Hazelnuts In Australia: Opportunities for long-term development

By Lester Snare and Stephen Gottschall
June 2017

AgriFutures™ Emerging Industries

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Foreword

There is growing worldwide demand for the European hazelnut (*Corylus avellana L.*), an important temperate zone nut crop. In Australia, pioneer efforts and past research supported by AgriFutures Australia and others has paved the way to build a knowledge base. It is now profitable to expand into larger scale commercial production. Current production is approximately 170 tonnes but is predicted to increase dramatically to between 2,000 and 3000 tonnes by 2020. Australian production is viewed as a potential $400-million-dollar industry. Expansion of the Australian hazelnut industry provides the opportunity to develop a year round fresh nut supply from this counter seasonal southern hemisphere source.

Agri Australis Pty Ltd is part of the Ferrero group, one of the largest global confectioners with 36 operating companies and 15 factories worldwide. The company has operations in Argentina, Chile, Georgia and Italy. In Chile the company has planted 3,000 hectares and encouraged a further 7,000 hectares from local farmers.

In 2011 and 2012 a large quantity of planting material was imported into Australia from South America by Agri Australis. The importation complied with Australian quarantine regulatory requirements. This planting material forms the basis for new large scale commercial plantings in Australia.

The support and track record of investment of a large confectioner provides confidence for a developing industry. Growers, investors and communities in Australia have the potential to benefit from buy back contracts with large processors. A strong local hazelnut industry will provide an alternative crop option for traditional tree crop producers looking to diversity or change crops. Communities also benefit from expansion of horticulture through increased employment opportunities in regional areas.

This report highlights the capacity of commercial hazelnut varieties to establish in warmer regions. This as well as commercial processor linkages provides confidence to growers and investors. Industry expansion will be assisted by recognising the boundaries for production in less traditional areas with available water and reasonably priced land.

Financial support for this project was provided by Agri Australis and AgriFutures Australia . NSW DPI provided significant in-kind support and resources including trial site locations and site management.

This report is an addition to AgriFutures Australia's diverse range of over 2000 research publications and it forms part of our Emerging Industries arena, which aims to support new and emerging rural industries.

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John Harvey
Managing Director
AgriFutures Australia

About the Author

Lester Snare has been involved with the development of the Hazelnut industry for over 25 years He has published a comprehensive producer's handbook, supported by Horticulture Innovation Australia Ltd and the Hazelnut Growers of Australia Ltd. He travelled to Chile with Biosecurity Australia in relation to the plant importation process mentioned in this report.

Previous projects include *Pest and Disease Analysis in Hazelnuts* (Horticulture Australia) and team member and co-author, *Hazelnut variety assessment for South Eastern Australia* (AgriFutures Australia).

Stephen Gottschall has supported temperate fruit and nut research for over 10 years with NSW DPI. His interests and skills include all aspects of pest, disease and orchard management.

Acknowledgments

This project is being conducted by NSW DPI and supported by Agri Australis and AgriFutures Australia.

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We also acknowledge the dedication of former AgriFutures Australia staff (particularly Alan Davey) who professionally assisted development of the project.

Finally we would like to thank Murray Spicer former Manager, Science, Strategy and Alliances NSW DPI who was involved from the initiation stage and whose enthusiasm and support is greatly appreciated

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Executive Summary

What the report is about

For Australian hazelnut producers the key aim is to grow regular high yielding and quality nuts. Profitability is the key driver for both small local growers and larger corporate agricultural enterprises.

This report documents the progress of three hazelnut trial sites planted in conjunction with a global confectioner and producer of hazelnuts. These sites have been established in warmer, less traditional areas and are providing insight into growth rates and management practices that require adaptation for plantings to be potentially successful in warmer regions. Investigations include water management, tree structure, phenology and developing strong early tree development strategies. This research is important because development of an industry in association with a large global confectioner has potential to provide an alternate long term market for producers. The project takes advantage of prior investment in research and development to expedite the development of large scale plantings of hazelnut in Australia.

The report focuses on the initial plant establishment phase and results to date.

Who is the report targeted at?

This report targets current hazelnut producers, those wishing to expand and those growers wising to plant in the future. There is interest by growers to produce in warmer regions, away from traditional areas where hazelnuts are thought best to grow. There is interest by growers to produce in warmer regions which offer many distinct advantages and potentially extend the area to which hazelnuts are traditionally thought best to grow. The report content is of interest to those horticultural and other primary producers located in warmer regions and who wish to diversify into nut production, some maybe members of the Hazelnut Growers of Australia Inc. Grower enquiries to NSW DPI has been and continues to come from a range of regional areas with many growers doing their own development work. Knowledge from the project will compliment this work.

The content is also of relevance to investors and advisors who are currently interested in investing in a crop with linkages to a buyer who is one the largest confectioners in the world.

Where are the relevant industries located in Australia?

Hazelnuts have been traditionally been grown in the cooler temperate areas of south-eastern Australia. Major production regions are the Central Tablelands of New South Wales around Orange/ Mudgee, and north-east Victoria around Myrtleford. Expansion of plantings has occurred in northern Tasmania whilst the largest recent expansion has occurred near Narranderra in NSW. Approximate estimates are that smaller plantings make up approximately 200 ha (ANIC 2016) whilst the large planting operated by Agri Australis is targeting 2,000 ha near Narrandera.

Current production in Australia is most likely less than 90 tonnes whilst consumption of kernel is about 2000tonne. Although theory based bioclimatology models for hazelnut expansion across Australia have identified potentially suitable regions for expansion, this report and associated research project highlights the applied aspects of tree establishment in less traditional warmer climates such as Yanco and Dareton in NSW.

Background

There is a high degree of interest by current Australian growers to expand their plantings into larger enterprises. Other horticultural producers have expressed interest to diversify into newer crops, and hazelnut production may have advantages over other fruit enterprises. These advantages include greater tolerance to hail and lower chemical inputs. Viticulturists in NSW and other states have expressed interest in replacing vine enterprises with hazelnut orchards.

As a major global processor of hazelnuts the Ferrero group is concerned about constancy of supply of fresh hazelnut kernel and the potential impacts this can have on the price of hazelnuts. Presently approximately 70% of hazelnuts are produced in Turkey. Risks to supply can be attributed to the susceptibility of concentrated production regions vulnerability to events that impact production. For example, in 2004 a single frost event in the Black Sea significantly affected the global availability and distribution of kernels resulting in premium prices. With the aim of diversifying production regions and securing constant, reliable hazelnut supply, the Ferrero group has identified Australia as a country suitable for hazelnut production.

