Australian almond industry study tour of Spain

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Almond Board of Australia (ABA)

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Study Tour:

Australian almond industry study tour of Spain

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Almond Board of Australia Inc

Project Number: AL13701

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Purpose of Report
This Study Tour Report has been prepared following the conclusion of travel to Spain in May/June 2014. The report summarises the outcomes of the study tour and how they relate to improving the Australian almond industry's productivity, harvesting systems and product quality.

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

June 2014

Table of Contents

Index of Figures

1 Media Summary

The Australian almond industry has sought to further enhance its productivity and safeguard the profitability of its growers.

The Australian almond industry is under constant pressure to maximise yield and profit in an environment where costs of production are continually increasing. Whilst this is consistent across its competitors, the cost of growing almonds in Australia begins from a higher base. With this in mind and the fact that large portions of the industry will require replanting at a similar time following the rapid expansion of the mid-2000s, it is critical future Australian almond orchards can maximise yield quickly and affordably. With 10-15 years still remaining in most orchards across the industry, now provides an opportune time to research and develop new competitive production systems and transform the industry. The industry can take comfort that other industries such as pomefruit have successfully met the same challenges in the past and their experiences are available for learning.

This study trip aimed to showcase dwarfing *Prunus* rootstocks, alternative tree training systems, increased planting densities, improved plant propagation techniques and alternative harvest systems that would see a holistic approach to developing future almond orchards and an appropriate R&D program.

The key outcomes of the study tour were:

- Understanding of three dwarfing rootstocks currently available for almonds.
- Approximate row and tree spacings that require R&D for high and super high density plantings.
- Potential tree training systems are available for high and super high density plantings.
- Improved understanding of the challenges and opportunities in adopting a new orchard production system.
- Almonds that fall to the ground (i.e. windfalls) prior to harvest are likely to be a barrier against the adoption of shake and catch harvesting equipment.
- Current Californian cultivars may not suit infield hulling; Spanish hard shelled cultivars do.
- Techniques and equipment exist for the successful drying of Spanish almonds that have been purposely harvested early or accidentally wet by rain.
- Techniques and equipment exist for the successful tissue culturing and micro-grafting of almond trees.

The key implications for the Australian almond industry are:

- Rootstocks are available for alternative production systems.
- It is critical to match the scion growth habit with a dwarfing rootstock in a high or super high density planting especially in regards to vigour and fruiting spurs.
- Improved relationships with specialist nurseries consisting of tissue culturing and micro-grafting capabilities.
- Greater understanding of the challenges and opportunities in adopting shake and catch harvesting techniques.
- Shake and catch harvesting machinery should be adapted to suit tree architecture.
- Improved knowledge of international competitors.
- Improved international relationships.

2 Expected Outcomes

The study tour was undertaken with several objectives:

- Investigate dwarfing rootstocks
- Investigate alternative tree training techniques for high density plantings
- Investigate alternative shake and catch harvesting methods
- Investigate alternative post-harvest management of almonds with higher moisture content
- Enhance relations with a nursery with proven tissue culturing and micro-grafting
- Enhance international relations with other key stakeholders in the Spanish almond industry.

The results of the discussions and the implications for the Australian almond industry are provided below.

3 Results of Discussions and Implications

3.1 Plant improvement

A Spanish government research station, IRTA (Francisco Vargas, Ignasi Batlle, Xavier Miarnau and Ignasi Iglesias) and a private tissue culture nursery, Agromillora (Xavier Rius) were visited to obtain an update on their dwarfing rootstock selections, evaluations and tree architecture/training systems for high density orchards.

3.1.1 Dwarfing rootstocks

3.1.1.1 IRTA selections

IRTA has a dwarfing rootstock called MB 1-37 which is currently under evaluation for potential in irrigated, high density orchards. IRTA and our other hosts indicated the matching of the scion to rootstock in high density orchards is critical. IRTA's preferred variety for high density orchards was Marinada due to the low scion vigour.

