

Final Report

Pistachio productivity improvement program

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Delivery partner:

Pistachio Growers' Association Inc

Project code:

PS17003

Project:

Pistachio productivity improvement program (PS17003)

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Funding statement:

This project has been funded by Hort Innovation, using the pistachio research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

Publishing details:

Published and distributed by: Hort Innovation

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www.horticulture.com.au

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1. PUBLIC SUMMARY

In 2019 the Australian Pistachio industry, continued as an exciting, profitable industry experiencing strong growth. Pistachios along with other nuts are rated as one of the health foods that should be regularly consumed.

The opportunity now exists to take the industry to a new level for both the experienced growers and the new growers entering the industry.

Present Australian supply satisfies about 40% of total domestic demand. Recent plantings of 100 hectares plus per year, since 2015, and, announced planting intentions will move the industry to an export surplus in about 2027-28.

The success of the yield improvements and the increase in new plantings has come off the back of the industry-based research, development and extension undertaken by the Pistachio Research Field Officer.

The Project Team, with the assistance of the Pistachio R&D Committee, has continued

- the defining and implementation of industry-based research,
- working with other research organisations, and
- communicating with growers the benefits of changing production practices.

With the broad objective of PS17003 established to deliver the Pistachio Productivity Improvement Program via on-going field research the Project Team has continued to work towards implementing those broad objectives.

The following are some of the major outputs:

- Establish a program logic framework.
- Development of Communications and Engagement Plan.
- Development of a Monitoring and Evaluation Plan.
- Preparation of a Project Work Plan.
- 6-monthly KPI Reports.
- Retention of Dr Jianlu Zhang as the Pistachio Emeritus Research Fellow.
- Engagement of a Pistachio Researcher – initially Dr Abeyasinghe and then Dr Mahadevan.
- Initial Project Planning meeting.
- Chill hour data collection and reporting and three newsletters per year (15 of).
- Benchmarking data collection and reporting and individual reports to 24 growers (120 individual reports).
- Project Team meeting. Pistachio R&D Committee meetings.
- Pistachio Researcher Reports to the Pistachio R&D Committee.
- Pistachio Researcher Reports to the Pistachio PIT Group sessions.
- Research Subsets undertaken by Dr Abeyasinghe.
- Research Subsets undertaken by Dr Mahadevan
- Information sheets on Mechanical Pruning, Fungal problems and the Application of AF36 prepared and distributed.
- Media article covering an overview of Polymer trials.
- Grower visits.

- Additional extension/development activities by Dr Abeysinghe.
- Additional extension/development activities Dr Mahadevan.
- Attendance at the 2023 International Almond and Pistachio Symposium and the presentation of a Research paper.
- Preparation of Research Papers by Dr Jianlu Zhang and Dr Maha Mahadevan.
- Stop/Go Milestone Review and Report by Dr Kevin Clayton-Greene.
- Milestone Reports (10 of).
- Final Report (1 of).

2. KEYWORDS

Pistachio; Pistachio Researcher; Productivity; Chill hours; Benchmarking; Juvenile Dieback; Dieback; Polymers; Sirora; Kerman

3. INTRODUCTION

In 2018 the Australian Pistachio industry, was an exciting, profitable business experiencing strong growth. Pistachios along with other nuts are rated as one of the health foods that should be regularly consumed.

The opportunity existed to take the industry to a new level for both the experienced growers and the new growers entering the industry.

The Australian pistachio industry primarily operates along the River Murray from Swan Hill in Victoria and up into South Australia. Production also occurs in Western Australia and New South Wales. Australian yields have improved 30% in the last 8 years. Australian orchards were achieving an average of about 3,000kg/ha, over the 2-year on/off cycle, peaking at over 5,300kg/ha in an on-crop year. Further improvement was possible – the best Californian orchards produce over 6,000kg/ha in an on-crop year and good Californian orchards average 3,500kg/ha.

The most recent data, in 2018, on Australian consumption (2016/17) was about 3,650 tonnes per annum. This represented a compound growth of about 9% per annum since 2000. There was scope for continued growth. Australian demand was still largely satisfied by imports. In 2018 Australian supply satisfied about 40% of total domestic demand. In 2018 the most recent plantings of between 50 and 100 hectares per year, since 2015, and, announced planting intentions were moving the industry to an export surplus in about 2027-28.

The success of the yield improvements and the increase in new plantings had come off the back of the industry-based research, development and extension undertaken by the Pistachio Research Field Officer.

The absence of any support work by the States' primary industry agencies for many years left a major gap in the detailed agronomy of pistachio growing under Australian conditions. The Pistachio Growers' Association Inc (PGAI) found it necessary to implement a program of 'self-help' and conduct industry-based research that would have been regarded as basic to more established industries.

In 2003, the Australian Pistachio industry, after 20 years, had reached a stage of profitability and success. The initial challenge of simply getting the trees to grow and bear fruit had been met. The industry had reached the point that in order to help the industry develop further, there was a need for a person to drive the research work and communicate with growers the benefits of changing production practices. The pistachio industry initiated a position, Research Field Officer, utilising pistachio voluntary contributions along with the financial support of the Australian government through Horticulture Australia Ltd.

The principal objectives of the position were to conduct and collect relevant research to achieve:

- Improved kernel fill.
- Reduction of shell damage to nuts.
- Reduction of the impact of alternate bearing.
- Most Australian orchards reaching the high yields currently being obtained by the best Australian Orchards.
- The Australian industry achieving better than world best practice for yield, quality and profitability.

Over the previous 15 years, leading into 2018, the PGAI has employed a Research Field Officer, Dr Jianlu Zhang, and significant improvements in the cultivation of pistachios in Australia had been very much due to the research and development work undertaken by Dr Zhang and the R&D initiatives of the Pistachio R&D Committee

With Dr Zhang's impending retirement, the industry wished to appoint a new person in order to continue the

strong and effective research, development and extension work and help industry develop further. The industry was committed to employing a person to drive the industry-based research, work with other research organisations and communicate with growers the benefits of changing production practices.

During the 15-year period the PGAI undertook the following projects utilising the expertise of Dr Zhang: -

PS03003	Facilitating the development of the Australian pistachio industry	01/07/2006
PS06001	Facilitating the technical development of the Australian Pistachio Industry	30/09/2011
PS11000	Maintaining and expanding the technical development of the Australian Pistachio Industry	30/09/2014
PS14000	Maintaining and expanding the technical development of the Australian Pistachio Industry	27/05/2016

Over the period from May 2016 to June 2018 the Pistachio Growers' Association Inc had funded the on-going work of Dr Zhang from the industry's general revenue (with no matching Australian Government funds) to ensure the industry research, development and extension continued.

As a result, the PGAI had an extensive set of grower-based and orientated research and development which had been communicated to growers on a regular basis throughout the period since October 2003.

Going forward project PS17003 developed and maintained strong linkages to the three current pistachio projects: -

PS16002	Pathogens and other factors contributing to dark staining on pistachio shells.	30/09/2019
PS16000	Understanding and managing insects on pistachio orchards	20/05/2019
PS17002	Technology Transfer for Pistachio growers utilising regional grower Tech Groups & events	31/01/2021

Based on these achievements and the strong response from the industry the Pistachio R&D Committee supported the continuation of the concepts and programs. The continuation of the employment of an industry-based researcher was built into the industry R&D priorities, and then translated into this new project being PS17003 - Pistachio Productivity Improvement Program.

PS11000 and PS14000 were developed, managed and implemented by a project team including Dr Jianlu Zhang (Pistachio Research Field Officer) and Trevor Ranford (Executive Officer, Pistachio Growers' Association Inc). This team was supported by a project steering committee comprising growers and members of the Pistachio R&D Committee) who gave general direction on timing, topics and overview of the aims they wanted to achieve from the project.

Over more recent years other research organisations have shown more interest in pistachio research and development and the PGAI was now looking to establish practical linkages with such organisations and involve them in components of PS17003 and/or additional research and development.

Based on this, the application to PS17003 was built around using: -

- a) some of the current project team – Trevor Ranford as the Project Team Leader and Dr Jianlu Zhang

(full time from 1st May to 30th June 2018 and then as a 'mentor' for the new Pistachio Researcher)

- b) a new Pistachio Researcher (PR) – to be employed on the success of the project application,
- c) research associates from Agriculture Victoria Research, NSW DPI and Plant and Food Research Australia, and
- d) a project steering committee comprising of an effective group of experienced and younger growers and a Hort Innovation representative.

Through Project PS17003 the Pistachio Growers' Association Inc, in broad terms, aimed to: -

- Undertake on-going field research building upon outcomes of *PS14000 - Maintaining and expanding the technical development of the Australian Pistachio Industry*.
- Improve yields by better understanding a range of orchard management issues.
- Benchmark and report on quality and yield to a participating grower collective.
- Explore new development areas for pistachio research.
- Contribute to the increase of planting of pistachios by 5% per annum of the existing planted hectares.
- Disseminate information and promote the adoption of R&D.
- Respond to changing environmental and seasonal issues that may arise.
- Cooperate with other research providers and allied industries to maximise the value of research.

The outputs and outcomes detailed below highlights the many successes resulting from PS170003.

4. METHODOLOGY

The initial process was that, on acceptance of the project, the Pistachio Growers' Association Inc would employ a new individual to fill the role of the Pistachio Researcher (PR) to follow-on from the retiring Research Field Officer.

