-23 hybrid	GF677 (p05)	B14-23	B13-23	B12-23	B11-23	23	B10-23	B9-23	B8-23	Antoneta (pl04)	21-323 (pl05)	R1065 (pl03)	R1066 (pl03)	Wood Colony(01	Livingston (pl 01)	R929 Glorieta (pl03)
24	B19-24	B18-24	B17-24	B16-24 hybrid	GF677 (p05)	B14-24	B13-24	B12-24	B11-24	24	B10-24	B9-24	B8-24	Fascionello (pl04	21-332 (pl05)	R1065 (pl03)	R1066 (pl03)	Wood Colony(01	Livingston (pl 01)	R1065 (pl03)
25	B19-25	B18-25	B17-25	B16-25 hybrid	GF677 (p05)	B14-25	B13-25	B12-25	B11-25	25	B10-25	B9-25	B8-25	Fascionello (pl04	21-332 (pl05)	R1065 (pl03)	R1066 (pl03)	Wood Colony(01	Livingston (pl 01)	R485 Ferraduel (pl03)
26	B19-26	B18-26	B17-26	B16-26 hybrid		B14-26		B12-26	B11-26	26	B10-26	B9-26	B8-26		AI28-19 (pl05)	R1065 (pl03)	R1066 (pl03)	Wood Colony(01)		R1049 (pl03)
27	B19-27	B18-27	B17-27	B16-27 /hybrid		B14-27	B13-27	B12-27	B11-27	27	B10-27	B9-27								

UPDATED:
Date: 04/10/07
By: MW

Notes:

t/t =	has undergone thermotherapy
pl=	planted in year eg pl03 = planted 2003
A128-19	Tag lost at planting, chech with DNA against example at Waite
21-332 and 21-323	CAUTION: numbers confusing and potential for error.

R'stock cuttings

2.2.1 Fruit Variety Foundation (FVF)

In 1961 plant virologists recognized the importance of establishing an area within Australia where local virus-tested fruit selections and those imported from overseas through plant quarantine stations, could be protected from re-infection. Because of interstate quarantine restrictions etc associated with the establishment of a field repository in one site, it was not until 1971 that it was decided to establish, over a 5-year period, units for holding mother stock of approved virus-tested varieties in facilities associated with certain establishments of State Departments of Agriculture. These were funded 50:50 Commonwealth/state basis, with state contributions based on their producing acreage of the particular crop (Handout: "Stud Buds. Fruit Variety Foundation (FVF) virus tested"; Smith, 1983; McLean and Revill, 1989).

The responsibility for maintenance of foundation trees of almonds initially lay with NSW Department of Agriculture in an insect-proof screenhouse at Rydalmere. Peaches were held in a screenhouse at Burnley, Victoria. Only 3 almond clones (Mission, Nonpareil and Peerless) ever went into the NSW repository. Other imports as indicated in Table 2 went from PEQ mostly to Northfield (SA), but also to Burnley, Knoxfield, Merbein and the Waite Institute of the University of Adelaide. An import of Nemaguard (presumably budwood) went to Northfield in 1974.

It was recognized that the establishment and maintenance of foundation or source plantings is fundamental to the development of propagation programmes. But the FVF had problems which in part resulted from its direction being provided only from plant health, rather than horticultural performance considerations (Paulin, 1990).

A review of FVF in 1989 recommended that FVF functions for stone fruit and citrus be fully funded by industry, but recommended that FVF continue in its current form with funding until 1993/4. Plant Health Committee (PHC) rejected the proposal for extended funding and recommended that government funding cease in 1991 with the future of FVF to be decided on the basis of financial support from industry. PHC believed that a mechanism existed for industry to contribute and attract matching government support through HRDC (now HAL) and this was endorsed by Standing Committee for Agriculture in 1990 (Blackstock, 1990). An Australian Horticultural Propagation Workshop was held at Gosford NSW in 1990 and attended by representatives of each of the perennial horticultural industries to determine how they would address the situation. Only the pome fruit and citrus industries rose to the challenge and today have multiplication schemes that include repositories of foundation trees.

There are several references in the form of funding submissions (Gathercole, 1997a and 1997b) and a project report (Gathercole, 1996), that reveal the strategy undertaken towards improvement of almond scion and rootstock material. Unfortunately there appears to be no collated, historical record of all almond imports and their various passages from AQIS PEQ to inclusion in FVF repositories to Burnley, Frankston, Knoxfield, Ausbuds, Northfield, Loxton and/or Monash. It is the recollection of Dr Richard Hamilton, former SA Dept Agriculture virologist, that the Monash mother trees were propagated directly from foundation trees, most of which were located at Northfield or Loxton. The original indexing of foundation material was carried out at Burnley (DPI Victoria) and repeated at Northfield, prior to the planting of mother trees in SA. Nurserymen Greg and Fred Keane were instrumental in the propagation of the mother trees.

There are differing recollections of the origin of the original Carmel clone introduced to the Monash block. Some believe it was from a clone illegally introduced, whereas others are of the firm opinion the original Monash Carmel trees were propagated directly from foundation material of a legal entry. There is broad agreement that the clone, regardless of its specific origin or condition of entry, was from California and that it has been successful and productive.

Importation details until 1996, were made available to horticultural industries in AQIS' List of Fruit Imports, but such information is no longer published. There are existing records of *Prunus* entries into Frankston and these are included in the Table of Varieties Imported in Appendix 3. More recent records of entries of almond material (including those intended only for breeding purposes) from various sources have been collated in Table 2. Those shown in bold print are established at Monash. In some cases the accession numbers and variety characteristic information released to growers, was assigned and developed in California, not Australia. Many clones of almond propagation material (scions, rootstocks, pollen) have been brought into Australia during the last 10-15 years, mostly by ABA, for commercial testing under test agreements and for breeding purposes.

Table 2 : List of Almond Imports in the last 15 years

Variety/Scion	Clone	Accession Number	PEQ Date	RD Date	Outcome	Source material	Quarantine Station
155*			*0102		RLSD	IRTA	
12-350*			*0102		RLSD	IRTA	
21-169*			*0102		RLSD	IRTA	
21-323*			*0102		RLSD	IRTA	
21-332*			*0102		RLSD	IRTA	
22-120*			*0102		RLSD	IRTA	
Ai*	**R269**		*0101		RLSD	INRA	
All-In-One*	3W59	IV863031	0986	0988	RLSD		PRI Burnley
Antoneta*			*1201		RLSD	CSIC	
Avalon			0398	*0602	RLSD	Burchell	
Butte 353188			0296	?	?		Knoxfield
Butte 353288*			0296	0399	RLSD		Knoxfield
Butte 353791			0196	0399	?		
Carmel*		IS825090	1182	0985	RLSD		Northfield
Desmayo Largueta*			2005	1007	RLSD	IRTA	Knoxfield
Fascionello*			1101	0404	RLSD	Italy, Uni Bari	Knoxfield
Felisia*			2005	1007	RLSD	IRTA	Knoxfield
Ferraduel*	R485		*0101		RLSD	INRA	
Ferragnes*	R486		*0101		RLSD	INRA	
Ferrastar*	R800		*0101		RLSD	INRA	
Francoli*	R932		*0101		RLSD	INRA	
Francoli*			*0102		RLSD	IRTA	
Glorieta*	R929		*0101		RLSD	INRA	
Glorieta*			*0102		RLSD	IRTA	
Guara*	R934		*0101		RLSD	INRA	
Lauranne	R916			0301	RLSD	INRA	Knoxfield
Le Grand		IS825091	1182	0985	RLSD		Northfield
Livingston*			0196	0398	RLSD	Burchell	Knoxfield
Mandaline*	R998		*0101		RLSD	INRA	
Marcona*	R185		*0101		RLSD	INRA	
Marta*			1201		RLSD	CSIC	
Masbovera*	R928		*0101		RLSD	INRA	
Masbovera*			*0102		RLSD	IRTA	
Moncayo	R937		Chance seedling	0602	RLSD		
Mono			0296		DESTROYED		Knoxfield
Monterey 3-62-1-93			0296		?		Knoxfield
Monterey 362193*			0198	0600	RLSD	FPMS	
NE Plus Ultra 37272*			0296	0399	RLSD	FPMS	Knoxfield
Nonpareil	3-8-4-72	IS825092	1282	0985	RLSD		Northfield
Nonpareil	3-8-5-72	IS825093	1282	0985	RLSD		Northfield

Variety/Scion	Clone	Accession Number	PEQ Date	RD Date	Outcome	Source material	Quarantine Station
Nonpareil	3-8-6-72	IS825094	1282	0985	RLSD		Northfield
Nonpareil	3-8-7-72	IS825095	1282	0985	RLSD		Northfield
Nonpareil	3-8-8-72	IS825096	1282	0985	RLSD		Northfield
Nonpareil	3-8-9-72	IS825097	1282	0985	RLSD		Northfield
Nonpareil	3-8-10-72	IS825098	1282	0985	RLSD		Northfield
Nonpareil	3-8-11-72	IS825099	1282	0985	RLSD		Northfield
Nonpareil	3-8-12-72	IS825100	1282	0985	RLSD		Northfield
Padre 329175*			0296	0399	RLSD	FPMS	Knoxfield
R1049*			*0101		RLSD	INRA	
R1065*			*0101		RLSD	INRA	
R1066*			*0101		RLSD	INRA	
R1146*			*0101		RLSD	Israel	
R1147			*0101		DESTROYED	Israel	
R1148			*0101		RLSD	Israel	
R887			*0101		RLSD	Israel	
Sauret 1*			0291		RLSD		Northfield
Sonora			0291		?		Northfield
Sonora 315170			0196	0399	RLSD	FPMS	
Steliette R975*			*0101		RLSD	INRA	
Supernova R943*	Fascionello mutation		*0101		RLSD	INRA	
Tardy Non-Pareil*		IS885511	1088	0591	RLSD		Northfield
Titan		IS775067			?		FVF Sydney Plant B
Wood Colony*			0196	0398	RLSD	Burchell	Knoxfield
SEED							
Lauranne 1	OP Lauranne			*1001	Seeds grown on	Sud Amande	Knoxfield
Lauranne 2	OP Mohassen			*1001	Seeds grown on	Israel via France	Knoxfield
Lauranne 3	Selfed Lauranne				failed to germinate	Newe- Ya'ar via France	Knoxfield
Lauranne 4	OP 887 (in shell)				failed to germinate	Israel via France	Knoxfield
Lauranne 5	OP 887 (kernel)				failed to germinate	Israel via France	Knoxfield
Lauranne P	OP Spiegel cross		*0202		Seeds grown on	Israel	Knoxfield
ROOTSTOCK							
Adafuel AI27-18			*0101		RLSD	Israel	
Adarcia AI28-19			*0101		RLSD	Israel	
GF557			*0101		RLSD	INRA	
GF677			*0101		RLSD	INRA	
GF749			*0101		RLSD	Israel	

Sources: Data from a number of sources: List Fruit Exports 5/3/96, C. Bennett's File, Frankston data (via Ausbuds), Monash data.

INRA= National Institute for Agricultural Research, France; CSIC=CSIRO; Burchell=Burchell Nursery, California; FPMS=Foundation Plant and Seed Materials (now FPS), University of California, Davis, California; IRTA=Institute of Agro-Food Research and Technology, Spain.

Italics – breeding line. **Bold** – present at Monash, * - present at Waite

2.3 Almond Industry Improvement Programme

The Australian almond improvement programme commenced in 1997, with the co-operation of the University of Adelaide, with the aim of developing scion and rootstock cultivars that produce superior product desired by Australian and overseas markets, and are better adapted to local conditions (Sedgley and Collins 2002; Wirthensohn *et al*, 2002). Little breeding has been done for rootstocks. The focus is primarily on scions.

Dr Michelle Wirthensohn of the University of Adelaide directs the Australian Almond Breeding Program in conjunction with the ABA. The hybridisation approach aimed at the generation of diversity has been combined with tissue culture, genetic fingerprinting, genome mapping and transformation research. The programme is currently supported by industry, HAL and the University of Adelaide and has an annual budget of around $250,000. The Australian Research Council (ARC) made significant contributions to the biotechnology work in the past.

The three strategies and key objectives of the Almond Improvement Program are summarised below:

Short-term strategy **Identification and release of superior varieties and rootstocks**	• Identify superior pollinators for Nonpareil • Evaluate and monitor performance of rootstocks
Medium-term strategy **Increase the range of varieties and rootstocks**	• Import best (have potential to perform in Australian conditions) selections from overseas breeding programmes • Ensure ABA has sound arrangements to access and manage patented and controlled material
Long-term strategy **Breed high quality, highly productive and self-fertile varieties for Australian conditions**	• Evaluate progeny to identify those with potential to surpass Nonpareil in commodity market • Evaluate for self-fertility

The Almond Breeding Strategic Plan, includes primary and secondary objectives, which are included in Appendix 4. Missing from the breeding strategy is the breeding of rootstocks. It is expected that the most likely progress in rootstock improvement will be via the short- and medium-term strategies, rather than breeding. The need for rootstock supply however is acknowledged in the Strategic Plan, as indicated below:

Ensure commercial availability of suitable rootstock	• Formulate a plan to ensure availability of high quality rootstock • Evaluate and monitor performance of rootstocks • Develop technology transfer in relation to the above

The almond improvement strategy acknowledges the Australian industry's vulnerability due to reliance on too few cultivars and rootstocks and the potential for disease incursions to render any of these unsuitable under changing environmental conditions. The short-term strategy is focussed on the identification and release of superior pollinators for Nonpareil, and other commercially-proven international varieties and rootstocks. The mid-term strategy is focussed on inclusion of the wide range of material available internationally, especially from the Mediterranean and European industries, into the breeding programme. Breeding parents currently include the Californian cultivars that are the backbone of the Australian industry, local selections and European cultivars with useful characters. The long-term strategy is breeding of new varieties that have high yields of high quality nuts from self-fertile trees. Self-fertility and improved nut quality are ranked highly in the breeding aims.

Inherent in the inclusion of international breeding material is the establishment of agency status of ABA for material that is privately held – either here or overseas. ABA's international collaboration has certainly strengthened in recent years, with a move away from California and towards Europe being obvious.

2.3.1 Scion Breeding

Almond cultivars developed in Australia are thought to have descended from two breeding lines (Woolley *et al.*, 2000) - one from hard-shelled Spanish/Jordan types and the other from paper-shell Californian types. Research has allowed estimation of genetic similarities between 50 accessions of almond cultivars derived from Australia, California, Europe and the Middle East and from individual accessions of *Prunus orientalis* (Miller) D. A. Webb and *Prunus webbii* (Spach) Vieh. The resultant dendogram showed the cultivars known to have originated in Europe or the Middle East clustered separately from those known to have originated in California, thus providing some evidence of the two suspected breeding lines. Specific derivation details for many individual Australian scion and rootstock cultivars are not available.

Scion breeding via controlled hand pollinations began in 1997 using 11 almond cultivars including 'Nonpareil', 'Carmel', 'Ferragnès', 'Le Grand', self-compatible genotypes, and the well-adapted Australian cultivars 'Chellaston', 'Keane's seedling', 'McKinlay's Magnificent' and 'Johnston's Prolific'. Hybridisations are conducted at multiple sites including the Waite Campus of the University of Adelaide, Angle Vale (northern Adelaide Plains) and Loxton in SA's Riverland. Since 1997, the breeding programme has produced over 31,000 seedlings. Of these, 11,000 have been evaluated. Markers have been developed for important characters, so that selection can proceed on young seedlings prior to flowering and fruiting, with savings in time and field space. The seedling progeny are planted at Monash, although some early lines were originally planted at Lindsay Point. Evaluations have been completed on the 1997-2000 progeny, with bud burst and flowering time scored (date and intensity), as well as nut and tree characteristics, such as shelling percentage, kernel taste and size, tree vigour, branching habit, and self-fertility. Consideration has also been given to any evidence of clonal susceptibility to non-infectious bud failure, as experienced in California in Carmel (Kester, 2000; Kester *et al*., 1998; Kester, 1994).

Propagation material in the scheme is screened annually for Prunus Necrotic Ringspot Virus (PNRSV) and Prune Dwarf Virus (PDV) using appropriate biological (budding/grafting), serological (ELISA) and/or molecular (PCR) methods (Mekuria *et al*., 2005; Wirthensohn *et al*., 2003; Bertozzi *et al*., 2002). The most promising selections will be protected by PBR. To progress this, field evaluation trials of 18 cultivars (5 replicates of each) have been established with comparators and reference cultivars, at Lindsay Point, Victoria. There is a small germplasm planting at Simaloo, in SA's Riverland region.

Pollen is a useful source of genetic material and its inclusion in breeding programmes comes with fewer biosecurity risks than with other forms of genetic material for perennials. For example: a few fungi, 39 viruses, and five viroids from a small number of hosts, are pollen-transmitted (or pollen borne), but there are no documented cases of pollen-transmitted nematodes, insects, phytoplasmas, bacteria or invertebrates (Card *et al.*, 2007). Wirthensohn has developed a testing protocol for the detection of PPV in pollen used in the almond breeding programme. New Zealand is currently undertaking research on validation of methods to directly test pollen, rather than via the seed derived from imported pollen (Card *et al*., 2007).

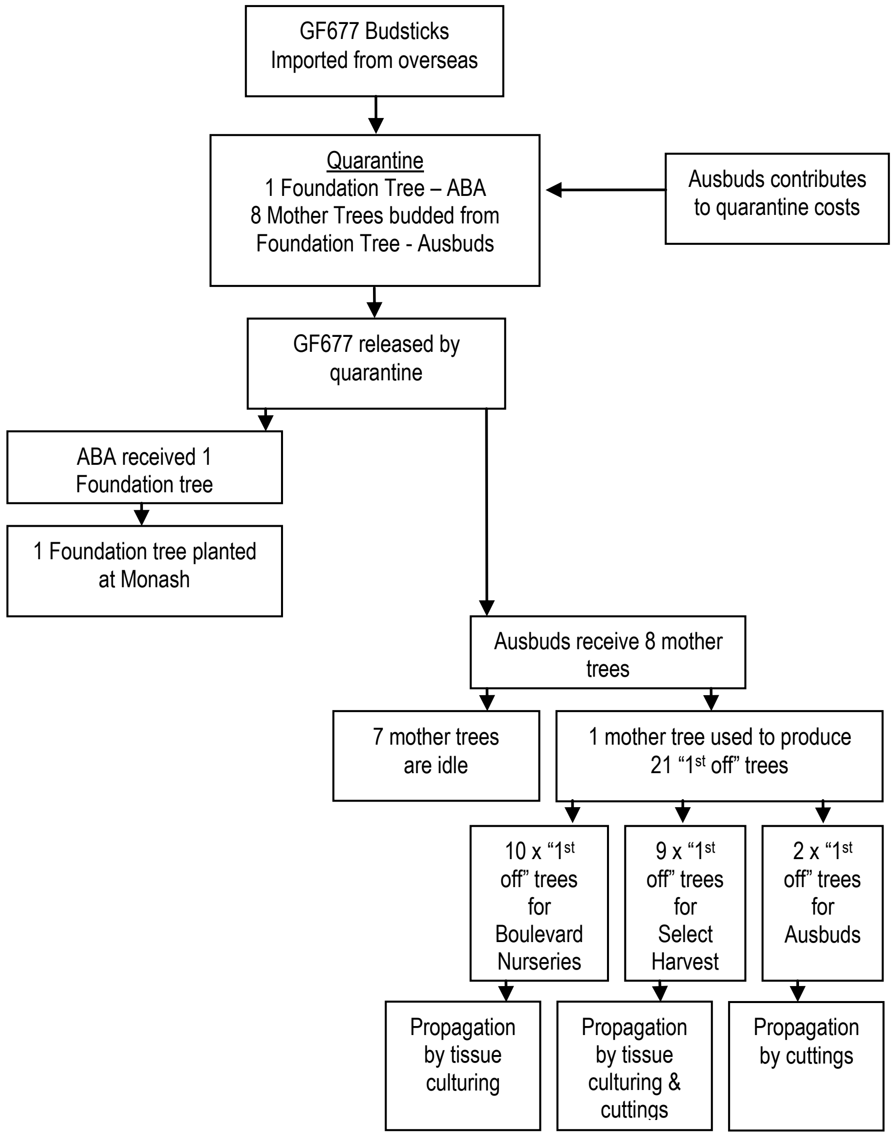
It is unclear who else within Australia is importing pollen of Prunus spp., but presumably there are other importers and if so, harmonisation and validation of pollen diagnostic protocols, is recommended.

2.3.2 Rootstock Improvement

Chris Bennett, former ABA Industry Development Manager, recognised the limited commitment of the industry to rootstock improvement and organised the importation by ABA of rootstocks for both breeding and commercial evaluation, from France, Spain and Israel. Comparative data generated under Australian conditions however are limited. Most characteristics available for grower consideration have been provided from international sources. Of concern to nurseries and growers are a rootstock's nematode (root-knot and lesion) resistance, lime/calcareous soil tolerance, replant site suitability, ease of propagation, compatibility with commercially-important scions, chilling requirements, water use, tolerance of wet feet, drought tolerance, and effects on tree vigour.

Europe's main rootstock, the French peach x almond hybrid 'GF677'[4] has been imported by the ABA and propagation material fully traceable to this importation of GF677 is being increased by Monash, Ausbuds and two approved nurseries. It is likely to become the major industry rootstock over the next decade and the preferred rootstock for trees in any re-development or expansion of the Monash collection. A foundation GF677 tree is planted at Monash, and Ausbuds has retained eight mother trees propagated in PEQ from the foundation budwood. One-off material from these mother trees has been shared with Select Harvests and Boulevarde Nursery, as indicated in the diagram below (Figure 3). Ausbuds is the primary importer of *Prunus*-relevant rootstock material as seed, and this company has a close working relationship with ABA. Ausbuds routinely imports Nemaguard seed, from a range of sources (wholesalers and agents) in California.

Figure 3 : History of ABA-imported (with Ausbuds) GF677



[4] GF677 is referred to in some US literature as Paramount™ - the market name adopted for GF677.

There are at least three variety managers/commercialisers who are importing almond relevant material independently of the industry improvement scheme. Each has established agency status with international breeders, or is part of an international nursery alliance. These importers have brought in rootstocks primarily, but one to our knowledge, has imported both rootstock and scion material.

2.3.3 Biotechnology

The programme has a range of technical pathways, including molecular breeding; evaluation; pathology – especially virus detection and elimination and some limited fungal (anthracnose and *Monilinia* sp.) resistance research; biotechnology assisting germplasm and genetic marker (hard-shell characteristic) identification, micro-propagation and long-term genebank storage through cryopreservation (Channuntapipat *et al*., 2003; Sedgley and Collins, 2002b). Some cultivars and rootstocks (Bright's hybrid, H184) have been successfully multiplied from tissue culture. Genetic fingerprints are available for the almond cultivars grown in Australia (Sedgley and Collins, 2002).

2.3.4 Disease Resistance

Disease resistance research within the breeding programme has focused on general fungal resistance and more specifically on anthracnose (with identification of the Australian isolates of *Colletotrichum acutatum*) (Colmagro *et al*., 2002; Sedgley *et al*., 2000).

The bacterial pathogen, *Xanthomonas arboricola* pv. p*runi* is widespread in stone fruit in Australia, and is suspected of being a nursery problem. An *in vitro* method using detached leaves has allowed assessment of the relative susceptibilities of almond varieties to the peach and almond strains of this bacterial pathogen (Li *et al*., 2004). It is unclear if this method is utilised in the breeding line indexing or if susceptibility to this disease is rated during visual assessments of trees.

2.3.5 Almond Evaluation Trials: Scion and Rootstock

Achievement of desired characteristics of Australian almonds to meet local/export market requirements drives the almond improvement programme. The breeding component of the improvement programme includes on-going evaluations. Relevant data are documented by Wirthensohn in HAL milestone reports (Project number AL99008).

In the past there were few almond evaluation trials established. Yield comparisons of Australian selections of Nonpareil clones were commenced in 1986 (Taylor *et al.*, 1991). Eight Nonpareil almond clones on Nemaguard rootstock were compared in a field trial at Irymple, Victoria, over four cropping seasons (1986-89). Although few significant differences in yield were recorded in any year, the results showed that the Nonpareil clones differed in total yield and in yield per unit of butt cross-sectional area by as much as 50%. Clone K5/7 proved prone to non-infectious bud failure, and clones G11/16 and P7/29 were identified as useful, high-yielding clones for the Australian almond industry. In establishing the Monash budwood supply block, consideration was given to the trends shown in this trial and the three superior clones were selected for inclusion.

Another comparative trial of Nonpareil clones was established in 1992 by Dr Richard Hamilton, at Waikerie. The 11 clones were planted on hybrid rootstocks. It is our understanding that no statistical differences in their performance were found, although the original report on this trial has not been reviewed. At the time and in the absence of flowering data, it was considered difficult to evaluate physiological differences between clones.

Primary Industries SA (PISA - forerunner of SARDI and PIRSA) and the AAIS planted two rootstock trials in 1987 to evaluate the impact of soil type on tree performance. The Lindsay Point trial was established on deep sands and the trial at Loxton on shallow soil over limestone. It has generally been known since that time Nemaguard does not perform well on shallow, calcareous soils and that hybrid rootstock while more tolerant of poorer soils, can cause canopy vigour problems. The specific results indicated that hybrid (Nemaguard × almond) out-yielded all others on both soil types, but only because of its large tree size. On deep soils Nemaguard is next in yielding ability followed by Alnems (Nos 1, 88 and 201). On shallow soil, the Alnems (especially 88) out-yielded Nemaguard. Seedling almond resulted in the lowest yields in both situations. The productivity of the Alnems (yield per unit tree size) was particularly high; that of hybrid was low (see http://www.fao.org/docrep/X5337E/x5337e08.htm).

While today we are recommending that industry drive comparative evaluation trials, it must be done with due prior consideration of exactly how the industry will value and use, disseminate and respond to, the resultant information. All evaluation trials, irrespective of their design, are expensive and require long-term commitment. They should not be embarked upon without clear guidelines, and due consideration of their timing and the relative value of their outcomes.

3 WHY DO WE NEED A BUDWOOD MULTIPLICATION SCHEME?

A budwood multiplication scheme is central to the viability of the Australian almond industry. It has given the industry access to good quality, relevant propagation material of the correct provenance. Industry has supported the scheme by demanding and planting its material.

The major benefit of a scion and rootstock multiplication scheme is access to high health status propagation material and consequently avoidance of the losses which can be caused principally by graft-transmitted pathogens. There are examples within several stone fruit industries of economic losses that have been attributed to the presence of virus and generally low health status, untested rootstock compatibility, unconfirmed provenance and identity. The almond industry is not immune to such situations, but is greatly advantaged by having the Monash budwood multiplication programme.

3.1 Exotic Disease Threats

In a project commissioned in 2006 by Plant Health Australia (PHA), the pest and disease threats to the Australian almond industry were specifically identified (McMichael, 2006). The complete disease list is included in Appendix 5. Many other lists of *Prunus* spp. diseases exist. The AQIS list of exotic Prunus pathogens is included in the draft Prunus PEQ Manual by Mark Whattam (Whattam, 2006) and in Appendix 5. The main exotic threats to Australian almonds are given in Table 3. Six of these pathogens (in bold) are graft-transmissible and therefore of concern to any propagation.

Table 3 : Main exotic disease threats of Australian almonds

Disease Common Name	Causal organism	Economic Importance	Entry Potential	Establishment potential	Spread potential	Rank
Almond leaf scorch	***Xylella fastidiosa***	M-H	M	M	H*	
Hyperplastic canker	*Pseudomonas amygdali*	M	L-M	M	M	
Perennial canker	*Leucostoma cincta* and *L. persoonii*	L-M	L	L-M	M	
Phomopsis canker or constriction canker	*Phomopsis amygdali*	M-H	M	M-H	M-H	
Red leaf blotch	*Polystigma ochraceum*	M	L	M-H	L	
Sharka	**Plum Pox virus**	U-L	M	U-L	M	
Tomato ringspot	**Tomato ringspot nepovirus**	L	L-M	M	M*	
European stone fruit yellows	**European Stone Fruit Phytoplasma**	M	L-M	L-M*	M*	
Almond brownline and kernel shrivel	**Peach Yellow Leafroll Phytoplasma**	M	L-M	L	L*	
Western X disease	**Western X phytoplasma**	L	L-M	L	L*	

Rating scale: L= low; M=Medium; H=High; U=Unknown
*Vector dependent
Bold = graft transmissible
Source: McMichael, 2006.

3.2 Endemic Disease Threats

The endemic pathogens of Australian almonds are capable of causing economic losses in multiplication blocks, nurseries and/or commercial plantings. They are listed in Table 4. Of particular importance to budwood and rootstock schemes are viral, viroid, and phytoplasma pathogens, and genetic disorders. There are no controls for such threats once trees are planted.

Economic losses in commercial orchards are also incurred routinely as the result of bacterial and fungal endemic pathogens. The losses however extend beyond yield losses and chemical costs. Bacterial spot for example, has affected the entire industry as it has resulted in a widely-grown variety becoming prematurely obsolete and uneconomic. Bacterial spot was first reported in Australian almonds in 1994/95 on Fritz and Ne Plus. Fritz is highly susceptible and given the propensity of the disease to cause young tree losses, growers are no longer choosing to plant this variety and many have removed it from their orchards. This serves as a useful reminder of the importance of disease susceptibility screening in evaluation trials, and in choosing promising varieties from international collections.

Table 4 : Endemic diseases of economic importance in Australian almond budwood multiplication schemes or nurseries

Scientific Name	Status*	Disease	References	Other Hosts	Distribution
BACTERIAL DISEASES					
Pseudomonas syringae pv. *syringae* van Hall 1902	B	Bacterial canker	APPD, Teviotdale *et al* 2002, APSNet	Wide - woody perennials esp Prunus	Worldwide
Agrobacterium tumefaciens (Smith & Townsend 1907) Conn 1942	N	Crown gall	Teviotdale *et al* 2002, APSNet	Wide – woody and herbaceous	Worldwide
Xanthomonas arboricola pv. *pruni* (Smith 1903) Vauterin *et al.* 1995 = *X. campestris* pv *pruni* (Smith 1903) Dye 1978	B, N	Bacterial spot	APPD, Teviotdale *et al* 2002, Ogawa *et al* 1995, APSNet	Two highly susceptible almond varieties. Stone fruit	Worldwide
FUNGAL DISEASES					
Chondrostereum purpureum (Pers.:Fr) Pouzar	B	Silver leaf	Ogawa *et al* 1995	Stone fruit	Worldwide
Colletotrichum acutatum J.H. Simmonds	B	Anthracnose	Teviotdale *et al* 2002, APPD, Colmagro *et al* 2002	Strawberry, avocado, citrus, peach , apple	USA, Australia, Israel
Monilinia laxa (Aderh. & Ruhl.) Honey *Monilia* sp. [anamorph]		Brown rot, green fruit rot, hull rot	APPD, Teviotdale *et al* 2002, APSNet, Ogawa *et al* 1995	Stone fruit	Worldwide – temperate zones
Phytophthora spp.	N	Phytophthora root, trunk, collar and/or crown rot	Farr *et al* 1995, Teviotdale *et al* 2002, APSNet		Wide distribution – temperate zones
Tranzschelia discolor (Fuckel) Tranzschel & Lit. Syn. *T. pruni-spinosae* var *discolour*	B, N	Stone fruit (prune) rust	Farr *et al* 1995, APPD, APSNet, Teviotdale *et al* 2002	Wide host range in Prunus.	Worldwide
Verticillium dahliae Kleb. = *Verticillium albo-atrum (some severe strains)*	N	Verticillium wilt	Farr *et al* 1995, APSNet, Teviotdale *et al* , APPD	Very wide	Worldwide. Defoliating strains with more limited distribution
Wilsonomyces carpophilus (Lev.) Adaskaveg, Ogawa & Butler = *Stigmina carpophila* (Lev.) M. B. Ellis	B, N	Shot hole	Teviotdale *et al* 2002, Ogawa *et al* 1995, APSNet, APPD	Stone fruit	Temperate world
VIRAL DISEASES					
Apple mosaic virus. Not known to be economically important in almonds	N	Almond mosaic	Teviotdale *et al* 2002, Ogawa *et al* 1995; APSNet, GREMPA Portugal (p193)	Many *Rosaceae*	Worldwide Strains important (esp Spanish strains of PDV; or viruses in combination) All graft transmissible
Prune Dwarf Virus. Severe strains are exotic. Mild Australian strains not yet economically important when one virus present.	N, S	PDV		PNRSV and PDV – synergistic infections (?) Most cultivated Prunus susceptible. Pollen, seed, graft transmissible.	
Prunus Necrotic Ring Spot Virus Wide symptom range i.e. infectious bud failure	N, B, S	PNRSV			
Apple Chlorotic Leaf Spot Trichovirus	N, B	Trichovirus – ACLSV	Teviotdale *et al* 2002.	Wide – some symptomless hosts – almonds?	
VIROIDS					
PHYTOPLASMA DISEASES					
MISC DISEASES & DISORDERS					
Genetic	B, N	Non-infectious bud failure = Crazy top			

* Important in budwood multiplication (B), Nurseries (N), Seed source (S)

Source: McMichael, 2006.

3.3 Effects of Graft-Transmissible Pathogens on Almonds

The influence of graft-transmissible pathogens on the development of fruit trees is extremely variable. The extent depends not only on the pathogen or its strain, but also on the fruit species, cultivar, rootstock, nutrient supply and the age of the tree when attacked (Nemeth, 1986). In some cases, infection remains more or less symptomless but in others, very severe symptoms develop upon infection which can cause yield losses, make the crop unmarketable or may have social and economic consequences resulting from the exclusion of certain fruit production from traditional fruit growing areas (Dunez, 1998).

Some graft-transmissible pathogens do not have any natural transmission or do not show any significant natural spread in the field and therefore propagation of such pathogen-free material can reduce incidence of that disease, e.g. **Apple chlorotic leaf spot virus** (ACLSV). Californian virologists have not detected ACLSV in almonds. The potential however exists for it to be an economically important virus when an additional virus is present, as occurs in other *Prunus* hosts (Uyemoto, J., pers. comm.).

Other diseases can be eliminated or their impacts considerably reduced by the use of virus-free propagation material as long as their vectors are absent, eg. the exotic **tomato ring spot virus** (TRSV) is naturally transmitted by a nematode *Xiphinema americanum,* which is absent from Australian soils and so the virus can be controlled by use of propagation material free of TRSV. TRSV is responsible for stem pitting in all *Prunus* spp., and is associated with graft-union abnormalities. With the **yellow bud mosaic** strain, almond and peach show symptoms of yellow bud mosaic (pale green to pale yellow, oblong, feather-edged blotches along the main vein or large lateral veins of the leaves; buds produce rosettes of small and often distorted leaves, with or without mottling, or are pale yellow and later die; fruits may be dwarfed or malformed) (EPPO, 1998). In the Sacramento Valley of California, where it presents as chlorotic ringspots and mosaic, prematurely dying yellow leaf tufts around young buds; terminal shoot death; and low yields of poor quality fruit (thick, wrinkled hulls), Nonpareil and Ne Plus are symptomless hosts, but Mission cultivars develop severe symptoms.

Prunus necrotic ring spot virus (PNRSV) is responsible for a range of symptoms: almond calico, line pattern, necrotic spots and shot holes, leaf tatter, mosaic, and in some trees, infectious bud failure. It has been reported that most of the strains of PNRSV in California, are latent in almonds. Only almonds infected with the strains that cause calico and infectious bud failure readily develop symptoms. The latent strains may present as poor bud take in some seasons, depending on budding time. Depending on the year, nurseries in California have had poor bud take with PNRSV-infected peach scions budded to clean rootstocks, especially when budding is done in cooler conditions. High temperatures are conducive to callus formation and vegetative growth, but not virus replication. It has been observed that budding taking place in hot conditions is usually highly successful, while the bud take may be low and scion bud necrosis high when budding is carried out in cooler conditions. It however has also been observed that excellent bud take in the nursery rows (with infected material) does not always mean successful commercial planting of the trees when another virus is present (Uyemoto, J., pers. comm.).

The Australian strain of **Prune Dwarf Virus** (PDV) apparently causes no symptoms on almonds, but in Spain severe symptoms have been attributed to strains of PDV. Virologist Jerry Uyemoto of California has reported that the California Department of Food and Agriculture (CDFA) and Foundation Plant Services (FPS) have not detected PDV in almonds. Experimentation with PDV graft-inoculated into almonds has resulted in symptoms but no PDV has been observed in commercial orchards in California (Uyemoto, J., pers. comm.).

There is reason to believe that the peach component of hybrid almond rootstocks might contribute to the development of symptoms in almonds infected with both PDV and PNRSV. In combination, these pathogens are more detrimental to peaches (synergistic) than either alone, and it is thought this may also be the case for almonds. Peach rosette and decline induced by a combination of PDV, PNRSV and ACLSV caused severe foliage symptoms and loss of fruit in "Golden Queen" peach trees in the Goulburn Valley, Victoria (Stubbs and Smith, 1971). Trees not infected with rosette yielded six times the crop by weight, of trees infected for two seasons (Smith and Challen, 1977) and the rate of spread rose from 0.9% to 91.5% over 10 years (Smith, 1975). Both PNRSV and PDV are pollen borne and control of their natural transmission is impossible. Infection occurs during pollination eg when the trees are 4-6 years old and start cropping. Wirthensohn *et al*. (2003) demonstrated that PNRSV, when present in both parents, may be transmitted at rates of 12-23% (Table 5).

Table 5 : The percentage of progeny testing positive for PNRSV

Progeny/year	Both parents NEGATIVE	Pollen parent NEGATIVE	Seed Parent NEGATIVE	Both parents POSITIVE
1997	0.4 %	0	6 %	22.6 %
1998	0.1 %	1.4 %	1.8 %	12.5 %

Source: Wirthensohn *et al.,* 2003. Virus testing for the Australian almond industry and breeding program. Australian Nutgrower. December 2003.

The synergistic (or other) effects of the four endemic viruses in almonds in Australia, and the impact of budding conditions on bud take, have not been researched.

Comparisons between plants initially infected at the time of planting and pollen-infected plants show a significantly reduced impact in the case of pollen infections. In most cases, the planting of virus-free trees is the most efficient method of controlling the impact of these viruses. Because these viruses may be seed borne, and the percentage of infected seed (and therefore seed transmission) varies with the *Prunus* species, any high health status multiplication scheme must apply also to the provision of healthy rootstocks. There is little information on the effect of these viruses in specific rootstocks, however we might assume from the peach research that their presence in rootstocks could affect top-working success, bud take, vigour of bud growth and unions, under certain conditions.

Some major diseases of stone fruit trees are efficiently vector-transmitted in nature. This is the case with **plum pox virus** (sharka) which is aphid-borne. It appears in experimental work that almonds are potentially a latent host of PPV, but natural infection has not been reported. While an effect of PPV on almonds is yet to be demonstrated, it is a very serious pathogen of other *Prunus* species and all pollen imported for the almond breeding programme is screened for the presence of PPV by the University of Adelaide. Appendix 8 includes this test protocol.

Almond plants may serve as a source of virus for aphid vectors, showing the potential role of almonds in the spread of sharka (Rubio *et al*., 2003). Should PPV be introduced to Australia, almonds would become part of the eradication if grown in the Pest Quarantine Area (PQA), the area of which would be substantial due to the aphid spread of the disease. Consequently it is important that this disease be kept out of Australia.

The **phytoplasma** disease **peach yellow leaf roll** causes delayed budbreak in spring, sparse foliage, poor shoot growth, and shrivelled kernels in almonds often in mature almond trees, with infections presumably occurring well after the orchards were established. Peach yellows phytoplasma almost completely destroyed the peach orchards in some regions of the USA in the late 1800's. It is probable that the pathogen is introduced during chance feedings by a migrating infective insect vector (Uyemoto *et al.*, 1999).

Another vector borne disease exotic to Australia is **almond leaf scorch** (ALS) which is caused by *Xylella fastidiosa* and transmitted by sharpshooters, eg the exotic glassy-winged sharpshooter. Californian research suggests that ALS in almonds results in reduced productivity, premature leaf drop from affected scaffolds, and tree death within 3-8 years of symptom onset. The most susceptible almond varieties are Sonora and Nonpareil in California, but the disease has also been detected in Fritz, Butte, Padre and Price (Haviland and Viveros, 2005).

Pierce's Disease (grape) strains of *Xylella fastidiosa* produce diseases in grape, alfalfa, almond, and some weeds, but they do not infect oleander, oak, peach, or citrus. ALS strains that belong to *X. fastidiosa* subsp. *multiplex* do not cause disease on grape (Chen *et al*., 2007; Hernandez-Martinez *et al.*, 2006). Thus alternate perennial fruit tree importations, as well as ornamentals, can pose a threat to almonds if infected with *X. fastidiosa.* Further spread can occur through infected weeds, eg 11 species of common ground vegetation in Californian almond orchards, tested positive for *X. fastidiosa*. Any outbreak of Pierce's Disease in grapes will impact on almonds because their production regions often overlap – i.e. SA's Riverland and Victoria's Sunraysia districts.

4 FACTORS AFFECTING THE SUCCESS OF A MULTIPLICATION SCHEME

The provision of propagation material to industry is a multi-faceted, inter-dependent process. There are material phases (sourcing, propagation and maintenance), testing phases in which the material's status (identity and health) is determined; and then the nursery production and distribution phases. Industry resources are relied upon in each phase and at present, the most important asset and resource of Australia's almond industry is its multiplication block at Monash and the associated almond improvement programme.

The challenge in developing a successful scion and rootstock multiplication scheme and consequently a highly productive almond industry, is to source, produce and maintain horticulturally-superior material free of graft-transmissible pathogens. The use of "pathogen-tested" trees will allow maximum horticultural potential to be achieved.

The provision of adequate supplies in excess of demand, of a wide range of commercially important varieties and clones which are high performing, true-to-type and of high health status are critical components of risk management.

4.1 Sourcing of New Varieties and Cultivars

The ABA has the opportunity to obtain almond clones from a number of sources:

- The local ABA-funded (levies and HAL matching funds) breeding program
- Local selection of improved clones
- Importation of budwood and seed from overseas collections: from germplasm or nuclear collections; breeding and/or selection programmes. These could be "accredited sources", "approved sources"; or "non-approved" sources (see below). The Australian almond industry has imported propagation material from major collections in California, France, Spain and Israel.
- Manipulating clones – i.e. heat-treated; meristem-tip cultured to obtain healthy material

The rights of the public, industry organisations, private individuals and corporate entities to import almond material through appropriate pathways, are generally understood. AQIS maintains strict privacy of the importer and the material imported. But a case exists for centralised (i.e. peak industry body) importation.

The greatest threat of introduction of an exotic almond pathogen lies with illegal, rather than legal, entries of *Prunus* propagation material. Other plants that are latent hosts to almond pathogens also pose a threat, i.e. grapes, ornamentals and other stone fruit.

The basis of any multiplication and improvement scheme should be a germplasm or foundation repository – a high health status, true-to-type collection of the varieties and clones of rootstocks and scions, available to the industry for further commercial or breeding use. The extent of the collection is not necessarily limited to commercially relevant material.

4.2 Ensuring High Health Status

4.2.1 Post-Entry Quarantine (PEQ) and Import Requirements

Ensuring biosecurity in Australia's horticultural crops is a complex responsibility shared by all levels of government and by each horticultural industry. Industry and government can best protect against exotic disease threats by proactively collecting and sharing knowledge of the existing threats, their potential for entry, establishment and spread.

The need for strictly enforced quarantine is self-evident and as pointed out by Fridlund (1983), certification and quarantine programmes have as their objective the improvement or maintenance of crop yields, quality and the economics of production.

In Australia, the Commonwealth Government through Biosecurity Australia (BA) and AQIS negotiate internationally, develop import conditions, and implement agreed quarantine standards. The specific conditions of entry for *Prunus* seed from India and USA (entering Australia), and for *Prunus* budwood are documented by AQIS on its ICON website: http://www.aqis.gov.au/icon32/asp/homecontent.asp). These conditions and those for *Prunus* seed entering New Zealand are included in Appendix 6.

BA/AQIS have approved four overseas sources of *Prunus* budwood. They are in Washington state, USA, Switzerland and Canada. The sourcing of propagation material from accredited or approved overseas facilities, currently confers to that material a degree of exemption from testing by AQIS in PEQ. But acceptance of material from approved multiplication schemes without prescribed, additional testing within PEQ can be a dangerous practice (Broadbent, 1987). Release of such material (whether to a private importer or to an industry budwood scheme) and its official declaration as being "virus-tested", "virus-free" or "pathogen-tested" cannot be relied upon for the following reasons:

- An approved scheme may have several categories of product health status, eg foundation trees, registered budwood source trees or an interim programme without full pathogen testing. Similarly for almond rootstock seed suppliers who provide both non-certified, untested seed and certified, tested seed for sale (eg. one of the seed sources in USA used by Australian importers of seed for almond nurseries).
- Material collected from field trees could become infected with a vector-borne pathogen or by pollen or mechanical transmission in the time between indexing and budwood supply
- Staffing and/or funding may alter the reliability of the scheme over time. Without regular independent audit, the changing status of the scheme and its pathogen-free material may go unnoticed in Australia
- Human error may result in the supply of wrong material or the failure to detect a pathogen.

The schedule of AQIS auditing of the inspection standards and methodologies of the certifying authorities abroad, is irregular, and therefore we cannot be certain that the imposed import and PEQ conditions are adequate in each case, to protect Australia's almond industry.

There is anecdotal information that shipments in 2006 of *Prunus* seed from India, apparently certified but with greater than 75% being of incorrect identity (not Nemaguard) were imported, fumigated and released to the importer within 24 hours of arrival. There are other reports of shipments that were found to be in breach of ICON with respect to the presence of pulp, debris and bird excrement, yet were released within 24 hours following sorting. Also a phytosanitary certificate for seed from India stated PPV freedom of the state where the seed was produced, as required in the import permit, but we have been unable to confirm if such statements were officially verified by AQIS prior to release of material. Such verification is important since the exporting country (India) does have both PPV and *X. fastidiosa*. Although a 3-month grow out period in PEQ is required by ICON for any non-certified Prunus seed, we understand from importers that this is not being carried out routinely.

Quarantine, as well as keeping out the important and devastating exotic diseases and pests of almonds and other stone fruits (i.e. *Xylella fastidiosa* and its exotic vectors, tomato ringspot nepovirus, viroids, European stone fruit phytoplasma, peach yellow leafroll phytoplasma, *Phomopsis amygdali*, *Pseudomonas amygdali*, almond stone wasp, navel orangeworm, Varroa mites etc.), is also important for keeping out pests and diseases of other crops, that may indirectly affect almonds, eg Plum pox virus (PPV) and perennial canker (*Leucostoma cincta).*

Quarantine, if applied, may also help limit the further distribution of pests and diseases that are present, but limited, in Australia, and those endemic pathogens for which more virulent strains remain exotic, eg PDV and PNRSV. AQIS however is not obliged to inspect or test budwood or seed for endemic organisms known to affect almonds and known to be present in Australia. Individual importers may therefore choose either further testing for endemic pathogens, eg PDV and PNRSV at additional cost, or ignore that testing option and proceed with acceptance of released material that has an undefined health status. The almond industry as a whole, may not yet fully appreciate that biosecurity in this area, is currently dependent on goodwill and corporate responsibility, rather than clear mandates.

It is incumbent on the industry and especially private importers, to ensure that endemic pathogens do not enter the multiplication chain with newly imported clones/varieties, seed or pollen.

At present most perennial horticultural material is released from quarantine without a defined health status in regard to endemic graft-transmissible pathogens. Many years ago, ACG lobbied the Minister to ensure that AQIS did not accept approved sources as justification for reduced PEQ testing, and that citrus imports from every source, were tested for both exotic and endemic pathogens in PEQ. Full testing for exotic and endemic diseases of citrus within PEQ was in line with what is, and was, occurring in South Africa, Spain and USA. Today citrus imports remain the exception amongst horticultural industries as they are fully tested while in quarantine for both endemic and exotic organisms.

In the case of almonds, seed for rootstocks enter the Tullamarine facility (AQIS Plant Quarantine – Tullamarine, Victoria) under prescribed ICON[5] conditions, while budwood has traditionally entered PEQ at the Knoxfield (Victoria) and Eastern Creek (NSW) facilities. More recently all almond budwood has been tested at the Knoxfield facility.

The almond industry has recently imported material from European countries, the United States and from the sub-continent. Although satisfying the importation conditions, importers should also be encouraged to acquire, and have accessible, as much information as possible about the source of their imported material. In the event of a problem it is often this additional information that allows validation and traceback. Important data include: accession number and clonal name; precise background on the source (ideally budwood would be collected from a single, identified

[5]AQIS Import Conditions Database http://www.aqis.gov.au/icon32/asp/homecontent.asp

tree), names of suppliers of the material (be they wholesalers, growers, breeders or propagation schemes), precise location of the growing region, and description of other hosts that might expose almonds in the region to exotic threats. If such background and relevant PEQ information (testing and pathogen elimination outcomes) could be contributed to an industry database, by all almond importers, the industry would over time develop a valuable resource.

The Federal Privacy Act[6] 1988 has limited the information on importations made available by AQIS to Australian perennial crop industries, yet detailed information as listed above is still recorded by AQIS in the Client Quarantine Registry. Until March 1996, when the last Fruit Imports Accession List was published, industries had available to them information (including accession numbers) of all imported propagating material and their sources. Now only information on the numbers of varieties and clones is available to industry via the PEPICC[7] meetings of industry with AQIS (Appendix 7).

The ABA, on behalf of the almond industry, is *encouraged to build a database of importers and relevant planting material entering the country through PEQ as best they can, and prior to the expected and potentially rapid growth in the number and type of private importations*.

It is our opinion that there are PEQ arrangements relevant to the Australian almond industry that need further development (i.e. auditing of overseas suppliers; verification of sources and pest-free status; private PEQ facilities; testing/indexing standards; closing/moving of AQIS facilities at Knoxfield and Eastern Creek). Some of these are addressed in this report and also in the draft Prunus PEQ Manual (Whattam, 2006).

4.2.2 Indexing in PEQ

The extent and adequacy of the current AQIS testing methodologies for *Prunus* spp. are discussed in this section and compared with those of other countries (Table 6). Indexing is the term used to encompass the methods available for determining the presence/absence of a pathogen. It includes visual (naked eye, light and electron microscopy), biological (woody and herbaceous hosts), molecular and serological testing of seed or plants for the presence of graft-transmissible pathogens. These methodologies are briefly described below. The specific relevance of the method to indexing of *Prunus* seed or budwood is noted.

4.2.3 Indexing Methodologies

The relative merits of testing methodologies need to be understood before agreeing on the minimum testing required by any diagnostic laboratory. Consider: the organisms of concern and how they are transmitted; the requirement for strain identification; the effect of host tissue type and sampling times on the results achieved; the required sensitivity of tests; accuracy and reproducibility, and cost of tests; testing efficiencies - number of samples able to be processed at one time and number of organisms potentially detected; labour needed and training required to operate and conduct tests.

The draft *Prunus* PEQ Manual (Whattam, 2006), submitted in 2006 to BA for official approval, outlines and recommends more specific and advanced testing regimes for *Prunus* spp. by AQIS during PEQ. It is stated (Whattam, 2006 - page 18) that opportunity exists for AQIS to adopt more molecular tests to shorten PEQ and allow for earlier provisional release of material that has been pre-screened for exotic pathogens.

Diagnostic standards for emergency plant pests are being prepared and co-ordinated in Australia, by the Sub-committee on Plant Health Diagnostic Standards (SPHDS). SPHDS lists the

[6] http://www.privacy.gov.au/act/privacyact
[7] Post-Entry Plant Industry Consultative Committee

diagnostic protocols for *X. fastidiosa* and Plum Pox Virus as currently being in 'final draft' status. It is expected that horticultural industries for which the protocols have relevance, will contribute to their validation. Once validated for a particular host, the protocol becomes a nationally-agreed protocol and should be implemented for all relevant diagnostic work, including that undertaken in PEQ. The *X. fastidiosa* and PPV drafts require validation on almonds. The reference for access to these draft protocols, and others from the University of Adelaide and AQIS are included in Appendix 8. Table 6 compares the indexing methodologies used by AQIS in PEQ, with the internationally-accepted methods adopted by other agencies.

It is recommended that the almond industry support the process of protocol validation on almonds, and also scientific peer review of the protocols.

It is recommended that the ABA formally acknowledge their desire for the draft Prunus PEQ Manual and the recommendations included within it, to be approved by BA and implemented for Prunus spp. *in PEQ*.

4.2.3.1 Biological Indexing

Biological indexing on herbaceous and woody indicator plants should be mandatory in certification schemes to ensure that a wide range of pathogens can be detected.

Herbaceous indexing is complementary to woody indexing and neither alone is sufficient especially for indexing of exotics in PEQ. Choosing the range and source of indicators is important. Indicators must be virus-free, well-grown and readily available, react rapidly and specifically to target organism/s. It is useful if, under varied conditions, they respond differently and if they are suitable for detecting more than one virus. The indicators utilised in PEQ must also accommodate rootstock testing. Some rootstocks are suitable indicators themselves, i.e. *P. tormentosa* Thunb., *P. serrulata* cv. Shirofugen, GF 305.

4.2.3.2 Serological Indexing

ELISA is used to detect many of the *Prunus* viruses. Although the technique has several advantages, it also has limitations (sampling time and tissue due to uneven virus distribution; grouping of samples; strains of pathogens). Strains of trichoviruses, including ACLSV, are not all detected by ELISA and detections of PNRSV and PDV with ELISA are unreliable. There is great serological variability in the ilarviruses, including PNRSV, PDV and ApMV. The time of sampling is important because of the different viral loads in different plant parts, at different times of the year. Detection of strains of PPV can be achieved with ELISA but uneven distribution of PPV in trees remains a problem.

In Australia, Mekuria *et al.,* 2003, 2005 and Wirthensohn *et al.,* 2003, demonstrated the lesser reliability of ELISA for the detection of PDV in almonds. Yet certification of almond trees, rootstocks and mother trees, in certain countries, eg California rely on the results of ELISA. The CDFA in California carries out all sampling and indexing in early spring at the first sign of bud burst and/or leaf out. This reportedly has overcome the erratic results achieved with ELISA. As a cross-check, trees indexed during spring and found with ELISA to be positive, are biologically indexed in summer on Shirofugen, to confirm infection (Uyemoto, J. pers. comm.). Serological tests are unsuitable for viroid detection.

4.2.3.3 Molecular Indexing

There are no universal sampling and processing conditions for molecular tests. The nature of the plant material and virus to be detected determine the best method to use. The early molecular tests relied on non-radioactive hybridisation. Polymerase chain reaction (PCR) techniques have been widely adopted in plant pathology as they are sensitive, specific, rapid and can be used for detection of viruses, viroids, bacteria, phytoplasma, nematodes and fungi.

At the University of Adelaide's Waite Institute, Mekuria developed a technique based on the reverse transcriptase-polymerase chain reaction (RT-PCR) to detect the presence of PNRSV and PDV simultaneously in almond (Mekuria *et al.*, 2003, 2005). A 3-year study compared ELISA and RT-PCR for the detection of PNRSV and PDV using 175 almond leaf samples. Multiplex RT-PCR was found to be more sensitive than ELISA, especially when followed by nested PCR for the detection of PDV. The RT-PCR technique reportedly has the added advantage that plant material can be tested at any time throughout the growing season. This two-stage testing has been implemented for the indexing of Monash trees since 2004/05, and has on occasions revealed (latent) PDV in symptomless trees.

4.2.3.4 Indexing of Imported Budwood in PEQ

Prunus budwood received by AQIS from any of the four approved almond sources, accompanied by a phytosanitary certificate (indicating health status), and the exporter's declaration of the procedures adopted for disease screening, passes through AQIS with visual inspection only, unless symptoms develop. The plants are observed in PEQ for two years.

At present most (95%) imported almond material does not come from approved sources. For screening *Prunus* spp. from non-approved budwood sources, the current AQIS regime is outlined in the draft *Prunus* PEQ Manual (Whattam, 2006) and also in Table 6:

The AQIS indexing of propagation material from either approved or non-approved sources:

- does not include active or required testing for the presence of phytoplasmas or viroids
- includes PPV testing routinely for *Prunus* spp. budwood only.
- includes testing for *Xylella fastidiosa* on all citrus, but only *Prunus* imports from the USA, despite its wider host range (esp. grapes, landscape and ornamental hosts). Grapes are hot-water treated.
- does not include screening for economically-important endemic organisms, eg *X. arboricola* pv. *pruni* (*Xap*), the cause of bacterial spot. Testing for PDV or PNRSV although not required, has often been undertaken through AQIS' goodwill towards protection of the Prunus industries.
- has not included routine testing for *Prunus* stem-pitting, but this is under consideration. This disease results from the combined presence of two otherwise latent viruses (in cherries, Uyemoto, J., pers. comm.) and possibly a strain of Tomato ringspot virus which is currently quarantineable.
- does not include indexing for exotic strains of endemic pathogens eg PDV.

4.2.3.5 Quarantine Approved Premise [QAP]

After the health of the imported material has been evaluated over a set minimum period and determined to be free of exotic viruses, it may be released from PEQ (directly or via a Quarantine Approved Premise [QAP]). There are defined conditions to be met before AQIS awards QAP status. These conditions are outlined in Section 46A of the Quarantine Act 1908. (www.daffa.gov.au/aqis/import/general-info/qap)

While there are recognised benefits to having off-site QAP facilities in research institutes (i.e. universities), private QAPs do raise concern. Although a QAP Accredited Person (QAP–AP) must personally conduct or directly supervise all activities involving physical contact with items subject to quarantine, questions have been raised about the qualifications of such people. The businesses with private QAPs do not generally include as core business, a commitment to biosecurity assurance for the country's benefit. The rigour with which QAPs are independently monitored (numbers of plants maintained, plant density, plant disposal, reporting of suspect material, hygiene etc), is unclear and the potential remains for early propagation from yet-to-be released, incompletely-tested plant material. Of interest to an industry like the almond industry should be how often symptoms of viral, bacterial and fungal pathogens are reported by private QAPs and if the growing conditions are conducive to the detection of pathogens like *X. arboricola* pv. *pruni.*

4.2.3.6 Comparison of International Budwood Indexing

International indexing methodologies and timeframes are not harmonised for budwood, seed or pollen. The existing variation in methodologies, choice of indicator plants, sources and maintenance of indicator hosts, testing and maintenance regimes for both positive and negative controls, and primers for molecular tests etc raise concerns about the scientific validity of some international data and the current level of acceptance afforded it, by AQIS. There is for example, insufficient information available for this review to independently assess the processes followed to determine legitimacy of import permit data, i.e. area freedom status for PPV in India; on *X. fastidiosa* distribution (other than in USA); and of indexing undertaken for the detection of the exotic and virulent Spanish strains of PDV which may cause severe symptoms in almonds. It is our understanding that regular audits of approved sources are not scheduled and as such, their reliability is for long periods, untested.

A comparison is presented of testing methods used by AQIS-PEQ, in Europe by EPPO, and the FAO/IPGRI (Technical Guidelines for the Safe Movement of Stone Fruit Germplasm), and international guidelines proposed by a group of stone fruit virologists attending the XVth International Symposium on Fruit Tree Diseases, Vienna, Austria, July 8-13, 1991 and subsequently published in *Acta Horticulturae*, 1992, Fruit and Tree Virus Diseases, 309: 407-420. See also http://nrsp5.prosser.wsu.edu/nrspid2.html#stone

Table 6 also includes testing conditions currently being negotiated by AQIS and MAF. They reflect the desired testing of NZ-destined stone fruit imports, by AQIS at Knoxfield. Full procedures where available are included in Appendix 9.

Table 6 : Comparison of budwood indexing methodologies used by AQIS with internationally-accepted methods

Pathogen – exotic	Methods	EPPO[8]	Proposed MAF requirements*	Current AQIS	FAO Safe Movement[9]	International Methods[10]
Viruses:						
Prunus necrotic ring spot virus (PNRSV) – exotic strains	Woody tests (field)	Bing (3/-/2y) Shirofugen (5/-/6-52w) GF305 seedling (3/-/2y)		Not tested unless requested by importer		*Prunus serrulata* 'Shirofugen' (Shirofugen)
	Woody tests (glasshouse)	GF305 seedling (5/20/12w)		"	GF 305 seedlings *Prunus tormentosa* Shirofugen *Prunus avium* 'F12/1'	*Prunus persica* Seedling GF 305 *P. tormentosa* IR 473/1 or IR 474/1 Shirofugen
	Herbaceous tests	*Chenopodium quinoa, Cucumis sativus, Cucurbita maxima*		"	*C. sativus*	*C. sativus*
	Serological or molecular tests	ELISA, PCR		"	ELISA early in season Immuno tissue printing Nucleic acid probes	ELISA
	Natural transmission	**Pollen, seeds**				
Prune Dwarf Virus (PDV) - exotic strains	Woody tests (field)	Bing (3/-/2y) Shirofugen (5/-/6-52w) GF305 seedling (3/-/2y)		Not tested unless requested by importer		Shirofugen
	Woody tests (glasshouse)	GF305 seedling (5/20/12w)		"	GF 305 seedlings *P. tormentosa*	*P. persica* Seedlings GF 305 *P. tormentosa* IR 473/1 or IR 474/1 Shirofugen
	Herbaceous tests	*C. sativus, C. maxima*		"	*C. sativus*	*C. sativus*
	Serological or molecular tests	ELISA, PCR		"	Serological, Molecular	ELISA
	Natural transmission	**Pollen, seeds**				
Tomato black ring virus (TBRV)	Woody tests (field)	GF305 or Elberta seedling (3/-/2y)				
	Woody tests (glasshouse)	GF305 seedling (5/20/12w)		Growing season inspection	GF305	
	Herbaceous tests	*C. quinoa, C. amaranticolor, C. sativus*	*C. quinoa, C. sativus*	*C. quinoa, C. sativus*	*C. quinoa, C. amaranticolor*	*C. quinoa*
	Serological or molecular tests	ELISA	ELISA or PCR		ELISA Molecular hybridisation	ELISA
	Microscopy		TEM			
	Natural transmission				*Longidorus attenuatus,* *L. elongates*	

EPPO/OEPP Bulletin , 2000

[9] Diekmann, M. and C.A.J. Putter. 1996. FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No. 16. Stone Fruits. Food and Agriculture Organization of the United Nations, Rome/International Plant Genetic Resources Institute, Rome.

[10] Adapted from information compiled by scientists attending the XVth International Symposium on Fruit Tree Diseases, Vienna, Austria, July 8-13, 1991 and subsequently published in *Acta Horticulturae*, 1992, Fruit and Tree Virus Diseases, 309: 407-420. See also http://nrsp5.prosser.wsu.edu/nrspid2.html#stone

* Proposed MAF requirements of AQIS for *Prunus* material destined for NZ (currently under negotiation)

Pathogen – exotic	Methods	EPPO[8]	Proposed MAF requirements*	Current AQIS	FAO Safe Movement[9]	International Methods[10]
Tomato ringspot virus (ToRSV)	Woody tests (field)					
	Woody tests (glasshouse)		Elberta or GF305 (4 plants, double budding in winter, inspections over 9 months)	Growing season inspection	*P. tormentosa*, *P.persica* 'GF305'	*P. persica* Seedlings GF 305 *P. tormentosa* IR 473/1 or IR 474/1
	Herbaceous tests		*C. quinoa, C. sativus* *Nicotiana benthamiana*	*C. quinoa, C. sativus,* *N. benthamiana*	*C. quinoa*	*C. quinoa*
	Serological or molecular tests		ELISA or PCR		ELISA Molecular hybridization Irregularly distributed; tissue samples from lower trunk more reliable	ELISA
	Microscopy					
	Natural transmission				Nematode *Xiphinema americanum*, *X. rivesi*, *X. californicum*	
Plum Pox Virus (PPV)	Woody tests (field)	GF305 or Elberta seedling, *P. tormentosa* (3/-/2y)				
		GF 31 (1/-/1y)				
		Ersinger (3/-/2y)				
	Woody tests (glasshouse)	GF305 seedling (5/20/12w)	Elberta or GF305 (4 plants, double budding in winter, inspections over 9 months)	Growing season inspection, Woody indicators	GF305 *P. tormentosa*	*P. persica* Seedlings GF 305 *P. tormentosa* IR 473/1 or IR 474/1
	Herbaceous tests	*Chenopodium foetidum*, *N. clevelandii*	*N. benthamiana*	*N. benthamiana*		
	Serological or molecular tests	ELISA and PCR. Due to the erratic distribution of the virus in infected trees, several samples from one tree should be tested	ELISA or PCR (2 sets)	ELISA or PCR (2 sets)	ELISA PCR (several samples due to erratic distribution in tree)	ELISA
	Microscopy		TEM			
	Natural transmission				Aphids Pollen & seed (Nemeth, 1986)	
Raspberry Ringspot Virus	Woody tests (field)					
	Woody tests (glasshouse)		Elberta or GF305 (4 plants, double budding in winter, inspections over 9 months)	Growing season inspection and woody indicators	*P. avium* 'Bing' GF305	
	Herbaceous tests		*C. quinoa,* *C. sativus,* *N. benthamiana*	*C. quinoa,* *C. sativus,* *N. benthamiana*	*C. quinoa,* *C. amaranticolor* *C. sativus*	
	Serological or molecular tests				ELISA	ELISA
	Microscopy		TEM			
	Natural transmission				Seeds, nematode *Longidorus elongatus* or *L. macrosoma*	

Pathogen – exotic	Methods	EPPO[8]	Proposed MAF requirements*	Current AQIS	FAO Safe Movement[9]	International Methods[10]
Cherry Mottle Leaf Virus	Woody tests (field)					
	Woody tests (glasshouse)		Elberta or GF305 (4 plants, double budding in winter, inspections over 9 months)	Growing season inspection and woody indicators	*P. avium* Bing	
	Herbaceous tests		*C .quinoa*	*C .quinoa*	*C. quinoa* *C. amaranticolor*	
	Serological or molecular tests		ELISA or PCR		ELISA Western blotting using monoclonal antiserum	
	Microscopy		TEM			
	Natural transmission				Leaf mite *Eriophyes inaequalis*	
European Stone Fruit Yellows Phytoplasma	Woody tests (field)	GF305 seedling, Luizet. Grafting should be performed during the summer				
	Woody tests (glasshouse)	GF305 seedling, Luizet (5/20/12w) Grafting should be performed during the summer		Woody indicators	Japanese plum 'Ozark Premier'. 'Red Heart' or GF305 peach seedling	
	Serological or molecular tests	PCR	Nested PCR using universal phytoplasma fU5/rU3 and R16F2n/R16R2 primers	PCR using universal phytoplasma primers		
	Microscopy	DAPI			Fluorescence microscopy, TEM	
	Natural transmission	*Cacopsylla pruni* Leafhoppers				
Western-X Phytoplasma	Woody tests (field)				Woody indicators	
	Woody tests (glasshouse)			Woody indicators		
	Serological or molecular tests		Nested PCR using universal phytoplasma fU5/rU3 and R16F2n/R16R2 primers	PCR using universal phytoplasma primers?	Molecular tests	
	Microscopy				Fluorescence microscopy	
	Natural transmission				Leafhopper *Macropsis trimaculata*	
Peach Yellow Leaf Roll Phytoplasma	Woody tests (field)					
	Woody tests (glasshouse)			Woody indicators		
	Serological or molecular tests		Nested PCR using universal phytoplasma fU5/rU3 and R16F2n/R16R2 primers	PCR using universal phytoplasma primers		
	Microscopy					
	Natural transmission					

Pathogen – exotic	Methods	EPPO	Proposed MAF requirements	Current AQIS	FAO Safe Movement	International Methods
Xylella fastidiosa	Woody tests (field)		Growing season inspection in PEQ	Growing season inspection in PEQ		
	Woody tests (glasshouse)					
	Serological or molecular tests		PCR	PCR	Culturing on selective media	
	Microscopy				Electron, phase contrast and fluorescence microscopy. ELISA PCR	
	Natural transmission				Various leafhopper vectors	
Pathogens – local						
Apple Chlorotic Leaf Spot Virus (ACLSV)	Woody tests (field)	GF305 or Elberta seedling (3/-/2y)			GF 305 *P. tormentosa*	
	Woody tests (glasshouse)	GF305 seedling (5/20/12w)				*P. persica* Seedlings GF 305 *P. tormentosa* IR 473/1 or IR 474/1
	Herbaceous tests	*C. quinoa*, *C. amaranticolor*			Sap transmission	*C. quinoa*
	Serological or molecular tests	ELISA, PCR and IC-PCR.			ELISA or immuno tissue printing; molecular	ELISA
	Natural transmission	Unknown				
Apple Mosaic Virus (ApMV)	Woody tests (field)	GF305 or Elberta seedling, or plum Ersinger (3/-/2y)			GF 305 Elberta peach	
	Woody tests (glasshouse)	GF305 or Elberta seedling (5/20/12w)				*P. persica* Seedlings GF 305
	Herbaceous tests	*C. quinoa*, *C. amaranticolor*, *C. sativus*, *C. maxima*, *N. clevelandii*, *Petunia hybrida*.			*P. hybrida* *C. quinoa*	*C. sativus*
	Serological or molecular tests	ELISA			Gel diffusion ELISA throughout growing season in young leaves	
	Natural transmission	Not known				
Hop Stunt Viroid	Woody tests (field)					
	Woody tests (glasshouse)			Growing season inspection		
	Herbaceous tests				Cucumber 'Sayo'	
	Serological or molecular tests		Hybridisation or PAGE or PCR		Two dimensional gel electrophoresis Dot Blot Northern Blot using labelled HSVd cRNA probe RT-PCR	
	Natural transmission				Mechanical	

4.2.3.7 Imported Seed

Diekmann and Putter (1996) published the FAO/IPGRI Technical Guidelines for the *Safe Movement of Germplasm No. 16 "Stone Fruits*". In it they recommend that seed should be collected from plants free from pests and diseases, extracted from pulp soon after harvest, surface sterilized with 0.5% sodium hypochlorite with 1% wetting agent for 10 minutes and thoroughly rinsed with water, germinated in an insect-free containment facility and indexed for PNRSV and PDV. The guidelines followed in countries exporting *Prunus* seed to Australia do not necessarily include these safeguards. If exported seed is harvested from certified trees it is presumed that the risk of endemic and/or exotic strains of PDV and PNRSV entering Australia in *Prunus* seed is being minimised.

Most Prunus seed entering Australia for use in the stone fruit, almond and ornamental industries is apparently from certified sources. Ausbuds routinely imports certified seed from California. California's certified seed is harvested from mother trees that have been indexed annually by the California Dept of Food and Agriculture (CDFA) for pollen borne viruses. Accompanying the certified seed on entry to Australia must be a phytosanitary certificate indicating freedom of the viruses for which they were tested.

It is however known that at least one of the regular providers of Nemaguard seed has both certified (tested) and non-certified (untested) product available, and that seed on occasions has been sourced from wholesalers. Seed wholesalers source seed of many genera from a number of unidentified sources. Although a 3-month grow out period in PEQ is required by ICON for any imported, non-certified *Prunus* seed, we have not been able to confirm how often such grow-outs are undertaken. NZ requirements suggest a 6-month grow out period is required for imported *Prunus* seed. See Appendix 6 for various conditions of entry for seed and budwood of *Prunus* spp.

The industry is encouraged to ensure that seed is imported only from direct suppliers of certified seed from identified sources, and that the certification procedures are validated.

4.2.4 Almond Problems for which PEQ is ineffective

While PEQ protects Australia and the almond industry from a wide array of problems, it is not possible to screen in-coming material for its propensity to genetic disorders. The almond industry in Australia was initially protected from such disorders by the consideration of international data and input provided by breeders. This allowed careful and informed selection of clones and continued awareness of potential problems throughout the multiplication scheme. If sourcing, supply and distribution of budwood without full traceability increases, and nomenclature changes occur without reference to clonal accession numbers, these problems are likely to become more apparent and more difficult to manage. One such problem is non-infectious bud failure (NBF). NBF is a genetic disorder and NBF-potential may gradually increase over time as specific cultivars are repeatedly vegetatively propagated (see Section 6.1.2).

4.2.5 Pests of Almonds

Pests of almonds are not discussed further in this review but are well documented in the PHA report by Dr Peter Ridland (Ridland, 2006). The pest list for almonds is included in Appendix 10. There are two exotic threats to bee colonies that on entry to Australia, would significantly affect the almond industry.

Varroa Mite: The mite *Varroa destructor* parasitizes the larvae in the bee hive resulting in a weakened colony, a decrease in disease resistance in the bees and ultimately a decline in colony population. In the United States, beekeepers were accustomed to losing 5-10 percent of their bees during winter, but arrival of the Varroa mite in the 1980s increased this to 15-25 percent and now losses of 60 percent or higher, are commonplace. The global spread of Varroa mite leaves Australia as the last major region where the mite has not established. In all regions where it has established, feral honey bees have been eliminated and managed pollination services severely damaged and unable to meet the demand for pollination services.

Colony Collapse Disorder: The death of billions of bees in the United States has been attributed to Colony Collapse Disorder (CCD), a strange occurrence that took place this past winter in the USA and has left beekeepers in 27 states with totally decimated colony populations. Not only are the keepers affected, but more than 90 crop types rely on pollination from bees including almonds, apples, pears, berries and peaches. There is a strong correlation between the occupancy of CCD and a virus, Israeli Acute Paralysis Virus (IVAP), but the cause of CCD remains unproven.

4.3 Pathogen Elimination from Infected Imported Budwood

On detecting virus-infected budwood in PEQ, material is either destroyed or may be submitted for pathogen elimination. For stone fruit, the pathogen elimination options are heat treatment and shoot tip or meristem-culturing. Despite evidence that *Prunus* viruses are readily inactivated by heat therapy (38°C for 60-70 days), there is little evidence that these services have been used widely on imported almond material, possibly because *Prunus* spp. are very sensitive to prolonged exposures to elevated temperatures. As a result, survival of heat-treated plant material is low (Spiegel *et al*., 1995). Some older Australian varieties, including Chellastons, Keanes Seedling and Baxendale have been considered useful in the breeding programme. In recent years selected material from these varieties has been 'cleaned-up' via thermotherapy undertaken at SARDI. 'Virus-tested' trees have been re-introduced to Monash (see Figure 2).

Therapy procedures applied to *in vitro* grown plant material allow controlled modification of various components of the nutrient media and other environmental factors which affect survival and regeneration of virus-free shoot tips. High temperature regimes were successfully applied to eliminate PNRSV from *in vitro* grown shoot cultures of sweet cherry, peach and recently almond (unpublished) (Spiegel *et al*., 1995).

The methods and time frame over which heat-treated clonal material is compared and evaluated after release, however need determination. Given the requirement for clonal characteristics and identity to be maintained, the industry position on heat (and other) pathogen elimination treatments may be decided only after investigation of their impact on the available means, legal and physical, of verification of clonal identity (i.e. DNA fingerprinting). Our information suggests that heat therapy would not change the DNA fingerprint of varieties. DNA fingerprints are not yet suitable for identifying clones and thus physical characteristics, rather than genetic ones, continue to form the basis of distinguishing clones and ensuring trueness-to-type. The Australian Apple and Pear industry through APFIP have routinely heat-treated imported material with no adverse, and several beneficial effects, even in the absence of known viral presence.

The option for heat-treatment of infected, imported plant material exists within the AQIS facility at Knoxfield. Services at Vic DPI, Knoxfield also include the provision of heat treatment and shoot-tip culturing. It is our understanding (Kimberley Thomas, pers. comm.) that most almond budwood found to be virus-infected by AQIS, is destroyed at the request of the importer, rather than heat-treated. It is unclear if, in Australia, there is resistance to heat therapy, or if the cost or release delay that it necessitates, have discouraged the uptake of this virus elimination option in post-entry quarantine. Apart from survival rates of heat-treated *Prunus*, we can find no published data on negative effects of heat therapy on almonds, although potential "baldness" has been mentioned. It is possible that industry biosecurity awareness has recognised the potential for heat therapy to temporarily suppress, rather than eliminate virus. There is also a recognised reduction in the degree of success when multiple viruses are present.

Heat therapy therefore remains a reasonable option for both improving the health status of otherwise-desirable, virus-infected planting material entering Australia, as a 'general clean up' suitable for material entering an industry budwood (or rootstock) scheme, or for material of undefined health status (because of incomplete testing for endemic pathogens), but intended for immediate propagation. The heat therapy methodology used within AQIS is included in the draft *Prunus* PEQ Manual (Whattam, 2006). Indexing following heat treatment is essential.

Meristem-tip culturing is also employed as a virus elimination technique, as a longer-term storage option or as a method of clonal propagation. In virus elimination, this technique appears to differ in its success depending on the distribution of virus in the *in vitro* ex-plant and the tissue culture conditions, as well as the pathogen (Spiegel *et al*., 1995).

Another method of pathogen elimination is the *in vitro* method of shoot-tip grafting (STG) developed to recover virus-free almond plants. It consists of aseptically grafting a 0.5-1.5 mm long shoot-tip from infected plants on 10-14 day-old Nemaguard peach seedlings grown *in vitro*. The grafted plants are grown for 4-6 weeks and then transplanted to the greenhouse. A 40-50% incidence of grafting success and 75-85% of survival on transplanting have been routinely obtained (Juarez *et al*., 1993). In this research, all plants recovered by STG were free of ApMV, regardless of shoot-tip size or growing conditions of infected plants. PNRSV and PDV could not be eliminated from plants growing in the open air but they were easily eliminated from plants growing in the growth chamber at 35°/30°C. Shoot-tip size had no influence on elimination of PNRSV, and around 80% of the micro-grafted plants were free of this virus. This parameter had a clear influence on elimination of PDV, since all plants regenerated from 0.5–0.9 mm long shoot-tips were healthy, whereas only 46% of plants regenerated from 1.0–1.5 mm long shoot-tips were free of PDV.

As far as we know, the only laboratory doing STG *in vitro* routinely in Australia is at EMAI, Camden (NSW DPI) for pathogen elimination in the Auscitrus citrus improvement programme.

In anticipation of an expansion of private importations and in the absence of mandated endemic organism testing of almonds in PEQ, the industry must take a considered position on acceptance or otherwise of routine application of heat treatment and shoot-tip culturing in PEQ (followed by pathogen testing), as a means of pathogen 'elimination' or general 'clean-up.'

4.3.1 Indexing Local Budwood and Seed Sources

PEQ indexing ensures the absence of exotic organisms in imported propagation material, but there is no requirement for screening for endemic organisms like PDV and PNRSV in either local or imported material.

For local material:

- Parents and progeny of the breeding program are indexed for PDV and PNRSV by University of Adelaide annually.
- Mother trees in the Monash multiplication block are indexed by PCR over a three year period for PDV and PNRSV, by University of Adelaide. NB the Australian Almond Industry STRATEGIC PLAN (2006-2011) states "maintain annual indexing".
- Trees in Select's budwood block near Shepparton have been indexed in the first three years for ApMV, ACLSV, PNRSV and PDV by Vic DPI, Knoxfield. Thereafter the contracted indexing is for PDV and PNRSV with grouped samples. It is not clear if indexing was undertaken in 2006 and 2007, but annual indexing has been contracted to the Vic DPI, Knoxfield.
- Ausbuds mother trees for seed production are indexed annually for PDV and PNRSV by Vic DPI, Knoxfield. Initially testing was by ELISA but is now done by PCR.

- Vic DPI, Knoxfield and University of Adelaide utilise different methodologies in indexing for viruses in almonds.

It is recommended that the ABA consider the eligibility criteria in terms of defined health status, for both local and imported material entering the almond budwood and rootstock multiplication facilities.

An isolated site may be required to accommodate incompletely-indexed material released from PEQ or submitted from local sources, but ideally all material would be fully indexed by AQIS prior to entry to any industry scheme.

Locally, samples are collected and submitted for pathogen testing for one of two reasons: the indexing of budwood mother trees to determine health status prior to budwood cutting, or for diagnosis of the cause of unthriftiness in commercial trees. The recognised pathologists carrying out routine almond testing are: Dr Brendan Rodoni (Vic DPI, Knoxfield) and Dr Michelle Wirthensohn, (University of Adelaide). The two laboratories utilise different methodologies for pathogen testing of almond varieties.

Research carried out by Mekuria *et al*., (2003, 2005) and Collins *et al*., (2004) at the University of Adelaide, compared the indexing of almonds for PNRSV and PDV by ELISA and RT-PCR. Withensohn has since validated the University of Adelaide methodologies (Wirthensohn, 2003). The two-stage testing of RT-PCR followed by nested PCR is now used.

Although in total, about one third of the trees at Monash are indexed each year, it has been confirmed that the indexing to-date has been targeted and responsive to clonal preferences and cutting demand. Trees cut for budwood have been individually indexed at intervals no longer than every second year. This has ensured that every tree cut for budwood has been indexed for the presence of PDV and PNRSV either in the season of cutting or the prior season. In contrast, those clones and varieties for which there is no demand, have not been indexed as often and the indexing intervals for these may have been 3-4 years. Newer entries to Monash have had both budwood and rootstock indexed. Before the first cut from any such trees, re-indexing is undertaken. It has been reported to us that additional testing may be accommodated, if there are specific industry requests for it. As the Monash collection expands, it is hoped the indexing intervals will not increase for either cut or uncut trees. Annual, individual indexing of mother trees of those varieties/clones in highest demand, is recommended.

Four year indexing intervals are too long for a multiplication scheme. The ABA should consider funding the indexing of mother trees every year, with at least one third also undergoing biological indexing.

In 2003/04, the indexing methodology advanced from serological ELISA testing, which had been shown to be unreliable for PDV, to molecular testing with nested PCR. The results since 2003/04 have suggested a greater incidence of PDV. However there has been no corresponding development of symptoms in any tree in the Monash collection. The significance of the PDV test results (with nested PCR methodology) remains unclear despite verification of the virus identity through cross-checking with ELISA and biological indexing on Shirofugen. Wirthensohn accessed the virus sequence database, sequenced the amplified PCR products, compared them with the virus sequences and confirmed 100 percent matched sequences for PDV. This provides some assurance as to the identity of the detections and the significance of them in terms of high health management in the collection (Uyemoto, J., pers. comm.). Shirofugen cherry (*Prunus serrulata*) indexing will detect but not differentiate PNRSV and PDV.

The necessity of biological indexing needs recognition by the ABA as it is an effective method of confirming molecular indexing. It is also the most reliable means by which new serotypes or strains of PNRSV and PDV would be detected.

Trees at Monash that are found to have detectable PNRSV in stage one of the indexing, are immediately removed. For PDV, it is only the second round testing (nested PCR) that has revealed positives. To-date these trees have been retained for validation of results and because there is no evidence of disease in the trees.

This review required assessment of the indexing methodologies of University of Adelaide and Vic DPI, Knoxfield as each institutional laboratory is providing indexing for a different almond budwood planting. It is in the industry's interest to have harmonised testing procedures (methodologies, extraction techniques; sampling time, tissue type, sample amalgamation; frequency of testing etc.) and agreed actionable tolerances, i.e. if an infected tree is detected, it should be removed. Therefore as part of this review we recommended comparative testing of the same trees at Monash by both the University of Adelaide and Vic DPI, Knoxfield laboratories.

Samples were collected in October 2007 and sub-samples were forwarded to each of the almond testing services. Virologists, Dr Michelle Wirthensohn (University of Adelaide) and Dr Brendan Rodoni (Vic DPI, Knoxfield) undertook molecular testing using primers from University of Adelaide or Knoxfield. The results are presented below in Table 7.

Table 7: University of Adelaide and Vic DPI, Knoxfield molecular test results for PNRSV and PDV detection in almonds at Monash

Virus	PDV					PNRSV	
Testing authority	Knoxfield			Univ of Adel (UofA)		Knoxfield	Univ of Adel
Primer source	Knox	UofA	Nested UofA	UofA	Nested UofA		
Clone A11-23 Ne Plus Ultra	-	-	-	-	+	-	-
1B-05 Lauranne	-	-	-	-	+	-	-
1B-11 Moncayo	-	+	+	-	weak +ve	-	-
2B-14 Mandaline	-	-	-	-	+	-	-
3B-26 Wood Colony	-	-	-	-	+	-	-
4B-23 R1066	-	-	-	-	+	-	-
5B-02 Ferragnès	-	-	-	-	+	-	-
6B-08 Chellaston	-	-	-	-	+	-	-
7B-11 Marta	-	-	-	-	weak +ve	-	-
7B-17 Ferralise	-	-	-	-	weak +ve	-	-

The results are consistent in the detection of PNRSV. Neither laboratory detected any PNRSV.

Knoxfield also tested for the presence of Apple Mosaic Virus (ApMV) and Apple Chlorotic Leaf Spot Virus (ACLSV). ApMV was detected in 5B-02 Ferragnès. The tree since the time of initial sampling has been re-inspected. There are no visible symptoms of disease on this tree.

The results are inconsistent in PDV detection. There is no confirmed explanation of the different PDV detection levels indicated by the two laboratories using the nested PCR methodology. It is suggested that the industry consider confirmation of budwood diagnostic results with the FPS laboratory at UC Davis or through the Californian laboratories relied upon by AQIS.

A potential variable between the University of Adelaide and Knoxfield laboratories, lies in their RNA extraction techniques. Wirthensohn at Adelaide uses an Ambion kit with modifications.

This laboratory confirms RNA integrity via spectrophotometry and a PCR round using primers from ribosomal RNA. The Knoxfield laboratory may utilise other pre-test confirmation and RNA extraction techniques.

It is in the industry's interest to have harmonised and validated testing procedures for all detection and screening analyses, and for industry to agree on the actionable tolerances for detections.

It is generally agreed that candidates of locally-selected almond material, found to be virus-infected should not progress further into the multiplication and improvement scheme, without pathogen elimination treatment and further testing. There are several locations at which heat therapy and shoot-tip culturing is being undertaken. At present meristem culture is primarily being used for rapid multiplication (Kester, 1970) of material in short supply, not for pathogen elimination. See Section 4.3.

4.4 Maintenance of Pathogen-Free Clones

It is the aim of an industry-funded budwood scheme to procure, secure and maintain pathogen-tested public clones of industry-relevant propagation material and to make them available on a basis equitable and advantageous to the national industry. Some germplasm may need to be maintained for future breeding programmes or to accommodate possible changes in varietal structure of an industry. Through consultation, we believe there is widespread agreement that the industry organisation, for example the ABA, should accommodate, where possible, the needs of private importers. ABA should ensure that the high health status of imported clones, both public and private or patented, is maintained by their inclusion in a "pathogen-free" repository; and provide some multiplication step to meet the requirements of the variety. This is being done by the Auscitrus citrus budwood scheme for private importers/commercialisers. As a consequence, the industry benefits from the maintenance of industry-accepted standards of high health and horticultural performance. The Apple and Pear industry has similarly resolved to accommodate and encourage the entry of privately-imported clones into their APFIP system, in the interests of the national industry development.

The Monash facility has in the past accommodated (and monitored) privately-protected varieties, i.e. Wood Colony, Avalon (which is trade marked). This is something the industry is encouraged to do more of in the future as the completeness of the budwood collection as a high health genetic resource, and the centralising of evaluations, will benefit the whole industry regardless of the potential distribution constraint on proprietary material. It is especially relevant if a secure (locked insect-proof screenhouse) foundation repository is introduced into the Scheme, as was initially the case during the tenure of the Fruit Variety Foundation.

The subsequent challenge is to maintain adequate supplies of the true-to-type material at its highest health status. For an industry such as the Australian almond industry, agreed PEQ testing protocols, agreed sampling and testing protocols for multiplication trees (implemented by independent and qualified laboratories, and supported by independent validation and research), would benefit the entire industry.

4.4.1 Foundation Repository

After release of the "pathogen-tested" material from PEQ, it is the importer's responsibility to maintain health status and integrity of that material. The released material is called 'foundation' or 'nuclear' material, and this high health status, true-to-type locally selected or bred clones or varieties, is the core of a multiplication scheme.

Plants of all genetic material that have been, are, or potentially will be, planted within multiplication blocks ideally should be propagated from budwood sourced from a foundation tree repository. A foundation repository or collection, generally includes two plants of each local or recently-imported virus-tested and horticulturally-desirable cultivar/clone. Each accession is thoroughly tested for graft-transmissible pathogens and each accession is maintained in an isolated or dedicated field site or protected screenhouse. From these trees, mother trees are established. Foundation trees are therefore the foundation of any properly established budwood scheme (Fridlund, 1983). Legitimate mother trees have direct traceability to the foundation tree.

The ABA must accept the need for a foundation repository, being a key component of certification and improvement schemes, but currently absent from the almond scheme. It should include two trees of clones or varieties of local and overseas origin. The existence of a foundation repository that included original Fritz trees, would have assisted today's deliberations on the removal of Fritz from the multiplication block, being a variety no longer of industry relevance, as two trees would still remain within the repository. They would remain available for future breeding, or in the event of a return to commercial importance.

It is recommended that the ABA maintain two original plants (rootstock or scion) released from PEQ (or local breeding programmes) as potted, foundation trees in a secure, insect-proof screenhouse, hereafter.

If the foundation trees are maintained in an open field block it is recommended that it be isolated by 1km from any wild or cultivated Prunus spp. (EPPO PM4/30 (1)).

It is in the industry's long-term interest to encourage private importers and local breeders to submit their relevant genetic material also to this repository. This repository of foundation trees is essentially an "insurance policy" against potential disease outbreaks in multiplication blocks, but also is the preferred location for material that is not currently relevant (and therefore not in a multiplication scheme).