3.1.1.2 Agromillora selections

Agromillora began rootstock breeding in 1998 to develop new rootstocks more adapted to intensive fruit production. They have selected rootstocks of low vigour, good soil adaptation and high productivity. Two dwarfing rootstocks are available:

- Rootpac-40 (*Prunus dulcis x Prunus persica) x (Prunus dulcis x Prunus persica*) – medium vigour, approximately 65-70% of GF677. Compatible with peach, nectarine and almonds. Highly suitable for high density plantings, moderately tolerant of asphyxia, and moderately tolerant of calcareous soils, salinity, and root knot nematodes. Susceptible to lesion nematodes. Very precocious.
- Rootpac-20 (*Prunus besseyi x Prunus cerasifera*) – low vigour, approximately 50-60% of GF677. Even though it is a plum hybrid it is reported to be compatible with peach, nectarine, almonds and Japanese plum. Highly suitable for super high density plantings, tolerant of asphyxia (plum heritage), adapted to heavy soils, moderately tolerant of calcareous soils and salinity, resistant to root knot and lesion nematodes and very precocious.

Agromillora also has three other rootstocks available for different scenarios:

- Rootpac-R (*Prunus cerasifera x Prunus dulcis*) – Withstands numerous soil limitations, in particular well adapted to replant orchards.
- Rootpac-90 (*Prunus persica x Prunus davidiana) x (Prunus dulcis x Prunus persica*) – High vigour, tolerant to calcareous soils and moderately resistant to root knot nematodes. Alternative to GF677, Garnem, etc.
- Rootpac-70 (*Prunus persica x Prunus davidiana*) *x* (*Prunus dulcis x Prunus persica*) – Medium to medium/high vigour, approximately 80% of GF677. Red leaf rootstock tolerant to

calcareous soils and moderately resistant to root knot nematodes. Suitable for moderate intensification of planting densities.

3.1.1.3 Field evaluation trials

IRTA

IRTA planted a selection of grafted dwarfing rootstocks to investigate effects on yield, growth habit and other characteristics at the Les Borges Blanques research site. Hybrids with traditional vigour were also planted in the same trial for comparison. The trees were planted in 2010, trained with a medium pruned vase and planted with row and tree spacings of 5m and 4m respectively. Varieties used were Marinada and Vairo and rootstocks included:

- Cadaman
- Garnem
- GF677
- Ishtara
- MB 1-37
- (PxA) x Myrobalan
- Puebla de soto
- Rootpac-20
- Rootpac-40
- Rootpac-R

The trial is young, but MB 1-37 and Rootpac-40 visually had a good balance of vigour. The use of a low vigour scion (Marinada) on dwarfing rootstocks looked out of character with the wide row and tree spacing (Figure 1) but would be more suited to a vineyard spacing i.e. 3m x 1-1.5m. The use of a low vigour scion on a high vigour rootstock (Garnem, Cadaman and GF677) looked fine and with the predominately spur bearing Spanish varieties, might still suit a moderately high density orchard i.e. 6-5m x 3-2m (Figure 1). IRTA also had a rootstock trial with peaches at the Gimenells research site.

Figure 1: Marinada/Rootpac 20, Marinada/MB 1-37, Marinada/Rootpac 40, and Marinada/GF677 (clockwise from top left)

3.1.2 Tree architecture/training systems for high density orchards

Following the visits with IRTA and Agromillora, it appears they have taken different approaches to developing high density orchards. IRTA have taken the approach of trialling different tree spacings and training systems to investigate the most productive orchard with a management system to be developed following R&D. Agromillora has selected rootstocks from its breeding program and matched it to a production system well adapted to existing mechanisation (i.e. over-the-row grape harvester, hedge pruning, etc) with the objective of reducing costs of production at a target yield.

3.1.2.1 IRTA

Two trials have been established, high density with GF677 and high density with MB 1-37.

High density with GF677

This was the first high density trial, planted in June 2009 on GF677 rootstock at the Les Borges Blanques site. GF677 was the only available rootstock at the time. Cultivars were Vairo and Marinada. Six training systems were investigated (Figure 2).

1. Standard vase – vase shape with regular pruning. Good vigour associated with annual pruning but the cumulative yields are less than the minimal or unpruned treatments.
2. Minimal vase – vase shape but with minimal pruning. Central scaffolds, vertical limbs and closely spaced scaffolds removed. Similar system to many Australian orchards. Visual observations indicate a larger canopy but a lower fruit count per canopy area in comparison to the traditional vase system. The yield is larger in this system in comparison to the traditional vase but it is unclear whether this will remain the same based on the lower fruiting density observed. Row and tree spacings were 5.5m and 3.5m respectively.
3. Minimal central leader – typical apple system with a single central leader, conserve all side branches other than those competing with central leader. Minimal pruning and looked well balanced in comparison to the intensive central leader system above. Row and tree spacings were 5m and 2m respectively.
4. Intensive central leader – typical apple system with a single central leader, thin out some of the side branches and tip side branches. Pruning is quite technical and time consuming. The tipping of branches led to increased vegetative vigour and the tree appeared out of balance. Row and tree spacings were 5m and 3m respectively.
5. Hedge (minimal prune) – similar to a two wire vertical system in wine grapes but with multiple side branches chosen and bent sideways along the row axis either side of the main trunk. This system had yielded less in the first harvest in comparison to the other systems. Row and tree spacings were 4.5m and 3m respectively.
6. Hedge (heavier prune) – same as the previous hedge system but with winter and summer box hedge pruning. Row and tree spacings were 4.5m and 3m respectively.