Once the PR was in place the PGAI undertook the following: -

- Hand-over period between the RFO and the PR.
- Induction for the PR detailing all relevant information relating to the Australian Pistachio industry.
- Tour and meetings with other research bodies and personnel.
- Tour of the growing regions and meetings with the growers.
- Meeting with the project steering committee.

The then Research Field Officer, Dr Jianlu Zhang prepared and presented a final report of his research, development and extension to the Pistachio R&D Committee in June 2018. This report covered the industry funded work undertaken during the period May 2016 to June 2018.

On completion of the above, the PR worked with Trevor Ranford and representatives of the Steering committee to develop the Project Operational Plan for the project. Such a plan looked at all past and current research undertaken and determined which specific components needed to be either continued or further expanded and where the gaps might exist.

Throughout the life of the Project the PR had access to a range of facilities including: -

- Office and IT at APPC/CMV Farms.
- Trial orchard at CMV Farms (previously used through the period 2003 to 2018)
- Grower orchards including CMV Farms, Kyalite Pistachios and Mallee Orchards.
- Workstation at the Agriculture Victoria Research worksite at Irymple including co-location with researchers who have access to laboratories, glasshouse, cool rooms, farm, library services, etc.
- Current pistachio trial site at Ag Vic, Irymple.
- Pistachio trees at the Dareton site of NSW DPI.

These orchards and trial sites were used at different times during the life of the project to undertake specific research projects/programs.

PS17003 had a wide range of objectives and the methodology, to undertake each of these objectives, was detailed in the initial application.

Rather than adding all the specific details this report will cover the main points and processes.

- Keep abreast of the published and latest national and international R&D developments of relevance to the Australian Pistachio Industry.
- Deliver the Pistachio Productivity Improvement Program via on-going field research building upon outcomes of *PS14000 - Maintaining and expanding the technical development of the Australian Pistachio Industry*.

The major recommendations from PS14000 included: -

- a) Mechanical pruning
- b) Chill response
- c) Nut Shell Pressure Model

- d) Predictive model on assessing the percentage of Blank Nuts
- e) Predictive model on assessing the percentage of Narrow Split Nuts
- f) Predictive model on assessing the length of the harvest season.

These and more topics have been absorbed into this PS17003 proposal.

Critical aspects of the program were as follows:

- Improving yields by better understanding and reducing the percentage of nut abortion and blanks grown (currently 25%)
- Improving the understanding of pollination, fungal and insect pests in pistachios
- Best practice crop nutrition, particularly the role of Boron and Potassium
 - Crop nutrition
 - Boron
 - Potassium
- Improving the nut size of Sirora pistachios
- Understanding and minimizing the impact to growers of poor chill years by measuring accumulated chill portions each winter and trialling various chill mitigation techniques

Chill Model and Management

The industry has established a model to predict the number of hours of field chill required for bud burst in 'Sirora' on *P. terebinthus* rootstock. Throughout the coming project additional data will be collected to further expand industry knowledge on the chill hour requirements and refine the model.

Processes to be used include routine work of

- a) collection of hourly temperature data,
 - b) weekly data processing,
 - c) bud break observation, and
 - d) to provide three (3) reports to growers (June, July, August).
- Understanding heat and daylight requirements
- Best practice pruning to moderate alternate bearing: -
 - Current mechanical pruning
 - Tree establishment
- Benchmark and report on quality and yield to a participating grower collective
 - The PR through their linkages with the Australian Pioneer Pistachio Company (APPC) was to continue to have confidential access to all harvest and processing data and would be able build on the industry data set that had been established and maintained over the past 20 years.
 - Annually the information was to be 'loaded' into the appropriate spreadsheets and a national set of data report on topics like marketable yield per hectare, count size/100 gms; in-hull yield; non-splits; dark stain and blanks, would be prepared.
 - This information would be presented to each of the individual growers during the June/July visits.
 - The PR would present the industry data to the Pistachio R&D Committee for review, and then the relevant industry data sets up-loaded onto the PGAI website.

- Exploring and proposing new development areas for pistachio research based on international advances, particularly Californian research and the Iranian pistachio industry.
- Contributing to the increase of planting of pistachios by 5% per annum of the existing planted hectares

The PR was to work with both existing growers and new growers to provide the necessary production 'tools' to commence and/or increase plantings.

Part of the process was to ensure growers have the best available technical information, from Australia and overseas, to ensure new plantings reach production in the most efficient and effective way to ensure the best Return on Investment (ROI).

- Complement field research with a variety of methods to disseminate information and promote the adoption of R&D. This may include print, electronic, social media and other face to face methods as well as field days. The PR will:
 - be required to prepare and submit relevant information for distribution to the pistachio industry and growers.
 - at times prepare and submit relevant scientific research reports/papers to the Australian Nutgrower magazine.
 - where appropriate, prepare papers to be submitted to relevant scientific journals for peer review and then publication.
 - be required to attend each of the 'PIT' group meetings (part of Project PS17002) during the period March 2018 to January 2021 and give a presentation on a relevant piece of research.
 - visit the growing regions and undertake one-on-one meetings with growers twice a year.
 - June/July – to review last harvest, present some performance graphs and discuss pruning.
 - Late October and early November – to check the response to winter chill and then report to the committee on likely crop prediction.
- Update and be guided by the Pistachio R&D Committee (inclusive of designated Hort Innovation representatives) via attendance at all meetings and through other channels specified by the committee.

The PR was required to attend and give a progress report at each of the Pistachio R&D Committee meetings held in February, June and September each year.

The PR was through observations and grower input be required to collect and collate topics and/or issues as they relate to the production of pistachios.

- Be able to respond to changing environmental and seasonal issues that may arise during the project.

As the PR will have had the opportunity to review all the past and current research undertaken by the RFO they will have developed a sound understanding of the results and where the gaps might be.

By being based at CMV/APPC the PR will have direct access to the trial orchard at CMV Farms plus other areas of the orchard. In addition, the PR will have access to the orchard facilities at Kyalite Pistachios and other grower properties.

Through the one-on-one orchard visits the PR will be able to communicate with growers and seek their inputs/comments of particular environmental, seasonal and production issues.

Also, through general observation the PR will see issues within the orchards.

Through regular communications with overseas researchers and through visits to the USA and other international growing areas will be able to keep abreast of international environmental, seasonal and production issues and will be responsible for bring such information back to the Pistachio R&D Committee.

- Cooperate with other research providers and allied industries to maximise the value of research.
- Develop a program logic framework to guide the project and have regular and ongoing evaluation measures built into the project. This should include a combination of KPIs measuring outputs and outcomes and inform monitoring and evaluation.

The Project Team Leader, Trevor Ranford, was to work with the PR and the Project Steering Committee to prepare a comprehensive operation plan that would include the following components:

- *monitoring and evaluation (M&E) plan.*
- *project risk register including detailing how risks will be managed.*
- *stakeholder communication and engagement (C&E) plan.*
- *5-year Work Plan broken into 6-monthly blocks.*
- *5-year broad KPIs broken down to 6-monthly KPIs.*

The Work Plan and the KPIs were to be used as components of the individual milestones to ensure the project was delivering the planned outputs and achieving the right outcomes.

- Conduct a mid-project evaluation to assess stakeholder satisfaction with the program. This will be a stop/go evaluation.

PGA was to commence a mid-year review in November 2020 with the report being delivered as part of milestone 108.

The review and evaluation would include: -

- A survey for growers to complete.
- One-on-one interviews with a number of growers.
- Input by the Pistachio R&D Committee.
- Input by the Executive Committee of the Pistachio Growers' Association Inc.
- Interviews with associated research organisations.
- Input from Hort Innovation representatives.

The evaluation will be undertaken by an independent consultant selected by the Pistachio R&D Committee and Hort Innovation.

As Project PS17003 was across a 5-year period the total program was divided into smaller 'subsets' and for each of these the PR was required to develop a document that covered a range of components and then present this to the Pistachio R&D Committee for comment and input.

The components to these 'subset' topics are detailed as follows: -

- Subset Topic.
- Hypothesis.
- Methodology.
- Trial Layout.
- Experimental setup.
- Trial Observations.

- Results.
- Assess the economic impact on industry.
- Resources – funds, materials, staff.
- Budget.

Once each 'subset' was signed-off the Pistachio R&D Committee would establish a Working Group to assist the PR in implementing and adjusting (where necessary) the research work.

5. RESULTS AND DISCUSSION

RESEARCH UNDERTAKEN BY DR SUBHA ABEYSINGHE

Dr Abeysinghe undertook a range of activities during the period covered by her engagement.

1) CONDUCTING TRIALS

A. Enhancing chill accumulation by using Polymer in pistachio trees.

1) Polymer + oil and oil trial – Commercial level - (2nd season):

Objective

Repeating the 2019/2020 commercial trials during the 2020/2021 season to find out the yield increment and blank nuts reduction by polymer + oil application.

Methodology

Trial was implemented in block 3, CMV orchard, Victoria. 0.5% Polymer was applied 4 days before the application of 3%, 1500L/ha oil.

