Horticulture Innovation Australia

# Final Report

## Zero residue concept – scoping study for citrus

Peter Taverner
South Australian Research and Development Institute (SARDI)

Project Number: CT14001

**CT14001**

This project has been funded by Horticulture Innovation Australia Limited with co-investment from South Australian Research and Development Institute (SARDI), the citrus levy, and funds from the Australian Government.



ISBN 978 0 7341 3840 8

Published and distributed by:
Horticulture Innovation Australia Limited
Level 8, 1 Chifley Square
Sydney NSW 2000
Tel: (02) 8295 2300
Fax: (02) 8295 2399

# Contents

# Summary

The zero residue concept (ZRC) - scoping study for citrus was commissioned to indicate current chemical use and provide a pathway to reducing chemical residues on Australian citrus. The first opportunity to discuss the concept was at the Strategic Agrichemical Review Meeting in Melbourne in 2013, where it was decided that the concept and strategies were worthy of closer examination. The aim of the program was to provide a situational analysis, define the ZRC goals and gaps in knowledge required to meet reduction in residue goals.

General consumers are apprehensive about agrichemical use in agriculture, due to potential effects on the environment as well as health concerns about chemical residues. Growers wishing to implement ultra-low residue programs for these consumers may be more enthusiastic about implementing programs that can build on existing IPM (integrated pest management) protocols rather than trying to implement whole new programs.

Obtaining low residues at consumption also requires knowledge of the degradation profiles of those chemicals to ultra-low levels.

This study identified a few prerequisites that are consistent with successful ultra-low residue orchard programs. They are:

- Potential loss of markets due to MRL breaches &/or strong consumer demand for low residue produce.
- Accurate and detailed grower 'agrichemical use' diaries
- Universal uptake of residue analysis
- Residue degradation profiles for chemicals in use
- Widespread collation of the data collected from above sources
- Long-term collaboration between growers and researchers.

The above prerequisites require a high level of information gathering and coordination. The best strategy to progress an ultra-low residue program is for researchers to build alliances with companies/groups identified as having a higher chance to meet ultra-low residue targets.

This study identified a significant gap in the degradation profile for agrichemicals in use and the uptake of residue analysis in some sectors. Priorities would be:

1) to determine the degradation profiles for frequently detected/used chemicals identified by this report,

2) encourage an expanded uptake of the National Residue Survey (NRS) citrus program,

3) collation of data from grower spray diaries.

Typical outcomes from any ultra-low residue program have outcomes that include:

- Residue prediction tools
- Improved IPM options/early intervention strategies for difficult pests
- Low residue disease management strategies
- Best practice low residue pest management guides for specific regions and cultivars
- Best practice low drift guidelines for herbicide use
- Regional demonstration orchards achieving low residue and ultra-low residues.
- Fact sheets on degradation curves of commonly used chemicals
- Cost/benefit analysis of maintaining ultra-low residue orchards
- Improved/discounted residue analysis service.
- Market designation system: Branding/marketing strategies for low residue and ultra-low residue citrus.

Importantly, the above programs do not account for chemicals applied after harvest. The need to reduce chemical residues is clear, but postharvest fungicide residues provide the basis for long-term protection during storage and shipping. Reducing postharvest chemical residues should be an integral part of any ultra-low residue program. The residue data collected by the National Residue Survey indicates that most chemicals are well below Codex MRLs. However, the data set is limited to voluntary participants, with a greater uptake, the NRS has the potential to provide comprehensive seasonal and chemical degradation trial data on chemical residues. Further information gathering initiatives, including linking NRS data to spray diaries, will guide targeted research into a low residue citrus program.

This is short summary of the findings from the scoping study.

# Keywords

Abbreviations commonly used in this document

EU – European Union

FAO – Food and Agriculture Organisation of the United Nations

FRW – Fuller's Rose Weevil

GRAS – generally regarded as safe

JMPR – joint FAO/WHO meeting of pesticide residues

IDM – integrated disease management

IPM – integrated pest management

IPHM – integrated postharvest management

MRL – maximum residue limit

NRS – National Residue Survey

TBZ – Thiabendazole

PSO – petroleum spray oils

ULR – ultra-low residue

WHO – World Health Organisation

# Introduction

Citrus is an important horticultural crop for Australia. It generates considerable export tonnage (170,000 tonnes of fresh citrus exported in 2014) to numerous countries (over 40 in total) which generates significant returns for industry (over $200m in 2014). In order to export fruit, the citrus industry needs to produce fruit of excellent quality. This has been achievable partly because of application of agrichemicals throughout the growing and packing process. These agrichemicals cover a broad spectrum of actives, including insecticides, fungicides, growth regulators and herbicides.