A trellis system consisting of wires firmly attached to the trunk is not recommended as the machine harvesting causes a shockwave to run through the wire and knock fruit to the ground from several trees in front of the shaker. However, a trellis system utilising the plastic clips for tree training observed on the Almond Board of Australia Californian Study Tour in 2010 might have a use in the early stages of tree training.

The pruning system is unique to each system, but variations are also needed based on the growth habits of different cultivars.

In our opinion, the minimal pruned central leader system visually looked the most natural and balanced. It was too early to confidently say which system performed the best but it was clear the single leader and the hedge systems were superior to the vase systems. The single leader and hedge systems would also facilitate the use of an over the row trunk shake and catch style of harvesting.

Figure 2: Vairo - Pruned vase, unpruned vase, minimal prune central leader, heavier hedge prune, minimal hedge prune, intensive prune central leader (clockwise direction from top left)

3.1.2.2 Agromillora

Semi-commercial grower trial of super high density

Agromillora showed us a semi-commercial trial in La Granja D'escarp of its super high density system planted in July 2010 with Rootpac-20 and Rootpac-40. The trial was part of a commercial orchard with the following management program:

- Grafted to Belona, Soleta and Mardia (CITA) cultivars.
- Row and tree spacings were 4m and 1-1.5m respectively.
- Mechanically hedge the top and side of trees.
- Mechanically hedge at each 30cm growth increment of the laterals to encourage ramification.
- No central leader.
- Maintain hedge depth of 80-100cm to facilitate mechanical harvesting.
- Maintain hedge height of 2020-2040cm to facilitate mechanical harvesting.
- Mechanically harvest with a wine grape harvester.
- Harvest at approximately 20% kernel moisture and immediately deliver to the local processor for drying.
- Once the hedge is established, hedge once per season following harvest (e.g. September in the northern hemisphere).
- Yield target of 2,000 to 2,500kg/ha.