The foundation repository serves as the industry's inventory and as such entry records, accession numbers and testing regimes and results, are core data for future traceability, and the foundation of the industry's genetic resource management.

The almond industry (ABA) is encouraged to build a database of all relevant importers and planting material entering the country as best they can, and prior to the anticipated growth in the number and type of private importations.

An example of a national, centralised database for germplasm is that of the United States Department of Agriculture (USDA). Its Germplasm Resources Information Network (GRIN) and National Plant Germplasm System (NPGS) allow individuals and industries to access information about germplasm collections, specific accessions, those protected by Plant Breeders Rights (and Plant Variety Rights in USA), and attribute descriptors of them (eg. disease resistance). See http://www.ars-grin.gov/npgs/fq/

The National Clonal Germplasm Repository (NCGR) in Davis, California, includes *Prunus* germplasm other than tetraploid cherries and ornamental *Prunus*. There are at least 15 entities that provide input to *Prunus* germplasm decisions (Prunus Vulnerability Statement http://www.ars-grin.gov/npgs/cgc_reports/prunusvulner99.pdf) and the Vulnerability Statement outlines some of the challenges facing *Prunus*. The Statement notes that in 1996, 92 accessions for *P. dulcis* were in the Davis repository and 120 were in GRIN. For almonds, it is noted that Nonpareils account for over 50% of USA almonds (similar to Australia) and the genetic base of almonds is relatively narrow, with stone fruits in general being genetically vulnerable (susceptible) to pests and diseases pre- and post-harvest. Almonds are somewhat protected by the nature of their 'fruit.'

4.4.2 Propagation Chains for Pathogen-Tested Varieties and Clones

The better the collaboration between orchardists, nurserymen, horticulturists, breeders, virologists and now “commercialisers” of patented varieties, the better the chance that only the best high performing, true-to-type cultivars and clones, free of graft transmissible pathogens, will be entered into a propagation scheme. Budwood source blocks require routine inspections for trueness-to-type, bud sports (mutations), and general health status and pathogen testing (indexing). Few propagation schemes are run without scientific assistance and they require considerable technical input and cooperative organization (Hansen, 1986). Selection of the most appropriate scheme for budwood multiplication depends on industry characteristics (eg size, organization), the degree of government support (and/or control), and the sources of funding, and the known biological, genetic and environmental risk factors.

A budwood multiplication scheme must offer long term stability, fairness to all concerned, potential for timely entry and appropriate introduction of new cultivars, reliability of service and horticultural quality (Hansen, 1986). Traceability is increasingly important.

The options for multiplication are:

1. ***Centralised budwood production,*** eg Monash or the Auscitrus budwood scheme; European certification scheme (EPPO) for the production of healthy plants (EPPO, 2000).

2. ***Supply of foundation buds*** to nurserymen, or nursery associations, who maintain their own mother trees with routine indexing for pollen borne viruses by a state authority eg in USA or the Italian Certification Scheme for fruit trees.

   The California Fruit Tree, Nut Tree, and Grapevine Improvement Advisory Board (IAB) allocates funds annually to support the Nursery Registration and Certification (R&C) programme. Under this programme, participating nurseries with deciduous fruit and nut trees and grapevines to be used as a source of certified propagation materials in following years, have their trees tested annually for various viruses. CDFA biologists coordinate with the nurseries and collect the samples. Sample collection is conducted during times of the growing seasons depending on the viruses to be tested. The CDFA nursery diagnostic laboratory carries out the testing of all samples collected from different nurseries. They mainly use ELISA, and PCR if necessary (Zhang, 2004).

3. ***Rapid nursery multiplication***, i.e. the cutting of scion budwood for a limited period from commercial nursery trees once removed (one-off) from a mother tree. This occurs in the Auscitrus scheme for citrus varieties where budwood is in short supply, eg. for recently imported varieties. Rapid nursery multiplication is currently being used in Australia for the propagation of GF677 rootstocks by semi-hardwood or greenwood cuttings and by tissue culture. The ABA has approved some nursery propagation of GF677 from high health status, true-to-type, one-off material. There are however other suppliers of GF677-labelled material that cannot claim full traceability to foundation stock.

The distribution of buds to nurseries for establishing mother trees, would allow nurseries to be self sufficient, but the case against this is the need for retention of control over propagation practices. Without the safeguard provided by a central multiplication facility utilising ‘best practices’, there is increased risk to the health status and genetic stability of the propagation material reaching commercial growers, due to lack of control over:

- multiplication and distribution of a bud sport,
- genetic problems that emerge as ‘generational distance’ from the foundation or mother tree increases, i.e. the NBF situation in California,
- re-working of rootstocks,
- propagation and utilisation of non-certified rootstocks for nursery mother trees.

Likewise, rapid nursery multiplication, i.e. the cutting of scion budwood for a limited period from commercial nursery trees once removed (one-off) from a mother tree, is not without its problems. While providing large numbers of buds in a very short period to meet temporary shortfalls in supply, the method has the propensity for propagation of a bud sport or to increase the risk of NBF. Without careful attention to labelling of stock, it has an increased possibility of supply of the wrong material. For the Australian scheme, there are two options – the rapid multiplication of material in short supply by ABA at Monash (as occurs in the Auscitrus scheme) or rapid nursery multiplication at nursery level. Auscitrus has found the latter method unsatisfactory as few of the nurseries return to high health foundation sources in subsequent years.

4.5 Horticultural Evaluation

4.5.1 Trueness to-type

While market failure of propagation material and trees in some industries has been attributed to quality and supply issues, in others it has resulted from the failure to provide a variety of the correct identity. Evaluating trueness-to-type and looking for bud sports (mutations) is a tedious yet essential annual process, especially critical for genetically unstable budlines (i.e. various Carmel clones). It must be applied annually to all source trees providing budwood or cuttings.

Sales of almonds are usually by specified variety name (i.e. Carmel, Marcona) and hence established, variety recognition and reputation are valued far higher by marketers, than the prospect of something ‘new’. Almond growers, like most citrus growers, make long-term (30+ years) commitments to their trees. The almond industry stability in this area differs from that experienced in other *Prunus* industries, and in the table grape industry where the market imperative to change varieties is significant. In the citrus and wine grape industries there are a few markets dedicated to specific clones – i.e. Pinot Noir clones specifically demanded for either sparkling or dry red wines. The different market incentives and imperatives of the four industries, are evident in the different rates and number of private and proprietary importations, and the time taken to commercial release in each.

4.5.2 Horticultural Performance

Market failure has also resulted from the sale of plants of unproven horticultural performance. This has generally been the result of too rapid commercial uptake after importation – i.e. lack of any evaluation or short-cut evaluation trials and buying a variety from a catalogue rather than seeing the variety performing in Australia. The table grape industry and the stone fruit industries have traditionally accepted such risks and the associated low success rates, since new varieties and marketing are the basis of their commercial advantage. By contrast, most citrus growers want to see the newly imported variety performing in the field in their area before committing to planting the variety. Consequently the citrus industry is willing to commit levy funds for short term horticultural evaluation of new varieties in each major production area.

Horticultural evaluation at some level (cultivar performance, flowering time, rootstock compatibility, confirmation of trueness-to-type and market acceptability) should be an essential component of the almond scheme, along with pathogen testing. It does not necessarily require long-term fully replicated research trials to obtain this information and “quick and dirty” observational trials on grower properties can often achieve the same outcome in a shorter period of time, if properly established. The minimum requirements should be clean material of the same generation, Nemaguard and GF677 as comparative rootstocks, multiple trees (not single tree replications) for each candidate scion, candidate rows having Nonpareil rows on each side, and two locations that allow adequate assessment of chilling requirements. Other parameters currently evaluated in the local breeding program are extensive and are included in Appendix 4. Where performance of patented varieties is being assessed, security of trees is clearly required.

Progressive growers, who frequently travel and observe almonds elsewhere in the world, have seen benefits from acquiring a few buds of new varieties to trial privately in existing orchards. They have reported that flowering time and nut characteristics overseas are the parameters on which their decisions are usually made, as they claim there is negligible effect of climate on kernel characteristics. However there has been little collation or review of this anecdotal information. Kodad (2006) found that bloom density, fruit set, fruit density and productivity were highly genotype and year dependent, but the interaction genotype × year was less important or even non-significant, stressing the special behaviour of each genotype as well as the effect of the year, probably linked to the climatic conditions and to the physiological status of the trees. Brief discussion of Californian regional almond trials is included in Section 6.5 Evaluations.

Although not a conscious consideration, growers have often assumed that the acquired, promising material placed in such trials was at its origin, screened for susceptibility to diseases of importance to Australia – bacterial spot, anthracnose etc. In reality however, this is not often the case. For example, varieties bred or selected in California, would not normally have been exposed to bacterial spot and therefore susceptibility to such a disease may only become known once local trials are undertaken.

Although the logistics have not been widely debated, it appears the almond industry would benefit from a coordinated system of regional trials for promising almond and rootstock clones.

Regional trials should include both local selections and advanced breeding lines, and those acquired internationally. At present, the Australian industry has limited Australian-generated data available on internationally-bred clones. Several Californian varieties have been commercialised and growers have had opportunities to view these trees planted within grower block trials. The numbered Spanish imports, Glorieta and Masbovera are yet to be included in grower blocks. The lack of focus on formal evaluation reflects in part the paucity of private importations to-date, the current lack of competitive advantage seen in rapidly introduced unknown clonal material, and the success enjoyed by most growers across all production districts, with the limited range of currently available varieties and rootstocks.

More extensive regional trials require standards for site choice, establishment, and data collection for example, as prepared by APFIP for the Apple and Pear industry. The APFIP protocols and software are available to approved users. The ABA has a bud development chart that would prove useful in harmonising the terminology and data collection related to flowering.

The ABA may wish to investigate the opportunity for, and associated costs of, modification and use of the APFIP trial protocols and software for specific use by the ABA and their trial co-operators.

The ABA has not previously driven regional evaluation as a component of industry development, nor as an essential part of the improvement scheme. It is important that comparative trials reveal genetic differences distinguishable from those resulting from environmental, temporal and/or spatial variation, and that comparative data are made available to growers.

The ABA must consider future regional evaluation of new clones of scions and rootstocks, a key component (currently missing) of the improvement scheme.

In the future as production districts extend beyond the ideal sites into more marginal areas, as water restrictions are imposed, and as product differentiation benefits increase, the industry would be well-served by a minimum disclosure requirement for commercialised almond material. It might include the material's accession number and origin, its AQIS testing regime, a DNA fingerprint, foundation trees provided to the ABA foundation collection, drought tolerance and/or disease susceptibility ratings, nut characteristics, flowering time, rootstock compatibility (with two designated rootstocks) etc. While this may be viewed as unnecessarily onerous at this time for private importers, it is essential in terms of the capacity for all growers to identify and manage their risk. As part of the HAL-funded citrus improvement project, variety and rootstock fact sheets are produced initially for imported varieties with overseas information on their performance, but as local information accrues that is also included. The information requirement may in fact, provide the incentive needed for importers to become engaged in the industry multiplication scheme and any industry-endorsed evaluation programme, to the benefit and protection, of the national industry.

Market failure is also being experienced as a result of nomenclature changes, in several horticultural industries. The grape industry is suffering from the current propensity of some importers to re-name clones at will, without any further reference to the accession number. It is unwise for this to occur prior to passage through the multiplication phase.

The development of a step-wise procedure for re-naming clones, that includes a specific public announcement (in an accepted journal) of the accession number and recommended name, is suggested.

Nomenclature problems due to incorrect identity of propagation material have been identified in the almond industry. Various rootstock clones have been named and sold as GF677 (*Prunus amygdalus* x *P. persica*). This has been clearly shown through DNA-fingerprinting and growers are advised to source GF677 from reputable suppliers who on request can provide evidence of the material's origin.

5 OTHER BUDWOOD SCHEMES IN AUSTRALIA

The current reality for most Australian perennial horticultural industries is that health status testing of propagation material, is unregulated and non-uniform. As such, there are few agreed phytosanitary specifications for rootstocks and scions, and the achievement of defined, high health status planting material within perennial horticultural industries is surprisingly rare. The ideal of no detectable graft-transmissible organisms, or other known pathogens exists widely, but in reality only the citrus and pome fruit industries in Australia test sufficiently to produce scion and rootstock material with a defined, high health status (not necessarily virus-free eg citrus may be pre-immunised with a mild isolate of the aphid-borne citrus tristeza virus). Other industries, both here and internationally, are compromised by either the limited range of testing undertaken (often just quarantineable viruses with no viroid or phytoplasma tests) and/or the acceptance of some virus presence in propagation stock (i.e. rupestris stem-pitting in grapes).

Management options for industry multiplication schemes in Australia are tabulated below (Table 8). Recommendations on the administration of the Australian almond budwood scheme are included in Section 8.

Table 8 : Comparison of Multiplication Schemes in other Australian horticultural crops

	Australia		
	Citrus	Pome Fruits	Grapes
Management	Aust. Citrus Propagation Association Inc. trading as Auscitrus[11].	Aust. Pome Fruit Improvement Program Ltd (APFIP)[12]	Australian Vine Improvement Association (AVIA)
	Representation on Auscitrus is by growing organizations (nursery and citrus) in each state		
	A not-for-profit (NFP) organisation	A not-for-profit company	NFP organisation
	Managed by a board of 5 directors who work in nursery or citrus industries and a Manager for the budwood and seed scheme. Directors are nominated annually by the growing organizations represented on Auscitrus and the Management team is elected by these representatives annually.	Managed by a board of 5 directors who work in nursery or pome fruit industries and a General Manager. Board vacancies (every 3 years) are filled by advertisement.	Managed by Board of Directors from each State Vine Improvement (VI) association. Exec. Officer and part-time tech officer.
Funding	*Budwood and seed supply:* through sales	Pome fruit grower levy with matching funds from HAL.	Levy of member organisations; funds from sales (only to VI groups)
	Foundation repository: citrus grower levy with matching funds from HAL but currently subcontracted[13] to NSW DPI		*Foundation repository* at Dareton: funded by support of members and HAL (possibly GWRDC in future?)
Budwood production (public varieties)	Currently on NSW DPI land at Dareton under a Deed of License, but trees to be established on Auscitrus' land at Dareton.	Certified scion varieties from APFIP block at Cambridge Tasmania currently do not meet demand. Production on nurseries can be certified if virus tested (by Crop Health Knoxfield) and true-to-type (assessed by APFIP or their representative)	On DPI land at Dareton, NSW, under deed of licence. 'Certified' material accounts for 100 % (but standards are not nationally agreed as yet).
Budwood production (Proprietry lines)	Owners encouraged to have multiplication carried out by Auscitrus. Some commercially important varieties (eg PBR late navels) are outside the Auscitrus system	On owner or commercialiser's land. With virus testing and ensuring trueness-to-type these proprietary lines can be certified (but not trade marked) by APFIP <u>if</u> traceable to mother tree inspected by APFIP	Inclusion of AVIA imported lines and other proprietary material needs to be PCR, ELISA, biologically indexed before entry to scheme. Strict hygiene also.
Rootstock production	Currently on NSW DPI land at Dareton under a Deed of License, but trees to be established on Auscitrus' land at Dareton. Linkage to seed supply from Qld. Citrus Improvement Scheme and from Monash seed source plantings of SA Citrus Improvement Scheme (SACIS).	Was at Monash until 2005. Now licensed to commercial nurseries	At DPI Dareton nuclear collection site – 100% 'certified' scion material and rootstocks.
Repository of nuclear (foundation) trees	Currently in insect-proof screenhouses at NSW DPI at EMAI Camden but to be relocated to new houses on Auscitrus' land at Dareton (*in centre of a citrus producing area*); field repository at NSW DPI at Dareton. Scions only in screenhouses.	Certified varieties and rootstocks in a new repository (*isolated from pome fruit production*) near Cambridge, Tasmania.	Foundation collection of scion and rootstock material held in field repository – 2 ha enclosed 500 m form Vitis spp. Developed from GWRDC project (Nicholas)
Indexing of mother (propagation) trees	By NSW DPI but totally funded by Auscitrus, for staff (1 full time virologist), and disposables and rent on screenhouses etc. ie not per tree.	By Crop Health Services at Knoxfield. Industry pays (via levy?)	Annual testing of foundation material by Vic DPI, Knoxfield – out of levies but needs national industry contribution.
Certification scheme	Working towards accreditation of nurseries for the use of Auscitrus high health status budwood and seed	Certification[14] scheme with Trademark encompassing virus status, trueness-to-type and minimum nursery tree standards/ specifications.	Certification scheme and standards not yet nationally agreed; guided by Tech Committee including pathologist.
Nursery Accreditation	3 citrus nurseries accredited by NIASA. The nursery at EMAI where biological indexing is conducted for Auscitrus is also NIASA accredited		VINAS and AVIA accreditation schemes available. Uptake – approx 70 accredited nurseries?
Arboretum (gene bank)	Operated outside budwood scheme and repository by NSW DPI		Germplasm collections of undefined health status in Vic and SA; CSIRO collection indexed. SA operates independently from scheme.
Varietal evaluation	Independent evaluation of newly imported public <u>and</u> private varieties is subcontracted by Auscitrus to NSW DPI, Dareton (principal investigator) with additional testing in each major citrus growing area. Funding to Auscitrus through citrus grower levy with matching funds from HAL. Growers can see fruit of patented varieties on trees once nursery trees are on the market. Prior to that fruit is displayed at field days. Some market evaluation of new public varieties.	Independent evaluation conducted by APFIP on grower properties (one per region). Results centralized and posted on APFIP website (password protected). Secrecy regarding sites.	Regional groups conduct uncoordinated evaluation. No centralized data collection, but regional trial guidelines exist for grape trials. No nomenclature changes within collection. Table grapes and dried grape industries operate differently with trials and nomenclature.

[11] See www.auscitrus.com.au
[12] See www.apfip.com.au
[13] This will change with the erection of insect-proof screenhouses to hold foundation trees to be erected on Auscitrus' land at Dareton. Re-indexing of foundation trees will continue to be done at EMAI with HAL funding
[14] For APFIP certification rules see www.apfip.com.au/certification/rules.cfm

6 BUDWOOD PLANTINGS AND ROOTSTOCK SUPPLY

It is fundamental that a successful, competitive, high quality, productive almond industry is founded on trees that have been proven true-to-type (both rootstock and scion) and are of the highest health status. An active improvement programme resulting in the timely release of new varieties and clones of a high health status is important to an industry's continued development and international relevance. The Monash multiplication block is a valuable asset of the almond industry.

It may not be apparent to growers somewhat new to the almond industry, that the supply of propagation material directly traceable and within 1 generation of high health status mother trees, has allowed the Australian industry to establish without any significant setbacks – i.e. non-infectious bud failure, loss of traceability and/or nomenclature problems.

6.1 Monash Budwood Plantings

The Monash collection consists of 601 almond trees of currently-, or recently-relevant cultivars domestically bred, selected or imported. The site is managed for production of budwood by several staff members shared with the SA Vine Improvement Committee. The operations are overseen by the ABA's Industry Liaison Manager (ILM) - formerly the Industry Development Manager.

The one hectare Monash budwood multiplication site was established 20 years ago and is now being expanded in area. The configuration is a 4m x 3m grid. A map of the Monash budwood site is included in Appendix 2. The relevance of the varieties included in the multiplication block, with perhaps the exception today of Fritz, is evident from the industry's variety planting data provided in Table 1. The collection includes foundation trees from PEQ, on Okinawa or Nemaguard rootstocks. Some mother trees lack direct traceability because the location of their foundation tree is no longer known.

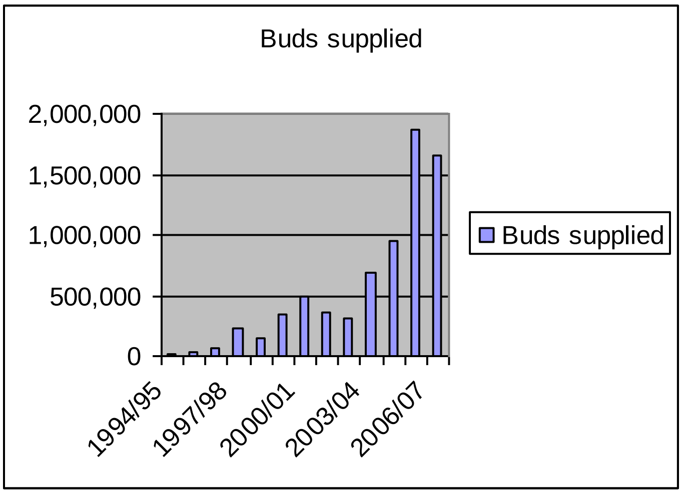
A complete list of known almond imports (and those that have at times been listed as 'of interest') has been compiled from various sources and is included in Appendix 3. The most recent entries are tabulated in Table 2. All recent imports are included in the Monash planting.

Monash is the site of two of the key components of the Australian almond improvement program: breeding progeny evaluation and budwood multiplication. These are discussed in more detail below. Additional components in some other horticultural industry multiplication improvement schemes are absent in the almond scheme (i.e. a foundation collection; local and regional independent evaluation of new varieties; seed/rootstock supply). The ABA has little input to rootstock multiplication and supply, as Ausbuds is the major supplier. More recently two other nurseries have been provided with GF677 material to multiply. During the 2006/07 season, a period when demand exceeded supply, other providers of rootstock and budwood material emerged and with them arose problems of propagation material quality and traceability.

Table 9 shows the buds supplied over the last decade from Monash. The large increases in 2004/05 and 2005/06 reflect the extensive plantings in MIS orchards. A reduction in demand is expected over the next five years as the impacts of shortages of preferred land, water restrictions, loss of MIS incentives and increased production from a second budwood block, are realised.

Table 9 : Buds supplied from Monash collection 1994-2006

Year	Buds Ordered	Buds supplied	Price per bud
1994/95		13,520	**20 cents**
1995/96		40,570	"
1996/97		72,100	"
1997/98		225,220	"
1998/99		141,970	"
1999/00		341,815	"
2000/01		485,000	"
2001/02		368,295	"
2002/03		309,356	"
2003/04		693,690	**40 cents**
2004/05		954,538	"
2005/06	1,680,748	1,871,976	"
2006/07	3,381,694	1,650,405	"



Each season orders for budwood are placed by faxing a prepared form (Appendix 11). Orders are due mid-October each year and in the past two seasons the ABA has had orders placed for 1.6 million and 3.4 million buds, with the 2006/07 orders being reduced mid-season as the Select site came into production. However, even in this season, Select Harvests took 50% of Monash budwood. Net profit from the self-funding Monash site and facility is approximately $600,000 per year and this is directed into research. Individual growers, nurseries and MIS schemes purchase buds and distribute them to their nurseries or bud the material themselves.

6.1.1 Horticultural Management

The horticultural management of the site in terms of irrigation, nutrition, crop protection, weed management, pruning and blossom minimisation are focussed on the maintenance of healthy, productive trees and the provision of high quality budwood. 'Productivity' relates to extension growth suitable for budwood, and as such, pruning, and manipulation of nutrition and irrigation are crucial. During the last 5-6 years soil moisture and nutrition have been monitored in the budwood block. There was a change to drip irrigation in 2005 and pressure problems that blew out some irrigation lines have been reported from the 2006 season. The records available on current practices are limited, but first-hand observation of the trees in February, 2007 suggest they are well-managed and productive, with 10,000 buds being produced per tree annually. Further specific details may be available from the ABA.

As would be expected in any nursery or propagation facility where high health standards are imposed, there is no top-working or re-working of rootstocks, and no propagation from commercial buds, at Monash. The hygiene practices followed at the site and associated record-keeping forms have been recently documented by Mr Ben Brown, ILM. They are included in Appendix 12, and will be implemented in the November 2007 cutting period and thereafter. It is our opinion that these, with some additional details (as noted in Appendix 12), are appropriate guidelines for the cutting and handling components of the budwood scheme. Winter prunings are also collected for budwood and more experimentation and research is needed in the best practice cutting, handling and storage, of this material. The operations for which we recommend the development of documented procedures are given in Section 8.1.1.

6.1.2 Non-infectious Bud-Failure[15] (NBF)

The management of trees influences the extent to which genetic disorders may present. NBF is a long standing problem in Californian almond orchards, nurseries and breeding programmes (Kester, 1994). Some of the varieties in which bud failure has been prevalent and severe are Carmel, Harvey, Merced and Jordanolo. Nonpareil NBF is less common. Peerless, Price, Thompson and Mission seldom show NBF. It has not been reported and verified in Butte, Padre, Sonora, Ne Plus Ultra, Fritz, and Monterey, but this is no assurance that NBF will never be seen in these varieties.

NBF is a genetic disorder and NBF-potential may gradually increase over time as specific cultivars are repeatedly vegetatively propagated. Eventually NBF phenotype trees begin to appear with high or low frequency. Variation in NBF propensity within a clone is transmitted to progeny, i.e. it is inherited. Most important therefore amongst the selection criteria for clonal material and/or propagation material from established trees, are the choice of individual tree and branch, and the specific bud position if propagation of a new mother tree is the intention.

The process of "clonal aging" or "clonal deterioration" in a susceptible clone, is driven by exposure to high summer temperatures and is directly proportional to accumulated degree days over 28°C (80°F). Tests show that the higher the average summer temperatures, the more rapidly NBF symptoms develop and the more severe NBF will become. The most severely affected buds are those that developed during periods of extreme heat. Some research and field experience indicates that water stress may also increase NBF the following year. This may be due to higher bud temperatures on stressed and partially defoliated trees.

In Australia the NBF problem has been carefully and specifically managed at Monash in Nonpareil and Carmel through the selection of low-NBF 'source-clones', selection from buds closest to the original bud, and through maintenance of small, spur-pruned trees. The bud choices for propagation of particular Carmel (and other) mother trees currently in Monash were made by Chris Bennett, after consideration of the bud proximity to the original bud, bud maturity, tree performance and pruning regime. This has been a successful, long-term strategy. The conditions during summer at Monash are conducive to the onset of NBF should it have been present within the managed clones. The close monitoring and management practices employed over a long period at Monash, have almost certainly contributed to this collection’s enviable NBF freedom. Informed propagation and management practices must continue if the expansion of Monash is to proceed without an increased threat of NBF.

NBF is present in Australian almond orchards at a low level. It has been observed in Carmel (Edstrom, 2006) and in several Australian varieties (Bennett, C., pers. comm.) in recent years, and in a Nonpareil trial established in 1986. NBF management could be effectively assisted by registration and certification programmes in which traceability of material source is paramount, and awareness of low-NBF clones, environment and management practices, is high. Avoidance of NBF in commercial orchards is best achieved through the choice of propagation material. Commercial orchards are unacceptable as budwood sources. Kester recommended propagating from low-NBF source trees in a three step program (Kester *et al*., 1998):

1) selection of single tree sources (i.e. foundation trees),

15 The University of California publication, Almond Production in California, publication 3364 has two chapters on bud failure and variety selection. Every almond producer should have a copy of this publication. Dr. Dale E. Kester's 25-page final report to the Almond Board on the Noninfectious Bud-Failure Project is accessible in pdf format on the Web at: http://fruitsandnuts.ucdavis.edu/alm2.html

2) maintenance in a foundation orchard in a hedge row or scion orchard (foundation clones), and

3) multiplication with reduced vegetative generations

The last step highlights why the Australian industry has been somewhat protected from this genetic disorder. The Monash budwood multiplication scheme supplies material to industry that is no further than one generation from the mother trees. With changes to this commitment or increasing acquisitions of budwood by growers and nurseries from unofficial sources, we can expect increased NBF in commercial orchards. Growers can provide useful information to the industry on NBF potential by closely examining the bud development and growth patterns in young trees over the first 5 years, and longer in cooler growing regions.

6.1.3 Health Status Management

6.1.3.1 Indexing

In a *Prunus* budwood scheme, reliable indexing is required since not all viruses of *Prunus* express symptoms (on all rootstocks), each season. Some symptoms are variable temporally, spatially and in intensity and therefore visual inspections are not reliable. The Australian almond breeding and improvement programme has incorporated regular indexing for a number of economically important endemic almond viruses (Wirthensohn *et al*., 2003; Bertozzi *et al*., 2002; Sedgley and Collins, 2002a). In addition, the ABA has supported research into other pathogens about which there is now greater awareness and capacity to screen, i.e. anthracnose and bacterial spot (Colmagro *et al*., 2002; Li *et al*.; 2004).

The Monash trees are visually inspected annually by the ILM for trueness-to-type, bud sports and overall appearance. On average one-third of the collection is sampled and tested annually, for the presence of two endemic viruses (PDV and PNRSV). The trees to be cut make up the majority of those sampled. In 2006, 300 trees were sampled and indexed. The sampling methodology requires that each canopy quadrant be sampled in early October, with a total of six leaves removed per tree. The leaves are bagged, labelled and placed on ice. A 100 mg sub-sample from each tree is individually analysed using PCR. No trees testing positive for PNRSV are cut that season. PDV testing of the Monash collection is important as the molecular test used by Wirthensohn is more sensitive than ELISA and more sensitive than the biological indexing used in AQIS PEQ (Shirofugen on Okinawa rootstock), and includes the Spanish strain as a control. The tests utilising nested-PCR is particularly sensitive and indicated more PDV-infected trees than expected. Given the trees are symptomless, the diagnostic results are not supported by field inspections, nor have they been by ELISA testing. The detections need further investigation, including by biological indexing on Shirofugen. Few trees in the Select block (see 6.2) have reportedly had PDV detections. This is somewhat surprising since the Select block was established with budwood from the Monash trees. Select trees however have been indexed utilising a different methodology. Validation of results by other laboratories is warranted before any tree removal, from either budwood block.

Sedgley *et al*. determined in 1999 that PNRSV was the more significant virus in Australian almond orchards. The reliability of ELISA and molecular indexing methodologies for the detection of the viruses was assessed under local conditions (Bertozzi *et al.*, 2002; Sedgley and Collins, 2002). ELISA reliably detected PNRSV in petals and young leaves from bud-break until the end of stem elongation. Petal or leaf tissue collected early in the season yielded the most reliable results. Herbaceous indexing was not as reliable as ELISA. Although PDV had not been reliably detected using ELISA, molecular tests produced a positive response. Woody indicators could differentiate positive from negative samples reliably throughout the testing period, but was too slow and costly for mass screenings and did not distinguish between the two viruses. No biological indexing of the trees, once established in Monash, is carried out.

To improve the Monash programme, and to progress the Australian Almond Industry STRATEGIC PLAN (2006-2011), it is recommended that all trees supplying budwood be tested annually for PNRSV and PDV.

6.1.3.2 Tree Removal

The indexing and visual inspection results that determine tree removal from the Monash planting are not documented. It is known that trees have been detected with PNRSV and removed. Off-type trees have been removed and in 2007 one tree showing symptoms of 'silverleaf' was removed. There has been discussion regarding the removal of Fritz from the planting. It is no longer a favoured variety and it has not been cut for several years and is susceptible to bacterial spot and anthracnose.

The industry's position on validation of test results and tolerances for removal of infected trees requires consideration. If for example, a tree is determined to be infected by nested-PCR only, and shows no symptoms, will biological indexing be used to validate the result before tree removal? The spatial distribution of trees with virus detections was mapped and monitored informally by the former IDO, and this should continue.

Consideration of the annual testing regime should include determination of a policy and tolerances, for removal of infected trees.

It is also recommended that the location of infected trees be analysed periodically to assess whether or not root-grafting may be involved in any virus transmission.

6.1.3.3 Isolation

Within the Monash site, the budwood trees are 30 m from the nearest breeding progeny. All trees (breeding and multiplication) are indexed and it is not considered that these pose a health threat to the budwood trees since they are indexed to the same standard. In Oregon, USA, the Fruit Tree registration/certification programme (http://nrsp5.prosser.wsu.edu/index.html) requires isolation distances of 30 m for scion source blocks from non-certified Roseaceae, and 100 m for seed source blocks from non-registered *Prunus* spp.

There appears to be room at Monash for expansion of the current plantings. However the isolation required for a field maintained foundation repository (1 km) would require expansion to the back sand hill area.

The Monash planting is isolated by several kilometres from other commercial *Prunus* spp. It is possible that some home garden *Prunus* trees are closer than this, and a recent apricot planting for the purposes of research is also closer.

It is recommended that the ABA confirm the known health status and the intended monitoring and indexing schedule for the apricots, with Dr Adrian Dahlenburg, SARDI.

Of importance in the event of an exotic disease outbreak of Pierce's Disease for example in the Riverland, will be the proximity of almond plantings (including those at Monash), to grapes. Grapes and almonds are both hosts for *X. fastidiosa* and even if the almonds were unaffected at the time, they would be included in the pest quarantine area (PQA).

6.2 Select Harvests' Budwood Planting

Select Harvests Limited (Select), Australia's largest almond grower, manages 60% of Australia's almond orchards, and is one of the largest almond growers globally (http://www.selectharvests.com.au). The Select budwood planting near Shepparton was established as a result of a 5-year nursery review. The budwood programme was viewed as protection of Select's opportunity for growth, while the supply of buds from Monash was 'restricted'. It has been reported to us that planning for the site commenced three years ago during a period in which Select considered bud shortfalls would occur. An “emergency block” known as “Blue’s Block” at Lake Powell was recently discontinued as a budwood source. The Shepparton site was considered suitable on several counts: cooler than Monash, isolated from *Prunus* spp., availability of good water, and confidence in the landowner’s ability to manage the planting. Vic DPI, Knoxfield carried out a site assessment for nematode and *Phytophthora* spp. populations and confirmed its suitability as an isolated (>1 km from any cultivated or wild *Prunus* spp.) budwood multiplication block.

It has been reported to us that trees in Select’s Shepparton block were propagated from commercial budwood from Monash and from rootstocks supplied by Ausbuds. The planting of 1.5 acres includes 616 trees of four varieties - Price, Nonpareil, Carmel and Monterey.

Dr. Brendan Rodoni of Vic DPI, Knoxfield indexed both the Blue’s and Shepparton blocks. Trees were first indexed for ApMV, ACLSV, PNRSV and PDV in late 2005 and a number of Carmel and Price trees were found to be infected with PNRSV in both the Shepparton and Blue’s block. Although the Shepparton planting material was ‘relatively clean’ (no detectable ApMV, ACLSV or PDV) and presumably true-to-type, it unfortunately is not traceable to foundation trees or individual mother trees at Monash. The distribution of budwood from this site has been limited to two nurseries of Select’s choosing at this stage.

6.2.1 Horticultural Management

The trees are not traceable to mother trees at Monash and as such generational ‘distance’ and NBF potential in particular clones (especially those of Carmel) need consideration and continued management awareness.

As in other budwood schemes, flowering is minimised and hygiene is strict. The Select cutters use bleach dips for secateurs and cut to order with 20,000 buds the maximum cut any day. Winter wood is cut just before dormancy and is stored at 2°C.

The nutritional programme includes five fertigations and two foliar applications each week and the young trees are watered daily during the growing season.

6.2.2 Health Status Management

6.2.2.1 Indexing

The Vic DPI, Knoxfield recommended programme for health management of the Select block calls for annual indexing of each tree for ACLSV, ApMV, PDV and PNRSV for the first three seasons. The testing methodology used is PCR, but its sensitivity to the endemic and exotic strains of PDV is unknown. From the fourth year, bulk testing of five trees per sample will be accepted and tests for PDV and PNRSV only will be undertaken. DPI Victoria at Knoxfield, is contracted to carryout the sampling and testing. The results from the 2005 indexing indicated few infected trees. Results from 2005/06 and 2006/07 were not available at the time of our visit or subsequent request.

6.2.3 Tree Removal

Several trees were reported to have had bacterial spot which was unusual given the varieties in the planting. (There have been several reports in recent years of bacterial spot-like symptoms on Monterey). Replacement Price trees in the planting each exhibited unusual lesions at the time of our visit, and the cause was thought to be nutritional by the Vic DPI monitor who is contracted to carry out tree inspections. This appeared to us unlikely given the visual appearance of surrounding trees. Trees that tested positive for PNRSV in 2005 have been removed.

6.2.4 Isolation

The Select budwood site is isolated from wild and commercial *Prunus* spp. As for Monash however, it is close to a grape-growing area and as such would likely be implicated in eradication of a grape exotic like Pierce's Disease.

6.3 Monash and Select as Suppliers of Budwood

In the almond industry there is general agreement on the need for a high health nuclear planting, and Monash at present is the only facility and collection that can *partially* satisfy this agreed need. There is no broad consensus on the relative need for another industry budwood programme, if of lesser provenance. The Select budwood source block is of lesser provenance by definition (traceability to parent foundation or mother trees), but is at present serving a defined, private customer base, rather than industry generally. Select has not stated they wish to be regular providers of budwood to industry, but rather they intend to satisfy the requirements of Select and their chosen nurseries. Their supply however was useful in 2006/07 as it relieved the excess demand for Monash material.

At this time it could be argued that a second budwood site offers some level of security in the event of hail or an exotic disease outbreak where the PQA envelops one site. However the two sites are not considered equivalent, nor is material from each equally accessible. Efforts to harmonise to the highest standards, the organisational, management and testing protocols across the two sites will be worthwhile. In the event there is no harmonisation of the protocols, the ABA may decide on labelling guidelines that distinguish the two sources of budwood.

Both sites have qualified isolation. Monash and Select budwood plantings are isolated from urban and commercial *Prunus*, but the evaluation block at Monash is adjacent to budwood trees. Both sites are near grape plantings and risk of inclusion in a PQA exists for both. To highlight the likely area a PQA could envelop, three shires at Emerald in Queensland were initially quarantined during the recent citrus canker outbreak.

It is our opinion that the industry can accommodate both collections without compromising the security, stability and financial status of the industry resource, being Monash. Whether in future there are one or two budwood sites, the imperatives are for supply to exceed demand and for health status and integrity to be equally high. When supply exceeds demand not only are nursery and grower demands met, but budwood source trees are not over-cut, resulting in the supply of poor quality budwood.

There are parallels of the Monash and Select situation, in the grape industry. Two vine improvement entities, one borne directly from the national peak body and the other independently of the peak body and external funding, proceeded with the development of "nuclear collections". Each meets a different range of objectives and different testing and traceability standards (Constable and Drew, 2004). Since there are no nationally-agreed 'certification' standards for grapevine material, a low uptake of nursery accreditation, and the three components of the industry (wine, table, dried grapes) differ in their level of commitment to high health standards, evaluation and nomenclature of clones etc., there has been significant waste of human and financial resources associated with the uncoordinated pursuits of raising planting material standards for an industry not fully committed to the provision of, or demand for, planting material of the highest health status and provenance. Nomenclature changes continue to plague the viticultural industries.

Table 10 : Comparison of Budwood schemes Monash and Select

Criterion	MONASH	SELECT SHEPPARTON BLOCK
Budwood traceability to mother and/or foundation trees	Yes	No
Scheme – site isolation, suitability	Qualified	Qualified
- site security	Adequate	Adequate
- tree security (i.e. for patented variety)	Untested	Untested
- age	Older; replanting programme started	Young
- equipment dedication	Secateurs –Yes; not cool room	Secateurs – Yes
Material available – varieties	Full range of industry relevant cultivars + Fritz, breeding lines	4 cultivars: Nonpareil, Carmel, Price, Monterey
- distribution	To wider industry; some priority	Restricted to Select, Tolley and Jay nurseries
Bud cutting	No positive trees cut	100% trees to be cut; removal of infected trees
Tree health – indexing	30% annual average; Cut trees tested ≤ 2 years as individual trees	100% annually recommended; grouped samples from year 3
- indexing targets	PNRSV, PDV (incl. exotic strain)	PNRSV, PDV; in years 1-3 also ApMV, ACLSV
- indexing schedule	Annual	Annual recommended. 22 Nov 2005. Results 2006? 2007?
- indexing methodology	ELISA, PCR nested and other	PCR
Trueness-to-type	Annually by IDM, now ILM	?
- removal of infected trees	Yes	Yes
Tree growth – -nutrition schedule	Visual - very good; 10,000 buds cut per tree per year Nutrient analysis annually	Visual - good 2 x foliar/week; 5 x fertigation per week
- irrigation management	Converted to drip 2006	Drip
- - tree protection: wind	Yes	No
Cutting practices – disinfection	Alcohol, bleach; dip between each tree. Dormant buds supplied and put in cool rooms at nurseries until November.	Bleach. Winter prunings collected and stored. Cut before winter dormancy tripped.
Time in storage	≤ 2 days in summer.	1 week for summer buds; 1 month for dormant winter buds*
Trimming environment		
- judgments	Stick maturity	Stick maturity
- system	Cut to wet Hessian sacking	Cut to wet Hessian
- temp parameters	Morning cutting	Morning cutting
- timetable	Cut to order; weekly despatch planner; fax contact between Monash and recipient, re despatch dates	Cut to order "just in time"
Trimming practices – timetable	Trimmed same day	
- judgments	Petiole stub length; stick length	
Coolstore – policy	2°C; rarely more than 2 days; usually < 6 hours	2°C
- suitability	Suitable	?
Packaging – type	Nursery specified: wet Hessian; newspaper	?
Transport	Couriers	Courier to Swan Hill then picked up by Select Robinvale Nursery (1 hr to cool room). Pack in Hessian with ice in polystyrene boxes
Performance criteria -	Supply=demand; quality; bud take; specifications – length, bud number; health status	Bud take; health status; specifications

Criterion	MONASH	SELECT SHEPPARTON BLOCK
Water availability	Unclear	Carryover of water from this year to next
Number of mother trees		616 on 1-1.5 ha
Rootstock source	Nemaguard is principal rootstock; Sourced - Ausbuds?	Nemaguard from Ausbuds
Future plantings	All Nemaguard and hybrid budded over; new trees on GF677; 557 and 184 rootstocks available also	
Soil health status	Virgin soil	Virgin soil plus testing for nematodes and *Phytophthora* spp. by Vic DPI Tatura and Knoxfield
General tree health	Routine inspection by IDM, now ILM Silver leaf on 1 tree	Inspection by pathologist from DPI Tatura – detected bacterial spot. Replacement Price trees have unresolved leaf spot problem
Blossom removal	Minimal blossoms after pruning, then hand picked	Minimal blossoms after pruning, then hand picked

*Winter storage of 1 month is unlikely to be successful. Winter pruning for budwood is carried out when the buds are mature and dormant. 'Slip' indicating sap flow in the seedling rootstocks is usually insufficient for reliable budding, prior to mid-October. For rootstocks carried over from the previous year, earlier chip budding may be possible, but even in these circumstances time in storage for winter budwood would exceed two months.

6.4 Multiplication of Rootstocks

Until recently the Australian almond industry had relied entirely on three rootstocks: almond seedling, Nemaguard peach, and 'hybrid' (peach x almond). Today GF677 is the favoured hybrid. The term 'hybrid' is used loosely in the industry. It is used in reference to Bright's hybrid (peach x almond), Sharp's hybrid and more recently GF677. There are numerous peach x almond hybrids with varying characteristics. Since the peach used in the cross may be either *Prunus persica* or *P. davidiana*, the variability in characteristics may be derived from both varietal and clonal differences.

With the recent shortage of Nemaguard and GF677, the poor appearance, dubious health status and incorrect identity of some imported seed, and the lack of trueness-to-type of some GF677, the industry has come under some criticism for not being actively involved with rootstock multiplication at Monash. The ABA however has a successful alliance with Ausbuds, the major supplier of Nemaguard seed.

The ABA has the only (traceable) foundation GF677 tree and it is established at Monash. Eight mother trees of GF677 were budded from the industry's foundation budwood, while in PEQ. These have been retained by Ausbuds who contributed to the costs of PEQ indexing. Budwood from these mother trees (i.e. one-off material) has been distributed to two contracted nurseries. The passage and distribution ex PEQ of the industry's imported GF677 is outlined in Figure 3.

Open-pollinated Nemaguard trees at Lindsay Point are occasionally used to supply some seed to the industry via Ausbuds, but primarily these trees were planted in order to establish hybrid rootstocks with Titan. The indexing undertaken on this local seed is not known.

6.4.1 Ausbuds

Ausbuds routinely imports about 3 million certified seeds from California. California's certified seed is harvested from mother trees that have been indexed annually by the California Dept of Food and Agriculture (CDFA) for pollen borne viruses (Zhang, 2004). There are five suppliers of Nemaguard seed from whom Ausbuds has ordered, but preference is directed to two particular suppliers. Ausbuds also provides about 500,000 seed from their own production and 160,000 summer cuttings of GF677. Ausbuds supplies virus-tested Okinawa seed to AQIS for their use in indexing in PEQ.

The Ausbuds mother trees are tested annually in spring, for PDV and PNRSV by Vic DPI at Knoxfield. Ausbuds has a strong copper programme and to our knowledge there has been no problem with bacterial spot in their trees.

Ausbuds has established strong links with the ABA, other nurseries and private importers, and with the MIS scheme managers.

6.4.2 Other Rootstock Suppliers

There are three, and possibly more, confirmed importers of almond-relevant material (especially rootstocks) who operate independently of the industry improvement scheme. Each has imported rootstocks. Recent rootstock releases from PEQ to these variety managers include clones of *P. empyrean* and *Prunus* hybrids. It is our understanding that some local selections from the plum breeding programme at Stanthorpe, Queensland are also being developed through variety managers. They are in various stages of private trialling.

Other nurseries have accessed Nemaguard from unfamiliar overseas sources in times of excessive demand and the success rates have been low. The almond industry is aware of the recent importations from India that were of dubious quality and identity. Such importations, in combination with the reported lack of grow-out testing in PEQ, present risks to those multiplying rootstocks and distributing seed.

With the seed component of the industry being somewhat removed from the ABA, and with accreditation and certification of propagation material being considered by the ABA, it is timely for the costs and benefits of an ABA-established source of Nemaguard at Monash to be evaluated. Consultation with the stone fruit industry and Ausbuds is advised.

Nomenclature irregularity has recently occurred in the almond industry. Various rootstock clones have been named and sold as GF677 (*Prunus amygdalus* x *P. persica*), but it has been confirmed that several on the market and being promoted by nurseries, are not this favoured clone. Because of the high demand for this rootstock, there is an urgency to provide the almond industry with the correct clone. The two nurseries that have received confirmed true-to-type GF677 one-off material, are rapidly multiplying GF677 through tissue culture and micro-propagation. Micro-propagated GF677 and in future meristem-cultured[16] (if no somaclonal variation), are expected to be available to industry in the 2007/08 season. This will assist in meeting industry demand this season and curbing the circulation of falsely-identified material. These nurseries were approved for this role in the interest of increasing the availability of GF677 to industry. Such arrangements could be increased if there were safeguards that controlled the release of material, its propagation, testing and labelling. See Section 4.4.2.

The status of "ABA-approved" (or other) nursery-multiplied and supplied GF677 needs resolution, particularly for those in Managed Investment Schemes (MIS) that have Product Development Statements (PDS) defining very specifically the accepted source and status of planting material.

6.4.3 Role of Variety Managers

At this time, there is no significant engagement in the almond multiplication scheme, of private importers such as Fleming's Nursery, Jempi and ANFIC. ANFIC has expressed interest in submitting their almond-relevant propagation material (mostly rootstocks) for inclusion in future industry evaluation trials as their decisions to proceed with PBR, are based on horticultural performance rather than release speed. This is to be encouraged with all private importers, as it

---

16 Dimassi-Theriou, K., 1995. In vitro rooting of rootstock GF-677 (*Prunus amygdalus* x *Prunus persica*) as influenced by mineral concentration of the nutrient medium and type of culture-tube sealing material. Journal of Horticultural Science 70, 105-108.

ultimately means the almond industry will have access to a wider range of proven material. Jempi has knowledge and involvement with the citrus improvement and evaluation programmes and has stated they would consider similar involvement in almond schemes.

Since most entries of imported almond material now originate from non-approved sources, it is recommended that engagement of private importers be increased.

The almond industry, like the stone fruit, apple/pear and grape industries, is likely to encounter nurseries or variety/managers or commercialisers who will not engage in the industry improvement scheme (with its likely requirements for complete health status testing, horticultural evaluation and multiplication, submission of foundation trees to industry foundation repository etc.) for the wider industry benefit. However as grower education about tree health status and risk management increases, and the reliance on independent, local evaluations for making planting decisions increase, their engagement is likely to become easier. Until then it is likely that the eagerness of some to release new varieties, will outweigh considerations of health status and horticultural performance.

6.5 Evaluations

6.5.1 Evaluation of Imported Material and Breeding Program Lines

At present there is little Australian-generated comparative horticultural data available to the industry, on internationally-bred clones. This reflects in part the paucity of private importations to-date, the current lack of competitive advantage seen in rapidly-introduced relatively unknown clonal material, and the success enjoyed by most growers across all production districts, with currently available material.

At the Monash site, virus status (for PDV and PNRSV) of new entries is determined either in PEQ (for imported clones) or by Michelle Wirthensohn (for pollen and new progeny). Horticultural evaluation has been predominantly in the area of flowering dates, and nut and tree characteristics of newly-bred scion material. The other parameters currently evaluated in the local breeding program are included in the Almond Breeding Strategic Plan, part of which is included in Appendix 4. Evaluating trueness-to-type has been undertaken and is a tedious yet essential annual process, especially critical for genetically unstable budlines (eg some Carmel clones).

The individual weaknesses of the rootstocks on which the industry is reliant (almond seedling, Nemaguard peach, and hybrids [peach x almond]) are well-known and further evaluation of them appears unwarranted. Recent rootstock evaluation efforts have been directed to the performance of GF677 and newer rootstock material. An evaluation trial of GF677 from a range of sources was established by Chris Bennett in 2000. It became immediately evident that growers were being greatly compromised by the marketing of mis-identified and mis-labelled GF677. It was also revealed that one nursery had been charging royalties for this public domain material. Mis-identified GF677 remains in the marketplace today. An ABA certification/accreditation scheme for provision of nursery trees of high health status and true-to-type (both scion and rootstock) will give growers confidence they are purchasing the correct material.

The drought and the frequency of almond plantings on pockets of calcareous soils suggest further consideration of other rootstocks is warranted. Isaakidis *et al*. (2004) suggested that scions on GN-22 (also referred to as 'Felinem') may be better adapted to 'water stress' since in comparison with GN-15, GF677 and Drepanoto, it had higher growth, higher predawn leaf water potential, and lower leaf shedding. Rootstocks bred in Iran (Dejampou *et al*., 2006), Spain (Xiloyannis *et al.*, 2007) and other Mediterranean countries may have some suitable traits. Caution is advised on extrapolation from some international trials to Australian field conditions, since various comparative trials have been laboratory-based; others have been established in non-irrigated sites on heavy soil; and others have not evaluated tree spacing and cropping effects.

It is recommended that trials that include the advanced selections by notable breeders, and established at research institutions, be reviewed in-person, occasionally. Through observation and evaluation of the comparative data, importations with future commercial relevance in Australia, may be targeted.

Although considered an optional component of improvement schemes, it is our opinion that the almond improvement scheme would be enhanced by the introduction of regional evaluation trials especially for rootstock evaluations. Knowledge of the effects of rootstock, regional environmental conditions and soils, on tree performance and the relative market acceptability of their produce, are essential components of the almond scheme, along with pathogen testing, identity confirmation and genetic stability. In such trials, the variable is limited to the planting location (and perhaps irrigation, depending on the site), while parameters of health status and tree size at planting, tree spacing, grafting height, choice of rootstock, and evaluation parameters (flowering time and intensity, yield measures, nut quality indicators etc) are uniform in each trial. Regional evaluation trials could enable growers in the area to see for themselves the relative performances of the scions or rootstocks. Although this approach may engender problems where patented varieties are being evaluated, it has been possible for evaluation of new patented citrus varieties in Australia.

Regional almond variety trials (RAVTs) have been planted at various sites in California. Standard cultivars are planted 1:1 with new cultivars; Nonpareil for the early-mid blooming cultivars and cultivar Mission for the late blooming candidates. Other standard cultivars planted include Butte, Carmel, Fritz (not at Butte RAVT), Monterey, Padre, Price, and Sonora. Data collected from these trials include bloom time, hull split/harvest time, yield, and nut quality. Trees in these trials are also observed and evaluated for growth characteristics, pest and disease susceptibility and non-infectious bud failure. The variability in performance of the cultivars at the different RAVTs suggests that there may be some cultivars with qualities conducive to planting in particular regions (Lampinen *et al.*, 2002).

APFIP's regional evaluation trials, protocols and software developed for them, are discussed in Section 4.5.2. The Citrus Improvement Program has commenced regional evaluation trials of newly imported (public and patented) varieties and has developed a poster of key phenological stages to aid uniform reporting of results. The ABA's bud development chart will be useful in harmonising the terminology and data collection related to flowering.

In the future, if the ABA and importers of proprietary lines are united in their commitment to independent almond evaluation trials, DNA finger-printing of all submitted material is recommended.

Related to evaluation, especially of proprietary lines, but not limited to them, is legal protection of planting material and of the co-operating nursery/orchard. This topic requires more input from the legal profession, but a general explanation of some implications is warranted here. PBR may offer legal protection and benefit to the discoverers or breeders of new, distinct, stable and uniform planting material. For almonds there are 45 (of which 16 are compulsory) characteristics to be included in assessments of the features of a candidate (variety/rootstock/clone) and these must be compared to other close relatives (i.e. parents) and like varieties.

In establishing an evaluation trial for the purpose of achieving PBR, scion candidates and comparators for example, must be grafted to either peach (GF305) or almond rootstock. There are no requirements for the health status of the candidates or comparators (rootstocks or scions), to be known, and there is, therefore, inherent risk in the introduction of such material to trial sites, and also in the value of the data derived from them. Propagation material of the same health status must be compared if their evaluation is to be meaningful, and not mis-leading. In Europe, nursery trees of candidate varieties will not be accepted without extensive virus testing and evidence of negative results.

It is recommended that the ABA in consultation with IP Australia consider the requirement for defined health status of propagation material intended for inclusion in evaluation PBR trials for almond scions and Prunus spp. *and hybrid rootstocks.*

7 ACCREDITATION AND CERTIFICATION

Accreditation is a *business* practice qualification. It is formal recognition that approved procedures, usually included in a manual, have been followed by staff competent to carry out the specific tasks. In the case of nurseries, the tasks usually relate to hygiene; occupational health and safety; calibrations, crop protection, crop and site management; water treatments; and record-keeping. ISO 9000 and NIASA are examples of schemes that have been suitable for accreditation of some horticultural businesses, including nurseries.

Certification is assigned to a *product* that meets specific standards and has been produced and managed according to agreed guidelines and testing regimes. Implicit in the guidelines is full traceability of the plant components to foundation stock or mother trees at a minimum.

A certification scheme by EPPO (2000) definition is "a system for the production of vegetatively-propagated plants for planting, intended for further propagation or for sale, obtained from selected candidate material after several propagation stages under conditions ensuring that stated health standards are met". The traceability (line of descent from a defined parent plant) of the material is considered throughout the scheme.

Certified *Prunus* budwood for example would be of a proven identity, have a prescribed high health status (i.e. free of detectable PNRSV, PDV etc), auditable to an official standard, and it might also meet specifications for budstick diameter and/or length etc. The traceability records would reveal its origin; the type and timing of virus tests and visual inspections; that maintenance procedures demonstrating the health status had been maintained; and the steps taken to minimise contamination or mixed identity etc. A *Prunus* tree could be certified only if produced from the union of a *certified* rootstock and *certified* scion budwood

Within horticultural industries, confusion has long surrounded the terms 'accreditation' and 'certification'. For both accreditation and certification, there are agreed, auditable standards and procedures. In the case of accreditation the procedures are applied across the business, regardless of the product range. In the case of certification, there is a candidate product to which the procedures are specifically relevant. An accredited nursery for example may produce both certified stock and common (uncertified) stock. While the uptake and adoption of the qualifications are generally voluntary, there are industry associations that reward in a variety of ways, qualified businesses and products. The merits of these qualifications are discussed below.

7.1 Mandatory Certification

Some countries have in place certification schemes mandated by government (eg Italian stone fruit scheme, Section 7.2.1). Other countries are proposing mandatory schemes to obviate the threat of spread of exotic pathogens (Roistacher, 1993). The recent outbreak of citrus canker in Queensland, through alleged illegal introduction and propagation of infected trees should be a convincing argument for mandatory certification. While it is unlikely that the Commonwealth Government would progress this measure, it is possible that industry-dictated planting of "ABA-certified" material of a defined health status would lead the almond industry in this direction – ultimately to the benefit of nurseries, growers, packers and exporters.

Mandatory certification of propagation material in the almond industry however will not remove the threat of pathogens of almonds that have alternate hosts, eg the *Xylella* sp. causing Pierce's Disease in grapes causes almond leaf scorch (Hernandez-Martinez *et al.*, 2006), and therefore the biosecurity of almonds is dependent also on the biosecurity of grapes, ornamentals etc.

It is recommended that HAL and PHA advance co-operative discussions on certification and accreditation between like industries and the government, in the interests of biosecurity and industry development. They should include consideration of the relative costs and benefits of mandatory certification or accreditation, and the shared investment required to advance them amongst perennial horticultural industries.

7.1.1 Benefits of an Accreditation Scheme

Accreditation, when based on national standards and/or business types (i.e. nurseries), broadly harmonises and raises standards to 'best practice' levels that might otherwise not be achieved. It is more than a marketing mechanism. The accreditation process, outcomes and recognised indicators (i.e. label/logo) must have value in delivering confidence to customers, benefits to the accredited business (i.e. profitability and efficiency, access to proprietary propagation material; preferred supplier status, mechanism supporting continuous improvement etc) and to the environment.

Industry associations assessing the relative benefits of an accreditation scheme, generally consider:

- the benefits to the industry, its clients and their customers, and the environment;
- the costs and benefits for the candidate business (i.e. implementation, audit and maintenance costs);
- if the process would overcome on-going problems unable to be addressed through other means;
- and if the scheme should be mandatory or voluntary.

Individuals or companies assessing the relative merits of becoming an accredited business, usually consider:

- the anticipated benefit derived from the accreditation (i.e. access to new products, higher grade product or markets; reduced costs etc);
- the costs of accreditation (i.e. what practices and facilities would require change; staff required to manage the accreditation; audit costs; number of different schemes to which their business is subjected; and availability of industry development resources and personnel for support through the accreditation process etc.).

Within Australian horticulture today there are commodity-based accreditation schemes, i.e. grapes have the Vine Industry Nursery Accreditation Scheme (VINAS) and the avocado industry introduced the Avocado Nursery Voluntary Accreditation Scheme (ANVAS). There are also accreditation schemes relevant to certain types of business activities that cross product ranges - i.e. for containerised and more recently in-ground nurseries, the Nursery Industry Accreditation Scheme Australia (NIASA).

7.1.2 Accreditation Schemes in Australia

The Australian avocado industry introduced its own nursery accreditation scheme (**ANVAS**), which incorporated product quality standards. The avocado industry developed the disease-free nursery scheme for the production of trees, with its primary aim being limitation of the spread of two disease-causing organisms: *Phytophthora cinnamomi*, the root rot fungus, and avocado sunblotch viroid (Whiley, 2000). The scheme operates under strict hygiene. It is a voluntary scheme, but carries the prestigious endorsement of the Australian Avocado Growers' Federation.

NIASA is a national scheme for production nursery (growers) and growing media (potting mix) businesses that operates in accordance with a set of national 'best practice' guidelines. Any wholesale/production nursery or growing media/potting mix manufacturer in Australia can join NIASA if they implement the NIASA Best Management Practice Guidelines (the Guidelines). The Guidelines may be used as a reference for the professional operation of production nurseries or as the mechanism for assessment to gain and maintain NIASA accreditation status. Such assessments are carried out by Nursery Industry Development Officers or a NIASA Technical Officer who has been appointed by the relevant state-based NIASA committee. NIASA membership is totally voluntary and participants are not required to belong to a Nursery & Garden Industry Association.

The components of the NIASA scheme are presented in the Guidelines and are broadly categorised as:

- Crop hygiene
- Crop management
- Site maintenance
- Water management
- Record-keeping

7.2 Benefits of a Certification Scheme

A grafted tree labelled as 'certified' comes with certain guarantees. The guarantees are specifically defined for each product. They are not the same in every horticultural industry. For example the guarantee might relate to tree health status, identity and/or measurements of diameter and height. At a minimum, a locally-produced certified *Prunus* tree should have both rootstock and scion proven to be true-to-type, free of detectable levels of economically important viruses according to testing undertaken on mother trees in the season of cutting or seed production; documented evidence to show they have been maintained at that high health status, and traceability of each component to a foundation tree. Certification provides clear product distinction useful to growers in their attempts to actively manage risk.

Certification through the Australian Pome Fruit Improvement Program Limited (APFIP) with its associated development of standards for propagation material, has assisted the international competitiveness of the Australian pome fruit industry.

7.2.1 Certification Schemes for *Prunus* Overseas

Global consolidation at the buying and selling level is putting pressure on suppliers to produce and supply consistent quality product that complies with strict food safety standards and is fully traceable. **EurepGAP** (now **GLOBALGAP**)[17] has developed a framework for certification, based on Good Agricultural Practices (GAP), but incorporating also aspects of nursery accreditation mentioned earlier. It defines the essential elements of best practice for plant propagation (Table 11). Within it, integrated pest management (IPM), integrated crop management (ICM) and Hazard Analysis Critical Control Point (HACCP) are accommodated. Independent verification is by a certifying body and implementation and certification of the standard is voluntary.

[17] Note: GLOBALGAP Version 2 is due in October 2007. (See Eurepgap General Regulations Guidelines for Plant Propagation Materials and checklist May, 2006. www.eurepgap.org).

The key control points in EurepGAP (Version 1) are:

- traceability
- record-keeping and internal self-inspection
- varieties and rootstocks
- site history and site management
- soil and substrate management
- fertiliser use
- irrigation/fertigation
- crop protection
- waste and pollution management, recycling and re-use
- worker health, safety and welfare
- environmental issues
- handling complaints

Table 11 : Control points and Compliance criteria in the EurepGAP framework for certification

CONTROL POINTS AND COMPLIANCE CRITERIA for PROPAGATION MATERIAL		
Control Point	**Criteria Level**	**Compliance**
Is purchased propagation material accompanied by officially recognized plant health certification?	A plant health certificate is available complying with national legislation or sector organisation guidelines.	Minor
Is purchased propagation material free of visible signs of pest and disease?	When plants have visible signs of pest and disease damage, a justification should be available (e.g. threshold for treatment).	Major
Are quality guarantees or certified production guarantees documented for purchased propagation material?	There are records to show propagation material is fit for the purpose i.e. quality certificate, terms of deliverance or signed letters.	Minor
Are plant health quality control systems operational for in-house nursery propagation?	A quality control system that contains a monitoring system on visible signs of pest and diseases is in place and current records of the monitoring system must be available.	Minor
Are crop protection product treatments on in-house nursery propagation applied during the plant propagation period recorded?	Records of crop protection product treatments applied during the plant propagation period for in-house plant nursery propagation are available and include product name, application date and doses.	Minor

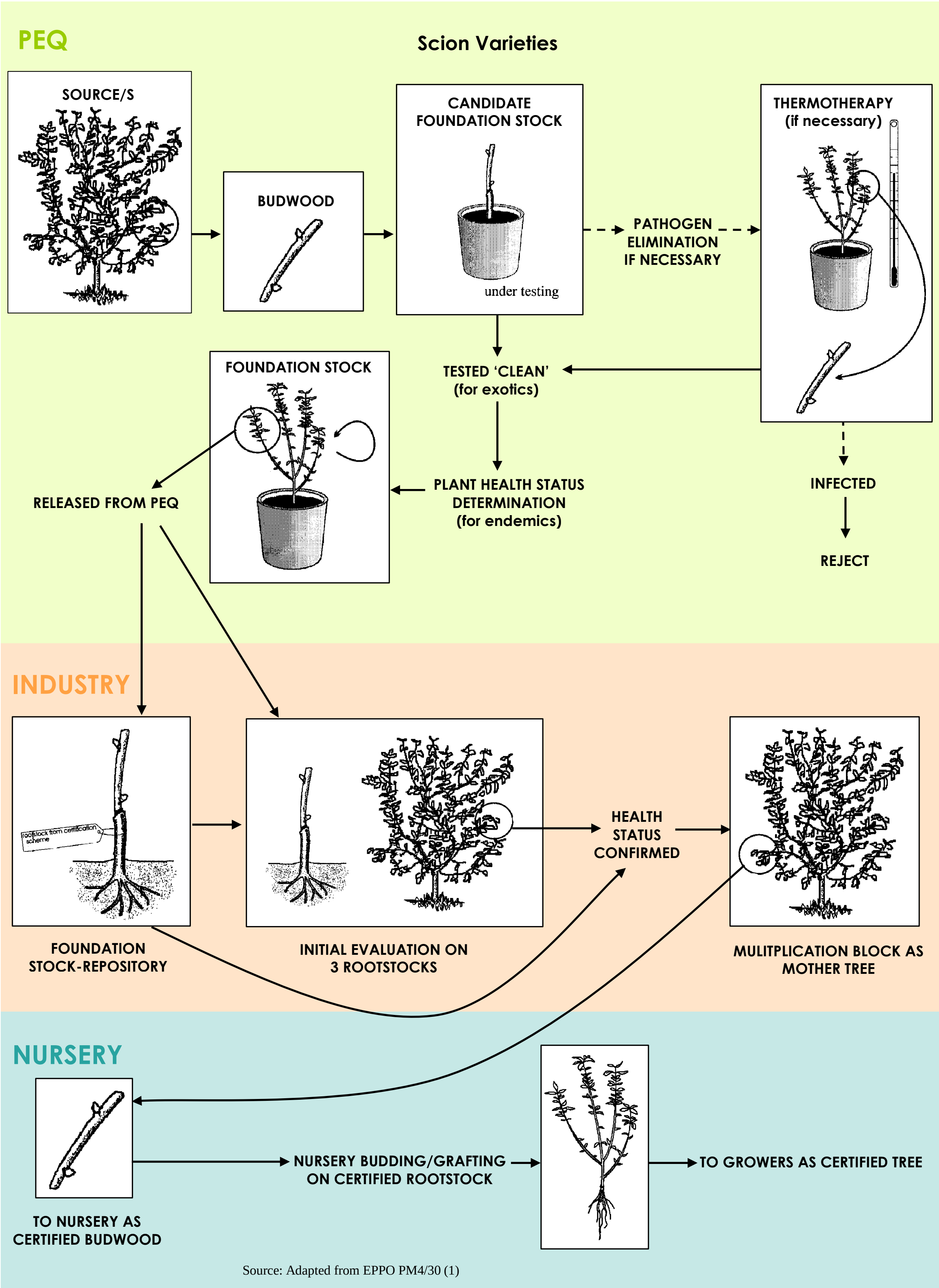
There are several international certification schemes for *Prunus* spp. and fruit trees and three of them are discussed and compared below in Tables 12 and 13. The procedures of the APFIP certification scheme are also outlined. Full descriptions of each of the schemes are included in Appendix 13.

7.1.2.1 EPPO Certification Scheme

The EPPO (2000) scheme for *Prunus* spp. describes the steps to be followed for the production of vegetatively-propagated planting material of a particular cultivated plant, whose health status is attested by an official certificate. In a typical certification scheme, the certified material is descended by not more than a fixed number of steps from individual plants each of which is tested and found free from pests, and is then maintained and propagated under rigorous conditions excluding recontamination. For a full description of this scheme see Appendix 13.

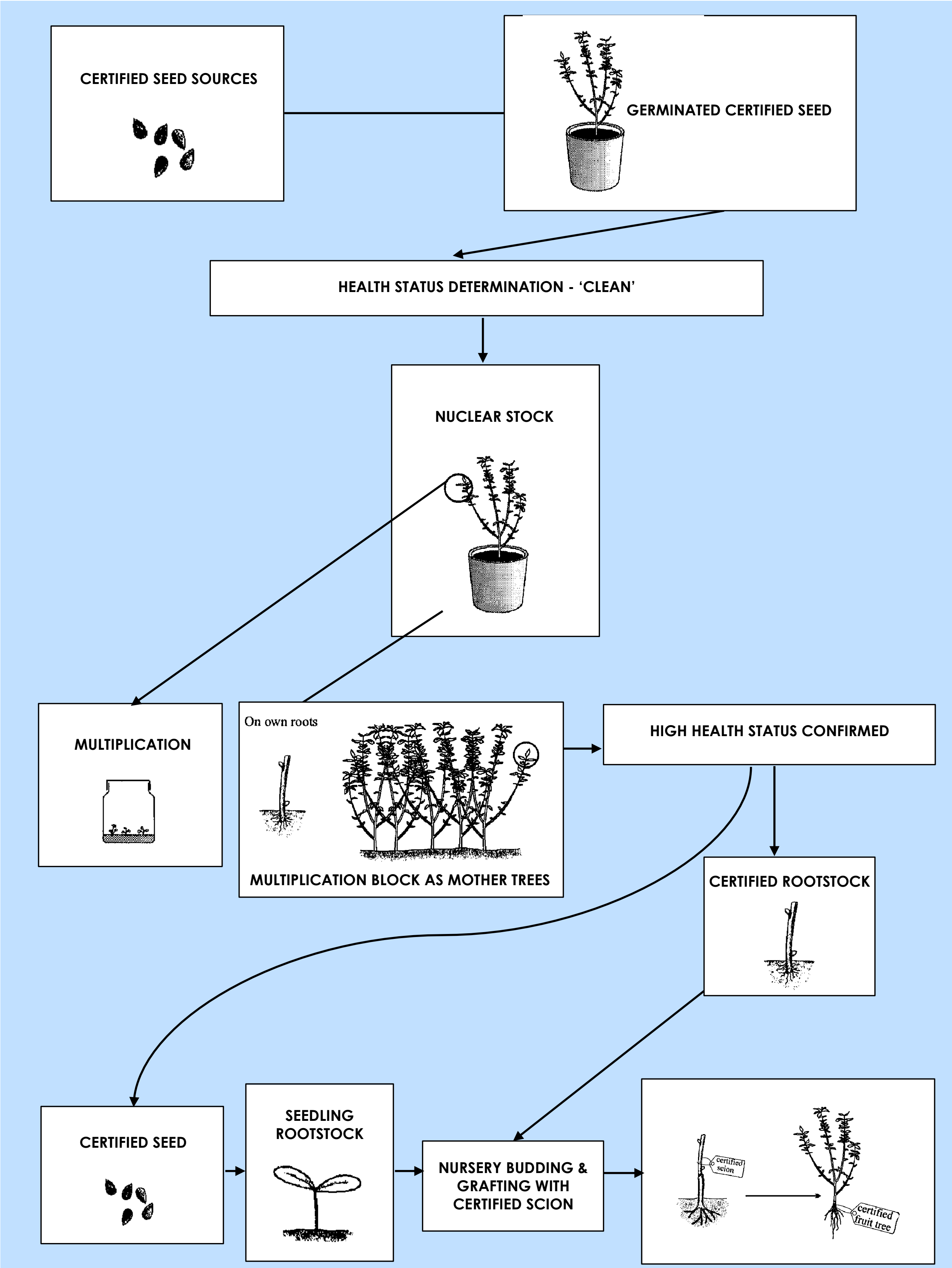
The diagrammatic representations of the EPPO certification stages for scions and rootstocks of almonds (apricots, peaches and plums), have been adapted in Figures 4 and 5 to illustrate recommended passage and stages for certified Australian almond scions and rootstocks.

Figure 4 : Recommended stages in the certification scheme for almond: scion material



Source: Adapted from EPPO PM4/30 (1)

Figure 5: Recommended stages in the certification scheme for almond: rootstocks



Source: Adapted from EPPO PM4/30 (1)

7.2.1.2 Fruit Tree Registration/Certification, Oregon State, USA[18]

This scheme is relevant for budwood multiplication blocks, nursery and seed sources and certification is based on demonstrated virus freedom and true-to-type identity.

For a full description of this scheme see Appendix 13.

Table 12 : Comparison of international certification schemes for *Prunus* spp.

COMPARISON OF TWO INTERNATIONAL CERTIFICATION SCHEMES FOR *PRUNUS*[19]		
	EPPO scheme for *Prunus* spp.	**Fruit tree registration/certification, Oregon State, USA**
Selection	• local material (scions and rootstocks) for pomological quality • virus-free starting material is imported from other countries.	
Production of nuclear stock[20]: (scions and rootstocks)	• Candidate nuclear stock plants established by propagation onto rootstocks of nuclear stock status. • kept under conditions ensuring freedom from infection by root contact, pollen, aerial or soil vectors in an isolated, suitably designed, aphid-proof house, separated from the nuclear stock during the testing period. • tested for the viruses and virus-like diseases • Alternatively, virus-free plants are produced by heat treatment followed by testing. • **Only if the candidate nuclear-stock plant gives a negative test result for all pathogens can it be promoted to nuclear stock and transferred to the nuclear-stock collection.**	**NRSP5** formerly known as Inter-regional Project-2 (IR2), develops **deciduous fruit tree clones** that are free of detectable virus and other graft-transmissible pathogens (hereafter, referred to collectively as **"viruses"**). These elite clones are distributed, upon request, to researchers, regulatory agencies, and horticulture industries nationwide and around the world. This project also provides for the importation of foreign varieties, virus elimination and virus testing services to fruit tree researchers, state and federal regulatory agencies, and to various components of the deciduous fruit tree industry worldwide.
Maintenance of nuclear stock:	• maintained under conditions ensuring freedom from infection by root contact, pollen or aerial vectors, with retesting as appropriate. • maintained in an aphid-proof house in sterilized growing medium or in the open separated by approximately 1 km from any cultivated or wild *Prunus* spp. of subgenera *Prunophora* and *Amygdalus* and prevented from flowering. • soil should be tested and found free from virus-transmitting nematodes and confirmed every 5 years • Each plant checked for trueness-to-type and inspected visually every year for possible mutations and disease. • Each nuclear-stock plant to be retested every year for PNRSV, PDV and ApMV. • all plants should be retested for all virus and virus-like diseases when plants are grafted onto new rootstocks. • **Any plant giving a positive test result or showing symptoms of viruses, virus-like diseases or other pests to be removed immediately from the nuclear stock collection.**	Maintained by NRSP5
Production of Propagation Stock: (EPPO) Scion budwood multiplication source blocks (Oregon)	• Nuclear-stock material budded onto rootstocks of equivalent certification status or onto certified seedling rootstocks. • propagation stock in fields that have been tested and found free from virus-transmitting nematodes and isolated from material of the same genus not certified or of lower certification status. • Multiplication *in vitro* may be used for rootstocks	• Supply of foundation buds by NSRP5 to nurserymen, or nursery associations, who maintain their own mother trees with routine indexing for pollen borne viruses by a state authority • Isolation distance 30 m for scion source blocks from non-certified Roseaceae • Ground within block and 7 m surrounding buffer maintained vegetation free or approved ground cover • Rootstock and scion (of scion source trees) both originated from foundation trees within the certification programme • Only registered trees within blocks and each tree bears a permanent registration number • Plant spacing and management ensures no branch overlapping between different varieties

[18] (from http://nrsp5.prosser.wsu.edu/index.html).
[19] For a full description of these schemes see Appendix 13
[20] For definitions see Glossary

COMPARISON OF TWO INTERNATIONAL CERTIFICATION SCHEMES FOR *PRUNUS*[19]		
	EPPO scheme for *Prunus* spp.	**Fruit tree registration/certification, Oregon State, USA**
Production of Propagation Stock: Seed multiplication source blocks (Oregon)	• Seeds produced on propagation stock of rootstocks may be harvested, tested for seed-transmissible viruses and germinated to produce seedling rootstocks to be used as rootstocks for certified trees at the nursery stage. • Seedling rootstocks may also be used as rootstocks for propagation stock, provided that the plants on which the seeds are produced are isolated by at least 300 m from any plants of *Prunus* and remain under propagation-stock conditions. • The propagation stock should be inspected visually each year for virus symptoms and other pests. Particular attention should be given to naturally spreading viruses. • Plants of the first generation of propagation stock may be retested each year for PNRSV and PDV. Any infected plant should be removed and, if there is an indication that infection may have derived from the previous generation, it is advisable to remove all the plants in the lot and to retest the possible source plant. • The plants should be inspected visually for possible mutations. This is the first time that an assessment of fruits can be made, but it should be noted that the type of rootstock can affect fruit characteristics.	• Isolation distance of 100 m for seed source blocks from non-registered *Prunus* spp. • Ground within block and 7 m surrounding buffer maintained vegetation free or approved ground cover • Only registered trees within blocks and each tree bears a permanent registration number • Plant spacing and management ensures no branch overlapping between different varieties
Production of Certified Plants:	• certified plants are produced by grafting propagation-stock material onto rootstocks of at least propagation-stock standard. • plants should be kept in fields isolated from potential sources of infection. • To be certified, plants should be inspected by the official organization for symptoms of virus, virus-like diseases or pests. Any plants showing symptoms to be removed and certification may be granted to the remainder. • For production of certified seeds, seeds from propagation stock of rootstocks should be cleaned, tested for seed-transmissible viruses	• Registered growing area and 3m buffer fumigated pre-plant or virgin soil used • Nursery stock on rootstocks from registered trees or imported from high health source with demonstrated freedom from seedborne viruses or *where the seed transmissible virus content does not exceed 5 percent* • Designated as to rootstock and scion sources • Spaced sufficiently apart to maintain identity and kept clean cultivated • No re-working or budding of nursery stock unless new bud from same registered scion tree • Off-types or infected material immediately removed and destroyed; notify authority • Use of certified (proprietary) scionwood allowed only after permission received from responsible authority
Administration of the certification scheme	• Throughout the certification scheme, the origin of each plant should be known so that any problems of health or trueness-to-type may be traced. • An official organization should be responsible for the administration and monitoring of the scheme. • If officially registered nurseries carry out the different stages of the scheme, the official organization should confirm that all necessary tests and inspections have been performed during production, and should verify the general health status of the plants in the scheme by visual inspections. Otherwise, certification will not be granted and/or the plants concerned will not be permitted to continue in the certification scheme. • Certification will be granted by the official organization on the basis of the records of the tests and inspections performed during production, and of visual inspections to verify the apparent health of the stock.	The methods and procedures used for virus indexing conform to agreed standards. At least one visual inspection shall be made of nursery rootstock in a planting for certification during the first growing season and any undesirable rootstock shall be rogued before propagation. At least two visual inspections shall be made of nursery stock during the growing season following budding or grafting. All nursery stock meeting the requirements of this certification program shall have the variety and rootstock designated. Official certification tags for the identification of nursery stock or seed meeting the requirements shall be furnished by the certifying authority. Certification shall be refused if plants have been propagated from registered trees determined to be affected by a virus or virus-like disease, of if provisions of the certification program have been violated. Fees charged by the certifying agency for certification are for the sole purpose of defraying expenses incurred in the inspection, approval, or certification procedures provided for in this certification programme.

7.1.2.2 Italian Certification Scheme for Fruit Trees

Table 13 : Italian certification scheme for stone fruit

Operative steps	Category	Responsibility	Description
Centre for Conservation and Pre-multiplication	Pre-base	Research Institutes, Ministry for Agriculture	Nuclear stock that is true-to-type, free from pathogens, maintained in a screenhouse. Identified by an accession number that is maintained through all production phases including commercial production.
Pre-multiplication Centre	Base	Research Institutes, Ministry for Agriculture	Certified mother plants maintained in a screenhouse
Multiplication Centre	Certified	Nursery associations	Base plant material is used for the production of certified mother plants. *In vitro* multiplication can be used. 10% of mother plants must be indexed annually. Mother plants must be separated by at least 100 m from non-certified plants, and are grown in open ground tested for nematodes. These mother trees are used for the budwood supply.
Nursery	Certified plant	Private nursery firms	Soil tested for nematodes. Certified nursery trees must be 5m from non-certified plants.

Source: (Barba, undated)

7.1.2.3 APFIP Certification (including Trade Mark) for Pome Fruit in Australia

(See Appendix 13 and www.apfip.com.au for copy of the APFIP *Rules Governing the Use of a Certification Trade Mark*).

The Certification stages are outlined below.

The APFIP Trademarked certification tags may be awarded to trees and rootstocks that:

- are true-to-type
- have been grown and maintained in specified and controlled conditions
- have been tested as negative for the viruses
- are able to be traced back to its Nuclear Stock Tree, and
- have tested negative for specified pests and diseases.

Scion Budwood Sources: Local or Direct Import

<u>Local trees</u>: Scion budwood sourced locally is eligible if:

- it has tested negative for each of the specified (4) viruses
- it has been assessed by APFIP as being true-to-type;
- the location of original tree is known (if nuclear stock tree is to be produced by APFIP or Approved User)
- the Approved User has right to use, produce, reproduce, propagate, sell the scion budwood

<u>Direct Importation</u>: Scion budwood sourced from imported foreign trees is eligible if it has met all Phytosanitary requirements, and:

- it has tested negative for each of the specified (4) viruses
- it has been assessed by APFIP as being true-to-type;
- the Approved User has right to use, produce, reproduce, propagate, sell the scion budwood

Production

Candidate Nuclear Stock Trees must comprise certified scion budwood budded or grafted onto certified vegetatively-propagated rootstocks; or certified seedling rootstocks. They must test negative for each of the specified viruses and be grown under specified conditions.

Candidate Propagation Stock Trees must comprise scion budwood from Nuclear Stock Trees budded/grafted onto certified vegetatively-propagated rootstocks; or certified seedling rootstocks. Multiply in as few steps possible to give required quantity. Volume of scion budwood taken from each Nuclear Stock Tree is recorded.

Maintenance

Propagation Stock Trees must have confirmed, verified, recorded and registered origin, with APFIP.

Propagation Stock Trees may be used to produce candidate Certified trees if:

- they have been virus indexed (and removed if infected*)
- they have been inspected for the presence of pests and diseases (and treated if any detected)
- they have fruited
- they are traceable to Nuclear Stock Tree
- they have been assessed as being true-to-type, by APFIP (and if not, will not be used)

*Parent tree of infected trees re-tested.

Production

Candidate certified trees comprise scion budwood from Propagation Stock Trees budded or grafted onto certified seedling rootstocks or certified vegetatively-propagated rootstocks. Union is to be 100mm-200mm from the ground.

A candidate Certified Tree shall qualify as a Certified tree if:

- it has been grown in and kept under specified conditions
- it has been inspected for the presence of pests and diseases (and treated accordingly if any present)
- it has a certified rootstock and scion
- trueness-to-type has been confirmed at each generation of rootstock and scion
- it has traceback records that identify the budder/grafter of the material

Selling Certified Trees

Certified Trees may be sold if they:

- meet the minimum Certified Tree requirements;
- have minimal damage from mechanical harvest or other operations;
- have a minimum height of 1.6 metres measured from the ground;
- have a minimum caliper size (trunk diameter) of 12 mm measured 100mm above the graft/bud union;
- have been left with a root system following lifting that can adequately support the tree with; where possible the main roots are minimum of 150mm in length;
- are free of residual soil;
- are bundled and transported in order to prevent damage; ensuring that tree roots remain damp;
- have been treated for pests and diseases
- have no visual symptoms of the pests and diseases.

Use of the Trade Mark

- Only APFIP or Approved Users may use the Trade Mark.
- The Trade Mark shall only be used by Approved Users authorized by APFIP on Certification Tags and in association with certified trees or certified rootstocks.
- Approved Users shall only use certification tags which are purchased from APFIP
- On certified trees, one certification tag per certified tree but both rootstock and scion must be certified and of the same generation
- On certified rootstocks, one certification tag per bundle
- A request to purchase a certification tag shall be accompanied by a signed declaration in a form prescribed by APFIP detailing the Approved User's right to produce, reproduce, propagate and sell the Certified Trees or Rootstocks.

Trade marks are a form of legal protection and responsibility. They are often used in association with PBR as the trade mark may apply to fruit, with PBR applying to the propagation material. The life of a trade mark is on-going while the life of PBR protection is 25 years for perennial trees, in Australia. It should be noted that in the APFIP scheme, APFIP guarantees trueness-to-type and the Approved User carries the liability for health status once the material has been delivered to them. The certification trade mark, which operates within the Trade Practices Act confers a right of the overseeing authority (in this case APFIP) to dictate specific support service providers – i.e. the diagnostic laboratory that carries out indexing. This, in other arenas, would breach the competition policy.

7.3 Certification and Accreditation for Parts of the Almond Industry?

There is widespread acknowledgement of the privileged position the almond industry has due to the Monash collection and facility, and existing industry structures. There is however support for further nationally-focussed industry development that includes an accreditation scheme, agreed health standards for propagation material, improved traceability through the nursery supply chain, and the introduction of an over-arching technical committee to ensure the integrity of the processes.

Certification of budwood and seed and accreditation of nurseries would provide industry in general, and nurserymen and growers in particular, with assurances about the integrity of propagation material and the facilities producing it. The following includes discussion of elements of the almond industry that may benefit from the introduction of protocols and auditable processes, in the form of accreditation and/or certification. Examples of how the systems might operate are from other horticultural industries.

There are several features of the almond industry that differ from other perennial horticultural industries that have implemented accreditation and certification schemes - i.e. rootstocks are propagated by various means (seed, cuttings and *in vitro*) and supplied to nurseries as cuttings, seed, seedlings, micro-propagated or tissue-cultured plantlets; containerised, unrooted or bare-rooted. In addition, the rootstock supply chain is largely outside the industry's control; rootstock requirements cannot currently be met from local supplies, requiring the importation of seed, which in years of poor seed production in California, may result in the importation of seed of dubious quality from other sources. It is expected that significant volumes of rootstock material will be ineligible for certification/trademarking because their source cannot be traced to foundation or mother trees. Imported seed from recognised sources and locally-produced seed will need to meet equivalent standards and traceability requirements, to qualify for certification. While several difficulties will certainly provide some challenges in the pursuit of certification, they are not reasons to avoid industry development supportive of the pursuit.

The almond industry would benefit from the establishment of a certification scheme for scion and rootstock material. There would be three clear objectives of such a scheme that would deliver to growers and/or nurseries certainty in: health (especially virus) status of seed, scion and/or rootstock material; genetic identity (i.e. trueness-to-type); and specifications (i.e. minimum nursery tree standards). However to achieve this, the certifying authority would have to establish certification standards, with documented requirements for PEQ, terminology, diagnostic and indexing testing methodologies and timetables, approved laboratories, eligibility criteria for entry to the scheme, certification levels and their nomenclature, horticultural management of isolation, sanitation, record-keeping; inspection programmes, re-testing programmes, approval of remedial measures, identity determinations; labelling, quality assurance, non-compliance and implications of non-compliance; required education and training, roles and responsibilities of programme participants, and performance criteria.

If the certification scheme and certified status of planting material exported from Australia, become officially recognised by other countries as conferring some PEQ exemptions, it is the responsibility of the certifying authority to notify international authorities to any changes incorporated into the Australian scheme.

Progress toward certification, will require the almond industry to determine and agree on, the standard to which product provided by Monash, Ausbuds and Select, will be certified; and on the potential of product provided by other suppliers, to become certified to this standard.

7.3.1 Options for Almond Nursery Accreditation

In exploring the best options for the almond industry it has been important to consider:

- the nature of the candidate nurseries - many of whom also produce grapes, citrus and some pome fruit;
- the accreditation schemes of other industries and,
- the inevitable costs of multiple audits if a harmonised accreditation scheme is not an option for these nurseries.

7.3.1.1 Accreditation Option 1

NIASA is a national scheme now sufficiently broad to accommodate both in-ground and containerised nurseries. It is a scheme that could be adopted by nurseries producing almond trees as well as other crops. Alternatively it could be the basis onto which a specific almond accreditation scheme is superimposed.

NIASA accreditation of in-ground production sites is permissible, where the production sites have tested free of soil borne pathogens, insect pests and weeds. Accreditation would require annual active testing of the effectiveness of hygiene practices at the direction of the NIASA Technical Officer. Sites contaminated by pathogens may be adequately disinfested/disinfected with properly applied fumigants or a recommended substitute.

The NIASA approach for in-ground nurseries is focussed on breaking any disease cycle and then avoiding introduced problems. To break disease cycles, attention is applied to drainage management, waste and prunings management; propagation hygiene; hygiene in handling and packing areas; effective and efficient crop management (nutrition and water, crop protectant use etc.). To avoid introducing problems, attention is focussed on ensuring the high quality of starting material (i.e. health status of planting material, mulch, water etc.); quarantining most vehicles and people from production and propagation areas; and hygiene (disinfestation of footwear, equipment, surface water etc).

The details provided in the NIASA Guidelines are sufficiently general to be applied easily to the almond nursery industry. In many cases, nurseries producing almond material will already be following most of these requirements. A foreseen difficulty for some nurseries accessing water from the River Murray is the NIASA requirement for treatment of water. It is our opinion however that the NIASA scheme is generally suitable for nurseries producing almonds, grapes and citrus, both containerised and in-ground. There are considerable resources available to support candidate nurseries in their pursuit of accreditation.

On behalf of industry, the ABA might consider the problem with water treatment and negotiate with NIASA directly on this requirement.

7.3.1.2 Accreditation Option 2

In the avocado industry's accreditation scheme, there is also a certification component. Trees are inspected and tested twice per year by government inspectors. Nurseries not reaching the required standard are expelled from accreditation until they correct their problems. Accredited nurseries may offer trees for sale that are *certified* free of Phytophthora root rot and avocado sunblotch viroid and that are true-to-type with respect to the variety offered for sale. This combination of accreditation and certification, is an option the almond industry could consider but it should be remembered that the avocado scheme is focussed only on two organisms rather than traceability etc. Accreditation is endorsed by the industry peak body, the Australian Avocado Growers' Federation.