However, the role of agrichemicals in controlling pests and diseases is now called into question by several of Australia's export markets. With a worldwide increase in environmental concerns, how farmers grow food and treat the land on which they grow it is increasingly important to everyday consumers. Consumers remain concerned with health risks associated with agrichemicals on fruit. In response, several markets are demanding fruit have fewer agrichemical residues on them. It has reached a point where most importing countries impose strict agrichemical residue limits, and some will not allow fruit that has certain residues of specific chemicals. This has led the citrus industry to re-examine use patterns for agrichemicals without affecting quality of fruit for export.

From an Australian perspective, changing market demands surrounding agrichemical residues present both a challenge and an opportunity. Unless this challenge is met, the citrus industry will face problems exporting its fruit in the future. However, if the goal of ultra-low residue production systems can be achieved, the marketing advantages for the entire citrus supply chain will be significant.

The following international case studies show how markets have influenced commodities in these countries and established well monitored and highly traceable programs for their growers and packers. This has ensured that market opportunities for their exports aren't lost.

*New Zealand (apples and kiwi fruit)*

The kiwifruit industry in the early 1990's was under pressure of being excluded from their major export market, Italy, for having agrichemical residue levels that exceeded local maximum levels (Aitken et al, 2004) and in the case of the apple industry, it faced declining interest from European export markets (from refs in Kaye-Blake 2012). Apple Futures aimed at producing apples for export markets with Maximum Residue Levels (MRLs) at below 10% of the EU MRL, with 3 or less active ingredients allowed per residue test, and the requirements applied for all European market apple varieties (Kaye-Blake and Zuccollo, 2012).

As a result of the KiwiGreen and Apple Futures programs, the kiwifruit and apple industries have not only been able to produce environmentally friendly produce, but have also managed to achieve their goal of retaining target export markets and accessing other markets leading to increased economic benefit.

*Citrus in Spain*

Citrus in Spain has implemented standards based on European Union laws and regulations for fruit production. These have involved sampling regimes to assist with controlling the levels of pesticide residues in order to make them compliant with maximum residue levels (MRLs), as outlined in government directives (EuroMedCitrusNet, 2007). Alongside official compliance directives there has been interest at the consumer level for reducing chemical use for both health and environmental reasons.

*Other International Case studies*

New Zealand and Spain currently run high profile programs geared specifically towards ultra-low residue horticulture programs. Research is still ongoing in this area and is aligned with general IPM and GAP.

Guatemala, Jamaica and Mali have programs in place that are not necessarily known as ultra-low residue programs, but do seek to minimise residues as well as provide pre-inspection documentation for quarantine pests to accommodate their specific exporting markets.

Over the last few decades developing countries have dramatically increased their fruit and vegetable production (Norton et al., 2003). Consequently, the US Agency for International Development (USAID) funded an Integrated Pest Management Collaborative Research Support Program (IPM CRSP) which aimed at helping to provide research and technical assistance to resolve quarantine problems for developing countries like Guatemala (Gebrekidan, 2003)

The IPM CRSP program implemented Integrated Pest Management systems in Guatemala utilise pre-inspection protocols and crop management systems to reduce the presence of leaf miner Liriomyza huidobrensis in export shipments of snow peas into the US (Norton et al., 2003). Programs set up by IPM CRSP also aimed to reduce pesticide use and residues as well as improve overall product quality.