The Polymer + Oil (P+O) applications were on 21 rows with 3 replicates. The 3%, 1500L/ha winter oil applied trees (W) were considered as the control area and included 31 pistachio rows. The bud temperatures were monitored for the 2 treatments ((P+O) & Oil (O)) from mid-August to the end of September 2020 utilising 16 thermocouples. In addition, diurnal temperature changes were assessed. Separate samples were collected from 12 rows of P+O and 12 rows of O. The bud burst and flowering were assessed and had been reported previously. Nut set, nut retention, yield, blank nuts and other nut qualities of P+O and O were assessed and the results are detailed below.

Results

(i) Nut set and Nut retention

Nut set was significantly ($P < 0.05$) different between treatments. In the P+O, nut set was 132 nuts/cluster while 114 nuts/cluster in the O. However, nut retention, which was 21 nuts/cluster in both treatments, was not significantly different.

(ii) Yield

Yields were not significantly different between treatments.

Shake	Treatment	Yield (kg/tree)	Increment (%)
1 st shake	P+O	20.8	
	O	22.4	7%
2 nd shake	P+O	9.5	7%
	O	8.9	
1 st + 2 nd shake	P+O	30.4	

Table 1: Summary of yield of P+O and O trees in different shakes

(iii) Blanks%

The reduction of blank nuts in the P+O treatment was not significant (1stshake).

Overall Blank nut percentages (%) for both treatments showed no significant difference but it may have been different if the 2nd shake was included.

Shake	Treatment	Blank Shell FM (%)
1 st shake	P+O	3.9
	O	4.6
2 nd shake	P+O	22.2
	O	21.9
1 st + 2 nd shake	P+O	9.6
	O	9.3

Table 2: Summary of blanks% of P+O and O trees in different shakes.

No significant difference in other quality parameters, as detailed below were seen based on merchantable yield.

(iv) Nut quality parameters

(Dry weight, % Blank, Blank shell FM, No1GradeSmall, No1GradeMedium, No1GradeJumbo, Light Stain, Narrow Split, Pick Out, Loose Kernel, Non-Split, Floaters, Adhering Hull %, Dark Stain %, Damaged Shells %, Gold Stain %, Chocolate drops %, Other Stain %, Floaters %, Total Non-Split %)

Conclusion

Even though nut set was significantly different nut retention was not significantly different. This may be an effect of the chill accumulation of 2020/2021 season and/or the availability of carbohydrate resources in P+O trees due to the higher yields of the previous season. Nut quality parameters were not significantly different based on merchantable yield including blank nuts %.

B. Shoot dipping trial in polymer solution - (Preliminary study)

Objective

To determine the optimal date/time of application of polymer for oil treated pistachios trees to achieve better bud break.

Methodology

7 treatments were applied based on different dates for 175 randomly selected, non-detached shoots of pistachio trees. In addition, 25 randomly selected, non-detached shoots were utilised as a control. During the trial period, bud burst %, flowering %, nut set and retention, and blank nut % were assessed manually. This trial was a preliminary trial which used only 5 trees in CMV, block 2 and 0.5% polymer was used. Oil was applied on the 20th of August to these shoots.

Treatments are as below:

Treatments	Date of application
Treatment- 1	31-July
Treatment- 2	6-Aug
Treatment- 3	13-Aug
Treatment- 4	20-Aug
Treatment- 5	27-Aug
Treatment- 6	31-July & 27-Aug
Treatment- 7	6-Aug & 27-Aug
Treatment- 8	Control/Winter oil only

Table 3: Polymer treatments are based on the application dates.

Results

(i) Nut set and nut retention

Nut set was not significantly different between treatments however nut retention was significantly different ($P < 0.05$) across the treatments (Table 4).

Characters	31-Jul	09-Aug	16 Aug	20 Aug	27 Aug	31 Jul + 27 Aug	06 Aug+ 27 Aug	Winter oil only
Nut set (nuts/cluster)	40 ^a	34 ^a	39 ^a	34 ^a	39 ^a	34 ^a	33 ^a	35 ^a
Nut retention (nuts/cluster)	21 ^a	23 ^a	23 ^a	19 ^a	20 ^a	14 ^b	23 ^a	14 ^b

- ^{a,b} – Showing significantly ($P < 0.05$) difference.

Table 4: Summary of nut set and nut retention.

(ii) Blank nuts

122 bunches were retained and harvested during the season. The blank nuts % are as below (Figure 1)

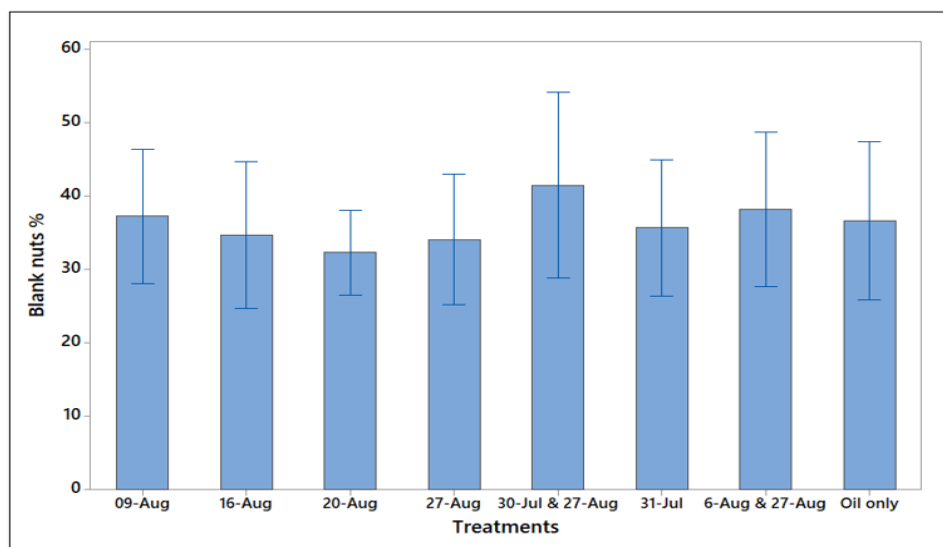


Figure 1: Blank nuts percentages based on the date of polymer application.

Conclusion

- Nut retention was significantly different with the different dates of the applications of the polymer.
- Blank nut % were not significantly different across the treatments in this preliminary trial (2 seasons). The number of samples taken may have affected the results.
- Different dates of application are recommended for future commercial level trials.

C. Observational study for reducing blanks.

Objective

To develop a polymer application method to reduce blank nuts.

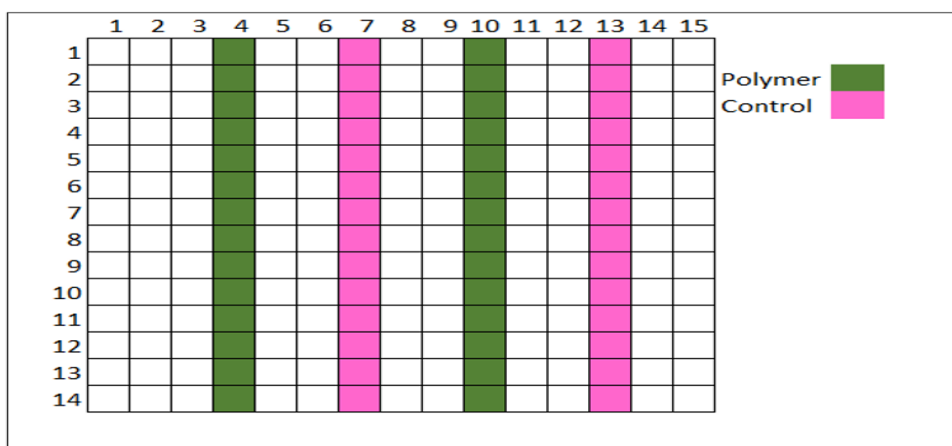


Figure 2: Layout of observational study for reducing blanks.

Methodology

0.5% Polymer was applied at 1500L/ha on the 13th of August 2020 to the block followed by the application of 6% Oil applied at 3000L/ha on the 25th of August 2020. 2 Polymer and 2 control rows were harvested separately at the time of commercial harvesting.

The observation rows were also harvested and weighed separately. Blank nut % were assessed according to APPC standards.

Results

(1) Yield

This data was not analysed statistically due to the low number of samples.

Shake	Treatment	Yield	Increment (%)	No of samples
1st shake	P+O	63.9		2
1st shake	O	67.7	5.5	2
2nd shake	P+O	15.1		2
2nd shake	O	17.8	15	2
1st + 2nd shake	P+O	39.5		4
1st + 2nd shake	O	42.7	7.5	4

Table 5: Summary of yield of P+O and O trees in different shakes.

(ii) Blank nuts

Shake	Treatment	Blank Shell FM%	Remarks
1st shake	P+O	1.1	Low blanks%
1st shake	O	1.7	
2nd shake	P+O	11.1	Low blanks%
2nd shake	O	14.3	
1st + 2nd shake	P+O	11.1	Low blanks%
1st + 2nd shake	O	14.2	

Table 6: Summary of blanks% of P+O and O trees in different shakes.

Conclusion

Observations of reduction of blank nut % in P+O was similar to other polymer trials.

It is recommended that commercial level trials be conducted.

D. Improving Zn absorption and translocation by using Zicron.

Objective

To increase Zn uptake and Zn mobilization in Pistachio trees, to overcome the barrier to Zn absorption, by the thick leaf cuticle.