In 2011 a large quantity of planting material was imported from South America and has the potential to form the basis for large scale commercial plantings in Australia. This import was one of the largest plant imports into Australia. Following clearance from quarantine Agri Australis established a large plantation and nursery facility. The establishment of a planting by the wider Ferrero group forms part of the industry expansion. It is likely that third party producers will also be interested. As the production of hazelnuts increases, the linkages with a company with an end use of the product may provide a degree of confidence to potential growers. Researchers from the previous AgriFutures Australia supported projects acknowledge the limitation of the original work in relation to warmer temperatures.

Aims/objectives

New industries require a competent RD&E program to provide confidence to investors that any problems arising can be resolved. This project aims to address some of those issues identified by commercial interests and issues previously identified from AgriFutures Australia research conducted in Australia. These include:

1. Value adding to previous varietal evaluation work by assessing hazelnut productivity in warmer regions for large scale plantings using the MIA as an example.

2. Determining irrigation requirements of hazelnuts in warmer regions.

3. Determining the optimum tree architecture for variety and how this interacts with the environment. i.e., Multi-stem may be more suitable in warmer regions vs. a single stem approach.

4. Improving knowledge of nursery and tree establishment practices particularly in warmer climates.

5. Identifying chemical registration requirements in line with IPM practices and registering with APVMA as required.

Methods used

Three trial sites were established in 2012 in collaboration with Agri Australis Pty Ltd. on 0.5 hectare blocks in three regions in NSW Trial blocks were established at two hot climate sites at Yanco and Dareton and a third block at Orange in a cooler, more traditional climate for

hazelnuts. The block at Orange was established to compare performance against the warmer climates and gain knowledge of previously untested varieties in Australia. Each 0.5 hectare trial block is planted with 250 trees.

Soils at all sites were different but representative of horticultural soils in each region. Sites were planted with a selection of productive commercial varieties identified from previous AgriFutures Australia projects plus new varieties recently imported by Agri Australis. The varieties planted have a range in chilling requirements. Some having a lower chilling requirement making them potentially more suitable in warmer regions. Tree establishment, growth rates and phenology were documented at each site to provide insight into production in warmer regions and identify the water usage patterns and cultural practices required to provide maximum growth rates. Nutritional status of the plantings was monitored to ensure levels remained consistent with international recommendations. Light traps were operated at two sites and at the Agri Australis property at Narrandera to identify potential pests that may present problems as production expands in each region.

Results/key findings

Tree establishment

Hazelnut trees at Yanco and Dareton were resilient to the extreme summer temperature with continued growth and high rates of establishment. Plants have resisted consecutive heatwaves and tolerated maximum temperatures in excess of 45°C. To allow protection from heat plants were managed as a bush during the establishment phase. Tree structure has been created and the tree canopy can now begin to provide not only protection but a structure to develop yield. Tree establishment is possible in hot climates and tree canopy management may increase the success of tree establishment.

The Orange/control site, as anticipated, is showing well above district growth rates with some nuts harvested in in February 2017. This site is providing a benchmark for Agri Australis management and agronomists.

The use of potted plants which has not been traditionally practised in Australia has shown promise in terms of initial establishment in hot climates. Adoption of some of the above practices has potential to reduce replants, establish plants in relatively hot environments and extend the window for planting via use of potted plants.

A further outcome, tree age considered, is the development of commercially acceptable levels of female flowers. This is encouraging as it continues to indicate sufficient chilling.

Irrigation

Multiple irrigations per day provide resilience and mitigate effects of heat. A further key outcome over the past four years is knowledge related to water management related to hazelnut and the fibrous root system.

Chemicals

Four chemicals were registered on behalf of the hazelnut industry during the life of this project. The applications were initiated in the early stages of this project in association with the AgriFutures Australia supported NRIA registration project and the Hazelnut Growers of Australia Inc. A key pest targeted was the hazelnut aphid.

Communication

The exchange of information with a large producer with experience of production in a range of climates in other parts of the world has potential to assist the future of hazelnut development in Australia.

Additional

Knowledge gained from contents of light traps will be advantageous for all hazelnut growers to detect presence of pests, in particular the fruit tree borer which has potential to cause severe damage if not controlled.

Implications for relevant stakeholders

The key implication of this project is that commercial hazelnut varieties can be established in the MIA environment and other warmer areas in Australia. Recognising the boundaries for production in areas that are less traditional, that have available water and land at suitable cost will assist industry expansion. Gaining knowledge of these areas and the environment in relation to hazelnut growth will allow for potential larger economies of scale. This has potential to make Australia less reliant on imports and supply commercial quantities of hazelnut kernel to commercial processors.

The research has wider implications in terms of offering producers strategies to deal with climate change issues. These strategies may well be used by growers in traditional growing areas to protect against warmer summer conditions.

Expansion of horticulture/employment opportunities in regional areas is another key benefit identified, in this case, in the region around Narrandera, Yanco and Leeton.

Growers, investors and communities in Australia have the potential to benefit from buy back contracts with large processors.

Environmental benefits are apparent as hazelnut cultivation is traditionally based around low chemical inputs in comparison to other tree crops. This crop offers growers the opportunity to develop plantings with minimal pesticide usage. In terms of bacterial and fungal disease production in warmer climates may have advantages over higher rainfall regions.

Recommendations

The presence of a large global confectioner and grower organisation in Australia has potential to contribute to a counter cyclic industry in the Southern hemisphere to ensure year round supply of fresh nuts. This project has identified opportunities for third party growers in Australia to grow hazelnuts and importantly provided some background to establishing trees in less traditional areas.

The linkages between grower and confectioner warrant exploration as they have potential to expand Australian production. This has been the case in other parts of the world where local plantings have expanded when a key stakeholder is present. Past Hazelnut Growers of Australia Inc. conferences have highlighted the importance of a key stakeholder to move an industry forward.

The availability of large quantities of plants potentially available from a key stakeholder makes large scale planting a reality in Australia. Cultural practices in this report can assist potential growers.

Introduction

The hazelnut industry in Australia currently produces170 tonne in shell (ANIC 2017), and consists of small family orchards with up to 6,000 trees. Hazelnuts are sold in small quantities for premium prices to local niche markets such as farmers markets or directly to value adding processors. Many plantings provide supplementary sources of income for growers and varieties grown are not necessarily those required by the locally existing processors. This is set to change with large scale plantings recently being established in NSW.