Jamaica too in the late 1990's, were subjected to quarantine procedures for their exports of hot peppers to the US due to gall midge infestation (Norton et al., 2003). However, with renewed interest in attempts to reduce methyl bromide use, the program also began to focus on less costly and environmentally safe pesticide options, thereby reducing overall residues. Due to the Jamaican hot pepper success, Jamaican sweet potato farmers are now being encouraged to also employ programs that will help access new markets (Gebrekidan, 2003)

Mali, a developing African country has also benefited from being able to manage their pesticide usage effectively, ensuring access for their horticultural products such as beans into the difficult European export markets (Norton et al., 2003)

*Reasons to adopt ultra-low residue*

Even though Australia's adoption of IPM strategies and programs has been widespread, implementing ultra-low zero residue strategies in the near future may be necessary in order to fulfil market requirements. Stringent demands from global markets in relation to residue levels have made it tougher for Australian horticultural products to compete. In order to reduce residues, strategies such as the use of agrichemical applications to fruit and vegetables at early growth stages, applying agrichemicals with rapid residue decay curves, or using environmentally friendlier compounds may need more frequent use.

Importantly, apart from the obvious market benefits for lowering residue levels, there are also biological benefits. In addition, there are enormous practical benefits of having an agrichemical product suitable for all export markets rather than the chemical residue profile dictating export market suitability, (Miles, 2014).

Similarly, if growers and packers could be guaranteed financial benefits for adopting low or zero residue growing techniques they would have a greater incentive to adopt new programs.

# Methodology

Situational analysis

Review the current situation in Australian citrus and compare with reduced chemical use strategies for horticultural crops in other countries, especially in citrus. Review the literature for emerging technologies to allow reduced chemical use. Interview chemical manufactures on emerging chemical and other information on existing chemical us. Review databases, such as the FAO (JMPR) Monographs on degradation profiles of existing chemicals. Interview packers/grower services to determine practical limitations and missing information (e.g. historical data on residue testing). This will be an iterative process as new information and approaches are discovered during review.

The majority of the information and collation will be conducted by SARDI staff. Project team members will collate and relay specialist information from regional sources (e.g., MIA and Queensland).

Key activities (chronological order):

- Situational strategy meeting
- Desk-top literature review
    - International zero residue case studies
    - Latest research on chemical-free approaches.
    - Chemical residue and degradation databases
- Interviews with regional grower/packers services to determine timing and chemical use.
- Interviews with chemical company representatives on new chemistries and degradation data.
- Collation and synthesis of data.
- Production of Situational Analysis document Time frame: August-December (5 months)

Define ZRC strategies

A technical experts group will review the situational report and define strategies from orchard to point of sale to achieve zero residues. Different strategies will be required for different cultivars, growing regions and chemical use groups. For example, disease control in Queensland will be much more challenging under a zero residue strategy, and this approach in the orchard may have consequences for postharvest disease control. The team members will collaborate to ensure the strategies within a region are complimentary.

Key activities (chronological order):

- Technical strategy meeting in Mildura
- Development of grower to point of sale strategies.  Probable ZRF strategies include;

- Sub-tropical/coastal citrus growing
- In-land/Mediterranean citrus growing
- Postharvest strategies
- Domestic vs. export focus
- Niche market approaches
- Insecticide vs. fungicide vs. herbicide strategies

- Collation and synthesis of approaches.
- Production of ZRC document

Gap analysis of ZRC strategies

The final stage is identifying gaps in the proposed strategies. For example, a cut-off application date for a chemical may be possible but the chemical degradation data in not known for Queensland: Residue studies are required. Review gaps against R&D investment plans for citrus.

Key activities (chronological order):

- Gap analysis review
- Teleconference of technical group to review gap analysis draft.
- Collation and synthesis of approaches.
- Production of gap analysis
- Production of HAL final report and recommendations.

# Outputs

- Waite meeting
- Technical Meeting, Mildura (17th March 2015)
- Zero residue citrus - concept & progress. Oral presentation (Nancy Cunningham). Citrus Technical 2015 Forum & Field Day. Mildura, Victoria. 16th March 2015.
- Recommendations of R&D to advance zero residue production (Report in appendix)

# Outcomes

- Greater industry awareness of concept through CAL forum presentations and Mildura workshops. The keynote and presentation by Jim Walker and Nancy Cunningham at the Citrus Technical 2015 Forum & Field Day greatly increased interest and awareness in the zero residue concept. Further discussions with Jim Walker, led to a change from zero residue to ultra-low residue targets. His practical experience has advanced the progress of the scoping study.
- Gaps documented
- R&D strategies and coherent plan to implement ultra-low residue production and packing.
- The final scoping study document, 'Zero Residue Concept -Scoping Study for Citrus' is available on request from Citrus Australia.