Methodology

The methodology was similar to 2019/2020 season and the leaf samples and soil samples were taken before Zn application in 2020/2021 season. Soil was sampled in mid-September 2020 and leaf samples were taken at the beginning of October 2020. Further, part of the leaf samples, of the 3 treatments, were washed with acid before sending them to the laboratory to reduce the effects of contamination.

Zn chelate and Zicron applications continued until January 2021.

Results

(i) Yield

In the 1st shake, the yield of Zn chelate was significantly different to the control however, there was no significant difference in yield between Zicron and the control. In the 2nd shake, yield was not assessed due to practical problems in the orchard.

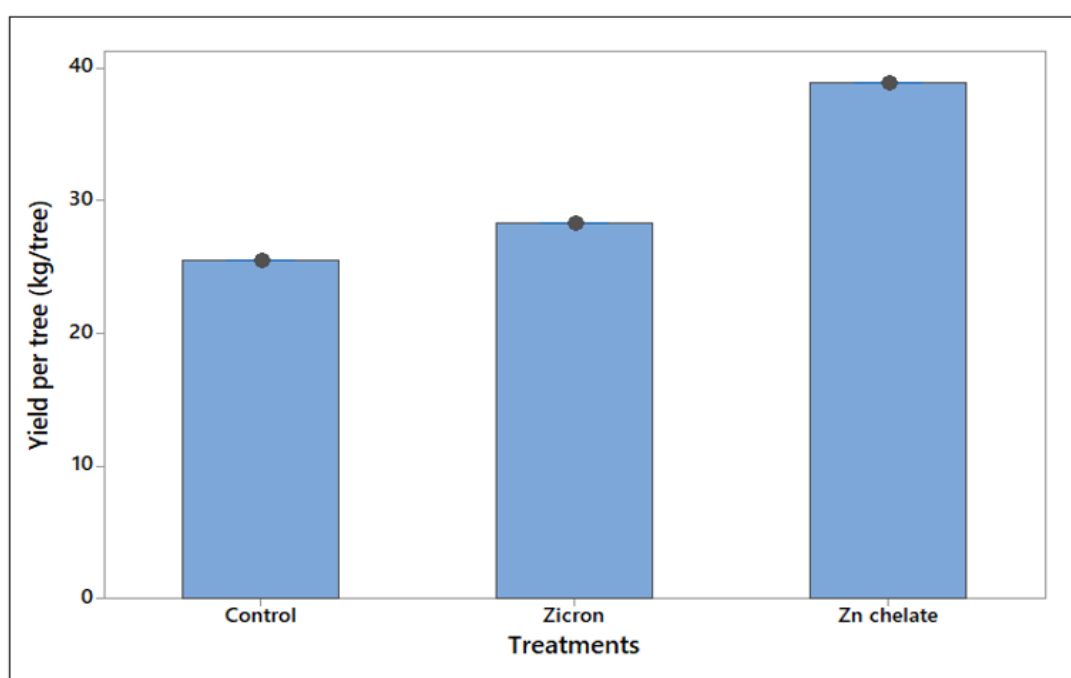


Figure 3: Yield of different treatments in the Zn trial

(ii) Leaf analysis

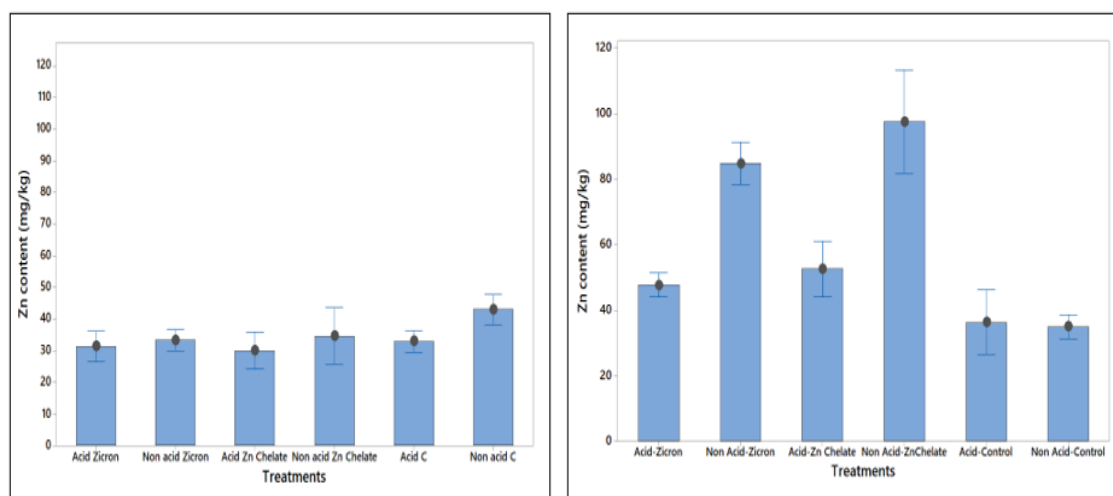


Figure 4: Zn content in the leaf before and after applying Zn treatments in 2020/2021 season.

In the before application situation, acid washed control, Zicron and Zn chelate were not significantly different. As previous report, only acid washed samples are considered due to the removal of any surface contaminants.

In the after application, the increment of Zn content in leaves which were treated with Zicron and Zn Chelate were 16.3 and 54.7 mg/kg, respectively. The Zn increment of the control leaves was only 3.4 mg/kg which may have been due to contamination. All samples were acid washed. The increment of Zn content in Zicron treated leaves was significantly higher than the control leaves.

(iii) Nut analysis

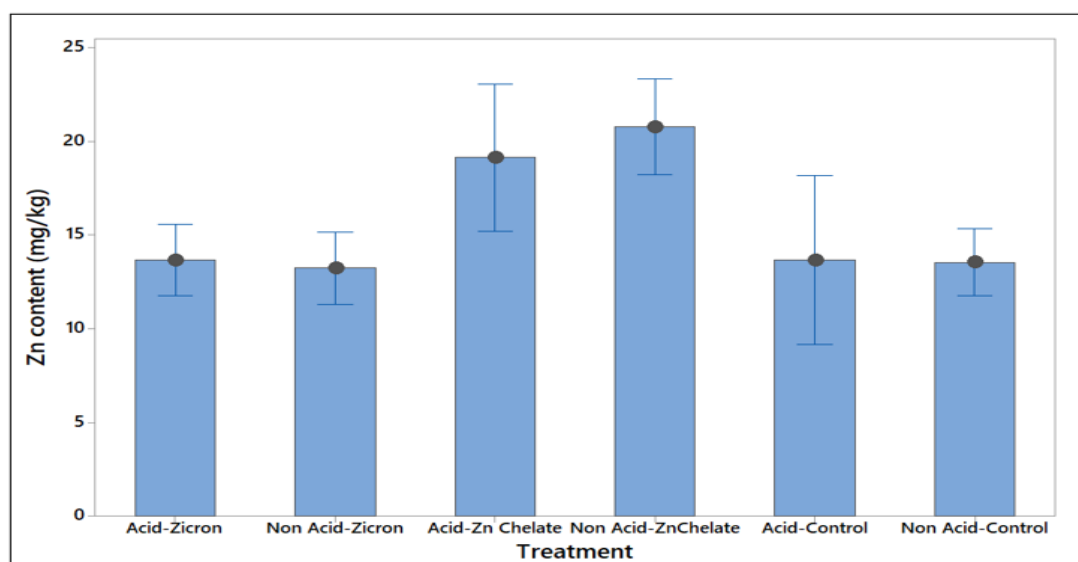


Figure 5: Zn content in the nuts after applying Zn treatments in 2020/2021 season.

The Zn content in acid washed Zicron and Zn chelate were not significantly different to the control.

E. Investigating the possibility to increase yield of young Kerman (related to bud abscission)

Objective

To find out the underlying causes of low yield of young Kerman trees (6 – 11 years).

Methodology

Based on the close observation of 2019/2020 season, a survey was developed and conducted in 4 orchards. The selected orchards were as below for the study.

- Kyalite orchard, NSW
- CMV Farm, Robinvale, Victoria
- Chislett orchard, Kenley, Victoria
- Kaniva orchard, Nhill, Victoria

Leaf analysis of Kerman and Sirora young trees (same age) was conducted to find out if there were any nutrient effects on bud abscission. Leaves were collected from both fruiting and non-fruiting shoots of each variety separately. Leaf analysis commenced at the beginning of November and continued until harvest. Samples were collected every week from the beginning of November to the beginning of December (starting of bud abscission in Kerman) and leaf samples were collected every 2 weeks from beginning of December to harvest.

Results

The nutrient content of fruiting and non-fruiting leaves of Kerman and Sirora are reported in the figures below.



Figure 6: Total nitrogen analysis in leaves of non-fruiting and fruiting shoots in Kerman and Sirora trees.