Currently, Ferrero Australasia imports approximately 2,000 tonnes of raw hazelnuts to meet local processing demands. As the one of the biggest consumers of hazelnuts globally, the processor has attempted to develop counter cyclic production sites in southern hemispheric areas to reduce fresh nut storage requirements and to ensure increased post-harvest freshness of product while mitigating risk due to environmental events. As part of this counter-cyclic production, the Ferrero wishes to establish and support hazelnut plantings in Australia. They have established, in conjunction with local farmer participation and support, about 10,000 Ha in Chile and another 1,000 ha in South Africa.

Australia exhibits favourable and stable geopolitically and environmental aspects. Traditional areas of production in other parts of the world combined with political instability, quality issues and increasing freight costs have made processor and growers search out new regions for hazelnut production. Some of these countries include Chile, Argentina and South Africa. Based on experience in South Africa about 750,000 plants are required as propagating stock to establish an industry. This critical mass allows plantations of scale. Land costs and availability of water are obvious key considerations in establishing large scale plantings.

Over 90% of the world's supply is sourced from the northern hemisphere. This implies that the crop is typically stored and fresh product is not available for another 12 months. If not stored appropriately then quality is compromised. This is of potential concern to processors.

Australian plantations have potential to provide a second crop into the northern hemisphere to provide a fresher nut as required by discerning consumers. Producers in Australia are well placed to supply the emerging markets of China and India as consumer growth increases.

A recent successful importation of commercial numbers of hazelnut plants and consequent multiplication by Agri Australis has expanded the potential for the development of large scale plantings in Australia. The scale and size of this plant importation, one of the largest attempted in Australia, forms the basis for development of larger scale plantings.

Prior to any importation, the Federal Department of Agriculture undertook a pest risk analysis to identify hazelnut pests and diseases currently in Chile and Australia. This extensive report is available on the Department of Agriculture website. (Biosecurity Australia 2011) The report found that after a process of due diligence, and consideration of pest and disease issues, the importation could proceed under conditions. The process of importation of plants from Chile to Australia was a long and thorough one. The process required collaboration and co-operation from agencies in the exporting country, the importer and federal and state agencies in Australia. NSW DPI collaborated with Biosecurity Australia and AQIS to provide technical assistance with this import. (Snare and Watson 2014) An open quarantine site was established at the NSW DPI Yanco Agricultural Institute, in NSW.

Following clearance from quarantine Agri Australis established plantings in the Riverina area of NSW. Stock utilised in the Riverina enterprise is based on material directly imported from Agri Chile nurseries in Chile. The trial sites reported in this document were planted in winter 2013, one year ahead of the commercial planting in the Riverina. The planting comprises Australian sourced varieties and plants imported from Chile.

Objectives

This project is an industry development project and takes advantage of prior investment in research and development to expedite the development of large scale plantings of hazelnut in Australia. The major objectives of this research project are centred in the areas of industry development as well as developing and improving the knowledge base and skills relating to physiological and environmental aspects of hazelnut production in warmer climates. This project also aims to develop and implement regulatory requirements to meet current and future hazelnut industry needs. The project has investigated improved nursery and tree establishment practices to facilitate expansion into warmer climate regions and to benefit the existing hazelnut industry

The time frame of this project precludes yield assessments as the plants are not of full bearing age. As such, the objectives need to be viewed in the context of plant establishment.

The objectives of this project are:

- Varietal evaluation work assessing hazelnut productivity in warmer regions for large scale plantings using the Murrumbidgee Irrigation Area (MIA) and Sunraysia as indicative examples.
- Investigation to determine efficient requirements and use of irrigated water for hazelnuts in less traditional warmer regions like the MIA/Sunraysia areas.
- Investigation to determine optimum tree architecture and how this interacts with the environment.
- Extending the existing pest and disease knowledge base to incorporate new areas of production.
- Investigating nursery and plant establishment techniques and practices which cater for expansion into different environmental climatic zones as well as the existing established hazelnut industry areas.
- Identification of chemical registration requirements in line with IPM practices and registering with APVMA as required.

Methodology

Three trial sites were planted in 2013 on NSW DPI properties at Yanco, Dareton and Orange. Significant collaboration occurred with the commercial operator in terms of determination of trial site locations, ground preparation, varietal composition, design and irrigation infrastructure (Snare 2014). The Yanco trial site is adjacent to the former Agri Australis quarantine site, now used for hazelnut nursery production. Area of the trial plots is 0.5 ha and they are planted with a selection of productive commercial varieties identified from previous AgriFutures Australia projects and some new varieties resulting from the importation program. Row spacing is 5m by 4m giving a density of 500 trees/ha. The design simulates a commercial planting in that the majority of the planting of main production varieties are in full rows of one variety for ease of harvesting. External buffer rows are mixed. Proximity of production/main varietal rows to each other was based on pollen compatibility and timing of pollen shed in relation to female bloom.

The inclusion of the Orange site provided a reference and allows observation of varieties in a cooler climate. Some of the varieties included in the study had not been grown previously in Australia and it was relevant to collect information such as timing of flowering on these varieties in more traditional areas.

All 3 blocks are irrigated with a double row of above ground poly laterals containing inline drippers. Systems were equipped with capacity to fertigate as required. Soil moisture was monitored using tensiometers and MEA G Dots. Soil testing was completed at commencement in 2013 at each site and annual consecutive nutritional requirements were determined by leaf analyses through NSW DPI NATA accredited commercial testing service laboratories at Wollongbar. The table below shows the irrigation capacity of each site.

Table 1. Irrigation capacity of trial sites

Site	Dripper spacing (m)	Row length (m)	Row width (m)	Tree spacing (m)	Trees/ hectare	Lines/ row	Row length/ hectare	Line length/ hectare	Dripper/ hectare	Dripper rate	Volume/ hour/ hectare
Orange	0.5	100	5	4	500	2	2,000	4,000	8,000	2.3	18,400
Yanco	0.3	72	5	4	500	2	2,000	4,000	13,333	1.6	21,333
Dareton	0.5	100	5	4	500	2	2,000	4,000	8,000	1.6	12,800

Growth rates, flowering times, productivity, and water consumption were monitored in all blocks. A multi stem approach to tree shaping was used to reduce effects of sun damage to stems. Experience in warmer climates has proven multi stemming to have a protective role in early plant development and a capacity to recycle limbs if damaged.

