Horticulture Innovation Australia

Final Report

Australian Almond Industry – Liaison and Extension Project

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Almond Board of Australia

Project Number: AL12000

AL12000

This project has been funded by Horticulture Innovation Australia Limited using the almond industry levy and funds from the Australian Government.

ISBN 0 7341 3811 3

Published and distributed by:
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Contents

Summary

The Australian almond industry liaison and extension project makes a major contribution towards the implementation of the industry's strategic plan that relies heavily on the outputs of the Horticulture Innovation Australia's almond research program to provide the gaps in knowledge and technologies to action the strategies. The achievement of the aims of both Plans regarding increasing yields, improving input efficiency and better managing risk is driven by this project by not only facilitating the provision of information from the Australian and international research communities but also drawing on established best practice to assist industry participants to make better business decisions.

The industry development staff have consulted with industry and other key stakeholders to identify issues, develop detailed strategies and put these into action. The almond industry development program has assisted in the scoping and provided guidance during the commissioning of most R&D projects to improve rootstock and varietal material, address pest and disease issues, enhance the efficiency of pollination services, chemical, nutrient and water inputs.

The relationship with these projects' researchers continues once they are underway with this project providing industry assistance to establish trial sites on commercial orchards and monitor progress. The staff also organize field days and forums for the researchers to present their work. Fact sheets, videos and incorporation into training courses are also used to extend research outputs.

The past and current outputs of the research program have also been utilized to successfully address market access and food safety issues that have arisen during this period of this project. An example of this was the submission to oppose the proposed reduction to the Fosetyl-Al maximum residue limit in Europe to a level that would jeopardise the industry's ability to continue to supply this market that took 42% of Australian almonds export volume or 25,800 tonnes in 2015 worth $310 million. The research program also provided information for a submission to the European Commission to reduce the sampling and testing of Australian almonds for mycotoxins that will reduce testing costs and the considerable expense and inconvenience associated with port delays upon landing product. Other food safety related work undertaken within the project included the running of chemical use courses. During the duration of the project the National Residue Survey detected no breaches of maximum residue levels for chemicals in the almond industry despite significant new grower entrants.

The project staff assisted researchers with year round in orchard monitoring of trials and also the accessing of product for processing and health benefits trials undertaken by Universities. The project team members have also undertaken research activities in their own right as urgent needs arise.

The industry is in a strong growth phase. During the period of this project production doubled to 80,000 tonnes and from 2015 to 2018, the industry's orchard plantings are expected to grow by an estimated 15,000 hectares, an increase of 50% on existing orchard plantings. When the new orchards are mature, the forecast additional annual value to be generated is $460 million at today's prices. This will add 6% to the current total value of Australian horticulture.

This investment is being undertaken by existing growers and many new growers coming to the almond industry from other horticultural crops, broadacre and from outside agriculture. This interest has led to a significant increase in personal contact with the industry development staff as those investing in the industry seek information on best practice from irrigation systems to varieties, equipment, water market and suppliers such as nurseries, harvest contractors etc.

Inquiries have also increased from Government Departments seeking to facilitate the growth of the industry in the river communities recovering from the drought and the collapse of returns in other industries.

It can be seen that this project tied together the efforts of many other past and present researchers and utilizes the knowledge and technologies they have created to drive innovation within the industry and move the industry along the strategic path endorsed by industry members.

Keywords

Industry development, extension, best practice, strategic plan implementation.

Introduction

The almond industry of Australia has recently undergone rapid expansion with production increasing from 50,000 tonnes in 2012 when the project commenced to greater than 80,000 tonnes in 2015 when the project completed. For every tonne sold domestically, three tonnes are now exported. In 2015, almond export sales were $745 million representing 36% of total Australian horticultural exports. In 2015, the GVP of almonds was nearly a billion dollars, around 10% of the total value of Australian horticulture. The industry is continuing to expand rapidly with an additional 15,000 hectares expected to be planted up to 2018. By 2024, the Australian almond crop is expected to be 130,000 tonnes.

Due to the expansion of the industry and the requirement to inform and empower the industry to make better business decisions, Horticulture Australia then Horticulture Innovation Australia funded the Almond Board of Australia (ABA) to employ an Industry Development Manager (IDM) and Industry Development Officer (IDO) to undertake an Australian Almond Industry Liaison and Extension project (AL12000).

The project began with an initial focus of completing the extension and development activities from the major project, Sustainable Optimisation of Almond Production which is delivering world's best yields due to improved water and nutrition management but moved onto food safety issues and a number of other emerging issues as they evolved such as bee hive health, efficient hive distribution, tissue culturing capability within Australia for rootstock multiplication, high health status budwood supply to nurseries, and one to one advice to new growers wanting to invest in almonds.

Within this program of addressing urgent issues as they arose there ran parallel implementation of the almond industry's Strategic R&D Plan, 2011-16. The project provided the resources to allow the actions necessary to implement the strategies focused on efficient input use and management of crop risks such as pests and disease, severe weather, biosecurity and limitations of existing orchard infrastructure.

The Strategic Plan provided guidance and the project staff continued to identify issues and develop detailed strategy to achieve change as often successful uptake of knowledge or technology requires impediments to be overcome more than information to be distributed. A thorough understanding of the industry is necessary to recognise the impediments and often trust is required to overcome them.

Gaps in the research program's outputs required to achieve the strategies were identified and considerable effort went into assisting Horticulture Australia with scoping and commissioning R&D, particularly in the area of developing advanced production systems suited to the growing conditions in Australia and

establishing the Almond Centre of Excellence experimental orchard that will accelerate the evaluation of new varieties and new tree architecture and orchard designs. It will enable the barriers to be pushed further in orchard design than a co-operating grower would be prepared to invest in.

The project staff were actively involved in the trial work of Adelaide University's "Australian Almond Variety Evaluation and Commercialisation Program" (AL12015) and also in the securing of co-operating growers for the larger scale evaluations. With the guidance of the ABA's Plant Improvement Committee five new varieties have been released with superior production and quality characteristics to the current US bred varieties. A key element of the project is the management of the industry's true to type, pathogen tested germplasm mother plantings that are crucial to supply varietal buds to nurseries to ensure the many new hectares of orchards being planted are using trees of high health status that grow vigorously to establish full production in the shortest possible timeframe. In 2014/15 and 15/16, over two million trees were propagated with pathogen tested buds taken from the mother planting orchards.