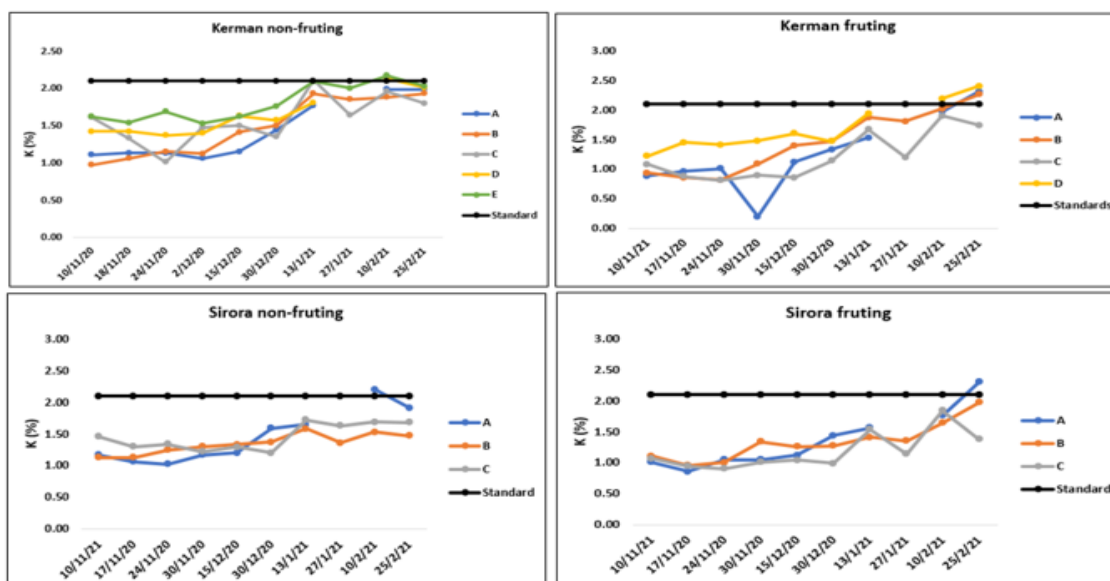


Figure 7: Potassium analysis in leaves of non-fruited and fruited shoots in Kerman and Sirora trees.

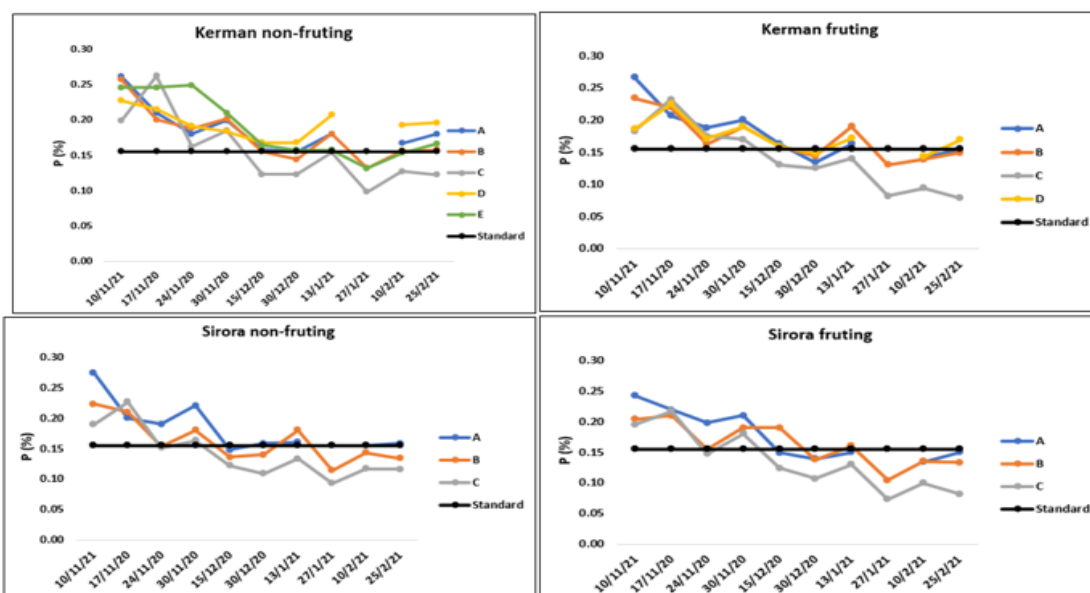


Figure 8: Phosphorus analysis in leaves of non-fruited and fruited shoots in Kerman and Sirora trees.

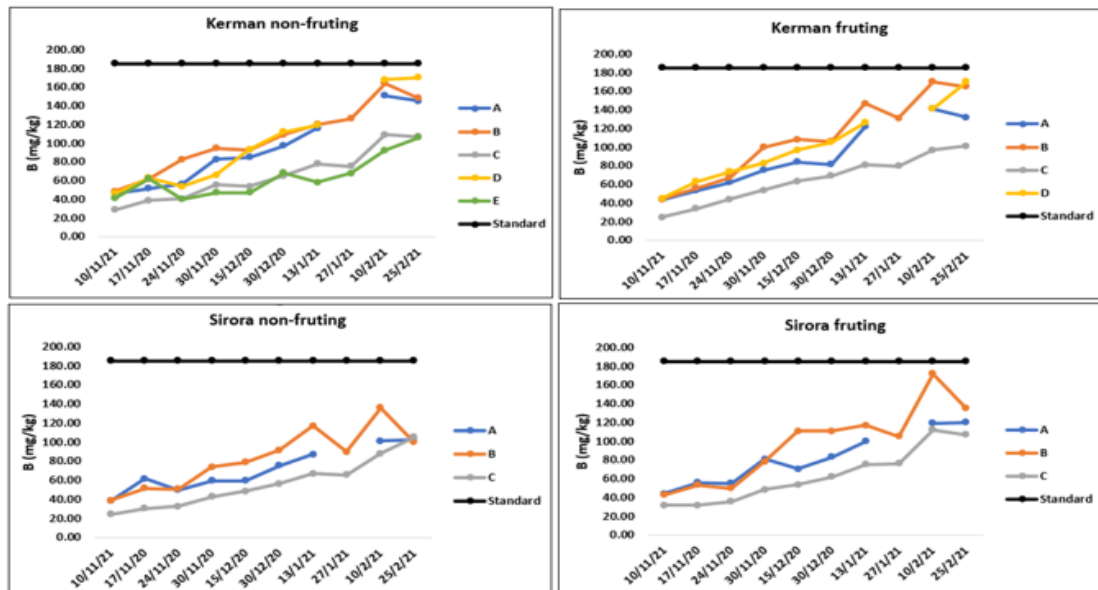


Figure 9: Boron analysis in leaves of non-fruiting and fruiting shoots in Kerman and Sirora trees.

Observations

From the leaf analysis results the following observations have been made:

- total N of leaves in Kerman non fruiting shoots were higher than Sirora non-fruiting shoots from the beginning in November to end of February,
- total N in Kerman fruiting shoots was higher than Sirora fruiting shoots,
- B content in leaves of non-fruiting and fruiting shoots of Kerman and Sirora was lower than the standard level throughout the season.

Future studies

The Kerman study working group have suggested the following for the next part of this program: -

- Applications of N, P, K and B need to be studied further.
- Patrick Brown's prediction model needs to be used to test the leaf analysis results.
- Leaf analysis should be done during an "on season".
- Reviewing the Californian manual to find out if there are differences in their programs compared to those used in Australian orchards.

F. PREPARATION OF THE INDUSTRY BENCHMARKING REPORT

The PGAI has long had a KPI of 75% of all growers achieving an average yield of 3,000kg/ha¹. The PGAI has been monitoring this KPI in its annual Benchmarking reports to individual growers. It has been measured using the **median** result for all growers, i.e., 50% of growers achieve better than the median yield and 50% achieve less than the median.

Chart 1 has been presented for many years using the results of the median grower, i.e., 50% of growers above and 50% of growers below. Whilst there has been considerable improvement since the 2011 pandemic the two-year moving average is still sitting at 2,500kg/ha for the median grower.

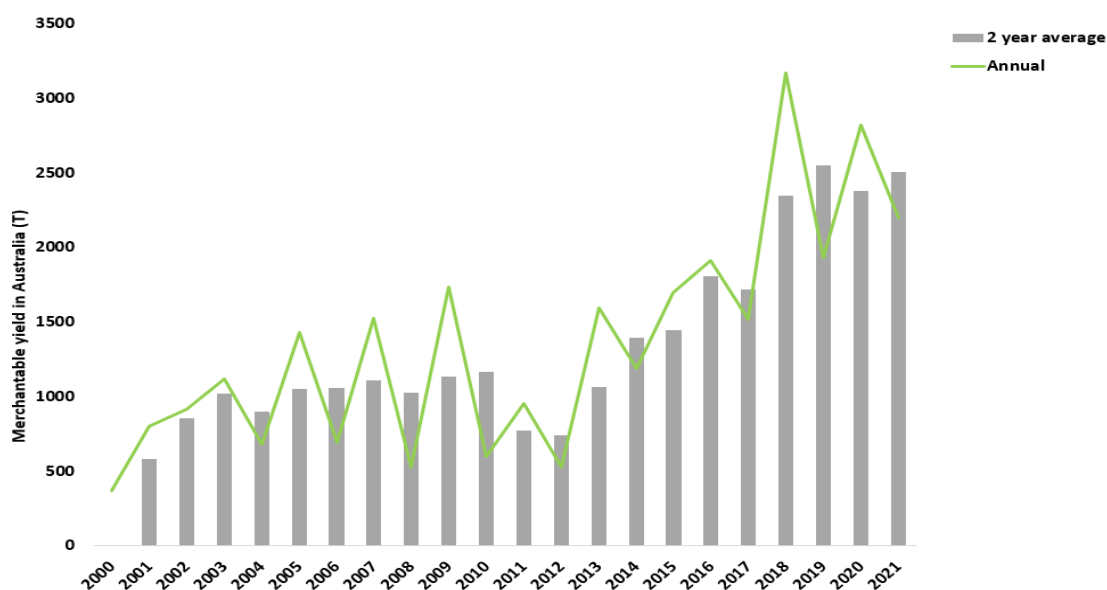


Chart 1: Source PGA annual benchmarking study

Through the work, initially by Dr Abeyasinghe and then continued by Dr Zhang, the 2021 harvest data has been assessed and the relevant benchmarking reports are being prepared.