Light traps were deployed at each site to gather some background data. This was particularly relevant for Yanco and Dareton sites where hazelnuts are not widely planted.

Project Specifications

Site Locations

Yanco

The Yanco hazelnut site is located on the Yanco Agricultural Institute situated in the centre of the Murrumbidgee Irrigation Area between Wagga Wagga and Griffith in NSW (34.63° S) The area consists of mixed irrigation and dryland farming country. With an elevation of 150 m, the area experiences hot, dry summers and cool, damp winters. Temperatures can range from a minimum of –3˚C in winter to a maximum of 42˚C in summer, with an average rainfall of 433 mm. Irrigation requirements are supplied from the Burrinjuck and Blowering Dams via the Murrumbidgee River and an extensive canal system. Soils are variable and range from grey self- mulching clays to lighter sandy soils. The trial site is a lighter sandy soil.

Dareton

The Dareton site is located on the Agricultural Research Institute in the Coomealla irrigation area, 3 km from Dareton and 10 km from Wentworth in NSW (34.0944° S). Wentworth is situated on the junction of the Murray and the Darling rivers, Australia's largest rivers. Dareton has an altitude of 60 m. The area forms part of the progressive fruit-growing areas of the Sunraysia District of New South Wales and Victoria, and the Riverland area of South Australia.

The main horticultural industries in the region around the Dareton site are dried vine fruit and citrus. Minor crops include avocados, stone fruit and pistachios. The climate is dry with warm to hot summers and mild winters. Mild frosts occur during the winter months. Average total rainfall is 280 mm and evaporation is high at 2400 mm per year. The Dareton site is a light textured sandy loam with some clay at depth and typical of citrus plantings in the area.

Figure 1. Hazelnut rows with sudex inter-planting at Dareton

Orange

The hazelnut trial block at Orange is located at the Orange Agricultural Institute in the Central Tablelands of NSW (33.32° S) at an elevation of 920 m. The site had previously been planted to hazelnuts for approximately 15 years prior to establishment of the current site. The relatively cool district climate suits pome fruit product production, viticulture and other temperate deciduous fruits requiring winter chilling. Average rainfall is 928 mm. Total annual rainfall in the district also varies with altitude and topography but with lesser rainfall during autumn. Snow usually falls in the district several times each winter. The soil is volcanic in origin and typical of a red krasnozem.

Site preparation attempted to be standardised across all blocks but accounted for any site differences and histories. Generally blocks were ripped and pH adjusted. Lime was omitted from the Dareton site due to the alkaline nature of the soil. The orange site was previously planted to hazelnuts and organic matter was added prior to planting.

Figure 2. Soils typical of the three sites

Table 2. Temperature and rainfall range of hazelnut trial sites

Major Characteristics of Hazelnut Trial Sites

Site			Orange	Dareton	Yanco
	Latitude (°S)		33.32	34.10	34.63
	Longitude (°E)		149.08	142.01	146.43
	Elevation (m)		920	60	150
		Max	18.1	24.3	24.1
		Min	7.2	11	11.4
		Max	26.5	32.9	33.9
		Min	13.3	17.1	18.8
		Max	9.5	15.6	14.3
		Min	1.5	4.8	5
		Max	39.2	48.1	46.1
		Min	-5.6	-2.8	-3
	Mean		929	287	406
	High		1592	705	737
	Low		324	102	156

All blocks were fertigated and annual plant nutrient levels were monitored through leaf tissue analysis.

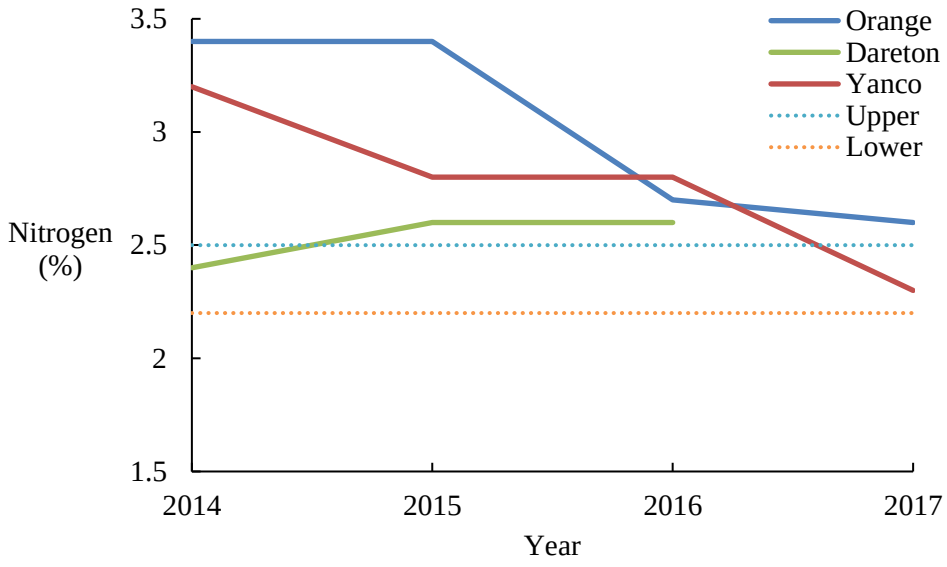


Figure 3. Leaf nitrogen levels at trial sites

Varieties

Varieties included in the three sites were sourced from Agri Australis, these included some Australian sourced material such as Ennis, Lewis and Tokolyi Brownfield Cosford (TBC) and also material derived from the importation process in 2011and 2012. It is recognised that Ennis, Barcelona, TBC and Lewis are popular varieties for some Australian growers and so these were also included in the plantings.

Table 3. Varieties included in trial sites

Azul*	Halls Giant	San Giovanni*
Barcelona	Jemtegaard No. 5	TBC
Blanco*	Lewis	Tonda Gentile delle Langhe
Casina	Mortarella*	Tonda Di Giffoni
Ennis	Nocchione*	Tonda Romana

*Varieties new to Australia

Characteristics of the varieties are well documented from previous studies in other parts of the world and Australia. In Australia, Azul, Blanco, Mortarella, Nocchione and San Giovanni were part of the importation in 2011 and 2012 and are relatively untested as pollinisers. These varieties were imported predominantly as polliniser varieties for main varieties such as Tonda Giffoni, Barcelona and Tonda Romana. They may be useful pollinisers for other main varieties if timing and genetic compatibility are considered.