Industry supply chain committees, field days, workshops, invited experts, grower meetings, domestic and international study tours, trials, participation in stakeholder committees, topical publications, website updates, fact sheets, decision support tools, regular email circulars, industry conference presentations, the provision of useful published research articles and website links, prioritisation of minor use permit applications, and more, were all used to achieve key outcomes.

The project has contributed towards: informing and empowering the industry to make better business decisions and assisted to achieve the HAL endorsed R&D Plan vision of "as a profitable industry to lead in the efficient production, processing and marketing of quality almonds and secure a position of preferred supplier".

Methodology

Industry development needs will be delivered through a diverse but structured strategy and methodology primarily revolving around the employment and responsibilities of the Industry Development Manager (IDM) and Industry Development Officer (IDO). The roles are full time, working predominantly between the almond growers, research providers and other key industry stakeholders. The IDO will report directly to the IDM who will report directly to the CEO. The project is supported by the provision of account management by the Finance Manager and Finance Officer and the Communications Manager.

A project reference committee, drawn from industry levy payers, will meet three to four times a year to monitor the project and provide guidance and support to the staff. The Almond Board of Australia Board of Directors is responsible for the implementation of the Australian Almond Industry's Strategic Plan that many of the activities of this project will impact on and so a further level of monitoring will be in place. The Board will also contribute additional funding to that provided to the project where necessary to achieve the project's goals that align with industry's.

The IDM and IDO will be responsible for industry development by aligning itself with the four objectives of the almond industry's Strategic R&D Plan, 2011-16:

- Objective 1 - Develop and maintain market opportunities (volume sold)
- Objective 2 - Increase product value (quality and price)
- Objective 3 - Improved efficiency and sustainability (costs and risks)
- Objective 4 - Provide a supportive environment (skills and communication)

The project will be responsible for industry development by undertaking the following methodology:

- Issue identification
  - Consult with industry through planned meetings with its four strategic sub-committees (Marketing, Processing, Production and Plant Improvement), Industry Advisory Committee (IAC) and the ABA Executive Board. Meetings will be held 2-4 times per year.
  - Actively consult with Horticulture Australia (HAL).
  - Actively consult with Department of Agriculture, Fisheries, and Forestry (DAFF).
  - Consult and survey other members and stakeholders of the industry to assess any relevant issues of interest, limitation or difficulty. Other stakeholders include additional almond growers, processors and marketers; irrigation manufacturers; chemical and merchandise manufacturers; beekeepers; international consultants and experts; government departments; horticultural consultants; etc.
  - Attend and actively be involved in other partner organisations such as Plant Health Australia (PHA), RIRDC Pollination R&D Advisory Committee, etc.
- Development of detailed strategies for each of the issues/objectives
  - The almond industry's R&D plan was developed in 2010 with numerous R&D strategies, some of which require little additional work. However, there are several strategies that either require additional detail or are nonexistent within the plan and require development.
  - Following consultation with industry and key stakeholders as mentioned above, the IDM and IDO will develop the additional key strategies requiring R&D. These strategies will be reported back to, and confirmed by the relevant stakeholders.
  - Those strategies that already exist within the almond industry's R&D plan follow:

    Strategy 1.3 - Research & educate key influencers about the health benefits of almonds

    Strategy 2.1 - Establish practices to enhance product quality throughout the value chain

    Strategy 2.2 - Promote food safety practices from production through to consumption

    Strategy 2.3 - Develop and enhance product differentiation

    Strategy 3.1 - Improve productivity and competitiveness across the value chain

    Strategy 3.2 - Safeguard industry production and marketing systems from potential biosecurity threats

    Strategy 3.3 - Support sustainable almond production

    Strategy 3.4 - Facilitate access to superior plant material

    Strategy 4.1 - Enhance skills and capacity to support current and future industry needs

    Strategy 4.2 - Develop and deliver effective R&D programs to support the Strategic Plan

    Strategy 4.3 - Support adoption of R&D outcomes by effective extension

    Strategy 4.4 -Facilitate the two-way flow of information through the value chain
- Identify gaps in the outputs required to achieve the strategies
  - The IDM and IDO will facilitate a gap analysis of the outputs required - also after consultation with industry and the key stakeholders as mentioned above.
- Ensure delivery of the outputs through scoping and commissioning R&D
  - The IDM will be actively involved in researching and determining the most appropriate R&D provider(s) by consulting with the R&D community, undertaking literature reviews, consulting with other industries, undertaking referee checks, etc.
  - Commissioning of R&D will occur through one of two scenarios. Firstly, the most preferred option will be to go directly to the R&D community by researching the most appropriate

R&D provider(s). If there is not a clear preference, an expressions of interest process will be instigated to assess the short listed R&D providers. Secondly, a general call will sometimes be instigated, but this will not the preferred option.
Note: This process has changed under the Horticulture Innovation Australia's procurement guidelines.