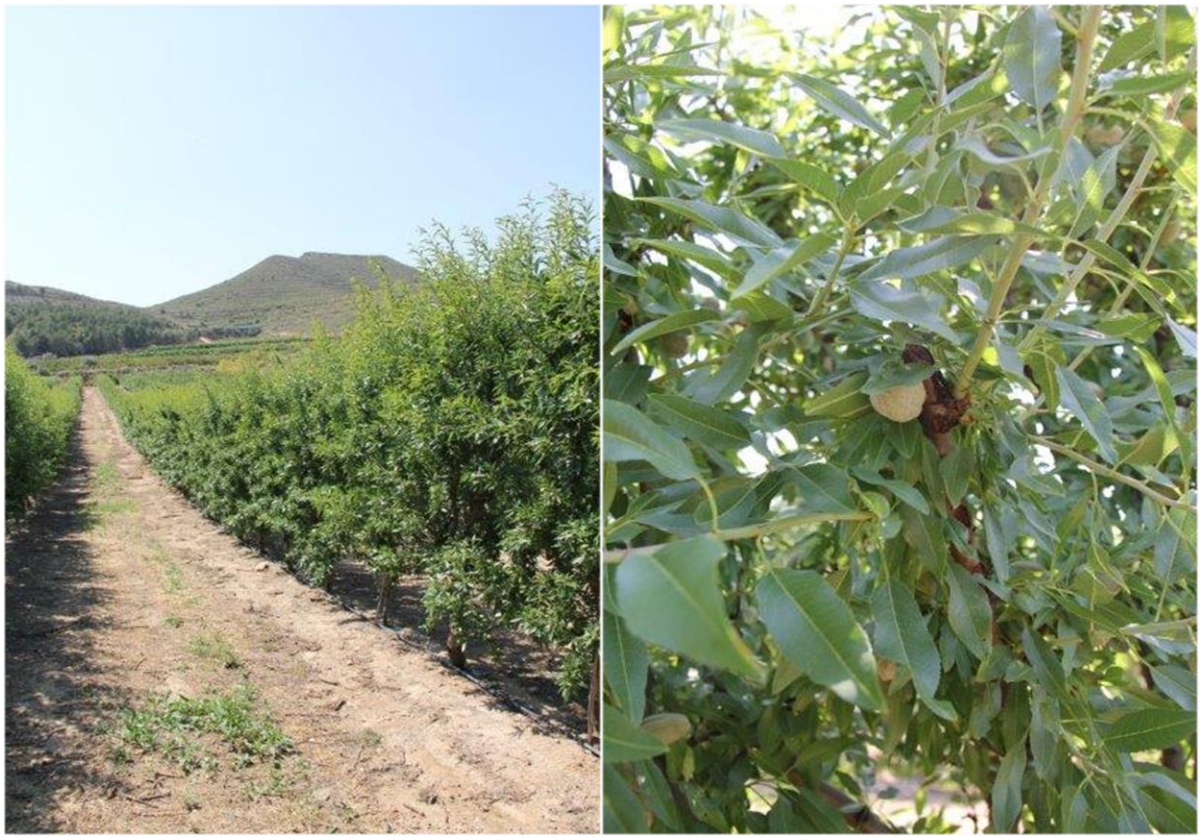

Figure 3: Super high density trial with Rootpac-40 (left) and illustration of ramification from hedging cuts (right)

The lessons learnt from the trial by Agromillora and the grower were:

- Plant closer with row and tree spacings of 3.5m and 1.0-1.5m respectively (2,222 to 2,857 trees/ha).

- Wine grape harvester removes approximately 5% of next year's buds.
- Need to match the cultivar to this system. The hedging stimulated vegetative and non-productive growth of vigorous cultivars such as Bolena and Mardia.
- They plan to "rejuvenate" the tree on a four year cycle by undertaking a heavier winter hedging cut on one side of the tree every two years. For example, heavy hedge eastern side in year 1, no heavy hedging in year 2, heavy hedge western side in year 3, no heavy hedging in year 4.

The trees looked productive and healthy however, there is visible damage to the tree from harvesting in the form of damaged buds or broken limbs/structural damage. My concern is damage to the limbs may be an entry point for pathogens which could have adverse effects on the tree if put under stress. The row spacing could also be reduced to 2.5-3m if orchard floor traffic was removed completely and all orchard operations were conducted 'over the row'. This would increase productivity per hectare.