# Evaluation and Discussion

The situational analysis was completed in December, 2014 and involved a review on the current status of reduced chemical strategies in Australia as well as reviewing the strategies as employed by other countries. Activity output included:

- Holding a situational strategy meeting with the technical group. A number of areas were identified by the group that needs further investigation.
- A desk top literature review identified two main international case studies – New Zealand apples and kiwifruit and Spanish citrus. Other countries that employed general IPM/IDM programs were also included as part of the literature review. These other programs involved reducing chemical usage indirectly, whilst addressing possibly losses in efficacy where pests and diseases of quarantine are concerned.
- Latest research on chemical free approaches indicated that reducing chemical usage can be done with strategies that incorporate integrated pest management (IPM) and integrated disease management (IDM) that are widely available at all stages of citrus growing. Postharvest diseases in particular need careful evaluation as they are responsible for a large proportion of rapid and extensive losses to fresh fruit exports. Investigation into GRAS compounds, such as carbonate salts, microbial antagonists, essential oils, plant extracts, certain peptides and proteins and compounds such as chitosan applied as edible coatings have shown promising results against postharvest disease (Cunningham, 2010).
- Interviews with companies, industry reps (consultants) regional growers/packers were conducted by the team members in Queensland, New South Wales, Victoria and South Australia. The data collected involved surveys on chemical types, use/concentrations and timings of applications. Substantial information was collected over a short period of time.
- Data from the National Residue Survey was collated and chemical use patterns for Australian oranges analysed. The results indicated several chemicals that were heavily relied upon for pest and disease control over the citrus season. Reviewing the residue data collected over the last 4 years showed that chemical type and usage was fairly uniform from year to year with particular chemistries standing out.

*Defining Zero-Residue Strategies, gaps and strategies for future work.*

It became apparent during the process of this scoping study that the term ‘zero-residue’ was no longer a suitable term. However, ‘ultra-low’ residue was considered more appropriate term and something that the citrus industry, to a degree, was already achieving with certain agrichemicals.

The key activities and outputs included:

- The completion of a strategic meeting in Mildura, where industry members and invited participants discussed the progression of strategies. The outcome of the meeting was consensus that spray-diaries and associated residue readings where of vital importance to assist with implementation of ultra-low residue strategies.

- Citrus Australia invited Dr Jim Walker of Plant and Food Research New Zealand to come speak at the Citrus Technical Conference held in march 2015. Although the original proposal did not schedule meetings with overseas researchers involved in low-residue programs, we were able to discuss with Dr Walker the implementation of a citrus ultra-low residue program here in Australia at our Mildura industry meeting.

- Various options for projects were discussed amongst the technical group given the outcome of the situational analysis and collation and synthesis of results from the surveys. A final document (attached) details the results of both the situational analysis and options for moving forward with the concept.

The final part of the scoping study involved:

- Identifying the gaps and research strategies. The final GAP analysis was completed with several options to continue the work put forward in the document. However, due to the limited amount of time given for this scoping study and the time of year that the study was due for completion we were unable to receive feedback from industry on the final document.

- A list of final recommendations for the direction of ultra-low residue programs was also put forward.

*Conclusion*

In recent years, the citrus industry in Australia has been working towards low pesticide residues for certain markets. However, general acceptance of low residue programs has been dependent upon production and yield outcomes. It also depends on the commitment and enthusiasm of growers and citrus packers to remove certain agrichemicals as first preference treatments for control of pests and diseases. The National Residue Survey indicated a number of agrichemicals were still heavily relied upon over the growing season and into the postharvest process.

Zero residues could be attained by the Australian citrus industry. However, achieving the lowest residue (ultra-low residue) is a far more realistic and practical goal for the citrus industry. This takes into consideration the variable seasonal changes to pest and disease pressures without risking markets where quarantine issues are relevant. It may also encourage those unwilling to adopt a complete zero residue program to try alternative ultra-low protocols.

The citrus industry has achieved low level chemical residue levels for some agrichemicals in some sectors. National residue survey data has indicated that many of the chemistries of concern were well below the MRL for sensitive markets, and in many cases, one tenth that of the Codex MRL, which is an encouraging foundation for the citrus industry.