The following are the overall industry results from the 2021 Benchmarking Study.

- These show the range of results for yields and qualities from the growers who supplied APPC.
- The quality aspects reported here are those that impact on the value of the crop, i.e., the \$/kg to the grower. The larger, cleaner, splits, the higher the \$/kg the grower will achieve.
- Each grower will receive a copy of this report together with a line that shows the performance of their orchard. The grower will be able to see their position relative to all other growers.
- The charts were produced by Dr Zhang, the commentary by Chris Joyce and the individual grower results will be sent during the first week of July 2021.

¹ The PGA also sets a KPI of 7.5kg/tree for less densely planted orchards. For the sake of simplicity, kg/ha has been used. If the data is reworked on a kg/tree basis, the same trend emerges with the same conclusion – better growers are doing very well, poor growers are doing badly.

This report has tried to exclude the yields from newly cropping orchards. This may not have been done perfectly, but any errors will not impact on the overall conclusions.

(i) Marketable Yield kg/ha

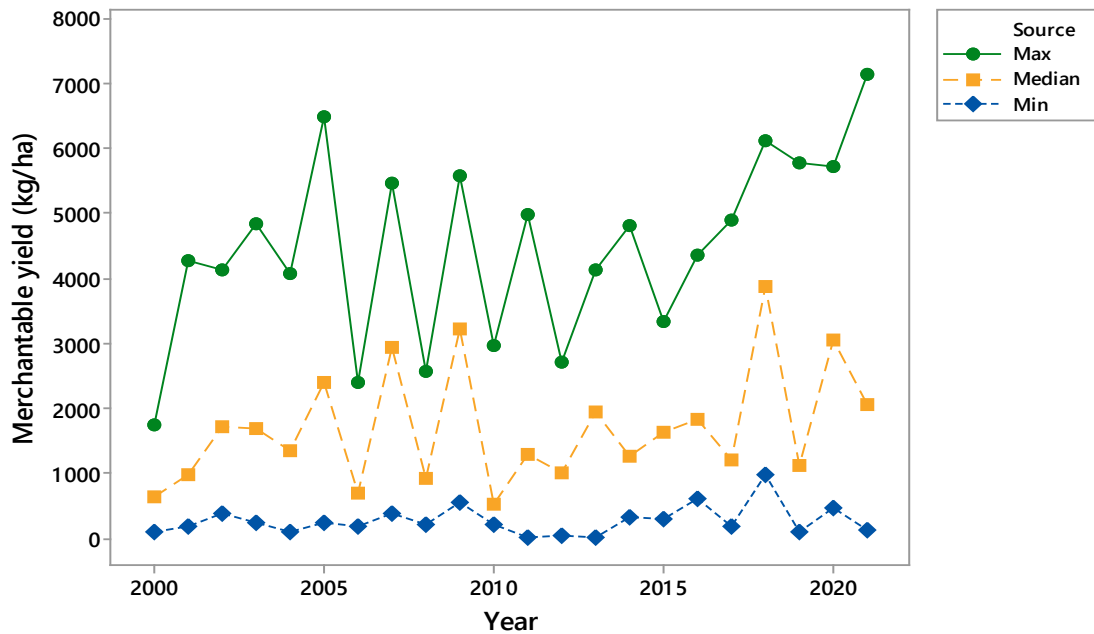


Chart 2: Source PGAI Benchmarking data 2000-2021

Chart 2 shows that the best result was over 7,000kg/ha – this is from a 75ha 15-year-old orchard, Sirora on PG1. The median grower managed about 2,000kg/ha which was the best ‘off crop’ result ever. The 2021 crop resulted in a 2-year moving average, over the on and off crop, of about 2,500kg/ha, well below the PGA KPI of having 75% of growers achieving an average of 3,000kg/ha. The lowest yielding (mature) orchards were less than 1,000kg/ha.

(ii) In hull, kg/tree

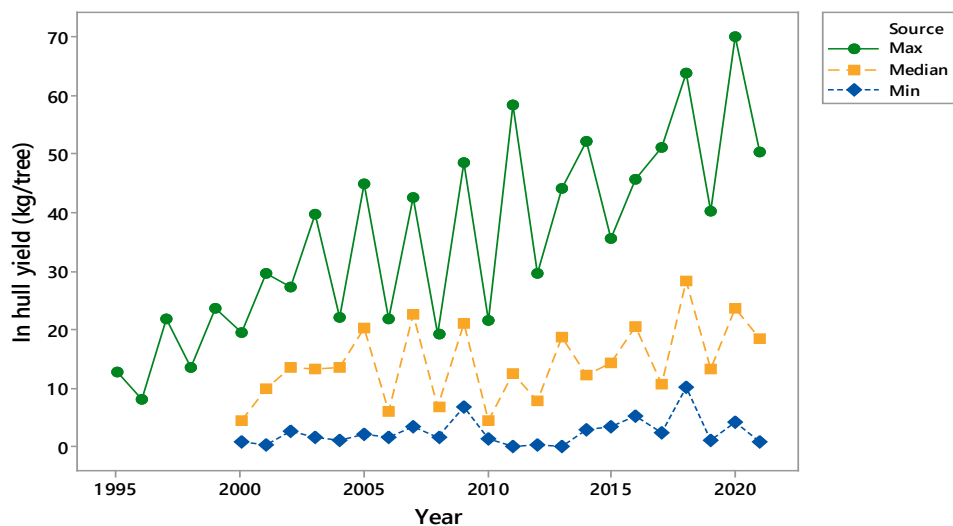


Chart 3: Source PGAI Benchmark data 2021

Chart 3 shows the variation in yields between growers, but, on a per tree basis rather than per hectare. On a per tree basis, the best performing orchard produced 5 times more per tree than the median orchard. Again,

the poor (mature) orchards did not do well.

(iii) Nut Size

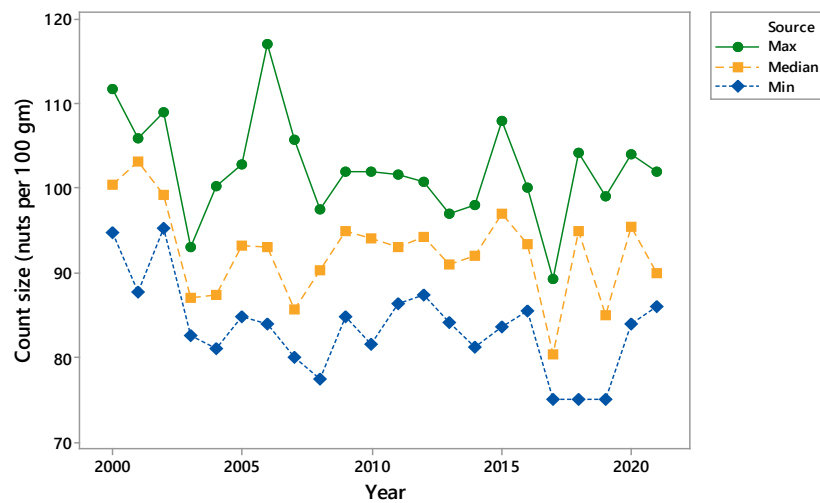


Chart 4: Nut size in nuts per 100gm. Source PGAI Benchmark data 2021

Nut size is shown in nuts/100gms, the lower the number the bigger the nut.

The median nut size has been smaller than 90 nuts/100gms for all bar two years of the past decade. As the crop size increases, it will be harder to find a home for the smaller nuts.

Improving nut size needs to be a focus for the PGAI.

(iv) Dark Stain

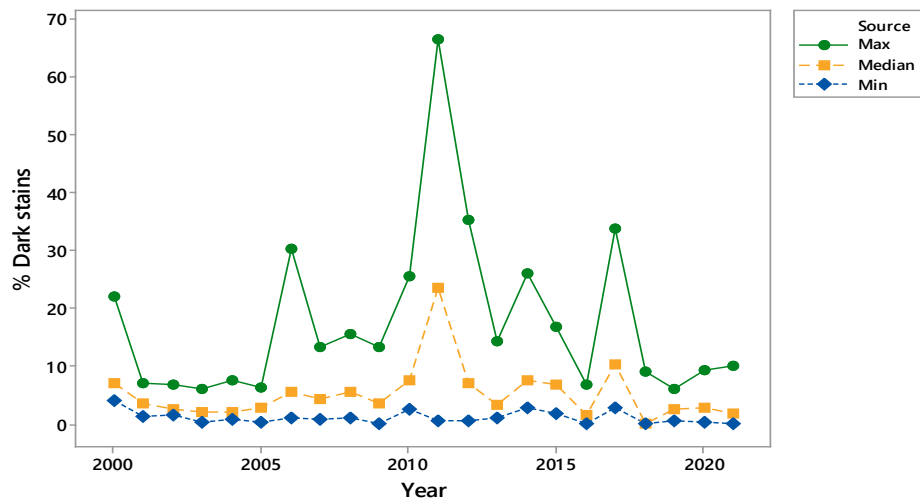


Chart 5: Source PGA Benchmark data 2000-2021

Dark Stain was generally very low in 2021. There were a few orchards who had high levels and whose \$/kg returns will be reduced.