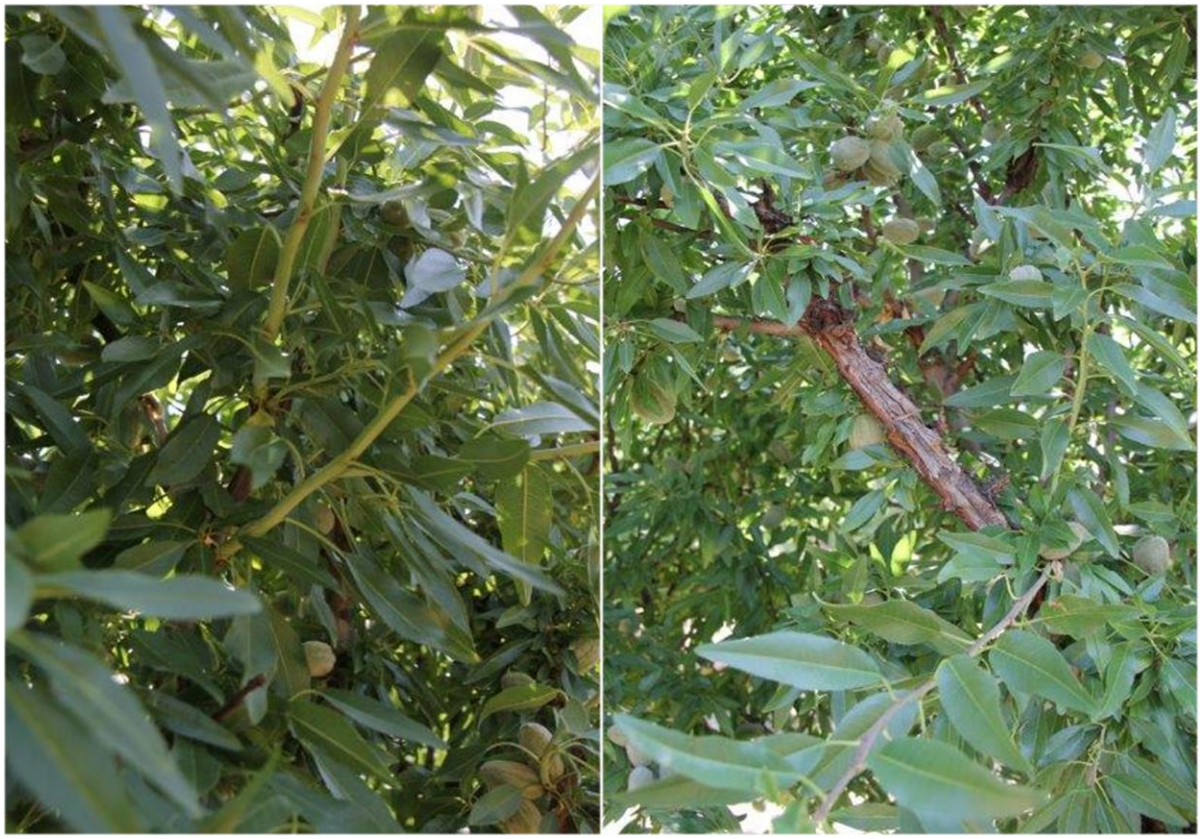

Figure 4: Super high density trial illustrating unbalanced vegetative growth habit by scion cultivar (left) and damage to a branch caused by the bow rods of a grape harvester (right)

3.1.3 Tissue culture

We visited Agromillora's tissue culture and micro-grafting facility at Sant Sadurní d'Anoia near Barcelona. Globally, Agromillora has eleven nurseries, but not all of them have tissue culture facilities.

The Sant Sadurní facility produces olive trees, grapevines, *prunus* rootstocks and micrografted trees for wholesale nurseries. The facility produces approximately 10-12 million plants per year. It takes approximately two weeks for each growth stage and eight months to produce one tree. The stage from the start of tissue culturing to small rootlings takes two months and 200 000 plants can be turned out each day. Trees are sold at 3.00-3.50 €/tree. The facility is well automated with machinery used at every opportunity; for example they manufacture their own jiffy pots with a self-filling and cutting "sock" which is then placed into trays, a robot loads multiple trays with small plants, and a dolly

collects benches from the greenhouse. A new initiative of providing a complete tree ready for planting was observed. It was branded the "smarttree" and included a small grafted tree with a small tree stake and tree guard already fitted.

Figure 5 shows the major steps in the growing of a tree ready for sale. Step 1 is the tissue culture process of placing cuttings into glass jars containing agar and then placed into a room with a controlled atmosphere. Once the cuttings have grown enough in the agar, they can be re-cut into more cuttings to 'bulk up' supply of the target material or transplanted into plugs containing a potting medium. The plugs containing cuttings are placed into a poly house to develop the emerging root system. The plugs are re-potted into larger pots and grafted if needed. Note the visible plugs in the larger pots in the photo in Figure 5, bottom right. The finished 'smarttree', ready for sale is shown in Figure 5.

Figure 5: Agromillora tissue culture facility; cuttings in agar, cuttings in plugs located in a polyhouse, barcoded grafted trees, finished 'smart tree' ready for sale (clockwise from top left)

3.2 Harvesting

3.2.1 Grape harvester

The Agromillora/private grower super high density trial in La Granja D'escarp used a commercial grape harvester to harvest the crop. A video of the harvesting process can be found at Agromillora's website: www.rootpac.com/en/super-high-density-system-shd.

3.2.2 Tenias harvester

An industrial machinery manufacturer was visited near Ejea de los Caballeros. The owners of the Tenias machinery company have a 230Ha which they also own. In order to fulfil their harvesting needs they developed their own over the row shake and catch harvester. The harvester combines elements of a grape harvester (spring loaded fish plates and conveyor belts) and a Californian style trunk shaking head (Figure 6). The harvester also has the facility to de-hull in the field using rubber rotors that knock the hulls off without damaging the in-shell almond (due to the hard shelled nature of Spanish varieties). The harvester currently requires a row width of 5.5m or greater, tree spacing of 3m or greater and is limited to a speed of 1-2kph. The crop can also be silo dried if needed.