Pollen shedding data contained in this report shows that these polliniser varieties in Orange range from being one of the earliest i.e. San Giovanni first week of June to Blanco which sheds pollen into mid-August. These varieties have potential to be useful additions to the Australian hazelnut industry.

Environmental Conditions

2013 – Year of Planting

Weather conditions coming out of a winter planting in 2013 proved challenging at Yanco and Dareton. 2013 was the warmest year on record for NSW maximum temperatures up until that point, and the third-warmest for mean temperatures. January and September recorded the warmest maximum temperatures on record. Both Dareton and Yanco recorded temperatures above 40°C with Yanco recording 44.8°C and nearby Narrandera 45.3°C on the 5th January. The benefits of a well-developed root system that could establish quickly was essential. Some losses were experienced at all sites but most noticeable is the survival of nearly 100% of potted plants as opposed to bare rooted plants. Mortality rates of potted vs bare rooted plants are presented below.

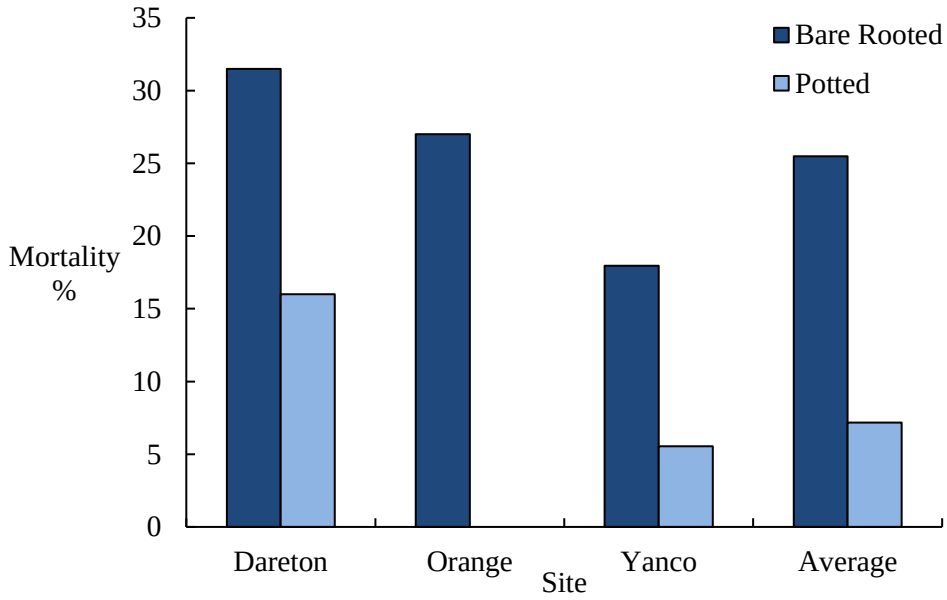


Figure 4. Planting mortality rates of potted versus bare-rooted trees

2014

New South Wales surpassed its 2013 record and recorded it warmest year on record (for maximum and mean temperatures) in 2014 with several heatwaves and persistently warm conditions across the State. Yanco and Narrandera reached 44°C. Trees continued to produce growth through these intense conditions. Following two consecutive years (2013 and 2014) of heat wave conditions plants were left unpruned to maintain more leaves for protection during the development phase. At all sites soil moisture was maintained at approximately 25 kpa and site were irrigated when moisture reached 30 kpa.

Figure 5. Two year old tree at Yanco

2015

New South Wales recorded well above average temperatures in 2015 and although not record breaking was the equal seventh warmest year for state-wide average mean temperatures. Maximum high temperatures of 43°C and 42°C were recorded at Narrandera and Yanco. Despite a warm spring, trial plots produced female flowers. Measurements of tree row volume (TRV) were taken.

Given that trees were trained as a multi stem plant, TRV was a suitable measure of vigour. As a component of tree row volumes height is a useful measurement. The figures below show establishment of trees and tree height in relation to the control block at Orange and tree row volume.

2016

2016 was the sixth-warmest year on record for NSW means temperatures, 1.08°C above the historical average. A prolonged heatwave affected much of Australia during the course of late February and the first half of March. Mildura/Dareton recorded 9 consecutive days of maximum temperatures above 37°C, Yanco recorded similar. Some heat stress occurred at Dareton as evidenced by leaf scorch, but growth, as in past years continued through the season. TRV measurements were again conducted.