(v) Closed Shell

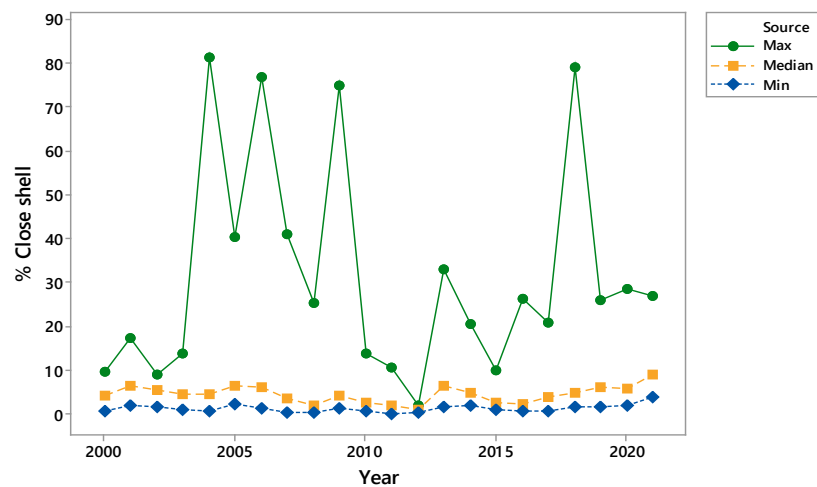


Chart 6: Source PGA Benchmark study 2000-2021

Closed shells were higher in 2021 than recent seasons. Perhaps the cool summer in January/February did not push the kernel growth as hard as recent seasons?

G. OTHER ACTIVITIES.

a. Virtual 2021 State-wide Pistachio Day

Dr Abeysinghe was registered for and participated in the Virtual 2021 State-wide Pistachio days organised by the University of California, Division of Agriculture and Natural Resources, which was held on the 12th and 13th January 2021.

The Pistachio Day delivered the latest research-based production practices to prospective or current growers, production managers, and pest control consultants so they are better able to achieve their pistachio growing goals.

The diverse program included an industry overview as well as sessions on various important topics within the areas of Food Safety and Regulations, Horticulture Science, and Integrated Pest Management.

2021's Pistachio Day was held in a webinar format online as a two-day event.

b. Dr Abeysinghe participated in the Australian Nut Industry Council (ANIC) Leadership Program.

The Program Objectives are:

1. Gain critical perspectives, enabling development of future foresight.
2. Communicate the industry's strategic direction, achieve alignment and build commitment to taking the industry forward.
3. Develop 'buy-in', engage people in the Nut Industry's strategic journey and get them collaborating to make it happen.
4. Increase creative thinking and innovation.
5. Solve complicated problems and take wise action amidst complex, rapidly changing conditions.

The Leadership Program was conducted over 14 sessions via Zoom between September 2020 and April 2021. A face-to-face session was held in Griffith, NSW over the period 29th April to the 1st of May 2021 at which Dr Abeysinghe participated in.

Dr Abeysinghe report that

“This program opened my mind and created me to think and see other aspects of opportunities. Now I have started to read which helps me to think differently. I need to do more reading, but I need to try to find time. As a researcher, I may not go to the highest level up the ladder, but the program helped me to understand problems and find solutions more proactively in the job as well as the life. Sometimes, we can’t distinguish levels of leadership in the real situation, but we act and deal which demonstrates different levels. Interesting to see the next few sessions.

Also, this program has created opportunities to deal with different topics in this pandemic environment.”

The program was undertaken outside of normal working hours and Dr Abeysinghe has shown a willingness to participate in the Program while still undertaking her normal daily work.

MID-TERM REVIEW:

As required within the Project the Pistachio Growers’ Association Inc (PGAI) conducted a mid-project evaluation to assess stakeholder satisfaction with the program.

The processes that were undertaken include the following: -

- A proposal was prepared in conjunction with Adrian Hunt (Hort Innovation) and signed off. This was distributed to a number of recommended consultants.
- Dr Kevin Clayton Greene was engaged, as an independent consultant, to undertake the review.
- All relevant project information was supplied to Dr Clayton-Greene.
- Interviews, either via Zoom or face-to-face, were undertaken through May 2021.
- A Final report was prepared and submitted to both PGAI (Trevor Ranford) and Adrian Hunt.
- The report has been distributed to the R&D Committee and the Executive Committee

The following is the summary and recommendations from the review: -

SUMMARY

A mid-term review of the Program (PS 17003) has found it to be a highly effective R&D vehicle for the Pistachio industry and that it should continue. Through its structure it addresses many of the perennial issues of traditional R&D delivery of relevance and implementation. It is a model that would serve many horticulture industries.

During the Review the scientist resigned to take up a position elsewhere and thus the Review was asked the opportunity to also take a broader view of the Program than the initial brief and this is reflected in the suggestions below.

Recommendations

General

- Putting a pause in R&D other than Bench marking and Chill unit monitoring while a new Scientist is appointed and ‘finds their feet’.
- A new appointee needs to be located in an environment where they can interact with peers.

- Irrespective of the work being performed it is important that the science be developed to understand mechanisms of action of treatments. The temptation to perform 'spray and pray' experiments need to be resisted.
- The industry needs to attach a tighter priority on the work and make decisions about the type of structure it wants in the future (viz. a wide spread of projects with a disparate skill set or more intensive projects)
- A new appointee needs to have a skill set to match the requirements of the R&D
- Consideration given to outsourcing or getting external and direct input into projects where the skills required are outside those of the appointee.
- Research Formulation should be more formally recorded and planned – a suggested pro-forma is attached (Appendix 3)
- In conjunction with the above, the R&D committee to develop a more comprehensive approach to project resourcing including a time budget against which actual projects can be measured and demands upon personnel monitored.
- Consider possible employment options for greater job security for the appointee and also the need to consider bridge funding between five yearly funding rounds.

Project Specific

- The Polymer work needs to be focused on mode of action and efficacy and sufficient data generated to provide clarity around whether registration is required.
- The Kerman study needs some basic but detailed information gathering on practices both here and in California in order to provide some guidance on the future direction of research.
- Unless a more convincing case can be made the Zn work should be discontinued. If it is decided to continue, then a much greater degree of rigour is required.
- Nutrition work needs to be performed by or in conjunction with someone expert in the field and contemporary practice.

Observations for PGA consideration

- Development of a web-based chat room for use by members as part of PS 20000
- Develop a strategic plan for expanded R&D in the future with a view to having a dedicated orchard trial site and a place for the industry in State government planning and thinking.
- Consider setting aside some funds for 'over the horizon' R&D to counter potential industry threats e.g., water availability and chill requirements against a backdrop of a warming climate. Precision agriculture is also an area which is rapidly developing and can offer significant benefits.
- There may be increased scrutiny of nitrogen application in future and although not part of the brief it was noted that the levels and form of nitrogen application appear to be very high for tree crops and may exacerbate deficiencies in other elements, whilst UAN will accelerate soil acidification. Calcium nitrate may offer some advantages."

At a meeting of the Pistachio R&D Committee, held on Thursday 24th June 2021 (via Zoom) the full report was tabled and reviewed. In particular the summary and recommendations were considered in detail and the R&D Committee agreed to:

- 1. Adopt all of the 'recommendations – general and project specific' - and the 'observations for PGA consideration'.**
- 2. Recommend to the PGAI Executive Committee that Project PS17003 continue but with appropriate**

variations coming from the summary and recommendations.

3. Recommend to the PGAI Executive Committee that a new Pistachio Researcher be engaged and that the relevant work plans be developed to continue the project utilising the skills of the new Researcher.

RESEARCH UNDERTAKEN BY DR MAHA MAHADEVAN:

Projects subsets as part of PS170003

1. Oil and polymer trial

- a. 2021/22 season

Background: Owing to the inadequate and below average dynamic chill portions accumulation by 15th August in 2021 in the Riverland regions of SA, a trial was conducted in Waikerie to explore and capture the potential effects of polymer and oil, alone or in combination.

Objective: Response of polymer and oil application alone or in combination to (i) Phenology, (ii) yield and yield components and iii) yield and quality

Materials & methods: The trial was conducted in Richard Isaacson's Orchard, Waikerie (34.18OS, 139.96OE) on 8-year-old Sirora on PG1 rootstock (spacing 7x5m) laid out as a Completely Randomised Block Design (CRBD) experiment with 5 treatments consisting of polymer (0.5%) and oil (6%) sprays at weekly intervals (Polymer only, Polymer followed by oil, oil only, oil followed by polymer, control (no polymer & no oil)) and three replications(blocks). Control trees were individually covered with tarpaulin during sprays. Treatments were colour coded and eight randomly selected shoots per tree (total of 120 shoots) were tagged (in four direction and two levels) for weekly phenological scores and yield and yield component determinations.