Figure 6: Tenias over the row shake and catch harvester, in-field de-huller, silo for drying in-shell crop, and shaking head (clockwise from top left)

3.3 Post-harvest

We visited UNIO in Reus which is an almond co-operative that could facilitate almond drying of fruit with high moisture content. The system included a dryer, silos and an automated handling system.

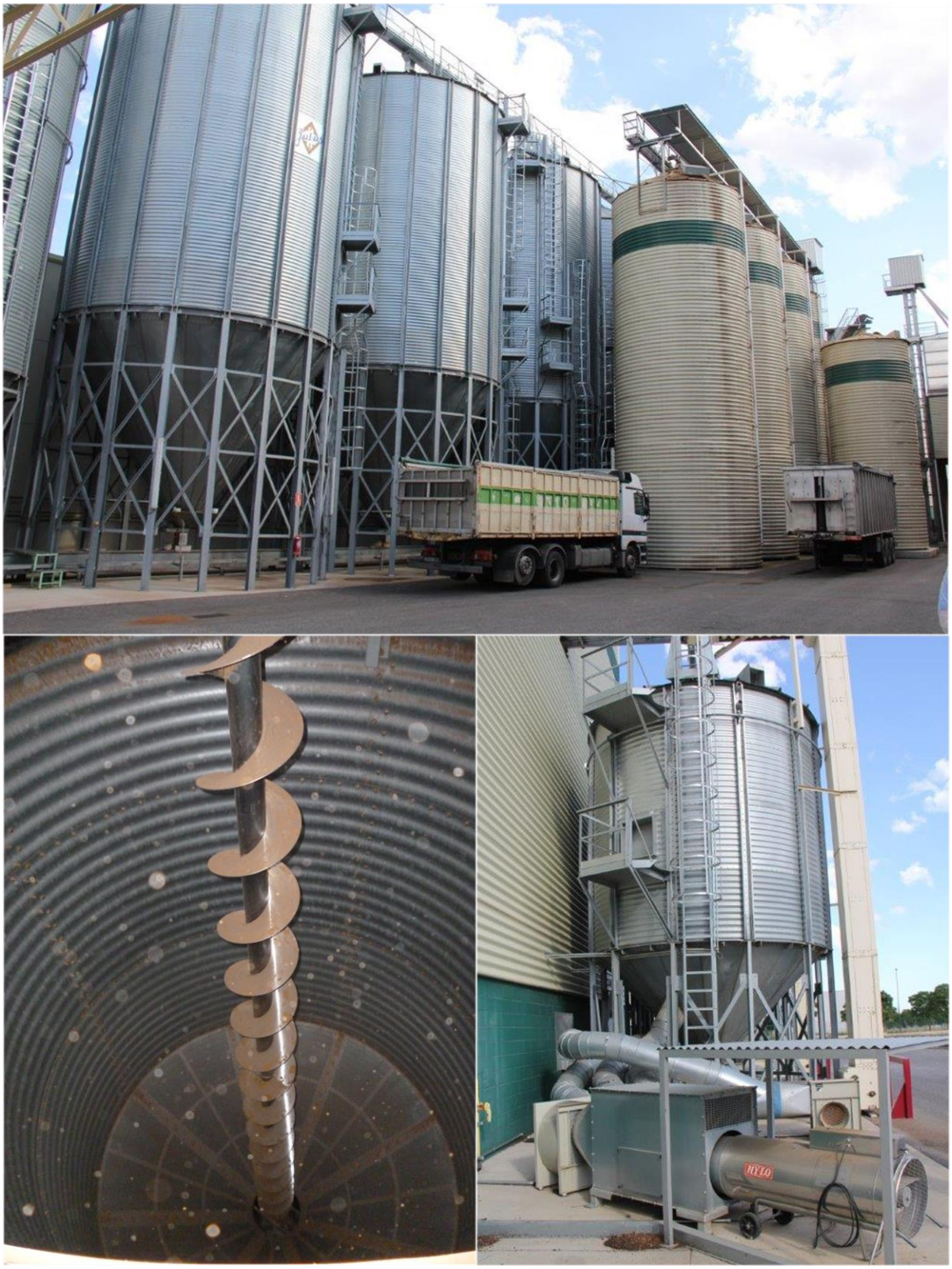

Figure 7: Almond silos (top), drying silo with auger (bottom left) and drying silos (bottom right)

3.4 International relations

A presentation was made about the Australian almond industry to Spanish growers, processors, consultants, IRTA staff and directors at a field day organised by IRTA in Les Borges Blanques. The field day was organised as an update on the progress of local cultivar, rootstock and tree training trials. The ABA was asked to be a guest speaker with Ignasi Battle acting as a translator during the hour long presentation. It was interesting to note the high number of younger growers and consultants present at the field day with approximately 250 people attending in total.