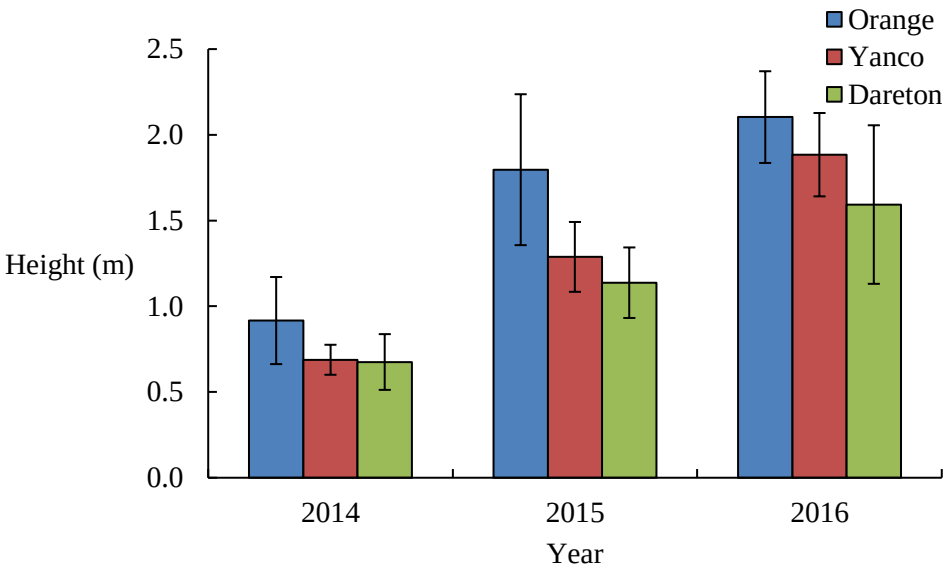


Figure 6. Average tree heights across trial sites

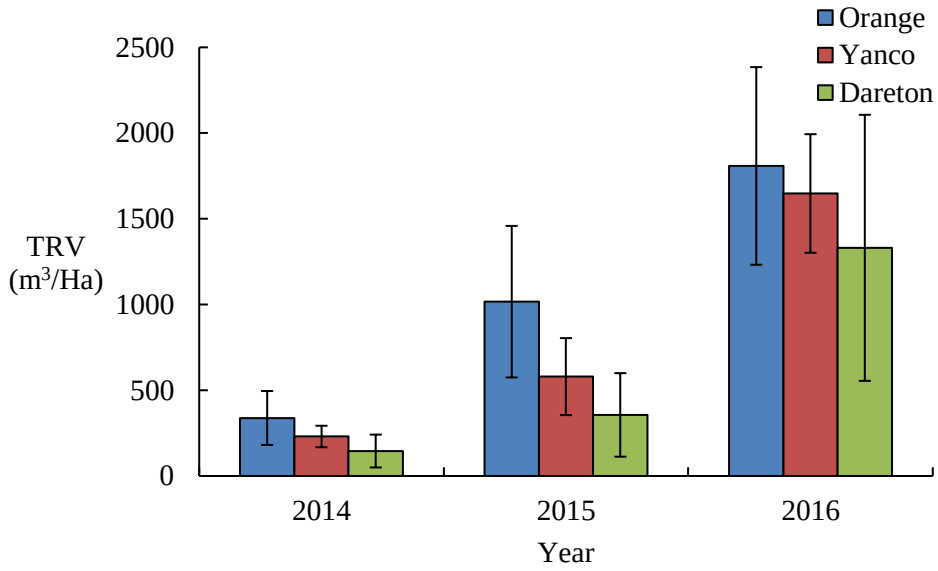


Figure 7. Average tree row volumes across trial sites

Flowering

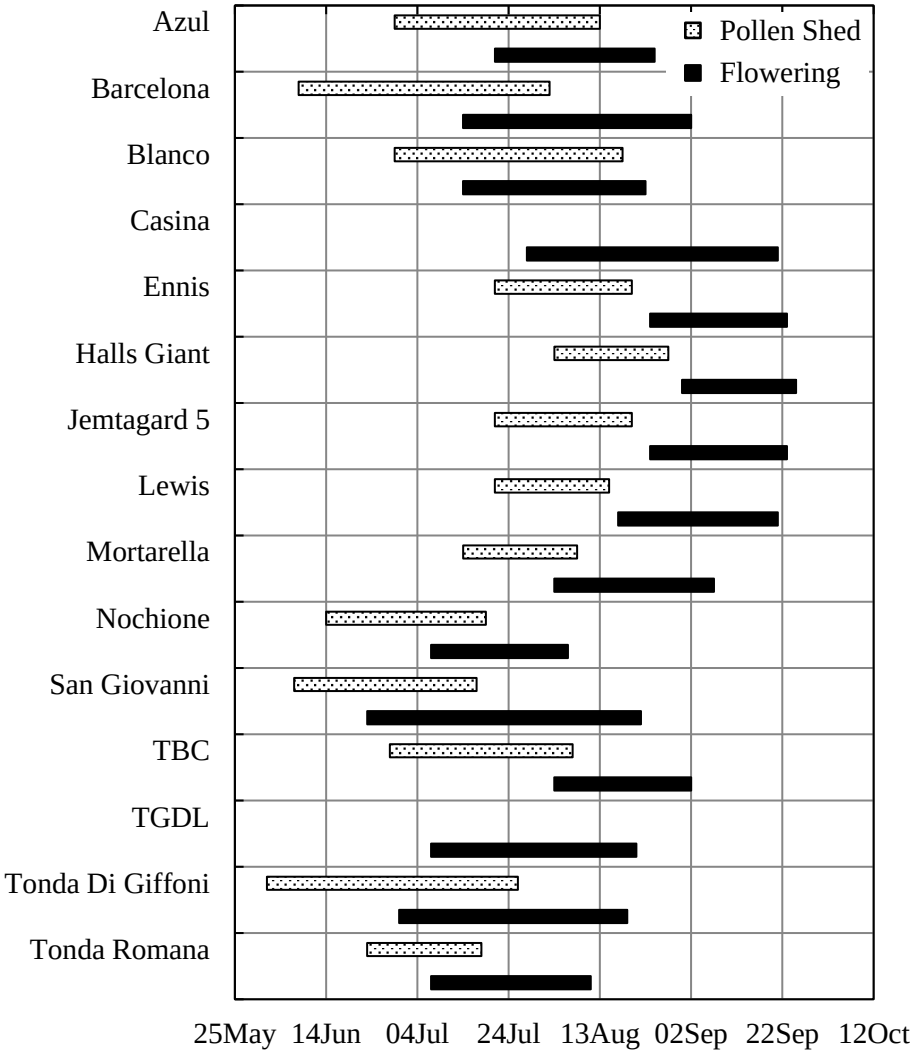
Flowering and pollen shed in Orange was consistent with previous studies conducted in NSW. New varieties imported to Australia are also included. These can be related to the traditional production varieties that currently exist in Australia. Orange flowering preceded Yanco and Dareton by about 7 to 14 days depending on variety. The juvenility of all the plantings should be considered when discussing flower development.

Female flowers were evident at all sites which is significant for the warmer sites as female flower chilling requirement in *Corylus avellana* is greater than the catkin requirement. The requirement for leaf bud development is higher than both. Barcelona, Casina, Ennis,Tonda di Giffoni, TGDL and San Giovanni all had some catkin development at Yanco. It is also noted that some catkin drop occurred at all sites most likely related to heat wave conditions.

Catkins of Jemtegaard #5, a late polliniser variety remained resilient through the warm summers at all sites. At the Orange site catkins of Casina and TGDL shedded prematurely limiting observations.

In winter 2016 a Lanzoni pollen sampler was used by Agri Australis to sample for pollen in a small local mature orchard in Orange. Although not an initial part of the methodology of this project it was a preliminary investigation into quantity of pollen and pollen viability. Pollen samplers were operated in Chile as part of commercial operations in commercial mature orchards. It is interesting to note that in Chile at Camarico and Korta total pollen concentrations were similar to that of the Orange orchard. This type of data can be used in Australia to better understand pollen quantities and quality in relation to other production areas in other parts of the world.

Table 4 Pollen shed and female flowering periods at Orange



Irrigation

The charts below show amount of water applied at all sites. Tensiometers were installed at multiple depths and the irrigation systems were automated to provide multiple watering's. A tensiometer reading in the range of 8-25Kpa is considered the optimal soil moisture levels for tree growth. Levels were maintained within this range. The following irrigation schedules were developed from observations, local experience and reading of soil tension measurements. There is scope for refinement of these schedules as trees mature.

