Final Report

Evaluation of Potential prunus Rootstocks for Almond Production

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Almond Board of Australia

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Summary

Almond growing has limitations in many of the traditional Australian almond growing regions as a result of the prevalence of calcareous soils, where most rootstocks, in particular Nemaguard - the Australian almond industries traditional first choice, show lime induced chlorosis. In addition, there is a need for a greater choice of rootstocks with desirable characteristics such as increased productivity through improvements in salinity tolerance, nematode tolerance, and water and nutrient efficiency. Furthermore, to achieve affordability rootstocks are required to be nursery friendly having a vertical growth habit, minimal feathering of side shoots, be easy propagate and compatible with the popular scion varieties of almonds.

A total of twenty one rootstocks, including Nemaguard, were sourced to undergo evaluation as there is a definite need for new rootstocks. The research assessed their compatibility to the common cultivars grown in Australia and their ability to perform under the various growing conditions.

The rootstocks were purchased, grafted and established in two trial sites in a replicated, randomised block design to enable statistical analysis and an independent evaluation. The orchard layouts trialled were:

- Conventional Almond Orchard Design – 18 high vigour and medium vigour rootstocks planted at spacing's of approximately 342 trees/ha and managed according to traditional management practices.
- High Density Almond Orchard Design – 3 low vigour rootstocks planted at high density spacing's greater than 1,000 trees/ha and managed according to new intensive management practices.

Keywords

Almonds, Rootstocks, Productivity, Prunus, Dwarfing

Introduction

Almonds are predominantly grown across three states and four growing regions, Northern Adelaide Plains (South Australia), Riverland (South Australia), Sunraysia (Victoria) and the Riverina (New South Wales). Each of the growing regions have varying growing conditions such as soil type, crop history, climate, water sources, water availability, water quality, and disease and insect pressures.

Despite these varying conditions, the majority of the almonds are grown on Nemaguard rootstock. Nemaguard rootstock has several advantages, such as; nematode tolerance, easy propagation, relatively cheap, virus free, and moderate productivity. However, Nemaguard also has some disadvantages, such as: susceptibility to calcareous soils and lime induced chlorosis, root pathogenic disorders in a replant situation, moderately tolerant to salinity, only moderately vigorous, and moderately efficient in water and nutrient use.

Over time there has been a large increase in the number of prunus rootstocks available and suitable for almonds (and summerfruit), and the great majority of the rootstocks have been imported into Australia. Some of these rootstocks are claimed to be tolerant or better performing in chlorotic soil types, in the presence of some nematodes, highly vigorous and nursery friendly.

Fifteen high to medium vigour rootstocks, including Nemaguard, were sourced and grafted to the popular varieties for planting and following a project variation, a further three size controlling rootstocks were added to the list.

The fifteen vigorous rootstocks were planted and trained during the period of this project in preparation for evaluation once they reach bearing age, three and half years after planting and mature to full production achieved at year seven or eight depending on tree vigour.

For the long term sustainability of the Australia almond industry, new rootstocks are required and there is a need to assess and evaluate their compatibility to the common cultivars grown in Australia and their ability to perform under the various growing conditions experienced in the different production regions.

Methodology

Table 1 outlines the twenty-one rootstocks that were to be propagated and grafted by six different nurseries that each hold the propagation rights to the rootstock material.

Rootstock	Parentage	Origin	Breeder	Source
Nemaguard	*P. persica x P. davidiana*	Georgia, USA	USDA	Ausbuds
Cadaman	*P. persica x P. davidiana*	Bordeaux, France	INRA	Factree Nurseries
Atlas	*Peach x Almond x Plum*	California, USA	Zaiger Genetics	Factree Nurseries
Viking	*Peach x Almond x Plum*	California, USA	Zaiger Genetics	Factree Nurseries
GF557	*P. persica x P. dulcis*	Bordeaux, France	INRA	ABA
GF677	*P. persica x P. dulcis*	Bordeaux, France	INRA	ABA
GF749	*P. kansuensis x P. dulcis*	Bordeaux, France	INRA	ABA
Adafuel	*P. persica x P. dulcis*	Zaragoza, Spain	CSIC	ABA
Controller 6	*P. persica x P. persica*	California, USA	UC Davis	Nuleaf
Controller 7	*P. persica x P. persica*	California, USA	UC Davis	Nuleaf
Controller 9.5	*P. persica x P. persica*	California, USA	UC Davis	Nuleaf
Felinem	*P. persica x P. dulcis*	Zaragoza, Spain	CITA	ABA
Garnem	*P. persica x P. dulcis*	Zaragoza, Spain	CITA	ABA
Monegro	*P. persica x P. dulcis*	Zaragoza, Spain	CITA	ABA
Bright's Hybrid	*P. persica x P. dulcis*	California, USA	Bright's Nursery	Ausbuds
Hansen 536	*P. persica x P. dulcis*	California, USA	UC Davis	Ausbuds
Nickels	*P. persica x P. dulcis*	California, USA	UC Davis	Mossmont Nurseries
Cornerstone	*P. persica x P. dulcis*	California, USA	Burchell Nursery Inc.	Mossmont Nurseries
Krymsk 86	*P. persica x P. cerasifera*	Krasnodar, Russia	Krymsk Breeding & Research Station	ANFIC
Penta	*P. persica*	Rome, Italy	ISF	ANFIC
Tetra	*P. persica*	Rome, Italy	ISF	ANFIC