- Assist implementation of the strategies that achieve industry outcomes through extension and technology transfer.
  - To enable the technology transfer of all projects there will be classroom sessions and field day sessions made available to inform and present the levy payers with the technical aspects of growing and producing almonds. Where possible, the sessions will be kept to a small size of less than 15 people to enable effective communication.
  - Develop industry tools to facilitate the commercial adoption and adaption of research outcomes from the industry's research program. This may include spreadsheets, manuals, etc.
  - Continue to develop, update and promote the ABA's website and the industry's levy payer access page. All relevant communications resources and links such as research and development progress results, water related information, pollination, minor use permits, industry tools, etc. will be uploaded and made available regularly.
  - Formal and informal technical articles published in literature resources such as the "Australian Nutgrower" magazine, the almond industry newsletter "In a Nutshell", industry fact sheets. All articles will be authored by the relevant collaborators and made available either by hardcopy (i.e. postage), electronic (i.e. industry website, email or fax) or a combination of both.
  - Assistance in organising and developing the program of the annual almond industry conference and levy payers meeting as well as verbal presentations on relevant, topical information to all attendees.
  - Facilitate and invite recommended experts to consult and provide advice on new or emerging industry needs. In the previous project AL09021 this was done for the drought, mice plague, locust plague, soil acidification, prune rust, spray coverage, etc.
  - Domestic and international study trips to keep abreast of technical advances and maintain industry development. Advances could include importation of new rootstocks, cultivars, fertigation techniques, pest and disease management, drought management, etc.
  - The IDM and IDO will also be responsible for communicating other crucial information pertaining to the almond industry such as information on food safety and contaminants, chemical permits, chemical registrations, spray drift policies, the Murray Darling Basin Plan, pollination and international advances in production technologies.

Outputs and Outcomes

The multifaceted nature of this industry development project has involved undertaking many actions to implement the strategies of the industry and R&D plans leading to numerous outputs and associated outcomes. To document these in a coherent manner the project outputs and outcomes are incorporated into the following table to enable the project outputs to be readily linked to their impact.

Steering Committee(s), issue Identification, development of strategies, identify gaps, scoping & commissioning R&D	**Outputs**	**Outcomes**
Stakeholder Consultation • Almond Plant Improvement Committee • Almond Production Committee • Almond Processing Committee • Almond Market Development Committee • ABA Board • HAL Almond IAC • Horticulture Australia Ltd /Horticulture Innovation Australia • R&D Lead Agency (Agriculture Vic) Meetings and Other Provider Meetings • Project Steering Committee – Almond Centre of Excellence • R&D Project Meeting – Pollination • R&D Project Meeting – Advanced Processing of Almonds • R&D Project Meeting – Breeding (AL8000) • R&D Project Meeting – Robotics (AH11009) • R&D Project Meeting – Carob Moth (AL12004 • R&D Project Meeting – Prunus Viruses (MT12005) • R&D Project Meeting – Monash Remediation (AL12011) • R&D Project Meeting – Rootstocks (AL11012)	**Number of meetings** • 14 • 7 • 5 • 13 • 12 • 7 • 7 • 14 • 8 • 5 • 17 • 15 • 5 • 6 • 2 • 1 • 4 • 11	• Almond industry better protected or prepared from Biosecurity threats. • Issues identified, strategies developed, R&D gaps required to implement strategies identified, R&D projects scoped, endorsed by industry and commissioned. • Industry capacity enhanced through skills development in pollination, chemical application, irrigation and nutrient management, food safety risk reduction, pest and disease management, and orchard benchmarking. • Industry R&D program has widespread levypayer support by strategic and consultative approach to project prioritisation. • R&D projects have co-ordinated industry assistance and guidance to achieve contracted outputs. • Researchers are aware of industry R&D priorities, current

• R&D Project Meeting – Harvesting of trials (AL1200, AL12015, AH11009) • R&D Project Meeting – Almond Productivity R&D Program Development • R&D Project Meeting – Almond Hull and Shell Waste Project Development • R&D Project Meeting – Aeration, drying and improved hulling of almonds • Varroa Continuity Strategy Management Committee • Plant Health Australia Nut Biosecurity Plan • RIRDC Pollination R&D Advisory Committee • Australia Nut Industry Council Joint R&D Priorities for Nuts • Australian Almond Conference • Almond Regional Meetings • Annual Almond R&D Forum • Horticultural Industry Network (HIN) • AgVet forum • Vic Apiarist Association Conference • NSW Apiarist Association Conference • Australian Honey Bee Industry Council Conference and Meetings • Water Use Efficiency Forum • Pollination Reserves Workshop	• 24 • 2 • 8 • 3 • 3 • 6 • 5 • 10 • 3 • 12 • 3 • 15 • 1 • 1 • 2 • 3 • 2 • 3	research projects and develop collegiate approach to solving industry issues. • Commitment to co-investment by research providers. • Stakeholders across the value chain informed and engaged. • Confidence amongst research community that project outputs are being adopted delivering a return on invested time, effort and money. • Industry agreement to invest in both short term and longer term research and documented as: Horizon 1 (current production system improvement); Horizon 2 (closer plantings); and Horizon 3 (advanced production systems based on vertical hedge tree architecture). • The importation of Spanish rootstocks has enabled the industry to access hybrid, nematode resistant rootstocks that perform well in Australian soils. Orders for over one million Garnem rootstocks have been advised by the nursery industry. • The lack of a world class tissue culture facility in Australia was identified as an impediment to rapidly accessing hybrid rootstocks. Duarte (USA) and Agromillora (Spain) nurseries were approached and Agromillora has joint ventured in a facility in Mildura.
Study Trips • International study trips to keep abreast of technical advances, international collaboration and maintain industry development.	• A study trip to New Zealand to meet with Plant & Food NZ, AgFirst, and the HortPlus Group. • New Zealand study trip briefing paper. • A study trip to California to meet with Almond Board of California, Californian almond researchers and attend the 2012 Californian almond conference. • California study trip briefing paper.	

	• A study trip to Spain to meet with Institute for Food Research and Technology (IRTA), tissue culture tree nursery and rootstock breeder (Agromillora), attend the International Nut Congress World Forum for Nutrition Research, and attend the 30th Anniversary World Nut and Dried Fruit Congress in May 2013. • Study trip report circulated to IAC, ABA Board, and industry R&D sub-committees. • A study trip to Spain for 11 almond growers to meet with Institute for Food Research and Technology (IRTA), tissue culture tree nursery and rootstock breeder (Agromillora), and Spanish almond growers and processors. HAL Project Code AL13701. • Final report submitted and approved.	

Alan Saunders of Agromillora Australia shows Almond Board of Australia Chair, Neale Bennett a tray of Garnem rootstock propagules at the facility in Mildura. The rapid multiplication of the rootstock by tissue culture means it is available to nurseries in sufficient quantities to meet the strong demand during the current planting boom.