7.3.1.3 Accreditation Option 3

A third option for quality assurance in almond nurseries, avoids formal accreditation, but relies on 'approval' of specific nurseries after assessment against the industry's improvement programme and standards. This approach has been adopted by the apple and pear industry, through APFIP. APFIP releases their virus-tested propagation material only to APFIP-approved nurseries. APFIP approves a nursery based on the evidence they employ high hygiene standards, propagation practices, site management etc. APFIP does not carry out formal audits but has provision to visit the nurseries at any time for inspections. Nurseries may apply directly to APFIP for approval. Importantly the APFIP scheme is based on the use of a trade mark.

7.3.1.4 Accreditation Option 4

A fourth alternative through which almond nurseries might gain formal recognition of their business practices is via a general business accreditation, i.e. ISO 9000. Such qualifications, while unrelated to horticultural best practices, do demand sufficient record-keeping to allow specific horticultural assessment should it be needed. One nursery growing almonds and grapes has ISO 9000 accreditation.

8 RECOMMENDATIONS FOR ACCREDITATION/CERTIFICATION FOR THE ALMOND INDUSTRY

In formulating suggestions for the future administration of a more comprehensive Australian Almond Multiplication Scheme, we have reviewed the operations of the citrus, grape and pome fruit multiplication schemes in Australia (Table 8) and the EPPO (European), Oregon and Italian schemes for Prunus certification (Tables 12, 13) (see Section 7.2).

8.1 Accreditation of Budwood Multiplication Operations

8.1.1 Monash

A Biosecurity Plan should be developed for Monash, whether or not the ABA moves towards accreditation/certification.

Guidelines for selecting mature budwood, and cutting and handling spring, dormant and winter budwood at Monash have been developed by Mr Ben Brown, ABA's ILM. These, with suggested additions, are included in Appendix 12. The guidelines and the record-keeping associated, will be useful in progressing accreditation of the Monash scheme and facility.

All activities that comprise the budwood multiplication operation, require documentation. The majority of activities relate to orchard management, biosecurity, and record-keeping. The Monash budwood scheme (and other schemes seeking equivalence) requires, in addition to a biosecurity plan and the guidelines already available (for bud selection, cutting and handling), documented procedures for:

- *Site hygiene*: Procedures required include - entry to the site (i.e. foot and wheel baths of specified disinfectant, its effective concentration and monitoring); access limitations for vehicles and personnel; equipment cleaning (method, location and frequency); disposal of budwood leaf trimmings and prunings; maintenance of vegetation-free zones and suitable 'isolation' characteristics; re-plant site assessment and preparation etc.

- *Tree management*: tree spacing; pruning decisions and practices (i.e. optimal tree size, access, vertical growth extension good budwood production, NBF – hedging?; lower lateral forcing, vegetation removal etc); crop protection (i.e. choice of registered products, nature of targets, resistance awareness and management, equipment suitability); tree removal tolerances and techniques; tree nutrition (i.e. regime, delivery mechanisms, assessment control points - leaf testing, extension growth etc); tree irrigation (i.e. monitoring and response guidelines etc.).

- *Indexing and identity management*: Since certification is founded on the production and provision of high health propagation material of correct provenance, the procedures for establishing each must be clearly documented. It is recommended that the approved diagnostic service providers assist industry with the development of an Indexing Manual. It should include amongst other things: approved and validated molecular, biological and serological test methodologies, indexing frequencies, tissue selection processes and timing etc.

  Qualified botanists or almond breeder/s with appropriate expertise may need to be engaged in order to fully document the processes of inspection and critical observations required, to establish trueness-to-type of material within the scheme/s.

- *Tree and bud selection for scheme expansion:* specific guidelines dictating from which tree and position, buds should be selected for further mother tree propagation, i.e. buds nearest original bud, low down on small original seedling or foundation tree. This is particularly important for the varieties and clones with higher NBF potential.

- *Record maintenance*: A documented system that includes assigned roles and responsibilities, for up-dating and maintenance of all records, must be prepared. Records should include: planting dates; tree propagation details; indexing results, diagnostician and methodologies; tree removals, current and complete block maps; crop protection applications (and relevant permit, registration details etc); nutrition records etc.

- *Staff and facility management*: Procedures and records of professional development, workplace safety, training and achievements etc must be documented. Operating procedures for facility maintenance and management are also needed, i.e. cold room servicing and cleaning regime; temperature control assessments; log books of contents and storage periods for plant material, chemicals etc.

The Manuals/guidelines should be developed after consultation with staff and almond specialists, and after consideration of the requirements for accreditation and certification, as outlined.

It is hoped the Monash facility will pursue accreditation and certification of its product. Certification of nursery trees as propagated from high health status, true-to-type material (scion and rootstocks) has the pre-requisite that both scion mother trees and rootstock sources are certified, and thus progress towards certification in the almond industry is reliant on the commitment of Monash *and* other propagation material providers to achieve certification.

8.1.2 Certification of Almond Budwood Sources

Certification of almond propagation material is highly recommended, given the problems of almonds that certification could overcome (graft-transmissible pathogens, non-infectious bud failure etc.). The requirements for almond certification should be demonstrated trueness-to-type, traceable to foundation or mother stock (at the least), demonstrated high health status (being virus-tested and free of detectable levels of PDV, PNRSV, and in the case of imported seed, a reputable and auditable, approved source that can meet these requirements) and budwood trees and seed sources, maintained in an agreed manner that minimises the chance of contamination or a loss of identity.

Of paramount concern are the health status and trueness-to-type and freedom from mutants (bud sports) of the budwood source trees. The following are recommended guidelines:

- rootstock and scion both originated from fully indexed foundation trees
- maintained under conditions for freedom from infection by root contact, mechanical transmission, pollen or aerial vectors, with retesting as appropriate
- maintained in the field separated by approximately 1 km from cultivated or wild *Prunus* spp. not of the same or higher health status, and prevented from flowering
- soil should be tested and found free from virus-transmitting nematodes and confirmed every 5 years
- each plant checked for trueness-to-type and inspected visually every year for possible mutations and disease symptoms
- all trees to be retested every year for PNRSV and PDV, under conditions of agreed, documented protocol
- only registered trees within blocks and each tree bears a permanent registration number
- plant spacing and management ensures no branch overlapping between different varieties
- any plant giving a *confirmed* positive test result (this may need more than one method of testing) or showing symptoms of viruses, virus-like diseases or other pests and diseases to be removed (according to agreed tolerances) from the nuclear stock collection, by agreed disposal methods.
- detailed record-keeping (as above).

8.1.3 Select Harvests

The above requirements of Monash should also apply to the Select block if it is to be part of the Australian Almond Multiplication Scheme.

8.2 Accreditation of Seed Supply Operations

Seed and rootstock supply businesses would also benefit from the pursuit of accreditation of their operations and the provision of certified material. Seed suppliers to the almond industry operate independently but some in close association with the ABA. Ausbuds provides imported Nemaguard seed and Nemaguard seed from indexed Ausbuds mother trees (two generations from the original FVF trees). Ausbuds also has mother trees of GF677 now in production. Lacton Nursery may provide open-pollinated Nemaguard seed to the industry. Boulevarde and Select have high health status GF677 which they are rapidly multiplying. These nurseries and variety managers that import large quantities of proprietary stone fruit material (i.e. Jempi and ANFIC) are likely to adopt accreditation if there are clear business advantages in doing so. There are still other nurseries that provide almond relevant rootstock material, but remain completely independent of the almond industry and its organisation. Their operations and standards remain undisclosed and as such these nurseries present a degree of uncertainty and risk to the almond industry. This exposure can be minimised by rewarding those nurseries who do operate transparently through audits and open communication with industry, in an environment of continuous improvement with commitment to the national industry's further development.

The protocols outlined above will also need to apply to Ausbuds (as the supplier of certified seed), and to the suppliers of certified GF677 (as providers of rooted cuttings or meristem tip cultured plantlets). All components of the Scheme must reach and maintain the same high standards for tree health, record keeping etc.

8.2.1 Certification of Almond Rootstock Material

The following are guidelines for certifying rootstock material:

- seed source trees should be tested annually for PNRSV and PDV
- seed source trees should be inspected visually each year for virus symptoms and other pests and diseases
- any infected tree should be removed
- plants should be inspected visually for possible mutations
- isolation distance of 100 m for seed source blocks from non-registered, uncertified *Prunus* spp.
- ground within block and 7 m surrounding buffer maintained vegetation free or with approved ground cover
- only registered trees within blocks and each tree bears a permanent registration number
- plant spacing and management ensures no branch overlapping between different varieties
- multiplication *in vitro* may be used for rootstocks provided the source tree is true-to-type and has indexed free of PNRSV and PDV
- detailed record-keeping

8.3 Accreditation of Almond Nurseries

In a review of the NIASA requirements, it is our opinion that superior nurseries could achieve this accreditation with little difficulty. There are however some requirements that may demand facility and staff development. These include: record-keeping, exit/entry hygiene and quarantine (personnel, vehicles, plant and animal movement); planting site preparation and sanitation, and water monitoring and/or treatment. The relevant pages of the NIASA Best Management Practice Guidelines are included in Appendix 14.

Trees that cannot be certified (i.e. have been propagated from non-certified budwood and/or seed), must be kept separate from candidate trees for certification with strict control over the use of separate tools such as budding knives, secateurs etc. on certified trees.

It is our opinion that the almond industry would benefit from nursery accreditation. It is a process that would recognise and reward superior practices within nurseries, and raise the standards of propagation material throughout the industry. Certification/accreditation is self-perpetuating and makes good business sense for nurseries. Productive, virus-tested trees, meeting nursery tree production standards will increase the demand for more such good trees. In the event sub-licensing and contract multiplication for privately-owned varieties become more common, ABA will potentially have a transparent mechanism for 'rewarding' accredited nurseries with responsibility to carry out certain multiplication steps, while still maintaining standards and control.

8.4 Almond Tree Specifications

It is also necessary for the almond industry to agree on a standardized system of sizing and describing plants to facilitate the trade in nursery stock. Diagrammatic examples of those accepted in the Australian pome (www.apfip.com.au/certification/nursery.cfm) and citrus industries are shown below in Figure 6 A and B respectively. In the USA there is an American Standard for Nursery Stock ANSI Z60.1–2004 produced by the American Nursery and Landscape Association. Such standards are useful for nurserymen and for growers, as growers can detail their preferences on nursery order forms.

The APFIP specifications of trees are requirements to be used in conjunction with tree descriptions. The specifications make specific reference to the health status of rootstock and scion and their trueness-to-type, in addition to the physical characteristics of the provided tree – i.e. minimum trunk diameter, budding height, tree height from graft, root mass, and freedom from disease and pests. The specifications do not dictate the rootstock/scion combinations as these are arranged between the grower and nurseryman directly.

Different categories of certified trees might occur depending whether the tree is field or container grown, eg for citrus the following were proposed:

Mini tree: A tree with scion growth of at least 30 cm

Whip tree: A tree without any scaffold branches, but with the stem already hardened off at the intended topping height. Trees may therefore be topped at any height to suit the grower's requirements.

Scaffold tree: A tree that has formed scaffold branches at a height required by the grower, with a stem thick enough to support the scaffold.

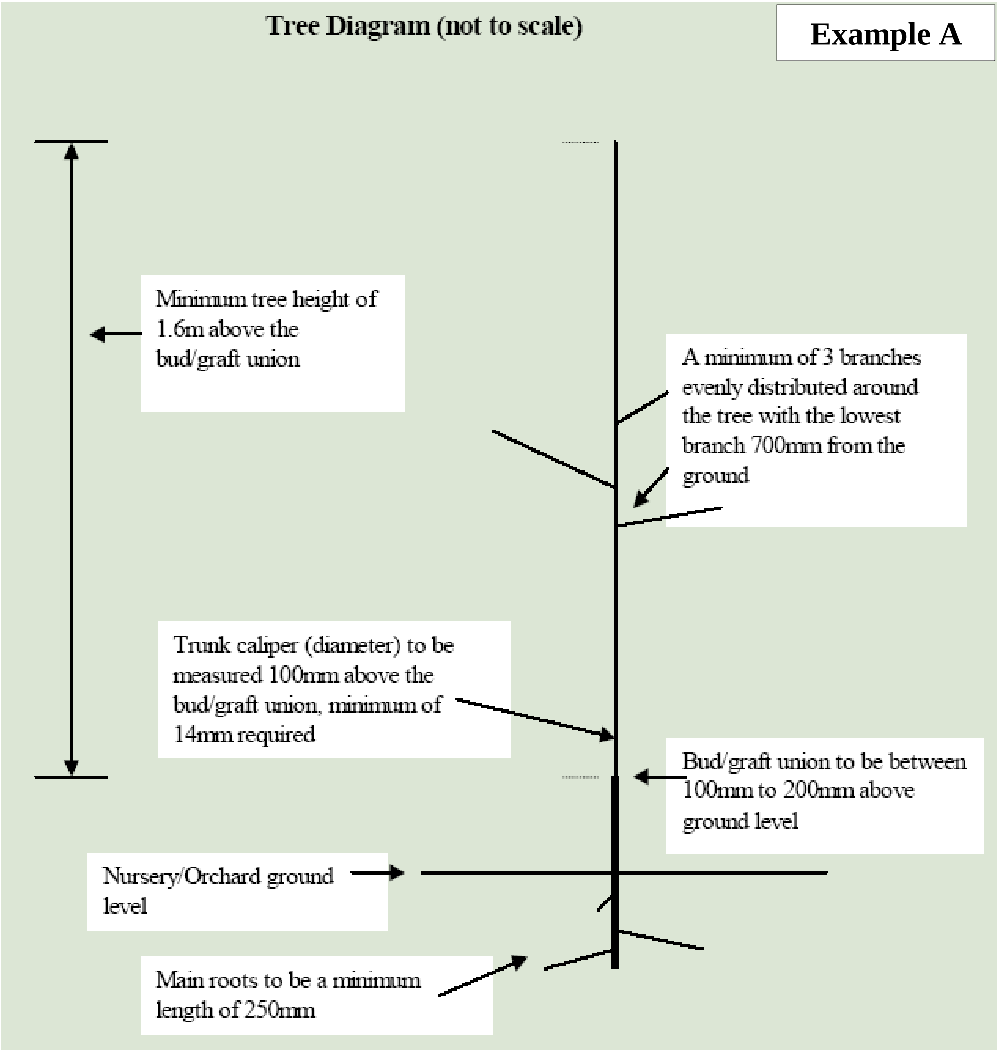
Select Harvests has provided specifications for their nurserymen and also their budders. The Monash order form allows growers to state their preferred budwood diameter. On-line ordering and feedback could be considered.

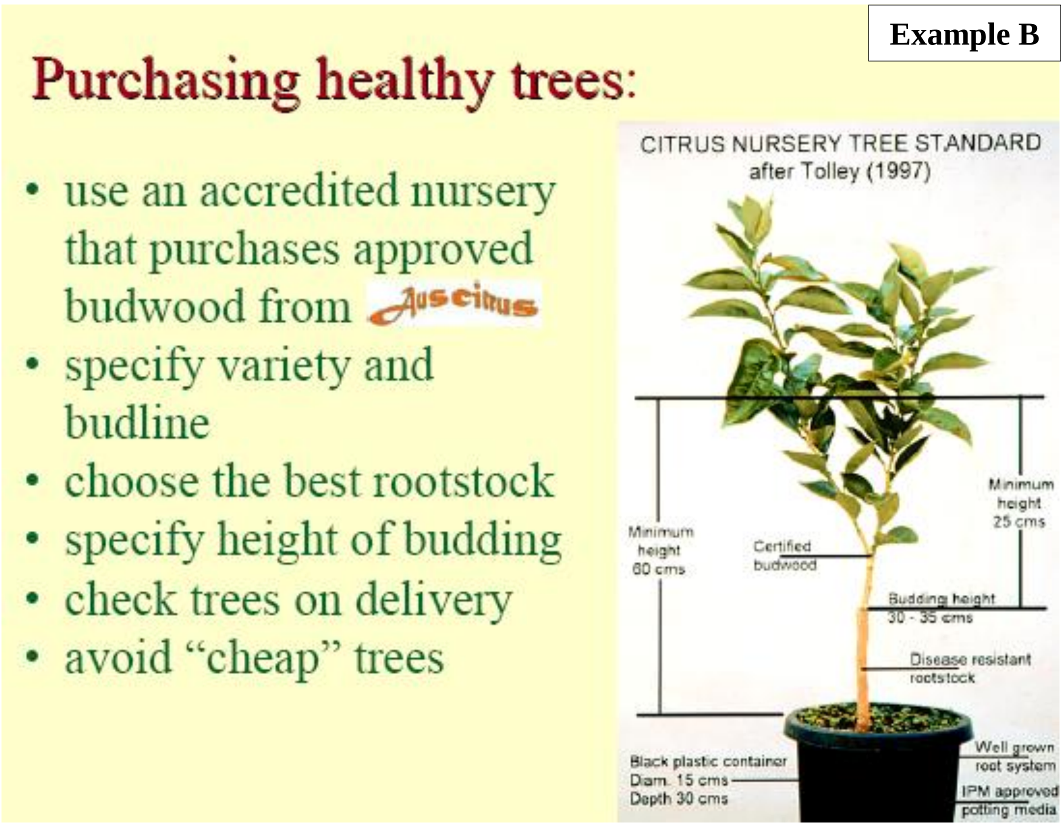
It is recommended that the ABA prepare diagrams for almonds that reflect agreed industry specification parameters and range of sizes for budwood and rootstocks, for the two budding periods of the year.

A requirement for root systems of trees to be dipped in 'No Gall' following digging should be an added requirement.

The industry might also consider the benefits of specifying registered treatments acceptable for application to propagation material nearing release and sale - i.e. dips for bacterial spot? defoliants? winter oils? – and how/where these pre-release treatments should be documented.

Figure 6 : Examples of diagrammatic tree specification descriptions





8.5 Certification of Nursery Trees[21]

A candidate Certified Tree shall qualify as a *Certified Tree* if:

- it has been grown in and kept under specified conditions
  - registered growing area of fumigated pre-plant or virgin soil with 7m buffer.
  - plants should be kept in fields isolated from potential sources of infection.
- nursery stock has been propagated on rootstocks grown from seed of certified trees or imported from high health source with demonstrated freedom from seedborne viruses, i.e. *certified budwood* and *certified seed*
- the label includes rootstock and scion source identification
- there has been no re-working or budding of nursery stock
- off-types or infected material have been immediately removed and recorded
- plants have been inspected for symptoms of virus, virus-like diseases or other diseases and pests by the certifying organization. Any plants showing symptoms to be removed and certification may be granted to the remainder.

8.5.1 Selling Certified Trees

Certified Trees may be sold if they:

- meet the minimum Certified Tree requirements;
- have minimal damage from mechanical harvest or other operations;
- have a minimum height measured from the ground;
- have a minimum caliper size (trunk diameter) measured at 100 mm above the graft/bud union;
- have been left with a root system following lifting that can adequately support the tree with, where possible, the main roots a minimum of 150 mm in length;
- are free of residual soil;
- are bundled and transported in order to prevent damage; ensure that tree roots remain damp;
- have been treated for pests and diseases;
- have no visual symptoms of the pests and diseases.

8.6 Drivers for Certification of Almond Propagation Material

To commence the process of producing candidate propagation material for certification, some industry development and investment is required.

It is recommended that the ABA first identify for industry members, the key drivers for certification, and then collaboratively pursue the required steps.

The required steps include:

- *use of internationally accepted terminology*, i.e. foundation material, foundation repository, mother trees etc.
- *development of propagation material and nursery tree specifications*, i.e. for budstick diameter, grafting/budding height, tree height, trunk circumference, root mass, agreed nursery treatments and pre-release handling etc acceptable to nurserymen and growers.
- *consideration of whom should serve as the certifying authority*. Ideally it should be government certified but that option is unlikely to be accepted by state or Federal governments. If the ABA would accept that role, it would need to distance its Board from the operations of the budwood/seed schemes by forming an affiliated organisation/association.

[21] See APFIP requirements for certified apple trees

- *determination of the legalities associated with certification, a certified product, and the relative benefits and costs of a trademark,* i.e. directed use of certified planting material in contracts? life of a certification label? i.e. first generation only from mother tree; where liability lies for trueness-to-type and health status, and for how long?
- *planned re-development requirements,* i.e. isolation distances; testing regimes etc. at Monash (and other) sites if they wish to become part of the industry certification scheme.
- *development of a foundation repository*
- *determination of entry criteria to the scheme*, i.e. for imported “certified seed”; budwood fully tested by molecular and biological and/or serological techniques? Full traceability to foundation material or mother tree?
- *confirmation of the commitment of rootstock suppliers to produce certified rootstock.* Note that without certified rootstock material, there can be no certified trees.
- *validation and harmonisation of testing methodologies* used on almonds - by AQIS, Knoxfield and University of Adelaide, and in partnership with SPHDS.
- *application of industry pressure on BA to approve as a starting point for strengthening biosecurity, the recommendations of Mark Whattam in the draft Prunus PEQ Manual* (Whattam, 2006) and to include “future new and improved diagnostic technology” within their approval.
- *determination with AQIS minimum requirements*, i.e. for imported, non-certified seed (i.e. to avoid last year’s problem imports from India)
- *negotiation with AQIS for mandatory PEQ testing for economically–important endemic organisms,* i.e. for PDV and PNRSV; possibly ApMV and ACLSV or, *heat treatment* followed by testing of imported almond material
- *negotiation with AQIS on information releases,* i.e. that would allow database development of almond importers and clones
- *consideration of budget needed to increase annual indexing of all mother trees, (seed and scion) identified for cutting or seed supply.*
- *consideration of resources required and optimal structure for management of ‘certification’*

The industry must also consider if there is to be a place for “ABA-approved” or similar material which is either provided by ABA to selected nurseries for further multiplication, or is ineligible for certification but meets high health status requirements. APFIP has accommodated private importers like ANFIC to the benefit of the whole pome fruit industry. Their material may pass through the APFIP testing scheme, and have its high health status confirmed, but such material, cannot carry the APFIP trademark unless there is full traceability to foundation stock or mother trees, within their care.

The industry may wish to consider the relative merits of label disclosures on material of variable status, so that growers can evaluate the risks associated.

It is our recommendation the only alternatives to ‘certified’ material be ‘uncertified’, ‘best available’ or ‘not from an approved source’, so as to avoid liability and the readiness of growers and nurserymen to accept one-off material as being of ‘equally’-acceptable health status and provenance.

8.7 Recommendations for Management of Budwood Scheme

It is our recommendation that the following management structures and roles be considered by the industry.

- *Formation of a not-for-profit association (like Auscitrus) or a not-for-profit company (i.e. Aust. Pome Fruit Improvement Program Ltd. - APFIP) to oversee the multiplication and improvement (evaluation and breeding programmes) for almonds.* This association/company should be an affiliate of the ABA, but should act independently enabling the ABA itself to be the overriding and official body that grants certification.
- *The association/company should have a management team comprising a Manager for the Improvement Scheme and Board of 5 directors representing and working in the almond production and/or nursery industries.*[22]
- *Rules for the association (if an association is the choice) should be developed as required by the state government body administering associations.*
- *Consideration should be given to inclusion of Ausbuds on the Board or as an Advisor.*
- *The Manager should be responsible for the day-to-day operations of the budwood and evaluation blocks (Monash, regional); maintenance of nuclear (foundation) stock; and management of the certification scheme, ensuring up-to-date pathogen testing, assessment of trueness-to-type, freedom from mutants, adherence to minimum nursery tree standards and liaison with suppliers of rootstock material, variety managers and governmental instrumentalities, i.e. state departments, AQIS, BA etc.*
- *Directors should serve a 3-year term with rotated (i.e. half Board at any one time?) vacancies filled following advertisement.*
- *The Management team should be assisted in their decision-making by the almond breeder, the Executive Officer of the ABA and a pathologist skilled in indexing for almond pathogens.* These skills-based appointees would be non-voting.
- *A Secretary/Administrative Assistant would assist with invoicing for budwood supplied; IP management, tests conducted, maintenance of records (tests, results, inspections); inspection schedules for all multiplication and production phases of the scheme and for visual inspections to verify the apparent health of the stock; evaluation data; management of HAL and other funding; management of the trademark (if undertaken) and legal protection and status of proprietary lines etc.*
- *The Management Committee should produce a Newsletter (also available on-line) to keep growers and nurserymen informed of recent developments in importations, operations of the budwood scheme, rootstock seed and budwood availability, horticultural evaluation results etc,* eg Auscitrus produces a newsletter three times each year[23]. APFIP website has a news section[24] that includes news, pome fruit Australia column, presentations, published articles and annual reports.

8.7.1 Funding

Horticultural industries have had to adapt to significantly-reduced contributions, commitment and specialist services to improvement schemes, by state governments. The almond industry has been successful in making budwood multiplication at Monash a self-funding programme. Today's pressures however are different and it is expected that water restrictions and the shortage of specialist services, may affect the improvement scheme and its rate of on-going

---

[22] See administrative structures of Auscitrus (www.auscitrus.com.au) and APFIP (www.apfip.com.au)
[23] http://www.auscitrus.com.au/newsletter/index.shtml
[24] http://www.apfip.com.au/news/news.cfm

redevelopment. External pressures on the scheme might also include a less consistent demand for buds as the additional budwood site develops supply capacity, as private importations increase, and as the predicted tax status for MIS schemes become reality.

Price setting for budwood distributed from propagation trees at Monash should be on a cost recovery basis and take into account the costs of tree maintenance, annual tree indexing, cutting, packing, invoicing and postage costs, and salaries of staff employed for these duties.

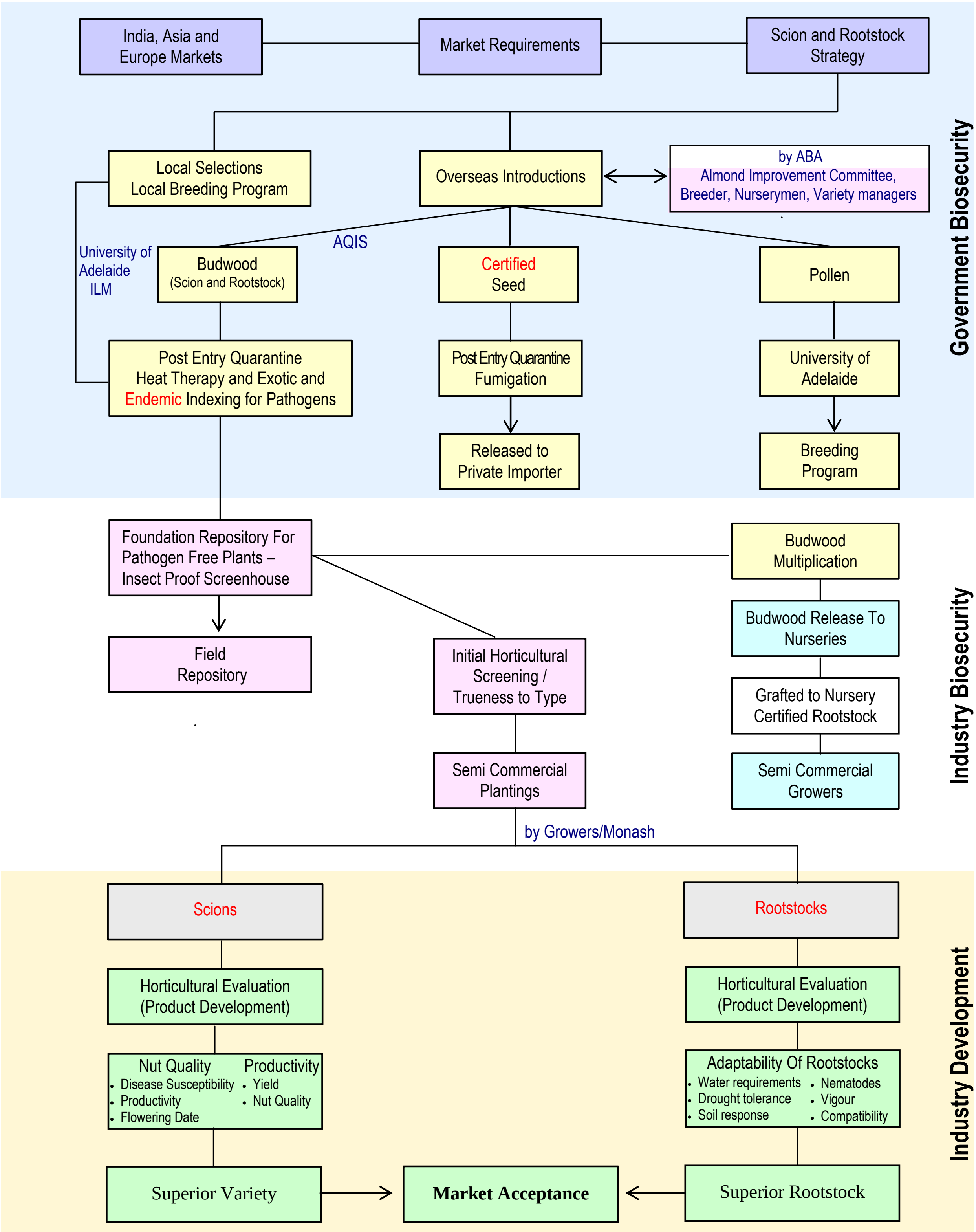
Industry development and adoption of proposed standards and schemes will require funding from individual importers, industry/growers via levies, and from relevant governments. For example:

- Identification and procurement of imported lines should remain with the ABA, and importers of proprietary lines.
- Testing in PEQ should remain at the importer's expense (even if the industry were to 'enforce' increased testing).
- Other industry development operations, eg establishment of new blocks and facilities (i.e. pre-entry nursery, foundation repository, insect-proof screenhouse), maintenance, health status and identity determination, and indexing of foundation (nuclear) stock, independent horticultural evaluation trials of new scion or rootstock varieties; breeding and assessment of new hybrids, development of importation database etc, should be through the industry levy with matching funds from HAL. However entries of proprietary lines into the foundation repository and evaluation trials could attract a management fee to be paid by the owner of the material. See Figure 7.
- Costs associated with the establishment of a Certification Scheme should initially be funded by the industry through the levy, but ultimately running costs should be borne by the users.
- Multiplication, propagation and distribution costs should be incorporated into the cost of material supplied – i.e. Monash should be self-funding from proceeds

Figure 7 is the proposed scheme for further almond rootstock and scion development. The drivers are biosecurity and industry development and as such governments, industry and research entities (funding bodies and providers) are integral to the programme. The most significant additions to the existing programme – which has over many years served the almond industry well – are the foundation repository, enhanced horticultural performance evaluations, and the formation of a skills-based committee to provide technical input to the programme.

To achieve the recommendations, stronger alliances will need to be forged with variety managers, government agencies with plant biosecurity responsibilities, research providers and funding bodies, international collaborators and allied industries like the other *Prunus* industries.

Figure 7 : Proposed almond rootstock and scion development program



Industry Liaison Manager ILM (ABA and Almond Improvement Committee)
Current Program
Product Development (HAL funded?)
Almond growers/nurseries
Not currently done

9 SWOT ANALYSIS OF AUSTRALIAN ALMOND BUDWOOD AND SEED MULTIPLICATION SCHEME

Table 14 : The strengths, weaknesses, opportunities & threats in the budwood & seed multiplication schemes for almonds

STRENGTHS	WEAKNESSES	THREATS	OPPORTUNITIES	OTHER
Industry control – ABA main importer to-date	Weak alliances with private importers / commercialisers	Other hosts of almond exotics and poor cross-industry communication	Establish certification terminology and standards	
Monash facility	No foundation trees in screenhouse or dedicated field repository	Competition policy – monopoly of Monash ?	Increased collaboration, sharing of resources and investments – i.e. with perennial hort. industries re foundation repository etc.	
Limited number of industry desired varieties	Incomplete identification records and limited testing of imports i.e. GF677	New exotic pests and diseases of almonds and bees	ABA as a commercialiser? Collect royalties?	
Cohesive industry with clustered locations	No system to accommodate private imports	No incursion management preparedness for ALS, PPV	Establish/contact new suppliers	
Risk management by industry control and location of schemes	Diagnostic standards not uniform; validation incomplete	Incursion quarantine zones – proximity to grapes and stone fruit if outbreak of Pierce's Disease or PPV - Monash and Select.	Establish standards for budwood and rootstocks, nursery trees	
Genetic resources – range and quality	No comparative regional evaluation	PEQ limited testing – no phytoplasmas; strains of PDV, Xylella, viroids	Agreement with AQIS to multiply in quarantine?	
Profitability of Monash	ABA holding all assets and liabilities	No mandated testing for PNRSV, PDV, endemic organisms in PEQ.	Strengthen alliances with Ausbuds, Select, University of Adel, nurseries, private importers	
Alliance with University of Adelaide	Independent auditing of the budwood scheme available?	Commercialisers outside system	Industry establishment of Nemaguard and GF677 planting	
Linkage with Vine Improvement scheme and shared resources	Non-equivalence of 2 multiplication blocks (Monash and Select)	Loss of levy and matching funds	Over-arching committee to provide technical input to multiplication and varietal improvement	
No apparent dependence on private QAPs	No contingencies for seed supply	Encroachment of urban Prunus; landscape and ornamentals into commercial areas	Establish case for certified budwood and seed and accredited nurseries	
History of research commitment	Possibility of root graft transmission of viruses	Inconsistent testing of all hosts for Xylella	Introduce QA for multiplication scheme	
	New nurseries missing out when demand>supply	Importation from Xylella-affected areas	Work with AQIS to strengthen import conditions	
	Demand > supply - short term	Loss of technical input from State departments	Renew contracts and close alliances with Californian breeders	
	Nemaguard and GF677 supply and quality outside ABA control	Inconsistent clonal name and identity checks	Co-operative research and international exchange	
	Technical input fragmented.	Relaxed plant transfer within expanded EU – "approved suppliers"	Newsletter to industry on multiplication and improvement	
	No water security for facility		Trade mark development	
	No dedicated equipment for facility			
	Limited communication with AQIS, BA, PHA etc			
	Reliance on few varieties and pollinators			
	One accredited (ISO 9000) nursery			
	No biosecurity plan for multiplication block			

10 ALLIANCES

As mentioned in Section 8 and throughout the report, the almond industry is dependent upon its members, and agencies and parties external to the industry to achieve its desired goals of superior, high health propagation material and high-yielding trees producing nuts of a premium quality.

In the current climate of variable confidence in water supplies and safeguards against exotic threats, increasing importation of patented and privately-owned varieties by commercialisers somewhat new to the industry, and decreasing support form the State departments of agriculture, the ABA is encouraged to:

- *take a leadership role in forging strong Prunus industry links with AQIS and Biosecurity Australia.*
- *communicate to industry the merits of a strong ABA role in industry service and development, in the areas of importation, multiplication and standards development for new propagation and breeding material (scions and rootstocks).*
- *urge HAL to promote widely the use of high health status planting material, and be the facilitator of nursery accreditation and product certification standards in perennial horticulture.*
- *strengthen alliances with research providers and ensure that research outcomes are delivered to industry.*
- *ensure that technical advice on almonds from commodity and discipline specialists continues to be available to the industry.*
- *maintain a strong alliance with Ausbuds and to include Ausbuds in discussions of propagation material quality and indexing standards and programmes, certification and industry involvement in rootstock supply.*
- *enhance alliances with key partners and industries, eg bees (in partnership with RIRDC), other Prunus industries; variety managers, and nurseries.*

11 RECOMMENDATIONS

Today the Monash site is appropriate as a budwood multiplication site capable of, although not currently, satisfying industry demand for budwood of public varieties. It needs expansion, with appropriate isolation distances, if it is to accommodate the additional activities (i.e. foundation repository) of a more robust and secure improvement scheme, producing adequate quantities of certified budwood.

The ABA must consider its position in years when Monash cannot satisfy the demand for budwood: i.e. is there a need for a second industry budwood site to meet future demand and to mitigate risk (eg hail, disease)? Should the ABA approve or carry-out rapid multiplication of material? What is the most equitable distribution when material is in short supply?

To do justice to the nursery component of the almond industry and to further improve the quality of planting material supplied, it is recommended that a not-for-profit association or company be formed to oversee the multiplication and improvement (evaluation and breeding programmes) for almonds. This association/company, representing almond production and nursery industries, should be an affiliate of the Almond Board of Australia (ABA), but should act independently enabling the ABA Board to be the overriding and official body which grants certification. The current plant improvement sub-committee may be a foundation of the proposed skills-based body, and appropriately contribute to the development of terms of reference, structure and composition of the recommended affiliate.

This body would be charged with making some of the tough decisions in regard to the future of almond improvement in Australia, as outlined in the report and below in the recommendations. For example, progress toward certification, will require the almond industry to agree on the standards to be met for budwood and rootstock quality and integrity, the inclusion within an industry certification scheme of product from Monash, and Ausbuds and/or Select, and on the potential for product provided by each, to be certified to the agreed standards. Our recommendations to assist in reaching agreement across industry on such decisions, follow. Associated tasks are included in Appendix 15.

11.1 Budwood Multiplication at Monash

The number of budwood source trees of relevant varieties/clones be increased so that budwood supply exceeds future demand.

To improve the Monash programme, it is recommended that all trees supplying budwood are tested annually for PNRSV and PDV.

Any infected trees at Monash should be removed following validation of the molecular indexing result.

It is also recommended that the location of infected trees be mapped/analysed periodically to assess whether or not root-grafting may be involved in any virus transmission.

In re-development, isolation and tree-spacing distances should reflect the known presence of other related hosts, potential for root-grafting, vector movement and pollen spread.

An isolated site may be required to accommodate incompletely-indexed material released from PEQ or submitted from local sources, but ideally all material would be fully indexed by AQIS prior to entry to any industry scheme.

It is recommended that the ABA maintain two original plants (rootstocks and scions) released from PEQ (or local breeding programmes) as potted, foundation trees in a secure, insect-proof screenhouse, hereafter. A field repository should also be considered.

A biosecurity plan should be developed for Monash.

It is recommended that the almond industry through HAL and the ABA, support the process of protocol validation on almonds (i.e. indexing methodologies for budwood, rootstocks and pollen), and also peer scientific review of the protocols.

It is incumbent on the industry and especially private importers, to ensure that endemic pathogens do not enter the multiplication chain with newly imported clones/varieties, seed or pollen. The industry should seek AQIS endorsement for post-entry quarantine indexing for endemic as well as exotic diseases.

It is recommended that the ABA consider the eligibility criteria in terms of defined health status and documented origin and identity, for both local and imported material entering the almond budwood multiplication facilities.

11.2 Rootstock Supply

With the seed component of the industry being somewhat removed from the ABA, and with accreditation and certification of planting material being considered by the ABA, it is timely for *the benefits of an ABA-controlled source of Nemaguard at Monash to be evaluated. Consultation with the stone fruit industry and Ausbuds is advised.*

The status of GF677 as "ABA-approved" or other, needs resolution, particularly for those in Managed Investment Schemes (MIS) that have Product Development Statements (PDS) defining very specifically the accepted source and status of planting material.

The industry is encouraged to ensure that seed is imported only from direct suppliers of certified seed from identified sources and that approved labelling and/or documentation allows traceability of such material, and validation of information provided on permit applications.

It is recommended that the ABA consider and document the eligibility criteria in terms of defined health status and documented origin and identity, for both local and imported material entering the almond rootstock multiplication facilities.

11.3 Post Entry Quarantine (PEQ)

There are PEQ arrangements relevant to the Australian almond industry that need further development.

We recommend that the almond industry engage PHA and HAL in dialogue that leads to strong representation to AQIS directly, and through PEPICC[25]*. Matters of interest to the industry are: auditing of overseas suppliers; verification of sources and pest-free status; private QAP facility and PEQ activity audits; testing/indexing standards; closing/moving of AQIS facilities at Knoxfield and Eastern Creek.*

It is recommended that the ABA formally acknowledge their desire for the draft Prunus PEQ Manual and the recommendations included within it, to be approved by BA and implemented for Prunus spp. *in PEQ.*

It is recommended that the almond industry support the process of protocol validation on almonds and peer review of the protocols.

The ABA is encouraged to discuss a requirement for freedom from PNRSV and PDV of all almond relevant material released from PEQ.

It is incumbent on the industry and especially private importers, to ensure that endemic pathogens do not enter the multiplication chain with newly imported clones/varieties, seed or pollen.

The industry is encouraged to ensure that seed is imported only from direct suppliers of certified seed from identified auditable sources.

The ABA, on behalf of the almond industry, is encouraged to build a database of importers and relevant planting material entering the country through PEQ as best they can, and prior to the expected and potentially rapid growth in the number and type of private importations. Representation on PEPICC is recommended.

[25] PEPICC acts as an effective conduit for information exchange between the plant importing industries and AQIS. In relation to the almond industry this is a forum in which concerns regarding approved sources, health status of imported rootstock seed, testing for phytoplasmas etc, can be raised.

11.4 Engagement of Private Importers of Almond Propagating Material & Variety Managers of Proprietary Lines

Since most entries of imported almond material now originate from non-approved sources, it is recommended that engagement of private importers be increased.

ABA leadership in developing a secure (physically and legally) and mutually-beneficial environment for private proprietary material to be included in the multiplication scheme and in industry-driven independent evaluation trials, is encouraged.

Determine if variety managers, at the least have an intention to provide propagation material of defined, high health status to the industry.

11.5 Future Industry Development and Services

In considering future industry structures relevant to propagation material quality and supply, it will be important for industry members and stakeholders to be canvassed on the desired and expected lead role of the ABA, of its affiliated improvement association or company, and of each of the directly allied bodies (PHA, HAL). Industry input will be valuable in determining the relative capacity of each group to drive forward, orchestrate or manage - individually and collectively - the following activities that affect supply of high quality planting material and the future of Monash.

Where possible we have identified suitable driver/s for the industry service and development activities. It is noted that our conclusions do not identify the funding sources in each case, but HAL would be expected to increase their involvement in industry development activities and also in some industry services. See Figure 7.

Appendix 15 includes suggested industry development tasks.

We are recommending that industry drive (via an independent, approved affiliate) comparative evaluation trials, carried out with due prior consideration of exactly how the industry will value and use, disseminate and respond to, the resultant information.

If the ABA and importers of proprietary lines are united in their commitment to independent almond valuation trials, DNA finger-printing of all submitted material is recommended.

It is recommended that the ABA (or appropriate affiliate) prepare diagrams of agreed almond nursery tree specifications and standards.

A Newsletter for nurserymen and growers be developed and made available on-line to provide information on budwood and seed supply, results of horticultural evaluations, presentations etc.

It is recommended that the ABA in consultation with IP Australia consider the requirement for defined health status of propagation material intended for inclusion in comparative evaluation PBR trials for almonds or almond relevant planting material (rootstocks).

The ABA commitment to breeding should be maintained.

The ABA should determine the relative financial and IP benefits of maintaining non-commercialiser status; and its alternative, i.e. becoming a commercialiser (variety manager) competing with major nurseries and importers.

ABA should be central manager of head agreements, testing agreements of ABA-imported material and a manager of IP, where required.

ABA should confirm its head agency status with FPS in California and breeders in USA, while also strengthening the opportunities for collaborative research and exchange of germplasm with Spanish and French researchers.

11.5.1 Industry Development

ABA

- Determine the composition and terms of reference of an over-arching affiliated association/company (ABA-AC) to manage genetic resources, their evaluation and multiplication.
- Establish/confirm head agency status with overseas breeding programmes and institutions.
- Strengthen international collaborations with evaluation and multiplication schemes.
- Determine the value of sub-licenses for imported material.
- Establish a foundation repository for high health status, true-to-type public and patented varieties.
- Introduce disclosure statements and/or labels that include health status and identity information – (and later), certification status.
- Provide assistance for validation of indexing protocols specifically on almonds.
- Facilitate dialogue with AQIS, PHA and Biosecurity Australia re more rigorous import conditions, extended quarantine services, and guidelines/protocols for testing in PEQ - testing for endemic, graft-transmissible organisms?
- Encourage and facilitate private importer commitment to national scheme – i.e. PEQ testing for endemic pathogens, eg PNRSV and PDV testing, certification, evaluation, submission of foundation tree to industry repository.
- Facilitate assessment (through test and service validations) of industry providers – diagnostic services, ampelography, education, communication providers.

PHA

- Facilitate dialogue with AQIS and Biosecurity Australia re more rigorous import conditions, efficient quarantine services, and guidelines/protocols for testing in PEQ - mandated testing for endemic, graft-transmissible organisms?
- Develop eligibility criteria for entry to the Monash budwood scheme and for certification (in consultation with HAL and AQIS).
- Encourage and facilitate private importer commitment to national scheme – i.e. mandated PEQ testing for endemic pathogens eg PNRSV and PDV, certification, evaluation, submission of foundation tree to industry repository.
- Facilitate development of Monash biosecurity plan.

HAL

- Assist the process, in consultation with current plant improvement sub-committee, of determining the composition and terms of reference of an over-arching affiliated association/company (ABA-AC) to manage genetic resources, their evaluation and multiplication. HAL involvement is advised since the structure and operations may require cross-industry input and considerations.
- With the benefits of insight into and experience in other perennial horticultural industries, contribute to the discussions of eligibility criteria for entry to the Monash budwood scheme, and for certification.

- Progress at a national level, nursery accreditation guidelines for perennial horticultural crops, through an industry workshop.
- Provide funding to establish a foundation repository for high health status, true-to-type public and patented varieties of relevance to the almond industry.
- Assist through the provision of advice, with the introduction of disclosure statements (or labels) for perennial horticultural propagation material, that document health status and identity.
- Provide financial assistance for validation of indexing protocols specifically on almonds.
- In partnership with peak bodies (i.e. ABA, Summerfruit Australia, NGIA), encourage and facilitate improved industry biosecurity through private importer commitment to: national budwood and seed schemes; increased PEQ testing for endemic pathogens (i.e. PNRSV and PDV, bacterial spot etc for almonds and other stone fruit); certification; evaluation; and submission of foundation trees to industry foundation repositories.
- In partnership with peak industry bodies and PHA, facilitate assessment (through test and service validations) of industry providers in the areas of diagnostic services, ampelography, specialist education, and communication.

ABA-AC (affiliated company)

- Determine the value of sub-licenses for imported material.
- Develop eligibility criteria for entry to the Monash budwood scheme and for certification.
- Determine audit roles and drivers for certification of propagules and accreditation of facilities, eg Monash, Ausbuds, nurseries.
- Determine equity within industry – for budwood distribution, etc.
- Facilitate dialogue with AQIS, PHA and Biosecurity Australia re more rigorous import conditions, quarantine services, and guidelines/protocols for testing in PEQ - testing for endemic, graft-transmissible organisms?
- Train staff - i.e. roles/responsibilities for budwood site, cutting, handling and distribution and a commitment to OH&S.

11.5.2 Industry Services

ABA

- Access, develop and manage imported material both public and patented.
- Manage intellectual property related to varieties and rootstocks.
- Manage assets and resources including the safeguarding of rootstock and budwood material.
- Implement budwood/rootstock certification and nursery accreditation schemes.
- Advise industry of legal protection (and liability) options for nursery trees and propagation material.
- Centralise collection of records and data relating to scion and rootstock improvement (in association with DAFF, PHA and new BioSIRT programmes).
- Educate the nursery and growing industries re adoption of standards, certification, labelling etc.

ABA-AC

- Access, develop and maintain imported material both public and patented.

- Manage assets and resources including the safeguarding of rootstock and budwood material.
- Evaluate varieties and rootstocks in different regions.
- Multiply and supply of commercially important scion budwood and rootstock material.
- Collect records and data relating to scion and rootstock improvement.
- Train staff - i.e. roles/responsibilities for budwood site, cutting, handling and distribution and a commitment to OH&S.

PHA

- Advise on options for centralised collection of records and data relating to scion and rootstock improvement (in association with DAFF, HAL and new BioSIRT programmes).

HAL

- Facilitate implementation of budwood/rootstock certification and nursery accreditation schemes (suitable for adoption by perennial horticultural industries).
- Educate the nursery and production sectors of the industry re adoption of standards, certification, labelling etc.

12 CONCLUSIONS

In summary, we have concluded that the ABA should aim to:

- remain the industry's 'first choice' supplier of almond propagation material that is pathogen-tested and (in the future) certified, and true-to-type;
- promote and further enhance timely and secure access to new varieties and rootstocks through effective international collaboration and efficient PEQ protocols;
- deliver independent and objective variety and rootstock performance information to all parts of the Australian almond industry;
- develop and promote high standards for almond management and propagation, that are suitable for adoption by all providers of almond propagation material.

SCHOLEFIELD ROBINSON
HORTICULTURAL SERVICES PTY LTD

PRUE McMICHAEL
Principal Consultant/Plant Pathologist
Almond Board of Australia\Nursery Review 06\Reports\Final\Rpmc0607NurseryReview FINAL 0208.doc

13 REFERENCES

Ainsley, P.J., Collins, G.G., Sedgley, M., 2000. Adventitious shoot regeneration from leaf explants of almond (*Prunus dulcis*. Mill.). *In-vitro* Cellular Development Biology-Plant 36: 470-474.

Almond Board of Australia (ABA). 2007. Annual Report 2007. 42 pp.

Australian Almond Industry STRATEGIC PLAN (2006-2011) http://www.aussiealmonds.com

Barba, M., (undated). The Italian Certification of fruit tree propagative material in the frame of the European Union. http://sichuan.iao.florence.it/documenti/CERTIFICATION.PDF

Bertozzi, T., Alberts, E., Sedgley, M. 2002. Detection of Prunus necrotic ringspot virus in almond: effect of sampling time on the efficiency of serological and biological indexing methodologies. Australian Journal of Experimental Agriculture 42(2): 207-210.

Blackstock, J. 1990. Where to from here? – Some models for an improved approach to horticultural propagation schemes. Pp. 61-70. In: Proceedings of the Australian Horticultural Propagation Workshop, 9-10 May, 1990, Gosford, NSW. HRDC. Australian Institute of Agricultural Science AIAS Occasional Publication 52. 97 pp.

Broadbent, P. 1987. Citrus budwood multiplication. FAO Plant Protection Bulletin 35(1): 2-10.

Card, S.D., Pearson, M.N., Clover, G.R.G. 2007. Plant pathogens transmitted by pollen. Australasian Plant Pathology. 36(4): 455-461.

Channuntapipat, C., Sedgley, M., Collins, G. 2003. Micropropagation of almond cultivars Nonpareil and Ne Plus Ultra and the hybrid rootstock Titan×Nemaguard. Scientia Horticulturae 98(4): 473-484.

Channuntapipat, C., Collins, G., Sedgley, M. 2001. Conservation of almond germplasm by cryopreservation . In Ak, B.E. (ed.). 11 GREMPA Seminar on pistachios and almonds = 11ème Colloque du GREMPA sur le pistachier et l'amandier . Zaragoza : CIHEAM-IAMZ, 2001. Pp. 101-106 : ref. (Cahiers Options Méditerranéennes ; v. 56), 11. GREMPA Seminar on Pistachios and Almonds, 1999/09/01-04, Sanliurfa (Turkey).

Chen, J., Groves, R., Zheng, Y., Civerolo, E.L., Viveros, M. and Freeman, M. 2007. Colony Morphology of *Xylella fastidiosa* almond leaf scorch strains. Can. J. Plant Pathol. 29: 1-7.

Collins, G., Mekuria, G., Alberts, E., Bertozzi, T., Wirthensohn, M., Sedgley, M., Bennett, C., Ramesh, S. 2004. Virus screening for Australian almonds. NUCIS Newsletter, 2004 (No. 12): 15-16.

Colmagro, S., Collins, G., Scott, E. 2002. Anthracnose disease in Almond. Australian Nutgrower 16(1): 17-19.

Constable, F. and Drew, C. 2004. Review of Vine Health Parameters, Implementation Priorities and capabilities for Vine Improvement groups and Accredited Nurseries. HAL report NVH 03/01.

Dejampour, J., H. Rahnemoun, D. Hassani. 2006. Breeding Almond Interspecific Hybrid Rootstocks In Iran. ISHS Acta Horticulturae 726: IV International Symposium on Pistachios and Almonds, pp. 45-50

Dimassi-Theriou, K. 1995. In vitro rooting of rootstock GF-677 (*Prunus amygdalus* x *Prunus persica*) as influenced by mineral concentration of the nutrient medium and type of culture-tube sealing material. Journal of Horticultural Science 70: 105-108.

Diekmann, M., Putter, C.A.J. 1996. FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm No. 16 "Stone Fruits", 109 pp.

Dunez, J. 1998. Strategies to control virus and virus-like diseases: state of the art and perspectives for stone fruits. Options Mediterraneennes Series B: studies and research 19: 73-79.

Econtech Pty Ltd. 2007. Independent Review of Managed Investment Schemes Involvement in Horticulture (HAL project number HG06115).

Edstrom, J. 2006. Report on visits by John Edstrom to Australian Almond Orchards – August/September 2006 (prepared for Scholefield Robinson Almond clients). Scholefield Robinson Horticultural Services Pty Ltd.

EPPO. EPPO PM 4/30 (1). 2000. Certification scheme for almond, apricot, peach and plum. OEPP/EPPO Bulletin 31: 463–478.

EPPO. EPPO PM 3/32(1). 1998. Phytosanitary Procedures Tomato ringspot nepovirus in fruit trees and grapevine inspection and test methods.

EPPO. EPPO Standards. 2000. Schemes for the Production of Healthy Plants for Planting. Certification scheme for almond, apricot, peach and plum PM 4/30(1).

EPPO. EPPO Standards. Schemes for the Production of Healthy Plants for Planting. Nursery Requirements. PM 4/7 (2).

FAO, 1999. International Standards for Phytosanitary Measures ISPM 10. Requirements for the establishment of Pest free places of Production and Pest Free Production sites.

Fasolo, F., Malavasi, F., Ranieri, R. 1987. Preliminary investigation on *in vivo* rooting of micro-propagation of GF-677, peach rootstock. Symposium on In Vitro Problems Related to Mass Propagation of Horticultural Plants. Acta Horticulturae 212: 181-287. http://www.actahort.org/books/212/212_43.htm

Felipe, A.J. 2002. Overlook on almond cultivars and rootstocks: A lifetime of experience. III International Symposium on Pistachios and Almonds. Acta Horticulturae 591: 29–41. http://www.actahort.org/books/591/591_1.htm

Fischer, H., Baumann, G. 1981. Selection of virus-free almond clones and investigations on *Prunus* viruses in Morocco. Acta horticulturae 94: 191-200. http://www.actahort.org/books/94/94_25.htm

Fridlund, P.R. 1983. Certification and supporting phytopathology. In: Moore, J.M., Jacik, J. (eds). Methods in Fruit Breeding. West Lafayette, Indiana. Purdue Univ. Press, pp. 398-407.

Gathercole, F.J. 1996. Report for period January 96-June 97. Project NT 96001 – Improved Almond Varieties.

Gathercole, F.J. 1997a. Improved Almond Varieties. Project NT 601. Horticultural Research and Development Corporation.

Gathercole, F.J. 1997b. Comparative Evaluation of Almond Rootstocks and Varietal Clones (cont'd NT609). Project NT96009. Horticultural Research and Development Corporation.

Gathercole, F. 2001. Introduction of Superior Almond Cultivars. Project NT 96001. Horticultural Research and Development Corporation.

Hall and Wilcox Lawyers. 2004. Rules Governing the Use of a Certification Trade Mark. Australian Pome Fruit Improvement Program Limited (APFIP)

Hansen, A.J. 1986. An end to the dilemma – virus-free all the way. Hortscience 20(5): 852-859.

Haviland, D.R. and Viveros, M.A. 2005. Surveys for almond leaf scorch in Kern County, CA, and implications on pruning as a tool for management. Annual Report to the Almond Board of California for the project ABC04-DH-01 2004-05.

Hernandez-Martinez, R., Costa, H.S., Dumenyo, C.K., Cooksey, D.A. 2006. Differentiation of strains of *Xylella fastidiosa* infecting grape, almonds, and oleander using a multiprimer PCR assay. Plant Disease 90, 1382-1388. Langford, G., 2007. New variety development and intellectual property (IP) protection process. Australian Fruitgrower June/July 2007: 18-19.

Isaakidis, A. T. Sotiropoulos, D. Almaliotis, I.Therios, D. Stylianidis. 2004. Response to severe water stress of the almond (*Prunus amygdalus*) 'Ferragnès' grafted on eight rootstocks. New Zealand Journal of Crop and Horticultural Science. 32: 355-362

Juárez, J., E. Camarasa, C. Ortega, V. Ortega, J.M. Arregui, M. Cambra, G. Llácer and L. Navarro. 1992. Recovery of virus-free almond plants by shoot-tip grafting *in vitro.* Acta Hort. 309: 393-400.

Kester, D.E., 1970. Growth *in vitro* of tissue of almond, almond hybrids and some other *Prunus*. HortScience 5(4): 349.

Kester, D.E. 1994. Solving the problem of non-infectious bud-failure in California almond orchards. I International Congress on Almond. Acta Hort. 373: 35-40. http://www.actahort.org/books/373/373_3.htm

Kester, D. 2000. Final Report of the non infectious bud- failure project No.: 99-dk-00. Almond Board of California, 25 pp. http://fruitsandnuts.ucdavis.edu/crops/Almond_Board_BF.pdf.

Kester, D.E., Shackel, K.A. Micke, W.C. Gradziel, T.M. Viveros M. 1998. Variability in potential and expression of non-infectious bud-failure among nursery propagules of 'Carmel' almond. Acta Horticulturae 470: 268-272 http://www.actahort.org/books/470/470_37.htm

Kodad and R. Socias i Company R. 2006. Influence of genotype, year and type of fruiting branches on the productive behaviour of almond. Scientia Horticulturae 109: 297-302

Lampinen, B.D., T.M. Gradziel, J.T. Yeager, M.A. Thorpe, W.C. Micke. 2002. Regional almond variety trials for cultivar evaluation in California. Acta Horticulturae 591: III International Symposium on Pistachios and Almonds. Acta Hort. (ISHS) 591:457-464 http://www.actahort.org/books/591/591_69.htm

Li, W., Wirthensohn, M., Sedgley, M. 2004. Testing for bacterial spot in the Australian Almond Breeding Program. Australian Nutgrower December 2004, 18-19.

Martin, R.R., James, D., Levesque, C.A. 2000. Impacts of Molecular Diagnostic technologies on plant disease management. Annual Review of Phytopathology 38,207-239.

McLean, G.D., Revill, P. 1989. Virus status of temperate fruit in Australia. Acta Hort. 240, 51-54. http://www.actahort.org/books/240/240_7.htm

McMichael, P. 2006. Identification and Analysis of Pathogen Threats to the Nut Industry. (prepared for Plant Health Australia, July 2006).

Mekuria, G., Ramesh, S.A., Bertozzi, T., Wirthensohn, M., Collins, G., Sedgley, M., Alberts, E. 2005. Comparison of ELISA and RT-PCR for the detection of PNRSV and PDV in Australian almond trees . In Oliveira, M.M., Cordeiro, V. (eds.). 13 GREMPA Meeting on almonds and pistachios = XIIIème Réunion du GREMPA sur l'amandier et le pistachier . Zaragoza : CIHEAM-IAMZ, 2005. Pp. 193-196: 14 ref. Summaries (En, Fr). (Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 63). 13. Meeting of the Mediterranean Research Group for Almond and Pistachio, 2003/06/01-05, Mirandela (Portugal).

Mekuria G., Ramesh, S.A., Alberts, E., Bertozzi T., Wirthensohn, M., Collins, G., and Sedgley, M. 2003. Comparison of ELISA and RT-PCR for the detection of Prunus necrotic ring spot virus and prune dwarf virus in almond (*Prunus dulcis*). Journal of virological methods 114: 65-69.

Nemeth, M. 1986. Virus, Mycoplasma and Rickettsia Diseases of Fruit Trees, Martinus Nijhoff Publishers, Dordrecht, the Netherlands.

Nyland, G. 1976. "Virus Diseases of Almond and Apricot: Almond Virus Bud Failure", Virus Diseases and Non-infectious Disorders of Stone Fruits in North America, U.S. Department of Agriculture, Agriculture Handbook 437: 33.

Ogawa, J. M., Uyemoto, J. K., Jaffee, B. A.; updated by Teviotdale B. L. 2001. Diseases of Almond (*Prunus dulcis* (Mill.) Webb). APS Net (update 7/16/01). http://www.apsnet.org/online/common/names/almond.asp

Ogawa, J.M., Zehr, E.I., Bird, G.W., Ritchie, D.F., Uriu, K., Uyemoto, J.K. 1995. Compendium of Stone fruit diseases. American Phytopathological Society.

Paulin, R. 1990. Industry requirements from propagation programmes. Pp. 16-20. In: Proceedings of the Australian Horticultural Propagation Workshop, 9-10 May, 1990, Gosford, NSW. HRDC. Australian Institute of Agricultural Science AIAS Occasional Publication 52. 97 pp.

Prunus Vulnerability Statement. 1996. ARS http://www.ars-grin.gov/npgs/cgc_reports/prunusvulner99.pdf

Ridland, P. 2006. Almond industry threat summary table – *extract* from Identification and Analysis of Pest threats to the Nut industry (prepared for Plant Health Australia 2006).

Roistacher, C.N. 1993. Arguments for establishing a mandatory certification program for citrus. Pp. 18-34. In Proc. Int. Soc. Citrus Nurserymen, South Africa.

Rowhani, A., Uyemoto, J.K., Golino, D.A., Martelli, G.P. 2005. Pathogen testing and certification of *Vitis* and *Prunus* species. Annual Review of Phytopathology 43: 261-278.

Rubio, M., Martínez-Gómez, P., Dicenta, F. 2003. Resistance of almond cultivars to Plum pox virus (sharka) Plant Breeding 122 (5): 462–464.

Sanchez-Navarro J.A., Aparicio, F., Herranz, M.C., Minafra, A., Myrta, A., Pallás, V. 2005. Simultaneous detection and identification of eight stone fruit viruses by one-step RT-PCR. European Journal of Plant Pathology 111(1): 77-84.

Schaad, N.W., Frederick, R.D., Shaw, J., Schneider, W.L., Hickson, R., Petrillo, M.D., Luster, D.G. 2003. Advances in molecular-based diagnostics in meeting crop biosecurity and phytosanitary issues. Annual Review of Phytopathology 41: 305-324.

Sedgley, M. 1999. The Australian almond improvement project. Australian Nutgrower 12(5): 18-19.

Sedgley, M. 2000. New work on almond and pistachio at the Waite Campus. Australian Nutgrower. 14(2): 25-28.

Sedgley, M., Scott, E., Wirthensohn, M. 2000. Plant improvement – almonds and pistachios. Proceedings of the Australian Nut Industry Council Conference 2000. Pp. 15-17.

Sedgley, M. and Collins, G. 2002a. Almond improvement in Australia. Fruits 57 (2): 129-134.

Sedgley, M. and Collins, G. 2002b. The Australian almond breeding programme. III International Symposium on Pistachios and Almonds. Acta Hort. 591: 241-244.

Sedgley, M., Collins, G.G., Romero, M.A., Vargas, F.J. and Batlle, I. 2002. The Australian Almond Breeding Programme. Acta Hort. 591:241-244 http://www.actahort.org/books/591/591_34.htm

Shapland, E.B., Daane, K.M., Yokota, G.Y., Wistrom, C., Connell, J.H., Duncan, R.A., Viveros, M.A. 2006. Ground vegetation survey for *Xylella fastidiosa* in California almond orchards Plant Disease 90(7): 905-909.

Smith, P.R. 1983. The Australian Fruit Variety Foundation and its role in supplying virus-tested planting material to the fruit industry. Acta Hort.130: 263-266. http://www.actahort.org/books/130/130_45.htm

Smith, P.R. 1975. Epidemiological and physiological studies of the effects of peach rosette and decline disease on the peach *Prunus persicae* L. Batsch. Ph.D thesis, University of Melbourne.

Smith, P.R. and D.K. Challen. 1977. Initial and subsequent yield reduction of peach trees affected by peach rosette and decline disease. Aust. J. Exp. Ag. and An. Husb. 17: 174-176.

Spiegel, S., Stein, A., Tam, Y. 1995. *In vitro* thermotherapy of rosaceous fruit trees. Acta Hort. 386: 419-420. http://www.actahort.org/books/386/386_57.htm

Stubbs, L.L. and P.R. Smith. 1971. The association of Prunus necrotic ringspot, prune dwarf and dark green sunken mottle viruses in the rosetting and decline disease of peach. Aust. J. Ag. Res. 22: 771-785.

Tabachnik, L., Kester, D.E. 1977. Shoot culture for almond and almond peach hybrid clones *in vitro.* HortScience, 12(6): 545-547.

Taylor, B.K., Blennerhassett, R.M., Hill, S.J., Welsh, M. 1991.Yield comparison of Australian selections of almond cv. Nonpareil. Australian Journal of Experimental Agriculture 31(1): 129-132.

Uyemoto, J.K., Asai, W.K., Kirkpatrick, B.C. 1999. Etiology of almond shrivelled kernel disease. New Zealand Journal of Crop and Horticultural Science 27: 225-228.

Viveros, M. 2001. Non-infectious Bud Failure or Crazy Top in Almonds. Fruit and Nuts Fact Sheet University of California, Co-Operative Extension, Kern County. http://cekern.ucdavis.edu/Custom_Program485/Noninfectious_Bud_Failure_or_-Crazy_Top-_in_Almonds.htm

Waterworth, H.E., Mock, R. 1999. An assessment of nested PCR to detect phytoplasmas in imported dormant buds and internodal tissues of quarantined fruit tree germplasm. Plant Diseases 83: 1047-1050.

Webster, A.D. 1995. Temperate fruit tree rootstock propagation. A review. New Zealand Journal of Crop and Horticultural Science 23: 355-372.

Wirthensohn, M., Collins, G, Sedgley, M. 2002. Biotechnology for almond improvement in Australia. NUCIS Newsletter (11) Dec 2002. Pp.15-16.

Wirthensohn, M.G., Sedgley, M. 2002. Almond Breeding in Australia. III International Symposium on Pistachios and Almonds. Acta Hort. 591:245-248. http://www.actahort.org/books/591/591_35.htm

Wirthensohn, M., Ramesh, S.A., Bertozzi, T., Alberts, E., Mekuria, G., Bennett, C., Collins, G., Sedgley, M. 2003. Virus testing for the Australian almond industry and breeding program. Australian Nutgrower 17: 37-38.

Whattam, M. 2006. (Draft) Prunus Post Entry Quarantine Manual. 28 pp.

Whiley, A.W. 2000. Avocado production in Asia and the Pacific. FAO RAP Publication 2000/09, 72 pp.

Woolley, F.M., Collins, G.G., Sedgley M. 2000. Application of DNA fingerprinting for the classification of selected almond [*Prunus dulcis* (Miller) D. A. Webb] cultivars. Australian Journal of Experimental Agriculture 40(7): 995-1001.

Xiloyannis, C., Dichio, B., Tuzio, A.C., Kleinhentz, M., Salesses, G., Gomez-Aparisi, J., Rubio-Cabetas, M.J., and Esmenjaud, D. 2007. Characterization and selection of *Prunus* rootstocks resistant to abiotic stresses: waterlogging, drought and iron chlorosis. Acta Hort. (ISHS) 732: 247-251.

Zhang, YunPing. 2004. Plant Pest Diagnostics Branch Annual Report 2004. Annual Survey of Stone Fruit and Grapevine Viruses for the Nursery Program. http://www.cdfa.ca.gov/phpps/ppd/PDF/PPDC2004.pdf

Almond Board of Australia

Almond Budwood Standard Operating Procedures

01/05/2012

Almond Budwood Site:

Riverland Vine Improvement Committee (RVIC), Monash S.A.

Almond Budwood Standard Operating Procedures
Riverland Vine Improvement Committee (RVIC), Monash S.A.

Ben Brown
Industry Development Manager

Almond Board of Australia
PO Box 2246
9 William Street
Berri SA 5343
T: 08 8582 2055
F: 08 8582 3503
E: bbrown@australianalmonds.com.au
W: www.australianalmonds.com.au

DISCLAIMER
Almond Board of Australia and its employees do not guarantee the use, or results of the use, of the information contained herein as to its correctness, accuracy, reliability, currency or otherwise. The information supplied in the Fact Sheet was the best available at the time of publication. However, the understanding and management of almonds is constantly evolving and recommendations regularly change. As such, the reader should seek professional advice before acting upon any information in this Fact Sheet and should always comply with the relevant processing factory requirements, food safety legislation and the information listed on chemical labels.

Revised, January 2010

Table of Contents

Spring Budwood - Guidelines

Spring budwood (SBW) is to be cut to orders **only,** unless otherwise directed by the Almond Board of Australia.

Spring Budwood Cutter Requirements:

- Supply one pair of snips.
- Supply one spray bottle filled with a solution of methylated spirits (70%) and water (30%). **Warning, solution is very flammable.**
- For each cutter per row or if there is more than one variety per row, each cutter per variety, supply:
  - One wet, hessian bag.
  - One tub/bucket filled with iced water.
  - One label. Each label is to include:
    - Date
    - Variety and Clone
    - Bud cutters initials / cutter number

Spring Budwood Field Cutting Criteria

- SBW collection is to start on approximately 1st November and be completed by approximately the 7th December. However, SBW collection is to abide by the cutting criteria below:
  - Cutting is recommended to take place in temperatures at or below 32°C
  - Cuttings are to be placed in tubs filled with cold water.
  - Once the bud cutter has obtained one handful of budsticks they are to be immediately submerged fully in the cold water and left in the tubs until full.
  - At no time should there be any budsticks out of the cold water.
  - The tubs of water are to be placed in shade and covered with wet hessian.
  - Once the tubs of cold water are full of cuttings, they are to be immediately delivered to the shed for de-leafing.
  - Snips are to be sterilised with methylated spirits between each tree with excess shaken free.
  - Buds and budsticks are to be collected from current season's growth.
  - Buds and budsticks are to be mature.
  - Validate maturity by assessing budstick internal colour and maturity. Maturity is also to be validated by bending the budstick and if the budstick springs back it is mature, if there is no spring back or creases/folds on itself, the budstick is not mature.
  - Validate maturity by assessing budstick cross-sectional shape. Budsticks are to be round or oval in shape they are not to be triangular or squarish in shape.
  - A "spot" inspection of two example budsticks per tree. Inspection is to include the visual assessment of the wood "healthiness" within the budstick as well as the wood "healthiness" behind each bud on the stick. This is best achieved by simply assessing the colour of the internal (vascular) tissue which must not be brown in colour. If the internal tissue is brown, discard and inspect more budsticks to reassess the tree and its readiness for budwood cutting.
  - On average, budsticks are to include 8 vegetative buds per budstick.
  - The vegetative buds are not to be surrounded by flowering buds.

  - All budsticks from individual varieties and rows are to be kept separate and labelled accordingly.
  - Date, initial and tag last tree collected for the day, per variety, per row.
  - Upon arrival from the field, the budsticks are to remain in cold water, covered with the wet hessian and placed inside the coolroom. The coolroom temperature is to be set at 2.5°C to 4°C.

Spring Budwood De-Leafing and Collation

- Complete and adhere to the instructions of the HYGIENE SHEET.
- Deleaf budsticks by leaving approximately 2-5mm of petiole behind on the budstick.
- Snips are to be sterilised with methylated spirits between each batch.
- Budsticks are to be bundled in lots of 100 and rounded up to nearest bundle to match the customer order.
- All budsticks are to be de-leafed on the same day of cutting and all attempts are to be made to finish deleafing within one to two hours of the budsticks arriving at the shed.
- When ready to de-leaf, the tubs of cold, covered water are to be removed from the coolroom.
- Only one handful of budsticks at one time is to be removed from the cold water and de-leafed.
- As the busticks are de-leafed they are to be submerged fully and placed in a waiting tub of cold water with the correct labelling.
- Once de-leafing of each tub has completed, the budsticks are to be wrapped in newspaper and again fully submerged in the cold water. The packages are then placed on a bench-top out of direct sunlight and allow for drainage to avoid excessive free water in storage.
- Place the drained packages directly into a labelled, polystyrene box with a cover of wet hessian and the lid placed on.
- Complete DAY CARD.

Spring Budwood Cold Storage

- Place boxes in cold storage with the temperature set at 2.5°C to 4°C until ready for collection or transport to the customer via refrigerated transport.
- Complete COOL ROOM TEMPERATURE RECORD.

Spring Budwood Dispatch

- The dispatch date of SBW is guaranteed to be less than three days old from the time of cutting.
- If any further storage or dispatch packaging requirements are necessary they are to be specified on the ALMOND BUDWOOD ORDER FORM prior to the commencement of cutting.

Nurseryman Handling of Spring Budwood

- SBW should be received via refrigerated transport and again placed in cold storage until use.
- Ideally, the SBW is to be used for grafting immediately but must be used within the first week from the date of receival.
- Take out of cold storage enough budwood for only one hour of grafting.
- When grafting the SBW it is best to place the material in a cool, shaded place out of direct sunlight, for example, a wet hessian bag or a bucket of cold water.
- The SBW is to be grafted using a chip (Figure 1) or 'T' bud and grafted onto an actively growing rootstock of similar diameter. This method is best used between after 15th November.

Figure 1: Chip bud using spring scion wood

Dormant Budwood - Guidelines

Dormant budwood (DBW) is to be cut to orders **only,** unless otherwise directed by the Almond Board of Australia.

Dormant Budwood Cutter Requirements:

- Supply one pair of snips.
- Supply one spray bottle filled with a solution of methylated spirits (70%) and water (30%). **Warning, solution is very flammable.**
- For each cutter per row or if there is more than one variety per row, each cutter per variety, supply:
  - One wet, hessian bag.
  - One tub/bucket filled with iced water.
  - One label. Each label is to include:
    - Date
    - Variety and Clone
    - Bud cutters initials / cutter number

Dormant Budwood Field Cutting Criteria

- DBW collection is to approximately start on 15th February and be completed by 30th March. However, DBW collection is to abide by the cutting criteria below:
  - Cutting is recommended to take place in temperatures at or below 32°C
  - Cuttings are to be placed in tubs filled with cold water.
  - Once the bud cutter has obtained one handful of budsticks they are to be immediately submerged fully in the cold water and left in the tubs until full.
  - At no time should there be any budsticks out of the cold water.
  - The tubs of water are to be placed in shade and covered with wet hessian.
  - Once the tubs of cold water are full of cuttings, they are to be immediately delivered to the shed for de-leafing.
  - Snips are to be sterilised with methylated spirits between each tree with excess shaken free.
  - Buds and budsticks are to be collected from current season's growth.
  - Buds and budsticks are to be mature.
  - Validate maturity by assessing budstick internal colour and maturity. Maturity is also to be validated by bending the budstick and if the budstick springs back it is mature, if there is no spring back or creases/folds on itself, the budstick is not mature.
  - Validate maturity by assessing budstick cross-sectional shape. Budsticks are to be round or oval in shape they are not to be triangular or squarish in shape.
  - A "spot" inspection of two example budsticks per tree. Inspection is to include the visual assessment of the wood "healthiness" within the budstick as well as the wood "healthiness" behind each bud on the stick. This is best achieved by simply assessing the colour of the internal (vascular) tissue which must not be brown in colour. If the internal tissue is brown, discard and inspect more budsticks to reassess the tree and its readiness for budwood cutting.
  - On average, budsticks are to include 8 vegetative buds per budstick.
  - The vegetative buds are not to be surrounded by flowering buds.

- All budsticks from individual varieties and rows are to be kept separate and labelled accordingly.
- Date, initial and tag last tree collected for the day, per variety, per row.
- Upon arrival from the field, the budsticks are to remain in cold water, covered with the wet hessian and placed inside the coolroom. The coolroom temperature is to be set at 2.5°C to 4°C.

Dormant Budwood De-Leafing and Collation

- Complete and adhere to the instructions of the HYGIENE SHEET.
- De-leaf budsticks by leaving approximately 2-5mm of petiole behind on the budstick.
- Snips are to be sterilised with methylated spirits between each batch.
- Budsticks are to be bundled in lots of 100 and rounded up to nearest bundle to match the customer order.
- All budsticks are to be de-leafed on the same day of cutting and all attempts are to be made to finish deleafing within one to two hours of the budsticks arriving at the shed.
- When ready to de-leaf, the tubs of cold, covered water are to be removed from the coolroom.
- Only one handful of budsticks at one time is to be removed from the cold water and de-leafed.
- As the busticks are de-leafed they are to be submerged fully and placed in a waiting tub of cold water with the correct labelling.
- Once de-leafing of each tub has completed, the budsticks are to be wrapped in newspaper and again fully submerged in the cold water. The packages are then placed on a bench-top out of direct sunlight and allow for drainage to avoid excessive free water in storage.
- Place the drained packages directly into a labelled, polystyrene box with a cover of wet hessian and the lid placed on.
- Complete DAY CARD.

Dormant Budwood Cold Storage

- Place boxes in cold storage with the temperature set at 2.5°C to 4°C until ready for collection or transport to the customer via refrigerated transport.
- Complete COOL ROOM TEMPERATURE RECORD.

Dormant Budwood Dispatch

- The dispatch date of DBW is guaranteed to be less than three days old from the time of cutting.
- If any further storage or dispatch packaging requirements are necessary they are to be specified on the ALMOND BUDWOOD ORDER FORM prior to the commencement of cutting.

Nurseryman Handling of Dormant Budwood

- DBW should be received via refrigerated transport and again placed in cold storage until use.
- Ideally, the DBW is to be used for grafting immediately but must be used within the first week from the date of receival.
- Take out of cold storage enough budwood for only one hour of grafting.
- When grafting the DBW it is best to place the material in a cool, shaded place out of direct sunlight, for example, a wet hessian bag or a bucket of cold water.

Winter Budwood - Guidelines

Winter Budwood Cutter Requirements:

- Supply one pair of snips.
- Supply one spray bottle filled with a solution of methylated spirits (70%) and water (30%). Warning, solution is very flammable.
- For each cutter per row or if there is more than one variety per row, each cutter per variety, supply:
  - One dry, hessian bag.
  - One empty tub.
  - One label. Each label is to include:
    - Date
    - Variety and Clone
    - Bud cutters initials / cutter number

Winter Budwood Field Cutting Criteria

- WBW collection is to start at the completion of defoliation (i.e. of May) and prior to June 30th. However, WBW collection is to abide by the cutting criteria below:
  - The budwood trees are to be foliar sprayed with a multi-site fungicide (e.g. captan or chlorothalonil) and bactericide (e.g. copper) prior to cutting. Capatan is used by the vine industry and know to be long lasting through extended storage periods.
  - Cutting can begin once the spray has dried or the rain fastness period on the chemical label has expired.
  - Budsticks are to be collected from current season's growth and only taken from the tip of the current seasons's growth. That is, there is to be only one cut end, the other end is to be in tact with its terminal bud. The budsticks are also to be thin (i.e. 3-5mm in diameter). This process will minimise dehydration in storage, allow for the selection of budsticks with the least number of flower buds, and the smallest buds which have the most success with grafting.
  - Cutting is recommended to take place in temperatures at or below 32°C
  - Cuttings are to be placed in the tubs and a dry hessian bag placed over the top.
  - Once the tubs are full of cuttings, they are to be immediately delivered to the shed for storage procedures.
  - Snips are to be sterilised with methylated spirits between each tree with excess shaken free.
  - Buds and budsticks are to be collected from current season's growth.
  - Buds and budsticks are to be mature.
  - Validate maturity by assessing budstick internal colour and maturity. Maturity is also to be validated by bending the budstick and if the budstick springs back it is mature, if there is no spring back or creases/folds on itself, the budstick is not mature.
  - Validate maturity by assessing budstick cross-sectional shape. Budsticks are to be round or oval in shape they are not to be triangular or squarish in shape.
  - A "spot" inspection of two example budsticks per tree. Inspection is to include the visual assessment of the wood "healthiness" within the budstick as well as the wood "healthiness" behind each bud on the stick. This is best achieved by simply assessing the colour of the internal (vascular) tissue which must not be brown in colour. If the

    internal tissue is brown, discard and inspect more budsticks to reassess the tree and its readiness for budwood cutting.
    - On average, budsticks are to include 8 vegetative buds per budstick.
    - Ideally, the vegetative buds are not to be surrounded by flowering buds.
    - All budsticks from individual varieties and rows are to be kept separate and labelled accordingly.
    - Date, initial and tag last tree collected for the day, per variety, per row.
    - Upon arrival from the field, the budsticks are to remain in cold water, covered with the wet hessian and placed inside the coolroom. The coolroom temperature is to be set at 1.5 to 2.0°C, and in a coolroom with an air renewal system.

Winter Budwood Collation & Treatment (Spanish Method)

- Complete and adhere to the instructions of the HYGIENE SHEET.
- Budsticks are to be bundled in lots of 100 and rounded up to nearest bundle to match the customer order.
- Bundled budsticks are to be thoroughly wrapped in 2 layers of commercial grade cling-film to protect the wood from the coolroom temperatures.
- Place budsticks into a labelled, polystyrene box with a lid.
- Complete DAY CARD.

Winter Budwood Collation & Treatment (Growtek Method)

- Complete and adhere to the instructions of the HYGIENE SHEET.
- Budsticks are to undergo the following treatments:
    - Dip the **cut end** of the sticks into a container with a 10mm depth of Solution A
        - **Solution A** is water treated with:
            - Chlorine (10ppm), **and**
            - IBA (100mL of IBA (8mg/L) solution plus 400mL of rain water)
            - Immerse bundle in Solution B.
        - **Solution B** is water to be treated with:
            - CAPTAN (2kg/1000L)
    - The budsticks are then placed on a bench-top out of direct sunlight and allow for some drainage over a minute or two to avoid excessive free water in storage.
    - Budsticks are to be bundled in lots of 100 and rounded up to nearest bundle to match the customer order.
    - Place budsticks in plastic bags and into a labelled, polystyrene box with a lid.
- Complete DAY CARD.

Winter Budwood Cold Storage (Spanish & Growtek Method)

- Place boxes in cold storage with the temperature set at 1.5 to 2.0°C until ready for collection or transport to the customer via refrigerated transport.
- Complete COOL ROOM TEMPERATURE RECORD.

Winter Budwood Post Cold Storage Treatment (Growtek Method)

- On the day of transport, remove WBW from cold storage and immerse in rain water to wash off excess CAPTAN.
- The WBW bundles are wrapped in newspaper.

Winter Budwood Post Cold Storage Treatment (Spanish & Growtek Method)

- Place the packages directly into a labelled, polystyrene box with a cover of moist, but drained hessian and the lid placed on.

Winter Budwood Dispatch (Spanish & Growtek Method)

- If any further storage or dispatch packaging requirements are necessary they are to be specified on the ALMOND BUDWOOD ORDER FORM prior to the commencement of cutting.

Nurseryman Handling of Winter Budwood

- WBW should be received via refrigerated transport and again placed in cold storage until use.
- When grafting the WBW it is best to place the material in a cool, shaded place out of direct sunlight, for example, a wet hessian bag or a bucket of cold water.
- Take out of cold storage enough budwood for only one hour of grafting.
- The WBW is to be cut into sticks containing 2 buds and grafted onto an actively growing rootstock of similar diameter using a v-shaped graft into the top of the rootstock (Figure 2). This method is best used between before 15th December (Spanish recommendation, TBC).

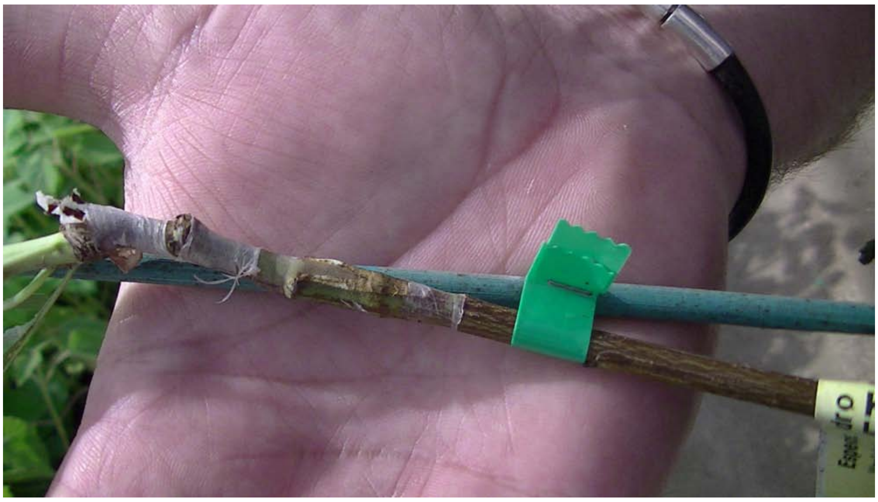


Figure 2: Consolidated v-graft using winter scion wood.

HYGIENE SHEET

SHED:______________________

The listed tasks are to be completed each day and signed by employee responsible and signed at the completion by the supervisor for a quality check of the task that has been performed.

- Wash down benches, plastic containers at the end of each day or the change of variety, clone and registration number with chlorine/methylated spirits solution.
- Clean all grafting machines and strapping machines at the end of each day or the change of variety, clone and registration number with chlorine/methylated spirits solution.
- Clean all snips and other cutting tools at the end of each day or the change of variety, clone and registration number with chlorine/methylated spirits solution.
- Sweep and wash floor daily
- Empty rubbish as required
- No vehicles in sheds unless it is the forklift

DATE	TASK DESCRIPTION	EMPLOYEE RESPONSIBLE	EMPLOYEE SIGNATURE	SUPERVISOR OR CHARGE EMPLOYEE

DAY CARD

Cutter Sheet No.:___________________

DAY:_______________________ **DATE:**_______________________ **MONTH:**____________________ **YEAR:** ______________

VARIETY	CLONE	REG. No.	No. BUDS	SIZE	DATE ALLOC.	CUST No.	NAME	ORDER No.	No. BUDS	SIZE	SERVICES				HANDLING INSTR.	GRADING CHECK
											SOL. A	SOL. B	FUNG	C/S		

FIELD COMMENT: ____

HYDRATION: **DATE IN:** ______________ **TIME IN:** ______________ **TANK No.:**______________

DATE OUT:____________________ **TIME OUT:**______________ **DURATION:**______________

SPOREKILL (A/B): **DATE IN (A/B):** ______________ **TIME IN (A/B):** ______________ **STRENGTH(s) (A/B):** ______________

DATE OUT (A/B): ______________ **TIME OUT (A/B):** ______________ **DURATION (A/B):** ______________

COLD STORAGE: **DATE IN:** ______________ **DATE OUT:**____________________

COOLROOM TEMPERATURE RECORD

____________________COOLROOM

CALIBRATION REPORT:_____________________ **DATED**: ___________________________

CALIBRATED RESULT: **Digital Display Temperature Indicated:** ___________________________

Actual Coolroom Temperature: __________________________________

Calibration Adjustment Required: __________________________________

PREFERED OPERATING TEMPERATURE: **2.5ºC +/- 1.5ºC**

ACCEPTABLE TEMPERATURE RANGE: **1ºC to 4ºC**

ALARM SETTING: **0.5ºC to 6ºC after 90 minutes delay**

DATE OF CHECK	TIME	DIGITAL TEMP	ACTUAL TEMP	ADJUSTMENT REQ	EMPLOYEE	WEEKLY ALARM CHECK	COMMENT

23rd June, 2011

2011/12 Almond Budwood Orders

Please find enclosed the 2011/12 Almond Budwood Order Form.

Thank you for your support of the Australian almond budwood repository situated at Monash, South Australia. Budwood from this site is managed by the Almond Board of Australia (ABA) to produce high health status, true to type budwood for the almond industry. The mother plantings undergo annual winter pruning, deflowering, visual pest & disease monitoring and virus testing for the pathogens Prune Dwarf Virus and Prunus Necrotic Ringspot Virus. Management practices are undertaken to exacting hygiene standards, including sterilising equipment between pruning trees and taking cuttings.

The ABA supports the use of high health status plant material and actively promotes the purchase of trees from nurseries using Monash sourced budwood.

To place budwood orders for this season please complete and return both pages of the order form to the ABA along with the deposit.

The cost per bud remains unchanged at 44 cents if the payment is prompt. A deposit of 11 cents per bud must accompany the order sheet to register your order. You will receive an acknowledgement that your deposit has been received and your order registered. The deposit is non-refundable, except in the event of supply not being available. In the unlikely event of the budwood not being available to fill your order, you will be notified as soon as this is determined and your deposit will be returned. Orders will be processed in a sequential order of receipt i.e. first in - best dressed.

Your order form will serve as a tax invoice for the deposit and the ABA will attach to the delivery packaging a tax invoice based on the full rate of 44 cents per bud plus packaging and postage expenses at cost, less the deposit paid. Note all amounts are inclusive of GST. Payment terms are strictly 30 days from the date of invoice. Overdue invoices will incur an additional charge of 6 cents per bud and external debt recovery will commence after 45 days with all collection costs invoiced as an additional charge.

Deposit and payments can be made by cheque or EFT.
Account Name: Almond Board of Australia Incorporated
BSB: 105-052
Account No: 04033 9140

Budwood cutting will be undertaken on Monday, Tuesday and Wednesday of each week to maintain short delivery periods. You will be contacted to ensure the delivery fits in with your nursery operations.

Please note that the ABA does not accept responsibility for any material beyond the point of dispatch where control of the storage conditions and length of storage ceases.

Any concern regarding the budwood must be notified within 7 days of budwood dispatch so it is advisable to undertake a check of material as soon as the delivery arrives.