However, there is a broad consensus that low level agrichemical use combined with IPM and IDM is good agricultural practice (GAP) and should be adopted throughout the industry. Ultimately if the citrus industry is looking to improve IPM and IDM adoption, researchers should work with growers and packers who are already using protocols to achieve low residues to produce IPM and IDM programs for the wider citrus industry. This will ensure that all of the industry can achieve ultra-low residue targets.

# Recommendations

The primary aim is to develop ultra-low residue protocols in all citrus growing regions and for all important cultivars. Ultra-low residue (ULR) is defined as one-tenth of the lowest MRL for that cultivar set by an importing country. The secondary aim is to reduce the total number of residue detections per sample to 4 or less chemicals.

Long-term orchard activities will involve developing spray programs using the MRL degradation profiles and a cost/benefit analysis of maintaining ultra-low residue orchards compared to conventional methods. Early intervention strategies for difficult pests will need to be developed and ultra-low postharvest residues are likely to require significant changes to current practice. Initially, activities likely to provide the earliest success should be given highest priority.

The following programs are recommended:

### *Regional ULR evaluation/demonstration sites*

First stage: identify growers with potential to be established as demonstration sites. Evaluation should include subsidised NRS residue data linked with spray diaries.

Second stage: develop draft ULR spray programs based on current knowledge and in consultation with demonstration site collaborators, pest scouts and leading IPM growers.

Third stage: evaluate and adjust URL program over 3 seasons. These seasonal programs should be linked to the data mining, reduced herbicide contamination, high pressure residue removal and cost comparison outcomes below.

Sites should be established for the following dominant cultivars in two broad climatic regions:

Southern Australia[1] (New South Wales, Victoria, South Australia, Western Australia) cultivars:

- Navels[2]
  - Early season
  - Mid-season
  - Late season
- Afourers
- Imperials
- Lemons
- Grapefruit

Northern Australia (Queensland, Northern Territory and Western Australia) cultivars:

- Murcotts[3]

[1] Southern Australia is highest region priority. Early success is more likely in this region.
[2] Cultivars in order of priority within region (highest to lowest)

- Imperials
- Lemons
- Limes
- Grapefruit

***Data mining***

Conduct analysis of retrospective data from the National Residue Survey and interviews with large grower/packer records to link historical spray diaries to NRS residue data. Historical data will improve the spray timetable for draft ULR programs.

***Degradation/residue profile***

The NRS data and grower interviews indicate the following residues are important, commonly used and consistently above ULR targets.

- Chlorpyrifos
- 2,4-D
- Methidathion
- Iprodione
- Dithiocarbamate

Further studies would include sourcing residue data from existing studies (e.g., manufacturers, government agencies and JMPR studies). This information can provide a starting point for conducting field studies using accepted protocols to determine degradation profile to ULR levels.

***Postharvest high pressure washing to remove orchard residues***

High pressure washers should be evaluated for their capacity to remove orchard applied chemicals. This can be a specific program or activity linked to the NRS data for draft ULR demonstration sites.

***General postharvest***

Postharvest fungicides pose the biggest challenge for ultra-low residue programs. Fungicides are critical to decay control and require a residual to protect against infection during storage. Replacing fungicides with 'generally regarded as safe' (GRAS) preservatives should be the priority. Food preservatives are not as efficacious as fungicides. As such, combinations of physical and chemical treatments, akin to a systems approach, should be pursued. The following activities are recommended:

- High pressure washing to remove pathogens. Mixtures of food-grade cleaners and processing aids (wetters and spreaders) to enhance removal. This approach can be combined with the use of high pressure washes to remove orchard applied pesticides.

[3] Cultivars in order of priority within region (highest to lowest)

- Postharvest aqueous sprays and dips using food preservatives and natural defence elicitors (ambient and heated).
- Edible coatings: using conventional waxes &/or edible coatings as slow-release carriers of food preservatives.
- Novel packaging to maintain fruit quality. Slow release natural antifungal compounds to maintain fruit quality to the consumer.
- Shipping and distribution using storage conditions (ethylene absorption, temperature and humidity) to optimise preservative rate and product durability.
- Collaboration with other overseas researchers pursuing low residue postharvest treatments on citrus to be encouraged.