Research & Development Activities	Outputs	Outcomes
Chemical Use and Availability • Assess the importance of disease, insects and weeds that can affect almond production. Evaluate the availability and effectiveness of fungicides, insecticides and herbicides to control plant pests. Determine any gaps in the pest control strategy.	• Strategic Agrichemical Review Process (SARP) co-ordinated for almonds. • Chemical use and equipment optimisation workshops undertaken in each production region. • Minor Use Permit (MUP) for Methoxyfenozide (Prodigy) for the control of Carob Moth. • MUP renewal approved and issued for the use of Chlorantraniliprole to control Carob Moth. • MUP renewal approved and issued for the use of Clofentezine to control mites. • MUP submitted for Carpophilus Catcha (attract and kill) system to control Carpophilus Beetle. • MUP extension submitted for the use of Abamectin to control mites. • MUP extension for the use of Phosphorous Acid to Suppression of Phytophthora approved until 31st March 2020. • MUP for the use of Simazine to control broadleaf weeds and grasses approved until 31st March 2020. • Permits available on APVMA website and the almond industry website. Industry members also notified of new permits by email. • Orchard hygiene was promoted at fieldays, forums and in articles to remove overwintering nuts as a source of reinfestation of the new seasons crop. This is now standard practice on the large majority of orchards. • Mating disruption technique extended to producers to assist in the management of Carob Moth.	• The threat of crop losses and downgraded kernel quality from Carob Moth and Carpophillus Beetle infestations have been reduced. At the height of the problem insect damage impacted on over 10% of the crop. 2016 crop monitoring at intake indicates this has been halved. • The improved management of tree defoliation by fungal diseases, particularly post harvest, has assisted yields. • The threat of potential orchard biosecurity threats has been lessened by the ABA's pathogen testing program for nursery material was recognised by PHA in the new Nut Biosecurity Plan. • The industry's reputation for good agricultural practice is maintained by no MRL breaches monitored by the National Residue Survey and the import sampling and testing program undertaken in Europe where 26,000 tonnes of almonds were shipped in 2015.

	• Extension of Carpophillus beetle traps on an area wide basis required the co-operation of growers managing large areas of orchard.  ***Carpophillus beetle emerged as a major issue in 2013.*** • Annual Almond National Residue Survey program negotiated with DAFF and industry marketers. • Work undertaken to determine Fosetyl-Al residue chemistry to enable strategy to reduce levels to meet proposed new EU MRL reduced to 2ppm from Codex's 75ppm. • Liaison undertaken with the International Nut Council and the Almond Board of California successfully deferred the MRL reduction until 2019 to allow the trial work for a Codex MRL to be undertaken.	
Quality Integrity Program • A salmonellosis issue occurring in 2011 led industry to focus on food safety as a priority. • An increased frequency of breaches of Aflatoxin maximum levels in the EU resulted in a fourfold increase in the sampling and testing of Australian almond consignments in 2015.	• An industry wide endorsement of pasteurisation of almonds led to a heavy investment in pasteurisation equipment and improved orchard practices to address critical control points in reducing bacterial contamination. • Development and implementation of a program of activities across the supply chain to address the risk of Aflatoxin that is produced from certain mould species. Improving practices across the supply chain to ensure prevention rather than identification by testing was the primary focus.	• Consumer safety enhanced. • Protection of the industry's reputation for high product integrity that was being threatened by the risk of bacterial and mycotoxin contamination. Following the implementation of the industry program to change critical practices only two breaches occurred in 2015 on a record 26,000 tonnes of product exported to Europe. No breaches have occurred in the past seven months. In over 230 samples tested of the 2016 crop by Australian processor / marketers none have exceeded the EU tolerances.

	This in part involved workshops and fact sheets to provide guidance on orchard practices. Liaison with industry processor / marketers was also crucial to enhance testing procedures prior to shipment. • Submission made to the EC supported by the Commonwealth Government to remove Australian almonds from the emerging risk list of products that required additional sampling and testing of consignments. • Liaison with Government officials in Brussels to manage the Aflatoxin breach issue.	• The submission documenting the industry actions in addressing the issue is aimed at reducing the level of costly sampling and testing of consignments at European ports and the delays caused by this process.
Canopy Spray Coverage • The 2011 season highlighted vast differences in the control of almond rust in the industry. A survey of practices highlighted both the need for best practice adoption and provided a strong insight into the requirements of high disease pressure periods. To assist in this, Geoff Furness (ex SARDI) who is an acknowledged expert in the field of spray application has been engaged to undertake field and laboratory evaluations of various scenarios.	• Evaluation and assessment of two spray machines to investigate optimum settings. • Preliminary report outlining the effectiveness of two spray machines. • Demonstration of the results to those co-operating orchards. • Four industry field days: 16/7/13 (Sunraysia region); 17/7/13 (Riverland region); 25/7/13 (Sunraysia region); and 16/7/13 (Adelaide region). • Four industry field days demonstrating the effectiveness of various machinery manufacturers: 27/11/13 (Adelaide region); 10/12/13 (Riverland region); 11/12/13 (Sunraysia region); and 12/12/13 (Riverina region). • Results presented at the Annual Almond Conference and Activated Almond R&D Forum	• Increased understanding of the role and requirement spray coverage plays in pest and disease management. • Reduce the threat of losses from pest and disease incidents. • Reduce the threat of potential orchard biosecurity threats. • Industry capacity is enhanced through increased skills development.

Almond Budwood Repository • Management and maintenance of two almond industry budwood repositories to ensure commercial nurseries and almond growers have access to true-to-type, pathogen tested high health plant material.	• Two almond budwood repositories managed to provide a reliable supply of high health status and true to type budwood to nurseries. Having two sites is a strategy to address the risk of pathogen contamination of one site. • Propagation of University of Adelaide breeding program trees for inclusion in the budwood repository.	• The industry expansion underway (estimated to 15,000 Ha) will be more profitable due to the use of pathogen tested true to type material. Healthy trees establish more quickly and generally produce bigger crops. • Grower access to the new Adelaide University varieties with superior yield potential is reliant on the rapid establishment of motherplantings to supply budwood to the nurseries. The five new varieties have shown in trials to out yield the industry standard variety Nonpareil by 10% to 15%. A 10% increase in yield on the 2015 Australian crop would have been worth $100 million.