Do not hesitate to contact me should you have any questions or require further information.

Yours sincerely,

Ben Brown
Industry Liaison Manager

2011/12 ALMOND BUDWOOD
ORDER FORM

COMPANY: ______________________________

CONTACT: ______________________________

ADDRESS: *(Postal)* ______________________________

ADDRESS: *(Delivery)* ______________________________

PHONE: *(BH)* ______________ FAX: ______________

MOBILE: ______________ EMAIL: ______________

Variety	**Nov / Dec**	**Jan / Feb**	**March +**	**Total Buds Required**	**Preferred Size**
	Enter Quantity Required				
Nonpareil					
Carmel					
Price					
Peerless					
Monterey					
Mission					
Fritz					
Ne Plus					
Keanes Seedling					
Chellaston					
Parkinson					
Somerton					
Sauret					
Sonora					
Butte					
Padre					
Total Buds					
Deposit Required - @ 10 cents per bud			$		

COMPANY NAME: ____

ORDERING REQUIREMENTS

- Three clear working days notice is required prior to dispatch date
- Please ensure that packaging and transport details are completed
- Please ensure that size preference is clearly indicated
- Orders to be in multiples of 100 buds

PRODUCT DESCRIPTION AND PRICING

Size	Length	Diameter	No. of Buds	Price (including GST)
Small	>200mm	1.5 – 3mm	Average of 8	44 cents per bud (10 cent deposit required)
Medium	>200mm	3 – 5mm	Average of 8	44 cents per bud (10 cent deposit required)
Large	>200mm	4 – 7mm	Average of 8	44 cents per bud (10 cent deposit required)

All material is wrapped in damp paper as standard Nil

PACKAGING	Price (including GST)	**TRANSPORT**	Price (including GST)
YES / NO Hessian	$2.20 per box – batch	YES / NO Customer to pick up	Nil
YES / NO Styrene Box	$5.50 per box – batch	YES / NO Commercial Transport	At cost + $10 handling fee
YES / NO Ice	$3.85 per box – batch		

Almond Board of Australia does not accept any responsibility for any material spoilt by delays or mishandling by commercial transport

TERMS OF TRADING

- Outstanding accounts are all accounts which have not been paid within 30 days from the end of the month after invoice date
- An additional fee of 6 cents per bud will be incurred for any overdue accounts
- Interest shall be charged monthly on overdue accounts
- Claims of alleged shortages or damage must be notified within 7 days of delivery otherwise claims will not be recognised

WARNINGS – WHILST ALL POSSIBLE CARE IS TAKEN:

The Almond Board of Australia give no guarantees in respect of the following in almond budwood material:

1. Presence of viral / viroid infection
2. Presence of phytoplasma infection
3. Presence of bacterial infection
4. Presence of fungal infection
5. Presence of any other pest or disease
6. The ultimate performance of trees propagated from this material for any reason

COMMENTS: ____

____

____

Signed: ______________________ **Date:** ______________________

Name: ______________________ **Position:** ______________________

GUIDELINES FOR FOOD SAFETY MANAGEMENT IN THE AUSTRALIAN ALMOND INDUSTRY

Almond Board of Australia Inc.

First Edition
2007

Acknowledgements

The Almond Board of Australia Inc. would like to thank Elizabeth Frankish of Silliker Microserve (Silliker Microtech Pty Ltd) for the preparation of this document.

In addition many people provided assistance in the preparation of the document. The following are particularly acknowledged for their valuable contribution:

Chris Bennett, Industry Development Manager, Almond Board of Australia Inc.
Graham McAlpine, McAlpine Management Services Pty Ltd
Paul Martin, Jubilee Almonds
Andrew Giles, Laragon Pty Ltd
Frank Condo, Swan Produce
Faye Sharp, Almondco Australia Ltd
Corrina Steeb, Nut Producers Australia
Michael Clements, Clemco
Annmarie Barone, Nut Producers Australia
Leroy Sims, Simarloo (Aust) Pty Ltd
Tony Costa, Costa Produce
Alex Harrison, Select Harvests
John Bird, Select Harvests Ltd
Brenton Woolston, Almondco Australia
Annmarie Barone, Nut Producers Australia
Wayne Francis, Laragon Pty Ltd
Peter Bartlett, Almondco Australia Ltd
Deanna Hutchins, Laragon Pty Ltd
Julie Haslett, Almond Board of Australia Inc

Disclaimer

Guidelines for Food Safety Management in the Australian Almond Industry

CONTENTS

TABLES

1 INTRODUCTION

1.1 Background to the issues

The almond industry in Australia is small accounting for approximately 3 percent of world production.[9.2] It has experienced rapid growth in recent years and 2005 production was *** tonnes. It has a reputation for high quality product in niche markets. In recent years the industry has increasingly recognised the importance of applying food safety management systems to the growing, harvesting and processing stages of almond production. Individual growers and processors have implemented quality assurance programs accordingly in an effort to address any potential food safety hazards. This approach has resulted in a variety of quality assurance programs being implemented throughout all stages of almond production.

Tree nuts are generally regarded as low risk produce. Almonds are grown more than 1 metre above ground and the final product has a low moisture content and low water activity. However two significant contamination events originating from the almond industry of California caused the Australian industry to review its perception of the microbiological safety of almonds. In 2001 *Salmonella* Enteritidis PT30 was the cause of a foodborne outbreak affecting 168 people in Canada. Again in 2004, around twenty nine people in the United States were infected with *Salmonella* Enteritidis from almonds. Whilst the origin of the *Salmonella* is unknown these events highlighted the need for increased knowledge of the food safety hazards associated with almond production and appropriate management of the risks.

The industry recognised that in order to maintain its history of safety and the concomitant reputation it must take a whole of chain approach to managing food safety. Failure to control the risks in one sector would impact on the viability of the whole almond industry. In addition maintaining and enhancing its good reputation is imperative to assisting growth in the industry and food safety must be at the core of that growth.

In 2002 Australian governments adopted a whole of chain approach to food safety regulation. This has resulted in the development and introduction of national primary production and processing standards for high risk food commodities. The almond industry is not currently regulated by specific commodity standards. By setting its own guidelines the almond industry provides the framework for a practical approach to managing food safety risks. This should result in minimising future regulatory burden as the industry will be seen as taking the initiative and responsibility to control public health and safety with respect to consumption of almonds and almond products.

1.2 Purpose of the document

These Guidelines have been developed as a result of the Almond Board of Australia co-ordinating a whole of chain approach in identifying potential hazards, assessing the risks, applying controls and monitoring outcomes of food safety controls in the industry. They are intended for use through the growing, hulling and shelling, and processing and marketing of Australian almonds. Chemical and physical risks are mentioned throughout the document, but the main focus of these Guidelines is the microbiological risks. The Guidelines should be used by all those involved in and responsible for food safety management in the almond industry, including facilitators, auditors and food safety and quality assurance consultants.

Each individual business must identify hazards specific to its operation. This document is designed to provide advice on key areas of food safety control with practical guidance on how to minimise contamination, investigate food safety risks and monitor the controls in place.

These guidelines should be used in conjunction with other documents relevant to the industry. In particular Codex Alimentarius documents outlining Good Agricultural Practices (GAP's), Good Hygienic Practices (GHP's) and Good Manufacturing Practices (GMP's) and codes of practice specific to tree nuts should be consulted. The processing and retail sector of the industry must also comply with the food safety requirements of the Australia New Zealand Food Standards Code.

2 OVERVIEW OF THE INDUSTRY

The almond industry operates under three main sectors – growing and harvesting, hulling and shelling, and processing including value adding. Hulling and shelling operations manage the harvest from multiple growers which are then transferred to the processors. Each sector is linked through transport operators.

Growing
↓
Harvesting
↓
Storage
↓
Transport to Huller
↓
Storage
↓
Hulling
↓
Shelling
↓
Transport to Processor
↓
Storage
↓
Process
↓
Storage
↓
Market

Each stage of almond production has associated inputs that potentially add food safety hazards. These inputs need to be understood so that an assessment can be made as to the level of risk each input presents. The degree to which an input is required will vary between operators and growing seasons. It is therefore likely that the level of risk will also vary.

3 PROCESS STEPS AND INPUTS

3.1 Growing and Harvesting Process Flow

This diagram shows the flow of steps that may occur during growing almond crops. The inputs indicate the most likely sources of food safety hazards at each process step.

Inputs	**Process Step**
Land usage history, soil, equipment	Select and prepare the growing site
	↓
Trees, equipment, water, chemicals	Planting
	↓
Water	Irrigating
	↓
Materials, plants	Weather/vermin protection
	↓
Soil, fertilizers, soil additives, water, equipment	Crop nutrition
	↓
Chemicals, shot guns, people, equipment	Pest/disease management
	↓
Herbicides, equipment	Weed control
	↓
Equipment, people	Pruning
	↓
Chemicals, water, equipment	Crop/growth regulation
	↓
Soil, shaker, sweeper, picker, equipment, people	Harvest
	↓
Vehicles, people	Transport to storage
	↓
Bins, materials, vermin, equipment	Storage on farm
	↓
Vehicles, people	Transport

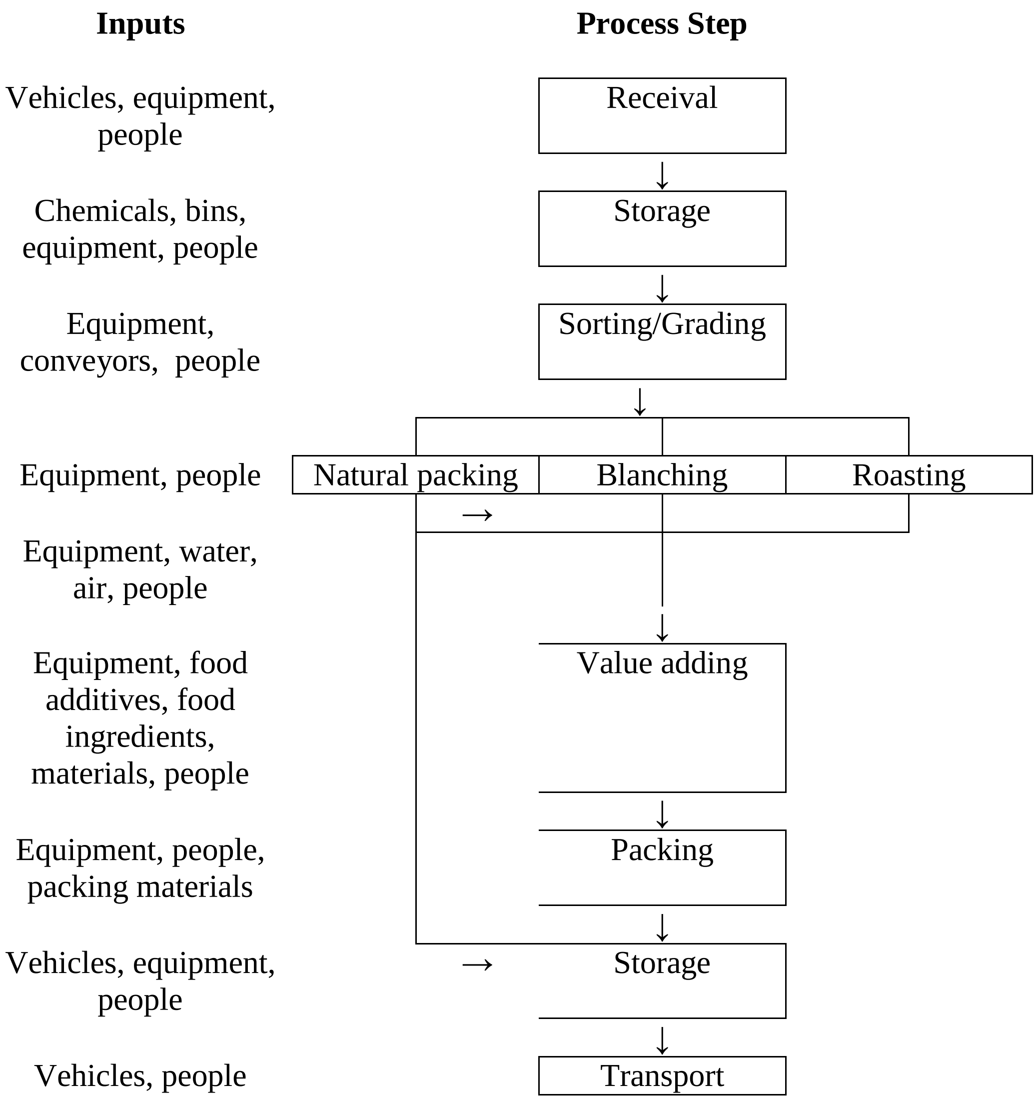
3.2 Hulling and Shelling Process Flow

This diagram shows the basic steps in hulling and shelling almonds to produce the almond kernel. The inputs indicate the most likely sources of food safety hazards at each process step.

Inputs	Process Step	
Vehicles, equipment, vermin, foreign materials	Receival	
	↓	
Elevators, silos	Storage	
	↓	
Conveyors, rollers, vermin	Hulling	
	↓	→ Stockfeed
Conveyors, rollers, vermin	Shelling	
	↓	→ Stockfeed
Equipment, people, vermin	Screening	
	↓	
Bins, materials, people	Storage	
	↓	
Vehicles, people	Transport	

3.3 Processing and Value Adding Process Flow

This diagram shows the basic steps in processing almonds to finished product stage. The inputs indicate the most likely sources of food safety hazards at each process step. Within the steps of blanching, roasting and value adding there are multiple stages of processes that include a range of equipment.



4 FOOD SAFETY HAZARDS ASSOCIATED WITH ALMONDS

Potential food safety hazards of almonds include microbiological, chemical and physical substances. Almond varieties are broadly classified as papershell, softshell or hardshell. Papershells have a soft crumbling pithy shell that can be easily rubbed away. Softshells have firm shells that can be broken by hand pressure. Hardshells cannot be broken by unaided hand pressure.[9.2] The variety of almond contributes to the potential for some food safety hazards to occur.

Contamination of almonds can occur as a result of agricultural, manufacturing, and hygienic practices and environmental conditions. It can occur directly or indirectly and may be a short-lived discrete event or due to a prolonged exposure.

4.1 Microbiological Hazards

In undamaged tree nuts, the outer shell typically protects the nutmeat from microbial contamination. However, fungal and bacterial penetration of the almond can occur if the shell is damaged or if the nuts are exposed to soil for extended periods of time. Shells may become damaged from birds and insects providing routes of infection for microorganisms. Rain damage or higher than normal levels of rainfall may also increase the likelihood of microbial infection.

A range of microflora naturally occurs on almonds. The composition of the microbial population will vary with geographical regions and time of harvest. Commonly isolated bacteria from the nut kernel include those from the *Pseudomonas, Xanthomonas, Achromobacter, Enterobacter, Clostridium, Corynebacterium, Bacillus, Brevibacterium, Micrococcus and Streptococcus* groups. *Salmonella* and *Escherichia coli* are less commonly isolated, however *Salmonella* is the primary bacterial pathogen of concern on almonds. *Salmonella* are known to survive for extended periods under low water activity conditions and this probably accounts for its association with food-borne illness outbreaks in almonds despite its low incidence.

A variety of fungal species can also be found on almonds including those that might be associated with diseases such as shothole and wilt. However of principal concern for food safety are those fungi capable of producing mycotoxins. Mycotoxins are naturally occurring chemical substances produced by a wide range of moulds, which are capable of producing toxic effects in humans and animals. *Aspergillus*, *Penicillium*, and *Fusarium* are common microflora in freshly harvested nuts, which are known to produce toxins. Mycotoxins can be carcinogenic, mutagenic, toxic to specific organs, or toxic by other mechanisms to humans and animals. Several toxins are classified as mycotoxins, and at least 14 mycotoxins are known to be carcinogenic. The most likely mycotoxins of concern in almonds are the aflatoxins, produced by some strains of *Aspergillus flavus, Aspergillus parasiticus* and *Aspergillus nomius.* The presence of these moulds does not necessarily mean that aflatoxins are produced. Environmental conditions conducive to toxin production are required and it is likely that toxin production is also linked to cultivar. Conversely aflatoxins may persist long after the vegetative growth has occurred and the moulds have died.

Aflatoxins can be produced both pre-harvest and post-harvest. Conditions of stress, such as drought or insect infestation, favour pre-harvest contamination, whereas post-harvest handling during rainfall or humid conditions, favours post-harvest aflatoxin contamination. Nuts falling prior to harvest due to windfall are likely to be at higher risk of aflatoxin development due to prolonged exposure to moisture whilst on the ground. The development of *Aspergillus flavus* and other mycotoxigenic fungi in nuts is a recognized problem during the storage at intermediate moisture levels. Maintaining moisture levels of in-shell almonds below 8-9% at 30°C is critical in the prevention of aflatoxin production.

The origin of microorganisms found on almonds, including those that may be pathogenic, includes soil, water, plant material, organic debris and air. People may also be both a direct and indirect source of some of these microorganisms. Management strategies including the use of standard sanitary operation procedures will largely determine both the likelihood of these microorganisms occurring in the nut and the level of risk they pose. In addition the use of almond hulls and shells as stock feed requires sound management practices to minimise contamination of these components with microorganisms and their toxins to prevent food safety problems in the food chain.

Table 1 Microbial Hazards

Hazard	**Factors that cause or enhance contamination**
Bacteria eg. *E. coli, Salmonella*	Contaminated water used for irrigation Soil contact during harvesting Ground contact during storage Insect infestation Faeces from birds, rodents and animals Contaminated bins, trailers and containers Contaminated harvesting and processing equipment due to inadequate cleaning Handling by people with poor personal hygiene practices
Fungi producing aflatoxins	Soil contact during harvesting, storage and transport Humid conditions Windfall nuts resulting in prolonged exposure to moisture from sprinklers or rainfall Rainfall at harvest or moist ground at harvest Excessive organic debris in orchard, bins and vehicles Insect damage or infestation Poor hygienic practices

4.2 Chemical Hazards

Chemical inputs to almond production occur throughout all stages. They include the use of chemical agents to assist in growth and disease control, cleaning and sanitising equipment and materials, and fuels to run and maintain vehicles and equipment.

The use of hulls and shells in stock feed is of interest with respect to the potential for accumulation of pesticide residues which may then find their way into the food chain.

The following table lists the most likely sources of chemical contaminants in almond production.

Table 2 Chemical Hazards

Hazard	**Source or cause of hazard**
Pesticide residues exceeding maximum residue limits (MRL's; ERL's)	Incorrect use of permitted pesticides: - fungicides - insecticides - herbicides Spray drift Withholding periods not observed Spillage or seepage into soil, water source or storage areas Orchard soils contaminated by persistent chemicals
Heavy metal residues (ERL's)	Naturally contaminated soils Development of soil conditions conducive to heavy metal uptake Contamination of water used for irrigation Use of fertilisers with high heavy metal levels Foliar fertiliser sprays
Natural toxins	Contamination of almonds with mycotoxins due to poor management practices
Other chemicals	Sanitiser residues on equipment and containers Fuels and oils used in machinery and equipment Spillage of chemicals, fertilisers, fuels and oils in nut storage and packing areas Inappropriate transport or storage of chemicals with product Use of inappropriate cleaning chemicals
Allergenic agents	Food additives use in value added products

It should be noted that the almond itself is a known allergenic food. Susceptible individuals may suffer a reaction to the consumption of almonds when eaten. Producers and manufacturers need to ensure that they comply with all current food labeling laws to minimise the risk to consumers who suffer tree nut allergy.

4.3 Physical Hazards

Physical hazards can be of concern throughout all stages of almond processing. However the growing, harvesting, hulling and shelling and storage stages present the highest risk of physical hazards in almond production.

Common physical hazards and their most likely sources are listed in the following table.

Table 3 Physical Hazards

Hazard	**Source or cause of hazard**
Glass	Breakage of vehicle windows, bottles, headlights, other glass
Shotgun pellets	Use of guns for bird control in orchards
Metal	Nails from bins Pieces of wire on orchard floor or in storage areas
Organic debris	Orchard floor Trailers Bins
Foreign objects from the environment eg. stones, wood	Sweeping and picking from orchard floor Storage sites Bins and trailers
Foreign objects from equipment and containers eg. rubber, metal, plastic, paint flakes	Damaged equipment or containers Inadequate maintenance and cleaning
Insects and rodent or animal faeces	Orchard floor Damaged nuts Pest infestation at storage Pest ingress to processing areas
Foreign objects from people eg. jewellery, hair	Untrained staff Inappropriate clothing Lack of appropriate policies

5 GROWING AND HARVESTING

5.1 Assessing the Risks of Contamination

Exposure to a potential food safety hazard does not in itself imply the presence of high risk. The likelihood of a hazard causing risk is dependent on many factors which may or may not interact. Assessment of the level of risk associated with a hazard is an important component of good management practices. Awareness of potential hazards and their origin and assessment of the associated risks allow risk reduction strategies to be implemented. As almonds are often eaten raw it is not possible to eliminate all potential food safety hazards. However through the use of good agricultural, manufacturing and hygienic practices the hazards can be controlled to reduce risks to an acceptable level.

A sound, common approach to managing risks will result in a more effective and cohesive response to contamination events when they occur and to emerging food safety issues.

5.1.1 Contamination from Water

Water may carry both microbiological and chemical contaminants. The quality of water required in almond production is determined by the stage of operations and whether the nut is in direct contact with water.

Irrigation water is generally supplied to almond crops by under tree sprinklers or drip irrigation. The application of fertilisers and pesticides is increasingly via these irrigation systems. Irrigation water does not normally come into direct contact with the nuts. However some growers still use sprinkler systems that may allow contact. Irrigation is normally suspended close to harvest allowing the soil surface to partially dry prior to the nuts falling on the ground. However windfalls will come into direct contact with irrigation water thereby being subjected to either direct contamination from the water or indirect contamination from moist soil. Excluding windfalls however routine practices minimise the potential for microbial contamination of almonds from the water supply. Poor water quality through contamination of pesticides, heavy metals, other chemicals or microorganisms upstream of the water draw off point could pose a food safety risk. Currently water from the Murray-Darling River System is drawn for irrigation of almond crops. Water bores and farm dams are also in use. Human activity on the river and on the surrounding land provides potential for frequent and ongoing contamination. Both the microbiological and chemical quality of the water used for irrigation should be known to manage risks as they arise.

Some nuts that remain on the ground at the end of harvest will subsequently have direct contact with water. This may be either irrigation water or rainfall. These nuts generally degenerate prior to the next season, but potentially some could be included in the next season's harvest, thereby increasing the risk of contamination that is carried over from one season's harvest to the next.

Water used for irrigation should comply with minimum quality criteria described in Australian Water Quality Guidelines for Fresh and Marine Waters[9.4].

See Table 4 in Appendix 2.

5.1.2 Contamination from Soil

Soil will carry microbiological contaminants and may also carry chemical contaminants. Soil microorganisms will include those for which soil is their natural habitat and those which have contaminated the soil from animal, bird and insect faeces, or from human sewage. Microbes which occur naturally in the soil may include human pathogens and fungi that cause disease.

The highest risks to almonds from soil contamination are pathogenic bacteria and fungi that produce aflatoxins. Persistent chemicals in the soil may exist but the risk of contamination to the almond kernel whilst still on the tree is low. During harvest when the almond is in direct contact with the ground the risk of contamination from microorganisms and persistent chemicals depends on the following factors:

- whether the shell is intact or damaged
- the dampness of the orchard floor
- the extent to which ground cover plants cover the soil
- the level of faecal contamination from native animals, birds and insects
- the timing of pesticide and fertilizer applications

Good orchard floor management should be used to minimise organic debris and foreign materials that might contaminate the crop. The use of ground cover crops to reduce direct soil exposure is an effective strategy but careful use of herbicides to control weeds is required to prevent chemical contamination. Orchard floor dampness encourages microbial growth and reduction of dampness close to harvest is important to minimise the potential for contamination with aflatoxins.

The likelihood of persistent chemicals in the soil relates to past use of the land. Chemicals belonging to the organochlorine and organophosphate groups may have been used on previous agricultural crops and there is the possibility of sites where spills occurred. The retention of these chemicals in the soil is determined by soil type, climatic conditions and how the chemicals were used. For the almond industry the highest risk will be in chemical contamination of hulls and shells that are used in stock feed. For areas designated for new crop plantings soil testing should be undertaken to determine the hazards that exist.

Under normal dry conditions there is little soil adherence to the nut. However if late rains occur, or if watering takes place too close to harvest, soil adherence may be significant. Contaminating soil attached to almonds from harvesting will remain with the nut during storage. The storage of the harvested nuts on the ground for about two months, but possibly up to four months, before transfer to hulling/shelling operations also increases the chances of nuts being contaminated with additional soil and dust.

Minimising the amount of soil that adheres to the shells at harvest and during storage will reduce the level of contamination and the associated risks. This in turn will reduce the risks in further processing operations.

See Table 5 in Appendix 2.

5.1.3 Contamination from People and Management Practices

People influence food safety through:

- personal hygiene
- illness
- causing cross contamination

They control food safety both directly by personal hygiene procedures and following appropriate guidelines when ill and indirectly through cleaning and sanitising equipment and other support programs. Whilst the level of hygienic procedures required to maintain food safety control varies with the type of operation all personnel involved in the growing, harvesting, hulling/shelling and processing of almonds have a responsibility to prevent contamination and assist in minimising the risks from hazards that cannot be eliminated.

Personnel handling food have regulatory obligations to keep food safe. Their level of responsibility and the type of contact they have with the product determines the level of training required to ensure food safety control. Details of food handler responsibilities are outlined in Part 3.2 Food Safety Requirements of the Food Standards Code Standard 3.2.2 Food Safety Practices and General Requirements.

Management practices in use at all stages of production influence the likelihood and levels of contamination. Management practice decisions and the implementation and control of management practices are dependent on the people involved in the operations. People have both a direct and indirect effect on management practice outcomes.

5.1.3.1 Personal hygiene

Personnel involved in the growing and harvesting of almonds should follow good hygienic practices at all times. This includes washing hands after visits to the toilet, handling rubbish, touching any part of the face or body, eating and drinking. Hands should where possible be washed in warm water and a sanitiser soap, but running water and soap are a minimum requirement. Disposable drying towels rather than re-usable towels should be used.

Hygienic controls are more important at the harvesting stage than during growing of the crop. Where possible eating, drinking and smoking should be undertaken in a designated area and at designated times to allow for easy management of hygienic practices such as hand washing before return to work.

Clothing should be clean at the start of each day’s work.

Cuts, minor wounds and abrasions should be covered with a coloured bandage that can be found easily if it falls off.

Personal hygiene controls should be more stringent when the food handler is in direct contact with the nuts. For example, personnel who drive machinery and do not handle the nuts are unlikely to pose a risk of contamination, whereas for those personnel directly handling nuts there is opportunity for contamination to be introduced.

5.1.3.2 Illness

Personnel suffering from serious intestinal illness such as gastroenteritis should not come into direct contact with almonds. This is particularly important close to and at harvest. Depending on the severity of the illness it may be acceptable to continue some tasks such as machinery and equipment maintenance. However if there is a risk that the microbe causing the illness could contaminate equipment that is in direct contact with almonds then other duties should be found.

Where there is any risk of a person causing contamination of almonds through illness there should be an adequate management system in place to control food safety. Relevant state and federal laws governing food handlers and disease microorganisms should be consulted.

5.1.3.3 Cross Contamination

Almonds and almond products are at high risk of cross contamination. At harvesting, storage and transport to hulling and shelling there is risk of cross contamination from soil, equipment and machinery, containers and bins. There is an input from personnel at each of these stages through cleaning and sanitising duties, monitoring pest infestation and pest control programs and orchard floor management.

Personnel may cross contaminate almonds through dirty clothing, gloves or poor hygienic practices.

Re-shakes and almonds left on the ground after harvest may contaminate batches if they are not screened adequately to eliminate obviously contaminated nuts. Vigilance at this stage of almond production can reduce the level of contamination entering the hulling/shelling operation and hence minimise food safety risks in the final product.

5.1.3.4 Management Practices

At growing and harvesting management practices that have a significant influence on food safety include control over chemical spray residues and orchard floor management. Use of correct application rates and the timing of spraying can be readily controlled by following standard operating procedures in place and manufacturer's instructions. However integral to the control of prevention of chemical contamination is to ensure that windfall almonds do not become inadvertently contaminated during routine weed management practices.

See Table 6 in Appendix 2.

5.1.4 Contamination from Equipment and Vehicles

The wheels of farm machinery carry soil and pests and transfer these from harvest areas to storage areas. Sweepers combine soil and debris with the nuts when forming windrows. Pick up machines then scoop soil and debris along with nuts, and hoppers, elevators and trailers become contaminated with soil and pests associated with it.

Orchard floor management to minimise organic debris, pests, foreign materials and mummified nuts from the previous season is important to reduce contamination of the almonds and transfer of this contamination into storage. Potentially birds that have been inadvertently shot during pest management could be included in harvest and orchard floor management should incorporate control of this risk.

Outside storage after harvest is a high risk time in almond production for microbial contamination. The use of walled bins to store the harvested nuts rather than direct ground storage will reduce risks of contamination by providing areas that can be effectively cleaned prior to storage. The use of covers will provide better pest management control. Use of walled bins with covers may provide the best means of minimising the entrance of rodents, insects, birds and other animals into the stockpile. However the use of covers must be well managed to minimise the development of warm, humid conditions in the stockpile that could lead to microbial growth. See Table 7 below for further guidance.

The trays on transport vehicles to the hulling/shelling operations, if not kept clean, will add to the possibility of contamination of the nuts. Transport vehicles are likely to be used for multiple purposes, particularly between seasons. The use of vehicles for transfer of animals, chemicals or organic manures introduces hazards to the almond operation if strict control over cleaning and sanitising between uses is not properly managed. Deliveries to and from hullers and processors in bins is a major source of rodent introduction to other sites and into the kernels.

Cleaning programs should be in place to reduce levels of contamination on all farm equipment, transport vehicles and storage bins.

Table 7 Risk level based on type of storage

Risk factor:	Moisture	Rodents	Consequence
Sand / limestone base	High	High	Increase Aflatoxin and *Salmonella* surveillance
Bunkers	Medium	High	Increase *Salmonella* surveillance, determine Aflatoxin surveillance needs
Undercover storage	Low	Medium	Determine *Salmonella* surveillance needs

Also see Table 8 in Appendix 2.

5.1.5 Contamination due to Environmental Conditions and Storage

Wet, humid conditions generally increase the potential for bacterial and fungal diseases in almonds. Contamination with aflatoxin producing fungi is directly correlated with high humidity. Failure to allow adequate drying of nuts prior to collecting by pick up machines will result in damp storage conditions, increasing the likelihood of microbial proliferation.

From studies conducted in California low incidence levels of *E. coli* are found on almonds still on the tree. *E. coli* incidence increases as the nuts fall, are harvested and placed in storage. *E. coli* incidence peaks during the hulling stage and then gradually declines through shelling and onto final processing. This pattern in contamination is likely to be related to an increasing amount of soil associated with the almonds and then an increased distribution of the soil through the almond batch as operations cause clumps to break up and contaminate more individual nuts. As soil contamination decreases through the process so does *E. coli.* No such studies have been conducted in the Australian almond industry. Most of the Australian industry no longer uses organic manures to fertilise almond trees and what data is available suggests the incidence of *E. coli* is low. However it is likely that the pattern of contamination will follow that seen in California and for those farmers who choose to use organic manures there is increased risk.

Climatic conditions that increase the chances of pest infestation will then result in increased usage of pesticides to control those pests. There may therefore be seasonal patterns to the risks of chemical contamination of the almonds.

5.2 Food Safety Controls

Assessment of the risks associated with known hazards provides the knowledge to determine appropriate control measures and how these should be monitored. The following table provides guidance on what controls should be in place growing and harvesting stages of almond production. However each operation should be assessed in detail as additional controls may be required in some circumstances and not every control is relevant to all operations. Only those process steps in the operation where controls can be implemented are listed.

Good agricultural practices (GAP) and good hygienic practices (GHP) should be used throughout to assist in control of food safety hazards.

Table 9 Food safety controls at growing and harvesting

Step	What to control	Control measures
Irrigating	Water quality Orchard floor dampness	Time irrigation in relation to water quality Use irrigation techniques to minimise water contact with nuts Cease irrigating prior to harvest to allow orchard floor to dry out
Weather / vermin protection	Pest infestation	Good orchard management Reduce organic debris Implement and maintain pest control program Adjust pest control program according to climatic conditions
Pest/disease management	Pest infestation Disease development	Good orchard management Reduce organic debris Implement and maintain disease control program Use only approved pesticides with current permits Strictly adhere to application rates on labels Adjust disease control program according to climatic conditions
Weed control	Pest harbourage Humidity and dampness	Implement and maintain an effective weed control program Do not spray on windfalls
Crop/growth regulation	Chemicals, fertilisers Water quality	Use application techniques to minimise chemical usage and spray drift Avoid use of manures Time application in relation to water quality
Harvest	Time nuts are in contact with soil Moisture content of nuts Soil moisture Birds rummaging on orchard floor	Good orchard floor management Leave nuts on ground for minimum time required for drying Bird control program
Transport	Addition of contaminants	Implement vehicle and equipment cleaning program
Storage	Pest infestation Moisture content of nuts	Implement and maintain pest control program Store nuts at a “safe” moisture content of hulls Prevent rainfall affecting nuts

At appropriate steps during harvesting poor quality nuts should be identified and screened out wherever practical.

5.3 Monitoring Food Safety Controls

Control measures are implemented to manage food safety hazards and reduce or eliminate risk. To determine if these control measures are effective, and achieving desired outcomes, observations or measurements must be made to monitor the controls. Monitoring verifies control or shows when control has been lost.

Monitoring parameters must be chosen that will provide appropriate information in as timely a manner as possible. Critical limits are set so that the monitoring procedure indicates acceptability or a failure in a process. Critical limits are likely to vary between operations and may sometimes be guided by regulatory requirements. For those critical limits where an absolute figure is specified they will include an acceptable level of variation, beyond which the control is deemed to have failed.

The monitoring steps and procedures outlined below refer only to assessment of microbiological and chemical contaminants that are analysed after collection of samples. They do not include other types of monitoring procedures that are relevant at various stages of production, such as visual observation for foreign material.

Within each operation the points at which samples are collected must be considered in relation to specific controls in place so that the results of testing effectively monitor changes in quality or risk levels in relation to the controls implemented.

The tables show recommended minimum testing requirements and additional testing that may be advisable. The minimum testing requirements should be regarded as the minimum industry standard expected. However Duty-of-Care dictates that each operation must assess monitoring needs in light of identified risks, availability of historical data and controls in place.

Guidance additional to this document may be required to determine appropriate MRL monitoring. Previous land usage, water quality, market and regulatory requirements all need to be considered in MRL management and monitoring requirements.

What to monitor and the frequency of testing may change over time as information accumulated allows a reassessment of the level of risk from a particular potential hazard. Monitoring programs are dynamic, require regular review and should respond to data trends.

Consideration may also need to be given to monitoring chemical and pesticide residues in soils when a new growing area is considered or where information or history of land usage indicates a potential hazard.

Table 10a Monitoring at growing and harvesting stages of production – Minimum Requirements

What to Monitor	How?	Frequency
Water quality – Microbiological Chemical Pesticide residues (MRL's)	Collect samples of irrigation water	At least annually and preferably close to harvest. More frequent monitoring is required where water quality is low or known to be highly variable, or when a contamination event occurs. Data accessed from state water authorities may be used.[§]
Almonds – Moisture content[*] Visual inspection for dirt and debris Exclusion of domestic animals	Collect samples after harvest	 Every harvest batch Continuous Continuous

Table 10b Monitoring at growing and harvesting stages of production – Additional Monitoring that can be Applied

What to Monitor	How?	Frequency
Water quality – Microbiological Chemical Pesticide residues (MRL's)	Collect samples of irrigation water	At least annually and preferably close to harvest. More frequent monitoring is required where water quality is low or known to be highly variable, or when a contamination event occurs. Data accessed from state water authorities may be used.[§]
Almonds – Moisture content[*] MRL's Visual inspection for dirt and debris Exclusion of domestic animals	 Collect samples after harvest	 Every harvest batch Annually Continuous Continuous

* Current industry practice is to commence harvesting when the moisture content of the kernel has reached 6%. Moisture levels higher than this would warrant increased surveillance of almonds for aflatoxins and bacterial contaminants such as *Salmonella.*

[§] Whilst treatment of irrigation water may not be possible when contamination is detected, the information gained about contamination can be used to review monitoring requirements and additional controls further down the processing chain.

6 HULLING AND SHELLING

6.1 Assessing the Risks of Contamination

Exposure to a potential food safety hazard does not in itself imply the presence of high risk. The likelihood of a hazard causing risk is dependent on many factors which may or may not interact. Assessment of the level of risk associated with a hazard is an important component of good management practices. Awareness of potential hazards and their origin and assessment of the associated risks allow risk reduction strategies to be implemented. As almonds are often eaten raw it is not possible to eliminate all potential food safety hazards. However through the use of good agricultural, manufacturing and hygienic practices the hazards can be controlled to reduce risks to an acceptable level.

A sound, common approach to managing risks will result in a more effective and cohesive response to contamination events when they occur and to emerging food safety issues.

6.1.1 Contamination from Water

Water may carry both microbiological and chemical contaminants. The quality of water required in almond production is determined by the stage of operations and whether the nut is in direct contact with water.

Wherever possible water used for cleaning and in sanitising procedures on hulling and shelling equipment should be of potable quality. Hand washing and toilet facilities should be supplied with potable water. Standards of potability should not be less than those contained in the Australian Drinking Water Guidelines 2004[9.3]. Where water used in hulling and shelling operations does not meet microbiological criteria for potability the water may need to be treated. A variety of treatment options is available and the reader is referred to other documents for details, such as Guidelines for On-Farm Food Safety for Fresh Produce[9.11] and Guidelines for the Management of Microbial Food Safety in Fruit Packing Houses[9.12].

See Table 4 in Appendix 2.

6.1.2 Contamination from Soil

Soil will carry microbiological contaminants and may also carry chemical contaminants. Soil microorganisms will include those for which soil is their natural habitat and those which have contaminated the soil from animal, bird and insect faeces, or from human sewage. Microbes which occur naturally in the soil may include human pathogens and fungi that cause disease.

Any soil associated with the harvested/stored nut will contaminate vehicles used in transport to the hulling and shelling operation. Vehicles, if not properly cleaned, may also add soil and dirt to the consignment. Hulling and shelling equipment, silos, bins and the general hulling/shelling environment will subsequently become contaminated. Inevitably the kernels will retain some of the microorganisms associated with the soil.

Cleaning and sanitising procedures are critical in controlling the level of risk from soil contamination. Personnel hygiene procedures to reduce the amount of soil entering hulling/shelling sheds on boots and clothing are also important. The potential for cross contamination from orchard to vehicles, storage facilities and hulling/shelling equipment is high and requires careful management.

See Table 5 in Appendix 2.

6.1.3 Contamination from People and Management Practices

People influence food safety through:

- personal hygiene
- illness
- causing cross contamination

They control food safety both directly by personal hygiene procedures and following appropriate guidelines when ill and indirectly through cleaning and sanitising equipment and other support programs. Whilst the level of hygienic procedures required to maintain food safety control varies with the type of operation all personnel involved in the growing, harvesting, hulling/shelling and processing of almonds have a responsibility to prevent contamination and assist in minimising the risks from hazards that cannot be eliminated.

Personnel handling food have regulatory obligations to keep food safe. Their level of responsibility and the type of contact they have with the product determines the level of training required to ensure food safety control. Details of food handler responsibilities are outlined in Part 3.2 Food Safety Requirements of the Food Standards Code Standard 3.2.2 Food Safety Practices and General Requirements.

Management practices in use at all stages of production influence the likelihood and levels of contamination. Management practice decisions and the implementation and control of management practices are dependent on the people involved in the operations. People have both a direct and indirect effect on management practice outcomes.

6.1.3.1 Personal Hygiene

Personnel involved in the hulling and shelling of almonds should follow good hygienic practices at all times. This includes washing hands after visits to the toilet, handling rubbish, touching any part of the face or body, eating and drinking, after breaks and after performing maintenance on equipment or machinery. Hands should be washed in warm water using a sanitiser based soap as a minimum requirement. Disposable drying towels rather than re-usable towels should be used.

Eating, drinking and smoking should be undertaken in designated areas away from or in a room separate to processing operations.

Clothing should be clean at the start of each day’s work and kept as clean as possible throughout the day. The use of hair nets and beard masks is advisable, particularly in the areas where kernels are exposed.

Cuts, minor wounds and abrasions should be covered with a coloured bandage that can be found easily if it falls off.

For operations where gloves are used these should be replaced as often as hand washing would occur. Gloves can also be used to cover cuts, minor wounds and abrasions.

Jewellery has the potential to carry dirt and harbour microorganisms. It is appropriate that jewellery is not worn in the hulling/shelling facility except for plain wedding bands. Consideration should also be given to the risks of jewellery being caught in machinery and equipment under occupational safety health and welfare regulations.

Following strict personal hygiene procedures, whilst important throughout the hulling/shelling operations, is likely to be of most significance at the end of the operations, where kernels are exposed and packing is taking place. Wherever possible personnel should move from the end of the process backwards to areas where the entire nut occurs. Moving from sites of finished product back to delivery areas reduces the risk of contamination in the kernel.

6.1.3.2 Illness

Personnel suffering from serious intestinal illness such as gastroenteritis should not come into direct contact with almonds. Depending on the severity of the illness some non-food contact duties may be appropriate. Where there is any risk of a person causing contamination of almonds through illness there should be an adequate management system in place to control food safety. Relevant state and federal laws governing food handlers and disease microorganisms should be consulted.

When suffering from any illness, such as colds or flu, working in areas where the kernel is exposed should be avoided where possible. Face masks can be used in these circumstances to minimise the potential for contamination.

6.1.3.3 Cross Contamination

Almonds and almond products are at high risk of cross contamination. At hulling and shelling stages there is risk of cross contamination from soil, equipment and machinery, containers and bins. There is an input from personnel at each of these stages through cleaning and sanitising duties, monitoring pest infestation and pest control programs.

At all stages of operations personnel may cross contaminate almonds through dirty clothing, gloves or poor hygienic practices.

The nature of almond operations inherently increases the risks of cross contamination between lots of almonds. Storage silos, conveyors and some hulling/shelling equipment hold batches in a continuous process where almonds from different growing areas partially mix. Re-shakes may enter processing facilities that increase the risk of cross contamination from almonds of poorer microbiological quality to those of higher quality. The potential hazards cannot be eliminated. However the application of good manufacturing practices, including product traceability, can reduce the hazards and associated risks. Product can be combined based on a risk assessment of batches received. Those of high risk of contamination should never be combined with those of low risk. This reduces both the amount of product and the time period over which product may be contaminated and pose a food safety risk. This provides opportunity to address cleaning and sanitising needs between high and low risk products.

Managing work flow to minimise the number of people and the number of times personnel move from areas of delivery and hulling into screening and packing areas will reduce the potential for cross contamination.

6.1.3.4 Management Practices

The management of cross contamination control as outlined in 6.1.3.3 is dependent on sound policy decisions that are supported by appropriate waste management, pest control and cleaning programs. These and additional standard operating procedures provide the tools for control that are verified through the monitoring program in place.

See Table 6 in Appendix 2.

6.1.4 Contamination from Equipment and Vehicles

The trays on transport vehicles to the facility, if not kept clean, will add to the possibility of contamination of the nuts.

Receival conveyors accumulate soil, foreign materials and pests throughout the processing season. Whilst the product at this stage is the entire nut with the hull, any damaged nuts are susceptible to contamination. Nuts with high moisture content are also at higher risk.

Where silos, elevators and other equipment cannot be entirely emptied of product the ability to effectively clean and sanitise is reduced and the risk of infestation with rodents or weevils increased. Although this would indicate these are high risk areas for contamination and cross contamination, many factors will influence the level of food safety risk introduced at this stage. The quality of the nuts, moisture level, amount of soil, and whether the product originates from a well managed orchard will all contribute to the risk level. Where there is a significant deterioration in the quality of a batch received, ie. high levels of soil and pests observed or high proportion of damaged shells, this would suggest an increased level of cleaning should be undertaken.

Conveyor belts and rollers should be kept in good condition as microbes will accumulate and survive in cracks and on damaged areas of these items. There is also risk from foreign material if equipment is not well maintained.

Equipment used for collecting samples of nuts for analysis should be included in the cleaning and sanitising program.

See Table 8 in Appendix 2.

6.1.5 Contamination due to Environmental Conditions and Storage

Receival of damp batches of nuts will result in more contamination of equipment in the hulling/shelling operation with soil and organic debris from the loads. The moisture level of the nuts will determine the potential for microbial growth in silos.

Various studies have shown that when nut meats are contaminated with *Salmonella* or *E. coli* the organisms die more rapidly when the nuts are held at ambient temperatures. When held at refrigerated temperatures or frozen, *Salmonella* survive on the nut for long periods of time. The same pattern of survival holds for the aflatoxin producing fungi. However the response to environmental conditions by particular groups of organisms may differ. There appears to be no correlation between total bacterial counts on nuts and the counts of pathogens like *Salmonella*. Whilst there is currently an absence of data to show whether fluctuations in ambient temperature may have an effect on pathogen survival it would seem reasonable to question whether there might be differences in survival between summer and winter months.
Storage conditions that control pest infestation are critical at hulling/shelling stages so that microbial contamination and chemicals used in pest control are not introduced.

6.2 Food Safety Controls

Assessment of the risks associated with known hazards provides the knowledge to determine appropriate control measures and how these should be monitored. The following table provides guidance on what controls should be in place at the hulling and shelling stages of almond production. However each operation should be assessed in detail as additional controls may be required in some circumstances and not every control is relevant to all operations. Only those process steps in the operation where controls can be implemented are listed.

Good manufacturing practices (GMP) and good hygienic practices (GHP) should be used throughout to assist in control of food safety hazards.

Table 11 Food safety controls at hulling and shelling

Step	What to control	Control measures
Receival	Nuts from growers without food safety system controls; Moisture content of nuts; Soil, foreign material contamination	Accept product from growers using a quality assurance program Implement and maintain equipment cleaning program Remove foreign material
Storage	Pest and vermin infestation Moisture content	Implement and maintain pest control program, particularly for meal moth Separate batches based on moisture content
Hulling	Damage to nuts Addition of contaminants	Implement equipment maintenance program Implement and maintain equipment cleaning program Implement and maintain pest control program Remove obvious contaminants
Shelling	Damage to nuts Addition of contaminants	Implement equipment maintenance program Implement and maintain equipment cleaning program Implement and maintain pest control program Remove obvious contaminants
Screening	Addition of contaminants Cleanliness of kernels	Implement and maintain equipment cleaning program Implement and maintain pest control program Remove poor quality and damaged nuts Implement work flow policies
Storage	Pest and vermin infestation Moisture content	Implement and maintain pest control program, particularly for meal moth
Transport	Addition of contaminants	Implement vehicle and equipment cleaning program

6.3 Monitoring Food Safety Controls

Control measures are implemented to manage food safety hazards and reduce or eliminate risk. To determine if these control measures are effective, and achieving desired outcomes, observations or measurements must be made to monitor the controls. Monitoring verifies control or shows when control has been lost.

Monitoring parameters must be chosen that will provide appropriate information in as timely a manner as possible. Critical limits are set so that the monitoring procedure indicates acceptability or a failure in a process. Critical limits are likely to vary between operations and may sometimes be guided by regulatory requirements. For those critical limits where an absolute figure is specified they will include an acceptable level of variation, beyond which the control is deemed to have failed.

The monitoring steps and procedures outlined below refer only to assessment of microbiological and chemical contaminants that are analysed after collection of samples. They do not include other types of monitoring procedures that are relevant at various stages of production, such as visual observation for foreign material.

Within each operation the points at which samples are collected must be considered in relation to specific controls in place so that the results of testing effectively monitor changes in quality or risk levels in relation to the controls implemented.

The tables show recommended minimum testing requirements and additional testing that may be advisable. The minimum testing requirements should be regarded as the minimum industry standard expected. However Duty-of-Care dictates that each operation must assess monitoring needs in light of identified risks, availability of historical data and controls in place.

Guidance additional to this document may be required to determine appropriate MRL monitoring. Previous land usage, water quality, market and regulatory requirements all need to be considered in MRL management and monitoring requirements.

What to monitor and the frequency of testing may change over time as information accumulated allows a reassessment of the level of risk from a particular potential hazard. Monitoring programs are dynamic, require regular review and should respond to data trends.

Where almonds are transferred to the hulling and shelling plant immediately after harvest the need for sampling and testing at both stages may change. This should be considered when using Tables 10a and 12b as a guide to monitoring.

Environmental monitoring, where surface swabbing is used to detect microbial contaminants, may be the most effective means of monitoring pathogen risks at this stage of operations.

It is likely that when almonds are exposed to unsafe chemical levels due to inappropriate chemical usage control the hulls and shells of the almond will harbour most of the accumulated compound. The use of these hulls and shells in stockfood then introduces a chemical risk to the food chain. Monitoring this risk prior to release of the product for stockfood use is an effective preventative measure.

Table 12a Monitoring at shelling and hulling stages of production – Minimum Requirements

What to monitor	How?	Frequency
Water quality – Microbiological Chemical Pesticide residues (MRL's)	Collect sample of water used for cleaning and sanitising	Annually and after a known contamination event or when any water treatment used is changed
Almonds – Moisture content	Collect samples at receival	Every grower batch
Hulls and shells - MRL's *Salmonella*	Collect samples from bins	Annually Twice per year at start and end of season
Equipment – *Salmonella*	Take swabs from conveyors, rollers, hoppers and screens	Annually at start of season after full cleaning program has been undertaken

Table 12b Monitoring at shelling and hulling stages of production – Additional Monitoring that can be Applied

What to monitor	How?	Frequency
Water quality – Microbiological Chemical Pesticide residues (MRL's)	Collect sample of water used for cleaning and sanitising	Annually and after a known contamination event or when any water treatment used is changed
Almonds – Moisture content Aflatoxin *E. coli, Salmonella*	Collect samples at receival May be collected to provide early warning if required by processors May be collected to provide early warning if required by processors	Every grower batch As required by processor with consideration to grower traceability, seasonal effects and other risk factors As required by processor with consideration to grower traceability, seasonal effects and other risk factors
Hulls and shells - MRL's *Salmonella*	Collect samples just prior to stockpile	Annually Twice per year at start and end of season
Equipment – *Salmonella*	Take swabs from conveyors, rollers, hoppers and screens	Annually at start of season after full cleaning program has been undertaken

Currently there is little data available on aflatoxin and microbiological contaminants in almonds at the hulling//shelling stages of production for the Australian industry. When data becomes available the above monitoring frequencies can be reviewed.

When choosing the time at which samples should be collected or the way in which samples are composited according to the schedule in Table 12b, consideration should be given to how the samples relate to individual growers. The monitoring program should ideally provide correlation of results with growers so that when problems arise there can be effective traceability to their source.

It may also be appropriate that samples are collected to correlate results with other events that may increase food safety risks such as high rainfall.

7 PROCESSING AND VALUE-ADDING

7.1 Assessing the Risks of Contamination

Exposure to a potential food safety hazard does not in itself imply the presence of high risk. The likelihood of a hazard causing risk is dependent on many factors which may or may not interact. Assessment of the level of risk associated with a hazard is an important component of good management practices. Awareness of potential hazards and their origin and assessment of the associated risks allow risk reduction strategies to be implemented. As almonds are often eaten raw it is not possible to eliminate all potential food safety hazards. However through the use of good agricultural, manufacturing and hygienic practices the hazards can be controlled to reduce risks to an acceptable level.

A sound, common approach to managing risks will result in a more effective and cohesive response to contamination events when they occur and to emerging food safety issues.

7.1.1 Contamination from Water

Water may carry both microbiological and chemical contaminants. The quality of water required in almond production is determined by the stage of operations and whether the nut is in direct contact with water.

Water used in the manufacturing process (eg. blanching), water used for cleaning and sanitising equipment and water in hand washing and toilet facilities should be of potable quality. Standards of potability should not be less than those contained in the Australian Drinking Water Guidelines 2004. Where water used in processing facilities is not of potable quality the water may need to be treated. In this instance it is advisable to consult the local water authority for guidance and seek assistance from other professional water treatment organisations.

See Table 4 in Appendix 2.

7.1.2 Contamination from Soil

Soil will carry microbiological contaminants and may also carry chemical contaminants. Soil microorganisms will include those for which soil is their natural habitat and those which have contaminated the soil from animal, bird and insect faeces, or from human sewage. Microbes which occur naturally in the soil may include human pathogens and fungi that cause disease.

Once the almonds reach the final processing facility the likelihood of any additional soil contamination is low. However vehicles used in transfer of the almonds from the huller may carry soil, dirt and dust if not properly cleaned and so contaminate the nuts at this stage. The processing operation must have controls in place to minimise the amount of soil entering the factory from dirty nuts and vehicles. Controls to prevent entry of soil and dust into the factory from the facility's surrounding environment will also reduce the potential for harmful microorganisms entering processing areas.

See Table 5 in Appendix 2.

7.1.3 Contamination from People and Management Practices

People influence food safety through:

- personal hygiene
- illness
- causing cross contamination

They control food safety both directly by personal hygiene procedures and following appropriate guidelines when ill and indirectly through cleaning and sanitising equipment and other support programs. Whilst the level of hygienic procedures required to maintain food safety control varies with the type of operation all personnel involved in the growing, harvesting, hulling/shelling and processing of almonds have a responsibility to prevent contamination and assist in minimising the risks from hazards that cannot be eliminated.

Personnel handling food have regulatory obligations to keep food safe. Their level of responsibility and the type of contact they have with the product determines the level of training required to ensure food safety control. Details of food handler responsibilities are outlined in Part 3.2 Food Safety Requirements of the Food Standards Code Standard 3.2.2 Food Safety Practices and General Requirements.

Management practices in use at all stages of production influence the likelihood and levels of contamination. Management practice decisions and the implementation and control of management practices are dependent on the people involved in the operations. People have both a direct and indirect effect on management practice outcomes.

7.1.3.1 Personal Hygiene

Personnel involved in almond processing, including value adding operations, should follow good hygienic practices at all times. This includes washing hands after visits to the toilet, handling rubbish, touching any part of the face or body, eating and drinking, after breaks and after performing maintenance on equipment or machinery. Hands should be washed in warm water and soap and a hand sanitiser used on entrance to the factory. Disposable drying towels rather than re-usable towels should be used.

Eating, drinking and smoking should not be allowed anywhere within the processing facility, restricted to designated outside areas and staff rooms.

Clothing should be clean at the start of each day’s work and kept as clean as possible throughout the day. The use of hair nets, and beard masks where required, should be mandatory in all areas.

Cuts, minor wounds and abrasions should be covered with a coloured bandage that can be found easily if it falls off.

For operations where gloves are used these should be replaced as often as hand washing would occur. Gloves can also be used to cover cuts, minor wounds and abrasions.

Jewellery has the potential to carry dirt and harbour microorganisms and should be banned from manufacturing facilities. Jewellery also presents risk of being caught in machinery and equipment causing injury to the wearer. Most manufacturers have a no jewellery policy.

The need for personnel to follow work flow rules on site is important in food safety control.

7.1.3.2 Illness

Personnel suffering from serious intestinal illness such as gastroenteritis should not come into direct contact with almonds. Depending on the severity of the illness some non-food contact duties may be appropriate. Where there is any risk of a person causing contamination of almonds through illness there should be an adequate management system in place to control food safety. Relevant state and federal laws governing food handlers and disease microorganisms should be consulted.

When suffering from any illness, such as colds or flu, face masks should be used and strict attention paid to the need for increased frequency of hand washing to minimise the potential for contamination.

7.1.3.3 Cross Contamination

Almonds and almond products are at high risk of cross contamination. The highest risks of cross contamination in processing facilities are from equipment and machinery, conveyors, containers and bins, and failure to follow process flows and appropriate work flow. There is an input from personnel at each of these stages through cleaning and sanitising duties, monitoring pest infestation and pest control programs.

At all stages of operations personnel may cross contaminate almonds through dirty clothing, gloves or poor hygienic practices.

The nature of almond operations inherently increases the risks of cross contamination between lots of almonds. Storage bins, conveyors and equipment may hold batches of almonds from different growers. Re-shakes may enter processing facilities that increase the risk of cross contamination from almonds of poorer microbiological quality to those of higher quality. The potential hazards cannot be eliminated. However the application of good manufacturing practices, including product segregation and product traceability, can reduce the hazards and associated risks.

Managing work flow so that people move from the end of operations through to the start of processing reduces food safety risks.

7.1.3.4 Management Practices

The application of HACCP based food safety programs provides the framework of management practices to control food safety. Standard operating procedures and work instructions are used to control compliance with the HACCP plan. Monitoring programs verify compliance or non-compliance and implementation of appropriate corrective actions where required is critical to ongoing control. Integration of sound management practices throughout the operation is required to achieve food safety control.

See Table 6 in Appendix 2.

7.1.4 Contamination from Equipment and Vehicles

The trays on transport vehicles to the processing facility, if not kept clean, will add to the possibility of contamination of the nuts.

Receival rooms should be cleaned between loads to minimise the potential for cross contamination.

Once in the processing facility it is obvious that the cleaner the nut at the start of the process the lower the level of contamination in the final product. Whilst some almonds will undergo heat treatment in blanching and roasting operations, if the level of microbial contamination on the raw kernel is high there is a greater possibility that heat treatment processes will not reduce the load to an acceptable level. The blanched almond also contains a moisture content sufficient to allow microbial growth and the exposed kernel is more susceptible to contamination.

In addition there is potential for contamination of the kernel post heat treatment. Cleaning and sanitising equipment including conveyors, hoppers, rollers, blades and grinders is critical to maintaining control over food safety.

The walls of blanching baths and roasters should also be cleaned regularly to prevent a build up of organic material that might enhance microbial survival.

All equipment should be kept in good condition as microbes will accumulate and survive in cracks and on damaged areas such as frayed conveyor belts. There is also risk from foreign material if equipment is not well maintained.

Where almonds are dried using air blowers the microbiological air quality should be controlled. Filters may be required and these should be cleaned and replaced as required.

Equipment used for collecting samples of nuts for analysis should be included in the cleaning and sanitising program.

Vehicles used in packing and dispatch areas should be kept clean and controls placed over movement of these vehicles from outside areas to within the building.

See Table 8 in Appendix 2.

7.1.5 Contamination due to Environmental Conditions and Storage

Generally the highest quality nuts have the lowest level of microbial contamination. Receipt of nuts that have been harvested and stored using good agricultural, manufacturing and hygienic practices provides assurance that food safety risks are low.

Reducing moisture content in the kernel after washing procedures is an important critical control point and will result in a stable product that can be stored for long periods of time. Minimising temperature fluctuations during storage will also reduce the risk of microbial growth. Studies of *Salmonella* survival on pecans show that kernel moisture levels of less than 5% are likely to have a lethal effect on the organism over time. In addition *Salmonella* survival reduced over time when in-shell nuts were stored at ambient temperatures, whereas storage at refrigeration temperatures enhanced survival. Whilst *Salmonella* strains will vary in their responses to these conditions it is likely that these general effects would also be observed in almonds.

Application of good agricultural practices in the early stages of almond production is important to prevent the introduction of aflatoxin risks to final processing. Aflatoxins are extremely heat resistant. The commercial roasting process of nuts will typically achieve only a twenty to fifty percent reduction of the aflatoxins present before roasting. Control measures must therefore be applied well in advance of any heat treatment processes.

Environmental conditions in the processing facility are readily controlled and should ensure appropriate air quality, control of humidity in areas using water and satisfactory temperature control. Processing facilities should ensure that their environmental conditions comply with Part 3.2 Food Safety Requirements of the Food Standards Code Standard 3.2.3 Food Premises and Equipment, and relevant state legislation.

7.2 Food Safety Controls

Assessment of the risks associated with known hazards provides the knowledge to determine appropriate control measures and how these should be monitored. The following table provides guidance on what controls should be in place at the processing and value-adding stages of almond production. However each operation should be assessed in detail as additional controls may be required in some circumstances and not every control is relevant to all operations. Only those process steps in the operation where controls can be implemented are listed.

Good manufacturing practices (GMP) and good hygienic practices (GHP) should be used throughout to assist in control of food safety hazards.

Table 13 Food safety controls at processing

Step	What to control	Control measures
Receival	Pest infestation Moisture content of nuts Level of contamination – foreign material, aflatoxins	Fumigate nuts on receipt Apply quality criteria to suppliers Visual inspection on receipt Separate batches based on inspection and quality criteria results
Storage	Pest infestation Moisture content	Implement and maintain pest control program Control storage environment
Sorting/grading	Assign nuts to appropriate processing area	Remove discoloured, shriveled or damaged nuts Remove foreign material Use trained operators Sort to specification

Natural packing	Use of poor quality nuts Addition of contaminants	Remove damaged nuts Remove foreign material Implement and maintain equipment cleaning program Use trained operators Use GHP
Blanching	Product receives food safe thermal treatment Final product meets moisture content criteria Prevent post process contamination	Process to specification and consider temperature/time controls Drying parameters to achieve desirable water activity Implement and maintain equipment cleaning program Implement and maintain pest control program Use GHP
Roasting	Product receives food safe thermal treatment Prevent post process contamination	Process to specification and consider temperature/time controls Implement and maintain equipment cleaning program Implement and maintain pest control program Use GHP
Packing	Prevent post process contamination	Implement and maintain equipment cleaning program Implement and maintain pest control program Use GHP
Storage	Pest infestation Quality criteria throughout shelf life	Implement and maintain pest control program Monitor storage temperatures and conditions Store product with safe water activity level
Transport	Pest infestation	Implement and maintain pest control program

7.3 Monitoring Food Safety Controls

Control measures are implemented to manage food safety hazards and reduce or eliminate risk. To determine if these control measures are effective, and achieving desired outcomes, observations or measurements must be made to monitor the controls. Monitoring verifies control or shows when control has been lost.

Monitoring parameters must be chosen that will provide appropriate information in as timely a manner as possible. Critical limits are set so that the monitoring procedure indicates acceptability or a failure in a process. Critical limits are likely to vary between operations and may sometimes be guided by regulatory requirements. For those critical limits where an absolute figure is specified they will include an acceptable level of variation, beyond which the control is deemed to have failed.

The monitoring steps and procedures outlined below refer only to assessment of microbiological and chemical contaminants that are analysed after collection of samples. They do not include other types of monitoring procedures that are relevant at various stages of production, such as visual observation for foreign material.

Within each operation the points at which samples are collected must be considered in relation to specific controls in place so that the results of testing effectively monitor changes in quality or risk levels in relation to the controls implemented.

The table below shows recommended minimum testing requirements for processors. The minimum testing requirements should be regarded as the minimum industry standard expected. However Duty-of-Care dictates that each operation must assess monitoring needs in light of identified risks, availability of historical data and controls in place. Guidance additional to this document may be required to determine appropriate MRL monitoring. Previous land usage, water quality, market and regulatory requirements all need to be considered in MRL management and monitoring requirements.

What to monitor and the frequency of testing may change over time as information accumulated allows a reassessment of the level of risk from a particular potential hazard. Monitoring programs are dynamic, require regular review and should respond to data trends. Customer and market driven requirements will also dictate some monitoring requirements. The table outlines the minimum requirements that would be expected as part of a HACCP-based food safety program. Additional testing may be required to verify that finished product meets the requirements of the Australia New Zealand Food Standards Code for food additives, contaminants and residues.

Wherever possible finished product should be retained in storage until results of analysis are known. Where this is not practical, at the very least retention samples should be held, so they are available in the event further investigation is warranted. The availability of data from points earlier in almond production also influences the need for product retention pending analysis results. For example, product release based on MRL's could be expedited where this information has been gathered at grower level, resulting in increased confidence of quality.

Table 14 Monitoring at processing and value adding stages of production

What to monitor	How?	Frequency
Water quality – Microbiological Chemical Pesticide residues (MRL's)	 Collect water sample inside factory	 Monthly for non-scheme supplies; six-monthly for scheme supply Annually Annually
Almonds – Moisture content Moisture content or water activity Aflatoxin *E. coli*, *Salmonella* Standard plate count, *E. coli*, *Salmonella*, Yeasts, Moulds (and other organisms required by the customer) MRL's	 Collect samples at receival After drying Collect samples at end of process line at packing Collect samples after thermal treatments – blanching and roasting Collect samples at end of process line at packing Collect samples at receival	 Every grower batch Determined by controls in place for drying process and HACCP plan Monthly (from random "grab" samples) Weekly or as appropriate based on HACCP plan and customer requirements Daily (from random "grab" samples) or as appropriate Additional testing based on customer requirements For grower verification only if data is not available earlier in the production chain

To verify that cleaning and sanitising programs are effective a surface swabbing program can be implemented. Priority should be given to direct food contact surfaces such as conveyors, hoppers and chutes. As a minimum these surfaces should be assessed for total viable microorganisms. Pathogens such as *Salmonella* can be included in the program from time to time. The required frequency of testing should be determined for each operation but should be at least monthly.

8 SAMPLING AND TESTING PROCEDURES

Procedures for collecting samples should be designed to ensure the sample collected is representative of the batch or lot or the process step being monitored. The analysis methods used for testing the samples should be validated and applicable to the matrix under examination. Where multiple laboratories undertake the testing it is important that results can be reasonably compared to allow correct interpretation of results. The industry should therefore ensure that test methods used for analysis of almonds and other samples related to production are consistent between laboratories. Testing should be undertaken by NATA (National Association of Testing Authorities, Australia) accredited laboratories that are competent to perform the tests required on the samples. Where test methods are specified in the Australia New Zealand Food Standards Code for a given parameter these should be followed. Equivalent validated test methods may be used and advice should be sought from the laboratory or NATA on test method equivalence.

Details on how to collect samples for analysis and conditions of transport to the laboratory are outlined in Appendix 3.

8.1 Collecting representative samples

8.1.1 Water samples

Water should be collected at the point of use. This will monitor all inputs to the water quality as they affect the stage of production. If water quality criteria are not met, points from the source to the point of use can then be investigated to determine at what stage the water became contaminated.

Water quality data for the Murray River should be accessed from the relevant state water authority to determine the variability in source water quality that can be expected.

8.1.2 Almond samples

Sampling should be undertaken so as not to bias test results. Records of samples collected should be kept to ensure traceability of results to lots, batches or dates of production of almonds and almond products. Where composite samples are tested duplicates of each of the individual samples should generally be retained. In the event of a pathogen detection or a parameter that exceeds the allowable limit the point at which control was lost and the extent of the contamination can then be investigated.

Sampling should be designed to provide results for a given lot of almonds.
A lot or batch of almonds is defined as:

- An identifiable unit of production over a known period of time eg. 24 hours
- Product where there has been no major interruption to flow
- No changes that could cause one portion of the lot to differ significantly from another, such as sources or quality of raw material or different equipment
- Production of a single end product

Detailed criteria for developing appropriate sampling plans, particularly in reference to microbiological testing can be found in ICMSF (1986) Microorganisms in Foods Volume 2 Sampling for microbiological analysis: Principles and Specific Applications[9.15].

8.1.2.5 Collecting almonds at growing and harvesting

Samples should be collected from trailers or storage bins. A minimum sample of 1kg for moisture, microbiological and aflatoxin testing should be collected and a separate 1kg for MRL testing should be collected. These samples should be comprised of samples collected from at least five separate trailer loads, five separate storage bins or five points within the stockpile. The five sample units can be combined. When samples are collected from stockpiles or bins they should be taken from the top, middle and bottom of the pile.

8.1.2.6 Collecting almonds at hulling and shelling

Samples collected at receival for moisture testing should consist of a minimum of 1kg.

Where samples are to be collected over a one week period for testing as a weekly composite, retain each day's sample separately for dispatch to the laboratory. Each day's sample may consist of a grab sample taken at random or a number of combined grab samples taken from separate bins throughout the day. The daily sample should represent a lot or batch. A lot or batch may represent one grower's product. Each daily sample should consist of a minimum of 500 grams, thus providing a weekly composite of 2.5kg.

These weekly composites are to be retained by the laboratory. At the end of each month the remaining portions of the weekly composites are combined to make a monthly composite from which a sub-sample is drawn by the laboratory for aflatoxin testing.

Where MRL testing is required a minimum of 1 kg should be collected.

Where hulls and shells are sampled a minimum of 500g should be collected (equivalent to 5 x 100g samples) for microbiological testing and a minimum of 1kg for MRL testing.

8.1.2.7 Collecting almonds at processing and value adding

Samples collected at receival for moisture testing should consist of a minimum of 1kg.

Where almond kernels are collected from continuous batch processing lines sub-samples should be collected approximately every hour to provide up to a total of ten sub-samples. This should be taken to represent a lot or batch. A lot or batch may be a day's production, a product type, or a defined group of grower's product. Each sub-sample for the day is combined as the daily sample. Each sub-sample should consist of a minimum number of grams to provide a total sample of 500g per day from which the microbiological tests are conducted.

Each daily composite is retained by the laboratory. At the end of each month the remaining portions of the daily composites are combined to make a monthly composite from which a sub-sample is drawn by the laboratory for aflatoxin testing.

Where samples are to be collected over a one week period for testing as a weekly composite, a minimum of 100g of kernels is to be collected each day. This should comprise of a minimum of five subsamples of 20g taken at regular intervals throughout the day and should be representative of the batch that has undergone the treatment being monitored.

This provides:

5x20g = 100g per day; 100g x 5 days = 500g weekly composite

Where MRL testing is required a minimum of 1 kg should be collected.

8.1.3 Surface swab samples

Sampling for surface contamination should be undertaken to provide the maximum chance of detecting organisms if they are present. Sites should be chosen to include areas of equipment that are known to be difficult to clean and sanitise or where a build up of organic material is likely.

Surface swabs collected for pathogen testing should cover a minimum of $100cm^2$ surface area. Swabs collected for enumerating total viable organisms should cover a minimum surface area of $10cm^2$. It is important to sample a consistent surface area size so that trends in results can be appropriately interpreted and results applied against guideline values where relevant.

9 REFERENCED DOCUMENTS

9.1 Almond Board of California

Food Quality and Safety Program
Good Manufacturing Practices for Almond Handlers ABC 083101
Good Agricultural Practices for Growers Traceback Procedures
Sanitary Standard Operation Procedures ABC.SSOP.083101

9.2 An Introduction to Commercial Almond Growing in Australia F.J. Gathercole SARDI Loxton Centre for Australian Almond Growers Association

9.3 Australian Drinking Water Guidelines. National Water Quality Management Strategy. NHMRC NRMMC 2004

9.4 Australian Water Quality Guidelines for Fresh and Marine Waters. Australia and New Zealand Environment and Conservation Council November 1992

9.5 Beuchat, L.R. and Heaton, E.K. *Salmonella* Survival on Pecans as influenced by Processing and storage Conditions Appl Microbiology June 1975 Vol 29:(6) pp 795-801

9.6 Isaacs, S. Aramini, J. et al. An International outbreak of Salmonellosis associated with raw almonds contaminated with a rare phage type of *Salmonella* enteritidis J. Food Protection Vol 68(1):191-198

9.7 King, A.D, Miller, M.J. and Eldridge, L.C. Almond Harvesting, Processing and Microbial Flora Appl. Microbiology Aug 1970 Vol 20:(2) p208-214

9.8 Kokal, D. and Thorpe, D Occurrence of *Escherichia coli* in Almonds of Nonpareil Variety Food Technology 1969 Vol 23: 227-232

9.9 Discussion Paper on Aflatoxins in Tree Nuts Codex Alimentarius Commission FAO WHO CX/FAC 03/23 – Rev 1 2003

9.10 Draft Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Tree Nuts Codex Alimentarius Commission FAO WHO CX/FAC 04/36/21

9.11 Guidelines for On-Farm Food Safety for Fresh Produce 2nd Edn 2004 Dept of Agriculture Fisheries and Forestry, Horticulture Australia Ltd

9.12 Guidelines for the Management of Microbial Food Safety in Fruit Packing Houses Bulletin 4567 Dec 2002 Department of Agriculture Western Australia

9.13 Macadamia Industry Quality Handbook – Minimum Standards and Guidelines. Australian Macadamia Society Ltd 2001

9.14 Manual on the Application of the HACCP System in Mycotoxin Prevention and Control FAO/IAEA 2001

9.15 Microorganisms in Foods 2 Sampling for microbiological analysis: Principles and specific applications. International Commission for Microbiological Specifications for Foods (ICMSF) 1986

9.16 Recommended International Code of Hygienic Practice for Tree Nuts Codex Alimentarius CAC/RCP 6-1972

9.17 Schade, J.E., McGreevy, K., King Jr, A.D., Mackey, B. and Fuller, G. Incidence of Aflatoxin in California Almonds. Appl Microbiology Jan. 1975 Vol 29: (1) pp 48-53

10 APPENDIX

10.1 Appendix 1 Definitions

Aflatoxins – a group of structurally related toxic compounds produced by some strains of *Aspergillus* fungi, capable of causing cancer

Code of Practice – a guideline document that can be incorporated into law if required, to assist industry in fulfilling food safety, quality, or other obligations

Colony Forming Unit (cfu) – the colony of a microorganism growing on an agar plate arising from the growth of a single cell or from a clump of cells. Each colony forming unit is assumed to relate to an original cell in the sample under test.

Critical limits - specified tolerances that must not be exceeded to ensure the process remains in control

Extraneous Residue Limit (ERL) – the maximum permitted limit of a pesticide residue, arising from environmental sources other than the use of a pesticide directly or indirectly on the food, expressed in milligrams of the chemical per kilogram of the food (mg/kg)

Escherichia coli – a organism used as an indicator of faecal contamination and the hygienic status of food. Some types are human pathogens.

Faecal contamination – the introduction into or onto nuts of microorganisms that originate from the gastrointestinal tract of animals or humans

Food-borne illness – illness transmitted by food caused either by infection or toxin

Good Agricultural Practices – the basic environmental and operational conditions that are necessary for the production of safe, wholesome tree nuts

Good Hygiene Practices – the measures and controls to ensure the safety and wholesomeness of food

Good Manufacturing Practices – the actions necessary throughout a process to ensure safe, clean and wholesome food products by prevention of contamination

Guidelines – advisory criteria that assist in consistent application of good practices and controls. They generally do not have regulatory backing.

HACCP – Hazard Analysis Critical Control Point – a method to identify, evaluate and control specified hazards

Hazard – a source of potential harm or a situation with a potential to cause loss. A food safety hazard is any biological, chemical, or physical substance or property that can cause an unacceptable health risk to consumers

Maximum Residue Limit (MRL) – the maximum level of an agricultural or veterinary chemical which is permitted to be present in a food, expressed in milligrams of the chemical per kilogram of the food (mg/kg)

Microbes/microorganisms – bacteria, yeasts, moulds, viruses, and parasites

Microbiological criterion – a microbiological value (eg. number per gram) established by use of defined procedures and applied in acceptance sampling of food

Most Probable Number (MPN) – a statistical technique for estimating the most probable number of bacteria per unit of the sample under test. The MPN is estimated from responses (positive or negative) in one or more decimal dilutions of the sample that are then referred to statistical tables from which can be calculated, with a known degree of certainty, the most probable number of bacteria per unit of sample.

Pathogen/Pathogenic – a microorganism capable of causing disease or illness in humans

Potable water – water that is suitable for drinking or food processing on the basis of both health and aesthetic considerations

Quality assurance – a framework in which hazards and risks are identified and managed to satisfy required product quality and food safety

Risk – the chance of something happening that will have an impact upon objectives. It is measured in terms of likelihood and consequences.

Risk analysis – a systematic use of available information to determine how often specified events may occur and the magnitude of their consequences

Risk assessment – the overall process of risk analysis and risk evaluation

Risk evaluation – the process used to determine risk management priorities by comparing the level of risk against predetermined standards, target risk levels or other criteria

Risk management – the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects

Salmonella – a widely distributed food-borne pathogen whose primary reservoir is the intestinal tract of humans, animals, and reptiles

Standards – developed by a relevant government authority and passed in law to provide regulatory backing

10.2 Appendix 2 Checklists of Risks based on Stage of Almond Production

Table 4 A guide to water quality requirements based on the stage of almond production and use

	Growing/Harvesting	Hulling/Shelling	Processing/Value Adding
Know the quality of the water in use	✓	✓	✓
Water should comply with ADWG 2004		✓	✓
Water should comply with AWQGFMW	✓		
If water does not comply treatment is required		✓	✓
If water does not comply management strategies to minimise risk are required	✓		

ADWG Australian Drinking Water Guidelines 2004
AWQGFMW Australian Water Quality Guidelines for Fresh and Marine Waters

Table 5 Assessment of the risks of soil contamination

	Growing/Harvesting	Hulling/Shelling	Processing/Value Adding
Risk of soil contamination: Low High	 ✓	 ✓	 ✓
Controls to reduce soil contamination required	✓	✓	✓

Table 6 Key areas of personnel control based on the stage of almond production the food handler is involved in

Procedure	Growing/Harvesting	Hulling/Shelling	Processing/Value adding
Handwashing after:			
- visits to the toilet	✓	✓	✓
- blowing the nose, coughing or sneezing	✓	✓	✓
- eating and smoking	✓	✓	✓
- handling rubbish	✓	✓	✓
- performing maintenance on equipment		✓	✓
- breaks		✓	✓
Eating and the use of tobacco and chewing gum are not allowed	Designated areas away from machinery and fallen nuts should be used	✓	✓
Use of hair nets and beard masks		✓ The tasks being performed should be assessed to decide the level of risk and the need to comply	✓
Cuts, minor wounds and abrasions to be covered using coloured bandage	✓	✓	✓
Use of protective clothing	✓	✓	✓
Clothing to be kept clean and changed daily	✓	✓	✓
Jewellery not to be worn	During harvesting	✓	✓

Table 8 Risk level of equipment and vehicles based on the stage of operations

	Growing/Harvesting	Hulling/Shelling	Processing/Value adding
Contamination from: Vehicles	High	High	Low
Storage bins/silos/rooms	High	High	Low
Conveyors / equipment	High	High	High
Packing		High	High

10.3 Appendix 3 Sample Collection Procedures

A PROCEDURES FOR COLLECTING WATER SAMPLES

Every care must be taken during water sampling to avoid contamination of the sample so that results obtained are truly representative of the water sampled. Where samples for several purposes are to be taken from the same source, the sample for bacteriological examination should be taken first.

Keep the sample bottle closed until the moment it is to be filled. Remove the screw cap, ensuring fingers do not come into contact with the neck of the bottle or with the inner surface of the screw cap. Hold the bottle near the base rather than the neck.

Fill the bottle without rinsing, leaving ample air space to facilitate mixing in the laboratory. (Fill to the level of the bottle's "shoulder"). Replace the screw cap immediately, observing the same precautions as for opening the bottle.

A.1 SAMPLING FROM A TAP

1. Remove any external fittings such as rubber tubes.
2. Clean any obvious contaminating material from the outside and inside of the tap.
3. Sanitise the tap opening either by
   (a) flaming with a butane or propane burner, or
   (b) wiping with cotton gauze soaked in alcohol
4. Turn on the tap fully and allow to run for 2 to 3 minutes to clear the service line.
5. Reduce the water flow to permit filling of the bottle without splashing.
6. Replace screw cap on bottle.
7. Return water sample to laboratory as soon as possible in an ice cooler. Samples must be kept cool but not frozen.

A.2 SAMPLING FROM A BODY OF WATER

1. Remove the screw cap from the bottle, and holding near the base, plunge the bottle neck downward below the surface.
2. Turn the bottle until the neck points slightly upward and the mouth is directed toward any current. If there is no current, create an artificial current by pushing the bottle forward horizontally in a direction away from the hand. Avoid the sides and bases of water basins, or the banks and beds of raw water supplies, to prevent sludge and other debris being collected in the sample.
3. When the bottle has almost filled with water, draw the bottle out of the water and immediately replace the screw cap.
4. Return the water sample to the laboratory, preferably within 6 hours, in an ice cooler. Samples must be received in the laboratory within 24 hours of collection. Samples must be kept cool but not frozen.

Record the company name, the site and date and time of sample collection on the bottle.

B PROCEDURES FOR COLLECTING SAMPLES OF ALMONDS

Samples should be collected using aseptic techniques as follows:

1. All utensils used in the collection of food samples shall be either:

   - Sterilised by autoclaving, or
   - Sanitised on site by wiping with an alcohol wipe immediately prior to use and allowing to air dry (air drying should take approximately 10 seconds), or
   - Sanitised on site by wiping with a paper towel or tissue soaked in methylated spirits and allowing to air dry.

2. Wear disposable gloves throughout the sampling process.
3. Where more than one sample is collected separate utensils shall be used for separate samples wherever possible. If two or more items need to be collected using the same utensils they must be:

   - Washed in potable water
   - Dried using paper towel and then,
   - Sanitised with an alcohol wipe or methylated spirits as outlined above between each sample.

4. All care shall be taken to prevent cross-contamination between samples.
5. Label the sampling container/bag with the following information:
   - company name
   - the date of collection
   - details of the sample (eg. blanched almond kernels)
   - date of manufacture if applicable
   - date of packing if applicable
   - batch number or lot number
   - Use By date or Best Before date if applicable
   - location of sampling if applicable (eg. pre-wash or post-wash, prior to packing)

6. Place gloves on hands
7. Remove the chosen sampling utensil/s from its packaging taking care not to touch the utensil with any surfaces other than the food product to be sampled. Where a utensil is sanitised immediately prior to use either:

   - Hold the utensil in the hand until used, or
   - Place the utensil onto a sanitised surface for a minimum amount of time prior to use

8. Open the container/bag so that the sample can be easily placed inside and taking care that the inside of the container/bag will not become contaminated during the sample transfer procedure.
9. Scoop the sample and transfer to the sample container/bag, taking care not to touch the sample or the sampling utensil on the outside of the container/bag during transfer.
10. Immediately fold over the bag and secure or replace the lid of the container. Place the sample into an insulated eski for transfer to the laboratory. Samples can be transported at ambient temperature but should be kept out of direct sunlight. If transport conditions would cause the sample temperature to exceed 250C an ice brick should be included in the eski.

C PROCEDURES FOR COLLECTING ENVIRONMENTAL SWABS

The swab supplied contains the swab stick and the swab sachet inside a soft plastic casing.

Proceed as follows for surface swabbing -

1. Tear the plastic casing across the corner as shown on the packet.

2. Choose the site to be swabbed. The area to be swabbed should be $100cm^2$ for pathogen testing and $10cm^2$ for enumerating total viable organisms.

3. Remove the swab sachet from the plastic casing. Remove the stopper from the sachet containing the transport medium and discard.

4. Carefully remove the swab stick from the plastic casing, taking care not to touch the swab end with any surfaces or the sampler's hands.

5. Place the swab stick into the sachet so that the cotton end is moistened by the transport medium.

6. Carefully remove the swab stick from the sachet and immediately swab the chosen surface area as follows:

   Place the swab on the surface to be tested, and using a rolling motion by rotating the swab between thumb and forefinger, swab the designated area in one direction using parallel strokes, then swab at right angles to the original direction, using parallel strokes.

7. Immediately and carefully replace the swab in the labelled sachet, ensuring the swab does not come into contact with anything other than the surface that has been tested. Make sure the stopper on the end of the swab stick is pushed firmly into the sachet.

8. When all swabs have been collected replace in the plastic bag supplied, and place in an insulated Esky container with an ice brick.

9. Return swabs to the laboratory as soon as possible and preferably within 2 hours. If there is to be any delay in transporting the swabs to the laboratory, store the swabs in a refrigerator until transport proceeds. The laboratory should start testing the swabs within 24 hours of collection.

10.4 Appendix 4 Relevant Guidelines and Standards

<u>Water Samples</u>

Refer to the following documents:

Australian Drinking Water Guidelines. National Water Quality Management Strategy. NHMRC NRMMC 2004
Australian Water Quality Guidelines for Fresh and Marine Waters. Australia and New Zealand Environment and Conservation Council November 1992

<u>Almonds</u>

Aflatoxins:
The Australia New Zealand Food Standards Code regulates aflatoxin levels in tree nuts at not greater than 0.015 mg/kg (which is equivalent to 15 µg/kg or 15 parts per billion). Allowable levels vary between countries and regions.

Microbiological Criteria:
The Australia New Zealand Food Standards Code does not provide microbiological criteria for tree nuts. The following criteria are drawn from currently available data in the literature and may be used as a general industry guide for finished product. Some businesses may choose to apply more stringent or additional microbiological criteria.

Test	Limit
Standard plate count	Less than 30,000 CFU per gram
E. coli	Less than 3 MPN per gram
Salmonella	Not detected in 250g
Yeasts and Moulds	Less than 10,000 CFU per gram

Processors may need to meet additional criteria or differing limits to comply with market requirements.

It should be remembered that detection limits may be exceeded from time to time and this does not necessarily result in failure of a batch. Failure of a batch depends on many factors such as the degree to which a limit is exceeded, the specific criterion that has failed and interpretation of the trend in results over time.

Maximum Residue Limits:
The Australia New Zealand Food Standards Code regulates permissible MRL’s in Standard 1.4.2. MRL’s for tree nuts apply. For routine monitoring a comprehensive MRL screen that includes organochlorines, organophosphates, carbamates and synthetic pyrethroids is recommended.

Australian almond export product MRL compliance review.

AKC Consulting Pty Ltd
26/12 Phillip Mall
West Pymble NSW 2073.

Summary:

This report reviews the current state of residue testing in the almond industry with regard to MRL compliance for export markets such as Japan. The report proposes possible options to address identified areas of concern.

It is apparent that current residue testing within the industry lacks the necessary breadth and scientific rigour to provide certainty that nut kernels were MRL compliant. The industry needs to consider completely revising the current *ad hoc* approach.

As a starting point the almond industry should update information on pest management requirements. A survey was completed in 2001 of pest and chemical needs the output of that survey needs to revisited to identify new chemical requirements, should they exist. This would ensure that appropriate approvals would be sought and residue monitoring adjusted.

The almond industry should also look to the development of in-field chemical management guidelines. The guidelines should be targeted at growers and provide information on products approved for use in almonds and harvest intervals required to ensure compliance with MRLs in major export destinations.

An industry wide residue monitoring program should be initiated. The residue monitoring program should be uniform across the industry, be designed to include current international best practises with regard to sample management and residue analysis and incorporate a data management element. auditing to confirm that the commodity is MRL compliant. System must be rigorous and scientifically valid.

Finally that consideration is given to developing a suitable program in conjunction with the NRS.

Table of Contents

1. Introduction

The Japanese positive list system for MRLs is to come into effect on May 29th, 2006. Following its introduction it will be illegal to distribute food in Japan that contains residues above the level specified in the list or if no MRL exists then residues must be below 0.01 mg/kg, i.e., 10 ppb. The provisional MRLs in the positive list will cover nearly 800 chemicals and have been developed through the incorporation of MRLs from a number of trading partners, e.g., EU, USA, Canada, Australia & NZ, and Codex standards. The positive list has been developed over a three year period of consultation and provided opportunities for input from interested trading partners via comment and/or the introduction of new data.

As Australia exports almonds to Japan, the industry is seeking advice on the capacity of current residue monitoring programs to meet compliance requirements and identify possible options that could be pursued to overcome potential areas of deficiency.

2. Methodology

2.1 Liaison

To collect the necessary information discussions (email, face-to-face and via telephone) were held with relevant government and almond industry stakeholders. This involved:-

- Liaising with regulatory organizations, including the Japanese MHLW[1], APVMA, DFAT and DAFF regarding issues arising from the positive list system.

- Liaising with key almond industry stakeholders regarding issues relating to residue monitoring and the implementation of the Japanese positive list system.

- Liaison with analytical laboratories with respect to their capacity to undertake the required residue analysis and its cost.

[1] Ministry of Health, Labour & Welfare.

2.2 Data collection

Data on current Australian and Japanese MRLs and regulations was gathered either directly from staff or via the APVMA, FSANZ, and MHLW websites.

3. Results

3.1 List of current chemicals approved for use in the almond industry

Outlined below is a breakdown of MRLs for chemicals with Australian approvals in almonds and their corresponding MRLs on the Japanese Provisional MRL listing, the established MRLs and Codex. Highlighted in Table 1 are those MRLs where Japanese standards are below those currently established in Australia, i.e., potentially problematic from a compliance perspective.

Table 1. Outline of chemicals with MRLs, approved for use in Almonds.