Figure 8: Brett Rosenzweig (background) and Ignasi Batlle (foreground) during the ABA presentation (left) and growers at the IRTA field day (right)

4 Dissemination of Information

The information from this study tour will be disseminated via a number of avenues:

- Almond Board of Australia Board Meeting – 27th August 2014
- Almond Industry Advisory Committee – 28th August 2014
- Almond Production Committee Meeting – 23rd July and Plant Improvement Meeting – 13th August 2014
- Study Tour Final Report – Circulation to industry & uploaded to ABA website

5 Recommendations

5.1 Plant improvement

5.1.1 Dwarfing rootstocks

Increased planting densities have the advantage of earlier and possibly higher production levels but it comes at the expense of increased orchard establishment costs. We recommend investigation of the most appropriate dwarfing rootstocks and scion combinations to obtain a balance between vegetation, fruit production and orchard establishment costs. It is noted that too higher dwarfing may not suit the hot, dry climate of the Australian almond growing regions. Too higher dwarfing may also result in ultra-high tree densities (3500-4000 trees/Ha) which would prove uneconomic due to tree costs in establishing an orchard.

5.1.2 Tree architecture/training systems for high density orchards

Dwarfing rootstocks will facilitate increased planting densities but, as mentioned above, we recommend the investigation of the most appropriate dwarfing rootstocks and scion combinations to obtain a balance between vegetation, fruit production and orchard establishment costs. Several management systems were observed for high density orchards on the trip and whilst they were all

quite young, the variability in tree behaviour was already noticeable. We recommend the approach of maximising fruit production by firstly designing the right combination of rootstocks, cultivars, planting densities and tree architecture/training systems. This approach should then be followed by designing the machinery and management system to suit. Undertaking the opposite approach or beginning with the primary goal of minimising costs of production will limit long term orchard potential.

5.1.3 Tissue culture

Encourage Agromillora to incorporate its tissue culture and micro-grafting expertise into its existing olive nursery in Waikerie, South Australia. Alternatively, keep liaising with other tissue culture nurseries about the development of suitable protocols for Prunus rootstocks.

5.2 Harvest

As mentioned in 5.1.2, the development of tree architecture and training systems should occur first before the development of suitable harvest machinery. From the observations at the Agromillora trial, trunks shaking is more preferable to canopy shaking. A R&D project into harvesting systems could be implemented once the R&D into aeration, in-field hulling and tree architecture/training systems has been completed.

5.3 Post-harvest

Continue to invest in R&D that can aerate and dry almond product to manage early harvested fruit using a shake and catch system or manage rain affected fruit. Suitable equipment exists for Spanish in-shell product, but it does not exist for in-hull or in-shell Californian varieties. The R&D will need to focus on de-hulling on-farm to be able to capitalise on the benefits of silo storage.

5.4 International relations

It is recommended to continue liaising with IRTA, Agromillora and other collaborators in the Spanish almond industry. Based on feedback from study tour participants, a study tour of 10-12 people could be held every two years.

6 Acknowledgements

The study tour members would like to acknowledge the financial investment of Horticulture Australia Limited and the Australian almond industry. In addition, we would like to acknowledge our overseas hosts who were very accommodating and gave up their valuable time and information freely.

7 References

(Brown, 2013) AL12000 - Study Tour: Investigating High Density Almond Production Systems

(Brown, 2011) AL10009 - Study Tour: Investigating Efficient Harvesting Systems that Improve Product Safety and Quality