Grower interest in the new variety field days held regularly has been very strong as growers look for alternatives to the US derived varieties currently planted.

International Variety Evaluations • Import and/or evaluate imported almond varieties for their suitability to almond production in Australia.	• Eight Californian varieties under evaluation. • Nine Spanish varieties under evaluation. • Three Israeli varieties under evaluation. • Eight fact sheets written and published.	• The industry has access to world's best plant material to ensure this basic requirement to ensure competitiveness is in place for Australian producers.

ABA organized forums to discuss the best available plant material featured a Californian nursery breeder and attracted large attendances in the producing regions.

Australian Almond Breeding • Assist with management and assessment of primary and secondary evaluation trees. • Assist in commercialisation strategies.	• Primary evaluation site at Dareton, NSW are maintained in a healthy condition suitable for evaluation. • Assisted the seasonal evaluation and crop harvesting of thirteen elite selections under consideration for commercialisation. • 32 New promising primary selections budded for inclusion in secondary evaluation trials (planted in 2013 & 2016). • Ordered and facilitated supply	• The new varieties will provide a significant production advantage to the Australian almond industry. The potential for price premiums related to quality exists but further market analysis is being undertaken by the ABA with the first commercial quantities of the nuts.

	and planting of 100 trees of each elite selection for further semi-commercial evaluation at three separate host orchards. Trees planted in August 2013. • Ordered supply of 14 secondary evaluations for inclusion in the ABA's budwood repositories. • Value added product trials were arranged with industry processor marketers to assess suitability for roasting, blanching and the production of almond meal. • Commercialisation plan drafted for the IP owners, HIA and Adelaide University. • Buds for 90,000 nursery trees of the new varieties were delivered by the ABA in 2015/16.	
Almond Waste Use • Investigating the feasibility of waste and energy demands within the almond production system to determine opportunities for industry and regional collaboration in carbon and energy management.	• Establish current energy demand, and Scope 1 and 2 carbon emissions across almond industry producers, processors and packers. • Assessed technological options for bio-energy production. • Preliminary economic analysis of the commercial viability of energy production.	• Almond hulls and shells comprise 2/3 of the bulk of an almond fruit. Once hulled to produce the almond kernel product the hull and shell produces 160,000 tonnes of waste product that can pose a fire risk through self-combustion. • Alternative uses for the waste will provide a revenue stream and reduce fire risk.

Spontaneous combustion fires of hulls are costly to control and pose a risk to processing facilities. The industry development staff liaised with the University of SA to develop sensors to monitor moisture and temperature in the stockpiles to warn of conditions suitable for a fire.

OrchardNet Benchmarking • Facilitate and actively take part in the development, access, training and use of a web based data management tool suitable for benchmarking almond productivity and profitability.	• One week devoted to industry consultation and OrchardNet development by ABA staff and AgFirst New Zealand staff in May 2013 and August 2014. • OrchardNet user's manual completed in August 2013. • YouTube video clip providing introductory training to OrchardNet completed in August 2013. • Almond demo orchard set-up within OrchardNet completed in August 2013. • Final version of OrchardNet completed in February 2014. • Promotion of OrchardNet to almond industry is ongoing.	• The Australian almond industry has a co-operative mindset and the benchmarking program offered through Orchardnet provides valuable insights into how individual businesses are performing compared to others. The booming nature of the industry during the period of this project has meant the limited staff resources have lacked the time to promote this strongly. The buoyant times of the industry have also worked against its uptake.
Awareness of Nematodes • Review *Prunus* rootstocks suitable for almond production and available in Australia for assessment undertaken by CSIRO for resistance to *Meloidogyne* spp (root knot) nematodes.	• Identified 18 rootstocks for evaluation. • Preliminary results using pathotypes from CSIRO's vineyard collection completed and reported to industry at the Almond R&D Forum (12 June 2013). • 18 *Prunus* rootstocks evaluated using 7 x RNK pathotypes from sampled vineyards and almond orchards. • A final report communicating the results (RKN susceptibility) and implications of the investigation. • Communication to growers of trial results in forums and articles.	• Growers are now aware of the susceptibility of a number of major rootstocks to nematodes. The growers' choice of rootstocks has moved significantly to nematode resistant rootstocks that will perform significantly better, particularly in replant situations and soils prone to nematodes.

Rootstock choic**e is crucial to maximizing orch**ard productivity** as nematodes ca**n be very** debilitating to a**lmond orchards.

Phil Watters Award AL09017 • The Phil Watters award recognises service to the almond industry, in particular a dedication to research and development, adoption of best practice and promotion of horticulture to the community.	• 2013 recipient selected and awarded (James Callipari). • James Callipari participated in the Spanish study trip AL13701.	• This project is preparing suitable young industry participants for future leadership roles in industry.
Autonomous Perception Systems for Horticulture Tree Crops (Robotics) AH11009 • The almond industry is one of two host crops for the across industry trial investigating autonomous perception systems. Ground truthing and matching sensing data with actual data was required by the project team.	• Organised the collaborating grower. • Third party Precision Ag Field Day organised with Sydney University staff and producers and held 3/10/14. • Assisted with the seasonal evaluation and crop harvesting. • Arranged industry presentations at the Conference and Research Forum.	• Further work is required but the technology has shown potential particularly in estimating crop loads that will facilitate adjustments to nutrient and irrigation management to ensure the trees remain in balance to produce consistently high crops. Yield monitoring is a high priority of industry to allow precision horticulture to be practiced.

Lake Cullulleraine Almonds agreed to host the University of Sydney trials. The ABA industry development staff arranged orchard sites for many projects and liaised with researchers to provide on-site assistance when required.