Active ingredient	Trade Names	Aust MRLs	Codex MRLs	Japanese MRLs	
				Established	Provisional
azoxystrobin	Amistar	T0.02	-	0.02	-
captan	Captan	T0.3	0.3	-	0.3
carfentrazone-ethyl	Hammer	*0.05	-	-	0.08
chlorothalonil	Bravo	T0.1	-	-	0.05
clofentezine	Apollo	T0.5	-	0.5	-
Copper	Various	25.0	-	-	Exempt
dicofol	Mastamite	5.0	-	-	3.00
diquat	Sprayseed	*0.05	-		0.03
glufosinate-ammonium	Basta	0.1	0.1	0.1	-
glyphosate	Round-up	0.2	-	1.0	-
haloxyfop	Verdict	*0.05	-	-	0.05
iprodione	Rovral	*0.02	0.2	10.0	-
isoxaben	Gallery	*0.01	-	-	-
maldison	Maldison	8	-	8.0	-
mancozeb	Dithane	T3	0.1	-	0.10
napropamide	Devrinol	*0.1	-	-	0.10
norflurazon	Zoliar	*0.2	-	-	0.20
oryzalin	Surflan	0.1	-	-	0.08
oxyfluorfen	Goal	0.05	-	-	0.05
paraquat	Sprayseed	*0.05	-	-	0.05
pendimethalin	Stomp	*0.05	-	0.05	-
phosphorous acid	Various	T1000	-	-	Exempt
piperonyl butoxide	Pestigas	8	-	-	8
pirimicarb	Pirimor	T*0.05	-	0.5	-
propiconazole	Tilt	T0.2	0.05	0.05	-
pymetrozine	Chess	T*0.02	-	-	0.02

Active ingredient	Trade Names	Aust MRLs	Codex MRLs	Japanese MRLs	
				Established	Provisional
pyrethrins	Pestigas	1.0	1.0[#]	1.0	-
pyridaben	Sanmite	T*0.05	-	1.0	-
simazine	Gesatop	*0.1	-	-	0.2
spinosad	Naturalure	T*0.01	0.01	0.02	-
Sulphur	Various	Exempt	-	-	exempt
tetradifon	Mastamite	5.0	-	-	1.0
trifluralin[∇]	Treflan	Not set	-	0.05	-
zinc phosphide/phosphine[2]	MouseOff	*0.01	-	-	0.01

In terms of the compounds with higher Australian MRLs, i.e., chlorothalonil, mancozeb, dicofol, oryzalin, propiconazole and tetradifon, the likelihood of an MRL breach occurring must be considered and thought given to how to minimise that risk. For oryzalin it is unlikely that the MRL difference would result in compliance breaches.

For other compounds where provisional MRLs are below Australian MRLs it may be possible identify determinant use patterns from which the provisional MRL was derived. For example, the provisional MRL for chlorothalonil is equivalent to that of the US MRL, i.e., 0.05 mg/kg. The US MRL is based upon a rate of 3.36-5.0 kg ai/ha with a 14 day withholding period. The Australian MRL of 0.1 mg/kg has been based upon a rate of 2.3 kg ai/ha with a 7 day withholding period. It may, therefore, be possible to extend the pre-harvest interval to 14 days as a means of ensuring compliance with the provisional Japanese MRL. It may be possible to also use this approach to develop ‘Export Withholding Periods’ for those other compounds where provisional MRLs are lower than Australian equivalents.

3.2 Current chemical Use

A profile of chemicals used in almonds has been collated from information provided by almond processors (see Table 2). This information provided only consisted of the chemicals applied, it is uncertain whether use pattern data is also collected, i.e., rate and timing. If this data is not collected consideration should be given to its collection

[#] New Codex MRL of 0.01 mg/kg proposed
[∇] PER5214
[2] Japanese MRL is for Hydrogen phosphide

by the processors as it would aid in confirming compliance with product labels in the event of an MRL breach.

In this listing three chemicals were identified as having been used in almonds for which no APVMA approval exists. The use of these three chemicals could be due either to off-label use or the Victorian Control of Use regulations. Under the Control of Use legislation in Victoria a grower can apply non-prescribed chemicals to any crop provided a) it is registered for use in Victoria, b) the maximum label rate is not exceeded, and c) there are nil residues at harvest. If such uses do originate from Victoria then given the last requirement an argument can be made that they should monitored for. However, given that such uses may only be occasional anticipating the need for their inclusion could be difficult. Further monitoring for such uses could be problematic as they may be viewed negatively by QA schemes and Japanese importers, i.e., no MRL, regardless of Victorian regulations.

The occurrence of potentially off-label uses highlights the need for the almond industry to update its pest management requirements. A survey of growers was undertaken in 2001 that identified a priority list of chemicals deemed as necessary for crop production. From this list a number of permits were sought to ensure that all chemicals used had regulatory approvals. Given the length of time that has elapsed since that review was completed the industry should consider updating its priorities and in the event that new chemicals being needed seek relevant approvals. Also linked to the chemical survey should be the development of pest and disease control guidelines. This would help ensure growers used the correct chemicals for specific problems, and provide a potential basis from which an industry best management (Quality Assurance) program could be built.

Table 2. List of current chemicals recently used in the almond industry.

Chemical	Trade name	Regulatory status
Bacillus thuringiensis	Dipel	Approved
Bromoxynil / diflufenican	Barracuda	Not registered
Captan	Captan	PER5654
Carbendazim	Spin Flo	Not registered

Chemical	Trade name	Regulatory status
Carfentrazone-ethyl	Hammer	Approved
Chlorothalonil	Bravo	Approved
Copper	Various	Approved
Diquat	Reglone	Approved
Glufosinate	Basta	Approved
Glyphosate	Round up	Approved
Petroleum oil	Summer oil	Approved
Iprodione	Rovral	Approved
Mancozeb	Penncozeb	Approved
Oxyfluorfen	Goal	Approved
Paraquat/Diquat	Sprayseed	Approved
Pendimethalin	Stomp	Approved
Phosphoric acid	Various	PER7161
Propargite	Omite	Not registered
Propiconazole	Tilt	PER5652
Simazine	Gesatop	Approved/PER8061

3.3 Current residue testing

All the processors contacted indicated that residue testing is undertaken on a routine basis and that NMI was used to do the analyses. However, while the number of chemicals analysed for was relatively high the number with almond approvals was low (see Table 4). As a result it could be argued that the testing undertaken to date might be of a limited value, particularly for the purposes of confirming MRL compliance.

Table 3. Compounds for which residue testing currently occurs, with approvals in almonds.

Compound	Almond MRL	Cost ($)
Oxyfluorfen	0.05 mg/kg	220
Pendimethalin	0.05	220
Captan	T0.3	220
Chlorothalonil	0.1	220
Iprodione	0.02	220

Compound	Almond MRL	Cost ($)
Propiconazole	T0.2	220

For residue monitoring to provide confirmation of MRL compliance, i.e., act as an audit, the industry will need to consider broadening the range of pesticides analysed. In addition, for the data to be of value the analyses would need to be done by suitably accredited (GLP) laboratories. The analyses would also have to be done to suitable levels of sensitivity, i.e., match analytical limits to those required for compliance purposes. This would be particularly important for exports to markets such as Japan where MRL breaches are viewed unfavourably.

The industry should, in the future, also give thought to developing a system which links in-field chemical management practises to residue testing results, i.e., capturing and linking spray diary data to residue results. Having such a system would provide two potential benefits. It would allow for a rapid response in the event of an MRL breach, i.e., traceback, and build a database which could be used to refine chemical management practises, i.e., aid in the development of export harvest intervals.

3.4 Residue testing options currently available

A number of laboratories were approached to provide quotations for undertaking residue analyses for aflatoxins and all chemicals with current approvals in almonds. All laboratories indicated that analysis could be undertaken to the required analytical detection levels. NMI indicated that for a number of compounds analysis could not be done in-house, as yet, and would need to be sub-contracted to other laboratories. Listed below are the laboratories approached and their quotations. See Attachment I for the full quote details.

Table 4. Quotations for analysis of almond kernels for all currently approved pesticides + aflatoxins.

Laboratory	Turn-around	Quote ($)
Agrisearch Analytical	2 weeks	1095
Amdel	1-3 weeks	1050
PIR Vic (SCL)	3-4 weeks	3962
NMI	2 weeks	4730
SGS	1-2 weeks	950

Laboratory	Turn-around	Quote ($)
Qld Health	-	NIP[3]

Coupled with a broadened testing regime the industry must also consider developing a uniform regime for the collection, transportation and documentation of nut samples. A possible starting point could be the Codex recommended methods of sampling[4]. The Codex document outlines sampling procedures to be follow to ensure representative samples are obtained prior to analysis. A standardised form of documentation covering such issues as dates of despatch, receival, analysis, storage conditions etc, is also needed to ensure that analytical results are acceptable in terms of importing country requirements.

3.5 Data management

At present there is no coherent system, across the almond industry, to collect and collate the data referred to above or data currently being generated. To effectively address any potential import or MRL compliance issues the industry needs to be able to provide valid historical information on past levels of compliance. Such information could also be used to justify a move to a more focused residue testing programs, i.e., targeting chemicals where positive detections may be considered problematic rather than testing for all chemicals. This could help ensure that any future monitoring programs would be cost effective. For such a system to be of value, however, the data collected must be of a suitable quality and standard.

4. Conclusion:

From the above it is apparent that current residue testing regimes lack the necessary breadth and scientific rigour to be considered helpful in attempting to assure industry customers that any chemical residues would be MRL compliant. The industry needs to consider completely revising the current *ad hoc* approach and look to developing an industry wide residue monitoring program. The elements of any such program must, however, be uniform and consistent with internationally recognised procedures, e.g., GLP accredited laboratories. The number and quality of pesticide analyses needs to be

[3] Qld Health Laboratory indicated that they were not in a position to quote for the work.
[4] CAC/GL 33-1999

broadened, sampling regimes and a means of managing the resultant data also need to be developed.

Given that the development and management of such systems, as outlined above, would require specific expertise the almond industry should consider what opportunities exist for outsourcing this service. From discussions it is apparent that the National Residue Survey (NRS) has the necessary capacity and skill to fulfil this function for the almond industry. This group within DAFF have specific expertise in all areas associated with residue analysis and validation, sample collection, data collation and management. They are currently used by a broad range of agricultural industry groups such as macadamia nuts, pome fruit, cereal grains and red meat. They can also serve the secondary role of industry advocate in the event of an MRL breach where government to government liaison is required.

The almond industry should also consider the development of pest and disease and in-field chemical management guidelines. These guidelines could specify which chemicals can be used for what pest or disease and/or include explicit harvest intervals for kernels destined for export markets. Having such information available should, ostensibly, remove the 'guesswork' with regard to MRL compliance in export markets.

5. Recommendations:

Recommendations flowing from the review are outlined below.

1. The industry should update current information on pest management needs by;
    a. Having a specialist(s) undertake a gap analysis and review and assess available pest management options.
    b. Having a pest and disease control guidelines developed for distribution to growers.

2. That the industry considers developing in-crop chemical management guidelines. The guidelines should include;
    a. Information on products approved for use in almonds.

  b. Harvest intervals to ensure compliance with MRLs in major export destinations.

3. That an industry wide residue monitoring program be initiated. The residue monitoring program should;
   a. Be uniform across the industry.
   b. Be designed to include current international best practises with regard to sample management and residue analysis.
   c. Incorporate a data management element.

4. That consideration is given to developing a suitable program in conjunction with the NRS.

Attachment I. Analytical Laboratory Quotations.

National Measurement Institute Quotation

Australian Government
National Measurement Institute

Quotation Number:*	AGAW01A-BR602
Date:	February 17, 2006
Validity:	May 17, 2006

THIS QUOTE NUMBER MUST APPEAR
ON ALL PAPERWORK.
NO QUOTE NUMBER - PREMIUM PRICES APPLY

L

QUOTED TO:

Contact:	Peter Dal Santo
Company:	AGAWARE CONSULTING PTY LTD
ABN:	
Address:	21 Rosella Avenue, Strathfieldsaye VICTORIA 3551
Telephone:	03 5439 5916 / 0407 393 397
Facsimile:	03 5439 3391
e-mail address:	pds@agaware.com.au
Customer Reference:	As per your email request to Ben Reys dated 13/02/06
Job (Project Name or No.):	Analysis of Almonds

51 – 65 Clarke Street
South Melbourne VIC 3205

Phone: +61 3 9685 1777
Facsimile: +61 3 9685 1788

www.measurement.gov.au

ABN 51 835 430 479

Dear Peter

Thank you for the opportunity to quote for the analysis of

Sample Type	No. of Samples	Test	Limit of Reporting mg/kg	Price Per Sample $	GST @10% $	Total Per Sample $
		Inorganics				
		Copper - total	0.5 mg/kg	$ 65.00	$ 6.50	$ 71.50
		Sulphur - total		$ 65.00	$ 6.50	$ 71.50
		Organic Residues				
		GC Screen including:				
Almonds	30-50	*Maldison / Malathion*				
		Oxyfluorofen				
		Piperonyl butoxide				
		Simazine				
		Propiconazole				
		Pirimicarb	0.05mg/kg	$ 200.00	$ 20.00	$ 220.00
		Pendimethalin				
		Tetradifon				
		Trifluralin				
		Captan				
		Chlorothalonil				
		Iprodione				
		Dithiocarbamates (includes Mancozeb/Dithane)	0.1 mg/kg	$ 110.00	$ 11.00	$ 121.00
		Pyrethrins	1.0 mg/kg	$ 130.00	$ 13.00	$ 143.00
		Phosphorous Acid	1.0 mg/kg	$ 155.00	$ 15.50	$ 170.50
		Organic Residues - NMI NSW				
		Aflatoxins by ELISA screen (B1, B2, G1, G2)	5 ug/kg	$ 75.00	$ 7.50	$ 82.50
		Aflatoxins confirmation by HPLC	1 ug/kg	$ 130.00	$ 13.00	$ 143.00
		Organic Residues (Sub-contracted)				
		Carfentrazon-ethyl	0.05 mg/kg			
		Clofentezine	0.5 mg/kg			
		Diquat & Paraquat	0.05 mg/kg			
		Haloxyfop	0.05 mg/kg			
		Spinosad	0.01 mg/kg			
		Glyphosate	0.2 mg/kg			
		Azoxystrobin	0.02 mg/kg			
		Glufosinate (glufosinate ammonium)	0.1 mg/kg	$ 3,500.00	$ 350.00	$ 3,850.00
		Isoxaben	TBA			
		Naproamide	0.1 mg/kg			
		Norflurazon	0.2 mg/kg			
		Oryzalin	0.05 mg/kg			
		Phosphine	0.01 mg/kg			
		Pymetrozine	0.02 mg/kg			
		Pyridaben	0.05 mg/kg			

Standard Fees		
Handling Fee.	A standard Handling Fee of $33.00 inclusive of GST (GST component $3.00) applies per invoice.	$33.00
Minimum Invoice Policy.	A minimum Invoice of $275 inclusive of GST applies This includes the $33.00 handling fee.)	EXEMPT

Comments & Special Conditions:

1. LORs are targets only and may be revised if your samples are found to contain substances which cause interferences, or if matrix effects become apparent, during analysis.

2. These prices are based on a minimum batch size of 6. Higher prices will apply for smaller batches.

3. NMI is NATA and GLP accredited for all in-house analysis.

4. If individual or selected analytes of subcontracted list is required, individual cost of analyses will be negotiated dependent on batch sizes.

*Please ensure the above NMI Quotation Number appears on all correspondence, sample submission or chain of custody forms. Sample analysis is dependent on this condition.

The prices shown are per test per sample and are based on the sample numbers detailed in your request. The prices also apply to any additional sample(s) requiring similar analytes delivered at the same time.I trust this quotation is suitable to your requirements. If you require any further information please contact NMI on (03) 9685 1777, Fax (03) 9685 1788 or email to<michelle.duffy@measurement.gov.au>

Goods & Services Tax	GST at the applicable rate (currently 10%) will be charged. NMI will issue valid tax invoices and adjustment notes as per requirements of GST legislation
Agreed Turnaround Time	Typically 10 working days from receipt at laboratory Sub-contracted analyses may require a longer TAT

Quoted By:

Ben Reys - Business Development Manager

Date 17/02/2006

NMI SERVICE TERMS & CONDITIONS

The lodgment of an order or receipt of samples for NMI services constitutes an acceptance of the following terms and conditions.

Unless otherwise agreed in writing, the following terms and conditions apply to services conducted by NMI, resulting from engagement of NMI either by accepting a quotation and/or submission of samples to NMI. The client agrees to be bound by and comply with these terms and conditions. Any terms and conditions you notify to NMI, will apply only if and to the extent that NMI agrees to them in writing.

SERVICES

NMI reserves the right to review prices at any time if: (a) significant changes to our costs are incurred beyond our control ie. changes to legislative requirements or variations in tax or excise rates; or (b) any of the assumptions set out in the quotation prove to be incorrect.

Alterations to the scope of the quoted services (including changes to timeframe of services, sample numbers, limits of reporting, agreed analyte suite etc), prior to commencement of the services, may require a review of the quotation.

Alterations to client requirements requested after commencement of the testing process will incur an administration fee of $22 inclusive of GST plus charges for extra service delivery costs incurred by NMI, if any.

Records will be kept for the required minimum period unless otherwise requested and agreed to by NMI (eg NATA technical accreditation requires records are kept for a minimum of three years).

BUSINESS HOURS

Services will be provided by NMI during normal business hours Monday to Friday (excluding public holidays), unless otherwise agreed.

Any services conducted outside NMI premises will be performed Monday to Friday (excluding public holidays) between 9am and 5pm, unless otherwise agreed.

TURNAROUND TIMES

Any samples received after 1630 hrs Monday to Friday or on Public Holidays are deemed to have been received the following working day.

It is the client's responsibility to ensure that NMI has access to all information and premises necessary to commence the services as agreed.

The due date of the services may be delayed where such information or access is not provided, or is judged by NMI to be inadequate for the services to commence.

ACCOUNTS & PAYMENT

GST at the applicable rate (currently 10%) will be charged in addition to the quoted prices. NMI will issue valid tax invoices and adjustment notes as per requirements of GST legislation.

A minimum invoice fee inclusive of GST applies (this includes a handling fee per invoice).

The establishment of a trading account is subject to the completion of an account application form.

NMI reserves the right to undertake credit verification of all established accounts or to request up-front payment of services before services can commence.

Terms of payment are strictly 30 days from date of invoice. A late fee of up to $11.00 inclusive of GST may apply if the client does not pay in full by the due date.

TREATMENT OF SAMPLES

Unless NMI has otherwise agreed in writing, the client is responsible for collecting samples and for delivering samples for testing to the address nominated in the quotation.

When providing samples to NMI, the client must give written notice of all known safety or health hazards and special procedures relevant to the handling, testing, storage, transport and disposal of samples. NMI reserves the right to refuse to conduct any test where NMI in its absolute discretion determines such testing may pose a safety or health hazard.

Where a formal request is made, NMI will return samples to the client, at the client's expense.

The client acknowledges that during conduct of the services the samples or parts of samples may be altered, damaged, lost or destroyed. NMI shall not be liable to the client or any third party for any samples that are altered, damaged, lost or destroyed during conduct of the services.

The client is responsible for ensuring that samples supplied for testing are representative of the product or material to be analysed and for retaining any duplicate or control samples.

Unless NMI has otherwise agreed in writing, NMI shall not be obliged to return samples to the client and may in its discretion store, experiment on, destroy or dispose of samples.

NMI reserves the right for samples deemed hazardous by NMI to be returned, to the client, at the client's expense.

Where possible a representative sample will be kept for a period of one (1) month from the date of final report. NMI will charge for costs incurred for longer term storage, or for disposal of noxious samples.

OWNERSHIP

NMI will own the final report until such time as full payment for the services is received, beyond which time the client will own the final report.

All intellectual property rights associated with sample analysis methods, processes and reports are vested, and shall remain vested, in NMI. No other party may replicate or appropriate the method or any part thereof for any use, be it commercial or otherwise, without the express written consent of NMI's General Manager or approved delegate.

LEGAL OBLIGATIONS

NMI, its proprietor, its officers, employees and agents are under no legal obligation to provide information or expert witnesses as an outcome of any testing undertaken at NMI.

Any requests for NMI, its proprietor, its officers, employees and agents to provide information or expert witnesses will not be granted without the express written consent of NMI's General Manager or approved delegate.

In circumstances where NMI, its proprietor, its officers, employees or agents agree or are required to provide information or appear as expert witnesses as an outcome of testing undertaken at NMI an hourly fee will be charged to the client.

FORCE MAJEUR

NMI shall not be responsible or liable for any delay to perform any of its obligations when such delay or failure to perform any of its obligations is caused by unforeseen circumstances beyond its reasonable control and without its fault or negligence, including, without limitation, Acts of God, fire, explosion, riot, sabotage, strike or other labor dispute, shortage of materials, transportation difficulties or compliance with any order, action, governmental officer, department, agency, authority or committee thereof that renders performance impracticable or impossible for NMI.

EXCLUSION OF WARRANTY

To the full extent permitted by law NMI and its proprietor exclude all warranties, terms, conditions or undertakings, ('terms'), whether express or implied, in relation to services, the report or its contents. Where any legislation implies any terms which cannot be excluded or modified then such terms shall be deemed to be included. However, (to the full extent permitted by law) NMI's liability to the client is limited at NMI's option to the re-performance of service or the refund of service fee.

Without limiting the generality of this clause, it is agreed that, to the full extent permitted by any applicable Commonwealth, State or Territory laws having jurisdiction, NMI and its proprietor will not be liable to the client or any other person for any loss of profits or business whether directly or indirectly incurred or any special, indirect or consequential damages arising from the client's use of NMI's services or reports.

CLIENT'S RELEASE AND INDEMNITY

The client hereby releases and indemnifies and shall continue to release and indemnify NMI, its proprietor, its officers, employees and agents from and against all actions, claims, proceedings or demands (including any costs and expenses in defending or servicing same) which may be brought against it or them, in respect of any loss, death, injury, illness or damage to persons or property, and whether direct or indirect and in respect of any infringement of any industrial or intellectual property rights, howsoever arising out of the use of the report or the services of NMI.

CLIENT'S ACKNOWLEDGMENT

The client acknowledges that:

The client at its own risk uses the report and its contents and any advice, opinions or information supplied by NMI, its proprietor, its officers, employees or agents concerning the service;

The service is performed on the understanding that the client will not hold NMI, its proprietor, its officers, employees or agents liable for any loss or damage resulting from the conduct of the service or the use of or reliance upon the report or its contents; and

It is the responsibility of the client to make its own assessment of the suitability for any purpose of the service, report and its contents and any information or advice generated therefrom.

GENERAL

The services are governed by the laws of the State in which services have been conducted, unless Commonwealth law prevails.

The client will not represent in any way that NMI supports or endorses the client's business, goods or services, without NMI's written consent. The client will not make any press release or public statement about the services or NMI without NMI's written consent.

Agrisearch Analytical

QUOTATION- DETERMINATION OF MULT-PESTICIDE RESIDUES IN ALMONDS

QUOTE NO: S6-ABA-01 **DATE:** 14th February 2006

ANALYTEs: see below

SUBSTRATE: Almond kernels

METHODS:

AATM-13(modified): C3, C5, C4

PRICE/TEST ($)

Test Category	Compounds covered	Price/sample
GC/MS	carfentrazone-ethyl, chlorothalonil, clofentezine, dicofol, ipridione, maldison, napropamide, norflurazon, oxyfluorfen, pendimethalin, piperonyl butoxide, propiconazole, pyrethrins, simazine	225
LC/MS/MS	azoxystrobin, captan, oryzalin, pymetrozine, spinosad haloxyfop, isoxaben, pyridaben, pirimicarb	160
Herbicides	glufosinate-ammonium, glyphosate	225
Herbicides	diquat, paraquat	175
Dithiocarbamate	mancozeb	130
Metals*	copper, sulphur (det limit 100ppm)	60
Aflatoxins*		120
TOTAL		$1095

***Note: These tests would be sub-contracted to another NATA accredited laboratory**
Note: These prices are exclusive of GST
Note: These prices are based on receiving a minimum of 10 samples per sample submission

QUALITY ASSURANCE: The prices above included the following QA parameters:

- One in 20 samples will be a matrix spike
- All test samples are fortified with a surrogate compound.

QA results are available for customer evaluation.

TURNAROUND: 10 working days.

QUOTE APPROVED:

Ross Shields

Ross Shields

active ingredient	Possible Trade Names	Aust MRLs	Codex MRLs	Japanese MRLs		MRL level to be tested to
				Current	Provisional	
$135 for all a.i. below						
azoxystrobin - $80	Amistar	T0.02	-	0.02	0.02	**0.02**
spinosad - $80	Naturalure	T*0.01	0.01	0.02	0.02	**0.01**
$185 for all a.i. below						
captan - $60	Captan	T0.3	0.3	-	0.3	**0.3**
chlorothalonil - $60	Bravo	T0.1	-	-	0.05	**0.05**
dicofol - $60	Mastamite	5.0	-	-	3.00	**3.0**
Iprodione - $60	Rovral	*0.02	0.2	10.0	10.0	**0.02**
Isoxaben- $70	Gallery	*0.01	-	-	-	**0.01**
Maldison - $60	Maldison	8	-	8.0	8.0	**8.0**
Napropamide - $70	Devrinol	*0.1	-	-	0.10	**0.1**
Norflurazon - $70	Zoliar	*0.2	-	-	0.20	**0.2**
Oryzalin - $70	Surflan	0.1	-	-	0.08	**0.08**
Oxyfluorfen - $60	Goal	0.05	-	-	0.05	**0.05**
Pendimethalin - - $60	Stomp	*0.05	-	-	0.08	**0.05**
piperonyl butoxide - $60	Pestigas	8	-	-	8	**8.0**
Pirimicarb - $60	Pirimor	T*0.05	-	0.5	0.5	**0.05**
Propiconazole - $60	Tilt	T0.2	0.05	0.05	0.05	**0.05**
Pyrethrins - $80	Pestigas	1.0	1.0[#]	1.0	1.0	**1.0**
pyridaben - $70	Sanmite	T*0.05	-	1.0	1.0	**0.05**
Simazine - $60	Gesatop	*0.1	-	-	0.2	**0.1**
Tetradifon - $60	Mastamite	5.0	-	1.0	1.0	**1.0**
Trifluralin [∇]- $60	Treflan	Not set	-	0.05	0.05	**0.05**
$135 for all a.i. below						
carfentrazone-ethyl - $80	Hammer	*0.05	-	-	0.08	**0.05**
haloxyfop - $80	Verdict	*0.05	-	-	0.05	**0.05**
$135 for all a.i. below						
clofentezine - $80	Apollo	T0.5	-	0.5	0.5	**0.5**
pymetrozine - $80	Chess	T*0.02	-	-	0.02	**0.02**
$30 for all a.i. below						
Copper	Various	25.0	-	-	Exempt	**25.0**
$135 for all a.i. below						
Diquat - $80	Sprayseed	*0.05	-	0.03	0.03	**0.03**
Paraquat - $80	Sprayseed	*0.05	-	0.05	0.05	**0.05**
$250 for all a.i. below						
glufosinate-ammonium $195	Basta	0.1	0.1	0.1	0.1	**0.1**
glyphosate - $195	Round-up	0.2	-	1.0	1.0	**0.2**
$70 for all a.i. below						
Mancozeb	Dithane	T3	0.1	-	0.10	**0.1**

[#] New Codex MRL of 0.01 mg/kg proposed
[∇] PER5214

$110 for all a.i. below						
phosphorous acid	Various	T1000	-	-	Exempt	**1000**
$30 for all a.i. below						
Sulphur	Various	Exempt	-	-	exempt	-
$110 for all a.i. below						
zinc phosphide/phosphine -	MouseOff	*0.01	-	-	0.01	**0.01**

Cost for complete list: $1050/sample

STATE OF VICTORIA as represented by its
DEPARTMENT OF PRIMARY INDUSTRIES
through its Division
Primary **I**ndustries **R**esearch **Vic**toria - Werribee Centre, situated at
621 Sneydes Road
Werribee Victoria 3030
AUSTRALIA

Telephone 03 9742 8755
Facsimile 03 9742 8700

Quote819.doc
Date: 22-Feb-06
Validity: 2 months

QUOTATION

Client: Peter Dal Santo
Company: AgAware Consulting Pty Ltd
Address: 21 Rosella Avenue
Strathfieldsaye
VICTORIA 3551
Phone No: 5439 5916
Fax No: 5439 3391

From: Gavin Rose
Organic Chemistry
Phone No: (03) 9742 8754
Fax No: (03) 9742 8700
email: Gavin.rose@dpi.vic.gov.au

TESTING OF ALMOND KERNELS	Test Cost per sample (GST incl)
Please see attached spreadsheet ***Almond quote-PIRVic.xls***	

Comments and Special Conditions:

1. **Immediately prior to submission of your samples contact the laboratory to discuss your requirements including any critical time lines.**
2. **Turn around time is normally 3-4 weeks based on one weekly batch of 8-10 samples.**
3. **There will be a Reporting/Handling fee of $44.00 applied to each batch of samples received**
4. **Costs quoted are for testing and reporting of results only. Supply of further data or results interpretation will incur additional costs.**
5. **On acceptance of this quotation, DPI Werribee will endeavour to complete this work within the time specified. However, this laboratory's primary role is to undertake analytical work for a range of State government projects. It is mandatory that we respond immediately to undertake government projects and urgent regulatory and investigatory work. Consequently, this may result in an extension of the anticipated turnaround time.**

If this quotation is acceptable please sign below and return this quotation with the associated samples or by fax.

Quotation prepared and signed for and on behalf of DPI Werribee ________________
Gavin Rose

Accepted for and on behalf of Clients by___________________________________

Date_____________

Print Name and Position ____

TERMS OF BUSINESS

1. Definitions

In this Agreement, the following definitions apply:

'Agreement' **means this agreement which comprises these terms of business including the Quotation;**

'Background Information ' **means any information, expertise, skills, knowledge (including any technology set out in the Quotation) including all Intellectual Property subsisting therein and which is owned by the Client before the date of this Agreement;**

'Client' **means the person which is identified as such in the Quotation;**

'Confidential Information' **of a Party ('Disclosing Party') means all information:**

(i). **treated by the Disclosing Party as confidential; and**

(ii). **disclosed by the Disclosing Party to the other Party or of which the other Party becomes aware, whether before or after the date of this Agreement, except information that is public knowledge otherwise than as a result of a breach of confidentiality by the other Party or any of its permitted discloses. Confidential Information of the Client includes confidential information subsisting in the Report;**

'Intellectual Property' **means all statutory and other proprietary rights in respect of know-how, trade marks, confidential information, patents, circuit layouts, designs, plant breeders rights, and all other rights as defined by Article 2 of the Convention establishing the World Intellectual Property Organisation of July 1967;**

'Party' **means either DPI Werribee or the Client and 'Parties' means both of them;**

'Quotation' **means the attached quotation;**

'Report' **means the written report to be provided by DPI Werribee to the Client in the time and manner set out in the Quotation;**

'Services' **means the activities to be to be carried out DPI Werribee and which is set out in the Quotation;**

'Services Fee' **means all monies and fees as set out in the Quotation;**

'Services Information' **means all information, discoveries, innovations, inventions, works, improvements, designs, databases and all other subject matter, including that subject matter which subsists in the Report (including all Intellectual property subsisting therein) and which is (are) created by DPI Werribee as a result of carrying out the Services;**

'Third Party Claim' **means any claim, notice, demand, action, proceeding, litigation, investigation, judgement or award by a third party which arises directly or indirectly as a result of the use of the Background Information by DPI Werribee or exploitation of the Services Information by the Client.**

2. Acceptance

The Client may accept the terms of this Agreement by:

(i). **signing the Quotation where indicated; or**

(ii). **forwarding samples of materials to DPI Werribee after receipt of this Agreement (whether or not signed by the Parties)**

3. Client's Role

3.1 **The Client must:**

(i). **provide DPI Werribee with; and**

(ii). **allow DPI Werribee to use all Background Information necessary for DPI Werribee to carry out the Services on a non-exclusive, royalty-free, basis.**

3.2 The Client warrants the accuracy of all Background Information provided under clause 3.1.

3.3 The Client agrees to pay DPI Werribee the Services Fee in the time and manner as set out in the Quotation.

4. Sending/delivery of samples

The Client shall indemnify DPI-Werribee in respect of all direct or indirect loss, damage of any samples being sent to DPI-WERRIBEE for analysis through any type of delivery service. Eg. AusPost & couriers.

(i). **The client shall cover the cost incurred for any fees and charges for the delivery of sample/s unless arranged otherwise.**

(ii). Dangerous goods

National, State and international safety regulations prohibit many substances from being posted. These include explosive, highly flammable, radioactive or dangerous articles. For further information please ask at you post office.

5. Sample Retention

(i). **DPI-Werribee will retain all samples for a period of one-month (30 days) after reporting unless otherwise arranged prior to delivery.**

(ii). **DPI-Werribee will retain all samples, which are the subject of contentious issues or samples relevant to court proceedings until clients approve disposal.**

(iii). **GLP samples – disposal of samples (specimens) must be documented and only occur following receipt of written approval from the Study Director.**

6. Sample Disposal or Return

(i). **Non hazardous samples are discarded in safe manner on DPI-Werribee premises.**

(ii). **Quarantine samples are sent to Steritech for gamma irradiation treatment or autoclaved and are discarded in a safe manner.**

(iii). **With the authority of the Unit or Section Leader, samples are returned to clients on request. The client shall cover the cost incurred unless arranged otherwise.**

(iv). **All sample/s damaged in the delivery process not suitable for analysis can be returned to the client upon request. The client shall cover the all cost incurred.**

7. Extra Costs

(i). **An additional cost may be incurred if a sample is requested for URGENT analysis. Urgent analysis is where the result/s is required before the normal turn-around time is reached.**

Consultation Fee

(ii). **A consultation fee will apply to clients requiring interpretation of results after analysis has been carried out at DPI-Werribee. This fee will be calculated case by case unless arranged prior to analysis.**

(iii). Quarantine Fee

Any fees and charges incurred with a sample shall be forwarded to the client unless arranged otherwise.

a) AQIS (Australian Quarantine and Inspection Service) Quarantine Inspection Fees (AIMS)

b) Material from overseas may require Irradiation through Steritech. Depending on weight/volume a minimum charge of $150.00 will be incurred.

8. Project

8.1 **DPI Werribee agrees to carry out the Services in accordance with the Quotation and otherwise in accordance with this Agreement.**

8.2 **DPI Werribee will provide to the Client the Report in the time and manner as specified in the Quotation.**

9. Report and Project Information

9.1 **The Client retains all title, rights and interest to its Background Information.**

9.2 to the Client paying DPI Werribee the Services Fee, the Client owns the Report.

9.3 DPI Werribee retains all title, rights and interest in the Services Information, at the time of creation. DPI Werribee hereby grants to the Client a royalty-free, non-exclusive licence to the Services Information to the extent necessary for the Client to exercise its ownership rights in the Report.

10. Confidentiality

Each Party ('Recipient'):

(i). **may use Confidential Information of a Disclosing Party only for the purposes of this Agreement; and**

(ii). **must keep confidential all Confidential Information of a Disclosing Party, except to the extent (if any) the Recipient is required by law to disclose any Confidential Information.**

11. Risk Mangement

11.1 **This Agreement excludes all warranties, conditions, terms and undertakings, whether express, implied, written, oral, statutory or otherwise, in respect of DPI Werribee undertaking of the Services, the Services Information and/or the Report to the full extent permitted by law. In so far as any warranty, condition, term or undertaking cannot be excluded by law, any liability of DPI Werribee with respect to this Agreement is limited to (in the sole discretion of DPI Werribee):**

(i). **re-performance of the Services; or**

(ii). **payment of the cost of having the Services re-performed**

11.2 Without limiting the generality of clause 7.1, DPI Werribee will not be liable for any special, indirect or consequential damages arising under or pursuant to this Agreement

11.3 **The Client releases and indemnifies and continues to release and indemnify DPI Werribee (and its directors, officers, employees, agents and contractors) from and against any Third Party Claim.**

11.4 **The Client agrees that any use and exploitation of the Services Information and the Report is at its own risk.**

12. Force Majeure

No Party will be required to perform an obligation under this Agreement, if that Party was prevented in performing that obligation as a result of circumstances beyond the reasonable control of that Party, other than an obligation to pay the Services Fee.

13. Dispute Resolution

13.1 **If any dispute arises between the Parties out of, or relating to this Agreement (a 'Dispute') any Party seeking to resolve the Dispute must comply with the provisions of this clause. Compliance with this clause 9 is a condition precedent to seeking relief in any court or tribunal in respect of the Dispute.**

13.2 **A Party seeking to resolve the Dispute must notify the existence and nature of the Dispute to the other Party ('Notification'). Upon receipt of the Notification, the Parties must refer the Dispute to their respective chief executive officers or their nominee for resolution.**

13.3 **If the Parties fail to resolve the Dispute within thirty (30) days from the date of receipt of the Notification, the Parties must refer the Dispute in accordance with the conciliation guidelines of the Australian Commercial Disputes Centre ('ACDC'). The proceedings must be held in Melbourne.**

13.4 **Nothing in this clause 9, will prevent a Party from seeking urgent interlocutory relief the through the courts of appropriate jurisdiction.**

14. Payment of Fees and Expenses, Terms of Payment

The Client will pay DPI Werribee all Fees and Expenses identified in the Proposal at the Dates nominated therein. Where no specific dates of payment are given in the Proposal, the terms of payment are within 30 days of receipt of invoice by the client (interest will be charged on late payments at applicable rates).

15. GST

The Project Fee includes GST. DPI Werribee will provide the Client with an invoice which separately shows the GST.

16. Applicable Law

This Agreement is governed by the laws of the State of Victoria, Australia.

17. Other Terms

17.1 **This Agreement constitutes the entire agreement of the Parties with respect to its subject matter.**

17.2 **In the event of any inconsistency between the terms of business and the Quotation, the terms of business shall prevail.**

17.3 **This Agreement may only be amended or modified by written agreement of the Parties.**

17.4 The Client must not use the name or corporate logo of the Department of Primary Industries or the State of Victoria

18. Liability

Subject to and to the extent permitted by statute, DPI-Werribee's liability in relation to performance of the Proposal shall be limited to the following:

(i). **in the case of goods, the replacement of the goods or the supply of equivalent goods, or the payment of the cost of replacing the goods or of acquiring equivalent goods; and**

(ii). **in the case of services the supply of services again, or the payment of the cost of having services supplied again, and shall not include any direct, indirect or consequential loss or damage caused to the Client or any other person.**

19. Termination and Survival

19.1 **The Services and this Agreement may be terminated by either Party upon forty-five (45) days written notice to the other Party.**

19.2 **The obligations of the Parties under clauses 5,6,7,9 & 10 survive termination of this Agreement.**

19.3 **Termination of this Agreement does not affect any accrued rights or remedies of either Party.**

20. Department Limitation

To the extent that this Agreement applies to the State of Victoria, it shall be limited to the activities and resources of the Department of Primary Industries and nothing in this Agreement shall affect or commit any other department of the State of Victoria.

Analysis of Almonds

Active ingredient	Possible Trade Names	Aust MRL	Codex MRL	Japanese MRLs		MRL level to be tested to	Achievable LOD	Cost per sample(GST incl)	
				Current	Provisional				
Aflatoxin B1						10 ppb	no test		
azoxystrobin	Amistar	T0.02	-	0.02	0.02	0.02	0.01	$220	LC-MSMS screen plus $110 on NPD screen
captan	Captan	T0.3	0.3	-	0.3	0.3	0.05	$198	ECD screen plus $45 on NPD screen
carfentrazone-ethyl	Hammer	*0.05	-	-	0.08	0.05	no test		
chlorothalonil	Bravo	T0.1	-	-	0.05	0.05	0.05	$176	NPD screen
clofentezine	Apollo	T0.5	-	0.5	0.5	0.5	no test		
Copper	Various	25	-	-	Exempt	25	1	$67.50	
dicofol	Mastamite	5	-	-	3	3	0.05	$198	
diquat	Sprayseed	*0.05	-	0.03	0.03	0.03	no test		
glufosinate-ammonium	Basta	0.1	0.1	0.1	0.1	0.1	no test		
glyphosate	Round-up	0.2	-	1	1	0.2	0.05	$352	includes AMPA metabolite
haloxyfop	Verdict	*0.05	-	-	0.05	0.05	0.02	$352	
iprodione	Rovral	*0.02	0.2	10	10	0.02	0.05	$176	
isoxaben	Gallery	*0.01	-	-	-	0.01	no test		
maldison	Maldison	8	-	8	8	8	0.05	$176	
mancozeb	Dithane	T3	0.1	-	0.1	0.1	0.1	$176	
napropamide	Devrinol	*0.1	-	-	0.1	0.1	no test		
norflurazon	Zoliar	*0.2	-	-	0.2	0.2	no test		
oryzalin	Surflan	0.1	-	-	0.08	0.08	no test		
oxyfluorfen	Goal	0.05	-	-	0.05	0.05	0.02	$198	
paraquat	Sprayseed	*0.05	-	0.05	0.05	0.05	no test		
pendimethalin	Stomp	*0.05	-	-	0.08	0.05	0.01	$220	
phosphorous acid	Various	T1000	-	-	Exempt	1000	1	$176	
piperonyl butoxide	Pestigas	8	-	-	8	8	no test		
pirimicarb	Pirimor	T*0.05	-	0.5	0.5	0.05	0.01	$220	includes dimethyl and formamido metabolites
propiconazole	Tilt	T0.2	0.05	0.05	0.05	0.05	0.01	$220	
pymetrozine	Chess	T*0.02	-	-	0.02	0.02	no test		
pyrethrins	Pestigas	1	1.0*	1	1	1	0.05	$198	plus $45 on NPD screen
pyridaben	Sanmite	T*0.05	-	1	1	0.05	no test		
simazine	Gesatop	*0.1	-	-	0.2	0.1	0.02	$220	
spinosad	Naturalure	T*0.01	0.01	0.02	0.02	0.01	0.01	$220	
Sulphur	Various	Exempt	-	-	exempt	-	no test		
tetradifon	Mastamite	5	-	1	1	1	no test		
trifluralin**	Treflan	Not set	-	0.05	0.05	0.05	0.05	$198	
zinc phosphide/phosphine	MouseOff	*0.01	-	-	0.01	0.01	no test		

* MRL of 0.01 proposed
** PER5214

WHEN YOU NEED TO BE SURE

SGS Australia Pty Ltd

Coburg Laboratory
34 Norfolk Court
COBURG VIC 3058
Tel: (61-3) 9350 4800
Fax: (61-3) 9350 4871
www.sgs.com

To	Peter Dal Santo
Copy	
Company	Agware Consulting Pty. Ltd
Fax	03 5439 3391
From	**Mitch Nguyen**
Date	15th of March 2006
Pages	(including cover page) 2

Quote No: MC.6034 - Agware.MN

Dear Peter,

Further to your request, we are pleased to provide the following quotation for analyzing Pesticide residues in Almonds.

This quotation is based on the receipt of approximately 30 – 50 during March and May. This project is anticipated to start on arrival of samples and the samples would be for analysis for the following.

Analysis:

Active ingredient	Possible Trade Names	Aust MRLs	Codex MRLs	Japanese MRLs		MRL level to be tested to	$ Cost per analyte
				Current	Provisional		
azoxystrobin	Amistar	T0.02	-	0.02	0.02	**0.02**	**250**
captan	Captan	T0.3	0.3	-	0.3	**0.3**	**250**
carfentrazone-ethyl	Hammer	*0.05	-	-	0.08	**0.05**	**250**
chlorothalonil	Bravo	T0.1	-	-	0.05	**0.05**	**250**
clofentezine	Apollo	T0.5	-	0.5	0.5	**0.5**	**295**
Copper	Various	25.0	-	-	Exempt	**25.0**	**110**
dicofol	Mastamite	5.0	-	-	3.00	**3.0**	**250**
diquat	Sprayseed	*0.05	-	0.03	0.03	**0.03**	**490**
glufosinate-ammonium	Basta	0.1	0.1	0.1	0.1	**0.1**	**305**

glyphosate	Round-up	0.2	-	1.0	1.0	**0.2**	**295**
haloxyfop	Verdict	*0.05	-	-	0.05	**0.05**	**350**
iprodione	Rovral	*0.02	0.2	10.0	10.0	**0.02**	**250**
isoxaben	Gallery	*0.01	-	-	-	**0.01**	**315**
maldison	Maldison	8	-	8.0	8.0	**8.0**	**250**
mancozeb	Dithane	T3	0.1	-	0.10	**0.1**	**150**
napropamide	Devrinol	*0.1	-	-	0.10	**0.1**	**315**
norflurazon	Zoliar	*0.2	-	-	0.20	**0.2**	**295**
oryzalin	Surflan	0.1	-	-	0.08	**0.08**	**315**
oxyfluorfen	Goal	0.05	-	-	0.05	**0.05**	**250**
paraquat	Sprayseed	*0.05	-	0.05	0.05	**0.05**	**495**
pendimethalin	Stomp	*0.05	-	-	0.08	**0.05**	**250**
phosphorous acid	Various	T1000	-	-	Exempt	**1000**	**250**
piperonyl butoxide	Pestigas	8	-	-	8	**8.0**	**250**
pirimicarb	Pirimor	T*0.05	-	0.5	0.5	**0.05**	**250**
propiconazole	Tilt	T0.2	0.05	0.05	0.05	**0.05**	**250**
pymetrozine	Chess	T*0.02	-	-	0.02	**0.02**	**295**
pyrethrins	Pestigas	1.0	1.0$^{\#}$	1.0	1.0	**1.0**	**250**
pyridaben	Sanmite	T*0.05	-	1.0	1.0	**0.05**	**315**
simazine	Gesatop	*0.1	-	-	0.2	**0.1**	**250**
spinosad	Naturalure	T*0.01	0.01	0.02	0.02	**0.01**	**305**
Sulphur	Various	Exempt	-	-	exempt	-	**100**
tetradifon	Mastamite	5.0	-	1.0	1.0	**1.0**	**250**
trifluralin$^{\nabla}$	Treflan	Not set	-	0.05	0.05	**0.05**	**250**
zinc phosphide/phosphine	MouseOff	*0.01	-	-	0.01	**0.01**	**135**
Aflotoxin (B1)							**150**
Complete List							**950**

- **Turn around time from analysis to reporting = 7 – 10 working days**
- **Handling and reporting fee per batch = $25.00**
- **Please note that all prices are exclusive of GST.**

Sample Requirements

Minimum Sample Size: 500 ml or 500 grams

Preservation: Cool

Payment & Reporting

Company policy is to receive upfront payment from new clients before work can commence. Upon sample receipt, an invoice will be issued. Payment by cheque, credit card or direct deposit into our bank account will be accepted. Our bank details will appear on our invoices. Alternatively, a credit application form can be completed and returned to me in full. Once approval has been granted, the report will have the invoice attached and payment can be made by our terms on the invoice.

With warm regards,

Mitch Nguyen

Business Development Manager

Terms and Conditions:

All inspections and testing services will be carried out as per industry standards and in accordance with SGS standard terms and conditions:

1. General

(a) Unless otherwise agreed in writing or except where they are at variance with (i) the regulations governing services performed on behalf of governments, government bodies or any other public entity or (ii) the mandatory provisions of local law, all offers or services and all resulting contractual relationship(s) between any of the affiliated companies of SGS SA or any of their agents (each a “Company”) and Client (the “Contractual Relationship(s)”) shall be governed by these general conditions of service (hereinafter the “General Conditions”).

(b) The Company may perform services for persons or entities (private, public or governmental) issuing instructions (hereinafter, the “Client”).

(c) Unless the Company receives prior written instructions to the contrary from Client, no other party is entitled to give instructions, particularly on the scope of the services or the delivery of reports or certificates resulting there from (the “Reports of Findings”). Client hereby irrevocably authorises the Company to deliver Reports of Findings to a third party where so instructed by Client or, at its discretion, where it implicitly follows from circumstances, trade custom, usage or practice.

2. Provision of Services

(a) The Company will provide services using reasonable care and skill and in accordance with Client's specific instructions as confirmed by the Company or, in the absence of such instructions:

(1) the terms of any standard order form or standard specification sheet of the Company; and/or

(2) any relevant trade custom, usage or practice; and/or

(3) such methods as the Company shall consider appropriate on technical, operational and/or financial grounds.

(b) Information stated in Reports of Findings is derived from the results of inspection or testing procedures carried out in accordance with the instructions of Client, and/or our assessment of such results on the basis of any technical standards, trade custom or practice, or other circumstances which should in our professional opinion be taken into account.

(c) Reports of Findings issued further to the testing of samples contain the Company’s opinion on those samples only and do not express any opinion upon the lot from which the samples were drawn.

(d) Should Client request that the Company witness any third party intervention, Client agrees that the Company’s sole responsibility is to be present at the time of the third party’s intervention and to forward the results, or confirm the occurrence, of the intervention. Client agrees that the Company is not responsible for the condition or calibration of apparatus, instruments and measuring devices used, the analysis methods applied the qualifications, actions or omissions of third party personnel or the analysis results.

(e) Reports of Findings issued by the Company will reflect the facts as recorded by it at the time of its intervention only and within the limits of the instructions received or, in the absence of such instructions, within the limits of the alternative parameters applied as provided for in clause 2(a). The Company is under no obligation to refer to, or report upon, any facts or circumstances which are outside the specific instructions received or alternative parameters applied.

(f) The Company may delegate the performance of all or part of the services to an agent or subcontractor and Client authorises Company to disclose all information necessary for such performance to the agent or subcontractor.

(g) Should Company receive documents reflecting engagements contracted between Client and third parties or third party documents, such as copies of sale contracts, letters of credit, bills of lading, etc., they are considered to be for information only, and do not extend or restrict the scope of the services or the obligations accepted by the Company.

(h) Client acknowledges that the Company, by providing the services, neither takes the place of Client or any third party, nor releases them from any of their obligations, nor otherwise assumes, abridges, abrogates or undertakes to discharge any duty of Client to any third party or that of any third party to Client.

(i) All samples shall be retained for a maximum of 3 months or such other shorter time period as the nature of the sample permits and then returned to Client or otherwise disposed of at the Company's discretion after which time Company shall cease to have any responsibility for such samples. Storage of samples for more than 3 months shall incur a storage charge payable by Client. Client will be billed a handling and freight fee if samples are returned. Special disposal charges will be billed to Client if incurred.

Obligations of Client

The Client will:

ensure that sufficient information, instructions and documents are given in due time (and, in any event not later than 48 hours prior to the desired intervention) to enable the required services to be performed;

(b) procure all necessary access for the Company's representatives to the premises where the services are to be performed and take all necessary steps to eliminate or remedy any obstacles to, or interruptions in, the performance of the services;

(c) supply, if required, any special equipment and personnel necessary for the performance of the services;

(d) ensure that all necessary measures are taken for safety and security of working conditions, sites and installations during the performance of services and will not rely, in this respect, on the Company's advice whether required or not;

(e) inform Company in advance of any known hazards or dangers, actual or potential, associated with any order or samples or testing including, for example, presence or risk of radiation, toxic or noxious or explosive elements or materials, environmental pollution or poisons;

fully exercise all its rights and discharge all its liabilities under any relevant sales or other contract with a third party and at law.

4. Fees and Payment

(a) Fees not established between the Company and Client at the time the order is placed or a contract is negotiated shall be at the Company's standard rates (which are subject to change) and all applicable taxes shall be payable by Client.

(b) Unless a shorter period is established in the invoice, Client will promptly pay not later than 30 days from the relevant invoice date or within such other period as may be established by the Company in the invoice (the "Due Date") all fees due to the Company failing which interest will become due at a rate of 1.5% per month (or such other rate as may be established in the invoice) from the Due Date up to and including the date payment is actually received.

(c) Client shall not be entitled to retain or defer payment of any sums due to the Company on account of any dispute, counter claim or set off which it may allege against the Company.

Company may elect to bring action for the collection of unpaid fees in any court having competent jurisdiction.

Client shall pay all of the Company's collection costs, including attorney's fees and related costs.

(f) In the event any unforeseen problems or expenses arise in the course of carrying out the services the Company shall endeavour to inform Client and shall be entitled to charge additional fees to cover extra time and cost necessarily incurred to complete the services.

(g) If the Company is unable to perform all or part of the services for any cause whatsoever outside the Company's control including failure by Client to comply with any of its obligations provided for in clause 3 above the Company shall nevertheless be entitled to payment of:

the amount of all non-refundable expenses incurred by the Company; and

(2) a proportion of the agreed fee equal to the proportion of the services actually carried out.

5. Suspension or Termination of Services

The Company shall be entitled to immediately and without liability either suspend or terminate provision of the services in the event of:

(a) failure by the Client to comply with any of its obligations hereunder and such failure is not remedied within 10 days that notice of such failure has been notified to Client; or

(b) any suspension of payment, arrangement with creditors, bankruptcy, insolvency, receivership or cessation of business by Client.

6. Liability and Indemnification

Limitation of Liability:

The Company is neither an insurer nor a guarantor and disclaims all liability in such capacity. Clients seeking a guarantee against loss or damage should obtain appropriate insurance.

Reports of Findings are issued on the basis of information, documents and/or samples provided by, or on behalf of, Client and solely for the benefit of Client who is responsible for acting as it sees fit on the basis of such Reports of Findings. Neither the Company nor any of its officers, employees, agents or subcontractors shall be liable to Client nor any third party for any actions taken or not taken on the basis of such Reports of Findings nor for any incorrect results arising from unclear, erroneous, incomplete, misleading or false information provided to the Company.

The Company shall not be liable for any delayed, partial or total non-performance of the services arising directly or indirectly from any event outside the Company's control including failure by Client to comply with any of its obligations hereunder.

The liability of the Company in respect of any claim for loss, damage or expense of any nature and howsoever arising shall in no circumstances exceed a total aggregate sum equal to 10 times the amount of the fee paid in respect of the specific service which gives rise to such claim or US$20,000 (or its equivalent in local currency), whichever is the lesser.

The Company shall have no liability for any indirect or consequential loss (including loss of profits).

(6) In the event of any claim, Client must give written notice to the Company within 30 days of discovery of the facts alleged to justify such claim and, in any case, the Company shall be discharged from all liability for all claims for loss, damage or expense unless suit is brought within one year from:

(i) the date of performance by the Company of the service which gives rise to the claim; or

(ii) the date when the service should have been completed in the event of any alleged non-performance.

Indemnification: Client shall guarantee, hold harmless and indemnify the Company and its officers, employees, agents or subcontractors against all claims (actual or threatened) by any third party for loss, damage or expense of whatsoever nature including all legal expenses and related costs and howsoever arising relating to the performance, purported performance or non-performance, of any services.

7. Miscellaneous

(a) If any one or more provisions of these General Conditions are found to be illegal or unenforceable in any respect, the validity, legality and enforceability of the remaining provisions shall not in any way be affected or impaired thereby.

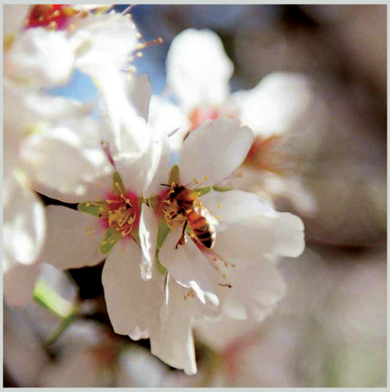
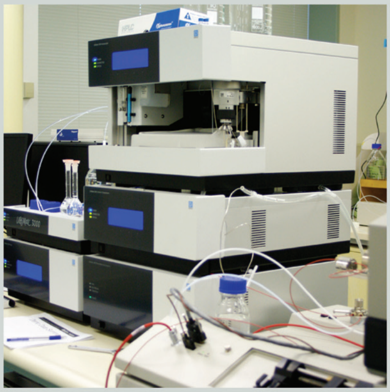
(b) During the course of providing the services and for a period of one year thereafter Client shall not directly or indirectly entice, encourage or make any offer to Company's employees to leave their employment with the Company.

(c) Use of the Company's corporate name or registered marks for advertising purposes is not permitted without the Company's prior written authorization.

8. Governing Law, Jurisdiction and Dispute Resolution

All disputes arising out of or in connection with contractual relationships hereunder shall be governed by and construed in accordance with the substantive laws of Australia exclusive of any rules with respect to conflicts of laws. All these disputes shall be submitted to the exclusive jurisdiction of the competent courts of Western Australia.

Australian Government
Department of Agriculture, Fisheries and Forestry


National Residue Survey

2008–2009

Almond program

Chemical residue monitoring results



OVERVIEW

The National Residue Survey (NRS) was originally established in 1961 to measure pesticide residues in exported meat. Today, NRS tests for residues of agricultural and veterinary chemicals and environmental contaminants in 25 animal and 26 plant commodities including five horticultural products. Since 1993, NRS has operated on full cost recovery, and is funded principally by levies from participating industries. The Australian Government provides funding for NRS national and international residue commitments that provide benefits for the community, for industry and for government programs. For further details please visit our website.

In 2008 the Almond Board of Australia (ABA) initiated a pesticide residue random monitoring program with NRS, involving 64 almond samples that were collected from three almond processors. The samples were tested for a broad range of insecticides, fungicides, herbicides, fumigants and metals.

The purpose of the random monitoring program is to confirm the residue status of the sampled produce, as specified by the maximum residue limits (MRLs) of the Australia New Zealand Food Standards Code (ANZFSC). The random monitoring program is carried out according to NRS procedures and protocols.

Sampling

Samples were collected from Almondco Australia Ltd and Riverland Almonds in South Australia and Select Harvests in Victoria. In cooperation with ABA and the almond processing plants, NRS organised two sampling rounds during the year, in January and April. Sampling was arranged to take place within specific timeframes.

At each sampling, approximately 1kg of kernel was collected by quality assurance staff based at the processing plants, and the nuts sent to NRS contract laboratories for analysis. Results were sent electronically from the laboratory to the NRS offices, where the data is collated and compiled for industry and government use.

Although the residue testing programs are fully designed and managed by NRS, external contractors provide many of the operational functions including laboratory services, and supply and distribution of sampling materials and freight.





Chemical testing 2008–2009

Samples were tested against an agreed chemical screen that was developed in consultation with ABA. Any sample showing a positive result for a chemical, is subject to further confirmatory testing, and any sample found to contravene the ANZFSC is traced back to its origin by relevant state and territory authorities and appropriate advisory or legal action is taken.

The chemicals listed in the following table include those that may be used in almond production in Australia, as well as those that may be important in terms of international trade.

In 2008–2009, 64 samples were collected and tested for chemical residues as shown below.

Chemical screen 2008–2009

GROUP	CHEMICALS	NUMBER OF SAMPLES	CONTRAVENTIONS	COMPLIANCE (%)
Insecticides	Acaricides	64	0	100.0
	Carbamates	64	0	100.0
	Organochlorines	64	0	100.0
	Organophosphates	64	0	100.0
	Other insecticides	64	0	100.0
Fungicides		64	0	100.0
Herbicides	Selective	25	0	100.0
	Broad spectrum	25	0	100..0
Fumigants	Phosphine	48	0	100.0
Metals	Cadmium, copper, lead, mercury	48	0	100.0
TOTAL		64	0	100.0

Residue testing results 2008–2009

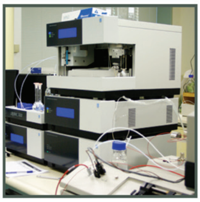
The residue testing results for all samples for all chemical screens indicate 100% compliance with Australian Standards.

These results demonstrate the appropriate use of agricultural chemicals to Australian domestic and export almond markets.





Laboratory performance evaluation and proficiency testing



NRS contracts analytical laboratories to perform the relevant residue analyses. Laboratories are proficiency tested in order to ensure the validity of analytical results.

NRS continues to be an accredited provider of proficiency testing schemes. Accreditation ensures that the NRS proficiency testing system is recognised within the laboratory community as meeting internationally accepted standards and having the ability to establish the technical competence of participating laboratories.

International maximum residue limits

In consultation with the Almond Board of Australia, NRS maintains international MRL tables for countries that are major export markets for Australian almonds. These tables can be found on the NRS website (see below).

Contacts

General enquiries

Phone: +61 02 6272 3187

Fax: +61 02 6272 4023

Email: nrs@daff.gov.au

Postal address:

National Residue Survey

GPO Box 858 Canberra ACT 2601 Australia

Manager, plant residue testing program

Phone: +61 02 6272 3436

Director, National Residue Survey

Phone: +61 02 6272 5668

Photos courtesy the Almond Board of Australia

NPA NUT PRODUCERS AUSTRALIA

SELECT HARVESTS

ALMONDCO PREMIUM AUSTRALIAN ALMONDS

ALMOND BOARD OF AUSTRALIA

www.daff.gov.au/agriculture-food/nrs

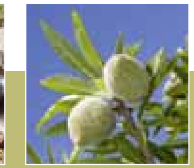
Almonds

National Residue Survey

2009–10

Australian Government

Department of Agriculture, Fisheries and Forestry

Almonds

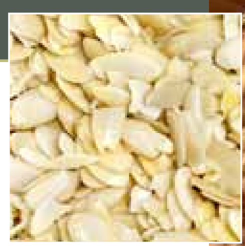
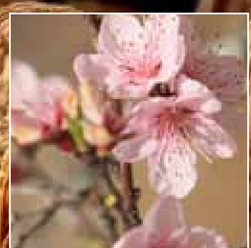
The National Residue Survey

The National Residue Survey (NRS) is part of an Australian Government and industry strategy to minimise chemical residues and environmental contaminants in Australian food products. NRS supports Australia's food industry and primary producers by facilitating access to key export markets and confirming Australia's status as a producer of clean food. NRS programs encourage good agricultural practices, help to identify potential problems, and indicate where follow-up action is needed.

Residues can be present in food either through natural circumstances or as a consequence of agricultural or industrial activities. NRS currently tests for residues of pesticides, veterinary medicines and environmental contaminants in 21 animal products including meat products, honey, eggs, wild-caught fish and aquaculture products; 21 grains, pulses and oilseeds; and 5 horticultural products including apples and onions.

Originally established in 1961 following concerns about pesticide residues in exported meat, NRS is largely industry-funded through levies on the animal and plant products that are tested.



The almond program is a cooperative arrangement between NRS and the Almond Board of Australia (ABA). In close cooperation with ABA, sampling arrangements, the choice of chemicals to be tested, liaison with industry and reporting procedures are reviewed upon completion of each year's sampling and appropriate adjustments made as necessary.

The almond program has been part of NRS random residue testing programs since 2008 and it is funded by the ABA and almond processing plants.

Sampling

Samples are collected from Almondco Australia Ltd and Riverland Almonds in South Australia and Select Harvests in Victoria. In cooperation with ABA and the almond processing plants, NRS organised two sampling rounds in January and April 2010. NRS contacted each processing plant prior to the sampling rounds to coordinate sampling within specific timeframes.

Each sample (approximately one kilogram of kernels) is collected by quality assurance staff at the processing plants in accordance with NRS procedures and protocols. The almonds are packaged in NRS bags and sent to the contract laboratory. Test results are sent electronically from the laboratory to NRS, where the data is collated and compiled for industry and government use. NRS designs and manages the sampling, and contracts external providers for operational functions such as laboratory services, supply and distribution of sampling materials, and freight.

Group	Chemicals	Samples	Contraventions	Compliance (%)
Fungicides		53	0	100
Fumigants	Phosphine	23	0	100
Herbicides	Selective broad spectrum	23	1	95.6
Insecticides	Caracides Carbamates Organochlorines Organophosphates Other insecticides	53	0	100
Metals	Cadmium, copper, lead, mercury	23	0	100
Total			1	98.1

Chemical screen

The almond program multi-residue screen is developed in consultation with industry, taking into account registered chemicals, chemical residue profiles and market sensitivity. The chemicals groups covered in the multi-residue screen include fungicides, fumigants, herbicides, insecticides and metals.

Almond testing results

During 2009–10, the residue testing results from the analysis of 53 almond samples collected from processing plants showed compliance rates with Australian Standards of 98.1 per cent.

Year	Samples	Compliance (%)
2008–09	64	100
2009–10	53	98.1
Total	117	99.1

Since 2008, 117 almond samples have been collected and analysed for agricultural chemical residues, with an overall compliance rate with Australian Standards of 99.1 per cent.

These results demonstrate that Australian almond producers use in-crop and post-harvest agricultural chemicals according to good agricultural practice, and assures customers of the excellent residue and contaminant status of Australian almonds.

Testing and traceback

Samples are tested against an agreed chemical screen that is designed to meet market requirements. If a sample is found to contain a residue above the Australian Standard, a traceback investigation is undertaken to establish the cause. The responsible state or territory agency will then provide advice to the producer to prevent recurrence. In more serious circumstances regulatory action may also be taken.

All traceback activities and findings are reported to NRS. This feedback is important in highlighting potential problems (such as inappropriate chemical use) and improving farm practices. Where appropriate, traceback information is also forwarded to industry and government authorities for consideration. Traceback information may also be forwarded to the Australian Pesticides and Veterinary Medicines Authority for consideration during its chemical review processes.

Laboratory performance

Residue testing is conducted by several laboratories under contract with NRS. Laboratories are proficiency tested to ensure the validity of analytical results. NRS is an accredited provider of proficiency testing schemes. The NRS proficiency testing system is recognised within the laboratory community as meeting internationally accepted standards to establish the technical competence of participating laboratories.

Laboratories are selected through the Australian Government tendering process on the basis of their proficiency, accreditation and value for money. Current laboratory contracts began on 1 July 2008 and will run to 30 June 2011.

International maximum residue limits

NRS maintains international maximum residue limit tables for countries that are major export markets for Australian primary produce. These tables can be found on the NRS website.

Contacts

General enquiries
f: +61 02 6272 4023
e: nrs@daff.gov.au
w: www.daff.gov.au/nrs

Postal address:
National Residue Survey
GPO Box 858
Canberra ACT 2601 Australia

Manager, Plant Programs
p: +61 (02) 6272 3436

Director, National Residue Survey
p: +61 (02) 6272 5668

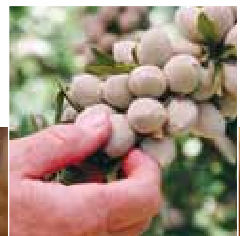
NPA
NUT PRODUCERS AUSTRALIA

ALMONDCO
PREMIUM AUSTRALIAN ALMONDS

ALMOND BOARD OF AUSTRALIA

SELECT HARVESTS

NCS INTERNATIONAL
CERTIFIED QUALITY MANAGEMENT SYSTEM
ISO 9001



Almond Industry

Pest & Disease Control Guide 2007-08

Almond Industry
Pest & Disease Control Guide 2007-08

PREPARED BY:

Lucy Pumpa, Consultant, Scholefield Robinson Horticultural Services Pty Ltd, and Dr Prue McMichael, Principal Consultant, Scholefield Robinson Horticultural Services Pty Ltd for the Almond Board of Australia.

ACKNOWLEDGEMENTS:

Ben Brown
Julie Haslett
Chris Bennett
Anne-Marie Broughton
Sarah Kivi
Amanda Schapel
Stuart Pettigrew
Barb Hall
Trevor Wicks

The Almond Board of Australia
PO Box 2246
BERRI SA 5343

Ph: (08) 8582 2055
Fax: (08) 8582 3503

Contents

Introduction

The Australian almond industry has recently experienced significant growth. New growers and investors, sizeable new plantings, the development of new production areas, and increasing compliance and regulatory pressures in the domestic and export markets, have resulted in great demand for production information and chemical use advice. This Guide has been prepared for the industry and should be viewed as a living document. It is accurate and up-to-date today but the rate of change in crop care technology (products, permits, registrations, chemistry, electronic support programs etc) is such that the Guide will require constant revision. Between reprints it will be the responsibility of growers to access and implement the latest information and recommendations. Useful sources of such information are included in the Guide.

Although this Guide includes technical information on the main almond pest and disease threats and products available for their control, it does not explicitly direct growers to specific chemicals (or beneficials), application times or rates. Growers must make these choices in compliance with the product labels and when appropriate, export market requirements. Regional climates, varieties grown, disease pressure, pest populations, orchard history, previous product choices and tank mixes, resistance threats etc must be considered before designing and implementing your pest and disease control program. To finalise a program most growers will also look at the economics of the available product range.

The Guide provides information on almond pests and diseases that can be managed and monitored by orchard managers. The Guide does not include discussion of abiotic tree stresses (poor nutrition, soil problems, toxicities and deficiencies, irregular watering, heat, flooding, frost etc), but growers should recognise these factors may influence the onset or severity of the pests and diseases that are discussed. The Guide does not include information on viruses, viroids or phytoplasmas, or on disorders with unknown causes since the management of these is either undefined or is required before planting. Steps taken by growers before planting greatly influence the effectiveness of orchard management thereafter. Site selections, soil suitability, irrigation plans, choice of planting material, evaluation of planting material quality and health are critical steps in the establishment of good orchards.

As members of the Australian almond industry, it is each grower's responsibility to give consideration to 'resistance management'. In combination, product chemistry and grouping, use patterns and pest biology, influence the potential for and development of resistance. Almonds do not have a wide range of product chemistries available amongst their crop protection products. This limits the opportunities for effective 'rotation' of product chemistry in resistance management. Growers must evaluate the effectiveness of their pest and disease control programs each season. To do this, detailed records of observations, monitoring, and applications are needed. This Guide includes examples of required records and useful recording forms.

Feedback: The authors of this Guide congratulate the almond industry on supporting the updating of the original 2006 document, through the provision of useful technical information, and funding. Users of the Guide have provided important feedback to the industry on the Guide's usefulness, format, completeness and gaps. It is hoped this will continue.

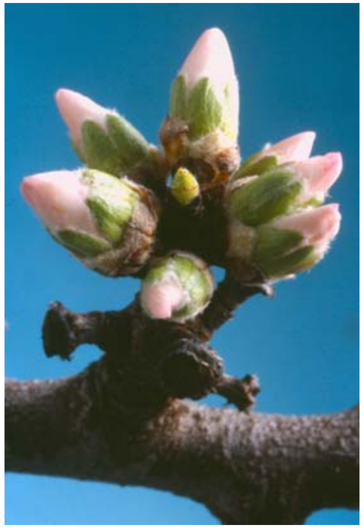
Flowering Stages for Almonds


Dormant


Bud Swell


Green Tip


Early Pink Bud


Mid Pink Bud


Early Bloom


Full Bloom


Petal Fall


Shuck Fall


Young Nuts

Pests and Diseases

There are a large number of pests and diseases of almonds. The bacterial and fungal causal organisms and the invertebrate pests that have the potential to cause economic damage to almonds are listed and discussed below. Those pests and diseases not listed include viruses, phytoplasmas, nematode, those with unknown causes and those not currently considered to be an economically significant threat.

The following table provides information on the critical periods for bacterial and fungal diseases of almonds.

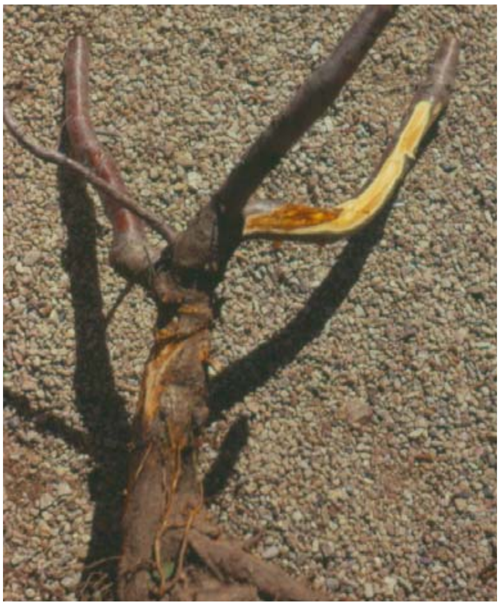
Table 1: Almond Disease Damage and Treatment Table

Disease	Pre-Plant	WINTER				SPRING			SUMMER		AUTUMN	
		Leaf Fall-Dormant		Green Tip – Full Bloom		Shuck Fall-Early Set		Nut Growth & Hardening			Harvest	Post-Harvest
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb-Mar	Apr-May
Alternaria*												
Anthracnose												
Bacterial Canker												
Bacterial Spot												
Band Canker*												
Blossom Blight												
Brown Rot												
Crown Gall												
Hull Rot												
Leaf Blight												
Phytophthora												
Rust												
Scab*												
Shot Hole												
Silver Leaf												
	No registered treatments available											
Verticillium Wilt												

	Damage period
	Monitoring and management period

* Disease-causing organism present in Australia, but disease as described in California, not found here. Damage periods and management response not defined for Australia.

BACTERIAL DISEASES



(Photo: SARDI)

Bacterial Canker (*Pseudomonas syringae* pv *syringae*)

This disease, also called gummosis, occurs worldwide on many hosts. Although infection may remain latent in buds, leaves or wood wounds for some time, the most commonly seen symptoms in young almonds, are bud death and blackened blossoms (blossom blast), and the sour-smelling, sunken, elliptical, rough, dark cankers from which watery exudates ooze. Under the bark near the cankered tissue, reddish flecks may be visible. Suckering from the rootstock may develop in trees with infected scions. The bacteria usually enter through leaf scars in the late autumn, but may also enter through injury sites caused by sand-blasting, wind or hail. The bacteria are active in the winter and therefore the first signs of infection are often seen the following spring. Tree stress enhances this disease and therefore site selection and environmental conditions are important in its management. No specific chemical controls are available.

Bacterial Spot (*Xanthomonas arboricola* pv *pruni*)

This bacterial disease affects almonds and stone fruit. On almonds, the leaf symptoms may resemble those of 'shot hole' and of copper phytotoxicity. The lesions are reddish-dark in colour and of irregular shape. They are clustered where wetness is prolonged – at leaf tips, along the midrib or on the sheltered side of the blade. Most infected leaves are found in the inner canopy. Infected nuts gum profusely from slightly sunken, corky lesions. Both young and established trees are susceptible with the most susceptible varieties being Fritz and Ne Plus. Economic losses result from the yield reduction through nut gumming and premature nut fall. Twig dieback and defoliation have longer term effects on tree productivity and longevity. Avoidance and protection are the best forms of management and no chemical treatment alone controls this disease.

(Photo: SARDI)

Crown Gall (*Agrobacterium tumefaciens*)

This bacterium has many potential woody and herbaceous hosts. Crown gall may be severe on almonds although significant losses in orchards and nurseries are rare. Infected roots develop galls at or near the soil line, in mild weather. Galls on young trees are likely to cause more damage than those on established trees. Treatment for crown gall must be applied before planting. Clean planting material is very important to avoid introduction of the bacterium to the orchard. Thereafter hygiene and injury minimisation are critical. If the bacterium is present in the orchard, growers must be aware of its potential spread via pruning tools and equipment. The bacterium requires an entry point; usually a wound, and therefore minimisation of injuries during planting, training and pruning, is important in the management of this disease.

KEEP AUSTRALIA FREE OF THESE BACTERIAL DISEASES

Almond Leaf Scorch (*Xylella fastidiosa*)

This disease, formerly called 'golden death', occurs sporadically in parts of California, and is not present in Australia. Strains of the same bacterium cause Pierce's Disease in grapevines, a disease of citrus and lucerne, and diseases of range of ornamental and landscape plants. It is vectored and spread by spittlebugs and sharpshooter leafhoppers that feed in the xylem. Leaves appear normal in spring, with symptoms first appearing late in the growing season. Tips and margins of leaves become chlorotic, progressing towards the base leaving zones of necrotic tissue. Newly infected trees only show a small number of affected leaves often having only one terminal branch affected. Management may include pruning out infected limbs 1 metre below symptoms, but this many be insufficient. Eliminating and preventing vectors is necessary and starting with clean propagation material is critical.

Marginal scorching of leaves with Almond leaf scorch. Note: Salt burn looks similar however is usually concentrated at leaf tips and does not have a yellow margin to necrotic area. (Photo: Jack Kelly Clark, UCDavis).

Bacterial hyperplastic canker (*Pseudomonas amygdali*)

This bacterial pathogen is not present in Australia, but its primary hosts are almonds and peaches. It is present in Europe around the Mediterranean. Infected trees have swollen bark around leaf scars and wounds. Buds die, canopies become thin, and perennial cankers form on the woody parts of the trees which then decline. Clean planting material is the best form of disease avoidance, since the bacterium does not survive in soil.

FUNGAL DISEASES

Anthracnose (*Colletotrichum acutatum*)

This is an economically-important fungal disease that may develop early in mild-wet seasons. Trees are susceptible from early bud movement until hull split and therefore the application of crop protectants must start before any symptoms are visible. Young infected nuts are often clustered. They abort, hang on and develop an orange colour. Mid-sized, infected nuts gum profusely. Infected leaves start with a water-soaked appearance that later resembles marginal 'burn'. Most leaves within an infected spur die, but hang on for some time. Twig dieback follows. The fungus survives the winter in buds, peduncles, mummies and twig lesions. All varieties appear susceptible, with Nonpareil perhaps the least severely affected. The disease has not been confirmed in trees less than five-years-old.

Blossom Blight (*Botrytis cinerea*)

B. cinerea is a ubiquitous fungus with a very wide host range that includes fruit, vegetable and flower crops. It may attack all almond flower parts in cool-mild, wet weather, or in conditions of high humidity. The blossoms die and characteristic masses of grey spores form on the dead and dying parts. Infection may extend into green almond fruit although this is not common in Australia. Although fungicides remain the best control method, it should be noted that resistant strains of *B. cinerea* are widespread and therefore resistance management strategies are very important in local orchards and regional areas where susceptible crops are grown.

Brown Rot (*Monilinia laxa*)

This fungal disease appears sporadically but can be a significant problem in almonds and stone fruit. Worst affected are the early flowering almonds, although all varieties are considered susceptible. The blossoms are attacked in cool-mild, wet or foggy weather. Infected blossoms wilt and die rapidly, but hang onto the spur giving a messy appearance. In humid weather a mass of light brown spores may form on the flower parts. The infection continues into the peduncle and twig. Terminal twig dieback is common. The fungus survives in buds, old flower parts, twig cankers and mummified fruit. It is important not to promote disease conducive conditions by irrigating during flowering.

Hull Rot (*Rhizopus sp.*)

This is a fungal disease that does not appear until late in the season. Twig and leaf death occurs after the hull of infected nuts has split. The fungus enters the moist hull area via the open suture. Sporulation and mycelial growth may be prolific in moist and warm, humid weather or humid conditions. Hull infection is followed by wilting and death of leaves on nearby spurs, and shoot death. Vigorous trees are more susceptible to hull rot as the air movement in such trees is reduced. Overhead irrigation further exacerbates environmental conditions conducive to the fungus. . Nut infection by *Monilinia sp*. may also contribute to hull rot. Although all varieties are susceptible, it appears that Nonpareil sustains most damage. There is no registered, effective chemical control, but cultural practices that improve air flow through canopies and careful irrigation during hull split, reduce the threat of hull rot.

Phytophthora spp.

These water-loving organisms may be economically significant within temperate growing regions, some seasons. Infested soil, water or planting material may introduce the fungi to an orchard, and infection may originate in the roots, crown or aerial tree parts. Infected almonds may first appear unthrifty and unresponsive to inputs (fertilisers and water) but crown rots, trunk cankers and/or branch dieback will later develop if the disease is not managed. Symptoms are especially obvious in spring and summer. Cultural management strategies are aimed at avoidance of standing water around roots, crowns or in the crotch of trees. Chemical controls are also available.

(Photo: SARDI)

Rust (*Tranzschelia discolor*)

This fungus attacks most *Prunus spp*. In almonds the outbreaks of rust generally occur later in the season – around December. The first signs of infection are yellow spots on the upper leaf surfaces. Corresponding orange pustules (of spores) soon develop on the lower surface and leaf drop may occur. Warm weather and dew periods favour development.

(Photo: SARDI)

Shot Hole (*Wilsonomyces carpophilus*)

This fungal disease is common in all almond growing areas of Australia. The fungus survives in buds and twigs. Early season rains activate the spores and splash them onto blossoms and leaves. Infected leaves develop small, circular purplish spots that enlarge and develop a defined centre within a yellow margin. The central area dies and often falls out. Similar lesions develop on the upper side of fruit and these become rough and corky with age. All varieties appear susceptible. Control is via the protection of leaves from emergence until five-six weeks after petal fall.

Silver Leaf (*Chondrostereum purpureum*)

This wood-rotting fungus, although very destructive in stone and pome fruit, is not commonly encountered in our almond orchards. Spores are released into the air from fan shell-like, mauve-brown fruiting bodies that develop on dead, infected wood (i.e. old stumps, pruning piles) or on alternative hosts like willows and poplars. Infection starts when the spores land on exposed wounds or pruning cuts, and progress to xylem tissue. Silvery, dull leaves on a particular scaffold are often the first symptom of infection on almonds, and these early signs may be confused with those resulting from a mite infestation. As the infection progresses, the fungus releases a toxin, and infected trees often die within three seasons of the first symptoms. Infected wood in cross-section shows dark-stained xylem. Infected scaffolds should be removed, burnt or buried, and surrounding trees checked for the fruiting bodies. Avoid all pruning in wet weather.

(Photo: SARDI)

Verticillium Wilt (*Verticillium dahliae*)

This fungus has a very wide host range, including almonds and other nuts. The disease generally affects young almond trees which either die quickly or 'grow out' of the symptoms. Infected roots result in xylem blockages that cause yellowing and wilting of several branches, but rarely the whole tree. The wilt is most frequently noticed with the onset of warm summer weather. Ne Plus trees are very susceptible. The fungus survives in the soil for long periods. It is therefore important not to introduce the fungus into an orchard via nursery plants, and not to plant into soil in which previous crops or weeds have been infected by the fungus.

(Photo: UC Davis www.ipm.ucdavis.edu)

Leaf Blight (*Seimatosporium sp.*)

This fungus has been isolated from almond leaves in Australia, but the disease remains sporadic and poorly recognised. Spores are splashed onto susceptible tissue during prolonged rains. Infected leaves are generally throughout the canopy. The blades may wither and fall, leaving petioles on the tree for some time. Most fungicide programs intended for the control of other fungal diseases of almonds (i.e. shot hole) should assist with the management of this disease.

LOOK OUT FOR THESE – *The Fungi are here but not the Diseases…yet*

(Photo: SARDI)

Alternaria Leaf Spot (*Alternaria alternata*)

This fungus is a common inhabitant of orchards. There are three fungal types of the *Alternaria alternata* complex that have been associated with leaf spots of almonds, but in Australia they have not been found as primary pathogens. In California, leaf symptoms first appear in late spring as small, light brown lesions. Lesions can expand to 5-20 mm in diameter on the leaf blade and are circular in appearance. As the season progresses the fungus sporulates, turning the centre of the lesions black. Infected leaves fall and trees may defoliate prematurely. Infected trees have more 'stick tight' nuts. The disease severity increases in orchards with stagnant air, high humidity and extended dew periods. Strobilurin and dicarboximide fungicides are somewhat effective, but control is difficult.

(Photo: SARDI)

Band Canker (*Botryosphaeria dothidea*)

This fungus has a wide host range, but the disease on almonds has not been reported in Australia. This is despite the pathogen being present on other hosts. In California, infection takes place through small growth cracks. The fungus kills the bark and can kill the cambium layer with the affected area becoming sunken and oozing large volumes of gum. Although the band cankers form infrequently, they are characteristic of the disease, since they extend around the branch or trunk, rather than longitudinally along them. The cankers are only active during warm summer weather and are most common in vigorous trees between 3-6 years old.

(Photo: SARDI)

Scab (*Cladosporium carpophila*)

In Australia we have generally found this fungus to be a secondary, rather than primary pathogen. However Prunus orchards worldwide, in warm, high rainfall or sprinkler-irrigated areas, are susceptible to this fungus. Leaves, twigs and fruit may be affected with infection beginning as small, water-soaked, somewhat circular, green-yellow lesions that first appear on the underside of leaves. Lesions turn olive green with fully developed lesions appearing dark brown and 10+ mm in diameter becoming visible from the upper surface of the leaf. Lesions may coalesce, forming larger necrotic areas. Extensive infection may result in defoliation. The disease can be controlled with various types of fungicides.

INVERTEBRATE PESTS

The following table indicates when various invertebrate pests are active or when symptoms can be observed in orchards. Timing for the treatment of these pests is also included.

Table 2: Almond Pest Presence and Treatment Table

Pest	Month											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Carob Moth												
Bryobia Mite												
European Red Mite												
Indian Meal Moth												
Light Brown Apple Moth												
Rust Mite												
San Jose Scale												
Tomato Russet Mite												
Two Spotted Mite												

(grey)	Damage Period
(black)	Monitoring and management period

(Photo: CSIRO www.ento.csiro.au/aicn/name_c/a_727.htm)

Carob Moth (*Apomyelois ceratoniae*)

Almonds become vulnerable as soon as the green hulls begin to split. The adult females are attracted to the odour of fungi that grow on the splitting hulls and eggs are laid in the splits. Larvae feed on the shells and penetrate the kernels. Moths may overwinter in old nuts on the ground. Summer rains increase infestations. The first spray should coincide with the splitting of the hulls.

Bryobia Mite (*Bryobia rubrioculus*)

Hot, dry conditions, and moisture-stressed trees suit the Bryobia (also called Brown) mite. Bryobia mites pierce the leaf epidermal cells and suck out the contents. Infested leaves develop whitish grey spots on the upper surface and a dull appearance overall. The damaged leaf surface reduces the photosynthetic capacity of the tree, subsequently weakening it. Unlike the signs of other mite infestations, bronzing of the leaf surface is not caused by Bryobia mites. Crop size may be reduced in heavy infestations because nut size and development rate can be affected. Biological control options are available, but usually a dormant winter oil spray is effective. If infestation occurs during the growing season, dicofol application is recommended. Populations of this mite appear to have decreased in recent years, with a notable increase in two-spotted mite populations over the same period.

European Red Mite (*Panonychus ulmi*)

(Photo: UC Davis www.ipm.ucdavis.edu)

European Red Mite populations are often controlled by natural enemies and do not commonly reach damaging levels in orchards. However, if an outbreak was to occur leaves become speckled as a result of feeding damage, and can appear pale, bronzed and burned at the tips and margins. Trees can tolerate high levels of infestation if they are not stressed; however, if they are stressed they may experience leaf defoliation. The mites over winter as eggs at the base of buds and spurs on small branches while eggs from summer generations are laid on leaves. Adults can start emerging as early as October and the best treatment involves a delayed dormant oil spray. Biological control programs may be implemented in an effort to control this pest, with the brown lacewing (*Hemerobius* sp.) being the most effective predator.

Light Brown Apple Moth (*Epiphyas postvittana*)

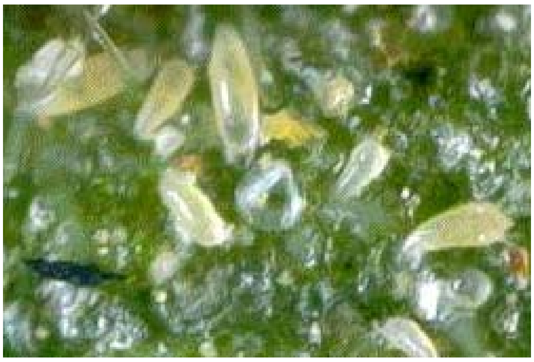
(Photo: Greg Baker)

Light Brown Apple Moth is a native insect with a wide range of alternative hosts. It is usually a minor pest of almonds and can be controlled with an insecticide application. Thorough coverage is necessary because larvae are often sheltered. The larvae are leaf feeders and they form webbed shelters in leaf folds and between leaves. Leaf injury is more likely to be found low down in the centre of the trees. Cool conditions extending well into the summer months favour this pest. It is important to reduce weeds on the orchard floor as they can provide an alternative host.

Rust Mite (*Aculus* spp.)

Rust Mites are very tiny mites that shelter and overwinter under bud scales, loose bark or other insect shells. They move onto expanding leaf buds in early spring and start feeding. Upward rolling of leaves along the midrib axis is one of the first signs of rust mite attack. Mite feeding kills epidermal cells of the leaves, causing them to bronze, desiccate and curl up. Oil sprays may be used in an effort to control this mite.

Tomato Russet Mite (*Aculops lycopersici*)



(Photo: UC Davis www.ipm.ucdavis.edu)

Tomato Russet Mites are very small mites that proliferate in warm, dry weather. They have the capacity to increase populations very quickly as their life cycle can be completed in six days. The mite scrapes the leaf surface and sucks the juice out of the leaves, with leaves becoming silvery, then bronze on the underside before curling and eventually dying. Early prevention is recommended rather than eradication.

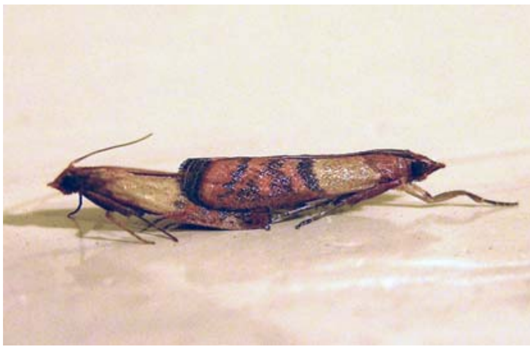
Two-Spotted Spider Mite (*Tetranychus urticae*)

Two-Spotted mites damage foliage by sucking the contents from individual leaf cells. Infestations normally are noticed first in the inner lower part of the canopy. The damage often appears as light-coloured stippling that progresses to brown leaves that fall from the tree. High populations of mites can cover the tree terminals with webbing. Mites over winter under bark and in ground litter; however, they have the ability to continue feeding and reproducing in the winter. The reduction in photosynthetic activity may reduce the size and development of nuts. Management can often be achieved via predatory mite populations. If however, treatment is necessary, pyrethroid, organophosphate and carbamate insecticides should be avoided as they upset the potential for biological control. Oils are the preferred treatment option.

(Photo: UC Davis www.ipm.ucdavis.edu)

San Jose Scale (*Diaspidiotus perniciosus*)

San Jose Scale has a high reproductive capacity, with the most rapid development occurring in warm, dry conditions. It can produce at least 2 but up to 4 generations per season, on a number of hosts. The scale feed on bark, foliage and fruit, sucking plant juices and injecting a toxin, resulting in loss of tree vigour, growth and productivity. In severe cases death of limbs may occur, while more commonly the fruiting wood for the next season is killed. The presence of gum on wood is a common sign of scale attack. The visual presence of scale on leaves occurs when the infestation is severe. San Jose Scale can be managed with natural enemies, including ladybirds, parasitic wasps and lacewing larvae. The use of sulphur and a dormant winter oil spray are also recommended for control, with thorough coverage right down to ground level required. If the scale is well-established, a second oil spray in spring may be necessary. Growers should be mindful that the application of broad-spectrum insecticides can interrupt the balance of the natural control cycle and scale populations can build up.