Table 1: List of rootstocks to undergo evaluation.

The two trial sites will consist of the following planting conditions:

Region	Town	Replant Situation	Soil Type	Topsoil depth	Calcareous Soil	Water Source	Water Quality	Approx. Irrigation Applications (ML/Ha)	Approx. Fertiliser Applications (N:P:K)
Riverland	Renmark	Yes	LS to SCL	Shallow	Yes	Murray River	Low Salinity	12-14	320:50:320

The rootstocks were grafted to the common cultivars grown in Australia; Nonpareil, Carmel and Peerless, and no graft incompatibility was observed. The trees were supplied by the nurseries as spring budded trees with Nemaguard as the control treatment. The trees were planted in a replicated, randomised block design (Appendix 1). The trees will take three and a half years from planting to establish and reach a harvestable age. At this stage of the orchard trial, a new project application will be submitted to evaluate the trees according to the criteria listed in Table 2.

Characteristic	Measurement	Units
Propagation	Ease of propagation	% take of hard and soft wood cuttings
Flowering*	Dates of pink bud, 50% bloom, full bloom	Dates of pink bud, 50% bloom, full bloom
Production	Seasonal yield	Kg/ha
	Accumulated yield	Kg/ha
	Precocity	0-5
Vigour	Cross sectional area of trunk	cm^2
	Index of production/efficiency	Kg/cm^2
Tree Habit	Light interception	% light interception
	Tree size	Very large, Large, medium, small
	Anchorage	0-5
Tree Water Stress	Midday stem water potential	Bar
Tree Nutrition	Leaf analysis	Full ICP analysis
	Fruit analysis	Full ICP analysis
Fruit	Crackout	%
	Fruit size	Kernels/ounce
	Fruit weight	gm
Graft Compatibility	Degree of compatibility	0-5
Sensitivity to Suckering	Number of suckers	# suckers/ha
Sensitivity to Iron Chlorosis	Degree of chlorosis	0-5
Sensitivity to Nematodes	Root lesion, root knot, ring	#'s adult females/roots #'s juveniles/250g soil
Sensitivity to Fungal Pathogens	Cankers, Phytophthora, Agrobacterium, Armillaria	0-5

* Assessment to be conducted in Nonpareil, Carmel and Peerless.

Table 2: Criteria for tree assessments.

A project variation was submitted in late 2013 to allow for the inclusion and evaluation of three size controlling rootstocks (Controller 6, 7 & 9.5) imported by Nuleaf from the University of California – Davis Campus.

Outputs

The primary outputs of this project are:

Conventional Almond Orchard Design:

- Rootstock / scion compatibility in the nursery observed.
- One trial site established consisting of 15 rootstocks, in the Riverland growing region.

High Density Almond Orchard Design:

- 1,250 size controlling rootstocks propagated in Post Entry Quarantine in preparedness for planting out into a field evaluation trial site investigating intensive almond production systems.

Outcomes

The primary outcome of this project and the proposed second phase is knowledge of the performance of the popular almond varieties grafted onto a range world leading rootstocks to enable growers to lift yields by establishing orchards to better plant material.

Evaluation and Discussion

The Australian almond industry has predominantly used Nemaguard rootstock as the industry standard, but with agronomic challenges in many of the traditional Australian almond growing regions there is a clear need for new rootstocks.

The trial design originally included eighteen rootstocks and four trial sites but due to ongoing propagation difficulties and delays. There was an original 12-month delay in 2011/12 while the rootstocks were being bulked up using vegetative propagation methods. This meant the grafting of the scions occurred in March 2012 and would necessitate the trees staying in the nursery during 2012/13 to be ready for dormant planting in August 2013 as two-year olds. Due to poor strike rates during propagation, three attempts were made to source the required total number of trees. Ultimately due to the difficulties outlined in obtaining the required number of trees, the trial was reduced to one trial site of four replicates and fifteen rootstocks (**Error! Reference source not found.**).