Assist implementation of strategies through extension & technology transfer	Outputs	Outcomes
Field Days / Workshops / Forums • Farm managers attended an organised orchard tour in different almond growing regions (i.e. Walkers Flat, Loxton, Overland Corner, Murtho and Lindsay Point) to observe and investigate bud strength, flowering density and general orchard operations	• A field day and orchard walk across two growing regions.	• Industry levy payers are cognisant of the HAL / Hort Innovation research program for almonds. • Industry capacity is enhanced through increased skills development. • Increased understanding of soil/root/plant mechanisms and irrigation and nutrition practices that increase orchard productivity. • Reduced threat of crop losses from pest and disease incidents. • Reduced threat of crop losses and increased product quality in relation to food safety contaminants. • The Australian almond industry is knowledgeable of world's best performing rootstocks and varieties. • Soil health sustainability now front of mind as impacts of soil compaction, fertiliser application, and saline irrigation water are being addressed. • Researchers motivated by industry interest and knowledge project outputs will be taken up as part of industries strategic drive to improve. The ABA is devoting resources to overcoming the impediments to uptake. • Decision making of growers supported through access to timely and relevant information. • New networking opportunities created by industry stakeholders. • All stakeholders are informed and engaged.
• Craig Day of Spray, Safe & Save presented a workshop on increasing efficacy of herbicide applications.	• A workshop. • Handouts and spray application tools outlining evaluation and assessment of herbicide machinery including nozzle selection, nozzle installation, machinery settings, etc. Advice on nozzle selection, spray calibration, water conditioning, optimum application conditions, etc.	
• Dr Trevor Wicks and Trevor Sluggett presented the latest information on Phytophthora and irrigation and soil management practices.	• A workshop. • Handouts discussing: diagnosis and management of Phytophthora and other soil/root pathogens; and best practice irrigation and soil management.	
• David Doll from the University of California was organised and funded to visit the Australian almond industry and discuss the latest research on almond diseases and their management.	• Two workshops. • Handouts discussing various pest and disease diagnosis, epidemiology, and management principles.	
• Prof Patrick Brown from the University of California was organised and funded to visit the Australian almond industry and discuss research on principles of plant nutrition, the latest almond nutrition best practice guidelines, and new Californian government regulations relating to groundwater nitrate contamination.	• Two workshops. • Handouts discussing basics and principles of plant nutrition and best practice almond nutrition. • Leaf tissue critical values (spring and summer sampling) for optimum and sustainable almond production.	

• Pre-Harvest Study Tour - 15 growers participated in a study tour of the Sunraysia and Riverina regions focusing on harvest maturity, canopy management and light interception, and the new Californian cultivar 'Independence' under evaluation.
• A fruit nutrient composition and removal survey has been undertaken across representative orchards to understand nutrient requirements.
• Canopy Spray Coverage – Part 1 & 2
Geoff Furness (ex SARDI) and Brett Rosenzweig (IDO) presented information on best practice such as reasons for calibration, determining the correct water rate, winegrape case study, nozzle selection criteria, canopy coverage assessments, and field demonstration of calibration.
 	
• Californian Almond Researchers
A visit by Dr. Themis Michailides, a plant pathologist from University of California, Davis was joint hosted with the Australian almond and pistachio industries. The visit presented information relating to lower limb dieback of almonds and *Aspergillus* and aflatoxin disease epidemiology and management across both crops.
 	
Dr. Bruce Lampinen (plant physiologist) and Roger Duncan (pomology farm adviser) from University of California, Davis was organised and funded to visit the Australian almond industry and discuss research on light interception, spur dynamics, lower limb dieback, stockpiling, rootstock field performance, close plantings and pruning.
 	
Dr Jim Adaskaveg (plant pathologist) and Dr Neal Williams (Bee biology, entomology and nematology) from University of California, Davis was organised and funded to visit the Australian almond industry and discuss research on management of foliar fungal and bacterial diseases and sustainable pollination strategies for agriculture
	• An organised domestic study tour.
	• A Fact Sheet "Independence Almond".
	
	• A Fact Sheet "Crop Nutrition – It's Not Just NPK."
	
	• Four industry field days: 16/7/13 (Sunraysia region); 17/7/13 (Riverland region); 25/7/13 (Sunraysia region); and 16/7/13 (Adelaide region).
	• Handouts relating to the presentations and made available on the industry website.
	• Eight secondary industry field days across four growing regions.
	  • Two field walks: 12/2/13 (Two Riverland orchards) and 14/2/13 (A Sunraysia orchard).
	  • Two workshops: 12/2/13 and 14/2/13.
	  • Handouts discussing various pest and disease diagnosis, epidemiology, and management principles.
	  • Three orchard walks: 1/11/13 (Adelaide); 4/11/13 (Riverland) and 6/11/13 (Sunraysia).
	  • Two symposia: 4/11/13 (Riverland) and 6/11/13 (Sunraysia)
	  • Handouts discussing the various topics made available on the website.
	  • A pest and disease field day (Jim Adaskaveg) held in Adelaide Plains region 31/10/14
	  • A pollination field day (Neal Williams) held in Riverland region 3/11/14

• 2013 Activated Almonds Research and Development Forum. Presentations by 12 almond researchers communicating their results and industry implications. This was the first R&D forum delivered to industry outside of the annual conference and was a great success, with approximately 80 people attending.	• A seminar: 12/6/13 (Renmark, South Australia). • Two presentations. • A book of abstracts, also made available on industry website. • Two handouts of presentations discussing the researchers' results and industry implications, also made available on industry website.

• 2014 Activated Almonds Research and Development Forum. Presentations by 13 almond research and development personnel communicating their work and implications to industry. This was the second R&D forum delivered to industry outside of the annual conference and was a great success, with approximately 90 people attending.	• A seminar: 18/6/14 (Renmark, South Australia). • Thirteen presentations. • A book of abstracts, also made available on industry website. Presentations made available on industry website.
• 2015 Activated Almonds Research and Development Forum. Presentations by 16 almond research and development personnel communicating their work and implications to industry. This was the second R&D forum delivered to industry outside of the annual conference and was a great success, with approximately 110 people attending.	• A seminar: 28/10/15 (Renmark, South Australia). • Sixteen presentations. • A book of abstracts, also made available on industry website.