Indian Meal Moth *(Plodia interpunctella)*

Indian Meal Moth is a post-harvest and storage pests of almonds. Larvae feed on the kernels and produce extensive webbing throughout the infested material. Various methods can be used to control the pest including post-harvest chemical fumigation, ionizing radiation, controlled atmosphere temperatures, cold treatments and various forms of heating. The baculovirus 'Indian Meal Moth Granulosis Virus' has been used in the USA (in the form of a microbial insecticide) to control the pest. Storage facilities must choose control methods approved for use in Australia.

KEEP AUSTRALIA FREE OF THIS INSECT

Glassy-winged Sharpshooter

(Homalodisca coagulate)

The glassy-winged sharpshooter is native to the southeastern United States. It is a large insect, almost 12 mm in length, with transparent wings. It is a dark brown to black, with lighter spots on back and head. In the USA, the insect overwinters as an adult and eggs are laid in late winter-spring, and again in late summer-autumn. The insect survives a wide temperature range. Sharpshooters pick-up the bacterium from infected plants and transmit it to healthy plants while feeding. The glassy-winged sharpshooter is a voracious feeder. It can consume 10 times its body weight in liquids per hour. The arrival in Australia of *Xylella fastidiosa* and/or its sharpshooter vector will present a significant problem to the almond industry. The more aggressive and efficient vector of this bacterium is the glassy-winged sharpshooter, which has recently been detected in several new locations including near neighbours, Tahiti and the Cook Islands.

Size comparison between two different sharpshooters. *(Photo: DPIVic)*

BIOSECURITY AND EMERGENCY PESTS

Plant Health Australia is developing and implementing programs and policies to improve Australia's plant biosecurity. Their initiatives recognise the important role of growers in early detection and reporting of unrecognised pests and diseases. Growers should call the Plant Pest Hotline on 1-800-084-881 if they find anything unusual in their orchard.

There are several emergency plant pests of almonds. These include disease-causing organisms and insects not known to be present in Australia. For more information refer to *Identification and Analysis of Pathogen Threats to the Nut Industry* (available through the ABA or Plant Health Australia).

Crop Protection Chemicals Registered and Permitted For Use on Almonds in Australia

Be informed. The use of crop protection products comes with responsibilities.

It is the responsibility of chemical users to check labels and keep up-to-date on registrations and permits. Chemical users must comply with the label rates and application timing. It cannot be assumed that all products with a particular active constituent are registered for the same use, on almonds. The most current and accurate information available on crop care product registrations and permits is found on the APVMA website: www.apvma.gov.au or, through the individual crop protection company websites.

The information given in the following tables represents the active constituents and products currently registered or permitted for use in Australian almond orchards. Please note that registrations can vary from state to state. For example the current Victorian Agricultural and Veterinary Chemical 'Control of Use' legislation, allows application in this case to almonds of a product not registered for use on almonds, if the product: is registered for similar use in Victoria; not on the 'prescribed' list; the maximum label rate is not exceeded; and there are no residues at harvest.

FUNGICIDES REGISTERED & PERMITTED FOR USE ON ALMONDS IN AUSTRALIA

Many of the fungicides registered for use on almonds in Australia are effective for the control of multiple diseases. However, in most cases broad efficacy is not reflected on individual labels and only one or two target organisms are named. Labels must be followed. The following table includes label information only for products registered for use on almonds in Australia.

Table 3: Almond diseases and registered active constituents

Disease	Active Constituent(s)	Remarks
Bacterial Canker	No registered products	-
Bacterial Spot	No registered products	-
Blossom Blight	Hydrocarbon liquid/Iprodione	Apply first at full bloom and, if conditions are favourable for disease development, up to two subsequent applications can be made; at petal fall and up to four weeks after petal fall. Do not spray under weather conditions that may cause drift. Do not mix with fertilisers: may be unstable if ≥ pH 7. Check label for compatibility with other chemicals.
	Iprodione	Apply first at full bloom. If conditions are favourable for disease development, up to 2 subsequent applications can be made at petal fall and up to four weeks after petal fall. Do not spray under weather conditions that may cause drift. Do not mix with fertilisers: may be unstable if ≥ pH 7. Check label for compatibility with other chemicals.
	Mancozeb	Apply at early bloom (1-10%). Repeat at mid-full bloom (50-100%), petal fall and shuckfall. Continue with protective spray program at 2 week intervals. Do not apply more than 10 times per season. Harmful to *Typhlodromus pyri*. Re-apply after significant rainfall (> 20mm). Never allow product to become wet during storage. Addition of agricultural surfactant may improve coverage and weatherability. Compatible with most commonly used fungicides, insecticides, miticides. Do not mix with lime sulphur.

Disease	Active Constituent(s)	Remarks
Brown Rot	Copper (copper oxychloride)	Apply at budswell, but before and within one week of bud opening. Treat varieties at optimal times; blocks with multiple varieties may need multiple application times. Do not apply at temperatures > 35°C. Do not apply when slow drying conditions prevail. Do not apply to copper sensitive crops and cultivars. Do not apply if rain likely before spray is dry. Do not apply to wet crops. Avoid windy conditions; rapid drying conditions. Compatible with most insecticides/pyrethroids, miticides, fungicides, dormant oils and urea. May not be compatible with some foliar fertilisers. Check individual labels before use. Do not apply in spray solutions with pH<6.5. Do not mix with lime sulphur
	Hydrocarbon liquid/Iprodione	Apply first at full bloom and, if conditions are favourable for disease development, up to two subsequent applications can be made; at petal fall and up to four weeks after petal fall. Do not spray under weather conditions that may cause drift. Do not mix with fertilisers: may be unstable if ≥ pH 7. Check label for compatibility with other chemicals.
	Iprodione	See prior listing.
	Mancozeb	See prior listing.
	Sulphur	Spray during dormancy-budswell. Apply in cool of day. Do not apply in freezing weather, or if air temperature is > 32°C. Do not apply within 2 weeks of oil spray except as indicated. Can be used with white oil during dormancy-semi-dormancy. Do not mix with acidic water at < pH 4.
Crown Gall	Agrobacterium	Pre-plant treatment only. Do not use with other pesticides, fertilisers or other chemicals.
Hull Rot	No registered products	-
Leaf Blight	No registered products	-
Rust	Chlorothalonil	Apply at bud swell, bud burst, pink bud, shuck fall and cap fall. Apply every 10-14 days. Apply 7 days pre-harvest. Do not apply to trees within 10 days of oil treatment. Do not mix with spraying oils, wetting agents or surfactants. Do not use oils after bud swell during the season if chemical is to be used after shuck fall. Do not mix with EC formulations after shuck fall. Compatible with wetting powder and flowable formulations of common fungicides, insecticides and miticides. Check individual labels for rates and spray limits.
	Mancozeb	See prior listing.
	Sulphur	See prior listing.
Shot Hole	Chlorothalonil	See above
	Copper (cupric hydroxide)	See prior listing.
	Copper (tribasic copper sulphate)	See prior listing. Do not apply if frost occurs.
	Copper (copper ammonium acetate)	See prior listing. Should not be mixed with acidifying or buffering agents.
	Copper (cupric (II) hydroxide)	See prior listing. Wetting agent may be added if necessary.
	Copper (copper hydroxide)	See prior listing. Concentrated spray not recommended.
	Copper (copper oxychloride)	See prior listing.
	Copper (cuprous oxide)	See prior listing. Do not apply if frost occurs. Not compatible with all foliar fertilisers.
	Mancozeb	See prior listing.
	Sulphur	See prior listing.
Silver Leaf	No registered products	-
Soilborne Fungi	1,3,-Dichloropropene/Chloropicrin	Pre-plant treatment only. Do not use on heavy clay soils. Do not dilute with water. Do not apply through any type of irrigation system. Do not use when soil temperature is below 5-10°C or above 27°C. Do not treat soil when very wet or very dry.

Disease	Active Constituent(s)	Remarks
Verticillium Wilt	1,3,-Dichloropropene/Chloropicrin	Pre-plant treatment only. Do not use on heavy clay soils. Do not dilute with water. Do not apply through any type of irrigation system. Do not use when soil temperature is below 5-10°C or above 27°C. Do not treat soil when very wet or very dry.

Table 4 includes diseases and active constituents for which there are minor use or emergency permits available, pending or currently under review. The APVMA website must be consulted frequently and especially before the use of any unregistered product. The APVMA website provides the latest information on a product's status – i.e. if a valid permit exists for that product on almonds, how to interpret the permit, under what conditions the permit (and product) may be used. Active constituents with permits pending cannot be used.

Table 4: Almond diseases and active constituents with current permits or permits pending

Disease	Active Constituent(s)	Permit ID	Date Issued	Expiry Date	Remarks
Anthracnose	Azoxystrobin	PER 9200	01/01/07	01/01/12	Do not use more than t3 times a season. Alternate with sprays from other chemical groups. Do not harvest for 4 weeks after application.
	Captan	PER 9256	21/08/07	28/02/09	Apply in sufficient water volumes ensuring uniform coverage when climatic conditions favour disease development. Do not apply more than 5 applications per season. Do not exceed a concentration of 400g/100L. Apply at pink bud, full bloom, petal fall or at 2-3 and 4-6 weeks post petal fall* using the shorter intervals under heavy pressure. Do not harvest for 30 days after application.
Blossom blight & Anthracnose	Propiconazole	PER 9255	22/12/06	30/06/11	Apply at pink bud, full bloom, petal fall and at 2-3 and 4-6 weeks post petal fall using the shorter intervals under heavy disease pressure. Do not apply more than 4 applications per season. Do not apply after hull split. Apply via orchard airblast / mister sprayers. Do not harvest for 6 weeks after application.
Phytophthora	Phosphorous Acid	PER 7161	14/10/04	13/10/09	Apply to the point of run-off. Make a maximum of two applications per season. Do not harvest for 28 days after application. Do not apply after hull split.
Root intrusion	Trifluralin	PER 9857	02/05/07	30/04/12	Apply 2 or 3 times per year. Apply post harvest and late spring by direct injection of diluted product into submain pipes using measured dose piston pump.

* Efficacy trials suggested that control required early applications.

PESTICIDES REGISTERED & PERMITTED FOR USE ON ALMONDS IN AUSTRALIA

Many of the pesticides registered for use on almonds in Australia are suitable for the control of multiple pests. However, in most cases this is not reflected on individual labels where only one or two approved target pests are usually named. The following table includes label information only for products registered for use on almonds in Australia.

Table 5: Almond pests and active constituents registered for their control

Pest	Active Constituent(s)	Remarks
Bryobia Mite	Dicofol / Tetradifon	Apply at first sign of mite activity in spring/summer. Do not use with integrated mite control programs, do not use if mites are known to be resistant to dicofol. Low hazard to bees.
	Paraffinic Oil	Do not spray when temperatures exceed 32°C or when soil is dry and trees are suffering from moisture stress. Spray for eggs during the dormant or delayed dormant season. Spray for San Jose Scale during the dormant season and for mites and other scales in summer or post harvest. Do not spray more than 4 times during the growing season, with a minimum of 2 weeks between applications. Do not spray when buds are fully opened and shoot elongation is occurring, avoid spraying open blooms. Do not use with dimethoate, carbaryl, sulphur or any other chemical incompatible with oil.
	Petroleum Oil	See prior listing. Do not use within 14 days of captan, chlorothalonil, morestan, euparen or sulphur. Do not apply pesticides or other chemicals incompatible with oil within 4 weeks before or after application of any other spray oils.
	Potassium Salts of Fatty Acids	Do not mix with other chemicals. Do not use during heat of the day. Spray when insects are noticed. Re-apply 5-7 days later if necessary.
	Sulphur	See prior listing.
Carob Moth	No registered products	-
European Red Mite	Dicofol / Tetradifon	See prior listing.
	Paraffinic Oil	See prior listing.
	Petroleum Oil	See prior listing.
	Potassium Salts of Fatty Acids	See prior listing.
	Sulphur	See prior listing.
Fruit Fly	Spinosad	Can be sprayed as band or spot spray. Apply as soon as monitoring indicates flies are present. Repeat every 7 days if necessary.
Indian Meal Moth	No registered products	-
Light Brown Apple Moth	No registered products	-
Mice	Zinc phosphide	Do not apply bait to bare ground. Do not apply bait in a trail. Do not apply if heavy rain is imminent. Do not apply to the outer 50m of crop or within 50m of native vegetation. Do not bait unless monitoring of mouse numbers indicate potential for significant economic loss.
Nematodes	1,3-Dichloropropene (fumigant)	Pre-plant treatment only. Do not use on heavy clay soils. Do not dilute with water. Do not apply through any type of irrigation system. Do not use when soil temperature is below 5-10°C or above 27°C. Do not treat soil when very wet or very dry.

Pest	Active Constituent(s)	Remarks
Rust Mite	Dicofol / Tetradifon	See prior listing.
	Paraffinic Oil	See prior listing.
	Petroleum Oil	See prior listing.
	Potassium Salts of Fatty Acids	See prior listing.
	Sulphur	See prior listing.
San Jose Scale	Paraffinic Oil	See prior listing.
	Petroleum Oil	See prior listing.
	Sulphur	See prior listing.
Tomato Russet Mite	Dicofol / Tetradifon	See prior listing.
	Paraffinic Oil	See prior listing.
	Petroleum Oil	See prior listing.
	Potassium Salts of Fatty Acids	See prior listing.
	Sulphur	See prior listing.
Two Spotted Mite	Paraffinic Oil	See prior listing.
	Petroleum Oil	See prior listing.
	Potassium Salts of Fatty Acids	See prior listing.
	Sulphur	See prior listing.

Table 6 lists pests and active constituents for which there are minor use or emergency permits available, pending or are currently under review. The APVMA website must be consulted before the use of any of these products. Active constituents with permits pending cannot yet be used. Growers must check the APVMA website to confirm permit status.

Table 6: Almond pests and active constituents with permits or permits pending

Disease	Active Constituent(s)	Permit ID	Date Issued	Expiry Date	Remarks
Aphids	Pirimicarb	PER 9241	23/02/07	31/03/10	Apply a maximum of two applications per season when aphids are detected in accordance with good agricultural practice. Do not make consecutive applications. Apply using airblast/mister application equipment.
	Pymetrozine	PER 9244	01/04/06	31/03/08	Do not apply more than 2 applications per crop. Do not make consecutive applications.
Mites	Clofentezine	PER 9914	04/02/08	31/03/13	Do not apply more than one application per season. Do not apply after hull split.
	Dicofol	PER 9764	22/12/06	31/3/09	Apply at first sign of mite activity.
	Bifenazate	PER 100096	28/8/07	30/06/08	Do not apply more than one application per season. Do not use if rainfall is expected.

COMPATIBILITY ADVICE

It is important that labels are read before applying any chemical. Some crop protection products cannot be mixed with other products, different formulations, with fertilizers or in water that is particularly basic or acidic.

It is important also to consider tank mixes in which oil or surfactants are used, as some combinations will damage trees. Oil should not be applied before or after (within 10 days) of some specific fungicides.

Consideration must also be given to the weather before, during and after applications and to the potential effects of the application on beneficial organisms.

ACTIVE CONSTITUENTS (BY PRODUCT NAME) REGISTERED FOR USE IN ALMONDS

Each active constituent is formulated and provided within different trademarked and registered products. Although the following tables include only crop care products specifically registered for use on almonds (or nuts) in Australia, it should be noted that there are more products than listed for each active constituent. Individual chemical labels need to be checked for each product.

Registered Fungicide Products

Table 7: Registered fungicide products for use in almonds

Active Constituent(s)	Registered Products	Withholding Periods (days)	State registrations
Agrobacterium	Nogall	0	All
Chlorothalonil	Applonil 720	0	SA, Vic, NSW, Tas, WA, ACT
	Bayer Chlorothalonil 500 SC	0	SA, Vic, NSW, Tas, WA, ACT
	Bravo	0	SA, Vic, NSW, Tas, WA Only
	Bravo Weather Stik	0	SA, Vic, NSW, Tas, WA Only
	Campbell Cheers 720	0	SA, Vic, NSW, Tas, WA Only
	Whack 500	0	SA,Vic,NSW,Tas,WA, NT, ACT
	Conquest Clash 720	0	SA, Vic, NSW, Tas, WA Only
	Crop Care Barrack 720	0	SA, Vic, NSW, Tas, WA Only
	Farmoz Cavalry 720 SC	0	SA, Vic, NSW, Tas, WA, ACT
	Farmoz Fung-O-Nil 500	0	SA, Vic, NSW, Tas, WA Only
	Halley Chlorothalonil 720	n/a	n/a
	Nufarm Elect 500	0	SA, Vic, NSW, Tas Only
	Nufarm Unite 720	0	SA, Vic, NSW, Tas, WA ,ACT
	SDS biotech KK Crotop 500	0	SA, Vic, NSW, Tas, ACT Only
	SDS biotech KK Crotop 720	n/a	n/a
	Sipcam Echo 720	0	SA, Vic, NSW, Tas, WA Only
	Sipcam Echo 900 WDG	0	SA, Vic, NSW, Tas, WA Only
	Sipcam Pacific Echo 500 SC	0	SA, Vic, NSW, Tas, WA, ACT
	Whack	0	SA, Vic, NSW, Tas, WA Only
	Ospray Chlorothalonil 720	n/a	SA, Vic, NSW, WA, Tas
	Nufarm Unite Ultrastik	n/a	SA, Vic, ACT, NSW, Tas
	Barrack Betterstik	n/a	SA, Vic, NSW, ACT, Tas
	Chemag Whack 900 WG	n/a	SA, Vic, NSW, WA, Tas
	Rotam Glider	n/a	NSW, Tas, Vic, SA, WA
	Faudel	n/a	ACT, NSW, Vic, SA, Tas, WA
	4Farmers Chlorothalonil 720	n/a	n/a
Copper (cupric hydroxide)	Flo-Bordo	1	SA, Vic, Tas, WA, Qld Only
	Nufarm Champ Dry Prill WG	1	All
	Yates Blitzem	n/a	n/a
	Tradewyns Blu-Cop 400DF	1	All
	Dupont Kocide Blue Xtra	1	All
	Cung Fu 350 SC	1	n/a
	Nufarm Champion WP	1	n/a

Active Constituent(s)	Registered Products	Withholding Periods (days)	State registrations
Copper (tribasic copper sulphate)	Cuprofix Disperss Nufarm Tri-Base Blue	1 1	All All
Copper (copper ammonium acetate)	Liquicop	n/a	SA, Vic, NSW, Tas, WA, ACT, Qld, NT
Copper (cupric (II) hydroxide)	Chemfarm Blue Mantel Multicrop Kocide DF Dupont Kocide Liquid Blue	1 n/a 1	Vic (shothole); SA, Tas, Qld and NT (leaf curl) n/a All
Copper (copper hydroxide)	Blue Shield DF Yates Fungus Fighter	1 n/a	Vic and WA (shothole); SA, WA, Tas and Qld (leaf curl) All
Copper (copper oxychloride)	Barmac Copper Oxychloride Melpat Coppox CRG Copper Oxychloride CCC Copper Oxychloride 50% WP Oxydul DF Brycop Copper Oxychloride Country Copper Oxychloride 500 WP AGCL-Parkens Copper Oxychloride WP Ospray Copper Oxychloride WP Neoram 375 WG Uni-Guard 500 WP Nufarm Copper Oxychloride	1 1 1 1 1 1 1 n/a n/a 1 n/a 1	SA, Vic, NSW, Tas, WA Only SA, Vic, NSW, Tas, WA Only All SA, Vic, NSW, Tas, WA Only SA, Vic, NSW, Tas, WA Only SA, Vic, NSW, Tas, WA Only SA, Vic, NSW, Tas, WA Only n/a n/a QLD, Vic, Tas, SA, WA n/a QLD, Vic, Tas, SA, WA
Copper (cuprous oxide)	Nordox 500 Norshield Norshield 750 WP Norshield WG Ag Copp 750	1 1 1 1 1	Vic (shothole); SA, WA and Tas (leaf curl) SA, Vic, NSW, Tas, WA Only All All All
Iprodione / Hydrocarbon Liquid	Rovral Liquid Farmoz Civet Liquid Iproval Corvette Liquid Farmoz Chief 250 Ospray Iprodione Liquid 250	0 0 0 0 0 0	All All All All All All
Iprodione	Rovral Aquflo Farmoz Civet Aquaflo Campbell Ippon 500 Aquaflo Rovral 750 WG Corvette Flowable Genfarm Iprodione Aquaflow Ospray Subscribe Farmoz Chief Quaflo Iproval Aquaflo Innova Iprodione 500 Aquaflo	0 0 0 0 0 0 0 0 0 0	All All All All All All All All All All

Active Constituent(s)	Registered Products	Withholding Periods (days)	State registrations
Mancozeb	Dupont Manzate DF	14	SA Only
	Dithane M-45	14	SA, WA Only
	Dithane DF	14	SA, WA Only
	Farmoz Mancozeb 800	14	SA, WA, NT Only
	Barmac Mancozeb DG	14	SA Only
	Farmoz Mancozeb 750 DF	14	SA Only
	Sabero Mancozeb 750 DF	14	SA, WA, NT Only
	Chemfarm Mancozeb 750 DF	14	SA Only
	Tradewyns Mancozeb 750 DF	14	SA Only
	Penncozeb 420 SC	14	All
	Kendon Mancozeb	14	SA Only
	Griffin Mancozeb WDG	14	SA, WA Only
	Rotam Winner Mancozeb WP	n/a	n/a
	Kendon Mancozeb DF	14	SA Only
	Penncozeb	n/a	n/a
	Penncozeb 750 DF	n/a	n/a
	Sabero Mancozeb 800 WP	14	SA Only
	Chemfarm Mancozeb 800 WP	14	SA Only
	Kenso Agcare Kencozeb 750 DF	14	SA Only
	Gemax Vine 750	14	SA Only
	Allfire Mancozeb 750 WG	14	SA Only
	Biotis Mancozeb 750 DF	14	SA Only
	Unizeb 800 WP	n/a	n/a
	Dithane Rainshield Neo Tec	14	All
	Runge Agrichems Manfil Mancozeb 750WG	14	n/a
	Dithane 430 SC	14	All
	Unizeb 750 DF	14	n/a
	Innova Mancozeb 750	14	n/a
	Ospray Mancozeb 750WB	14	n/a
	Titan Mancozeb 750 DF	14	n/a
Sulphur (polysulfide sulphur)	Kendon Lime Sulphur	n/a	SA, Vic, NSW, Tas, WA ,ACT
Sulphur (calcium polysulphide) & (calcium thiosulphate)	Miller Lime Sulphur	0	SA, Vic, NSW, Tas, WA

Registered Pesticide Products

Table 8: Registered pesticides for use in almonds

Active Constituent(s)	Registered Products	Withholding Periods (days)	State registrations
Almonds			
Dicofol / Tetradifon	Masta-Mite Miticide	7	n/a
Paraffinic Oil	Biopest Bioclear Trump Spray Oil	1 1 1	SA, Vic, NSW, WA, ACT; Tas (eggs) SA, Vic, NSW, WA, ACT; Tas (eggs) SA, Vic, NSW, WA, ACT; Tas (eggs)
Petroleum Oil	Biocover	1	SA, NSW, WA; Tas (eggs); Vic (mites, scale)
Petroleum Oil / Unsulphonatable Residue	Biocover	1	SA, Vic, NSW, WA; Tas (eggs)
Nuts			
Potassium Salts of Fatty Acids	Natrasoap Natrasoap Ready to Use Multicrop BugGuard Insect Spray	0 0 0	n/a n/a n/a
Glycerol 99.5% / Potassium Hydroxide – Flake / Potassium Salts of Fatty Acids / Water	Multicrop BugGuard Insecticide Concentrate	0	n/a
Spinosad	Naturalure Fruit Fly Bait	0	All

Registered Soil Fumigant and Vermin Control Products

Table 9: Registered soil fumigants and vermin controls for use in almonds

Active Constituent(s)	Registered Products	Withholding Periods (days)	States
1,3-Dichloropropene	Telone Soil Fumigant	n/a	Check label
1,3-Dichloropropene / Chloropicrin	Telone C-35 Soil Fumigant Rural Telone C-35 Soil Fumigant	n/a n/a	Check label Check label
Zinc phosphide	Mouseoff Zinc Phosphide Bait	14	n/a

Products with Permits and Permits Pending

Table 10: Permitted (and permit pending) products for use in almonds

Active Constituent(s)	Permitted Products	Withholding Periods (days)	States
Captan +	Captan WG Merpan 800 WG Orthocide WG Kendon Captan WG Sipcam Captan WG	30 30 30 30 30	All All All All All
Azoxystrobin +	Amistar WG	28	All
Clofentezine +	Apollo SC Miticide	35	All
Phosphorous Acid +	Foli-R-Fos 400 Phos-A 400 PhosAcid 400 Fungacid 400 Nipro Throw Down Phospot 400 pH 7.2	28 28 28 28 28 28	All All All All All All
Pirimicarb +	Pirimor WG	-	All
Propiconazole *	Tilt 250 EC	-	All
Pymetrozine +	Chess	28	All

* Permit pending; + Current permit

Maximum Residue Limits (MRLs)

Almond growers must be aware of MRLs since their kernels are frequently exported. To establish MRL compliance, residue testing is undertaken. Export destinations (countries) specify the maximum level of acceptable residue in food products imported into their country. For example, Australian and Japanese MRLs differ for some chemicals, with the Australian ones exceeding the Japanese ones, or vice versa. Exported Australian product destined for Japan, must meet the Japanese standards.

In-orchard chemical use and management, influence directly the likelihood of residues being present at harvest, and therefore MRL compliance. The choice of product and pre-harvest interval, are especially critical in achieving MRL compliance.

Resistance Management and Rotation of Chemicals

The effective life of some crop protection products can be shortened by overuse of the active constituent and the response of selection and/or mutation within the pest population. Insects, mites and pathogens have within their normal populations both resistant and susceptible individuals. In a region where a particular active constituent or activity group is used repeatedly, the proportion of resistant members of the pest population increases over time. Once this proportion is high enough to render the chemical no longer effective, we have 'resistance' to that chemical, i.e. the pest or disease-causing organism can survive doses of chemical that previously would have controlled it.

To minimise the threat of resistance, and the rate of resistance development, growers must choose resistance management strategies that suit their region's crop range and growing environment. Such strategies include chemical rotation. This requires an understanding and consideration of the chemical activity groups of their chosen crop protection products, their modes of action, seasonal needs for each active constituent and the biology of the intended target/s. Chemicals from different chemical activity groups should be rotated.

Table 11: Activity groups and names of chemicals registered and permitted for use on almonds

Chemical Activity Group and Name		Resistance Potential	Activity	Target Site
Fungicides				
A	Benzimidazole	High	Systemic	Single site
B	Dicarboximide	Low (with low frequency application)	Systemic	Multi-site
K	Strobilurin	High	Systemic	Single site
Y	Multi-Site Activity (eg. Aromatic nitriles, phthalamides)	Low	Not systemic	Multi-site
Pesticides				
2B	Polychlorocycloalthanes	-	-	GABA-gated chloride channel antagonists
5A	Spinosyns	-	Contact	Nicotinic Acetylcholine receptor agonists
9A^{+}	Pymetrozine	-	Systemic	Unknown or non-specific (selective feeding blockers)
10A	Clofentezine^{+}, Hexythiazox	-	-	Unknown or non-specific (mite growth inhibitor)

$^{+}$Current permit

- Unknown

GENERAL RESISTANCE MANAGEMENT GUIDELINES FOR FUNGICIDE USE IN ALMONDS

Do not apply more than two consecutive sprays of fungicides from the same group before changing to another group (in particular Group B, C and K chemicals). Do not use more than three Group K sprays per season. If two or three consecutive applications of Group K chemicals are used, they must be followed by at least the same number of applications of fungicide(s) from a different activity group before Group K chemicals may again be used.

GENERAL RESISTANCE MANAGEMENT GUIDELINES FOR PESTICIDE USE IN ALMONDS

Rotate between miticides from different activity groups. Do not apply sequential applications of products from any one activity group. Treat infestations before threshold limits are reached. Rotate modes of action and ensure that no chemistry group (mode of action) is used more than twice in a season. Miticide use should be incorporated into an integrated mite management program, including predatory mites.

Crop Protection Products and the Environment

Crop protection products must only be used for their labelled purpose. Every effort must be made to ensure they do not harm applicators or damage the surrounding environment through off-label use, harmful or extended exposures, off-target applications, drift or hazardous disposal of remaining solutions or containers. Growers should consult the relevant Material Safety Data Sheet for safety directions before applying any agricultural chemicals. Growers are strongly encouraged to record details of all products used, the conditions under which they were applied, and the stage of crop/tree development at the time.

The following table ranks different environmental factors requiring consideration by growers. The tabulated rankings have been concluded after consideration of a range of readily available information.

Table 12: Environmental hazard rankings for active constituents approved for almonds

Active Constituent	Solubility in Water	Volatility	Soil Sorption	Leaching Potential	Aquatic Life	Birds	Bees	Soil Micro-Organisms	Poison Schedule	Activity Group
Fungicides										
Agrobacterium (bacterium)									0	Biological-Live
Azoxystrobin	2	1	3	2	4	2	2	2	S5	K
Captan	1	2	3	3	5	2	2	2	S6	Y
Chlorothalonil	1	1	3	2	5	2	2	3	S6	Y
Copper (cupric hydroxide)									S6	Y
Copper (tribasic copper sulphate)					4	2	1		S6	Y
Copper (copper ammonium acetate)									0	Y
Copper (cupric (II) hydroxide)									S6	Y
Copper (copper hydroxide)	1	0	5	2	5	2	5	5	S6	Y
Copper (copper oxychloride)	0	1	5	1	4	2	2	5	0	Y
Copper (cuprous oxide)					2	2	1		Ex	Y
Iprodione	2	1	3	2	3	2	0	1	S5	B
Mancozeb	1	1	3	2	3.5	2	0	2	S5	B
Phosphorous acid									S5	Y
Propiconazole					3	2	1		S6	C
Sulphur	0	0	4	2	1	0	0	2	Ex	Y
Insecticides										
Clofentezine									S5	10A
Dicofol					4	2	2		S5	2B
Paraffinic Oil									S5	Petroleum Derivative Oil
Petroleum Oil									S5	
Pirimicarb									S6	1A
Potassium Salts of Fatty Acids									0	Acid Fatty
Pymetrozine									S5	9A
Spinosad					3	2	5		Ex	5A
Tetradifon									S6	2B
Soil Fumigants and Vermin Control										
1,3-Dichloropropene									S7	Solvent
Chloropicrin									S7	Gas
Zinc phosphide									S7	Ungrouped

Toxicity Scale	Toxicity Scale	Hazard Scale	
5 = Very High / Very Highly Toxic	1 = Very Low / Very Slightly Toxic	Dangerous Poison	S7
4 = High / Highly Toxic	0 = None	Poison	S6
3 = Medium / Moderately Toxic	Unknown	Caution	S5
2 = Low / Slightly Toxic		Exempt	Ex

The Lethal Dose 50 values (LD_{50}), enable us to evaluate the toxicity of the chemicals applied in an orchard. Such values have been considered above in determining the given hazard rankings in Table 9. Specific LD_{50} values are tabulated below.

Table 13: LD_{50} values for various active constituents

Active Constituent	LD_{50} ORAL (mg/kg) Rat	LD_{50} DERMAL (mg/kg) Rabbit	LC_{50} INHALED (mg/L/4hr) Rat
Fungicides			
Agrobacterium (bacterium)	n/a	n/a	n/a
Azoxystrobin	>5000	>2000	>4.67
Captan	9000	4500	0.668
Chlorothalonil	>10000	>10000	0.1
Copper (cupric hydroxide)	1346	>5000	1.3
Copper (tribasic copper sulphate)	2500	>2000	>2500
Copper (copper ammonium acetate)	>5000	>4000	n/a
Copper (cupric (II) hydroxide)	489-1630	>5000	>2.15
Copper (copper hydroxide)	1300	>2000	>11.45
Copper (copper oxychloride)	700-800	>2000	>30
Copper (cuprous oxide)	1160-3165	>2000	>4.84
Iprodione	3500	>1000	>5.15
Mancozeb	>5000	>5000	>5.14
Phosphorous Acid	n/a	n/a	n/a
Propiconazole	2105	>2500	>1.0
Sulphur	n/a	n/a	n/a
Insecticides / Miticides			
Clofentezine	>5000	>2400	>9
Dicofol	575-690	2000-5000	>5
Paraffinic Oil	>2000	n/a	n/a
Petroleum Oil	>2000	>2000	5
Pirimicarb	100-200	>2000	0.86
Potassium Salts of Fatty Acids	n/a	n/a	n/a
Pymetrozine	>5000	>2000	>3.09
Spinosad	>5000	>5000	17.02
Tetradifon	>10000	>10000	>2.97
Soil Fumigant & Vermin Destroyer			
1,3-Dichloropropene / Chloropicrin	<300	<500	0.477
Zinc Phosphide	n/a	n/a	n/a
Root Intrusion	n/a	n/a	n/a
Trifluralin	>10000	> 2000	> 2.8

Biological Control of Almond Pests

Predatory mites play an important role in the management of pest mites within an orchard. Beneficial green lacewings and several parasitoids released (or naturally-occurring) in orchards enhance control of invertebrate pests. Biological control organisms need to be used in conjunction with softer pesticides and fungicides, so that the beneficials have an environment in which they can survive and reproduce.

Table 14: Beneficials available for biological control of almond pests

Pest	Biological Control Agent (Common Name)	Species
Light Brown Apple Moth	Parasitoid	*Trichogramma carverae*
Two Spotted Mite	Predatory Mite	*Typhlodromus occidentalis*
Aphids, Moth eggs, Scale, Whitefly	Green Lacewings	*Mallada signata*

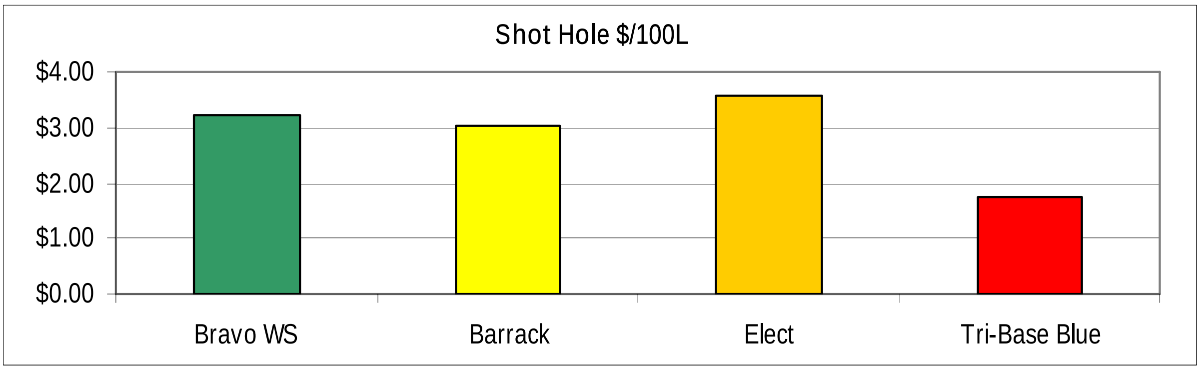
Further information about biological control and beneficials: www.goodbugs.org.au

Material Cost

There are over 100 crop care products registered or permitted for use on almonds in Australia. Each varies in per unit cost. Chemicals may not be directly comparable in performance or price. Some active constituents control more than one disease/pest; others may persist after a rain event and therefore require fewer applications etc. Recommended application rates and volumes also vary between products, and with tree size. Given prices of products therefore do not necessarily provide useful information on 'effective value for money.' Accurate comparisons however are essential if potential cost savings are to be identified. These may be undertaken using a representative unit of measure. For example, *cost per ha*, *cost per 100L* or *cost per tree*. For simplicity, the following examples compare *cost per 100L* and *cost/litre* or *kilogram*.

Product	Size (L or kg)	Cost/pack[1] (ex GST)	Application rate (L-kg/ 100L)	Cost $/L or kg	Cost $/100L
Tri-Base Blue®	20	$ 126.00	0.280	$6.30	$1.76
Bravo WS®	10	$ 201.80	0.160	$20.18	$3.23
Barrack®	10	$ 190.00	0.160	$19.00	$3.04
Elect®	10	$ 223.00	0.160	$22.30	$3.57

A quick way to compare costs (not relative performance) is to graph the unit cost for one application of each product. Bravo WS, Barrack and Elect consist of the same active constituent (chlorothalonil). Tri-Base Blue is tribasic copper sulphate.



Growers are encouraged to construct cost tables for their chosen crop protection products.

[1] Check costs with your local re-seller and modify application rates depending on your requirements.

Application Records

Good management (and approved supplier and quality assurance (QA) programs) requires all crop protection application details, be recorded. Records should be kept for a minimum of three years, as evidence of compliance. Examples of documents (*Agrochemical Application Record*; *Orchard Sprayer Calibration Record*) follow. These may be copied for use by growers.

AGRICHEMICAL APPLICATION RECORD

This is a general multi-purpose form. Applicators with specialised use patterns may prefer to use a customised form. In any case, records must be kept for three years, and entries should be made within 24 hours of each application.

General Information

Operator. The operator, or person applying the pesticide, must fill in their contact details. If the operator is not the owner, e.g. a contractor or employee, then the owner's details must also be provided. One copy of the record should be kept by the applicator; the other by the owner.

Date of application, start time, finish time. Date, time of the day of application (start and finish) must be recorded.

Crop Details

Crop sprayed. Addition of details such as crop variety and growth stage are important for QA schemes, but also serve to positively identify the area treated as required by the regulation.

Block/area and size of block sprayed. Identify the block/area and progression of treatment along rows. These may be filled in prior to the start of application. If using a contractor or an employee, this information should also be given before starting the job. Applicators using GPS systems could include a GPS reading in addition to the block number/name.

Product/Application Details

Pest/Disease targeted. It is desirable to identify the pest or disease that is being targeted. It would be helpful to provide as much detail about the pest or disease as possible, e.g. for a grub - 3rd instar/10mm etc; for a disease – extent or severity of existing symptoms.

Equipment used. As a minimum, equipment used must be recorded. Positive identification can be assisted by specifying the settings used for the application, e.g. nozzle type and angle, pressure. The nozzle type will usually include the angle. Pressure readings should be taken close to the nozzle. Other details are useful: date of calibration, water quality and source etc.

Product used. The product name, formulation and batch date, and approved rate/dose should be transcribed from the label. For tank mixes, include all products in the mixture. If the allowed use is on Permit, a copy of the permit should be read and attached. The permit rate/dose may vary from that on the label.

Amount of concentrate used and total volume of spray applied. The water volume may be noted on the label, or may be determined by the grower depending on size of trees. Water volume must be recorded. It is best calculated at the completion of the application. If additives or wetters are included in the tank mix, this must also be noted. If the label has a WHP (withholding period), record this and observe that this requires full (24 hour) days following the end of application.

Horticultural dips, e.g. post harvest treatments, must be recorded. For those producers seeking ICA (Interstate Certification Assurance) status, enter the time of dip mixture or top-up preparation, e.g. 'mixture prepared 9.00 am, top-up 3.00 pm'. Other details which could be recorded include time when the mixture was discarded, e.g. 'discarded 25.12.03' and the approximate quantity of fruit treated. Under 'Total quantity of spray applied', enter both volume of dip and concentrate, e.g. '20 ml Lebaycid/200 L mixture'.

WEATHER CONDITIONS

Wind Speed & Wind Direction (Changes to Wind Speed & Direction)

As a minimum, record wind speed and direction at time of application. This is best measured rather than estimated. It is helpful to know the capacity of the nearest weather station. Record any changes during application. Weather records have to be kept for all applications that distribute pesticides through the air. While records of weather during dip baths for plant produce are not required, any unusual or extreme conditions should be noted.

Other Comments

Rainfall and/or heavy dews or fog should be recorded for the 24 hours before and after applications.

Temperature and relative humidity should also be recorded, particularly if either or both are referred to in the restraints or critical comments sections of the label. Temperature and relative humidity can affect efficacy, phytotoxicity and the risk of off-target drift.

'Sensitive areas' on the property or in close proximity should be identified in advance, and marked on a sensitive areas diagram appended to the Pesticide Application Record. Applicators must be made aware of such areas before starting the application and have in their possession details (including map) of the sensitive areas or crops.

It is often useful to keep photographic records that are labelled and dated. Records such as crop stage by date and variety; evidence of spray coverage; effects of sprays etc. are particularly useful if subsequent damage or crop loss is incurred.

Explanation and examples of Agrochemical Application Records

EXPLANATIONS: Terms used for keeping Agrochemical Application Records

Date	Crop Sprayed (or variety)	Block (in order sprayed)	Growth Stage	Target Pest or Disease	Full Registered Product Name(s)	Amount of Product Used per 100L (g, kg, mL or L): Label Rate	Amount of Product Used per 100L (g, kg, mL or L): Conc. Rate (if applicable)	Conc. Factor (CF)	Applied Spray Vol. (L/ha)	Comments (Compulsory NSW)
Date Applied	If entire block sprayed, write "all"	Block name(s) Row order of spraying	Growth stage of crop	Pest or disease targeted	Agrochemical product name - from the label. eg Kumulus DF is required, not just Sulphur.	Amount added per 100L of water (label)	Amount added per 100L for 'Concentration' (Conc. Rate = Label Rate X CF)	Multiplier used for Concentrate spraying. If Dilute spraying, write "1".	The actual volume (L) of spray mixture applied per hectare	Operator Start/Finish Wind Sp./Dir Weather Conditions Equipment

EXAMPLES: How to complete the Agrochemical Application Records:

Date	Crop Sprayed (or variety)	Block (in order sprayed)	Growth Stage	Target Pest or Disease	Full Registered Product Name(s)	Amount of Product Used per 100L (g, kg, mL or L): Label Rate	Amount of Product Used per 100L (g, kg, mL or L): Conc. Rate (if applicable)	Conc. Factor (CF)	Applied Spray Vol. (L/ha)	Comments (Compulsory NSW)
? / ? / 2008	Nonpareil	5 start row 30	Shuck fall	Brown rot	Dithane RS	200g		1.0	1,800	Operator *WW*
	Carmel	1 & 2 start row 15	Shuck fall	Shot hole	Barrack	160g				Start/Finish *0825 - 1500*
					LI 700 Surfactant	10mL				Wind Sp./Dir *2B - NE*
	Dilute Spray Example									Weather Cond *clear, 22℃*
										Equipment *Croplands Air blast*
? / ? / 2008	Non Pareil	5	Shuck fall	Brown rot	Dithane RS	200g	500g	2.5	600	Operator *WW*
	Carmel	1 & 2	Shuck fall	Shot-hole	Barrack	160g	400g			Start/Finish *0825 - 1500*
					LI 700 Surfactant	10mL	10ml			Wind Sp./Dir *2B - NE*
	Concentrate Spraying Example									Weather Cond *clear, 22℃*
						A	C	B		Equipment *Croplands Air blast*

NOTE: Concentration factors are not applicable to adjuvants. For these products, the Concentration Factor is always 1.0. For all other agrochemicals: A x B = C

Crop Sprayed	Block Area	Growth Stage	Target: Pest, Disease or Weed	Full Registered Product Name(s) *Eg. Fungicide /insecticide/ herbicide*	Withholding Period	Label Rate of Registered Product Used per 100L	Conc. Factor (CF)	Amount of Water Sprayed (L/ha)	Amount of Registered Product Used (per ha)	Comments
Date of Application										Operator
Non Pareil	5	Shuck fall*	Brown rot	Dithane RS	14 days	200g/100L	1	2000	4 kg/ha	Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment
Date of Application										Operator
										Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment
Date of Application										Operator
										Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment
Date of Application										Operator
										Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment

* Photo taken

Adapted from Spray Diary format, AWRI website, 2006.

ORCHARD SPRAYER CALIBRATION RECORD

(Modified from 'Orchard Plant Protection Guide for deciduous fruits in NSW 2005/06)

Spray unit …………………………………………………………	
Nozzle Set-up ……………………………………………………..	
Operating pressure ……………………………………………..	
Tractor …..………………………………………………………	
Operating Speed and gear …………………………………	

Air Calibration

Air inlet area (m^2) …...………………………………………….		
Air speed at intake (m/sec) …………………………………..		
Air volume (m^3/a) ……………………...……………………….		
Tree dimensions (m) …..……………………………………	Canopy width:	Canopy height:
Optimum tractor speed (km/h)………………………………..		

Water Calibration

Actual tractor speed (km/h) ...………………………………	
Total nozzle output (L/min) ………………………………....	
Row spacing (m). ……………………...………………………	
Application volume (L/ha) …..……………………….....…….	

Calibrated by:	Date:

Generalised Almond Protection Guide

Stage of Development*	Target	General products and Activity groups	Comments
Post-Harvest Leaf Fall		Urea or zinc (defoliation) Group Y fungicide + copper (after leaf fall)	Aims to clean up trees and protect leaf scars. Fungicidal clean up useful after problem seasons with high numbers of sticktights etc.
Dormant	Mites Fungal spores	Winter Oil at full dormancy + copper or Summer oil as bud burst nears + copper	Ensure 10+ days after zinc and before oil applied. Use high water volumes.
Green Tip - early Pink Bud	Shot hole Bacterial spot Brown rot	Group Y fungicide + copper (*Note*: no captan or chlorothalonil) within 10 days of oil.	Ensure fungicide coverage of Fritz and NePlus and early flowering varieties, to achieve brown rot control. Water volume of 1200+ L/ha.
Pink bud – early bloom (<5% bloom)	Bacterial Spot Shot hole Anthracnose Brown Rot	Group Y fungicide + copper (if not applied at green tip)	Treat varieties at correct flowering stage. May require multiple passes through orchard
Early-mid bloom 20-50%	Shot hole Botrytis Anthracnose Brown Rot	Iprodione (Group B) + captan (Group Y)	If strains resistant to dicarboximides exist, select other Botrytis control product. Check compatibilities on each label.
Full Bloom 80+%	Shot hole Botrytis Anthracnose Brown Rot	Multi-site fungicide from Group Y.	Necessary if early bloom sprays missed and when rain has persisted since early bloom. Use different Group Y product to that used in early bloom. Use higher water volume 1600+ L/ha.
Petal Fall – Shuck fall	Shot hole Brown Rot Anthracnose Bacterial spot	Multi-site fungicide from Group Y.	If wet spring persists and there are exposed new leaves, consider bringing forward next suggested spray, or tank-mixing DMI with this spray.

Stage of Development*	Target	General products and Activity groups	Comments
2 Weeks Post-Bloom	Anthracnose Shot hole Botrytis Alternaria complex? Leaf blight?	Strobilurin (Group K) or DMI (Group C) fungicide	Includes propiconazole, azoxystrobin. Protection and eradicant activity. Ensure all leaves covered. Increase water volume to 2000L/ha. Avoid applying copper any later than this.
5 Weeks Post-Bloom	Alternaria complex? Anthracnose Shot hole Mites	Group Y fungicide (*Note:* do not use captan or chlorothalonil if oil used for mite control within 10 days)	Monitor for mites. Fungicide schedule from this point is weather-dependent; ensure new leaves are protected.
Late Spring Early Summer	Alternaria complex? Rust	Group C fungicide + mancozeb (or other Group Y)	Start looking for rust before hull split. Read label for tank compatibilities and withholding periods
Summer December-January	Rust Hull Rot	Multi-site Group Y fungicide	As needed; weather-dependent hereafter.

NOTES:

Herbicides – no pre-emergent sprays before early July
Activity groups and action sites are explained in above document
No chlorothalonil or captan with, before or after (within 10 days) oil
Ensure good coverage and adequate water volumes
Use monitoring and growth stages of crop as guide rather than calendar dates
Bloom sprays – avoid bee disruption; spray later in day
Surfactants/ spreaders – check labels for compatibility
Tank mixes with nutrients require particular attention to pH of mix and chloride levels.
Compatibilities – check all labels
Non-bearing trees may not require the intensity of above-mentioned chemical protection, but should not be ignored as they are susceptible to many diseases.

Reference List

Adaskaveg J, Holtz B & Michailides T et al. (2006). Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut Crops, and Grapevines. University of California.

Almond Board of California (2003). The Foundation for a Pest Management Strategic Plan in Almond Production, *Summary of a Workshop Held December 12, 2002, Modesto, California*. Almond Board of California.

AWRI (2006). Spray Diary Format <http://www.awri.com.au/agrochemicals/spray_diary/SPRAY0405.xls>

Bower CC & Thwaite WG (1995). The Mite Management Manual : A Practical Guide to Integrated Mite Control in Apples. NSW Agriculture, Orange.

CropLife Australia (2005). Fungicide Resistance Management Strategies. CropLife Australia Ltd, Canberra.

CropLife Australia (2005). Insecticide Resistance Management Strategies. CropLife Australia Ltd, Canberra.

Hely PC, Pasfield G & Gellatley JG (1982). Insect Pests of Fruit and Vegetables in NSW. Inkata Press, Melbourne.

Hetherington S D, Bright J & Mooney A (2005). Orchard Plant Protection Guide for Deciduous Fruits in NSW 2005/06, 15th edition, NSW Department of Primary Industries, Orange.

Sutton J, Trainer S & Sivyer M (2003). Pome & Stone Fruit Orchard Spray Guide 2003/04. Department of Agriculture WA.

Swaine G, Ironside DA & Corcoran RJ (1991). Insect Pests of Fruit and Vegetables, 2nd edition, Queensland Department of Primary Industries, Brisbane.

University of California (1985). Integrated Pest Management for Almonds. University of California, Oakland.

Zalom FG, Pickel C, Bentley WJ et al. (2005). UC IPM Pest Management Guidelines: Almond. University of California, Davis.

Almond Industry

Pest & Disease Control Guide 2009-10

Almond Industry
Pest & Disease Control Guide 2009-10

PREPARED BY:

Scholefield Robinson Horticultural Services Pty Ltd for the Almond Board of Australia

Authors: Dr Kate Delaporte, Consultant
Sarah Kane, Technical Officer
Dr Prue McMichael, Principal Consultant

ACKNOWLEDGEMENTS:

Current Edition

Ben Brown
Anne-Marie Strudwick
Peter Dal Santo
Julie Haslett

Significant Contributors to Earlier Editions

Lucy Pumpa
Chris Bennett
Amanda Schapel
Stuart Pettigrew
Barb Hall
Trevor Wicks

The Almond Board of Australia
PO Box 2246
BERRI SA 5343

Ph: (08) 8582 2055
Fax: (08) 8582 3503

Contents

Introduction

The Australian almond industry has recently experienced both significant growth and challenges. New growers and investors, sizeable new plantings, the ongoing development of new production areas, and increasing compliance and regulatory pressures in the domestic and export markets, have resulted in great demand for production information and chemical use advice. This Guide has been prepared for the industry and should be viewed as a living document. It is accurate and up-to-date today but the rate of change in crop care technology (products, permits, registrations, chemistry, electronic support programs etc) is such that the Guide will require constant revision. Between reprints it will be the responsibility of growers to access and implement the latest information and recommendations. Useful sources of such information are included in the Guide.

Although this Guide includes technical information on the main almond pest and disease threats and products available for their control, it does not explicitly direct growers to specific crop protection products (or biological control organisms), application times or rates. Growers must make these choices in compliance with the product labels and when appropriate, export market requirements. Regional climates, varieties grown, disease pressure, pest populations, orchard history, previous product choices and tank mixes, resistance threats etc must be considered before designing and implementing your pest and disease control program. To finalise a program most growers will also look at the economics of the available product range.

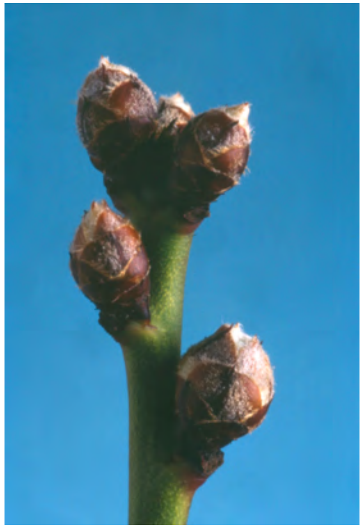
The Guide provides information on almond pests and diseases that can be managed and monitored by orchard managers. The Guide does not include discussion of abiotic tree stresses (poor nutrition, soil problems, toxicities and deficiencies, irregular watering, water quality, heat, flooding, frost etc), but growers should recognise these factors may influence the onset or severity of the pests and diseases that are discussed. The Guide does not include information on viruses, viroids or phytoplasmas, or on disorders with unknown causes since the management of these is either undefined or is required before planting. Steps taken by growers before planting greatly influence the effectiveness of orchard management thereafter. Site selections, soil suitability, irrigation plans, choice of planting material, evaluation of planting material quality and health are critical steps in the establishment of good orchards.

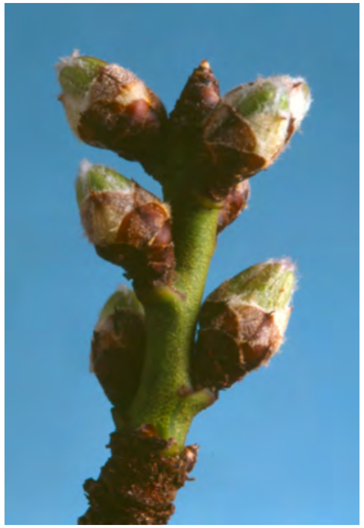
As members of the Australian almond industry, it is each grower's responsibility to give consideration to 'resistance management'. In combination, product chemistry and grouping, use patterns and pest biology, influence the potential for and development of resistance. Almonds do not have a wide range of product chemistries available amongst their crop protection products. This limits the opportunities for effective 'rotation' of product chemistry in resistance management. Growers must evaluate the effectiveness of their pest and disease control programs each season. To do this, detailed records of observations, monitoring, and applications are needed. This Guide includes examples of required records and useful recording forms.

Feedback: The authors of this Guide congratulate the almond industry on supporting the updating of the previous Guides (2006, 2008), through the provision of useful technical information, and funding. Users of the Guide have provided important feedback to the industry on the Guide's usefulness, format, completeness and gaps. It is hoped this will continue.

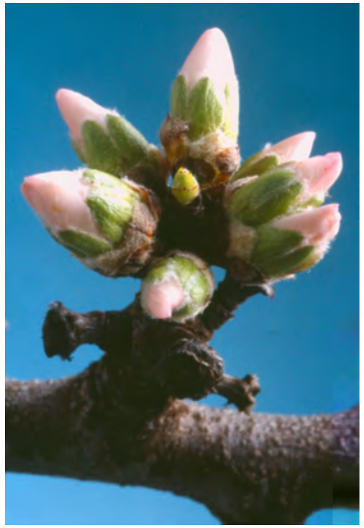
Flowering Stages for Almonds

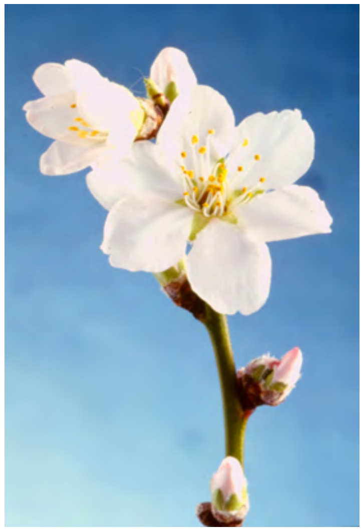

Dormant

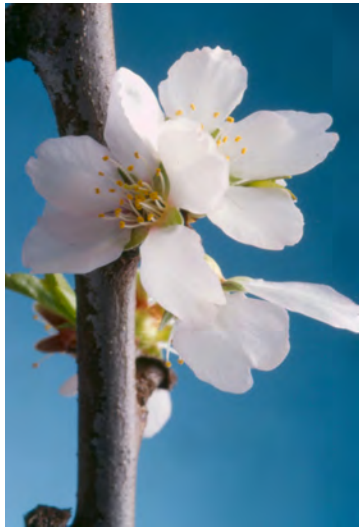

Bud Swell


Green Tip


Early Pink Bud


Mid Pink Bud


Early Bloom


Full Bloom


Petal Fall


Shuck Fall


Young Nuts

Pests and Diseases

There are a large number of pests and diseases of almonds. The bacterial and fungal causal organisms and the invertebrate pests that have the potential to cause economic damage to almonds are listed and discussed below. Those pests and diseases not listed include viruses, phytoplasmas and nematodes. Those organisms not currently considered to be an economically significant threat to almonds in Australia are not listed. Disorders for which a cause is unknown are also not listed.

The following table provides information on the critical periods for bacterial and fungal diseases of almonds.

Table 1: Almond Disease Damage and Treatment Table

Disease	Pre-Plant	WINTER				SPRING		SUMMER			AUTUMN	
		Leaf Fall-Dormant		Green Tip – Full Bloom		Shuck Fall-Early Set		Nut Growth & Hardening			Harvest	Post-Harvest
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb-Mar	Apr-May
Anthracnose						░	░	░	░	░	░	
				█	█	█	█	█	█	█		
Bacterial Canker			░	░	░	░	░	░	░	░	░	
								█	█	█		
Bacterial Spot							░	░	░	░	░	
					█	█	█	█				
Blossom Blight				░	░	░						
				█	█	█						
Brown Rot				░	░	░	░					
				█	█	█	█					█
Crown Gall		░	░	░	░	░	░	░	░	░	░	░
	█											
Hull Rot									░	░	░	
									█	█	█	
Leaf Blight						░	░	░	░			
					█	█	█	█	█			█
Phytophthora							░	░	░	░		
				█	█	█	█	█	█	█		
Rust									░	░	░	
								█	█	█	█	
Shothole			░	░	░	░						
			█	█	█	█	█	█				
Silverleaf												
	No registered treatments available											
Verticillium Wilt								░	░	░	░	
	█											

Disease-causing organism present in Australia, but disease as described in California not found here												
Alternaria Leaf Spot	*Damage periods and management response not defined for Australia*											
					█	█	█	█	█	█		
Band Canker	*Damage periods and management response not defined for Australia*											
								█	█	█	█	
Freckle & Scab	*Damage periods and management response not defined for Australia*											
						█	█	█	█	█	█	

░	Damage period
█	Monitoring and management period

BACTERIAL DISEASES

(Photo: SARDI)

Bacterial Canker (*Pseudomonas syringae* pv *syringae*)

This disease, also called gummosis, occurs worldwide on many hosts. Although infection may remain latent in buds, leaves or wood wounds for some time, the most commonly seen symptoms in young almonds are bud death and blackened blossoms (blossom blast), and the sour-smelling, sunken, elliptical, rough, dark cankers from which watery exudates ooze. Under the bark near the cankered tissue, reddish flecks may be visible. Suckering from the rootstock may develop in trees with infected scions. The bacteria usually enter through leaf scars in the late autumn, but may also enter through injury sites caused by sand-blasting, wind or hail. The bacteria are active in the winter and therefore the first signs of infection are often seen the following spring. Tree stress enhances this disease and therefore site selection and environmental conditions are important in its management. No specific chemical controls are available.

Bacterial Spot (*Xanthomonas arboricola* pv *pruni*)

This bacterial disease affects almonds and stone fruit. On almonds, the leaf symptoms may resemble those of 'shothole' and of copper phytotoxicity. The lesions are reddish-dark in colour and of irregular shape. They are clustered where wetness is prolonged – at leaf tips, along the midrib or on the sheltered side of the blade. Most infected leaves are found in the inner canopy. Infected nuts gum profusely from slightly sunken, corky lesions. Both young and established trees are susceptible with the most susceptible varieties being Fritz and Ne Plus. Economic losses result from the yield reduction through nut gumming and premature nut fall. Twig dieback and defoliation have longer term effects on tree productivity and longevity. Avoidance and protection are the best forms of management and no chemical treatment alone controls this disease.

(Photo: SARDI)

Crown Gall (*Agrobacterium tumefaciens*)

This bacterium has many potential woody and herbaceous hosts. Crown gall may be severe on almonds although significant losses in orchards and nurseries are rare. Infected roots develop galls at or near the soil line in mild weather. Galls on young trees are likely to cause more damage than those on established trees. Treatment for crown gall must be applied before planting. Clean planting material is very important to avoid introduction of the bacterium to the orchard. Thereafter hygiene and injury minimisation are critical. If the bacterium is present in the orchard, growers must be aware of its potential spread via pruning tools and equipment. The bacterium requires an entry point; usually a wound, and therefore minimisation of injuries during planting, training and pruning, is important in the management of this disease.

FUNGAL DISEASES

Anthracnose (*Colletotrichum acutatum*)

This is an economically-important fungal disease that may develop early in mild-wet seasons. Trees are susceptible from early bud movement until hull split and therefore the application of crop protectants must start before any symptoms are visible. Young infected nuts are often clustered. They abort, hang on and develop an orange colour. Mid-sized, infected nuts gum profusely. Infected leaves start with a water-soaked appearance that later resembles marginal 'burn'. Most leaves within an infected spur die, but hang on for some time. Twig dieback follows. The fungus survives the winter in buds, peduncles, mummies and twig lesions. All varieties appear susceptible, with Nonpareil perhaps the least severely affected. The disease has not been confirmed in trees less than five-years-old.

Blossom Blight (*Botrytis cinerea*)

B. cinerea is a ubiquitous fungus with a very wide host range that includes fruit, vegetable and flower crops. It may attack all almond flower parts in cool-mild, wet weather, or in conditions of high humidity. The blossoms die and characteristic masses of grey spores form on the dead and dying parts. Infection may extend into green almond fruit although this is not common in Australia. Although fungicides remain the best control method, it should be noted that resistant strains of *B. cinerea* are widespread and therefore resistance management strategies are very important in local orchards and regional areas where susceptible crops are grown.

Brown Rot (*Monilinia laxa*)

This fungal disease appears sporadically but can be a significant problem in almonds and stone fruit. Worst affected are the early flowering almonds, although all varieties are considered susceptible. The blossoms are attacked in cool-mild, wet or foggy weather. Infected blossoms wilt and die rapidly, but hang onto the spur giving a messy appearance. In humid weather a mass of light brown spores may form on the flower parts. The infection continues into the peduncle and twig. Terminal twig dieback is common. The fungus survives in buds, old flower parts, twig cankers and mummified fruit. It is important not to promote disease conducive conditions by irrigating during flowering.

Hull Rot (*Rhizopus sp.*)

This is a fungal disease that does not appear until late in the season. Twig and leaf death occurs after the hull of infected nuts has split. The fungus enters the moist hull area via the open suture. Sporulation and mycelial growth may be prolific in moist and warm, humid weather or humid conditions. Hull infection is followed by wilting and death of leaves on nearby spurs and shoot death. Vigorous trees are more susceptible to hull rot as the air movement in such trees is reduced. Overhead irrigation further exacerbates environmental conditions conducive to the fungus. Nut infection by *Monilinia sp*. may also contribute to hull rot. Although all varieties are susceptible, it appears that Nonpareil sustains most damage. There is no registered, effective chemical control, but cultural practices that improve air flow through canopies and careful irrigation during hull split reduce the threat of hull rot.

(Photo: UC Davis www.ipm.ucdavis.edu)

Leaf Blight (*Seimatosporium sp.*)

This fungus has been isolated from almond leaves in Australia, but the disease remains sporadic and poorly recognised. Spores are splashed onto susceptible tissue during prolonged rains. Infected leaves are generally found throughout the canopy. The blades may wither and fall, leaving petioles on the tree for some time. Most fungicide programs intended for the control of other fungal diseases of almonds (i.e. shot hole) should assist with the management of this disease.

Phytophthora (*Phytophthora spp.*)

These water-loving organisms may be economically significant within temperate growing regions, some seasons. Infested soil, water or planting material may introduce the fungi to an orchard, and infection may originate in the roots, crown or aerial tree parts. Infected almonds may first appear unthrifty and unresponsive to inputs (fertilisers and water) but crown rots, trunk cankers and/or branch dieback will later develop if the disease is not managed. Symptoms are especially obvious in spring and summer. Cultural management strategies are aimed at avoidance of standing water around roots, crowns or in the crotch of trees. Chemical controls are also available.

(Photo: SARDI)

Rust (*Tranzschelia discolor*)

This fungus attacks most *Prunus spp*. In almonds the outbreaks of rust generally occur later in the season – around December. The first signs of infection are yellow spots on the upper leaf surfaces. Corresponding orange pustules (of spores) soon develop on the lower surface and leaf drop may occur. Warm weather and dew periods favour development.

(Photo: SARDI)

Shothole (*Wilsonomyces carpophilus*)

This fungal disease is common in all almond growing areas of Australia. The fungus survives in buds and twigs. Early season rains activate the spores and splash them onto blossoms and leaves. Infected leaves develop small, circular purplish spots that enlarge and develop a defined centre within a yellow margin. The central area dies and often falls out. Similar lesions develop on the upper side of fruit and these become rough and corky with age. All varieties appear susceptible. Control is via the protection of leaves from emergence until 5-6 weeks after petal fall.

Silverleaf (*Chondrostereum purpureum*)

This wood-rotting fungus, although very destructive in stone and pome fruit, is not commonly encountered in our almond orchards. Spores are released into the air from fan shell-like, mauve-brown fruiting bodies that develop on dead, infected wood (i.e. old stumps, pruning piles) or on alternative hosts like willows and poplars. Infection starts when the spores land on exposed wounds or pruning cuts, and progress to xylem tissue. Silvery, dull leaves on a particular scaffold are often the first symptom of infection on almonds, and these early signs may be confused with those resulting from a mite infestation. As the infection progresses, the fungus releases a toxin, and infected trees often die within three seasons of the first symptoms. Infected wood in cross-section shows dark-stained xylem. Infected scaffolds should be removed, burnt or buried, and surrounding trees checked for the fruiting bodies. Avoid all pruning in wet weather.

(Photo: SARDI)

Verticillium Wilt (*Verticillium dahliae*)

This fungus has a very wide host range, including almonds and other nuts. The disease generally affects young almond trees which either die quickly or 'grow out' of the symptoms. Infected roots result in xylem blockages that cause yellowing and wilting of several branches, but rarely the whole tree. The wilt is most frequently noticed with the onset of warm summer weather. Ne Plus trees are very susceptible. The fungus survives in the soil for long periods. It is therefore important not to introduce the fungus into an orchard via nursery plants, and not to plant into soil in which previous crops or weeds have been infected by the fungus.

(Photo: SARDI)

Alternaria Leaf Spot (*Alternaria alternata*)

This fungus is a common inhabitant of orchards. There are three fungal types of the *Alternaria alternata* complex that have been associated with leaf spots of almonds, but in Australia they have not been found as primary pathogens. In California, leaf symptoms first appear in late spring as small, light brown lesions. Lesions can expand to 5-20 mm in diameter on the leaf blade and are circular in appearance. As the season progresses the fungus sporulates, turning the centre of the lesions black. Infected leaves fall and trees may defoliate prematurely. Infected trees have more 'stick tight' nuts. The disease severity increases in orchards with stagnant air, high humidity and extended dew periods.

(Photo: SARDI)

Band Canker (*Botryosphaeria dothidea*)

This fungus has a wide host range, but the disease on almonds has not been reported in Australia. This is despite the pathogen being present on other hosts. In California, infection takes place through small growth cracks. The fungus kills the bark and can kill the cambium layer with the affected area becoming sunken and oozing large volumes of gum. Although the band cankers form infrequently, they are characteristic of the disease, since they extend around the branch or trunk, rather than longitudinally along them. The cankers are only active during warm summer weather and are most common in vigorous trees between 3-6 years old.

(Photo: SARDI)

Freckle & Scab (*Cladosporium carpophila*)

In Australia we have generally found this fungus to be a secondary, rather than primary pathogen. However *Prunus* orchards worldwide in warm, high rainfall or sprinkler-irrigated areas are susceptible to this fungus. Leaves, twigs and fruit may be affected with infection beginning as small, water-soaked, somewhat circular, green-yellow lesions that first appear on the underside of leaves. Lesions turn olive green with fully developed lesions appearing dark brown and 10+ mm in diameter becoming visible from the upper surface of the leaf. Lesions may coalesce, forming larger necrotic areas. Extensive infection may result in defoliation. The disease can be controlled with various types of fungicides.

OTHER PESTS & PROBLEMS

The following table indicates when various pests are active or when symptoms can be observed in orchards. Timing for the treatment of these pests and problems are also included.

Table 2: Almond Pest Damage Periods and Treatment Table

Pest	Month											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Aphid (Black Peach)	░	░	░									
	█	█	█									
Bryobia Mite			░	░	░							
	█	█	█	█	█	█						█
Carob Moth						░	░	░				
				█	█	█	█	█				
European Red Mite				░	░	░	░	░	░			
	█		█	█	█	█	█	█				█
Indian Meal Moth								░	░	░	░	
								█	█	█	█	
Light Brown Apple Moth			░	░	░	░						
				█	█	█	█	█	█	█		
Nematodes	░	░	░	░	░	░	░	░	░	░	░	░
	Pre-planting management required in conjunction with using resistant rootstocks in problem areas											
Rust Mite			░	░	░	░						
	█	█	█	█	█	█	█	█				
San Jose Scale			░	░	░	░	░	░	░	░	░	
	█	█	█	█	█	█						█
Tomato Russet Mite			░	░	░	░	░	░	░	░		
	█	█	█	█	█	█	█	█				
Two Spotted Mite						░	░	░	░			
			█	█	█	█	█	█	█			

░	Damage Period
█	Monitoring and management period

NOTE: Ants, Apple Weevil, Earwigs and Snails are sporadic pests of almonds however there are no registered products for their management (refer to Dal Santo, 2008 Almond SARP Guide).

Black Peach Aphid (*Brachycaudus persicae*)

The black peach aphid (BPA) attacks both the roots and the above-ground portions of the trees. Wingless forms overwinter on the roots and in early spring, some migrate from roots at budswell to early summer, feeding on the newly developing flowers, leaves and shoots. Several generations of female aphids are produced. In early summer, winged adults are produced and migration to other trees occurs. Above ground colonies usually disappear by midsummer as wingless forms that migrate to the roots to feed and overwinter. Winged and wingless adults of the black peach aphid are shiny black and about 2 mm long. The nymphs are reddish brown. Of most concern is the feeding of BPA on the roots of young trees which can stunt growth and predispose the tree to damage from other organisms and harsh environmental conditions. Injury from above ground colonies is seldom serious and consists primarily of leaf curling, yellowing, and premature drop. Some fruit distortion may occur. If aphids are abundant, honeydew excretion may result in spotting of leaves and fruit with a black sooty mould.

In spring when growth begins, look for colonies of this aphid when monitoring other pests. If this aphid has presented problems in the past, take control measures in spring.

Natural enemies, such as ladybirds, lacewings and parasitic wasps, can be very important in controlling aphids, however, their populations usually do not appear in significant numbers until aphids begin to be numerous.

Bryobia Mite (*Bryobia rubrioculus*)

Hot, dry conditions, and moisture-stressed trees suit the Bryobia (also called Brown) mite. Bryobia mites pierce the leaf epidermal cells and suck out the contents. Infested leaves develop whitish grey spots on the upper surface and a dull appearance overall. The damaged leaf surface reduces the photosynthetic capacity of the tree, subsequently weakening it. Unlike the signs of other mite infestations, bronzing of the leaf surface is not caused by Bryobia mites. Crop size may be reduced in heavy infestations because nut size and development rate can be affected. Biological control options are available, but usually a dormant winter oil spray is effective. If infestation occurs during the growing season, dicofol application is recommended. Populations of this mite appear to have decreased in recent years, with a notable increase in two-spotted mite populations over the same period.

(Photo: CSIRO www.ento.csiro.au/aicn/name_c/a_727.htm)

Carob Moth (*Apomyelois ceratoniae*)

Almonds become vulnerable as soon as the green hulls begin to split. The adult females are attracted to the odour of fungi that grow on the splitting hulls and eggs are laid in the splits. Larvae feed on the shells and penetrate the kernels. Moths may overwinter in old nuts on the ground. Summer rains increase infestations. The first spray should coincide with the splitting of the hulls.

(Photo: UC Davis www.ipm.ucdavis.edu)

European Red Mite (*Panonychus ulmi*)

European Red Mite populations are often controlled by natural enemies and do not commonly reach damaging levels in orchards. However, if an outbreak was to occur leaves become speckled as a result of feeding damage, and can appear pale, bronzed and burned at the tips and margins. Trees can tolerate high levels of infestation if not stressed; however, if they are under stress they may experience leaf defoliation. The mites overwinter as eggs at the base of buds and spurs on small branches while eggs from summer generations are laid on leaves. Adults can start emerging as early as October and the best treatment involves a delayed dormant oil spray. Biological control programs may be implemented in an effort to control this pest, with the brown lacewing (*Hemerobius* sp.) being the most effective predator.

Indian Meal Moth *(Plodia interpunctella)*

Indian Meal Moth is a post-harvest and storage pests of almonds. Larvae feed on the kernels and produce extensive webbing throughout the infested material. Various methods can be used to control the pest including post-harvest chemical fumigation, ionizing radiation, controlled atmosphere temperatures, cold treatments and various forms of heating. The baculovirus 'Indian Meal Moth Granulosis Virus' has been used in the USA (in the form of a microbial insecticide) to control the pest. Storage facilities must choose control methods approved for use in Australia.

(Photo: Greg Baker, SARDI)

Light Brown Apple Moth (*Epiphyas postvittana*)

Light Brown Apple Moth is a native insect with a wide range of alternative hosts. It is usually a minor pest of almonds and can be controlled with an insecticide application. Thorough coverage is necessary because larvae are often sheltered. The larvae are leaf feeders and they form webbed shelters in leaf folds and between leaves. Leaf injury is more likely to be found low down in the centre of the trees. Cool conditions extending well into the summer months favour this pest. It is important to reduce weeds on the orchard floor as they can provide an alternative host. Commercial Almond producing areas near grapevines may be at greater risk.

Nematodes

Nematodes live in the soil and on plant roots. They feed on the roots of almond trees and reduce the ability of the trees to uptake water and nutrients. Symptoms of nematodes include lack of vigour, stunted growth, twig dieback, slight yellowing of the foliage, lack of response to water and nutrient applications, and reduced yield. (IPM for almonds.)

(Photo: UC Davis www.ipm.ucdavis.edu)

San Jose Scale (*Diaspidiotus perniciosus*)

San Jose Scale has a high reproductive capacity, with the most rapid development occurring in warm, dry conditions. It can produce at least 2 but up to 4 generations per season, on a number of hosts. The scale feed on bark, foliage and fruit, sucking plant juices and injecting a toxin, resulting in loss of tree vigour, growth and productivity. In severe cases death of limbs may occur, while more commonly the fruiting wood for the next season is killed. The presence of gum on wood is a common sign of scale attack. The visual presence of scale on leaves occurs when the infestation is severe. San Jose Scale can be managed with natural enemies, including ladybirds, parasitic wasps and lacewing larvae. The use of sulphur and a dormant winter oil spray are available for control, with thorough coverage right down to ground level required. If the scale is well-established, a second oil spray in spring may be necessary. Growers should be mindful that the application of broad-spectrum insecticides can interrupt the balance of the natural control cycle and scale populations can build up.

Rust Mite (*Aculus* spp.)

Rust Mites are very tiny mites that shelter and overwinter under bud scales, loose bark or other insect shells. They move onto expanding leaf buds in early spring and start feeding. Upward rolling of leaves along the midrib axis is one of the first signs of rust mite attack. Mite feeding kills epidermal cells of the leaves, causing them to bronze, desiccate and curl up. Oil sprays may be used in an effort to control this mite.

(Photo: UC Davis www.ipm.ucdavis.edu)

Tomato Russet Mite (*Aculops lycopersici*)

Tomato Russet Mites are very small mites that proliferate in warm, dry weather. They have the capacity to increase populations very quickly as their life cycle can be completed in six days. The mite scrapes the leaf surface and sucks the juice out of the leaves, with leaves becoming silvery, then bronze on the underside before curling and eventually dying. Early prevention is recommended rather than eradication.

Two-Spotted Spider Mite (*Tetranychus urticae*)

Two-Spotted mites damage foliage by sucking the contents from individual leaf cells. Infestations normally are noticed first in the inner lower part of the canopy. The damage often appears as light-coloured stippling that progresses to brown leaves that fall from the tree. High populations of mites can cover the tree terminals with webbing. Mites over winter under bark and in ground litter; however, they have the ability to continue feeding and reproducing in the winter. The reduction in photosynthetic activity may reduce the size and development of nuts. Management can often be achieved via predatory mite populations. If however, treatment is necessary, pyrethroid, organophosphate and carbamate insecticides should be avoided as they upset the potential for biological control. Oils are the preferred treatment option.

AUSTRALIAN ALMOND INDUSTRY BIOSECURITY PLAN FOR INCURSIONS OF EXOTIC PESTS AND DISEASES

Plant Health Australia (PHA) is developing and implementing programs and policies to improve Australia's general plant biosecurity. The Almond industry is aware of the shared responsibility of government and industry to manage biosecurity. Post-border, the responsibility for biosecurity is increasingly on industry. As such, on-farm and regional biosecurity plans and activities will require broad awareness and engagement with producers, service providers, and the community; surveillance by growers, community members, on-farm workers and personnel in allied industries (i.e. pollination, contractors etc).

The early detection of suspect pests and diseases, the immediate reporting of them, readily available diagnostics expertise, and adequate resources and human capacity to respond to threats, will increase our industry's chances for exotic pest eradication or management, should an incursion occur.

There are several emergency plant pests of almonds. These include disease-causing organisms and insect pests and vectors not known to be present in Australia. For more information refer to *Identification and Analysis of Pathogen Threats to the Nut Industry* (available through the ABA or PHA).

The Almond Board of Australia has been proactive in developing an Almond Orchard Biosecurity Manual to enhance our efforts, preparedness and awareness.

If anything unusual is spotted, call the **Plant Pest Hotline** on **1800 084 881**.

Crop Protection Chemicals Registered and with Permits for Use on Almonds in Australia

Be informed. The use of crop protection products comes with responsibilities.

It is the responsibility of chemical users to check labels and keep up-to-date on registrations and permits. Chemical users must comply with the label rates and application timing. It cannot be assumed that all products with a particular active constituent are registered for the same use, on almonds. The most current and accurate information available on crop care product registrations and permits is found on the APVMA website: **www.apvma.gov.au** or through the individual crop protection company websites.

The information given in the following tables represents the active constituents and products currently registered or permitted for use in Australian almond orchards. Please note that registrations can vary from state to state.

For example the current Victorian Agricultural and Veterinary Chemical 'Control of Use' legislation, allows application to almonds of a product not specifically registered for use on almonds, if the product:

- is registered for similar use in Victoria;
- not on the 'prescribed' list;
- the maximum label rate is not exceeded; and
- no residues remain (can be detected) at harvest.

FUNGICIDES REGISTERED AND WITH PERMITS FOR USE ON ALMONDS IN AUSTRALIA

Many of the fungicides registered for use on almonds in Australia are effective for the control of multiple diseases. However, in most cases broad efficacy is not reflected on individual labels and only one or two target organisms are named. Labels must be followed.

Table 3 includes chemicals currently registered for use on Almonds and active constituents for which there are minor use or emergency permits available, pending or currently under review.

The APVMA website must be consulted frequently and especially before the use of any product that does not have full registration. The APVMA website provides the latest information on a product's status – i.e. if a valid permit exists for that product on almonds, how to interpret the permit, under what conditions the permit (and product) may be used. Active constituents with permits pending cannot be used. All chemicals require annual registration fees to be paid from 1 July to 30 September in each year. Check the APVMA website at the last possible opportunity to confirm that the chemicals have been re-registered.

In October 2008, CropLife Australia completed a review of the Australian Fungicide Activity Groups classification system. In summary:

- the general intent of activity grouping by risk has not changed;
- there are now 27 activity groups designated by number (and letter) codes, and aligned with those of the International Fungicide Resistance Action Committee; and
- most active constituents have not changed activity group (only the code has changed). The new activity group number and letter codes are listed in Table 3 along with the previous activity codes.
- Existing product labels will require updating within three years (ie. before October 2011) to reflect the new activity groups.
- Refer to **www.croplifeaustralia.org.au** for further information.

Table 3: Fungicides registered and with permits for use on Almonds (in Australian Orchards)

Active Constituent(s)	Activity Group 2009 (2008)*	Registered Products	APVMA Registration/ Permit No.	Relevant Dates
Pest Organism				
Anthracnose (*Colletotrichum acutatum*)				
Azoxystrobin	11 (K)	No Registered Products, Permit Only	PER 9200	Reg: 01/10/2007 Exp: 01/01/2012
Propiconazole	3 (C)	No Registered Products, Permit Only	PER 9255	Reg: 22/12/2006 Exp: 30/06/2011
Bacterial Canker *(Pseudomonas syringae pv syringae)*				
		No Registered Products		
Bacterial Spot (*Xanthomonas arboricola pv pruni*)				
		No Registered Products		
Blossom Blight (*Botrytis cinerea*)				
Hydrocarbon liquid/Iprodione	2 (B)	Corvette Liquid Country Iprodione 250 Farmoz Chief 250 Liquid Farmoz Civet Liquid Ospray Iprodione Liquid 250 Rovral Liquid Sipcam Iprodione	59698 63471 61083 58476 60941 30462 59541	n/a
Iprodione	2 (B)	Campbell Ippon 500 Aquaflo Country Iprodione 500 Farmoz Chief Aquaflo Farmoz Civet Aquaflo Genfarm Iprodione Aquaflow 500 SC Innova Iprodione 500 Aquaflo Ospray Subscribe Rovral 750 WG Rovral Aquaflo Sipcam Iprodione Aquaflo	54939 63472 61072 50361 60258 62463 60940 55964 45725 59541	n/a
Propiconazole	3 (C)	No Registered Products, Permit Only	PER 9255	Reg: 22/12/2006 Exp: 30/06/2011
Brown Rot (*Monilinia laxa*)				
Copper (copper oxychloride)	M1 (Y)	Heiniger Copper Oxychloride	47087	
Hydrocarbon liquid/Iprodione	2 (B)	Corvette Liquid Country Iprodione 250 Farmoz Chief 250 Liquid Farmox Civet Liquid Ospray Iprodione Liquid 250 Rovral Liquid Sipcam Iprodione	59698 63471 61083 58476 60941 30462 59541	
Iprodione	2 (B)	Campbell Ippon 500 Aquaflo Country Iprodione 500 Farmoz Chief Aquaflo Farmoz Civet Aquaflo Genfarm Iprodione Aquaflow 500 SC Innova Iprodione 500 Aquaflo Ospray Subscribe Rovral 750 WG Rovral Aquaflo Sipcam Iprodione Aquaflo	54939 63472 61072 50361 60258 62463 60940 55964 45725 61321	n/a

Active Constituent(s)	Activity Group 2009 (2008)*	Registered Products	APVMA Registration/ Permit No.	Relevant Dates
Brown Rot (*Monilinia laxa*) continued....				
Mancozeb	M3 (Y)	Allfire Mancozeb 750WG	58964	
		Barmac Mancozeb DG	41117	
		Biotis Mancozeb 750DF	59339	
		Chemfarm Mancozeb 750 DF	57747	
		Chemfarm Mancozeb 800 WP	57749	
		Dithane DF	30599	
		Dithane M45	30598	
		Dithane Rainshield Neo Tec	59688	
		Dithane 430 SC	60861	
		Dupont Manzate DF	30582	
		Farmoz Mancozeb 800	48049	
		Farmoz Mancozeb 750DF	39325	
		Gemax Vine 750 WG	58668	
		Imtrade Mancozeb 750 DF	63513	
		Innova Mancozeb 750	61356	
		Kendom Mancozeb DF	53223	
		Kendon Mancozeb	51295	
		Kenso Agcare Kencozeb 750DF	56103	
		Mancozz 750 WG	62791	
		Ospray Mancozeb 750WG	61485	
		Penncozeb 420 SC	49487	
		Penncozeb 750 DF	53987	
		Penncozeb	53986	
		Rotam Winner Mancozeb WP	51793	
		Runge Agrichems Manfil Mancozeb 750WG	59516	
		Sabero Mancozeb 750DF	54451	
		Sabero Mancozeb 800WP	54452	
		Titan Mancozeb 750 DF	62383	
		Unizeb 750 DF	61100	
		Unizeb 800 WP	59330	
Sulphur (as polysulfide sulphur)	M2 (Y)	Kendom Lime Sulphur	53131	
		Stollers Lime Sulphur	49990	
		Yates Insect & Disease Control Lime Sulphur	59403	
Sulphur (as calcium polysulfide & calcium thiosulfate)	M2 (Y)	Miller Lime Sulfur Solution	57750	
Crown Gall (*Agrobacterium tumefaciens*)				
Agrobacterium		Nogall	39304	
Freckle & Scab (*Cladosporium carpophilum*)				
Copper (copper oxychloride)	M1 (Y)	Heiniger Copper Oxychloride	47087	
Mancozeb	M3 (Y)	Dithane Rainshield Neo Tec	59688	
		Dupont Manzate DF	30582	
		Imtrade Mancozeb 750 DF	63513	
		Innova Mancozeb 750	61356	
		Mancozz 750 WG	62791	
		Ospray Mancozeb 750WG	61485	
		Penncozeb 750 DF	53987	
		Runge Agrichems Manfil Mancozeb 750WG	59516	
		Sabero Mancozeb 750DF	54451	
		Titan Mancozeb 750 DF	62383	
		Unizeb 750 DF	61100	

Active Constituent(s)	Activity Group 2009 (2008)*	Registered Products	APVMA Registration/ Permit No.	Relevant Dates
Freckle & Scab *(Cladosporium carpophilum)* continued...				
Sulphur (as polysulfide sulphur)	M2 (Y)	Kendom Lime Sulphur Stollers Lime Sulphur Yates Insect & Disease Control Lime Sulphur	53131 49990 59403	
Sulphur (as calcium polysulfide & calcium thiosulfate)	M2 (Y)	Miller Lime Sulfur Solution	57750	
Hull Rot (*Rhizpus sp.*)				
		No Registered Products		
Leaf Blight (*Seimatosporium sp.*)				
		No Registered Products		
Phytophthora (*Phytopthora* spp.)				
Phosphorus Acid	33 (Y)	No Registered Products, Permit Only	PER 7161	Reg: 14/10/2004 Exp: 13/10/2009
Rust (*Tranzschelia discolor*)				
Chlorothalonil	M5 (Y)	4Farmers Chlorothalonil 720 Applonil 720 Barrack Betterstik Bayer Chlorothalonil 500 SC Bravo Bravo Weather Stik Campbell Cheers 720 Flowable Campbell Cheers 720 Weathershield Chemag Whack 500 Chemag Whack 900 WG Chemtura Chlorothalonil Conquest Clash 720 Country Chlorothalonil 720* Crop Care Barrack 720 Farmoz Cavalry 720 SC Farmoz Fung-O-Nil 500 Faudel* Halley Chlorothalonil 720* Nufarm Elect 500 Flowable* Nufarm Unite 720 Nufarm Unite Ultrastik Ospray Chlorothalonil 720 Rotam Glider SDS biotech KK Crotop 500* SDS biotech KK Crotop 720* Sipcam Echo 720 Sipcam Echo 900 WDG Sipcam Pacific Echo 500 SC Whack Whack 500	62069 54196 61016 45008 54115 58118 56005 63122 57619 61278 63635 58831 63204 53884 59986 46002 62030 55133 50052 58564 61015 60939 61705 48110 53392 52518 54080 50457 54641 53613	
Mancozeb	M3 (Y)	Dithane Rainshield Neo Tec Dupont Manzate DF Imtrade Mancozeb 750 DF Innova Mancozeb 750 Mancozz 750 WG Ospray Mancozeb 750WG Penncozeb 750 DF Runge Agrichems Manfil Mancozeb 750WG Sabero Mancozeb 750DF	59688 30582 63513 61356 62791 61485 53987 59516 54451	

Active Constituent(s)	Activity Group 2009 (2008)*	Registered Products	APVMA Registration/ Permit No.	Relevant Dates
Rust (*Tranzschelia discolor*) continued...				
Mancozeb (continued)	M3 (Y)	Titan Mancozeb 750 DF Unizeb 750 DF*	62383 61100	
Sulphur (as polysulfide sulphur)	M2 (Y)	Kendom Lime Sulphur Stollers Lime Sulphur Yates Insect & Disease Control Lime Sulphur	53131 49990 59403	
Sulphur (as calcium polysulfide & calcium thiosulfate)	M2 (Y)	Miller Lime Sulfur Solution	57750	
Shothole				
Chlorothalonil	M5 (Y)	4Farmers Chlorothalonil 720 Applonil 720 Barrack Betterstik Bayer Chlorothalonil 500 SC Bravo Bravo Weather Stik Campbell Cheers 720 Flowable Campbell Cheers 720 Weathershield Chemag Whack 500 Chemag Whack 900 WG Chemtura Chlorothalonil Conquest Clash 720 Country Chlorothalonil 720* Crop Care Barrack 720 Farmoz Cavalry 720 SC Farmoz Fung-O-Nil 500 Faudel* Halley Chlorothalonil 720* Nufarm Elect 500 Flowable* Nufarm Unite 720 Nufarm Unite Ultrastik Ospray Chlorothalonil 720 Rotam Glider SDS biotech KK Crotop 500* SDS biotech KK Crotop 720* Sipcam Echo 720 Sipcam Echo 900 WDG Sipcam Pacific Echo 500 SC Whack Whack 500	62069 54196 61016 45008 54115 58118 56005 63122 57619 61278 63635 58831 63204 53884 59986 46002 62030 55133 50052 58564 61015 60939 61705 48110 53392 52518 54080 50457 54641 53613	
Copper (as cupric hydroxide)	M1 (Y)	Cung Fu 350 SC Dupont Kocide Blue Xtra Flo-Bordo Melpat Hydrocorp Nufarm Champ Dry Prill WG Nufarm Champion WP* Tradewyns Blu-Cop 400DF Yates Blitzem*	59873 58989 49922 62910 53935 49348 58775 57768	
Copper (tribasic copper sulphate)	M1 (Y)	Nufarm Tri-Base Blue Flowable	53568	
Copper (copper ammonium acetate)	M1 (Y)	Copper-Count-N Liquicop Copper	62832 50722	
Copper (cupric (II) hydroxide)	M1 (Y)	Chemfarm Blue Mantel Dupont Kocide Blue Xtra* Multicrop Kocide DR Garden*	42610 52321 49928	

Active Constituent(s)	Activity Group 2009 (2008)*	Registered Products	APVMA Registration/ Permit No.	Relevant Dates
Shothole continued...				
Copper (copper hydroxide)	M1 (Y)	Blue Shield DF	46869	
		Yates Fungus Fighter	61144	
Copper (copper oxychloride)	M1 (Y)	AGCL Parkens Copper Oxychloride WP*	56015	
		Barmac Copper Oxychloride	41095	
		Brycop Copper Oxychloride	53597	
		CCC Copper Oxychloride 50% WP	48128	
		Country Copper Oxychloride 500 WP	53655	
		Heiniger Copper Oxychloride	47087	
		Melpat Coppox	40480	
		Melpat Coppox WG	59562	
		Neoram 375 WG	59375	
		Nufarm Copper Oxychloride	61683	
		Ospray Copper Oxyxhloride WP	59711	
		Oxydul DF	51820	
		Uniguard 500 WP*	60674	
Copper (cuprous oxide)	M1 (Y)	Ag Copp 750	60507	
		Nordox 500	46493	
		Norshield	50738	
		Norshield 750 WP	50780	
		Norshield WG	52033	
Mancozeb	M3 (Y)	Dithane Rainshield Neo Tec	59688	
		Dupont Manzate DF	30582	
		Imtrade Mancozeb 750 DF	63513	
		Innova Mancozeb 750	61356	
		Mancozz 750 WG	62791	
		Ospray Mancozeb 750WG	61485	
		Penncozeb 750 DF	53987	
		Runge Agrichems Manfil Mancozeb 750WG	59516	
		Sabero Mancozeb 750DF	54451	
		Titan Mancozeb 750 DF	62383	
		Unizeb 750 DF*	61100	
Sulphur (as polysulfide sulphur)	M2 (Y)	Kendom Lime Sulphur	53131	
		Stollers Lime Sulphur	49990	
		Yates Insect & Disease Control Lime Sulphur	59403	
Sulphur (as calcium polysulfide & calcium thiosulfate)	M2 (Y)	Miller Lime Sulfur Solution	57750	
Silverleaf				
		No Registered Products		
Verticillium Wilt				
1,3,-Dichloropropene/Chloropicrin+		Agrocelhone Liquid Injectable Fumigant	62102	
		Inline Soil Fumigant	60895	
		Rural Inline Soil Fumigant	63054	
		Rural Telone C35 Soil Fumigant	54436	
		Telone C35 Soil Fumigant*	52476	

* no label available   + for use on nuts   * 2008 Fungicide Activity Group classifications

PESTICIDES REGISTERED AND WITH PERMITS FOR USE ON ALMONDS IN AUSTRALIA

Most of the pesticides registered for use on almonds in Australia are insecticides. They may effectively control multiple pests, however most individual labels do not reflect broad efficacy or registration. Only one or two approved target pests are named on most labels. Labels must be followed.