The trial is a 3.74-hectare almond replant site at Lindsay Point, Victoria. The soil is a typical Mallee soil profile with 30 to 60cm topsoil over carbonate subsoils.

Figure 1: Tree planting at Lindsay Point, August 2013

The fifteen rootstocks were sourced from two nurseries and grafted to Nonpareil (50%), Carmel (25%) and Peerless (25%) and the trees were planted in August 2013 (Figure 1) in a replicated, randomised design to enable statistical analysis and an independent evaluation. Further modifications were made to the trial layout with the replacement of Penta with Cadaman and Tetra with Atlas.

The three size controlling rootstocks from UC Davis were released from Post Entry Quarantine and delivered to Agromillora Australia in Irymple Vic. Tissue culturing protocols were developed and initiation undertaken. Each of the Controller series have now been sufficiently bulked up to enable grafting to a mixture of the common cultivars grown in Australia and the most promising elite selections from the Australian almond breeding program (AL12015) in preparation for planting in stage 2 of the rootstock trial.

There was difficulty in obtaining the required rootstocks from nurseries and this led to a subsequent two years of planting to fill in the gaps in the planting design. Despite the despite the delay, Cadaman was not able to be sourced from the contributing nursery to be included in the assessments.

Preliminary assessments of the trunk circumference were measured in spring 2015 and initial yield data from the 2016 harvest has been collected. Given the variable age of the plantings, these results have not been reported in this milestone but will form a base line from which to report in a future project.

Figures 2 – 15 show the current growth of the trees after the 2016 harvest. Each photo contains a 2m wooden pole with pink flagging tape at 1m to help gauge overall height.

Figure 2: Adafuel

Figure 3: Atlas

Figure 4: Bright's Hybrid

Figure 5: Cornerstone

Figure 6: Felinem

Figure 7: Garnem

Figure 8: GF577

Figure 9: GF677

Figure 10: GF749

Figure 11: Hansen

Figure 12: Krymsk 86

Figure 13: Monegro

Figure 14: Nemaguard

Figure 15: Nickels

Recommendations

The primary recommendations of this project will be:

Conventional Almond Orchard Design:

- Fund a new project to facilitate the collection and analysis of the rootstock assessment criteria outlined in Table 2.
- Host regular field days at key phenological dates to inform industry stakeholders of any key differences between rootstocks/scion combinations.
- Publish annual updates of key assessment criteria to inform industry stakeholders.

High Density Almond Orchard Design:

- Develop a randomised planting plan as per the current projects design to facilitate the trialling of the three Controller series of rootstocks in comparison to Nemaguard as the control. Additionally, Garnem and the three Rootpac series of rootstocks from Agromillora should also be evaluated. The three Rootpac rootstocks are: Rootpac 20 (20% vigour of GF677), Rootpac 40 (40% vigour of GF677) and Rootpac R (90% vigour of GF677).
- Propagate new rootstock/scion combinations utilising new varieties owned by The Adelaide University and Horticulture Innovation derived from the Australian Almond Breeding Program (AL12015) with Nonpareil as a control.
- Incorporate new tree training designs into the High Density Almond Rootstock project to be located at the new 60 hectare Almond Centre of Excellence experimental orchard at Loxton.

Scientific Refereed Publications

None to report.

Intellectual Property/Commercialisation

No commercial IP generated

Acknowledgements

The Almond Board of Australia wishes to acknowledge to ongoing contributions to the project from Lacton Pty Ltd and in particular; Andrew Lacey, Tony Spiers and John Kennedy.

Appendices

Appendix 1: Rootstock trial plot.

ROOTSTOCK TRIAL LEGEND	
NP	= Nonpareil (non-pollinator)
C	= Carmel (pollinator)
P	= Peerless (pollinator)
o	= monitored trees
ROOTSTOCKS	
1	Nemaguard
2	GF557
3	GF677
4	GF749
5	Adafuel
6	Garnem
7	Felinem
8	Monegro
9	Brights Hybrid
10	Hansen 536
11	Cornerstone
12	Nickels
13	Krymsk 86
14	Cadaman (was Penta)
15	Atlas (was Tetra)
16	Spare (Nemaguard)
7.30 m	Spacing between rows
4.00 m	Spacing between trees
0.06	Hectares per block
3.74	Hectares planted
C =	Monash Carmel budline
C =	SHV Carmel budline (excep
=	Missing

	Row 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Tree 1	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
2	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
3	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
4	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
5	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
6	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
7	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
8	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
9	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
10	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
11	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
12	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
13	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
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16	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
17	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
18	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
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24	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
25	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
26	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C	NP	P	NP	C
27	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
28	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C	o	P	NP	C
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