The participants at the Activated Almond Research Forum were a mix of the producer and research communities. A field walk of trial sites for researchers was part of the 2015 Forum.

• Monitor Blocks/Orchard Walks/Tours – Bloom	• Four orchard walks held in the Riverina (4/8/14), Sunraysia (5/8/14), Riverland (6/8/14) and Adelaide (7/8/14) growing regions discussing: bud numbers; return bloom; orchard sanitation; carob moth; and OrchardNet functions. • Four orchard walks held in the Riverina (14/10/14), Sunraysia (15/10/14), Riverland (16/10/14) and Adelaide (17/10/14) growing regions discussing: fruit set; carob moth; and OrchardNet functions. • Handouts relating to the discussions made available in hardcopy on the day
• Almond Pollination Efficiency Dr. Saul Cunningham the project leader of the enhancing almond pollination efficiency project (AL11003) conducted an information session in conjunction with the almond variety field day below. Key findings on the effect of hive placement and stocking rates on pollen removal and fruit set rates.	• A field day 13/8/14 (Riverland).
• Almond Variety Field Day Dr. Michelle Wirthensohn the project leader of the almond breeding program (AL12015) and John Slaughter the plant breeder at Burchell Nursery Inc. were organised to hold a joint field day at the Australian and Californian evaluation trials. Dr. Michelle Wirthensohn the project leader of the almond breeding program (AL12015) in conjunction with the Almond Board of Australia delivered a field day to observe bloom performance and dates, and discuss the key traits of the initial five most promising cultivars.	• A field day 13/10/13 (Riverland). • A field day 13/8/14 (Riverland). • A field day 12/2/15 (Riverland). • A field day 3/9/15 (Riverland) • A field day 29/10/15 (Riverland) • Handouts relating to the presentations made available in hardcopy on the day.
• On-Farm Stored Pest Management Peter Botta from PCB Consulting Pty Ltd in conjunction with the Almond Board of Australia delivered a series of presentations gathering information from the lessons and experiences of the grains industry and how they manage stored pests during on-farm product storage.	• Four workshops held in the Sunraysia (28/8/14), Riverina (29/8/14), Riverland (2/9/14) and Adelaide (2/9/14) growing regions. • Handouts discussing the various topics made available on the website.
• 2014 Crop Review An industry meeting was facilitated by the ABA in July to discuss the reasons behind the lower than expected 2014 crop. The meeting was well attended by 23 participants with numerous key points raised and discussed for consideration.	• A workshop held in the Sunraysia (22/7/14). • Handouts discussing the various topics made available in hardcopy on the day. • A "In a Nutshell" Newsletter article (September 2014) summarising key discussion points.
• Nutrition Workshop – assisted with a Haifa Australia Nutrition Workshop featuring Dr Patrick Brown from UC Davis	• Three workshops held in Riverland, Sunraysia and Riverina growing regions (18-21 Aug 2015). • A workshop was recorded and currently being formatted ready for uploading to the website.
• Craig Simes (Almondco GSM) and Brett Rosenzweig (ABA IDO) co-hosted a new grower workshop for Griffith irrigators and services providers wishing to know more about the technical aspects of almond growing.	• A workshop held 15/9/15 for new almond growers in Griffith.

• A Tree Planting Field Day to demonstrate GPS technology for preparing and planting almond orchards.	• A field day held 16/7/15 in Riverland.
• Trunk/Branch Diseases Workshop with Mark Sosnowski and Suzanne McKay (SARDI). The workshop presented outcomes from Viticulture research into vine trunk and branch diseases and the similarities to the Lower Limb Dieback to almond industry is observing.	• A workshop held 24/9/15 in Adelaide. • A project proposal developed by SARDI to address lower limb dieback. Preliminary sampling and testing of trees to guide application development.
• A Researchers Day was held prior to the 2015 Activated Almond R&D Forum to allow researchers to showcase their trials at Lindsay Point, Vic and facilitate networking amongst service providers.	• A forum held 27/10/15 in Riverland.
• A Carpophilus Beetle workshop with David Madge and Mofakhar Hossain (DEDJTR) was presented to Riverland growers outlining the latest findings from ongoing research.	• A workshop held 1/9/15 in Riverland.
• Ian Moss from Mossmont Nurseries, John Slaughter and Kaylan Roberts from Burchell Nursery and Brett Rosenzweig (ABA IDO) hosted a series of workshops and field walks on the topics of new varieties, tree training	• Four workshops and field walks held in Riverina, Sunraysia, Riverland and Adelaide Plains (20-30 Oct 2015).
Communication	
• 'In a Nutshell' newsletters - prepared and published articles in the industry's quarterly newsletter.	• Thirteen 'In the Orchard' articles prepared and published. • Nine 'R&D Update' articles prepared and published.
• Factsheets	• A factsheet – Supersoils. • Three factsheets – Carob Moth. • Two factsheets – Carpophilus Beetle. • A factsheet – Water Budgeting. • Eight factsheets – Californian Varieties. • Five factsheets – Australian Varieties. • A factsheet – Fruit Nutrient Removal. • A factsheet – Root-Knot Nematodes and Almond Rootstocks. • A factsheet – Self Fertility in Almonds. • A factsheet – Pollination Basics. • Ten factsheets – OrchardNet. • A Manual – Introduction to Almond Growing.
• Annual Almond Conference (2012, 2013 & 2014) - Assisted in organising and developing the annual levy payers meeting and conference program.	• Annual levy payers meeting. • Domestic and international presenter's abstracts/presentations delivered to stakeholders as per AL12702. • Two presentations provided by the IDM. • A presentation provided by the IDO.
• Photographic library and time-lapse photography – photos capturing key orchard operations, tree development, extension activities, etc. for promotional and communication purposes.	• Photographic library and time-lapse photography.
• Website – update information and notifications on industry website.	• Updated website.