Table 4 lists chemicals currently registered for use against almond pests, the active constituents for which minor use or emergency permits exist, are pending or are currently under review.

The APVMA website must be consulted frequently and especially before the use of any product that does not have full registration. The APVMA website provides the latest information on a product's status – i.e. if a valid permit exists for that product on almonds, how to interpret the permit, under what conditions the permit (and product) may be used. All chemicals require annual registration fees to be paid from 1 July to 30 September in each year. Check the APVMA website at the last possible opportunity to confirm that the chemicals have been re-registered. Active constituents with permits pending cannot be used.

Table 4: Pesticides Registered and with permits for use for use on Almonds (in Australian Orchards)

Active Constituent(s)	Activity Group 2009 (2008)*	Registered Products	APVMA Registration /Permit No.	Relevant Dates
Pest Organism				
Aphids				
Pirimicarb (Green Peach Aphid only)	1A	No Registered Products, Permit Only	PER 9241	Reg: 23/02/2007 Exp: 31/03/2010
Pymetrozine (Chess) (Green Peach Aphid only)	9A	No Registered Products, Permit Only	PER 10005	Reg: 01/04/2008 Exp: 01/04/2012
Aphids (eggs)				
Paraffinic Oil	n/a	Bioclear Paraffinic Oil Sacoa Biopest Paraffin Oil Trump Spray Oil	58360 54179 59092	
Petroleum Oil	n/a	Biocover Horticultural Oil	59091	
Aphids -Black Peach Aphid *(Brachycaudus persicae)*				
		No Registered Products		
Carob Moth *(Apomyelois ceratoniae)*				
		No Registered Products		
Indian Meal Moth *(Plodia interpunctella)*				
		No Registered Products		
Light Brown Apple Moth *(Epiphyas postvittana)*				
		No Registered Products		
Mites (general)				
Paraffinic Oil	n/a	Bioclear Paraffinic Oil SACOA Biopest Paraffin Oil Trump Spray Oil	58360 54179 59092	
Petroleum Oil	n/a	Biocover Horticultural Oil	59091	
Mites - Bryobia Mite *(Bryobia rubrioculus)*				
Bifenazate	2D	No Registered Products, Permit Only	PER 10963	Reg: 13/08/2008 Exp: 31/08/2010
Clofentezine	10A	No Registered Products, Permit Only	PER 9914	Reg: 13/08/2008 Exp: 31/08/2010
Dicofol/Tetradifon	2B	Masta-Mite Miticide	48757	
Sulphur (as polysulfide sulphur)	M2 (Y)	Kendom Lime Sulphur Stollers Lime Sulphur Yates Insect & Disease Control Lime Sulphur	53131 49990 59403	

Active Constituent(s)	Activity Group 2009 (2008)*	Registered Products	APVMA Registration /Permit No.	Relevant Dates
Sulphur (as calcium polysulfide & calcium thiosulfate)	M2 (Y)	Miller Lime Sulfur Solution	57750	
Mites - European Red Mite *(Panonychus ulmi)*				
Dicofol/Tetradifon	2B	Masta-Mite Miticide	48757	
Mites - Rust Mite *(Aculus spp.)*				
Dicofol/Tetradifon	2B	Masta-Mite Miticide	48757	
Mites - Tomato Russet Mite *(Aculops lycopersici)*				
Dicofol/Tetradifon	2B	Masta-Mite Miticide	48757	
Mites - Two Spotted Mite *(Tetranychus urticae)*				
Abamectin	6A	No Registered Products, Permit Only	PER 5658	Reg: 09/06/09 Exp: 31/03/12
Dicofol/Tetradifon	2B	Masta-Mite Miticide	48757	
Clofentezine	10A	No Registered Products, Permit Only	PER 9914	Reg: 13/08/2008 Exp: 31/08/2010
Bifenazate	2D	No Registered Products, Permit Only	PER 10963	Reg: 13/08/2008 Exp: 31/08/2010
Nematodes				
1,3,-Dichloropropene/ Chloropicrin		Agrocelhone Liquid Injectable Fumigant Inline Soil Fumigant Rural Inline Soil Fumigant Rural Telone C35 Soil Fumigant* Telone C35 Soil Fumigant	62102 60895 63054 54436 52476	
1,3,-Dichloropropene		Rural Telone Soil Fumigant Telone Soil Fumigant*	60921 52475	
San Jose Scale *(Diaspidiotus perniciosus)*				
Paraffinic Oil	(n/a)	Bioclear Paraffinic Oil SACOA Biopest Paraffin Oil Trump Spray Oil	58360 54179 59092	
Petroleum Oil	(n/a)	Biocover Horticultural Oil	59091	
Sulphur (as polysulfide sulphur)	M2 (Y)	Kendom Lime Sulphur Stollers Lime Sulphur Yates Insect & Disease Control Lime Sulphur	53131 49990 59403	
Sulphur (as calcium polysulfide & calcium thiosulfate)	M2 (Y)	Miller Lime Sulfur Solution	57750	

* no label available

n/a = not applicable

* 2008 Fungicide Activity Group classifications

COMPATIBILITY ADVICE

It is important that labels are read before applying any chemical. Some crop protection products cannot be mixed with other products or different formulations, with fertilizers or in water that is particularly basic or acidic.

It is important also to consider tank mixes in which oil or surfactants are used, as some combinations will damage trees. Oil should not be applied before or after (within 10 days) some specific fungicides.

Consideration must also be given to the weather before, during and after applications and to the potential effects of the application on beneficial organisms.

Maximum Residue Limits (MRLs)

Almond growers must be aware of MRLs since their kernels are frequently exported and therefore residue tested. Export destinations (countries) specify the maximum level of acceptable residue in food products imported into their country. For example, Australian and Japanese MRLs differ for some chemicals. For some the MRL accepted in Australia exceeds that accepted in Japan, and vice versa. Exported Australian product destined for Japan, must meet the Japanese standards.

The timing and nature of orchard chemical use directly influence the likelihood of residues being present at harvest, and therefore MRL compliance. The choice of product and pre-harvest interval, are especially critical in achieving MRL compliance.

The National Residue Survey (NRS) is part of the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) located in Canberra. The primary function of the NRS is to monitor chemical residues and environmental contaminants in the products of participating industries. Residue monitoring is an important part of an overall strategy to minimise unwanted residues and environmental contaminants in food.

The almond industry commenced NRS almond residue testing in 2008/09. In cooperation with the Almond Board of Australia and the almond processing plants, NRS organised two sampling rounds in January and April. Results will be collated and compiled for industry, and individual results reports will also be provided directly back to the processors.

Results are also used by the State Government organisations responsible for agricultural and veterinary chemicals management, as well as Commonwealth bodies involved in chemical regulation and policy such as the Australian Pesticides and Veterinary Medicines Authority (APVMA), Food Standards Australia New Zealand (FSANZ) and Department of Health and Ageing.

Resistance Management and Rotation of Chemicals

The effective life of some crop protection products can be shortened by overuse of the active constituent and the response of selection and/or mutation within the pest population. Insects, mites and pathogens have within their normal populations both resistant and susceptible individuals. In a region where a particular active constituent or activity group is used repeatedly, the proportion of resistant members of the pest population increases over time. Once this proportion is high enough to render the chemical no longer effective, we have 'resistance' to that chemical, i.e. the pest or disease-causing organism can survive doses of chemical that previously would have controlled it.

To minimise the development of resistance, especially the rate of resistance development, growers must adopt resistance management strategies that suit their region's crop range and growing environment. Such strategies include chemical rotation. This requires an understanding and consideration of the chemical activity groups of their chosen crop protection products, their modes of action, seasonal needs for each active constituent and the biology of the intended target/s. Chemicals from different chemical activity groups should be rotated.

GENERAL RESISTANCE MANAGEMENT GUIDELINES IN ALMONDS

Do not apply more than two consecutive sprays of fungicides from the same group before changing to another group (in particular Group 2, 3 and 11 chemicals (old Group B, C, and K)). Do not use more than three Group 11 (old Group K) sprays per season. If two or three consecutive applications of Group 11 (old Group K) chemicals are used, they should be followed by at least the same number of applications of fungicide/s from a different chemical activity group before Group 11(old Group K) chemicals are used again.

Rotate between miticides from different activity groups. Do not apply sequential applications of products from any one activity group. Miticide use should be incorporated into an integrated mite management program, including predatory mites. Treat pest infestations before threshold limits are reached. Rotate 'modes of action' and ensure that no chemistry group is used more than twice in a season.

Table 5: Activity groups and chemical families registered and with permits for use in Australian Almonds Orchards

Activity Group 2009	Activity Group 2008*	Chemical Family (Active Constituent)	Resistance Potential	Action	Target Site
Fungicides					
2	B	Dicarboximide (iprodione)	Medium to High	Systemic	Multi-site (with protectant and curative action)
3	C	Triazole (propiconazole)	Medium to High	Systemic	DeMethylation Inhibitors (DMIs)
11	K	Methoxy acrylate (azoxystrobin)	High	Systemic	Quinone outside Inhibitors (QoIs)
33	Y	Ethyl phosphonate (phosphorus acid)	Low	Systemic	Multi-site (protectant)
M1	Y	Inorganic (copper)	Low	Contact	Multi-site (protectant)
M2	Y	Inorganic (sulphur)	Low	Contact	Multi-site (protectant)
M3	Y	Dithiocarbamate (mancozeb)	Low	Contact	Multi-site (protectant)
M5	Y	Chloronitriles (chlorothalonil)	Low	Contact	Multi-site (protectant)
Activity Group 2009	**Activity Group 2008***	**Chemical Family (Active Constituent)**	**Beneficial Toxicity**	**Action**	**Target Site**
Pesticides/Miticides					
1A	1A	Carbamates (pirimicarb)	Low/Moderate/High	Systemic	Acetyl Choline Esterase inhibitors (aphicide with contact, respiratory and stomach action)
2B	2B	Polychlorocycloalthanes (dicofol, tetradifon)	Moderate/High	Contact	GABA-gated chloride channel antagonists (non-systemic acaricide with contact action)
2D	2D	Bifenazate (bifenazate)	Low	Contact	Neuronal Inhibitor (acaricide with contact and residual activity against motile stages)
6A	6A	Avermectin (abamectin)	Moderate/High	Contact, some translaminar movement	Chloride Channel activators (acaricide with stomach action)
9A	9A	Pymetrozine (pymetrozine)	Low/Moderate	Systemic	Unknown or non-specific (selective feeding blockers)
10A	10A	Clofentezine, Hexythiazox (Clofentezine)	Low	Contact	Unknown or non-specific (selective feeding blockers)

* Changes to the Fungicide Activity Groups classification system in 2008.

In October 2008, CropLife Australia completed a review of the Australian Fungicide Activity Groups classification system. In summary:

- the general intent of activity grouping by risk has not changed;
- there are now 27 activity groups designated by number (and letter) codes, and aligned with those of the International Fungicide Resistance Action Committee; and
- most active constituents have not changed activity group (only the code has changed). The new activity group number and letter codes are listed in Table 3 along with the previous activity codes.
- Existing product labels will require updating within three years (ie. before October 2011) to reflect the new activity groups.
- Refer to **www.croplifeaustralia.org.au** for further information.

Crop Protection Products and the Environment

Crop protection products must only be used for their labelled purpose. Every effort must be made to ensure they do not harm applicators or damage the surrounding environment through off-label use, harmful or extended exposures, off-target applications, drift or hazardous disposal of remaining solutions or containers.

Growers should consult the relevant Material Safety Data Sheet for safety directions before applying any agricultural chemicals. Growers are strongly encouraged to record details of all products used, the conditions under which they were applied, and the stage of crop/tree development at the time.

The following table ranks different environmental factors requiring consideration by growers. The tabulated rankings have been concluded after consideration of a range of readily available information.

Table 6: Environmental hazard rankings for active constituents approved for almonds

Active Constituent	Solubility in Water	Volatility	Soil Sorption	Leaching Potential	Aquatic Life	Birds	Bees	Soil Micro-Organisms	Poison Schedule	Activity Group 2009 (pre 2009)
Fungicides										
Agrobacterium (bacterium)									0	Biological-Live
Azoxystrobin	2	1	3	2	4	2	2	2	S5	11 (K)
Chlorothalonil	1	1	3	2	5	2	2	3	S6	M5 (Y)
Copper (cupric hydroxide)									S6	M1 (Y)
Copper (tribasic copper sulphate)					4	2	1		S6	M1 (Y)
Copper (copper ammonium acetate)									0	M1 (Y)
Copper (cupric (II) hydroxide)									S6	M1 (Y)
Copper (copper hydroxide)	1	0	5	2	5	2	5	5	S6	M1 (Y)
Copper (copper oxychloride)	0	1	5	1	4	2	2	5	0	M1 (Y)
Copper (cuprous oxide)					2	2	1		Ex	M1 (Y)
Iprodione	2	1	3	2	3	2	0	1	S5	2 (B)
Mancozeb	1	1	3	2	3.5	2	0	2	S5	M3 (Y)
Phosphorous acid									S5	33 (Y)
Propiconazole					3	2	1		S6	3 (C)
Sulphur	0	0	4	2	1	0	0	2	Ex	M2 (Y)
Pesticides										
Abamectin									S6	6A
Bifenazate									Ex	2D
Clofentezine									S5	10A
Dicofol					4	2	2		S5	2B
Paraffinic Oil									S5	n/a
Petroleum Oil									S5	n/a
Pirimicarb									S6	1A
Pymetrozine									S5	9A
Tetradifon									S6	2B
Soil Fumigants and Vermin Control										
1,3-Dichloropropene									S7	
Chloropicrin									S7	8A

Toxicity Scale			
5 = Very High / Very Highly Toxic	(red)	1 = Very Low / Very Slightly Toxic	(dark blue)
4 = High / Highly Toxic	(orange)	0 = None	(light blue)
3 = Medium / Moderately Toxic	(yellow)	Unknown	(blank)
2 = Low / Slightly Toxic	(green)		

Hazard Scale	
Dangerous Poison	S7
Poison	S6
Caution	S5
Exempt	Ex

Biological Control of Almond Pests

Predatory mites play an important role in the management of pest mites within an orchard. In orchards, naturally occurring (or released) green lacewings, ladybirds and several parasitoids enhance control of invertebrate pests. Biological control organisms need to be used in conjunction with softer pesticides and fungicides, so that beneficial organisms have an environment in which they can survive and reproduce.

Table 8: Biological Control Agents available for biological control of almond pests

Pest	Biological Control Agent (Common Name)	Species	Other Local Natural Enemies
Aphids	Green Lacewings Brown Lacewings Lady Beetles Aphid parasitoids Damsel bugs	*Mallada signata* *Micromus tasmaniae* *Hippodamia* *Aphidius colemani* *Nabis kinsbergii*	Brown and green lacewings, aphid parasitoids, ladybirds, hover fly
Light Brown Apple Moth	Parasitoid	*Trichogramma carverae*	Local *Trichogramma*, predatory bugs and predatory beetles
Two Spotted Mite	Predatory Mite	*Typhlodromus occidentalis* *Phytoseiulus persimils*	Other predatory mites and *Stethorus* beetles

Further information about biological control and beneficial organisms: **www.goodbugs.org.au**

Biological control organisms can be supplied by Biological Services of Loxton South Australia:

Phone: (08) 8584 6977
Fax: (08) 8584 5057
Email: info@biologicalservices.com.au
Website: www.biologicalservices.com.au

Postal address: PO Box 501, Loxton SA 5333, Australia
Street address: Balfour Ogilvy Avenue, Loxton SA 5333, Australia

Application Records

Good management (and approved supplier and quality assurance (QA) programs) requires all crop protection application details, be recorded. Records should be kept for a minimum of three years, as evidence of compliance and to assist 'traceability' should any adverse and ineffective response be experienced. Examples of documents (*Agrichemical Application Record*; *Orchard Sprayer Calibration Record*) follow. These may be copied for use by growers.

AGRICHEMICAL APPLICATION RECORD

This is a general multi-purpose form. Applicators with specialised use patterns may prefer to use a customised form. In any case, records must be kept for three years, and entries should be made within 24 hours of each application.

General Information

Operator. The operator, or person applying the pesticide, must fill in their contact details. If the operator is not the owner, e.g. a contractor or employee, then the owner's details must also be provided. One copy of the record should be kept by the applicator; the other by the owner.

Date of application, start time, finish time. Date, time of the day of application (start and finish) must be recorded.

Crop Details

Crop sprayed. Addition of details such as crop variety and growth stage are important for QA schemes, but also serve to positively identify the area treated as required by the regulation.

Block/area and size of block sprayed. Identify the block/area and progression of treatment along rows. These may be filled in prior to the start of application. If using a contractor or an employee, this information should also be given before starting the job. Applicators using GPS systems could include a GPS reading in addition to the block number/name.

Product/Application Details

Pest/disease targeted. It is desirable to identify the pest or disease that is being targeted. It would be helpful to provide as much detail about the pest or disease as possible, e.g. for a grub - 3rd instar/10mm etc; for a disease – extent or severity of existing symptoms.

Equipment used. As a minimum, equipment used must be recorded. Positive identification can be assisted by specifying the settings used for the application, e.g. nozzle type and angle, pressure. The nozzle type will usually include the angle. Pressure readings should be taken close to the nozzle. Other details are useful: date of calibration, water quality and source etc.

Product used. The product name, formulation and batch date, and approved rate/dose should be transcribed from the label. For tank mixes, include all products in the mixture. If the allowed use is on Permit, a copy of the permit should be read and attached. The permit rate/dose may vary from that on the label.

Amount of concentrate used and total volume of spray applied. The water volume may be noted on the label, or may be determined by the grower depending on size of trees. Water volume must be recorded. It is best calculated at the completion of the application. If additives or wetters are included in the tank mix, this must also be noted. If the label has a WHP (withholding period), record this and observe the full period. Signage is recommended during the WHP.

Horticultural dips, e.g. post harvest treatments, must be recorded. For those producers seeking ICA (Interstate Certification Assurance) status, enter the time of dip mixture or top-up preparation, e.g. 'mixture prepared 9.00am, top-up 3.00pm'. Other details which could be recorded include time when the mixture was discarded, e.g. 'discarded 25.12.03' and the approximate quantity of fruit treated. Under 'Total quantity of spray applied', enter both volume of dip and concentrate, e.g. '20 ml Lebaycid/200 L mixture'.

WEATHER CONDITIONS

Wind Speed and Wind Direction (Changes to Wind Speed & Direction)

As a minimum, record wind speed and direction at time of application. This is best measured rather than estimated. It is helpful to know the capacity of the nearest weather station. Record any changes during application. Weather records have to be kept for all applications that distribute pesticides through the air. While records of weather during dip baths for plant produce are not required, any unusual or extreme conditions should be noted.

Other Comments

Rainfall and/or heavy dews or fog should be recorded for the 24 hours before and after applications.

Temperature and relative humidity should also be recorded, particularly if either or both are referred to in the restraints or critical comments sections of the label. Temperature and relative humidity can affect efficacy, phytotoxicity and the risk of off-target drift.

'Sensitive areas' on the property or in close proximity should be identified in advance, and marked on a sensitive areas diagram appended to the Pesticide Application Record. Applicators must be made aware of such areas before starting the application and have in their possession details (including map) of the sensitive areas or crops.

It is often useful to keep photographic records that are labelled and dated. Records such as crop stage by date and variety; evidence of spray coverage; effects of sprays etc. are particularly useful if subsequent damage or crop loss is incurred.

Explanation and examples of Agrichemical Application Records										
EXPLANATIONS: Terms used for keeping Agrichemical Application Records										
Date	Crop Sprayed (or variety)	Block (in order sprayed)	Growth Stage	Target Pest or Disease	Full Registered Product Name(s)	Amount of Product Used per 100L (g, kg, mL or L) Label Rate	Conc. Rate (if applicable)	Conc. Factor (CF) (if applicable)	Applied Spray Vol. (L/ha)	Comments (Compulsory NSW)
Date Applied	If entire block sprayed, write "all"	Block name(s) Row order of spraying	Growth stage of crop	Pest or disease targeted	Agrichemical product name - from the label. eg Kumulus DF is required, not just Sulphur.	Amount added per 100L of water (label)	Amount added per 100L for 'Concentration' (Conc. Rate = Label Rate X CF)	Multiplier used for Concentrate spraying. If Dilute spraying, write "1".	The actual volume (L) of spray mixture applied per hectare	Operator Start/Finish Wind Sp./Dir Weather Conditions Equipment

EXAMPLES: How to complete the Agrichemical Application Records:

Date	Crop Sprayed (or variety)	Block (in order sprayed)	Growth Stage	Target Pest or Disease	Full Registered Product Name(s)	Amount of Product Used per 100L (g, kg, mL or L) Label Rate	Conc. Rate (if applicable)	Conc. Factor (CF) (if applicable)	Applied Spray Vol. (L/ha)	Comments (Compulsory NSW)
? / ? / 2009	Nonpareil	5 start row 30	Shuck fall	Brown rot	Dithane RS	200g		1.0	1,800	Operator *WW*
	Carmel	1 & 2 start row 15	Shuck fall	Shot hole	Barrack	160g				Start/Finish *0825 - 1500*
					LI 700 Surfactant	10mL				Wind Sp./Dir *2B - NE*
	Dilute Spray Example									Weather Cond *clear, 22 °C*
										Equipment *Croplands Air blast*
? / ? / 2009	Non Pareil	5	Shuck fall	Brown rot	Dithane RS	200g	500g	2.5	600	Operator *WW*
	Carmel	1 & 2	Shuck fall	Shot-hole	Barrack	160g	400g			Start/Finish *0825 - 1500*
					LI 700 Surfactant	10mL	10ml			Wind Sp./Dir *2B - NE*
	Concentrate Spraying Example									Weather Cond *clear, 22 °C*
						A	C	B		Equipment *Croplands Air blast*
<u>NOTE</u>: Concentration factors are <u>not</u> applicable to <u>adjuvants</u>. For these products, the Concentration Factor is always 1.0. For all other agrichemicals: A x B = C										

Crop Sprayed	Block Area	Growth Stage	Target: Pest, Disease or Weed	Full Registered Product Name(s) *Eg. Fungicide /insecticide/ herbicide*	Withholding Period	Label Rate of Registered Product Used per 100L	Conc. Factor (CF)	Amount of Water Sprayed (L/ha)	Amount of Registered Product Used (per ha)	Comments
Date of Application										Operator
Non Pareil	5	Shuck fall*	Brown rot	Dithane RS	14 days	200g/100L	1	2000	4 kg/ha	Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment
Date of Application										Operator
										Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment
Date of Application										Operator
										Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment
Date of Application										Operator
										Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment
Date of Application										Operator
										Start/Finish
										Wind Sp./Dir
										Weather Cond
										Equipment

* Photo taken

Adapted from Spray Diary format, AWRI website, 2006.

ORCHARD SPRAYER CALIBRATION RECORD

(Modified from 'Orchard Plant Protection Guide for deciduous fruits in NSW 2005/06)

Spray unit …………………………………………………………	
Nozzle Set-up …………………………………………………….	
Operating pressure ……………………………………………	
Tractor …..………………………………………………………	
Operating Speed and gear ………………………………	

Air Calibration

Air inlet area (m^2) …...…………………………………………		
Air speed at intake (m/sec) ……………………………….		
Air volume (m^3/a) ……………………...………………………		
Tree dimensions (m) …..……………………………………	Canopy width:	Canopy height:
Optimum tractor speed (km/h)……………………………….		

Water Calibration

Actual tractor speed (km/h) ...………………………………	
Total nozzle output (L/min) ……………………………...	
Row spacing (m). ……………………...………………………	
Application volume (L/ha) …..………………………...…….	

Calibrated by:	Date:

Generalised Almond Protection Guide

Stage of Development*	Target	General products and Activity groups	Comments
Post-Harvest Leaf Fall		Urea or zinc (defoliation) Copper (after leaf fall)	Aims to clean up trees and protect leaf scars. Fungicidal clean up useful after problem seasons with high numbers of sticktights etc.
Dormant	Mites Fungal spores	Winter Oil at full dormancy + copper or Summer oil as bud burst nears + copper	Ensure 10+ days after zinc and before oil applied. Use high water volumes.
Pink Bud	Shothole Bacterial spot Brown rot	Copper (*Note*: no chlorothalonil) within 10 days of oil.	Ensure fungicide coverage of Fritz and NePlus and early flowering varieties, to achieve brown rot control. Water volume of 1200+ L/ha.
Mid-Full Bloom 50-80%	Shothole Botrytis Anthracnose Brown Rot	Multi-site fungicide from Group Y.	Necessary if early bloom sprays missed and when rain has persisted since early bloom. Use different Group Y product to that used in early bloom. Use higher water volume 1600+ L/ha.
Petal Fall – Shuck fall	Shothole Brown Rot Anthracnose Bacterial spot	Multi-site fungicide from Group 28 (Group Y).	If wet spring persists and there are exposed new leaves, consider bringing forward next suggested spray, or tank-mixing DMI with this spray.
2 Weeks Post-Shuck Fall	Anthracnose Shothole Botrytis Alternaria complex? Leaf blight?	Strobilurin (Group 11 (Group K)) or DMI (Group 3 (Group C)) fungicide	Includes propiconazole, azoxystrobin. Protection and eradicant activity. Ensure all leaves covered. Increase water volume to 2000L/ha. Avoid applying copper any later than this.
5 Weeks Post-Shuck Fall	Alternaria complex? Anthracnose Shothole Mites	Group 28 (Group Y) fungicide (*Note:* do not use chlorothalonil if oil used for mite control within 10 days)	Monitor for mites. Fungicide schedule from this point is weather-dependent; ensure new leaves are protected.
Late Spring Early Summer	Alternaria complex? Rust	Group 3 (Group C) fungicide + mancozeb (or other Group 28 (Group Y))	Start looking for rust before hull split. Read label for tank compatibilities and withholding periods
Summer December-January	Rust Hull Rot	Multi-site Group 28 (Group Y) fungicide	As needed; weather-dependent hereafter.

NOTES:
- Herbicides – no pre-emergent sprays before early July
- Activity groups and action sites are explained in above document
- No chlorothalonil with, before or after (within 10 days) oil
- Ensure good coverage and adequate water volumes
- Use monitoring and growth stages of crop as guide rather than calendar dates
- Bloom sprays – avoid bee disruption; spray later in day
- Surfactants/ spreaders – check labels for compatibility
- Tank mixes with nutrients require particular attention to pH of mix and chloride levels
- Compatibilities – check all labels
- Non-bearing trees may not require the intensity of above-mentioned chemical protection, but should not be ignored as they are susceptible to many diseases.

Reference List

Adaskaveg J, Holtz B & Michailides T et al. (2006). Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut Crops, and Grapevines. University of California.

Almond Board of California (2003). The Foundation for a Pest Management Strategic Plan in Almond Production, *Summary of a Workshop Held December 12, 2002, Modesto, California*. Almond Board of California.

APVMA Website http://www.apvma.gov.au/index.asp

AWRI (2006). Spray Diary Format <http://www.awri.com.au/agrochemicals/spray_diary/SPRAY0405.xls>

Bower CC & Thwaite WG (1995). The Mite Management Manual : A Practical Guide to Integrated Mite Control in Apples. The State of New South Wales, NSW Agriculture, Orange.

Bright JD Hetherington SD & Mooney A (2008). Orchard Plant Protection Guide for Deciduous Fruits in NSW 2008-09, 18th Edition, NSW Department of Primary Industries, Orange.

CropLife Australia (2008). Fungicide Resistance Management Strategies. CropLife Australia Ltd, Canberra. http://www.croplifeaustralia.org.au

CropLife Australia (2008). Fungicide Resistance Management Review Group Activity Group Table. CropLife Australia Ltd, Canberra.

CropLife Australia (2008). Insecticide Resistance Management Strategies. CropLife Australia Ltd, Canberra.

CropLife Australia (2008). Insecticide Resistance Management Review Group: Mode of Action Classification for Insecticides as registered with the APVMA as at 29 August 2008 (Current as al 10 September 2008). CropLife Australia Ltd, Canberra.

Dal Santo, P. (2008) Almond Board of Australia SARP: Strategic Agrichemical Review Process DRAFT. Horticulture Australia Project No: MT07029.

Hely PC, Pasfield G & Gellatley JG (1982). Insect Pests of Fruit and Vegetables in NSW. Inkata Press, Melbourne.

Hetherington, S (2005). Integrated Pest & Disease Management for Australian Summerfruit. Ed A Munroe. The State of New South Wales, NSW Department of Primary Industries & SummerFruit Australia Inc.

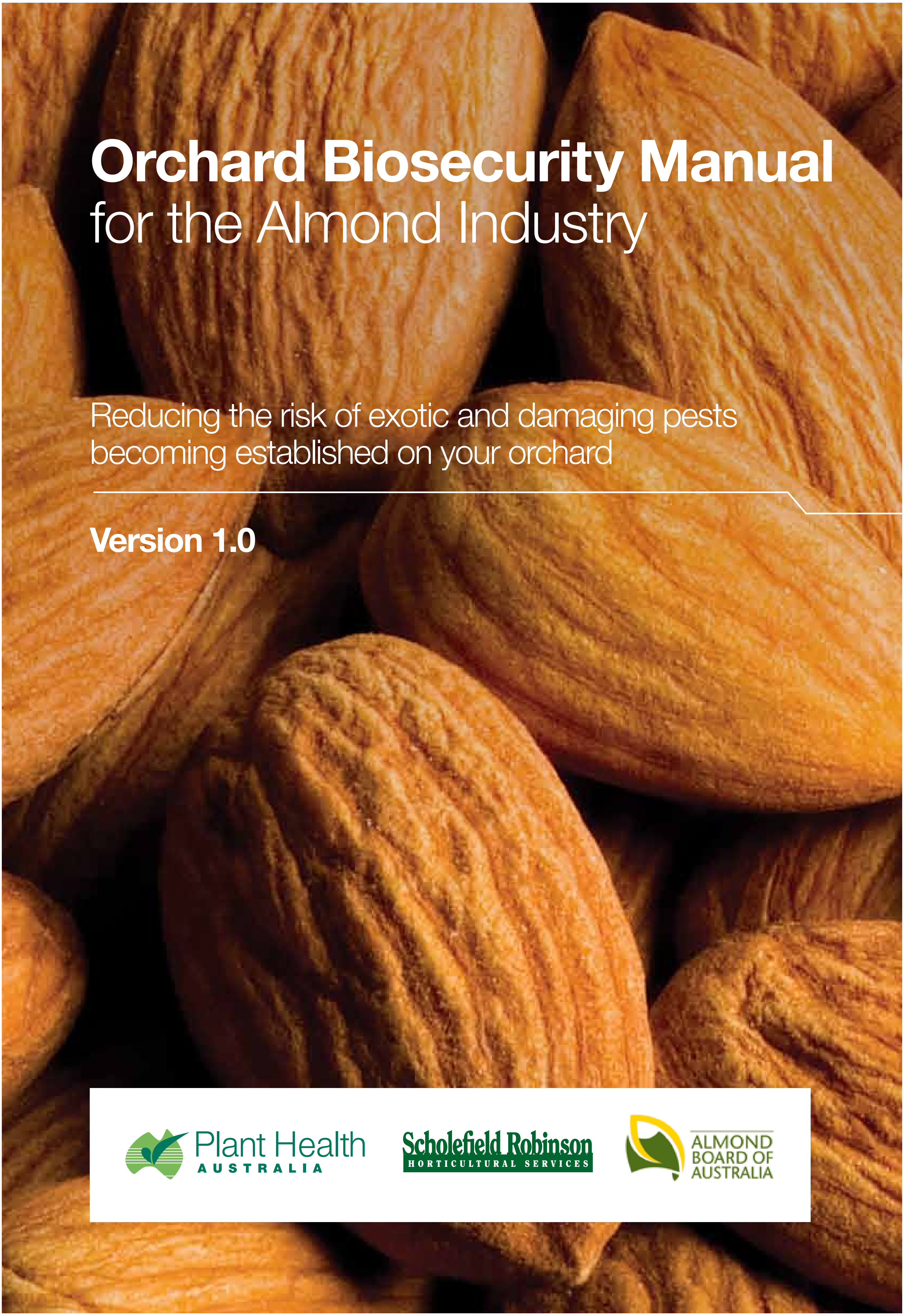
NRS (2009). Draft. Almond Program Chemical Residue Monitoring Results, 9pp.

Sutton J, Trainer S & Sivyer M (2003). Pome & Stone Fruit Orchard Spray Guide 2003/04. Department of Agriculture WA.

Swaine G, Ironside DA & Corcoran RJ (1991). Insect Pests of Fruit and Vegetables, 2nd edition, Queensland Department of Primary Industries, Brisbane.

University of California (1985). Integrated Pest Management for Almonds. University of California, Oakland.

Zalom FG, Pickel C, Bentley WJ et al. (2005). UC IPM Pest Management Guidelines: Almond. University of California, Davis.



Orchard Biosecurity Manual
for the Almond Industry

Reducing the risk of exotic and damaging pests becoming established on your orchard

Version 1.0

Plant Health AUSTRALIA

Scholefield Robinson HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA

Plant Health Australia (PHA) is the lead national coordinating body for plant health in Australia. PHA works in partnership with industry, governments, researchers and others, providing national coordination to improve biosecurity policy and practice across Australia's plant industries and to build capacity to respond to plant pest emergencies.
www.planthealthaustralia.com.au

The Almond Board Australia (ABA) is the peak almond industry body. The ABA represents and promotes the interests of Australian almond growers, processors and marketers. Membership is voluntary and currently encompasses more than 95% of the Australian almond production base. The ABA provides a channel for communication and dissemination of information between members of the Industry, governments and other sectors of horticulture; manages research and development and fosters industry growth, profitability and sustainability. The ABA is a member of PHA.
www.australianalmonds.com.au

Phone: 02 6215 7700
Fax: 02 6260 4321
E-mail: admin@phau.com.au
Website: www.planthealthaustralia.com.au

An electronic version of this manual is available from the website listed above.

Table of contents

Six easy ways to protect your orchard

2 You have an important role to play in protecting your orchard and the almond industry from biosecurity threats

Here are six simple things you can do to reduce the threat of new pests entering and establishing in your orchard:

1. Be aware of biosecurity threats

Make sure you and your employees are familiar with the most important exotic almond pests.

2. Use high health status, pest-free propagation material from known sources

Ensure all propagation material and orchard inputs are fully tested and pest-free. Keep records of your orchard inputs.

3. Keep it clean

Practicing good sanitation and hygiene will help prevent the entry and movement of pests onto your property. Workers, visitors, vehicles and equipment can spread pests so make sure they are decontaminated before they enter and leave your orchard.

4. Check your crop

Monitor your trees frequently. Knowing the usual appearance of your trees will help you recognise new or unusual symptoms and pests. Keep records of all unusual symptoms and pests.

5. Abide by the law

Support and be aware of laws and regulations established to protect the almond industry.

6. Report anything unusual

If you suspect a new pest – **report it immediately.**

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881

EXOTIC PLANT PEST HOTLINE
1800 084 881

3

Biosecurity overview

4

This manual is designed to assist you in protecting your almond orchard and the almond industry from new and invasive pests. By implementing the recommended measures in your day-to-day operations, you will enhance your biosecurity and that of your region, while minimising productivity losses and unnecessary costs.

The definition of a **pest** used in this manual covers all insects, mites, snails, nematodes, pathogens (diseases) and weeds that are injurious to plants or plant products. **Exotic** pests are those not currently present in Australia. **Endemic** pests are established within Australia.

What is biosecurity?

Biosecurity is about the protection of livelihoods, lifestyles and the natural environment, which could be harmed by new pest incursions.

Biosecurity is a national priority, implemented at pre-border, border and post-border locations. It is essential for your business.

Australia's geographic isolation has meant that we have few of the pests that affect plant industries overseas. Freedom from these exotic pests is a vital part of the future profitability and sustainability of Australia's plant industries. Biosecurity ensures that our plant health status is maintained. This allows us to preserve existing trade opportunities, and provide evidence to support new market negotiations.

In addition, 'area freedom' from a number of endemic pests, is vital to the prosperity of the almond industry.

What is orchard biosecurity?

Orchard biosecurity is a set of measures designed to protect a property from the entry and spread of pests. Orchard biosecurity is your responsibility, and that of every person visiting or working on your property.

Through the implementation of orchard biosecurity measures, producers play a key role in protecting the Australian almond industry from exotic pests. If a new pest becomes established in your orchard, it will affect your business through increased orchard costs (for monitoring, cultural practices, additional chemical use and labour to apply them), reduced productivity (yield and/or quality reductions) or loss of markets.

Early detection and immediate reporting increase the chance of effective and efficient eradication.

More information on how to secure your orchard and secure your future can be found online at **www.farmbiosecurity.com.au** a joint initiative of Plant Health Australia and Animal Health Australia.

5

Regional biosecurity

To strengthen the biosecurity measures implemented on your property, consider initiating biosecurity meetings and activities to promote biosecurity at the regional level. Through this collaborative approach, biosecurity threats to all properties in your region can be minimized.

Potential sources of biosecurity threats may be neighbouring orchards (operating or abandoned), nurseries, other commercial plantings, native vegetation and/or peri-urban residential or amenity plantings.

Implementation of orchard biosecurity underpins regional biosecurity, which in turn underpins national biosecurity. Promotion of biosecurity at the regional level is enhanced through broad engagement of the community, understanding the region's vulnerability, and the source and nature of threats, knowledge of the expertise base and resources available to the region, and a commitment from stakeholders to implement biosecurity measures, surveillance and reporting.

If orchard measures are supported by community-based measures, a regional framework for biosecurity can be coordinated and is achievable.

Pests

The following are the high priority exotic pest threats for the Australian almond industry as decided through the development of the Industry Biosecurity Plan, and all would have serious consequences should they be introduced. These are not the only exotic pests of the Australian almond industry. The severity of the impact may be dependent on rootstock-scion combinations and the presence/absence of pathogen vectors.

The climate of Australian almond production regions would allow each of these pests to survive, establish and spread, should they be introduced. Additional information on each of these pest threats is included in the fact sheets at the back of this manual.

High priority exotic pests of the almond industry

Almond leaf scorch

POTENTIAL ECONOMIC IMPACT – HIGH

- Bacterium – *Xylella fastidiosa*
- Found in North and South America, and the Mediterranean
- 'Burn' zones on leaves with golden margin; causing wilted, 'scorched' canopy resembling salt damage; and stunted trees
- Spread by sap-feeding leafhoppers or by grafting of infected planting material

J. K. Uyemoto

Glassy-winged sharpshooter

POTENTIAL ECONOMIC IMPACT – HIGH

- Sharpshooter insect (Hemiptera) – *Homalodisca vitripennis*
- Found in the USA, Mexico and some Pacific islands
- Vector of *X. fastidiosa* and also produces excrement showers
- Large (13-14 mm) and dark, with yellow dots on head
- Voracious feeder of a wide range of hosts
- Eggs laid in side-by-side rows on underside of leaves
- Good flyer that can spread quickly and eggs can also spread on plant material

J. N. Dell

Hyperplastic canker

POTENTIAL ECONOMIC IMPACT – HIGH

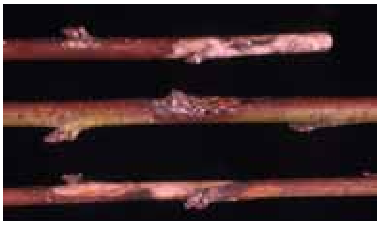
- Bacterium – *Pseudomonas amygdali*
- Found in Europe
- Swollen bark that cracks open longitudinally around buds and leaf scars on twigs and branches. Results in no bud burst in cankers and tree decline
- Spread by wind and rain from active cankers as well as in infected plant material

C. Panagopoulos

Phomopsis canker

POTENTIAL ECONOMIC IMPACT – HIGH

- Fungus – *Phomopsis amygdali*
- Found in Europe, the Mediterranean, USA and South America
- Dark lesions near buds, wilting of new growth, sunken cankers in summer and nuts shrivelled
- Spread in infected planting material



University of Georgia Plant Pathology Archive, Bugwood

Almond seed wasp

POTENTIAL ECONOMIC IMPACT – HIGH

- Wasp (Hymenoptera) – *Eurytoma amygdali*
- Found in Europe, Asia, Middle East and North America
- Eggs and larvae develop in mummies with a tiny circular hole evident
- Nut meat eaten

H. Dumas

Navel orangeworm

POTENTIAL ECONOMIC IMPACT – HIGH

- Larvae of moth (Lepidoptera) – *Amyelois transitella*
- Found in USA and Canada
- Moths lay eggs on new fruit or in mummies
- Larvae feed on nut meat, leaving webbing and frass
- Increases threat of aflatoxins in nuts
- Orchard hygiene important for control

J. K. Clark

Peach twig borer

POTENTIAL ECONOMIC IMPACT – MEDIUM-HIGH

- Larvae of moth (Lepidoptera) – *Anarsia lineatella*
- Found in North America, Europe and the Mediterranean
- Small brown caterpillar with black head and white bands between segments
- Bore under bark and leave chimneys of frass, damage crotch and developing limbs, new shoots wilt.
- Larvae feed on nuts
- Several generations each year

H. Audemard

Ten-lined June beetle

ECONOMIC IMPACT – MEDIUM

- Beetle (Coleoptera) – *Polyphylla decemlineata*
- Found in western USA in sandy soil
- Cream, C-shaped larvae
- Feeds on roots, resulting in clusters of weak trees
- Beetles are 2.5 cm long with white stripes on back and are attracted to light

Anthony Young

European stone fruit yellows

POTENTIAL ECONOMIC IMPACT – MEDIUM

- Phytoplasma – European stone fruit yellows phytoplasma
- Found in Europe
- Infected trees have low vigour and leaf out before flowering
- Leaves are longitudinally-rolled and droop, and trees may defoliate early

B. Schneider

Almond brownline and decline, and Almond kernel shrivel

POTENTIAL ECONOMIC IMPACT – MEDIUM

- Phytoplasma - Peach yellow leafroll phytoplasma
- Found in Europe and USA
- Type of rootstock affects rate of decline
- On plum rootstock: yellow canopies, line of dead cells at union, small leaves and bark splits (Almond brownline and decline)
- On peach rootstock: delayed bud burst, stunted growth, pale leaves, kernels shrivelled (Almond kernel shrivel)
- Psyllid vectors likely

Jerry K. Uyemoto

Priority pests of pollination

Varroa mite

POTENTIAL ECONOMIC IMPACT – HIGH

- Mite of bees (Acarina) – *Varroa destructor* and *V. jacobsoni*
- Widespread, including recently arrived in New Zealand and Papua New Guinea
- Reddish, oval-shaped, pinhead-sized mites carried on European and Asian bees as external parasites
- Infest hives, introduce pathogens and damage developing bees
- Look for unusual bee behaviour

S. Bauer

Keep an eye out for anything unusual in your orchard. If a pest is found that is not normally present in your orchard, it may be new not only to your orchard, but to the region, state or even Australia.

Case Study – Navel orangeworm

The Australian almond industry has not yet experienced the impact of a pest like Navel orangeworm (NOW), but its capacity to reach our shores is in no doubt. NOW has been previously intercepted at our border on citrus imports.

In orchards overseas where this pest is established, it not only reduces almond yield and quality and increases operating costs, but also contributes to a food safety problem with trade and regulatory implications. Its management is onerous and demands high level orchard hygiene, including field monitoring of moth flights, spore traps and environmental conditions, together with additional well-timed insecticide applications and inspections and removal of mummies from trees.

NOW moths lay eggs in nuts and the resulting larvae consume the developing kernels, leaving frass and webbing behind. NOW-damaged nuts are more susceptible to attack by fungi. *Aspergillus* spp. fungi, which produce a toxin of human health concern, are commonly associated with NOW-damaged nuts and damp nuts in stockpiles. Food safety assurances for almonds must therefore be underpinned by good orchard hygiene, vigilant insect and mummy monitoring, as well as specific testing for aflatoxin presence.

Pest surveillance

Pest surveillance, or crop monitoring, involves looking for, recording and managing plant pests. Conducting regular surveys of your orchard gives you the best chance of spotting a new pest soon after its arrival. Surveillance can be incorporated into existing Integrated Pest Management (IPM) practices, quality assurance programmes, or as a component of best management practices.

Active pest surveillance is necessary because:

- Early detection of exotic pests improves the chance of eradication or containment within a region. Early detection, in conjunction with contingency planning and preparedness by government and industry bodies (e.g. preparing emergency chemical registrations, permits for importation of biocontrol agents, awareness material and training in pest diagnostics) assists with a more rapid and effective response.

- Depending on the type of pest and seasonal conditions, many pests can quickly build up to high levels. General management of established pests requires regular inspections to determine presence and population levels. IPM should be a fundamental part of your orchard management practices.

- Export destinations for almonds (and other nuts) require 'evidence of absence' data for exotic and some endemic pests that are of their concern. The Australian almond industry, in collaboration with governments, must prove through surveillance that exotic pests have been looked for and found to be absent. This underpins claims of 'area freedom' in that a pest is 'known not to occur'.
- Surveillance at the orchard level contributes essential information to regional biosecurity efforts and ultimately to the national status (presence/absence) of a pest.

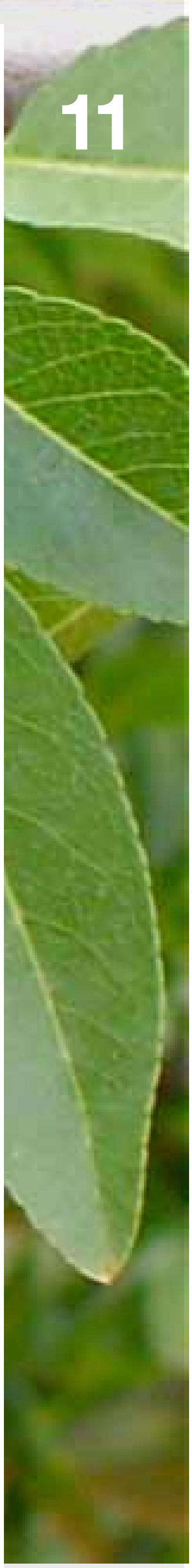
All pest (exotic and endemic) surveillance activities carried out on your property should be recorded. These records can be used in the response to a pest outbreak and provide support to industry surveillance activities. The addition of exotic pests to current datasheets used by consultants is an effective recording mechanism. An example pest surveillance datasheet is included in this manual (page 29).

Report suspect pests

Report any unusual or suspect plant pest immediately via the Exotic Plant Pest Hotline on 1800 084 881. Early detection and reporting may prevent or minimise long-term damage to, or quarantine period of, your orchard and the almond industry.

Calls to the Exotic Plant Pest Hotline will be forwarded to an experienced person in the department of primary industries in your state or territory, who will ask some questions about what you have seen and may arrange to collect a sample. Do not send samples without first speaking to someone from the state department, who can discuss the correct type of sample, its packaging, handling and transport to the laboratory assigned for diagnosis.

In some states, the Exotic Plant Pest Hotline operates only during business hours. Outside these hours, leave your full contact information and a brief description of the issue and your call will be followed up as soon as possible. Every report will be taken seriously, checked out and treated confidentially.



If you have found a suspected exotic plant pest, the following general precautions should be taken:

- Do not allow movement of people or equipment near the affected area.
- Wash hands, clothes and boots that have been in contact with affected plant material or soil.
- Do not touch, move or transport affected plant material. Incorrect handling could spread the pest further or render the samples unfit for diagnosis.

While waiting for the identification of the suspected exotic pest, the following measures should be put in place to contain the pest and protect other parts of your orchard:

- Mark the location of the pest detection.
- Limit access to the area.
- Restrict operations in the area.

If you see anything unusual, call the Exotic Plant Pest Hotline 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

The Emergency Plant Pest Response Deed (EPPRD) and the Almond Industry

The EPPRD is a formal legally binding document between Plant Health Australia, Australian and state/territory governments and plant industry signatories. As a signatory to the EPPRD, the Almond Board of Australia has a seat at the decision-making table and also contributes to funding if an approved Response Plan is implemented to eradicate an Emergency Plant Pest (EPP).

Under the EPPRD, almond industry members have a responsibility to report suspect pests. The earlier a new pest is detected, the greater the chance an eradication response will be mounted and the greater the chance it will be successful.

Within an approved Response Plan, grower reimbursement payments (Owner Reimbursement Costs - ORCs) for direct costs incurred as a result of eradication of a pest incursion are included.

12

Product management

Planting and propagating material

Use only high-health, ‘clean’ (i.e. tested with no pest detections) planting and propagation material. Obtain these only from nurseries that will provide you with reliable records of the material’s source and testing history.

You cannot visually assess the health of your planting material. Viruses, viroids and phytoplasmas will not display symptoms on dormant wood, bare roots and in many other circumstances. Even many bacterial, nematode and fungal pathogens present no obvious symptoms on dormant trees.

To minimise the risk:

- Purchase plant material only from a nursery that takes biosecurity, hygiene, health testing and record keeping seriously. Those nurseries will have evidence to support answers to the nursery biosecurity checklist included in this manual.
- Check your nursery and planting material thoroughly.
- Maintain a register of your orchard’s propagation material, including its source (with contact details), cultivar/rootstock combinations, specific planting locations, numbers of plants and date planted.

When purchasing planting material, seek as much information as possible from your nursery, complete the nursery biosecurity checklist included in this manual, and request and retain all documentation. Information that should be requested includes:

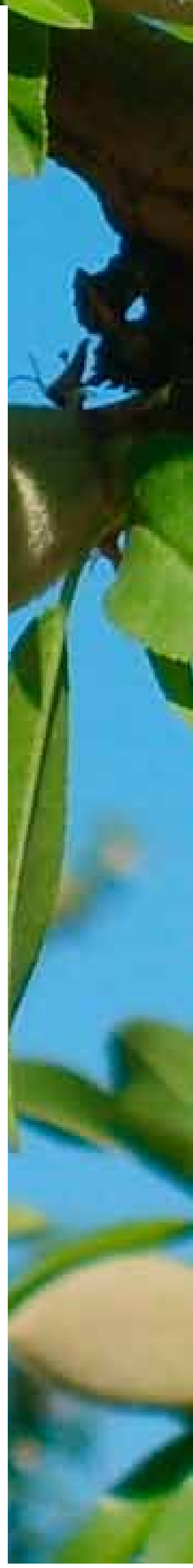
- The source of budwood (and seed for rootstocks).
- Mother tree health testing regime and timetable (get in writing what virus testing was completed, by whom and when).
- If the cultivar or rootstock is a recent import, ask for its accession number, import date and source.
- Location of foundation material of new imports (should be in screen house or isolated area away from commercial production trees).
- Quality Assurance scheme or certification status of the nursery itself and planting material provided.

Australian Almond Budwood Scheme

The Australian almond industry has established its own budwood multiplication block at Monash, South Australia. The site is managed by staff of the Almond Board of Australia, the University of Adelaide and the Riverland Vine Improvement Committee. Mother trees were established as a source of virus-tested planting material for the industry and a pre-determined proportion of the trees are tested for virus presence each year. The production of clean stock is supported by the implementation of best management practices throughout the Monash orchard.

Budwood from this scheme is made available to industry through reputable nurseries. This scheme in combination with high levels of good nursery hygiene, has contributed to the existing high quality of almond plantings.

Additional information on the scheme is available on the Almond Board of Australia website **www.australianalmonds.com.au**



Almond (or other Prunus species) by-products

Maintaining good orchard and nursery hygiene can minimise cross-contamination and breeding environments for pests. This should be achieved in combination with an effective monitoring/pest management program. A ‘spray diary’ record should accompany each consignment of almonds.

Collect all plant waste and dispose of it away from nursery and orchard areas and water sources. Appropriate disposal mechanisms for plant waste include deep burial (away from production areas), burning or hot composting.

Ensure that no soil, plant material or insects are left adhering to vehicles, bins, and other equipment (including hand tools) used for harvesting the nuts.

Biosecurity and Quality Assurance

If your orchard or the nursery providing your trees is accredited (i.e. maintains a Quality Assured scheme such as ISO 9000, SQF 2000, NIASA, Freshcare or Woolworths Quality Assurance Scheme), it is likely that some fundamental techniques of biosecurity best practice are already being applied.

Ensure that your scheme and your records allow full traceability. That is the ability to traceback plant material on your orchard to its source (including the budwood sources, seed source, health testing specifics and authenticity records), to traceforward plant material or produce that has left your property, and provision of records of surveillance and pest management practices undertaken on your property.

Auditable Quality Assurance schemes and achievement of membership to them, is beneficial in terms of biosecurity, market access, meeting specifications and customer expectations, and food safety.

15

People and biosecurity

16

Biosecurity signs

Well designed signage informs visitors that biosecurity in your orchard is a focus and that they share responsibility for maintaining it. The signs serve to alert people to the potential impact of their visit.

Signs also demonstrate your commitment to orchard hygiene, safety and auditable systems. Biosecurity signage should be placed at the main gate, external entrances, visitor parking areas and wash-down facilities.

Biosecurity signs at entrances or near sheds should direct visitors to contact the owner/orchard manager or formally register their presence, before entering any production areas. The signs should include important contact details, such as the home telephone number, mobile number and/or two-way channel.

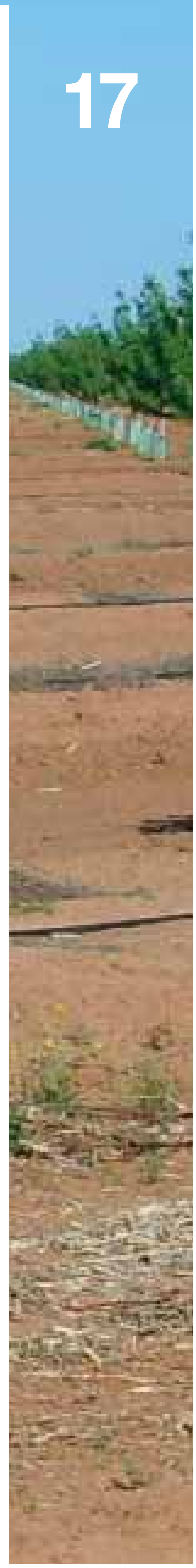
Contact Plant Health Australia for further information on obtaining biosecurity signs for your property.

Managing people movement

People moving between orchards, nurseries and other horticultural regions can spread pests on vehicles, equipment, boots and clothing. Even hair and watchbands can carry fungal spores or bacteria. The most obvious risks are pests carried in soil and plant material.

Implementing the following measures will reduce the threat of human activity introducing new pests into your orchard:

- Maintain a Visitor Register (example included in this manual).
- Inform all employees and visitors that their footwear and clothing must be free of soil and plant material before entering or leaving the orchard.
- Provide scrubbing brushes, footbaths, boot covers, rubber boots and protective clothing such as disposable overalls, for people entering or leaving your orchard, or moving from contaminated to clean areas of the property.
- Ensure budding crews are particularly diligent about cleaning their knives and footwear between cuts. At a minimum, knives should be cleaned between each bundle.



- Train and motivate staff to be aware of all threats and biosecurity measures. Test them occasionally and reward biosecurity awareness and initiative.
- Brief all casual or itinerant workers, contractors and visitors on your orchard hygiene measures.
- Display biosecurity awareness material in staff rooms, trimming and packing sheds. Keep the messages simple and effective.

Overseas travellers

People returning from overseas are a threat to our biosecurity, especially if they have visited orchards, nurseries, or markets where plant material or produce was sold.

Several specimens carrying Prunus pests have been intercepted at the Australian border and overseas travellers have unknowingly brought in pests in the past. Air travel means exotic plant pests are only a few hours away.

To protect your orchard from overseas pests, ensure that all people who have recently returned from overseas have cleaned their boots and clothes before entering the orchard. Great care should be taken to prevent the introduction of plant pests into Australia.

Casual workers and tourists

Itinerant workers (budding crews, contract harvest crews, backpackers, retirees, etc.) are often employed to assist with orchard budding, pruning, harvesting/picking and packing. While their contribution is highly valued, they are a particular biosecurity threat because they move orchard-to-orchard and region-to-region. They can potentially carry and spread pests from and to susceptible hosts on their clothing, footwear, gloves, and equipment (e.g. knives).

Before entering production areas or packing sheds, make sure itinerant workers are well briefed on biosecurity measures at your property, have changed or washed their clothes and boots, and all tools and equipment are cleaned and disinfected.

18

Equipment and vehicles

Movement of vehicles and machinery

Vehicles and orchard equipment such as sprayers, tractors and hand tools can carry pests in adhering soil, sap and plant material. Pests can then be introduced to a previously clean property, or directly into previously pest-free plant material.

It is impractical to stop all vehicle and equipment movement on and off the property, but using dedicated orchard vehicles, washing down of machinery on concrete pads and denying access of dirty machinery can reduce the spread of pests.

A simple additional measure to reduce the risk of direct pest transfer is to park equipment not in use in full sun on hot days.

Contractors, re-sellers, service providers and drivers of delivery trucks (compost/mulch, fertiliser, etc.) and earth moving equipment entering the property should be requested to clean their vehicles and equipment before entering your orchard. Orchards open to the public (e.g. U-Pick businesses) and those open to growers (e.g. for field days, equipment demonstrations) have a heightened risk and designated parking areas away from production sites are important.

Inspecting and cleaning machinery is more time and cost effective than managing a new pest introduced to your property.

Measures to reduce the risk of pest entry on equipment and vehicles include:

- Keep orchard vehicles clean by clearing the vehicle floor of soil, weed seeds and insects, especially after visiting other properties.
- Where possible, use your own vehicle to carry visitors around your orchard.
- In production areas, keep vehicle movement to a minimum, especially on wet soil. Stick to regular pathways through the orchard to minimise the threat of spreading pests.
- Hose off and disinfect machinery in a designated wash-down area before moving between properties.
- Ensure contract mechanical pruners are washed down thoroughly to remove any plant material or soil before entering your orchard.
- Use high pressure water or air to remove plant material and soil from larger equipment and machinery. Ensure that waste water and debris don’t enter production or storage areas.
- Always make sure that borrowed and second-hand equipment and machinery is cleaned of all plant material and soil before moving them into your orchard.
- Regularly clean all tools and equipment, including pallets, palecons, cherry pickers, boxes, bags, trimmers and any other equipment used in the orchard, preferably with an antiseptic or bleach solution.

Designated parking areas

A well sign-posted designated parking area should be provided for all visitors to your property. Ideally, dedicated orchard vehicles should be used for transport around your property with other vehicle movement limited to direct entry to a designated visitor parking area.

Designated parking areas serve to contain the entry of new pests to an area away from production sites. It also allows for the inspection of tyres, equipment, floor mats and boots for soil and plant material which may carry new pests.

A biosecurity sign in the parking area will remind visitors of the threat of spreading pests between properties.

Do not allow the movement of orchard machinery through the parking area.

Wash-down facilities

A wash-down facility allows orchard employees, contractors and visitors to clean their vehicle and equipment in an easily managed area where wash water is contained.

Providing a high-pressure wash-down facility and cleaning equipment will assist you and your visitors to clean down vehicles and equipment.

For additional protection, an added detergent-based degreaser or disinfectant (for example, Septone Truckwash®, Castrol Farmcleanse® or Virkon®) may be appropriate. For best results, seek advice from re-sellers on the best product, and remove as much soil and plant material as possible from the equipment before using the disinfectant.

The wash-down area should have a sump or water collection area. The sump and area surrounding the wash-down facility should be treated or checked regularly for the presence of pests and weeds.

The wash-down area may be the same as that used for chemical wash-down of vehicles and equipment. If so, all occupational health and safety issues associated with chemical wash-down areas must be taken into account.

Wash-down areas should:

- Be readily accessible and located between the driveway and orchard roads.
- Be isolated from production areas.
- Have access to power and high-pressure water.
- Have a sealed (concrete or bitumen) or packed gravel surface.
- Not drain into a waterway or orchard.
- Have a sump or collection area for easy inspection.

21

Orchard biosecurity checklist

Orchard/property name:
Date of biosecurity check:

RECOMMENDED PRACTICES	YES	NO	Comments
Pests			
Commercial trees and neighbouring vegetation regularly inspected for pests			
Orchard staff know how and where to report pests			
Orchard staff are familiar with the high priority pest threats for the almond industry (see pages 6–8)			
Active pest surveillance is regularly conducted			
Survey activities and results are recorded, even when nothing is found			
Numbers of mummies left after harvest are minimised and those remaining are inspected			
Product management			
Propagation material is free from pests – visually and by documented testing			
Planting or propagation material is ‘certified’ or has defined health status			
Records of planting material and its source maintained			
Planting material without complete documentation not accepted on property			
Staff have specific knowledge of symptoms of almond pests spread in propagation material			
Effective monitoring/pest management program maintained			
No soil, plant material or insects left on equipment or in bins			
Almonds loaded and unloaded on paved or sealed pad away from production areas			
Fallen or waste almonds and packing shed waste disposed of away from production areas and irrigation sources			

RECOMMENDED PRACTICES	YES	NO	Comments
People movement			
Biosecurity signs are located at main entrances			
Visitors sign a Visitor Register on arrival			
Visitors, clothing, footwear and tools are free of loose soil or plant matter before entering or leaving the orchard			
All people recently returned from overseas have clean footwear and clothes before entering the orchard			
Footbaths and scrubbing brushes provided for visitors and staff moving from contaminated to clean areas of the orchard			
Orchard vehicles used to transport visitors around the property			
Orchard staff aware of biosecurity procedures in place			
Equipment and vehicles			
Designated parking area for non-orchard vehicles			
Cleaning and wash-down facilities, preferably on a concrete pad, provided for people, machinery and equipment			
High pressure water or air available for use to remove plant material and soil from equipment and machinery			
Sump installed in wash-down facility to catch unwanted weeds and stop run-off			
Orchard vehicles kept clean by regularly clearing the vehicle floor of soil, weed seeds and insects			
Vehicle movement kept to a minimum in production areas			
Borrowed and second-hand machinery and equipment is cleaned of all plant material and soil before use			
Secateurs and grafting knives are disinfected using a bleach solution between trees			
Machinery cleaned before being moved off property			

Nursery checklist

To be completed through discussion with your nurseryman when purchasing propagation material from a nursery, to reduce the risk of introducing new pests to your orchard.

Nursery name:
Date of propagation material purchase:
Propagation material purchased:

RECOMMENDED PRACTICES	YES	NO	Comments
Pests			
Nursery staff familiar with general biosecurity practices			
Nursery staff familiar with exotic and endemic threats of almonds			
Specific testing periods for mother plants and seed are programmed			
Test results are recorded and auditable			
Pest threat posters displayed			
Staff know how and where to report pests			
No unlabelled or material of unknown source accepted as propagation material			
An effective monitoring/pest management program maintained and recorded in ‘spray diary’ or similar			
Active surveillance is formally conducted – inspections, sticky cards, etc.			
Survey activities are recorded, even when nothing is found			
Product management			
Propagation material is free from pests			
Certified plant material is physically separated from non-certified plant material			
Register of planting material and its specific source maintained			
Member of Nursery and Garden Industry Australia and using NIASA and Biosecure *HACCP*			

RECOMMENDED PRACTICES	YES	NO	Comments
Product management cont.			
Register of plant material by accession number and date of importation maintained			
Staff are familiar with symptoms of almond pests transmissible in propagation material			
Pots and bins are regularly and thoroughly cleaned			
Plant debris and trimmings are disposed of appropriately			
Staff understand laws governing declaration and introduction of plant material			
People movement			
Biosecurity signs with contact details located at main entrance			
All visitors enter details into Visitor Register before moving about property			
All visitor and staff clothing, footwear and tools are free of loose soil or plant matter before entering and leaving the nursery			
All people recently returned from overseas are checked to ensure they have clean footwear and clothing before entering nursery			
Footbaths and scrubbing brushes are provided			
Staff trained in biosecurity measures and threats			
Staff understand neighbouring enterprises and their activities			
Equipment and vehicles			
Designated parking area provided for visiting vehicles and contractor equipment			
Paved, sealed or compacted walkways through the nursery propagation areas			
Suitable cleaning and wash-down facilities for in-field propagators			
Effective water treatment, recycling and run-off containment			
Vehicle and people movement minimised in production areas			
Borrowed and second-hand machinery and equipment is cleaned of all plant material and soil before entering production areas			
Root trimming secateurs, budding and grafting knives are disinfected (with bleach solution) between trees			

Useful contacts

Plant Health Australia

Phone: 02 6215 7700 **Email:** admin@phau.com.au
Website: www.planthealthaustralia.com.au

Almond Board of Australia

Phone: 08 8582 2055 **Email:** admin@australianalmonds.com.au
Website: www.australianalmonds.com.au

Scholefield Robinson Horticultural Services

Phone: 08 8373 2488 **Email:** srhs@srhs.com.au
Website: www.srhs.com.au

Australian Nut Industry Council

Phone: 08 8582 2055 **Email:** anic@riverland.net.au
Website: www.nutindustry.org.au

Australian Government

Department of Agriculture, Fisheries and Forestry (DAFF)
Phone: 02 6272 3933 **Website:** www.daff.gov.au

EXOTIC PLANT PEST HOTLINE
1800 084 881

If you see anything unusual, call the Exotic Plant Pest Hotline 1800 084 881.

State governments

New South Wales – Department of Primary Industry and Investment

Phone: 1800 808 095 / 02 6391 3100
Email: nsw.agriculture@dpi.nsw.gov.au
Website: www.dpi.nsw.gov.au

Queensland – Department of Employment, Economic Development and Innovation

Phone: 13 25 23 / 07 3404 6999
Email: ccemail@dpi.qld.gov.au
Website: www.dpi.qld.gov.au

Northern Territory – Department of Regional Development, Primary Industry, Fisheries and Resources

Phone: 08 8999 5511
Email: info.drdpifr@nt.gov.au
Website: www.nt.gov.au/d

Tasmania – Department of Primary Industries and Water

Phone: 1300 368 550 / 03 6233 8011
Email: PI.Enquiries@dpiw.tas.gov.au
Website: www.dpiw.tas.gov.au

Victoria – Department of Primary Industries

Phone: 13 61 86 / 03 5332 5000
Email: customer.service@dpi.vic.gov.au
Website: www.dpi.vic.gov.au

South Australia – Department of Primary Industries and Resources

Phone: 08 8226 0222
Website: www.pir.sa.gov.au

Western Australia – Department of Agriculture and Food

Phone: 08 9368 3333
Email: enquiries@agric.wa.gov.au
Website: www.agric.wa.gov.au

Visitor register

Please enter your details to assist us with our orchard biosecurity records

Date	Time on property		Name	Reason for visit	Vehicle registration or mobile	Blocks visited	Location/date of last contact with commercial almonds or other Prunus species
	Arrival	Departure					

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881

EXOTIC PLANT PEST HOTLINE
1800 084 881

Pest surveillance data sheet

Orchard:
Scout:
Date:

		Endemic pests				Exotic pests			
Block	No. sites	Pest 1	Pest 2	Pest 3	Pest 4	Pest 1	Pest 2	Other pests found	Comments

If you see anything unusual in your orchard call the Exotic Plant Pest Hotline on 1800 084 881

EXOTIC PLANT PEST HOTLINE
1800 084 881

Estimated infestation level of endemic and exotic pest presence/absence to be scored (e.g. zero/low/med/high or % trees affected)
Pests targeted by surveillance must be named before surveillance initiated (for both endemic and exotic pests)

30

Fact sheet

Hive biosecurity

Good orchard biosecurity protects your crops and livelihood from the threat of exotic pests. Orchard biosecurity is everyone's responsibility.

As the owner or manager of an orchard, you need to ensure that every person working or coming onto your property is well informed of your active biosecurity measures.

Orchard hygiene is critical to maintaining effective biosecurity. Ensuring that people, vehicles, machinery and equipment do not carry exotic pests onto your property will offer protection from the expense and potential devastation of an exotic pest incursion.

The pollination services used by orchardists bring a contractor with special biosecurity considerations onto your property. Minimising the risk of new pest introductions to the Australian honey bee industry through good hive biosecurity practices provides benefits to beekeepers and growers, and protects the honey and pollination-dependent industries.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Scholefield Robinson HORTICULTURAL SERVICES
ALMOND BOARD OF AUSTRALIA

Scott Bauer

European honey bee with a Varroa mite on its back

Waugsberg

Varroa mite on a recently hatched western honey bee

Stephen Ausmus, USDA ARS, Bugwood

A young worker bee emerges from a brood cell with a mite on its back

Bee and hive threats

The Australian honey bee industry currently faces several key biosecurity threats. The highest priorities are Varroa mites (*Varroa destructor* and *V. jacobsoni*), which attack Asian and European honey bees. Other pests of honey bees that would have an economic impact if they entered Australia include Tropilaelaps mites and Tracheal mites. Establishment of exotic pest species of bees such as Asian honey bees (*Apis cerana*) and Giant earth bumblebee (*Bombus terrestris*) also pose a threat.

Varroa mite

What is it?

Varroa mites are external parasites that feed on both adult bees and brood (larvae and pupae). The mites are carried into hives on bees, where they leave the bee and invade brood cells. They are obligate parasites and do not survive many days away from bees. Mite feeding weakens adult bees and new bees emerging from mite infested brood cells are often deformed and die prematurely. Progressive loss of bees results in weakening of the hive and eventually colony death. In addition, movement of mites between hives and within the hive spreads any pathogens that they carry.

What to look for?

The mites are the size of a pinhead and hard to see with the naked eye. Detection of the mites is most easily achieved through other apparent signs of their presence, such as unusual bee behaviour (itchy bees trying to scratch off mites) and weak or deformed bees. The other major sign is a sudden decline in bee numbers in a colony or complete death of the colony. The weakened bees die and cannot be replaced at the rate required to maintain the hive. Honey production also drops as there are fewer bees capable of foraging.

Where are they found?

Varroa mites are present in most bee keeping countries of the world, except for Australia. The threat is as close as Indonesia, Papua New Guinea and New Zealand. Following arrival in New Zealand in 2000, they have had a significant economic impact on the honey bee and pollination-dependant industries.

Scott Bauer

An adult female Varroa mite feeds on a developing bee

Scott Bauer

Visible as a dark, oval shape, an adult female Varroa mite feeds on the midsection of a developing worker bee

Lilia De Guzman

Honey bee population infested with Varroa mites

EXOTIC PLANT PEST HOTLINE
1800 084 881

Early detection underpins effective eradication of these unwanted pests of honeybees and pest bee species.

What impacts would they have in Australia?

The potential impact on the Australian plant industries has been estimated at up to $50 million per year due to reduced and poor quality crop production. Effects would be most severe on pollination-dependent horticultural crops. There would also be direct effects on honey production and a requirement for additional chemical treatments to control Varroa mite.

Other bee and hive threats

Other threats not currently in Australia include:

- Tracheal mite (*Acarapis woodi*): Infestations result in sick adult bees that do not work as hard or live as long as healthy bees. The mite infests the trachea and air sacs, resulting in affected bees having difficulty in flying. Within the hive, spread occurs from adults to newly emerging bees. Spread to other hives occurs through drifting bees entering new hives and through beekeepers interchanging hive components or introducing infested queen bees. Detection is difficult because the signs are non-specific. Laboratory diagnosis is required.

- Tropilaelaps mite (*Tropilaelaps clarae*): These mites are external parasites affecting brood in the hive. They cause brood death or shortened life span for any bee that survives the brood phase. The brood appears to have an irregular sealed and unsealed brood pattern and newly emerged bees have deformities of wings, legs and abdomen. Normal hive management can spread these mites once they become established.

- Asian honey bees (*Apis cerana*): Asian honey bees are an exotic pest bee species, and are often linked with Varroa mite. They are aggressive competitors with European honey bees for floral resources but most strains are not good pollinators, produce only small amounts of honey and are too difficult to handle. Asian honey bees will rob honey from European honey bee hives and in large numbers are capable of starving them out.

Good biosecurity measures will also reduce the impact of pests already established in Australia, such as the Small hive beetle, American foulbrood and European foulbrood of honey bees.

What is the best protection for my orchard?

There are a number of things you can do to improve your orchard biosecurity and to help safeguard Australia's almond and honeybee industries.

As an almond producer reliant on bees for pollination, you should expect your hive provider to:

- Check the health of any newly purchased bees, including asking for a vendor declaration of health status.
- Specifically check bees and brood for signs of disease.
- Maintain strong hives that are not susceptible to pest attack.
- Avoid placing hives in proximity of rubbish tips.
- Avoid placing hives near abandoned hives, as these are more likely to be diseased.
- Avoid placing hives near abandoned orchards which might have pests that can be carried by bees.
- Regularly inspect bees for unusual behaviour.
- Isolate captured swarms for six months to ensure they are free from pests before adding them to the main apiary.
- Check swarms for unusual bees as they may be an exotic bee species.
- Ensure all hives are registered and branded so there is no confusion about ownership.

Working together, almond producers and hive providers should:

- Ensure a clean water source is available for the bees.
- Ensure all orchard and hive equipment is cleaned between uses.
- Wash and disinfect hands before and after handling hives.
- Ensure boots and clothing are free from plant material, soil, insects and other pests before entering and leaving orchards or handling hives.
- Minimise the number of people that visit hives.
- Prevent vehicles from driving close to hives.
- Secure honey stores and sticky frames so robbing bees cannot gain access.
- Check hives when monitoring the orchard and report any unexplained decline in bee numbers, crawling or dead bees near hive entrances or any unusual bee behaviour.
- Advise your hive provider of any intended use of chemicals that might be harmful to bees.

Record keeping is an important aspect of good biosecurity practices. You should request and record information from your hive provider on the previous locations of their hives and their pest inspection program. Asking for this information shows that biosecurity is important to you and will help track and minimise any pest spread should there be a new pest incursion.

If you see any unusual symptoms or behaviours in your bees call the Emergency Animal Disease Watch Hotline on 1800 675 888. If you spot anything unusual in your orchards, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

More information?

The Australian Honey Bee Industry Council (AHBIC), as the peak honey bee industry body, has a focus on protecting beekeepers and their hives through sound biosecurity practices. Visit **www.honeybee.org.au** or call **02 9221 0911**.

For more information on biosecurity and a range of tools to help you secure your farm and secure your future, visit **www.farmbiosecurity.com.au.**

Fact sheet

Almond leaf scorch (ALS)

What is it?

Xylella fastidiosa can infect almonds and cause leaf scorch (also called 'golden death'). Other strains infect grapes (Pierce's disease), citrus (variegated chlorosis), peach, pecans, plums, and some perennial ornamentals trees. No strains of this bacterium are present in Australia.

This bacterial pathogen is spread through grafting or by sap-feeding (xylem) insect vectors (such as spittlebugs, sharpshooters and leafhoppers). Vectors pick up the bacterium by feeding on infected plants.

It is possible that natural vectors of this pathogen may exist in Australia, but the most efficient vector overseas (Glassy-winged sharpshooter) is not currently found in Australia – and needs to be kept out. Green and red-headed sharpshooters are also proven vectors of the almond strain overseas.

Jack Kelly Clark, UC Statewide IPM Program

Almond leaf scorch symptoms showing zonate pattern

Jack Kelly Clark, UC Statewide IPM Program

Marginal scorching of leaves

What to look for?

Look for both the symptoms and the presence of sharpshooter or spittlebug vectors. These potential vectors are large enough to see with the naked eye.

Where is it found?

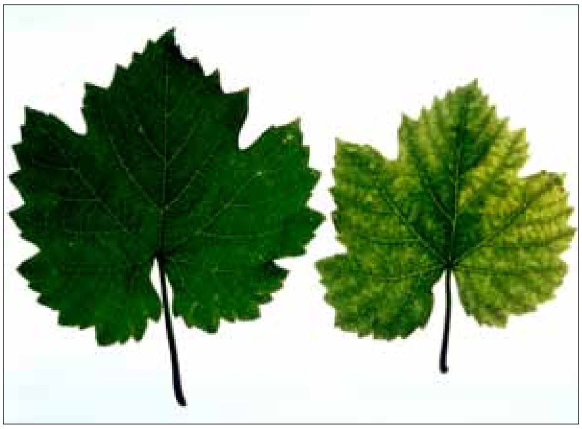
This pest occurs in North and South America, Europe and the Mediterranean and infects a variety of plant species. Winter severity affects bacterial and vector survival. Australian winters in all zones would allow both to persist.

Scholefield Robinson HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA

Rebecca A. Melanson

Leaf scorch symptoms on pecan trees



Alex H. Purcell, University of California

Pierce's disease symptoms in grapevine

ENSA – Montpellier archive

Yellowing and dessication of grapevine leaves, and wilting of bunchers, due to Pierce's disease

Glassy winged sharpshooter and other sharpshooter eggs may be laid on a wide range of plants and therefore any imported host plant material needs thorough inspection.

Almond leaf scorch symptoms first develop as 'burn and bleaching' at the leaf tip and margins. They progress towards the mid rib and leaf base, leaving zones of necrotic tissue and a golden band between the part of the leaf still green and the scorched area. Unlike salt burn, almond leaf scorch symptoms are not uniform along the leaf margin. Even when dead, the ALS-affected leaves stay attached until autumn. Infected trees are stunted, less productive, have reduced terminal growth and may also bloom and leaf out later than healthy trees.

What is the best protection for my orchard?

Ensure windbreaks and neighbouring ornamentals are not preferred hosts of either the bacterium or its vectors. Some reservoir hosts do not develop symptoms.

Inspect in-coming plant material thoroughly for any symptoms or egg masses. Keep delivery, label and health-status testing records. If a range of cultivar/rootstock combinations are received, keep a field map of their planting. This assists traceability to nurseries, should an incursion occur.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Glassy-winged sharpshooter (GWSS)

What is it?

This leafhopper causes direct damage through its feeding activities and excrement 'showers'. However, the greatest threat associated with this pest is as the highly efficient vector of *Xylella fastidiosa*, which causes Almond leaf scorch. It is a strong flier and can travel large distances directly or as a hitchhiker on plant material.

GWSS feeds and reproduces on a wide range of host plants, most of which can be infected by the pathogenic bacterium. The bacterium is delivered into the water conducting tissues of the host plants through the piercing and sucking feeding action of GWSS.

Phil A Phillips

Adult GWSS

What to look for?

Adult GWSS are 13-14 mm long and easily seen with the naked eye. They are dark brown-black with yellow dots on head and body (thorax). Their wings are translucent with reddish veins.

'Clutches' of up to 27 eggs are laid on the underside of leaves in a side-by-side arrangement. Eggs are deposited just under the leaf surface giving a blister-like appearance. Egg masses on imported plant material (especially ornamentals) are a significant threat.

Reyes Garcia III

Egg mass ready to hatch

Where is it found?

GWSS is found in eastern and western USA and in Mexico. Recently the GWSS has been detected in a number of new locations, including the neighbouring countries of Tahiti and the Cook Islands.

Scholefield Robinson
HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA

Johnny N. Dell

Adult GWSS on leaf surface

PaDIL

Adult GWSS

Russ Ottens

Side view of adult GWSS on a plant stem

Crepe myrtles and many other commercial and ornamental woody and annual plants may harbour the insect. Commercial hosts like almonds, citrus and grapes would be threatened if GWSS became established, particularly if it carries *X. fastidiosa*.

What is the best protection for my orchard?

Limit unnecessary movement of landscape and commercial plant material in leaf. Thoroughly inspect plant material introduced to your orchard and residential surrounds for egg masses and insects. Dispose of all orchard waste plant material appropriately, through deep burial, burning or hot composting.

Report neglected orchards and feral almonds to your local department of primary industry.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests and insects that inhabit vegetation neighbouring your almond orchard so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Hyperplastic canker

What is it?

Hyperplastic canker is a disease caused by the bacterium *Pseudomonas amygdali*. Primary hosts of this bacterium are almonds and peach. Infection affects branches and twigs of the host plant and results in tree decline.

Short distance spread of the pest occurs from active cankers during wind and rain.

What to look for?

Symptoms of Hyperplastic canker infection can be detected from leaf emergence. Infected trees have swollen bark canker around leaf scars and wounds. As the symptoms progress a longitudinal crack develops in the swollen bark. These cankers look like the bark has been peeled back to show discoloured wood beneath.

C. Panagopoulos

Longitudinal crack with peeled bark symptoms caused by Hyperplastic canker

Where is it found?

Hyperplastic canker is currently found only in the European countries of Greece, Afghanistan and Turkey.

Scholefield Robinson HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA

C. Panagopoulos

Sparse foliage and cankers in infected tree

C. Panagopoulos

Discoloured wood visible underneath split bark

Check for soft, rough tissue at the margins of cankers. If there are multiple cankers they can girdle shoots. The buds in cankers will not develop so affected trees generally have little foliage. There are no specific leaf symptoms, however infected trees decline because of the lack of new growth.

Non-pareil shows some tolerance to this pest, so detection inspections should focus on other cultivars.

What is the best protection for my orchard?

Use clean planting material from a known source that utilises high health and hygiene strategies. Additional protection can be obtained by visually checking for cankers in all planting material before use.

Protect scars and wounds on tree stems and leaves to reduce the chance of infection.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Phomopsis canker

What is it?

Phomopsis canker (caused by the fungus *Phomopsis amygdali*) attacks almonds, peach and apricot. Infection results in lesions on limbs and wilted, yellow leaves.

Rain and warm temperatures during autumn promotes infections and the Australian almond production districts have suitable conditions to allow establishment of this pest if it were introduced. Spread of the fungus occurs through infected planting material.

Infected almond trees require additional treatments and pruning. Summer, autumn and spring chemical treatments are currently used in Europe, but none are fully effective in managing the fungus.

What to look for?

Symptoms of Phomopsis canker can be first detected in early spring. On affected limbs there may be dark, elliptical lesions visible around or near the buds. By late spring, a toxin produced by the fungus will cause leaves to wilt and turn yellow. New growth may die and by summer the lesions become sunken cankers that may have black dots (fruiting body of fungus) in their centre.

Infected hulls turn grey-brown and have shrivelled nuts inside.

Themis J. Michailides

Longitudinal section through a canker of Phomopsis

Themis J. Michailides

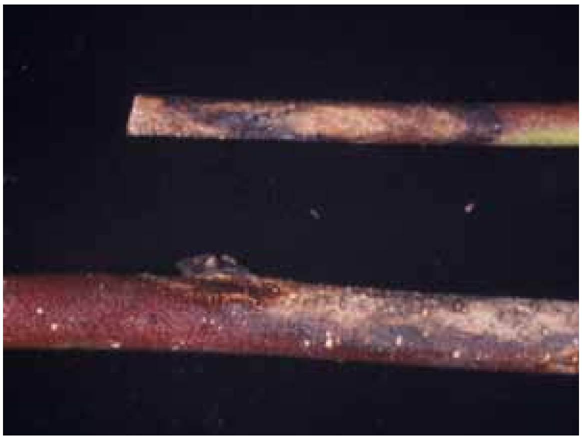
Cankers of Phomopsis in cross-section of almond trunks

Where is it found?

This fungus occurs in Europe, the Mediterranean, South America, and in the USA.

Scholefield Robinson Horticultural Services

Almond Board of Australia



Themis J. Michailides

Pyenidia of Phomopsis on leaves dropped onto the ground

University of Georgia, Plant Pathology Archive, Bugwood

Phomopsis cankers and twig blights in peach

What is the best protection for my orchard?

Use clean planting material from a known source that utilises high health and hygiene strategies.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Almond seed wasp

What is it?

The Almond seed wasp (*Eurytoma amygdali*) is capable of infecting up to 80% of almond crops, resulting in reductions in both yield and quality of the crop.

This pest is difficult to control and if it were to become established in Australia there would be considerable additional management costs incurred for re-shaking orchards each year, monitoring, trapping and insecticidal applications. Organophosphates have not been successful in controlling the pest in Europe.

H. Dumas

Emergence of female Almond seed wasp from an almond

What to look for?

In Europe, the Almond seed wasp has one generation per year, with larvae overwintering in mummies. The adults emerge in spring through a tiny circular exit hole in the mummies. These holes are the best evidence of the presence of this pest.

The adults mate and lay eggs in the young, developing, green fruit. Larvae of this wasp remain in that fruit and are therefore protected from applied contact insecticide sprays. They eat the developing nuts.

H. Dumas

Female Almond seed wasp ovipositing in an almond

Where is it found?

The wasp is currently found in Europe, Asia, North America and the Middle East. It is thought to have originated in Asia and it arrived in France in 1980 where it has had a significant impact on their almond crops.

Scholefield Robinson HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA

H. Dumas

Almond seed wasp larva inside the almond

H. Dumas

Larva removed from an almond in winter

What is the best protection for my orchard?

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

Inspect all mummies and remove as many as possible following harvest. Neglected orchards and feral almonds should be reported to your local department of primary industries.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Naval orangeworm

What is it?

Navel orangeworm (*Amyelois transitella;* NOW) is a major moth pest wherever it is established. It attacks the nuts of almond, pistachio, macadamia and walnut, as well as citrus.

NOW larvae reduce yield through consuming the nut meat. The larvae also leave frass and webbing behind and the damage increases the likelihood of infection by aflatoxin-producing fungi, which further reduce quality and food safety. As NOW larvae are concealed within the shell, nuts-in-shell can continue to be spoilt post-harvest.


Jack Kelly Clark, UC Statewide IPM Program

Older Naval orangeworm larvae consume most of the nut

What to look for?

NOW larvae overwinter in mummy nuts left on the trees or on the ground. In spring, moths emerge and lay the first pink to orange eggs on or near other 'sticktight' nuts on the tree. Eggs may also be laid on new crop nuts after hull split. Larvae bore into the nuts or kernels damaged by sunburn or other pests.