8 Itinerary

DATE	DAY	LOCATION	CONTACT	TOPIC
25th May	Sunday	Depart Adelaide		
26th May	Monday	Arrive Barcelona		
27th May	Tuesday	Barcelona		Sightseeing
28th May	Wednesday	Sant Sadurni d'Anoia	Xavier Rius	Agromillora tissue culture laboratory and nursery
29th May	Thursday	Mas de Bover	Xavier Miarnau, Ignasi Batlle	IRTA meeting, almond huller/sheller/drier and processor
30th May	Friday	Reus/Riudoms	Inigo Vargas	Crisol/Arboreto almond and hazelnut co-operative
31st May	Saturday	Barcelona		Sightseeing
1st June	Sunday	Barcelona		Sightseeing
2nd June	Monday	La Granja d'Escarp/Caspe	Xavier Rius	Super high density almond trial of Agromillora dwarfing rootstocks
3rd June	Tuesday	Les Borges Blanques	Ignasi Iglesias & Xavier Miarnau	IRTA rootstock, scion and tree training trials, stone fruit rootstock trial
4th June	Wednesday	Ejea de los Caballeros	Xavier Miarnau	High density orchard with Tenias over row harvester
5th June	Thursday	Les Borges Blanques	Xavier Miarnau, Ignasi Batlle	
6th June	Friday	Depart Barcelona		
8th June	Saturday	Arrive Adelaide		

9 Contact List

NAME	ORGANISATION	TOPIC / EXPERTISE	ADDRESS	PHONE	MOBILE	EMAIL
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10 Feedback

Attended:	10		
Responses:	9	**90%**	**1 = less than expected; 5 = more than expected**

QUESTIONS	RESPONSES					% FEEDBACK				
	1	2	3	4	5	1	2	3	4	5
Did the study tour provide you with what you expected to learn?				4	5	0%	0%	0%	44%	56%
Did the itinerary include enough items of interest? If not, what else could be included?				3	6	0%	0%	0%	33%	67%

QUESTION	RESPONSES			% FEEDBACK		
	YES	NO	UNSURE	YES	NO	UNSURE
Do you intend to implement any knowledge gained from this study tour into your business?	6		3	67%	0%	33%

QUESTIONS	RESPONSES					% FEEDBACK				
	1	2	3	4	5	1	2	3	4	5
Overall, how satisfied are you with the organisation of the study tour?				2	7	0%	0%	0%	22%	78%
Overall, do you think the study tour was value for money?				3	6	0%	0%	0%	33%	67%

QUESTION	RESPONSES			% FEEDBACK		
	YES	NO	UNSURE	YES	NO	UNSURE
Would you attend another organised study tour?	9			100%	0%	0%

QUESTIONS	Number of years between study tours					% FEEDBACK				
	1	2	3	4	5	1	2	3	4	5
If yes, how often would you attend an organized study tour?		8			1	0%	89%	0%	0%	11%
Suggested future destinations?	California, Israel, Portugal, Spain,									

QUESTION	RESPONSES							% FEEDBACK						
	DESTINATION	ITINERARY	BUSINESS OPPORTUNITIES	IMPROVE KNOWLEDGE OF COMPETITORS	BUILDING O'SEAS RELATIONSHIPS	TIMING	OTHER							
What was the main reason for attending this study tour?	4	5	2	4	2		1	44%	56%	22%	44%	22%	0%	11%

QUESTION	RESPONSES					% FEEDBACK				
	EMAIL	INTERNET	FAX	POST	OTHER	EMAIL	INTERNET	FAX	POST	OTHER
How did you find out about the study tour?	5				4	56%	0%	0%	0%	44%

2 gave no response

ANY OTHER COMMENTS OR SUGGESTED IMPROVEMENTS?
Brett did a fantastic job or organising and leading the tour. My only complaint is that we visited too many processing facilities and that is not where my main interest lies.
The study trip for me was excellent. It was well organised with quality visitations each day with leading operators throughout the almond supply chain.
The cross over into stone fruit and rootstocks was also very informative. The IRTA personnel involved in the tours were excellent and even more so considering the language gap between us. Not much in the way of improvements apart from maybe visiting one less processing facility, but overall still enjoyed each visit. Overall Brett did an excellent job even with a horrible cold during the first week that luckily most of us managed to avoid.
I thought it was well organised and run. The local Spanish researchers and breeders were very goods hosts. Brett did a good job.
It was a well run study tour which reflected the strong relationship between the Almond Board of Australia and the Spanish Almond Industry.
Well run - great job Brett.
A visit to the manufacturer of the over-the -row harvester would have been great.
Great tour, well organised and value for money. Can't wait for the next tour.
Maybe a tour in Australia to visit other nut variety growers to get an insight of what they are doing that could be utilised in the almond industry. Sometimes you can find valuable information in other industries that can make improvements to your business.