Initially, these strategies will be assessed by either laboratory-based or packing line trials. After two seasons, draft URL protocols will be developed with commercial collaborators. ULR protocols will be evaluated using dedicated packing lines (semi-commercial trials).

***New chemical registrations***

Registrants for newly developed products (insecticides/fungicides/herbicides/other) should be encouraged to provide extended decay profiles to ULR levels. This will assist industry in meeting a one-tenth MRL for all chemicals used on citrus.

***Reduce herbicide contamination***

Herbicides should not be sprayed onto fruit but NRS data indicates herbicide contamination. Spray application studies (i.e., low drift) &/or adapting organic orchard methods for weed suppression should be encouraged. This could be aligned with draft ULR programs.

***Cost comparison analysis***

A cost/benefit analysis comparing conventional with ULR programs should be undertaken. This will vary with cultivar and climatic region and could easily be aligned with draft ULR programs and postharvest programs.

Regardless of the program, there are common outcomes that activities should provide to growers. They include:

- Improved IPM options/early intervention strategies for difficult pests
- Low residue disease management strategies
- Best practice low residue pest management guides for specific regions and cultivars
- Best practice low drift guidelines for herbicide use
- Fact sheets on degradation curves of commonly used chemicals
- Cost/benefit analysis of maintaining ultra-low residue orchards
- Improved/discounted residue analysis service.

- Regional seminars, workshops and other promotion of ultra-low residue practices.
- Market designation system: branding/marketing strategies for ultra-low residue citrus.

# Scientific Refereed Publications

No refereed scientific publications published during the project.

# Intellectual Property/Commercialisation

No commercial IP generated.

# References

Aitken, A.G., Kerr, J.P., Hewett, E.W., Hale, C.N., Nixon, C., 2004, Growing Futures Case Study Series # 2 KiwiGreen. Martech Consulting Group in association with NZIER, Auckland, New Zealand, p. 11.

Cunningham, N.M., 2010. Combinations of treatments to replace the use of conventional fungicides for the commercial control of postharvest diseases of citrus fruit. Stewart Postharvest Review 6, 1-8.

Gebrekidan, B., 2003. Integrated Pest Management Collaborative Research Support Program: Highlights of its Global Experience, In: Maredia, K.M., Dakouo, D., Mota-Sanchez, D. (Eds.), Integrated Pest Management in the Global Arena. CABI, Blacksburg, VA, pp. 407-418.

Kaye-Blake, W., Zuccollo, J., 2012. The economic impacts of the Apple Futures program, 2012 Conference of the New Zealand Association of Economists, Palmerston North, New Zealand, 27 June 2012.

Miles, A. K. (2014). MRL minefield? Plan ahead and tread carefully. Australian Citrus News 89(March): 14-15.

Norton, G.W., Sanchez, G.E., Clarke-Harris, D., Traore`, H.K., 2003. Case Study: Reducing Pesticide Residues on Horticultural Crops, In: Unnevehr, L.J. (Ed.), Food Safety in Food Security and Food Trade. International Food Policy Research Institute (IFPRI), Washington DC.

# Acknowledgements

Author: Nancy Cunningham, Senior Research Officer, South Australian Research and Development Institute.

Co-Author (Lit review): Nancy Leo, Research Officer, South Australian Research and Development Institute.

Participant survey collectors and project team members /collaborators/advisors –

Andrew Miles, Plant Pathologist / Director, Research and Development for Primary Industries Pty Ltd

Steve Falivene, Citrus Development Officer, Dept of Primary Industries NSW Trade & Investment

Dr Jianhua Mo, Research Entomologist Horticulture, Dept of Primary Industries NSW Trade & Investment

Andrew Harty, Market Development Manager, Citrus Australia Ltd

National Residue Survey data provider: Ian Reichstein, A/g Assistant Secretary, Residues & Food, Exports Division, Department of Agriculture

Survey participants in South Australia, Victoria and New South Wales.

Qld survey participants included: Malcolm Wallis (Citricare), Steven Grant (Burnett Ag Supplies), Craig Pressler (2PH Farms) and Leonie Wittenberg.



***PLEASE NOTE: The full scoping study document is available on request from Citrus Australia.***