Jack Kelly Clark, UC Statewide IPM Program

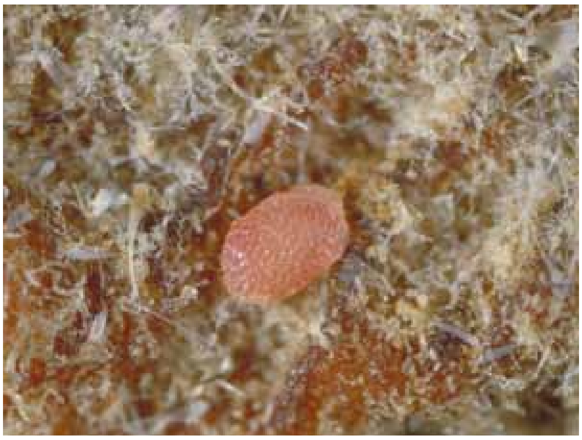
Naval orangeworm moth

Where is it found?

This pest is found in the USA and Canada where it causes damage to almond, pistachio, walnut, fig and orange crops. It is also known to attack macadamia and grapes. Current management requires well-timed applications of organophosphates and costly monitoring.

Scholefield Robinson HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA



Jack Kelly Clark, UC Statewide IPM Program

Naval orangeworm eggs turn reddish orange before hatching

Jack Kelly Clark, UC Statewide IPM Program

Naval orangeworm larvae can be distinguished by a pair of crescent-shaped markings in the second segment behind the head

Jack Kelly Clark, UC Statewide IPM Program

Navel orangeworm pupae are encased in woven cocoons that may be found within webbing and frass inside nuts

Larvae are reddish-orange but become white or pale pink as they develop. The pupae are found within the nuts, with webbing. Checks for the presence of larvae and pupae in mummies should be completed during winter. Inspection of twigs for the presence of pink to orange eggs is another method of detection.

This pest has been intercepted by border quarantine on citrus imports from California demonstrating an ability to reach Australia.

What is the best protection for my orchard?

Remove as many mummies as possible from trees and the ground following harvest. Practice good orchard sanitation and complete harvest quickly. Regularly inspect nuts and mummies for the presence of any insect pests.

Neglected orchards and feral almonds should be reported to your local department of primary industries.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Peach twig borer

What is it?

The Peach twig borer (*Anarsia lineatella*) is a major pest of several tree crops, especially *Prunus* spp. In Californian almond orchards, control of this pest requires insecticide use during the dormant, post-bloom, and sometimes hull split stages.

The female moth lays pale yellow-orange oval eggs in fruit, twigs and leaves and the emerging larvae overwinter in holes bored under the bark of trunks and young (1-3 years) limb crotches. The larvae cause damage to growing shoot tips, developing scaffolds and to nuts. Direct feeding on nut meat causes the greatest economic damage, with soft-shelled almonds being the most susceptible.

The pupae shelter in crevices, curled leaves and debris, or between the hull and shell of old nuts. They can grow up to 1 cm in length.

H. Audemard

Peach twig borer larvae

Jack Kelly Clark, UC Statewide IPM Program

Adult peach twig borer

What to look for?

The overwintering larvae produce small ‘chimneys’ of frass on bark surfaces. During early to mid-bloom (of Non-pareil), larvae can be seen leaving the bark and making their way towards young buds and leaves.

Where is it found?

The Peach twig borer is found throughout North America, Europe and the Mediterranean.

Scholefield Robinson HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA

Jack Kelly Clark, UC Statewide IPM Program

Peach twig borer feeding damage on almond kernels

Jack Kelly Clark, UC Statewide IPM Program

Pile of frass at entrance of peach twig borer hibernaculum

Look for wilted strikes where the larvae have mined into young shoots. They are easiest to see on young trees and on water shoots. Cutting the infested shoots longitudinally will expose the larvae. The caterpillars are small with a brown body and a black head. White bands are present between each body segment.

If not detected and controlled early, the Peach twig borer produces obvious shallow channels in the nuts. These larvae do not form webbing in affected nuts, unlike the Naval orangeworm.

Adult moths are nocturnal, grow up to 11 mm long and have grey, mottled wings.

What is the best protection for my orchard?

Neglected orchards and feral almonds should be reported to your local department of primary industries.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Ten-lined June beetle

What is it?

The Ten-lined June beetle (*Polyphylla decemlineata*) is a very serious pest when it occurs, with control being difficult and expensive to implement.

The beetle larvae live in sandy soil and feed on the roots, weakening and sometimes killing infested trees. Adult beetles, which are about 2.5 cm in length, feed on foliage but this activity does not cause major losses. There is no effective control except for tree removal and fumigation of soil before replanting.

Eugene E. Nelson

Adult Ten-lined June beetle

What to look for?

This pest can infest a range of species, with almonds, most deciduous fruit tree, roses and potatoes the most susceptible.

The larvae are typical scarab larvae, cream in colour and C-shaped. Larvae have a brown head and may reach 50 mm in length.

Adult beetles are attracted to light and are active during summer nights. They are distinctive due to the longitudinal white stripes on their back and clubbed antennae.

Whitney Cranshaw

Ten-lined June beetle larvae

Where is it found?

The Ten-lined June beetle is currently found in western USA, where it is a serious problem, particularly on sandy soils.

Scholefield Robinson
HORTICULTURAL SERVICES

ALMOND BOARD OF AUSTRALIA

Calibas

Adults have distinctive longitudinal white strips and clubbed antennae

Cheryl Moorehead

Adult Ten-lined June beetle

Jack Kelly Clark, UC Statewide IPM Program

Almond trees dying from root damage by Ten-lined June beetle larvae

The death of a cluster of almond trees, especially in sandy soil, may indicate the presence of this pest. In these cases, trees should be investigated for the presence of larvae or evidence of its feeding in both the woody and young roots from the top 60 cm of soil. Because the life cycle of this beetle is long, infestations do not expand rapidly.

What is the best protection for my orchard?

Do not introduce soil to your orchard and all virgin soil (especially if sage bush has grown there previously), should be checked thoroughly before planting trees.

Neglected orchards and feral almonds should be reported to your local department of primary industries.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

European stone fruit yellows

What is it?

European stone fruit yellows (ESFY) is caused by a pathogenic phytoplasma. It infects almonds in Spain, and feral and amenity almonds in Germany. Apricots, peaches, Japanese plums (European plums are symptomless hosts) and several weeds are also susceptible. Decline and death of affected Prunus trees has occurred within 24 months of first symptoms, however almonds do not appear to be as quickly or severely affected.

Natural spread of the pathogen occurs via vectors, with Cicadellids presumed to be the most important ones. Reservoir hosts of both the pathogen and the vector are important for pest spread.

There is no in-field control for infected trees, however management of vectors provides a reduction in pathogen spread.

B. Schneider

Necrosis of the vasculer tissue of an ESFY infected Prunus tree

B. Schneider

Chlorosis and rolling of peach leaves on a shoot affected by ESFY (right) compared to unaffected peach (left).

What to look for?

An early sign of infection is the emergence of new growth during dormancy. Infected trees leaf out before flowers open.

Where is it found?

This pathogen is prevalent throughout Europe. Wild and reservoir hosts maintain the pathogen which has epidemic potential in conducive conditions.

B. Schneider

Prunus tree affected by ESFY (left) showing early defoliation and decline compared to an unaffected tree (right)

B. Schneider

Development of corky tissue along a lateral vein of a peach leaf affected by ESFY

In summer, look for pale, longitudinally-rolled leaves that droop downwards. They become thickened, and have a rough and stiff texture.

Infected trees defoliate early and over time lose their vigour. This can be followed by dieback within 2-5 years of the first symptoms.

The likelihood of early detection of the pest can be increased through surveillance of neighbouring native vegetation for potential vectors.

What is the best protection for my orchard?

Ensure planting material is pest-free, as infected budwood is the most likely entry pathway. Maintain good orchard hygiene practices to reduce potential vector levels.

Observe orchard trees closely for out-of-season leaf out, and monitor all neighbouring vegetation for increased vector levels.

Neglected orchards and feral almonds should be reported to your local department of primary industries.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881

Fact sheet

Peach yellow leafroll phytoplasma

What is it?

This phytoplasma, which causes the diseases Almond brownline and decline (ABLD) and Almond kernel shrivel (AKS), is potentially transmitted by psyllids or, more frequently, through infected planting material. There are several strains of the pathogen with almond symptom development dependent on the scion/rootstock combinations.

Jerry K. Uyemoto

Symptoms of almond kernel shrivel on peach rootstock

What to look for?

Yellow, thinning canopies in almond orchards can be caused by infection by this phytoplasma.

The rootstock determines the rate of decline of infected trees. The plum rootstock Marianna promotes a rapid decline of infected almonds, particularly evident at the union as a brown line of dead cells, pitting of the wood under bark at the union, stunting, small leaves and bark splits (ABLD).

Infected almonds on peach rootstock, are more likely to produce symptoms of AKS. In these trees, budburst is delayed, new shoots can be stunted, leaves are pale and smaller, canopies are thin and the harvested kernels are shrivelled. However, the overall tree decline is slow.

Jerry K. Uyemoto

Almond trees on peach rootstock with kernel shrivel disease

Where is it found?

Peach yellow leafroll phytoplasma is found widely amongst tree fruits, but infections in almond are apparent only in the USA.

Scholefield Robinson Horticultural Services

Almond Board of Australia

Jerry K. Uyemoto

Small green leaves and stunted shoots caused by ABLD

Jerry K. Uyemoto

Pitting & necrosis along unions caused by ABLD

Jerry K. Uyemoto

Almond brown line and decline caused by ABLD

Transmission of the pathogen is most likely through the planting of infected material. However, since older trees may become infected, spread by insect vectors is also likely.

Best protection for my orchard?

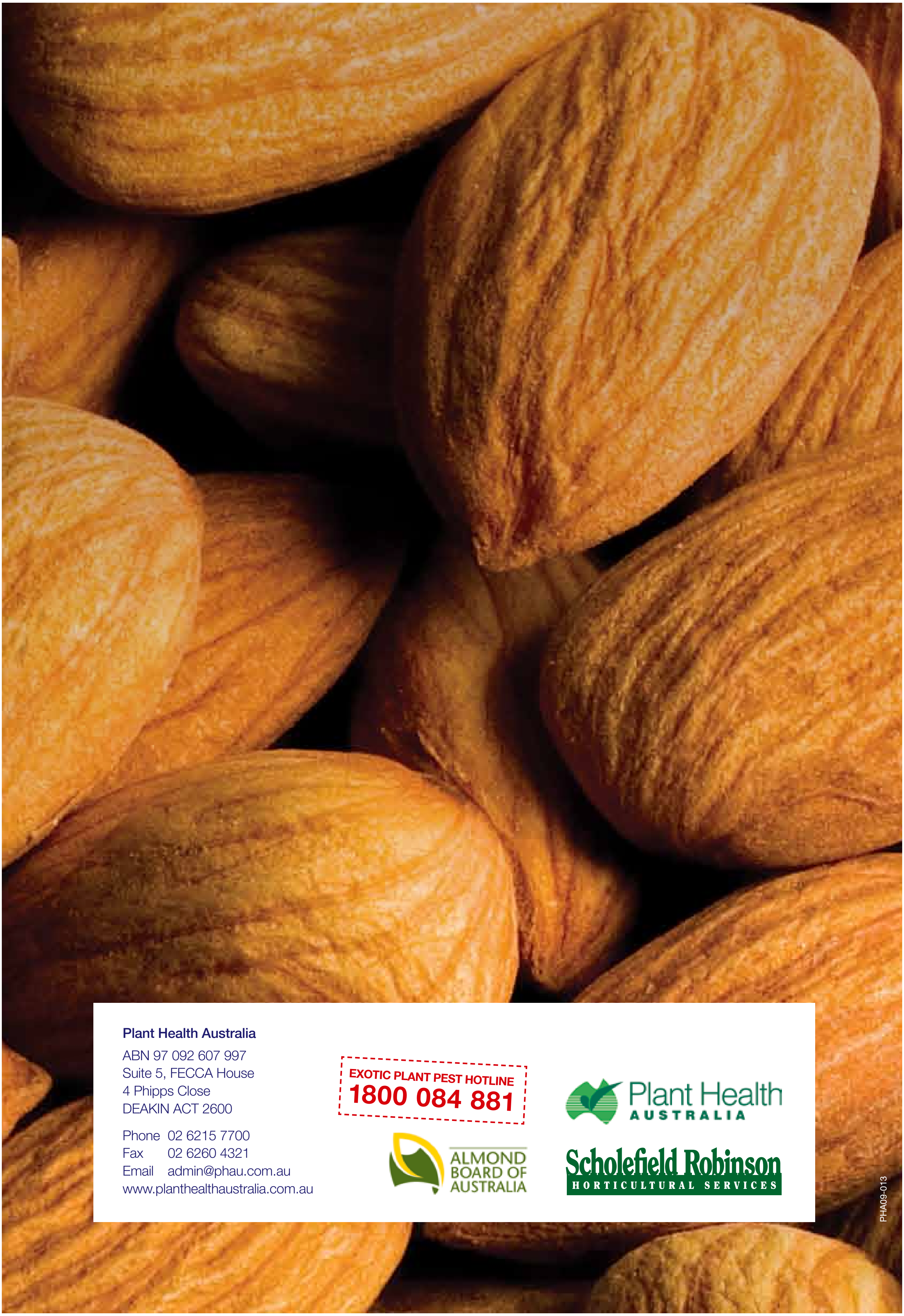
Ensure that all planting stock is pest-free and that compatible rootstocks are used. Maintain good orchard hygiene practices to reduce potential vector levels.

Neglected orchards and feral almonds should be reported to your local department of primary industries.

Check your orchard frequently for the presence of new pests and unusual symptoms. Make sure you are familiar with common pests so you can tell if you see something different.

If you see anything unusual, call the Exotic Plant Pest Hotline on 1800 084 881.

EXOTIC PLANT PEST HOTLINE
1800 084 881



Plant Health Australia

ABN 97 092 607 997
Suite 5, FECCA House
4 Phipps Close
DEAKIN ACT 2600

Phone 02 6215 7700
Fax 02 6260 4321
Email admin@phau.com.au
www.planthealthaustralia.com.au

EXOTIC PLANT PEST HOTLINE
1800 084 881

Plant Health AUSTRALIA

ALMOND BOARD OF AUSTRALIA

Scholefield Robinson HORTICULTURAL SERVICES

PHA09-013

AL 06006
Ensuring Market Access through Quality Assurance - A Review of Almond Industry Quality Assurance

FINAL REPORT

David R. Pocock
Rural Solutions SA

RURAL SOLUTIONS SA

(3 May 2010)

David Pocock
Horticultural Consultant

Rural Solutions SA

PO Box 411
Bookpurnong Road
Loxton SA 5333
T: 08 8595 9100 F: 08 8595 9199
E: david.pocock@sa.gov.au
W: http://www.ruralsolutions.sa.gov.au/

Disclaimer

Rural Solutions SA and its employees do not warrant or make any representation regarding the use, or results of the use, of the information contained herein as regards to its correctness, accuracy, reliability, currency or otherwise. Rural Solutions SA and its employees expressly disclaim all liability or responsibility to any person using the information or advice.

Any recommendations contained in this publication do not necessarily represent current ABA policy. No person should act on the basis of the contents of this publication, whether to matters of fact or opinion or other content, without first obtaining specific, independent professional advice in matters set out in this publication.

CONTENTS

ACKNOWLEDGMENTS

Funding: This project has been funded by the Almond Board of Australia and Horticulture Australia Ltd.

Co-operators: Special thanks to the processors, hullers/shellers and growers who assisted in the preparation of this report.

1 EXECUTIVE SUMMARY

The key changes and project recommendations for almond quality assurance are listed below with a brief description of each point.

Continued education is essential to control the presence of glass and metal and new initiatives to highlight the growing importance of stones and other foreign material as a hazard is vital. Education needs to be supported by other forms of reward/penalty to ensure quality improvements occur.

Research into the potential hazards of aflatoxins and *salmonella spp* .is needed before such hazards appear in the Australian crop. The research should include a literature review and an on-farm project to determine specific sources of contamination.

The development of harvest guidelines for growers and a fact sheet on management of almond stockpiles is required as on-farm storage of almonds increases and the hazard for contamination increases with it.

The establishment of moisture testing network with calibrated machines to enable effective management of almonds before storage and development of guidelines for moisture testing is necessary to provide an objective basis for on-farm storage of almonds.

The develop documentation to include a spray diary and a delivery book. A consistent industry driven approach will improve the commitment to quality processes.

The adjustment of hulled weights back to 5% kernel moisture is necessary to remove the incentive of delivering moist out of specification almonds.

Huller and processor charges based on delivered weight rather than output weight to improve quality. This recommendation will give growers an immediate incentive to remove waste on-farm and reduce freight and hulling cost. Processors will also improve plants capacity as waste material is removed further up the production chain.

The non-acceptance of out of specification material for moisture and foreign material using load inspection will return this poor quality material back to the farm and sends a firm quality message to growers delivering the poorest quality material.

Improving the feedback loop to growers on quality parameters at all stages of the processing chain, with all residue results and outturn reports are sent to growers regardless of the results.

The use of second party auditing as a minimum and the development of an audit checklist provides a consistent base for quality standards to be applied.

2 BACKGROUND

Some twelve years ago the Australian Almond Growers' Association (AAGA) engaged a Hazard Analysis Critical Control Point (HACCP) Practitioner to develop HACCP templates for use by Australian almond growers. Since this time, significant changes have taken place within the Australian industry and on a global front in food safety.

The industry has a history of pro-active change to improve quality parameters and better meet our customer's requirements. The identification, monitoring, control and corrective actions taken over the last 10 years can now be used to demonstrate a good level of control over some 36 000 tonnes of almonds from approximately 150 different properties.

Chemical residues have been the primary issue of concern that cannot be controlled further down the chain of production. Systems such as spray diaries, a Pest and Disease guide, Permits Support Program, regular audits and residue testing program have all been implemented in the past decade.

A new level of understanding with respect to potential quality and food safety risks associated with orchard management practices has been an objective of this project.

This understanding has been aided by the development of Food Safety Guidelines for the Australian almond industry by microbiologist, Dr Elizabeth Frankish. Although this document was developed and generally agreed by the industry more than two years ago, the recommended practices have never been formally integrated into existing HACCP / (Safe Quality Food) SQF systems.

Tree nuts are generally a low risk product as the nuts are grown off the ground and the final product has a low moisture content and low water activity[1].

Global changes and sensitivities to potential s*almonella* and aflatoxin contamination continue to place increased pressure on the Australian almond industry, which is increasingly dependent upon export sales due to exponential production increases. Pasteurisation is now mandatory for domestic consumption in the US, with Australian processors also researching this technology.

Increased size and scale of the industry in Australia is placing additional pressure on the harvest and post-harvest supply chain from timely harvest, on-farm storage of harvested product, cracking and hulling (i.e. primary processing), and sorting and packaging of saleable finished product (i.e. secondary processing). In addition, new growing regions and climatic conditions are also bringing new challenges to production and quality management.

[1] Frankish E. (2007) "Guidelines for Food Safety Management in the Australian Almond Industry" Almond Board of Australia First Edition.

The industry is not regulated by specific commodity standards and a continued approach of setting a practical framework with guidelines to work within is a practical way to manage food safety risks. In addition, this proactive approach of taking the initiative and responsibility to public health will minimise any future potential threats to public food safety.

Given the above changes that have occurred since the development of the almond industry HACCP templates for on-farm use, it is now timely to conduct a review of both these templates and the existing systems in place within the industry.

3 METHODOLOGY

3.1 Stage 1 Market Requirements and Current Practice

A consultation process with industry, including processors, hullers/shellers, and growers was completed to determine the current QA systems in operation.

Three initial meetings with representatives from Select Harvests, NPA/Riverland Almonds and Almondco were conducted to assist in defining the scope of the work.

The agenda included the following items for discussion:

- Current systems in use
- Current adoption level and audit/verification process used
- Residue testing programs in place for chemicals and micro-organisms
- Detection levels
- Other hazards
- Current and anticipated customer specifications

Through this process of consultation the best approach for this work can be agreed, including any required grower training to assist with industry uptake. This forms the basis of future work in quality assurance supported by the industry.

The smaller private processors of almonds will also be contacted to gain an appreciation of their current QA systems and feedback.

3.2 Stage 2 Growers consultation and QA Recommendations

On conclusion of the discussions a paper was presented to the Almond Board of Australia Annual Conference 2009 and a discussion paper developed to take back to the industry (Appendix 1,2).

The discussion paper discusses the primary hazards in almond production on farm. Other secondary hazards and mention of the minor issues resolved through Good Agricultural Practices are part of the discussion.

A Gap Analysis using the HACCP process was then used to put the consultation, discussion and recommendation into a quality systems framework for action. The aim was to provide components for use in HACCP systems for the industry, which are up-to-date and cover key risks for on-farm practices.

Furthermore, these HACCP templates encompassed new industry programs such as the almond industry's MRL testing program operated by the NRS, and the ABA's Voluntary Aflatoxin Sampling Program (VASP).

A set of agreed basic QA requirements is a central part of the project requirements. Supporting material validates recommendations based on current research papers, HACCP methodology and industry best practice.

4 DISCUSSION

4.1 Adoption Widespread

Discussions with almond hullers/shellers, processors and a small number of growers indicate that the adoption of food safety management systems is widespread throughout the almond industry and is increasingly recognised as a core program to address potential food safety hazards. Adoption is however not mandatory for almond growers. Both fully compliant CODEX HACCP and approved supplier systems are used through all stages of almond production. Auditing of these systems is conducted by both third party accredited auditors or second party company specific audit arrangements. A few smaller growers (producing less than 3 tonnes) are not involved in maintaining a food safety system and these almonds are segregated from mainstream lines.

4.2 Auditing

Growers are using both third and second party audits to gain certification to a level required by their processor. The costs and quality of audits vary widely depending on the outcome sought by the grower and their processor.

The packers and sorters also use third party audited systems but not all huller/shellers use HACCP systems to certify their processes.

4.3 Pesticides

Pesticide control has greatly improved in the last ten years with registration of chemicals, permits for newer chemicals, and residue testing now becoming accepted practice by industry[2]. Furthermore, maximum residue limit (MRL) requirements of export and domestic markets are a key driver of chemical use[3].

Over the past five years growers within the industry have good control of chemical use, with no indication of any specific causes for concern based on residue tests applied to composite batches ready for market. Furthermore, in 2008/09 the whole of industry implemented a more detailed and scientifically based industry Pesticide Residue Screen with the results indicating no chemical detections over the MRL[4]. Occasionally traces of chemicals used for insect control in storage of almond kernel have occurred at less than 20% of the minimum MRL for that chemical. A continued monitoring program is required and the industry now participates in the National Residue Survey for both pesticides and heavy metals. The National Residue Survey (NRS) has moved to batch testing of specific growers from the 2009 crop.

Some packers and sorters have used composite sampling in the past for residue testing. This is of limited value in determining the level of non-compliance with on farm pesticide application but provides verification of food safety for export and domestic food safety.

[2] AgAware Consulting (2008) “Strategic Agrichemical Review Process 2008” Horticulture Australia Limited and Almond Board of Australia.

[3] AKC Consulting Pty Ltd, “Australian almond export product MRL compliance review”

[4] Almond Program Chemical Residue Monitoring Results July 2008 to June 2009. Australian Government DAFF (2009)

4.4 Metal

Primarily almond hullers and shellers continue to extract large quantities of ferrous metals from pre-sorting. Usually this is bolts, nuts, sprinklers, clamps, wire and smaller metal fragments. In addition, almond processors have incorporated highly sensitive metal detectors for ferrous and non ferrous materials that can detect very small (3mm diameter) metal fragments. Lead is also picked up by these detectors in addition to ferrous metals.

Recalls from customers have not demonstrated that metal is getting through the processing system. However, every effort needs to be made to reduce metal contamination at every stage of almond production. Metal contamination is of continued concern, but is a hazard under control.

4.5 Glass

The processing industry reports that small amounts of glass are found from some batches. Glass contamination results in downgrading of the batch and the cost to ensure removal can be significant for the grower.

Previous block history is an important determinant of glass contamination; hence, an effective trace back program is essential to prevent future contamination from blocks found to contain glass. Sources include old house sites, dumps and occasional random broken bottles.

Growers can harvest suspect areas separately, pick up any glass in pre-harvest inspections and continue to monitor suspect areas before harvest.

The continued emphasis of glass as a contaminant in HACCP systems is supported across the industry.

4.6 Other Hazards

In reviewing hazards named in earlier HACCP plans there is no recommendation to change any additional on-farm management programs such as fertilizer application or irrigation practices. However, scientific research trials indicate these management programs may require environmental monitoring.

Other new hazards that have emerged over the past 10 years and now require attention are listed below.

4.6.1 Stones

Small stones are an increasing problem in the sorting of almonds. The problem is most evident on newly developed properties with poorer soils. De-stoners and colour sorters in the hulling and sorting processors remove much of the stone but a small portion is difficult to separate due to its specific gravity, colour and size.

4.6.2 Biological Contamination

Reviewing the literature indicates that both aflatoxin and salmonella contamination are of concern in international markets. Interviews across industry clearly indicate all segments of the industry are concerned with potential contamination.

These two contaminants must be differentiated as their cause and effects are quite different. It is important to recognise that aflatoxins are mycotoxins caused by mould growth. Salmonella is a bacteria or pathogen and is the causative agent of sickness in humans and other species.

4.6.2.1 Aflatoxins

Aflatoxins produce acute necrosis, cirrhosis, and carcinoma of the liver in a number of animal species. No animal species are resistant to the acute toxic effects of aflatoxins; hence, it is logical to assume that humans may be similarly affected. wide variation in LD50 values has been obtained in animal species tested with single doses of aflatoxins. For most species, the LD50 value ranges from 0.5 to 10 mg/kg body weight making them highly toxic.

Aflatoxins are a toxin produced as a result of mould infections, in almonds this is usually *Aspergillus flavus* and *A. parasiticus*. The most pronounced contamination has been encountered in tree nuts, peanuts, and other oilseeds, including corn and cottonseed. The major aflatoxins of concern are designated B1, B2, G1, and G2 with B1 usually predominant and the most toxic[5]. Allowable limits for raw almonds[6] in Australia have reduced in recent years and it is currently 10 ppb.

At the grower's part of the production chain there is a long list of aflatoxin concerns, particularly from the US[7]. Detection of aflatoxin does occur in Australia and further research is indicated to determine the likely predisposing factors to aflatoxin contamination. The factors include open shells, moisture on the orchard floor, almonds stored at higher moistures, temperatures and covered stockpiles with condensed moisture or wet almonds in the stockpiles[8]. Some samples of finished product have tested positive at low levels to aflatoxin presence[9].

Direct damage by insects in the US especially Navel Orange Worm can lead to the infection by *Aspergillus* and subsequent production of aflatoxin. US research implicates the Navel Orange Worm and insect damage as a prime concern[10]. An assessment of the impact of insect damage, specifically Carob Moth in Australia, warrants further investigation in relation to the development of *Aspergillus* moulds and aflatoxin contamination.

[5] USDA Food Safety and Inspection Service Fact Sheet, Safe Food Handling Molds On Food: Are They Dangerous? Molds On Food: Are They Dangerous?

[6] Almond Board of California (2005) "International Aflatoxin Tolerances"

[7] Schade J.E, McGreevy K., King A.D.,Mackey B. ((1975) "Incidence of Aflatoxin in California Almonds" Applied Microbiology January;29(1) pp 48-53.

[8] Kader A.E. (1992) "Postharvest Technology of Horticultural Crops 2nd Edition University of California Oakland pp257.

[9] VASP Voluntary Aflatoxin Sampling Plan (2007)

[10] Schatzki, TF, Ong, MS'Dependence of aflatoxin in almonds on the type and species of insect damage", Journal for Agricultural and Food Chemistry, Sept 2001 V49 (issue 9) pp 4513-9.

Brief literature reviews, US research and personal interviews do not indicate a sole source of contamination in the US or any indicative sources of infection in Australia. Predisposing factors such as nuts left in the orchard from the previous season, general hygiene, almond moisture content, weather conditions, storage conditions at harvest, and insect damage during storage result in aflatoxin development. In Australia, a research project is required to investigate the presence or absence of *Aspergillus* moulds and aflatoxin along the supply chain with a view to distinguish and manage critical control points.

4.6.2.2 Salmonella

Salmonella is a rod-shaped, motile bacterium with widespread occurrence in animals, especially in poultry and swine. Environmental sources of the organism include water, soil, insects, factory surfaces, kitchen surfaces, animal faeces, raw meats, raw poultry, and raw seafood to name only a few.

Acute symptoms in human infection include nausea, vomiting, abdominal cramps, abdominal diarrhoea, fever, and headache. Onset time is 6 to 48 hours and the infective dose is as little as 15 to 20 cells; depending upon age and health of the host and strain differences among the members of the genus. Acute symptoms may last for 1 to 2 days or may be prolonged, again depending on host factors, ingested dose and strain characteristics[11].

Salmonella is a cause for future concern for two reasons;

- Firstly, European markets have imposed strict controls on the presence of salmonella bacteria.
- Secondly, there have been major issues of contamination in California and while detections of Salmonella have occurred, the actual source has not been identified. The problem has been more prevalent in pistachios and recalls of processed products have occurred.

The Australian almond industry moved to ban orchard use of raw animal manures when food safety systems were first introduced ten years ago. While this has reduced the likely incidence of salmonella contamination, the potential still exists for it to occur. The need to understand the likely sources of contamination, predisposing factors and means of on-farm control is important. A program to search for likely sources of this pathogen is indicated. Development of guidelines for reduction of contamination can then occur.

4.6.3 Insect Damage

Insect damage in Australia occurs from time to time and while knowledge of stored grains would show that almonds stored at high moistures for long periods may be a food safety risk. Hullers and shellers report insect contamination occurs with almonds that are stored for short or long periods, indicating insect contamination in field is also an issue.

[11]http://www.fda.gov/Food/FoodSafety/FoodborneIllness/FoodborneIllnessFoodbornePathogensNaturalToxins/BadBugBook/ucm069966.htm

5 GAP ANALYSIS

5.1 Review the HACCP templates

HACCP templates developed in 1999 have been reviewed. The templates were the basis of early attempts to improve Quality Assurance (QA) and quantify risks to food safety and quality. The primary focus of these templates was the use of chemicals at all stages of almond production – herbicides, fungicides and insecticides.

The HACCP templates developed in 1999 developed a process flow diagram and HACCP plan that delivered both Critical Quality Control Points (CQP) and Critical (Food Safety) Control Points(CCP). In the past decade Food Safety Systems have developed to focus on those CCP's that cannot be controlled further down the production process. Today the CQP's such as almond sizes, shrivelling, poor kernel characteristics, harvest damage and varietal mixing are sorted out in the processing line and are not considered points of attention in food safety systems today.

5.2 Outline HACCP Process

HACCP has become synonymous with food safety. It is recognised world wide as a systematic preventative system that addresses biological, chemical and physical hazards through quantifying the risks and implementing control for those hazards.

There are seven principles in its application. These require a business to:

- conduct a hazard analysis
- determine Critical Control Points(CCP's),
- establish specifications for critical limit(s),
- establish a system to monitor control of the CCP's,
- establish corrective action,
- establish verification procedures and
- establish record keeping procedures.

The focus in almonds has been on hazards of chemical contamination and foreign materials (especially glass and metal), but with extensive data now available over a 10 year period, systems can be altered to reflect and validate changes proposed in this paper to food safety systems. Using the HACCP methodology this report proposes several documents as fact sheets, forms, discussion papers and a research report to be undertaken to improve current HACCP plans used by growers adding traceability and control of agreed hazards and to undertake research where risks are not properly quantified.

5.3 Changes and Support materials to HACCP Plan

The application of the HACCP principles consists of the following tasks as identified in the logic sequence for the application of HACCP. Changes to the HAACP approach adopted or proposed since the last HACCP template published in 1998 are listed.

1. **Assemble the HACCP team**

- Encourage full adoption of HACCP using a second party audit system by all growers

2. **Describe the Product**

- Develop a Harvest Specification for almonds stored on farm
- Adjusted kernel moisture limits with weight deduction back to 5%
- Rejection of almonds at the huller and sheller that are badly out of specification

3. **Identify intended Use**

- Aflatoxin and Salmonella allowable limits introduced at receival

4. **Construct a Flow Diagram**

- Stockpiles are an important step in the process as storage time increases
- Change in charges for hulling based on received weight or plant processing time rather than output weight.

5. **On-site confirmation of flow diagram**

- No change

6a. **List all Potential Hazards**

- Stones identified as a new hazard
- Aflatoxin and Salmonella spp are potential new hazards
- Fertiliser rates are a potential environmental hazard
- Increasing insect contamination may be a source of aflatoxin infection.

6b. **Conduct a Hazard Analysis**

- Research work undertaken to develop an objective view of the hazard and possible control measures for aflatoxin and Salmonella spp.

6c. **Consider Control Measures**

- A Fact Sheet on Stockpile Management is required

7. **Determine CCP's**

- Stones become a new CCP for almonds

8. **Establish critical limits for each CCP**

- Guidelines for Pest and Disease control published
- New chemical permits available on ABA website
- New critical limits established for stones

9. **Establish a monitoring system for each CCP**

- Develop a network of moisture testing machines calibrated the same for use by the industry

10. **Establish corrective actions**

- Rejection of out of specification loads at the huller

11. **Establish verification procedures**

- Individual sampling by processors tested for pesticides and microbiological pathogens and toxins
- Participate in the National Residue Survey
- Results communicated to growers for their samples
- Voluntary Aflatoxin Sampling Program (VASP) commenced

12. **Establish documentation and record keeping**

- Spray Diary published by industry
- Disease and Pest Guide for almonds
- Access to chemical registrations and permits
- Delivery book for growers published by industry.

6 RECOMMENDATIONS

Given that almonds are a low risk product and the industry can clearly demonstrate a long term validation of its low level of chemical residues from on-farm operations, it is logical that some change may be justified in the way food safety is conducted on farm compared to a decade ago.

6.1 Key Risks (CCP's)

6.1.1 Chemicals

Significant steps have been made to control chemical hazards in the production of almonds with an effective process of hazard identification, monitoring and verification. Growers are maintaining effective spraying records supported by the ABA to improve the chemical range available. Chemical permits for new chemicals are an active program supporting controls of emerging and current disease threats.

A monitoring scheme run by the NRS and previously by almond processors has verified that there have been no residue detections over any Australian or international MRL in the past 5 years (limit of questioning). This has effectively validated that chemical use programs implemented on farm do not present a risk to the customer. Growers need to continue to be vigilant and professional to maintain this record as while no residue detections have occurred it cannot be assumed that no off-label use has occurred.

Low level residues have occurred at below 20% of the MRL for pesticides used to treat stored almonds. While these levels do not present any food safety concerns, they indicate the need of close monitoring and control of the chemicals used. This chemical used in stored almonds at processing plants is outside the scope of the project as it is part of the processor's HACCP plans.

Due to the low chemical footprint and the stream of data produced for individual properties the need to provide verification of chemical use with an inventory is not considered necessary. While chemical use can be considered to be under good control, it remains a CCP and needs to be maintained. The current "*Pest and Disease Control Guide 2009/10*"[12] and *"Strategic Agrichemical Review Process 2008"*[13] are important support programs in reaching an effective HACCP industry wide.

6.1.2 Glass

Glass is an ongoing hazard on some orchards and while the industry has a nil tolerance for glass, it does occur from time to time. No change to the presence of glass is suggested but continued education programs are warranted throughout all sections of the industry. Strong traceability to determine likely sources of glass contamination and separation of this product for processing are important in future control of this hazard.

6.1.3 Metals

Hullers and shellers report significant quantities of ferrous metals are retrieved in processing plants. The almond processors do not report metal contamination as

[12] Delaporte K, Kane S., McMichael P. " Almond Industry Pest and Disease Control Guide 2009/10" Almond Board of Australia Berri SA 2009.

[13] Del Santo "Strategic Agrichemical Review Process 2008", Horticulture Australia Limited and Almond Board of Australia 2008.

a complaint from customers. Improved metal detection on packing lines in recent years has further improved this. Orchard hygiene with shotgun shells, old sprinklers and rubbish removal is normal practice.

6.1.4 Lead

Shotgun lead shot is not an issue in almond production when growers adhere to practices that do not result in shot embedding in the almond kernel.

6.2 New Hazards

6.2.1 Small Stones

Small stones the size of almond kernel are an issue and customer complaints have occurred. These stones are attempted to be removed in the processing of almonds through hulling, shelling and sorting. Improved reporting down the supply chain to make growers aware of the level of hazard in their orchard is an important communication to reduce this hazard. A program of education, compliance and penalty will assist in diminishing this hazard on properties where stone is an issue. In addition penalties for breaching product specifications adds incentive to improve.

6.2.2 Insects

In some seasons insect damage can be prevalent. The damage appears to be from infection occurring in the orchard rather than developing problems in stockpiled almonds. While the damage itself has a quality impact, the potential for pathogen growth is present and hence better monitoring of insect damage at harvest is important.

6.2.3 A Watching Brief

Biological contaminants are an important concern world wide in almonds; however, in reviewing the likelihood and severity of these hazards, it does not rate promotion to a critical control point. The industry would be well advised to be proactive in testing for biological contamination (*salmonella spp.* and aflatoxin) while providing guidelines in avoiding problems from these contaminants.

A change in the HACCP plans is proposed where a specification for on farm storage of almonds be developed to reduce occurrence of these two biological hazards. Before this can occur, work is required to determine the likely sources of inoculums, predisposing conditions for contamination and control mechanisms of the moulds and bacteria that cause aflatoxin and salmonella respectively.

6.3 The role of Education, Compliance and Reward/Cost

The implementation of the recommendations of this report requires careful consideration and must combine education, compliance requirements and penalty/rewards that are applied to the finished product. Education has served the industry well and is a positive approach to change. However, if all parts of the industry are not compliant with the Food Safety Code, the cost to a grower or the industry could be very high. Applications of penalties and rewards for material outside specification or rewards where through-put may be improved are also an important balance if the correct quality messages are to be sent to the growers.

6.4 Excellent Record

Chemical residues have been the primary issue of concern that cannot be controlled further down the chain of production. Systems such as spray diaries, a Pest and Disease guide, Permits Support Program, regular audits and residue testing program have all been implemented in the last 10 years and can now be used to demonstrate a good level of control over some 36 000 tonnes of almonds from approximately 150 different properties.

6.5 2nd Party Audits

Modifications in the application of HACCP need to maintain the monitoring framework but it is recommended that the need for third party auditing be removed. Some form of audit from a second party is necessary as progress to self-audit is risky and may result in just a few growers not paying proper attention to the risks of chemical contamination and the reputation of Australian almonds is bought into question.

6.6 Small Lots

Some growers who do not run QA systems place others at risk in any pooled marketing arrangements. Such growers could be residue tested as a mandatory practice. Alternatively any processing of such batches is done with other batches of similar unreliable food safety history.

6.7 Training

Consistent training of growers in food safety should continue with courses and on farm inspections to ensure consistent grower understanding of QA issues and standards.

In addition a set of materials that support QA adoption should be available. This includes a basic HACCP plan, some guidelines and specifications for the storage and delivery of almonds and the documentation mentioned below. This is most efficiently done on the web.

6.8 Documentation

A standard set of basic QA records should be developed for use by growers that provide a single point of reference. These records should include a;

- spray diary – duplicate,
- Disease and Pest Guide to list registered and permitted chemicals supported by an up-to-date database,
- delivery book – triplicate,
- harvested almond guideline,
- moisture testing guidelines
- guideline for storage of almonds[14] and
- checklist to ensure consistent auditing.

Other records include a;

- customer specification for delivery to the sheller and processor and
- property map.

6.9 Clearer cost-quality messages

As almonds are hulled cracked, graded, sorted and packed the quality issues should be directly fed directly back to the grower of those almonds and any cost differentials for these operations. Where growers meet the delivery specification or exceed it, there may be a cheaper rate or alternatively penalties for product that slows processing time. For example, if difficulty is encountered in hulling due to moisture or contaminants, the slow down of the plant should be charged directly to the grower. Currently the same cost per kilogram is incurred for all growers, regardless of initial product quality.

Growers should receive a detailed quality report on each batch supplied so that quality issues are understood. There is little point in providing general statements on quality issues if it is not supported by individual information. Consequently, more growers may actually deliver high quality product and not be confused by the general messages sent by hullers, shellers and processors about their overall quality issues.

6.10 Continued Support

One of the unique features of food safety in the almond industry is the level of cooperation and the manner in which each part of the value chain has dealt with its roles and responsibilities.

Continued support for the Pest and Disease diaries, permits and registrations, the National Residue Survey (NRS) and VASP form important keys to this approach.

6.11 Research

Other research required includes projects on;

- Salmonella and
- Aflatoxin

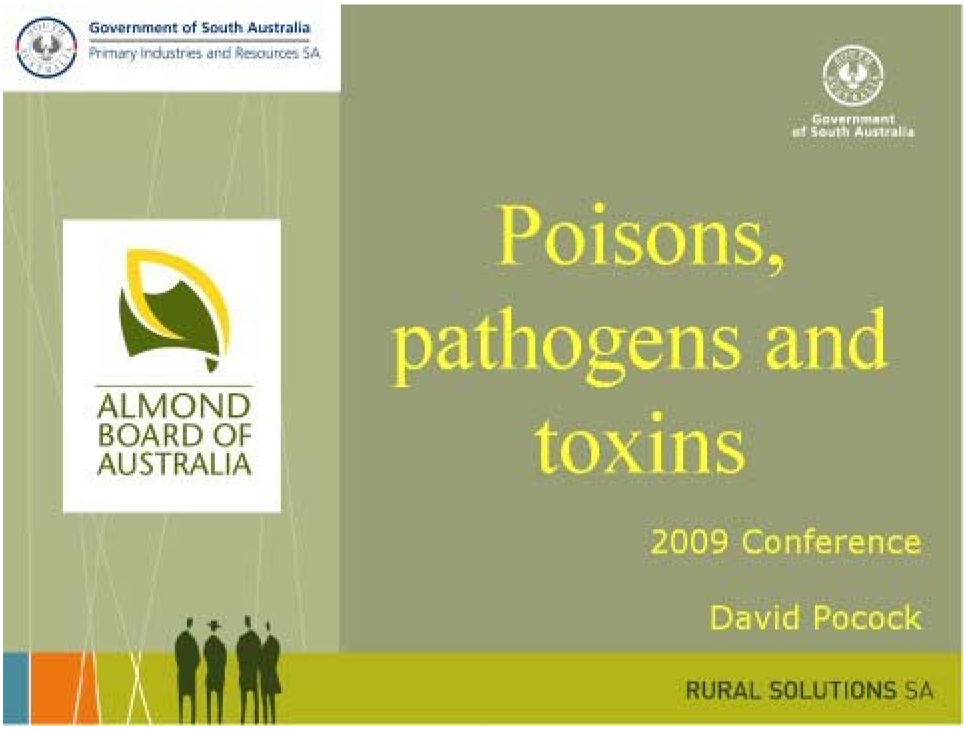
The research should include a literature review and an on-farm project to determine specific sources of contamination. Processing facilities cannot pinpoint the contamination sources as heavy cross contamination of samples has occurred by the time they test samples.

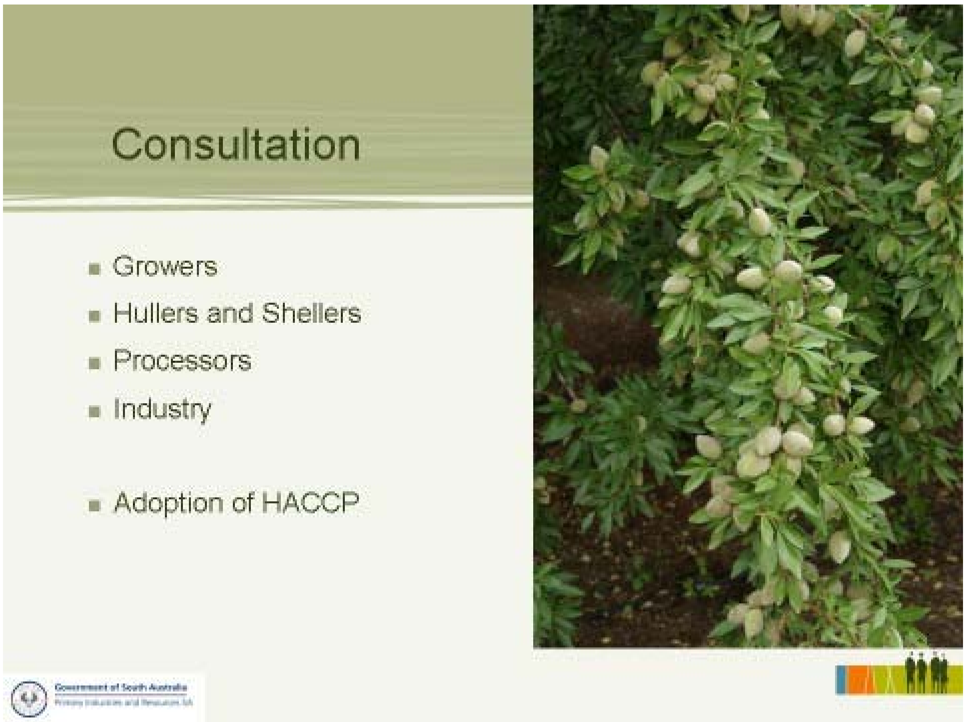
The outcome required is to enable growers to more effectively manage potential contamination sources.

[14]Almond Facts Blue Diamond “Managing Stockpiles to Reduce Aflatoxin Potential” Growers newsletter July- August 2009-09-09

As a result of early consultation in the project, a presentation to the 2009 Australian Almond Conference (Appendix 1) and a discussion paper (Appendix2) were completed.

APPENDIX 1 AUSTRALIAN ALMOND GROWER'S CONFERENCE PRESENTATION





Consultation

- Adoption of HACCP
- Major Hazards
  - Pesticides

Government of South Australia
Primary Industries and Resources SA

Consultation

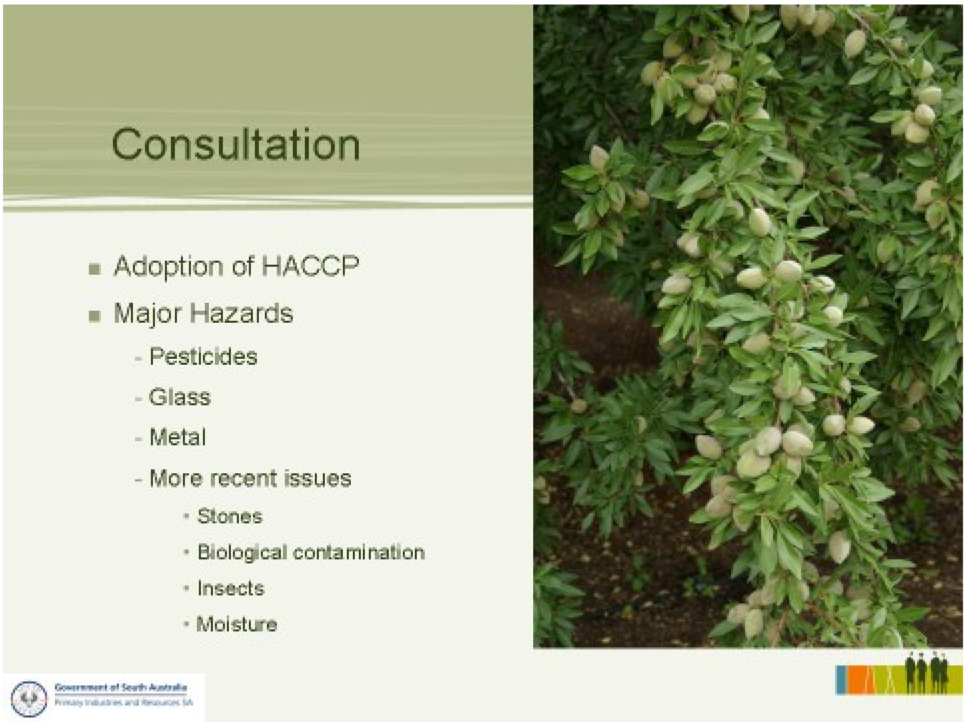
- Adoption of HACCP
- Major Hazards
  - Pesticides
  - Glass

Government of South Australia
Primary Industries and Resources SA


Consultation
Adoption of HACCP
Major Hazards
- Pesticides
- Glass
- Metal


Consultation
Adoption of HACCP
Major Hazards
- Pesticides
- Glass
- Metal
- More recent issues
• Stones


Consultation
Adoption of HACCP
Major Hazards
- Pesticides
- Glass
- Metal
- More recent issues
• Stones
• Biological contamination
• Insects
• Moisture
Government of South Australia
Primary Industries and Resources SA


Consultation
Adoption of HACCP
Major Hazards
- Pesticides
- Glass
- Metal
- More recent issues
• Stones
• Biological contamination
• Insects
• Moisture
Government of South Australia
Primary Industries and Resources SA

HACCP

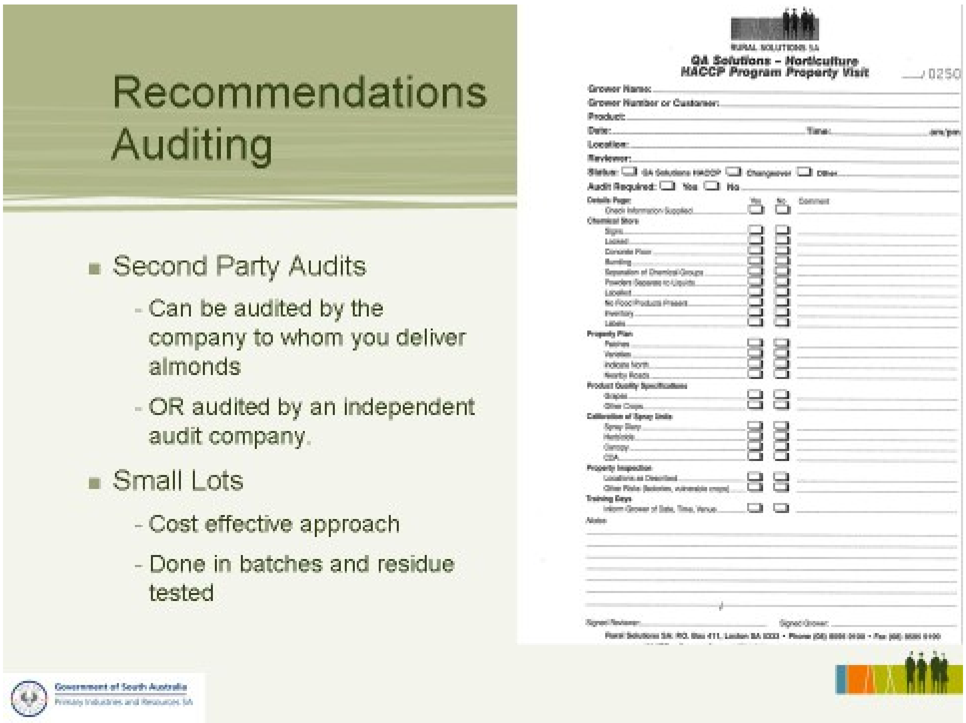
- Wide adoption
- Second and Third Party audited systems
- HACCP Templates
- Industry Roles and Responsibilities
  - NRS program
  - (VASP) Aflatoxin monitoring
  - Disease and Pest Guide
  - (SARP) Registrations and Permits
- The vital role of validation and verification

Government of South Australia
Primary Industries and Resources SA

Recommendations
The record

- Excellent Record of control
  - The last 5 years
  - The NRS survey
  - Watch the permits and new chemicals

Government of South Australia
Primary Industries and Resources SA


Recommendations
Auditing
Second Party Audits
- Can be audited by the company to whom you deliver almonds
- OR audited by an independent audit company.
Small Lots
- Cost effective approach
- Done in batches and residue tested
RURAL SOLUTIONS SA
QA Solutions – Horticulture
HACCP Program Property Visit
Government of South Australia
Primary Industries and Resources SA


Recommendations
Training and recording
Consistent Training
-On farm inspection
-Standard set of materials
Government of South Australia
Primary Industries and Resources SA

Recommendations
Training and recording

- Documentation
  - HACCP Plan
  - Spray diary (duplicate)
  - Delivery Book (x3)
  - Pest and disease guide
  - Almond harvest guideline
  - Storage of almonds
  - Checklist for consistent auditing

Government of South Australia
Primary Industries and Resources SA

Recommendations
Rewards/penalties

- Quality rewards/penalties
- Hullers and Shellers
  - Delivery charges
  - Reward rates/penalty rate
    - For moisture,
    - For foreign material(sand, sticks)
    - For glass, metal, stones
- Reporting back to growers-traceability

Government of South Australia
Primary Industries and Resources SA

Recommendations Rewards/penalties

- Quality rewards/penalties
- Processors
  - Reward rates/penalty rate
  - For moisture,
  - For glass, metal, stones
  - For almond sizing/end use
- Reporting back to growers-traceability

Government of South Australia
Primary Industries and Resources SA

Recommendations Research

- New Research into the biological hazards
  - Driven by customer specifications
  - And limited on-farm knowledge of risk

Government of South Australia
Primary Industries and Resources SA

APPENDIX 2 INDUSTRY DISCUSSION PAPER

The discussion paper for the Production Committee, Hullers and Shellers and Processors has been complied with the following notes.

ALMOND INDUSTRY QUALITY ASSURANCE REVIEW DISCUSSION PAPER

6.12 Harvest Guidelines

A specification exists for growers delivering to hullers and shellers. The proposal is to provide an additional guideline for the harvesting of almonds before storage in stockpiles. The primary issue is to ensure that moisture requirements are met and in conjunction with other recommendations in this report, to provide a positive force for improved quality at the farm gate.

Growers are able to determine high moisture content subjectively in almonds but may still continue to harvest moist almonds in order to complete harvest. Hullers and shellers have attempted to educate growers on the importance of moisture levels, but there are still deliveries of very high moisture content, especially when harvested late in the season. The high moisture content causes significant slow downs in processing flows.

At this stage not all growers have access to moisture testing equipment and hence the term guideline, rather than a specification.

6.13 Moisture Testing

In order to meet the Harvest Guideline for almonds, growers need to have better access to testing equipment. Of course, growers can easily determine high moisture almonds using subjective means and crunching almonds between the teeth indicates levels above say 10%. With the pressure to complete harvest an objective means of assessment using moisture testing equipment will make the out-turn more reliable.

A network of machines could be made available at a per test cost using machines currently owned by growers and other machines where reasonable access is not possible. The use of testing equipment removes the need to guess the commencement of harvest or recommencement of harvest following unfavourable weather events such as rainfall.

6.14 Bunker Storage of Almonds

A fact sheet for the storage of almonds to better enable storage would benefit industry. Issues covered in the fact sheet should include;

- locating the pad,
- materials used for the base,
- construction of bunker walls,
- covering the stockpile and moisture management and
- pest control in and around the stockpile.

6.15 Contaminants

Metal and glass already have significant controls and no change is proposed to the way in which control is currently implemented.

Newer hazards including stones and biological contamination need further discussion.

Stones are usually a feature of specific orchards or patches. The direct feedback to growers of quality issues caused by stones is a vital part of the HACCP process, although this contamination is not present on many orchards.

Biological contamination is an emerging risk. The project has proposed more work to be conducted in the infection, presence and predisposing factors of alflatoxin and *Salmonella spp*. on-farm. Markets have set limits and testing has occurred at the processor outlet, but at this point locating the source of infection using traceability systems is impractical and scientifically flawed with end point testing. Clearly the testing for contamination must occur further up the production chain closer to potential contamination sources.

6.16 Documentation

A recommendation of the report is to produce a consistent type of grower delivery book. The books, initially produced at cost by the Almond Board of Australia, would be a triplicate book listing all necessary details.

A Spray Diary and List of Chemical Registrations and Minor Use Permits would also be available.

The industry produced a HACCP plan available for industry in 1997. This plan needs review to enable the progress made in the last ten years to be incorporated.

Acceptance of second party audits is recommended in the report due to the level of control of hazards that can be demonstrated and the level of cooperation achieved by various sections of the production quality chain.

6.17 Options to Improve Receival Quality

To improve the quality of receival almonds and therefore throughput at hullers and shellers, three proposals are put forward;

6.17.1 Adjustment in weights post hulling and shelling to 4.5% kernel moisture

The aim of this recommendation is to remove any incentive to deliver high moisture almonds. Balancing kernel moisture to 4.5% is an ideal processing percentage and will remove the temptation to maximise moisture content whilst not disadvantaging growers who deliver low moisture kernels. Low moisture almonds are also not desired as these kernels are more likely to scratch.

6.17.2 Charges based on receival quantity

Charges for hulling and shelling of almonds have been based on the out-turn quantity. As a result, there is little incentive for growers to improve the delivery quality of almonds, as their imperative is to complete harvest as quickly as possible. High levels of sand (from higher speed harvesting and sandy blocks), sticks (older or younger orchards), and rocks (from shallow soils) can result in waste levels well above the current, average foreign material amount being delivered to the plant of 6%.

We have the advantage today that hullers and shellers all have weighbridges to measure the intake. This was not available 10 years ago. Therefore, if a 30% crack-out percentage is assumed (usually a little lower) and the cost of cracking is $0.30/kg then a change in the charging rate to $0.10/kg on delivered weight should deliver approximately the same operating cost to hullers and shellers. At this rate, cost of hulling and shelling will also not increase for growers. Growers would respond quickly to the change in the charging system, as they will not want to deliver and pay for the delivery of sand, rocks and sticks. The impact of this approach should reduce the foreign material deliveries and result in production efficiencies for hullers and shellers.

6.17.3 Non acceptance of badly out of specification material

Some growers may still deliver small quantities of badly out of specification material in the hope of retrieving some value. This material should be rejected in the main part of the season as growers are well aware of the nature of the material. It effectively becomes material for rework with high waste, slow through-put and significant potential for high levels of contaminants. Of course, the new delivery charge recommended above may even result in non-delivery of such material.

For example a tonne of mixed almonds that also has a moisture content of say 10% will cost $100 to process plus ($56.70 - 12c/kg) dehydration. The crack out could be 15% (150kg) less 5.5% for moisture 141.75 kg or $453.60 ($3.20/kg) less $156.70 costs or $296.90 return. Freight for a single truck could also cost an additional $200. The cost to pick up this material is not calculated for this example. The same material delivered at average quality would be a total weight of 500kg costing $45.00 to crack (at $0.30/kg) delivering $525.00 ($3.50/kg) less $45 costs, a more viable proposition.

7 REFERENCES

[1] Frankish E. (2007) “Guidelines for Food Safety Management in the Australian Almond Industry” Almond Board of Australia First Edition.

[2] AgAware Consulting (2008) “ Strategic Agrichemical Review Process 2008” Horticulture Australia Limited and Almond Board of Australia.

[3] AKC Consulting Pty Ltd, “Australian almond export product MRL compliance review”

[4] Almond Program Chemical Residue Monitoring Results July 2008 to June 2009. Australian Government DAFF (2009)

[5] USDA Food Safety and Inspection Service Fact Sheet, Safe Food Handling Molds On Food: Are They Dangerous? Molds On Food: Are They Dangerous?

[6] Almond Board of California (2005) “International Aflatoxin Tolerances”

[7] Schade J.E, McGreevy K., King A.D.,Mackey B. ((1975) “Incidence of Aflatoxin in California Almonds” Applied Microbiology January;29(1) pp 48-53.

[8] Kader A.E. (1992) “Postharvest Technology of Horticultrural Crops 2nd Edition University of California Oakland pp257.

[9] VASP Voluntary Aflatoxin Sampling Plan (2007)

[10] Schatzki, TF, Ong, MS’Dependence of aflatoxin in almonds on the type and species of insect damage”, Journal for Agricultural and Food Chemistry, Sept 2001 V49 (issue 9) pp 4513-9.

[11] http://www.fda.gov/Food/FoodSafety/FoodborneIllness/FoodborneIllnessFoodbornePathogensNaturalToxins/BadBugBook/ucm069966.htm

[12] Delaporte K, Kane S., McMichael P. “ Almond Industry Pest and Disease Control Guide 2009/10” Almond Board of Australia Berri SA 2009.

[13] Del Santo “Strategic Agrichemical Review Process 2008”, Horticulture Australia Limited and Almond Board of Australia 2008.

[14] Almond Facts Blue Diamond “Managing Stockpiles to Reduce Aflatoxin Potential” Growers newsletter July- August 2009-09-09

Spray Diary Checklist

Have you;

- ❑ Filled out at least one calibration form for each type of spray unit.
- ❑ Filled in all the relevant boxes on all calibration and spray diary forms.
- ❑ Checked all calibration calculations and verified them in field.
- ❑ Recorded the full trade name, as shown on the label, of the product used and not just the common name ie. Kocide Blue Xtra not copper. Include any letters or numbers associated with the name.
- ❑ Recorded all agrochemicals used including all fungicides, herbicides, insecticides, dyes, nematicides, nutrient sprays, setting sprays, wetting agents and baits.
- ❑ Recorded the units of measurement eg. grams as g, kilograms as kg., litres as L.
- ❑ Recorded your property name on all sheets.
- ❑ Have you checked your scales for accuracy this year using a calibrated measuring jug. This is recorded on the canopy calibration sheet.
- ❑ Have a property map that accurately defines the patches you have shown in your diary.
- ❑ Recorded formal training completed in the last year for chemical use and pest (rodents, bird) control.
- ❑ Recorded production delivered in the Delivery Advice book including the date harvest commenced
- ❑ Received a copy of product specifications from both your huller and processor of almonds.
- ❑ Received a copy of any residue tests done on your product.

Speed Calibration Chart

Select the number of seconds to travel 100metres and the box below indicates the speed.

Secs.	km/hr
42	8.6
44	8.2
46	7.8
48	7.5
50	7.2
52	6.9
54	6.7
56	6.4
58	6.2
60	6.0
62	5.8
64	5.6
66	5.5
68	5.3
70	5.1
72	5.0
74	4.9
76	4.7

ALMOND BOARD OF AUSTRALIA

Almond Board of Australia. 9 William Street, Berri SA 5343
Ph: +61 8 8582 2055 Fax: +61 8 8582 3503

www.australianalmonds.com.au
admin@australianalmonds.com.au

AUSTRALIAN ALMONDS
www.australianalmonds.com.au

Australian Almond

Spray Policy &

Spray Diary

Season: ______________________

Orchard Name: ______________________

Manager: ______________________

Contact Number: ______________________

Chemical Usage

General Safety Precautions

Chemical application procedures must only be carried out if you have current accreditation

- Read the label directions and check if the chemical is approved for the intended purpose.
- Check the withholding period as shown on the label or permit.
- Determine the registered chemical rate for the crop from the chemical label or permit.
- Check the Spray Calibration Sheet to confirm if equipment has been calibrated as specified.
- Calibrate the equipment if required (at least annually) and enter the details into the Spray Calibration Sheet.
- Mix the chemical at the appropriate rate and in accordance with label directions.
- Apply the chemical according to label instructions.
- Fill out the Spray Diary. (See example within book). You should keep a copy of the Spray Diary for at least one year after the completion of harvest of the crop.
- Use trade names for all chemical entries. All products eg fungicides, insecticides, herbicides, baits and nutrients should be included in this spray diary.

Calibration of Herbicide Sprayers (Area Calibration)

ALMOND BOARD OF AUSTRALIA

The step-by-step procedure for calibrating a herbicide sprayer is as follows:

STEP 1 - Nozzle Check

- Clean filters and nozzle strainers.
- Partly fill the sprayer with water and while running the sprayer at normal operating pressure, measure the output of each nozzle over a given time usually one minute. It may be necessary to fit a tube or hose over each nozzle to enable the proper collection of liquid.
- Discard any nozzle varying from the manufacturer's recommended output (at a similar operating pressure) by ± 10 per cent. The lower the volume used per hectare the less the tolerance between nozzles should be if pressure is accurate.
- Determine the total output from all nozzles in litres per minute (L/min)

STEP 2 - Spraying Speed (km/hr)

Place two permanent marker pegs 100 metres apart on a soil surface similar to that of the property and record the time in seconds to travel the distance (It is normal to travel the distance at least twice and average the results). Ensure that you have reached the normal spraying speed and that the sprayer is operating at the chosen pressure before passing the first marker.

- Use the following formula to calculate the speed:

Spraying Speed (km/hr)
= 3.6 x distance travelled in metres (m) ÷ time taken to travel that distance (sec)

OR

Refer to the table on the inside front cover.

STEP 3 - Determining Spray Output

Calculate spraying width in metres. This is the same as the row width (in metres) when spraying between rows for total herbicide control. When under tree spraying with side jets this is the distance from the middle of the tree line to the inner limit of the sprayed strip. When spraying on both sides of the sprayer, both of the sprayed widths should be added together.

Calculate the sprayer output (in L/ha) by using the formula:

Sprayer output (L/ha)
= total output (L/min) x 600 ÷ spraying width (m) ÷ speed (km/h)

STEP 4 - Amount of product per tank

Use the following formula to determine the amount of product (in litres or kilograms) to add to the spray tank. Remember, read the label carefully before handling chemicals and take the safety precautions recommended.

Amount of herbicide / tank
= recommended rate/ha x tank capacity (L) ÷ output of sprayer (L/ha)

For spot spraying only

Amount of product / tank
= recommended rate/100 L x tank capacity (L) ÷ 100

Calibration of Canopy Sprayers (Distance Calibration)

Directions for use and rates of sprays on the chemical label have changed. The changes are:

- There will be no indication on the label of volumes of water that should be applied to various sized canopies.
- No rate of product recommended per hectare will be provided.
- The directions are based on the volume of dilute spray required to wet the canopy to point of run-off.

The AVPMA has made these labelling changes, as it is consistent with the way that products are tested prior to registration. It is thus not considered appropriate to specify a single rate per hectare. The single rate fails to take into account differences in canopy size and crop growth stages. Instead volumes of water and rates of chemical should be matched to the amount of foliage to be covered to minimise the risk of under or overdosing. In addition the AVPMA has introduced regulations to control spray drift to be included on the label.

Calibration for Dilute and Concentrate Sprayers

Prior to spraying the sprayer must be set up so that coverage is even and maximised. Throughout the growing season this set up will have to be altered to allow for the growth of the plant and increased canopy volume.

The variables that must be considered and adjusted are: -

- tractor speed,
- nozzle size arrangement and direction,
- volume of water,
- pump pressure,
- volume of air, its speed and direction.

For Dilute Spraying

Dilute spraying refers to the application of the spray mixture to thoroughly wet the target.

- Use a sprayer designed to apply large volumes of water up to the point of run-off and matched to the crop being sprayed.
- Set up and operate the sprayer to achieve even coverage throughout the crop canopy. Apply sufficient water to cover the crop to the point of run-off avoiding excessive run-off. See the Nozzle check **(Step 1)** and Spraying Speed **(Step 2)** procedures below
- The required water volume may be determined by applying different test volumes using different settings on the sprayer **(Step 3)**, or alternatively from industry guidelines or from expert advice.

STEP 1 - Nozzle Check

- Clean filters and nozzle strainers.
- Partly fill the sprayer with water and while running the sprayer at normal operating pressure, measure the output of each nozzle over a given time usually one minute. It may be necessary to fit a tube or hose over each nozzle to enable the proper collection of liquid.
- Discard any nozzle varying from the manufacturer's recommended output (at a similar operating pressure) by ± 10 per cent. The lower the volume used per hectare the less the tolerance between nozzles should be if pressure is accurate.
- Determine the total output from all nozzles in litres per minute (L/min)
- Add the amount of product specified in the Directions for Use table on the label for each 100 L of water and spray to the point of run-off **(Step 4)**.

Calibration of Canopy Sprayers (Distance Calibration cont.)

ALMOND BOARD OF AUSTRALIA

STEP 2 - Spraying Speed (km/hr)

Place two permanent marker pegs 100 metres apart on a soil surface similar to that of the property and record the time in seconds to travel the distance (It is normal to travel the distance at least twice and average the results). Ensure that you have reached the normal spraying speed and that the sprayer's PTO is operating at the chosen RPM before passing the first marker.

- Use the following formula to calculate the speed:

Spraying Speed (km/hr)
= 3.6 x distance travelled in metres (m) ÷ time taken to travel that distance (sec)

OR

Refer to the table on the inside front cover.

STEP 3 - Determining Spray Output for dilute spraying

Test spray with water both sides of the tree row in different sections of the orchard with a range of sprayer setup and observe the results. If wetter is to be used when spraying it should be added to the water. Determine the combination that can be considered to cover all parts of the canopy more or less to the point of run-off. The volume applied and the stage of growth is then recorded so that it may be used in following seasons. This test spraying will need to be repeated several times through the season.

Calculate the volume sprayed per 100 metres or per hectare for a double-sided unit. Rate is halved if only one side is sprayed.

Calculate the sprayer output by using one of the formulas below:

Litres per 100m
Sprayer output (L/100 metres) = total output (L/min.) x 6 ÷ speed (km/h)

OR

Litres per hectare
Sprayer output (L/ha) = total output (L/min.) x 600 ÷ speed (km/h) ÷ row width (m)

STEP 4 - Amount of product per tank for dilute spraying

Use the following formula to determine the amount of product (in litres or kilograms) to add to the spray tank. Remember, read the label carefully before handling chemicals and take adequate safety measures.

Amount of product / tank
=recommended rate/100 L x tank capacity (L) ÷ 100

Distance sprayed per tank (m)
= 100 x tank capacity (L) ÷ output of sprayer (L/100 metres)

- The required dilute spray volume will need to change and the sprayer set-up and operation may also need to change, as the crop grows.

Calibration of CDA Sprayers

The step-by-step procedure for calibrating a CDA herbicide sprayer is as follows:

STEP 1 - Nozzle Check

- Partly fill the sprayer with water and while running the sprayer at normal operating pressure, measure the output of each nozzle over a given time usually five minutes. It may be necessary to fit a wide mouth bucket over each spinner to enable the proper collection of liquid.
- Discard any nozzle varying from the manufacturer's recommended output (at a similar operating pressure) by ± 5 per cent.
- Determine the total output from all nozzles in litres per minute (L/min)

STEP 2 - Spraying Speed (km/hr)

Place two permanent marker pegs 100 metres apart on a soil surface similar to that of the property and record the time in seconds to travel the distance (It is normal to travel the distance at least twice and average the results). Ensure that you have reached the normal spraying speed and that the sprayer is operating at the chosen RPM before passing the first marker.

- Use the following formula to calculate the speed:

Spraying Speed (km/hr)
= 3.6 x distance travelled in metres (m) ÷ time taken to travel that distance (sec)

OR

Refer to the table on the inside front cover.

STEP 3 - Determining Spray Output

Calculate spraying width in metres. This is the same as the sprayer width (in metres) when spraying with a CDA sprayer.

Calculate the sprayer output (in L/ha) by using the formula:

Sprayer output (L/ha)
= total output (L/min) x 10 ÷ spraying width (m) ÷ speed (km/h)

STEP 4 - Amount of product per tank

Use the following formula to determine the amount of product (in litres or kilograms) to add to the spray tank. Remember, read the label carefully before handling chemicals and take the safety precautions recommended.

Amount of herbicide / tank
= recommended rate/ha x tank capacity (L) ÷ output of sprayer (L/ha)

Delta T Explained

ALMOND BOARD OF AUSTRALIA

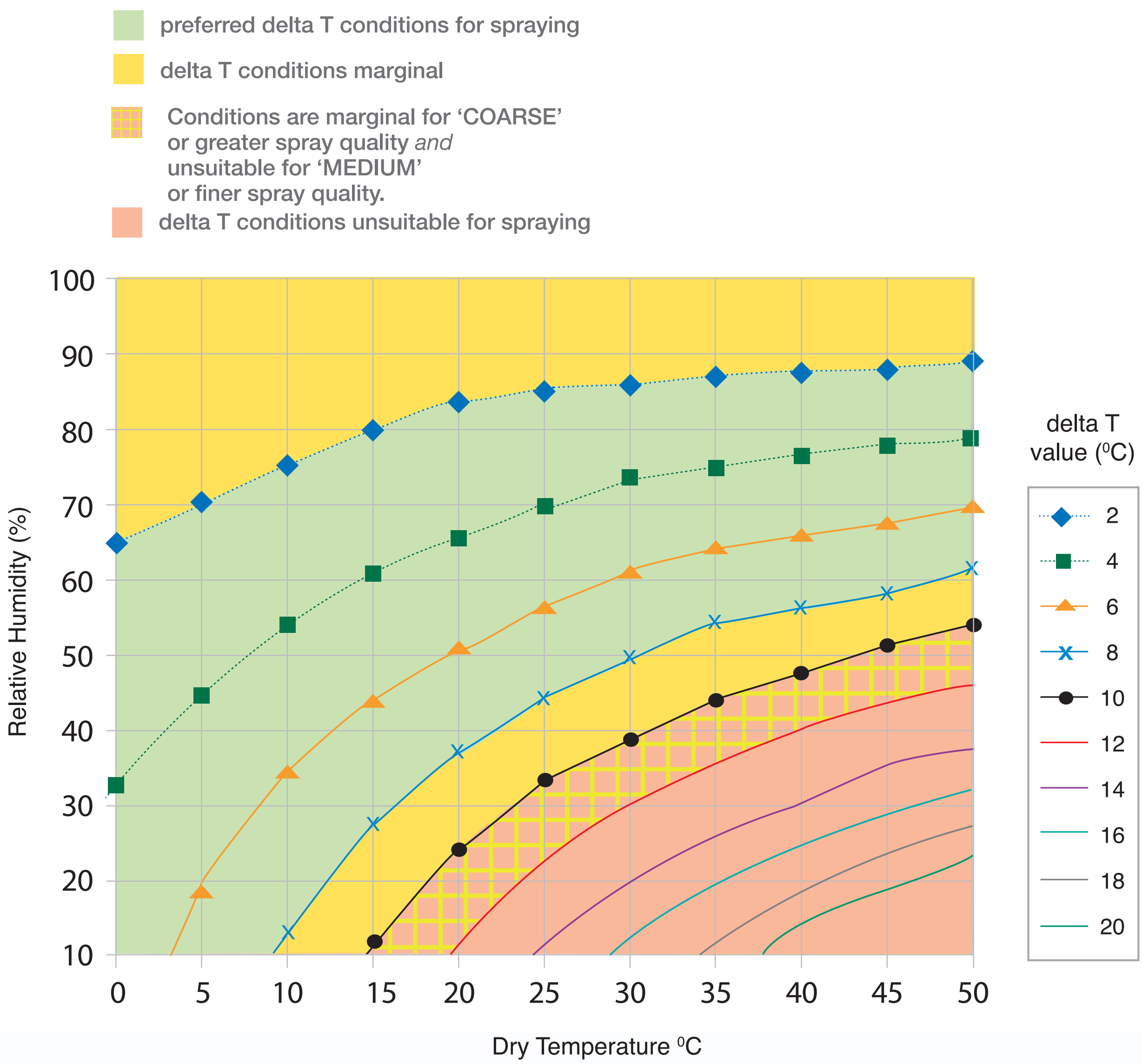
Delta T (ΔT) is becoming one of the standard indicators for acceptable spray conditions. It is the difference between wet and dry bulb temperatures. It is used as a measure of the relationship between temperature and relative humidity.

Effective spray coverage is dependent on spray droplet size and survival and the ΔT score impacts droplet survival. For example, the survival of a 50-micron droplet will be reduced from 5.2 seconds at a ΔT of 6 to 3 seconds at a ΔT of 12. This effectively reduces the distance the droplet will travel before it disappears from 20 cm to 10 cm.

You can use a weather meter to determine temperature and humidity. It is also available on Bureau of Meteorology internet sites. You can use the following chart you can work out your ΔT, which is the point at which your recorded temperature and humidity meet. A ΔT of 8 or greater compromises the amount of product that meets the target and is when you need to make a decision to stop spraying or use a nozzle with a larger droplet size and a higher water rate depending on the weather and target conditions.

ΔT conditions of less than 2 may increase drift potential with fine droplets, due to increased droplet survival.

The recommended droplet size on the label is when the droplet leaves the nozzle. Take into consideration the survival and size of the droplet on its way to the target.



NEVER SPRAY DURING A LOW-LEVEL INVERSION

Delta T Image reproduced with permission (www.nufarm.com.au)

Herbicide Calibration Record

(Calibrate the sprayer prior to the season and at least once a year)

Packer Copy

Herbicide Sprayer Setup

Property Name ______________________

Date ______________________

Spray Unit # ______________________

Tractor ______________________

Gearing ______________________

RPM ______________________

Sprayer Pressure ______________________

Width of Treated Strip (m) (C) ______________________

Declaration I declare that this is a true and accurate calibration record

(Signature)

Date

Chem User #

STEP 1 - Nozzle Check

Nozzle Manufacturer ______________ Nozzle Type ______________

Specified Output ____________ (L/min) @ Pressure ____________ kPa

	1	2	3	4	5	6	7	8	
L									
									R

Measure each nozzle's output in litres for a minute

Add all nozzle outputs
TOTAL OUTPUT (L/min) [ ] (A)

STEP 2 - Sprayer Speed

Measure time in seconds to travel 100 metres

Speed (km/h) = 360 ÷ [ ]

= [ ] (B) **km/h**

<u>OR</u> use chart on folded back cover

STEP 3 - Output for Herbicide sprayers

Output (L/ha) = [ ] x 600 ÷ [ ] ÷ [ ] = [ ] (D) **L/ha**

(A) **Total output (L/min)** (B) **Speed (km/h)** (C) **Treated Strip (m)**

STEP 4 - Product per tank

Product	Chosen label rate /ha	x	Tank Volume (L)	÷	(D) Output (L/ha)	=	Product per tank
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	

Herbicide Calibration Record

(Calibrate the sprayer prior to the season and at least once a year)

Grower Copy

Herbicide Sprayer Setup

Property Name ____________

Date ____________

Spray Unit # ____________

Tractor ____________

Gearing ____________

RPM ____________

Sprayer Pressure ____________

Width of Treated Strip (m) (C) ____________

Declaration I declare that this is a true and accurate calibration record

(Signature)

Date

Chem User #

STEP 1 - Nozzle Check

Nozzle Manufacturer ____________ Nozzle Type ____________

Specified Output ____________ (L/min) @ Pressure ____________ kPa

	1	2	3	4	5	6	7	8	
L									
									R

Measure each nozzle's output in litres for a minute

Add all nozzle outputs
TOTAL OUTPUT (L/min) ____________ (A)

STEP 2 - Sprayer Speed

Measure time in seconds to travel 100 metres

Speed (km/h) = 360 ÷ ____________

= ____________ (B) **km/h**

<u>OR</u> use chart on folded back cover

STEP 3 - Output for Herbicide sprayers

Output (L/ha) = ____________ x 600 ÷ ____________ ÷ ____________ = ____________ (D) **L/ha**

(A) **Total output (L/min)** (B) **Speed (km/h)** (C) **Treated Strip (m)**

STEP 4 - Product per tank

Product	Chosen label rate /ha	x	Tank Volume (L)	÷	(D) Output (L/ha)	=	Product per tank
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	

Canopy Calibration Record

Packer Copy

Canopy Sprayer Setup

Date ____________________

Spray Unit ____________________

Tractor ____________________

Gearing ____________________

RPM ____________________

Sprayer Pressure ____________________

Weight Used ____________________

Check scales using tared measuring jug containing 3 litres of water = 3kg

Scales Correct **Y / N**

Declaration I declare that this is a true and accurate calibration record

(Signature)

Date

Chem User #

STEP 1 - Nozzle Check

Nozzle Manufacturer ____________ Nozzle Type ____________

Specified Output ____________ (L/min) @ Pressure ____________ kPa

LEFT			RIGHT		
1	6	11	1	6	11
2	7	12	2	7	12
3	8	13	3	8	13
4	9	14	4	9	14
5	10	15	5	10	15

Add all nozzle outputs
TOTAL OUTPUT (L/min) ☐ (A)

STEP 2 - Sprayer Speed

Measure time in seconds to travel 100 metres

Speed (km/h) = 360 ÷ ☐

= ☐ **(B) km/h**

OR use chart on folded back cover

STEP 3 - Output for Canopy sprayers

Actual Spraying Volume = ☐ x 6 ÷ ☐ = ☐ x 100 ÷ ☐ = ☐ **L/ha**

(A) **Total output (L/min)** (B) **Speed (km/h)** **Row Width (m)**

STEP 4 - Product per tank

Product	Chosen label rate /100L	x	Tank Volume	÷ 100 =	Product per tank
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	

Canopy Calibration Record

Grower Copy

Canopy Sprayer Setup

Date ____________________

Spray Unit ____________________

Tractor ____________________

Gearing ____________________

RPM ____________________

Sprayer Pressure ____________________

Weight Used ____________________

Check scales using tared measuring jug containing 3 litres of water = 3kg

Scales Correct **Y / N**

Declaration I declare that this is a true and accurate calibration record

(Signature)

Date

Chem User #

STEP 1 - Nozzle Check

Nozzle Manufacturer ____________________ Nozzle Type ____________________

Specified Output ______________ (L/min) @ Pressure ______________ kPa

LEFT			RIGHT		
1	6	11	1	6	11
2	7	12	2	7	12
3	8	13	3	8	13
4	9	14	4	9	14
5	10	15	5	10	15

Add all nozzle outputs
TOTAL OUTPUT (L/min) ☐ (A)

STEP 2 - Sprayer Speed

Measure time in seconds to travel 100 metres

Speed (km/h) = 360 ÷ ☐

= ☐ **(B) km/h**

OR use chart on folded back cover

STEP 3 - Output for Canopy sprayers

Actual Spraying Volume = ☐ x 6 ÷ ☐ = ☐ x 100 ÷ ☐ = ☐ **L/ha**

(A) **Total output (L/min)** (B) **Speed (km/h)** **Row Width (m)**

STEP 4 - Product per tank

Product	Chosen label rate /100L	x	Tank Volume	÷ 100 =	Product per tank
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	
		x		÷ 100 =	

CDA Sprayer Calibration Record

Packer Copy

CDA Sprayer Setup

Property Name ______________________

Date ______________________

Spray Unit # ______________________

Tractor ______________________

Gearing ______________________

RPM/Speed ______________________

Flow Rate (L/min) ______________________

NOTE: If using reading from vehicle speedometer; speed must still be calculated in Step 2

Declaration I declare that this is a true and accurate calibration record

(Signature)

Date

Chem User #

STEP 1 - Sprayer Settings

Total Output per Minute (L/min) [ ] **(A)**

Total Sprayed Width (m) [ ] **(B)**

STEP 2 - Sprayer Speed

Measure time in seconds to travel 100 metres

Speed (km/h) = 360 ÷ [ ]

= [ ] **(C) km/h**

OR use chart on folded back cover

STEP 3 - Output for CDA sprayers

Output (L/ha) = [ ] x 10 ÷ [ ] ÷ [ ] = [ ] **(D) L/ha**

(A) Total output (L/min) **(B) Sprayed Width** **(C) Speed (km/hr)**

STEP 4 - Product per tank

Product	Chosen label rate /ha	x	Tank Volume (L)	÷	(D) Output (L/ha)	=	Product per tank
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	

CDA Sprayer Calibration Record

Grower Copy

CDA Sprayer Setup

Property Name ____________

Date ____________

Spray Unit # ____________

Tractor ____________

Gearing ____________

RPM/Speed ____________

Flow Rate (L/min) ____________

NOTE: If using reading from vehicle speedometer; speed must still be calculated in Step 2

Declaration I declare that this is a true and accurate calibration record

(Signature)

Date

Chem User #

STEP 1 - Sprayer Settings

Total Output per Minute (L/min) [ ] **(A)**

Total Sprayed Width (m) [ ] **(B)**

STEP 2 - Sprayer Speed

Measure time in seconds to travel 100 metres

Speed (km/h) = 360 ÷ [ ]

= [ ] **(C) km/h**

<u>OR</u> use chart on folded back cover

STEP 3 - Output for CDA sprayers

Output (L/ha) = [ ] x 10 ÷ [ ] ÷ [ ] = [ ] **(D) L/ha**

(A) Total output (L/min) **(B) Sprayed Width** **(C) Speed (km/hr)**

STEP 4 - Product per tank

Product	Chosen label rate /ha	x	Tank Volume (L)	÷	(D) Output (L/ha)	=	Product per tank
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	
		x		÷		=	

Spray Application Record

Packer Copy

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
28/8/11	5,7,9,15	Shuck Fall	Prune Rust	Dithane WG	14day	200 g	1800	3·6 kg	Date	27/11	28/11	
			Prune Rust	Tilt 250 EC	1 day	32 ml		0·58Kg	Operator	DP	DP	
Comments				Urea Lo-Bi	0	300g		5·4kg	Start	8·30am	8·00am	
Example: Delayed spraying for 2hrs due to gusty conditions									Finish	6·00pm	4·00pm	
									Wind Sp	3kph	5kph	
									Direction	SW	W	

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Application Record

Grower Copy

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
28/8/11	5,7,9,15	Shuck Fall	Prune Rust	Dithane WG	14day	200 g	1800	3·6 kg	Date	27/11	28/11	
			Prune Rust	Tilt 250 EC	1 day	32 ml		0·58Kg	Operator	DP	DP	
Comments				Urea Lo-Bi	0	300g		5·4kg	Start	8·30am	8·00am	
Example: Delayed spraying for 2hrs due to gusty conditions									Finish	6·00pm	4·00pm	
									Wind Sp	3kph	5kph	
									Direction	SW	W	

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Application Record

Packer Copy

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Application Record

Grower Copy

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions	Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Application Record

Packer Copy

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Application Record

Grower Copy

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Spray Completion Date	Block Ref & area (ha)	Crop Stage (see Pest & Disease Guide)	Weed/pest/disease targeted	Full Registered Product Name used	Withhold Period (See Label)	Chosen Label Rate of Registered Product Used	Litres of spray applied (per/ha)	Amount of Registered Product Used (per ha)	Spraying Conditions			
										Day 1	Day 2	Day 3
									Date			
									Operator			
Comments									Start			
									Finish			
									Wind Sp			
									Direction			

Almond Industry Spray Diary

Prepared by Rural Solutions SA for the Almond Board of Australia

***Author**: POCOCK, David, Horticultural Consultant, Rural Solutions SA*

Contents

Disclaimer

Intentionally Blank

Useful Links

Almond Board of Australia
www.australianalmonds.com.au
P +61 8 8582 2055 F +61 8 8582 3503
E admin@australianalmonds.com.au

APVMA (Permit & Label Information)
www.apvma.gov.au

Bureau of Meteorology
www.bom.gov.au

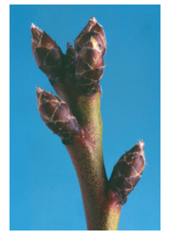
State Chemical Use

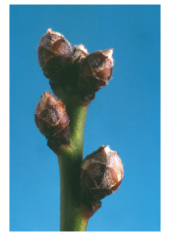
Victoria
www.new.dpi.vic.gov.au/agriculture/farming-management/chemical-use/agricultural-chemical-use

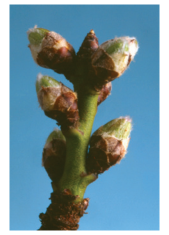
New South Wales
www.environment.nsw.gov.au/pesticides/chemicalmgt.htm

South Australia
www.pir.sa.gov.au/biosecuritysa/ruralchem

Growth Stages

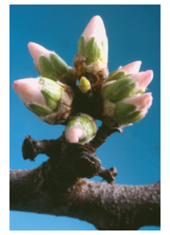

Dormant

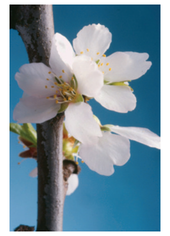

Bud Swell


Green Tip

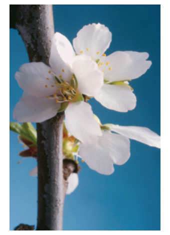
2 weeks — *1 week*


Green Tip


Pink Bud


Full Bloom

2 weeks — *1 week*


Full Bloom


Petal Fall


Shuck Fall

2 weeks — *1 week*


Shuck Fall


Young Nuts


Hull Split

1 week — *20 weeks*


Hull Split


Fully Mature


Leaf Fall

4 weeks — *10 weeks*

*Timings above are approximate and may vary according to season and variety

ALMOND DELIVERY ADVICE

SEASON ______________________

AUSTRALIAN ALMONDS
www.australianalmonds.com.au

Inside Front Cover

Harvest Start

Date	Variety

Moisture Test Percentage

Date	Variety	%

A00001

Almond Delivery Advice

Grower/Trading Name: ....

Variety:

Nonpareil ☐ Price ☐ Carmel ☐

Other ....

Patch OR Bunker: ....

Is this the final delivery of this variety? Yes ☐ No ☐

Truck Clean? Yes ☐ No ☐

Truck Rego: .... **Trailer Rego:** ....

Estimated Load Weight: ....

Grower or Rep. Signature: ....

Date: .... **Time:** ....

DELIVERY TO: ....

Comments: ....

....

....

Office use only:

W/B Dkt: .... Date: ....

This Page Folds over between duplicate copies

To Re-Order Almond Delivery Booklets please visit our website or contact the Almond Board office on the details below.

ALMOND BOARD OF AUSTRALIA

Almond Board of Australia. 9 William Street, Berri SA 5343
Ph: +61 8 8582 2055 Fax: +61 8 8582 3503

www.australianalmonds.com.au
admin@australianalmonds.com.au

ALMOND BOARD OF AUSTRALIA

Almond Board of Australia. 9 William Street, Berri SA 5343
Ph: +61 8 8582 2055 Fax: +61 8 8582 3503

www.australianalmonds.com.au
admin@australianalmonds.com.au