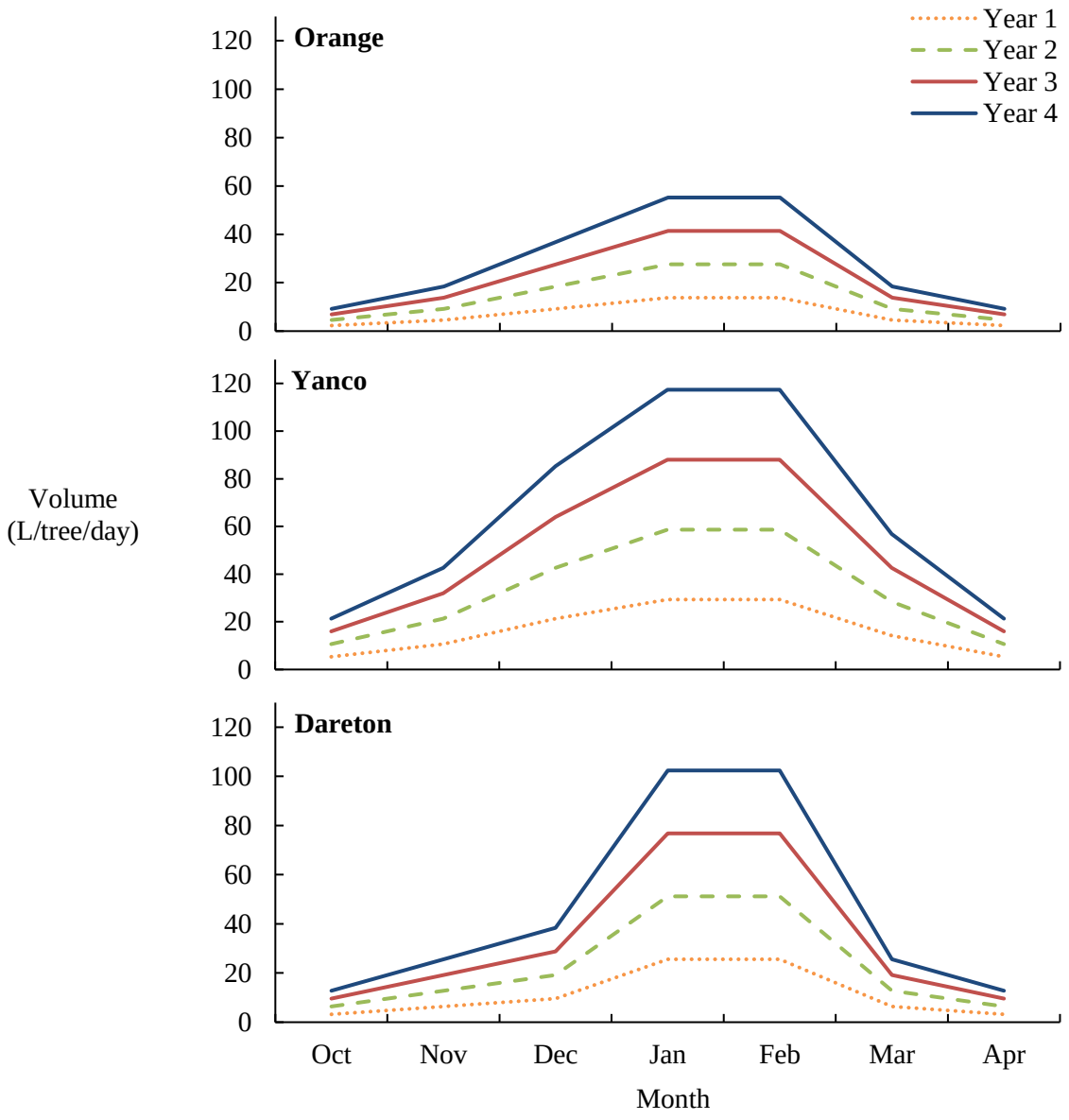


Figure 8 Irrigation schedules for trial sites

Results

This project represents an initial plant establishment phase and so yield data does not form a large component of this report. The trial blocks will be supported into the future by Agri Australis and so yield figures will become available.

Previous research in Australia shows the variety Tonda Di Giffoni producing 0.5 kg/tree at year 5 in a traditional cool climate. At the Orange trial site, the Barcelona trees produced an average of 1.1 kg/tree which was harvested in March/April 2017. These are only preliminary yield results, but shows the potential for Barcelona to yield 0.5 T/ha in the 4th summer when planted at 500 trees/ha. In addition, nut production is commencing at the warmer sites with a handful of nuts produced to date. The results aligned to the key objectives of tree establishment in less traditional areas are positive.

- Hazelnuts are resilient and show continued growth despite extremely high temperatures at Yanco and Dareton, over four summers. Of note was 13th Jan 2016 at both Dareton and Yanco. During the establishment phase plants have been managed as a bush to allow protection from heat. Structure has now been created and the tree canopy management can now commence to provide not only protection but a structure to develop yield. This is a key management strategy for tree development at these extremely warm sites

- The use of a multi stem plant through the establishment phase has proved beneficial in the warm climates of Yanco and Dareton. Although sucker removal is practiced generally in the industry there is a role for suckers to protect from sunburn and sand blasting, particularly in the sandy soils around Dareton. This strategy may not be so relevant in tableland environments

- At all trial sites, the potted plants had a survival rate of nearly 100%, which was greater than the survival rate of bare rooted plants. Production varieties such as Tonda Di Gifoni, Barcelona, TBC and associated pollinisers have performed well at all sites which is encouraging in terms of establishment. In addition to increased survival rates, the use of potted plants can also extend the window for planting, given that pots are well managed.

- The Orange site was previously planted to hazelnuts for over 15 years. It is significant that this site to date appears to suffer from no replant issues and is producing growth superior to that of previous variety trials conducted at the institute.

- Female flower development has occurred at all sites indicating that chill is sufficient for female flower initiation.

- An understanding of water management has developed over the tree establishment stage. In season 2016/17 the Orange site utilised 3 ML/ha whilst Dareton utilised 4.8 ML/ha. This is based on trees with maximum vigour.