The outcomes of the project have facilitated the growth of the Australian almond industry and have been many and varied. The following provides a summary of the major outcomes impacting on the industry's continued growth:

- Availability of planting material. The major overseas tissue culture company, Agromillora has recently established a facility in Mildura and is already rapidly multiplying the Spanish rootstock Garnem which is suitable for limestone soils. When the new orchards are mature, the forecast value to be generated from them each year is $460,000,000. This will add more than 6% to the value of Australian horticulture.
- The ABA is progressing the establishment of experimental and training orchards in SA and Victoria to develop and promote new production systems that address yield gains, crop risks from weather, improved input efficiency, enhanced quality and better food safety management. This is being done in consultation with HIA staff. As this progresses input from the research community and HIA staff will be sought to develop the projects to be undertaken on the orchards.
- Detections of Aflatoxin in Australian almonds in nine shipments to Europe led to an increase in sampling and inspection in the EU as from April 1, 2015. The ABA prepared briefing papers for the Commonwealth Department regarding the cause of the contamination and the industry's actions to address this food safety risk based on the research undertaken in the HIA project AL11009. The extension program for the control of Aflatoxin has been developed from the Victorian Department's research and has proven effective in reducing the number of breaches to two consignment totalling 40 tonnes from the export shipments to Europe in 2015 of nearly 26,000 tonnes.
- The ABA worked with the international nut industries to successfully have the European Commission maintain the 75ppm MRL for Fosetyl-Al residue in nuts. The testing of Australian product for Fosetyl-Al residue was undertaken and showed results up to four times the proposed EU MRL of 2ppm. The research trial work undertaken to have phosphorous acid registered in Australia provided valuable information to support the higher MRL in Europe. The ABA continues to work with the Californian nut industries to establish a Codex MRL that will be accepted in Europe.
- Extension of the research done on controlling insect damage caused by Carob Moth (AL12004) and more recently Carpophilus Beetle has been a priority and has halved the percentage of crop impacted to five percent in 2016.
- Good practice in the application of chemicals has been verified by the National residue survey with 100% compliance with MRL's. All the effort to ensure food safety is front of mind throughout the supply chain has safeguarded almond exports that represent 36% of the total value of Australian horticultural exports in 2015.
- The assistance of many new grower entrants into the industry estimated to increase plantings from 30,000 hectares to 45,000 hectares by 2018 has drawn heavily on the project's staff resources as they provided advice across the gamut of considerations in orchard establishment from varietal selection to irrigation infrastructure requirements.
- The assistance of project staff to researchers working on almond projects has been highly regarded and very valuable in ensuring the investment by almond R&D levypayers deliver a high rate return.
- The implementation of the Industry and R&D Strategic Plans has been central to the activities of the project and contributions have been made to achieving the following strategies:

3.1 Improve productivity & competitiveness across the value chain.
3.2 Safeguard industry production and marketing systems from potential biosecurity threats.
3.3 Support sustainable almond production.
4.1 Enhance skills and capacity to support current and future industry needs.
4.2 Develop and deliver effective R&D programs that support the Strategic Plan.
4.3 Support adoption of R&D outcomes by effective extension.
4.4 Facilitate the two-way flow of information through the value chain.

Evaluation and Discussion

Many of the extension activities were evaluated by participants and the results taken into account when preparing similar events. The project was monitored by the supply chain committees that met regularly throughout the duration of the project and the ABA Board of Directors received a briefing note on past and current activities for consideration at their quarterly meetings. The most telling evaluation of the project's value was the ABA Board's decision to continue to fund the program of activities once the Horticulture Innovation Australia funding concluded. Given the ABA Board represents 99 percent of industry production and hence R&D levy paid it can be taken from this that the project is considered to have been very worthwhile.

Since the end date for the project the ABA has appointed an additional Industry Development Officer to cope with the workload that has escalated during the period of the project due to the growth in the industry from 50,000 tonnes in 2012 to 80,000 tonnes in 2015 and the 50% expansion in orchard area currently underway. Further resources are also being considered by the ABA Board as the implementation of the Industry Strategic Plan is considered the basis for the success of the Australian almond industry that has grown to nearly a billion dollar industry in little more than a decade.

The research community has come to trust the vision for the future Australian almond industry and are working collaboratively with industry to achieve this. The co-ordination of the research effort provided by the industry development program is highly valued by industry and the research community.

The loss of the Voluntary Contribution funding is a concern to industry as it played a key role in securing early adopters to invest in new technologies and act as demonstration sites for the rest of industry.

Recommendations

With the loss of Voluntary Contributions funding which the industry utilized extensively to build the almond R&D program, the ABA is mindful that more funding is being sought from the R&D levy account. To alleviate the demand on the Pool 1 levy funds the ABA will continue to self-fund the industry development program in the short term.

Scientific Refereed Publications

Nil.

IP/Commercialisation

As the project was extending the outputs of other project there was no IP developed.

References

Nil.

Acknowledgements

The Almond Board of Australia acknowledges the willingness of the research community supporting the Australian almond industry to co-operate to bring their knowledge to bear on key issues in a collegiate manner with the project staff, other researchers and industry members. The ABA also thanks the many industry members that generously assisted in providing orchard space and management to field trials for projects. The contributions of overseas researchers that hosted study tours and also travelled to Australia to share their knowledge is much appreciated. Finally, the project staff appreciates the progressive attitude that characterizes the industry and facilitates change adoption and allows a focus on today's issues but permits investment in a production system research for well into the future.

Appendices

Nil

Outcomes

Evaluation and Discussion

Recommendations

Scientific Refereed Publications

Journal article

Orange, V., Apple, G.S., Banana, L.F., 2013. The nutritional profile of fruit varieties in Australia. *Journal of Horticultural Research* **163**, 51–59.

Whole book

Lettuce, I., Tomato, B.R., 2014. The Base Elements of a Salad (second edition). Vegetable Publishing, Melbourne.

Chapter in a book or Paper in conference proceedings

Broccoli, G., Capsicum, R.G., 2013. Growing fruits and vegetables. In: Peach, J.S., Avocado, R.D. (Eds.), Introduction to Australian Horticulture. Horticulture Publishing, Sydney, pp. 281–304.

Intellectual Property/Commercialisation

References

Acknowledgements

Appendices