- An objective of this project also included minor use registration of chemical options to provide support for growers, four chemicals were registered. NSW DPI prepared and lodged application for winter oil for use in hazelnuts. This relatively safe chemical has the potential to break the pest cycle on a number of pests. Discussions regards this registration included Hazelnut Growers of Australia Ltd (HGA) and the AgriFutures Australia supported NRIA registration project

- Other applications were initiated in the early stages of this project in association with the AgriFutures Australia supported NRIA registration project and the Hazelnut Growers of Australia. These included:
  - Pirimicarb / Hazelnut Aphid
  - Imidacloprid-Various Pests
  - Potassium Bicarbonate – Various Diseases
  - Bacillus Thuringiensis – Various Pests
  - Mono-Di Potassium Phosphite – Various Diseases

Light trapping data has provided a snapshot of potential pests that could affect hazelnut plantations in these newer warmer areas. It is significant that no fruit tree borer *Maroga melanostigma* was recorded but further trapping over longer periods and earlier in the season to determine presence is required. Results of light trapping are in Table 5.

Figure 9 Tree growth and multi-stem system at Orange.

Table 5. Light Trap Results.

Order	Family	Common Name
Coleoptera	Elateridae	click beetles
Coleoptera	Hydrophilidae	water beetles
Coleoptera	Scarabaeidae: Melolonthinae	scarab beetles*
Coleoptera	Meloidae	blister beetles
Coleoptera	Dytiscidae	predaceous diving beetles
Coleoptera	Staphylinidae	rove beetles**
Coleoptera	Heteroceridae	mud-loving beetles
Coleoptera	Scarabaeidae: Aphodiinae	*
Coleoptera	Lycidae	net-winged beetles
Coleoptera	Pselaphinae	antlike stone beetles
Coleoptera	Anthicidae	antlike flower beetles
Coleoptera	Scarabaeidae: Bolboceratinae	truffle beetles*
Coleoptera	Dytiscidae	predaceous diving beetles
Coleoptera	Haliplidae	crawling water beetles
Coleoptera	Heteroceridae	mud-loving beetles
Coleoptera	Carabidae	gound beetles**
Coleoptera	Noteridae	burrowing water beetles
Coleoptera	Notonectidae	backswimmers
Coleoptera	Heteroceridae	mud-loving beetles
Coleoptera	Staphylinidae	rove beetles*
Coleoptera	Scarabaeidae: Dynastinae	rhinoceros beetles
Coleoptera	Scarabaeidae: Heteronychus arator	African black beetle*
Coleoptera	Elateridae	click beetles
Coleoptera	Carabidae: Harpalinae	ground beetles**
Coleoptera	Scarabaeidae: Melolonthinae	scarab beetles*
Coleoptera	Hydrophilidae	water beetles
Coleoptera	Scarabaeidae: Heteronychus arator	African black beetle
Coleoptera	Carabidae: Harpalinae	ground beetles**
Coleoptera	Hydrophilidae	water beetles
Diptera	(Nematocera)	midges
Diptera	various	flies and midges
Hemiptera	Miridae	plant bugs
Hemiptera	Notonectidae	backswimmers
Hymenoptera	Apidae: Apis mellifera	honeybee
Isoptera	Termitidae	termites*

Order	Family	Common Name
Lepidoptera	various	moths*
Lepidoptera	Noctuidae: Spodoptera	armyworms*
Lepidoptera	Noctuidae: Agrotis infusa	Bogong moths
Lepidoptera	various	various, mainly grass moths
Lepidoptera	Pyralidae	snout moths
Lepidoptera	Gelechiidae: Catoryctis sp.	concealer moths
Lepidoptera	Anthelidae: Anthela denticulatus	lappet moths
Lepidoptera	Erebidae: Utethesia pulchelloides	heliotrope moth
Lepidoptera	Pyralidae	snout moths
Trichoptera	various	caddisflies

***Potential Pest; **Predator**

Implications

Economic Benefits

This project has focused on tree establishment. Once larger scale farms commence production there is potential for growers, investors and communities in Australia to benefit from buy back contracts with large processors. Opportunities for construction of processing and harvesting equipment are one of the many flow on benefits involved with this development. Ferrero views Australian production as a potential $400 million industry. The company anticipates an investment of around $40 million initially.

The value of nut exports across the broader nut commodity group exceeded AU$900 million in 2015-16 and is projected to exceed AU$1 billion within the next few years (ANIC 2016). Buoyant markets and sound business models can facilitate continued investment.

Commercial production will allow processors within Australia to replace imported kernels, source higher quality kernels and increase processing capacity. Other benefits include provision of an alternative crop option for traditional tree crop producers. Many pome, stone, and grape producers are looking to diversify due to new trade agreements allowing imported fruit into Australia. Development of the industry in association with a key processor has potential to provide an alternate long term market.

Environmental Benefits

Hazelnut cultivation is traditionally based around lower chemical inputs in comparison to pome and stone fruit production. This crop offers growers the opportunity to develop plantings with minimal pesticide usage.

Bacterial blight is a key disease and has proven to be difficult to control in tableland environments but it may be less relevant in warmer and drier regions. This appears to be the case in dry areas of Chile where plantings have minimal bacterial issues.

Water delivery systems to tree crops are efficient when compared to some other crops Targeting and monitoring water usage at key stages will allow for efficiencies to be better understood.

Hazelnuts trees are long lived, up to 80 years and varietal change is less than pome and stone fruit trees. These crops can be removed every decade or less due to market demand and consumer preference. The kernel market is stable, in particular the confectionery segment and so hazelnut production allows for long term sequestration of atmospheric carbon.

Recognising the boundaries for production in areas that are less traditional, that have available water and land at suitable cost will improve the knowledge base around hazelnuts.

Recommendations

This project has some positive results in terms of the establishment of hazelnut trees in different climatic regions of NSW. In order to properly support industry expansion further work is required and ongoing assessments of the progress of the trial site is needed to gain an understanding of the productivity of hazelnuts in these different regions. Based on this, recommendations are:

- Continue to take phenology observations and yield data at Dareton and Yanco to ascertain the true potential of productivity levels
- Identify chemical permits to be extended or negotiated for more permanent usage patterns
- Continue to identify pest threats in warmer climates in particular scouting for fruit tree borer.
- Continue collaboration with existing commercial enterprises to facilitate development of the industry and associated knowledge base
- Facilitate the broader distribution of newly imported polliniser varieties to the Australian industry

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Appendix

Hazelnut articles

1. Australian Nutgrower, *Hazelnut project in the Riverina*, June 2014
2. Australian Nutgrower, *Assessing potential for hazelnuts*, June 2014
3. Australian Nutgrower, *Importation of hazelnut planting material from Chile*, December 2014

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