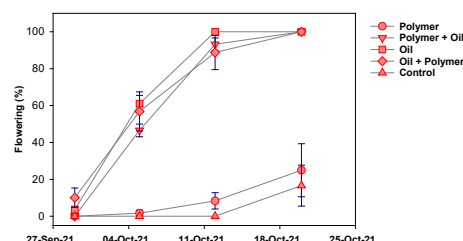
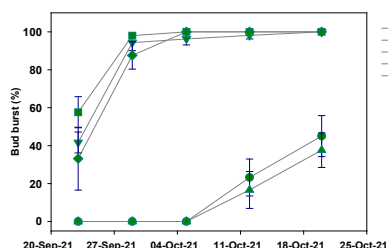
OBSERVATIONS

1. **Phenological response:** Bud burst (%), flowering (%); determine uniformity and window.
2. **Yield & Yield components:** Determine number of bunches at shoot and tree level and number of nuts at bunch, shoot and tree level and establish relationship within hull yield per tree to identify significant yield contributing traits.
3. **Yield & quality:** Marketable yield & Quality with focus on blank nuts (%), estimated based on industry standards.

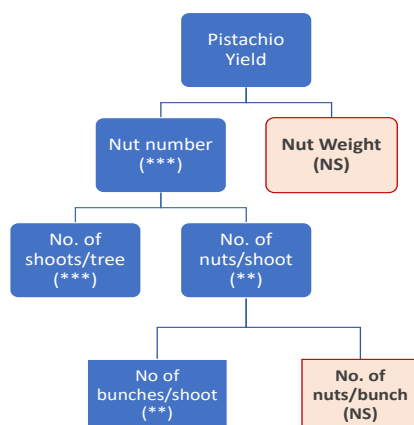
RESULTS & DISCUSSION

1. Phenology:

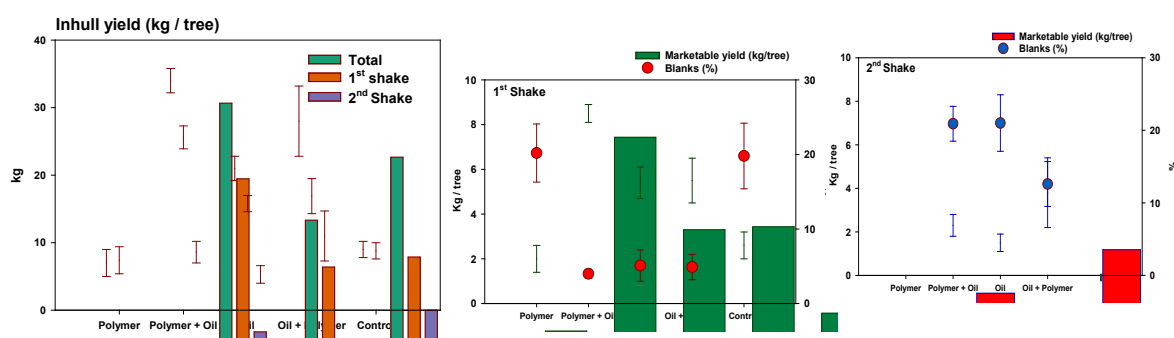
- a. **Bud burst:** Oiled treatments were early with narrow window of 9 days to reach 100% while polymer only and control treatments showed 22 days delay and never attained 100% budburst.
- b. **Flowering:** Flowering was similar to budburst, treatment with oil application was early and reached 100% flowering in 10 days while polymer only and control treatments were 15 to 20 days behind and never reached 100% flowering.



- c. **Harvest:** Maturity of polymer only and control treatments were delayed causing harvest to be pushed by 22 days and had only one shake. The delay for bud burst carried on to delay in flowering and subsequently delayed harvest in polymer and control treatments suggesting the importance of oil application for uniform and early budburst and flowering.
2. **Yield and yield components:** Pistachio yield could significantly be improved by increasing the no. of bunches per shoot and no. of shoots per tree, which eventually culminates in more nut numbers.



3. **Merchantable yield and blank nuts:** Polymer application significantly increased total yield while it does not show significant difference for blank %. Polymer followed by oil application treatment outyielded the rest of the treatments. Polymer only and control showed significantly lower yield and highest blank %; 73% lower yield and 80% more blank % than polymer followed by oil application treatment. The results indicated that polymer application (before or after oil) could complement oil application for yield. However, polymer application did not have any influence on blank %, suggesting that yield increase could possibly be through increased no. of nuts/tree through improved no. of nuts per shoot there by increasing the viability of buds and shoots resulting in improved productivity of a tree.



2. Bud opening and flowering study

Background: Of interest to the pistachio industry, an observational trial on bud burst and flowering of different age trees and response of buds to the directions was taken up.

Objective: Determine the tree age and direction on differences in response to phenology.

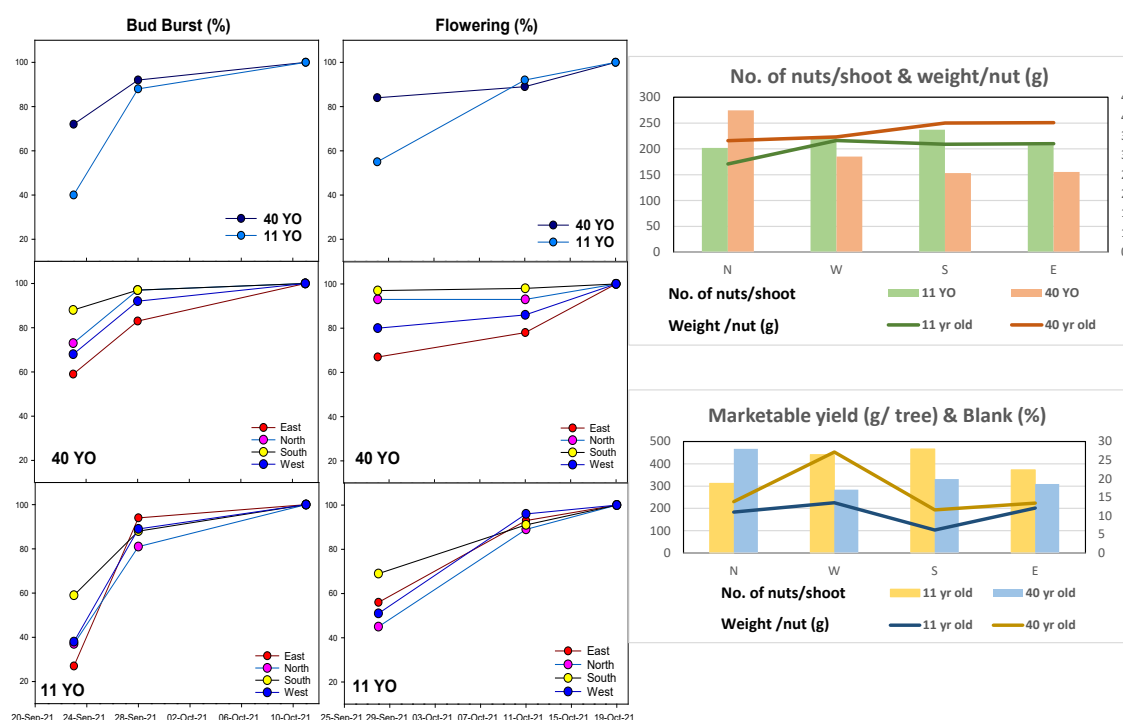
Materials and methods: The observations were taken up in Simpfindorfer's orchard, Paringa in the Riverlands, SA. Five trees in each of the block, 40-year-old trees in block P2 and 11-year-old trees in block P3 were selected. Four shoots, one in each direction, were tagged for observation.

OBSERVATIONS:

1. **Phenology response:** Scoring phenology to determine bud burst (%) and flowering (%) of different age trees for the directions.
2. **Yield and quality:** Observations on number of nuts per shoot and nut weight (g) were recorded for each direction and tree age and the respective marketable yield (g/tree) and blank (%) were estimated.

RESULTS & DISCUSSION

- (i) **Phenology:** Bud burst (%) and flowering (%) were earlier and narrower in 40-year-old trees compared to 11-year-old trees. South side showed quicker and shorter while shoots in the East had the latest and longest budburst and flowering in 40-year-old trees. There was a mixed trend for bud burst and flowering in 11-year-old trees for the directions.
- (ii) **Yield and quality:** 40-year-old trees had lower no. of nuts/shoot (192) with an average nut weight of 3.1g/nut while 11-year-olds produced more numbers of nuts per shoot (217) with 2.7g/ nut. North side shoots had the highest and south had the lowest no. of nuts/shoot while the nut weight was the highest in south and lowest in north side shoots in 40-year-old trees. 11-year-old trees showed exactly the opposite results. Both the age trees showed similar trends for marketable yield (g/tree) and blanks (%).



3. Chill mitigation survey

Background: Chill accumulation

Records showed mixed bag of chill accumulation for winter 2021 (1st March to 31st August) across the pistachio growing regions. Insufficient chill (56 dynamic chill portions) was recorded in the Riverlands, SA and just sufficient chill (64 dynamic chill portions) in Sunraysia, VIC. This would potentially impact pistachio production for the season.

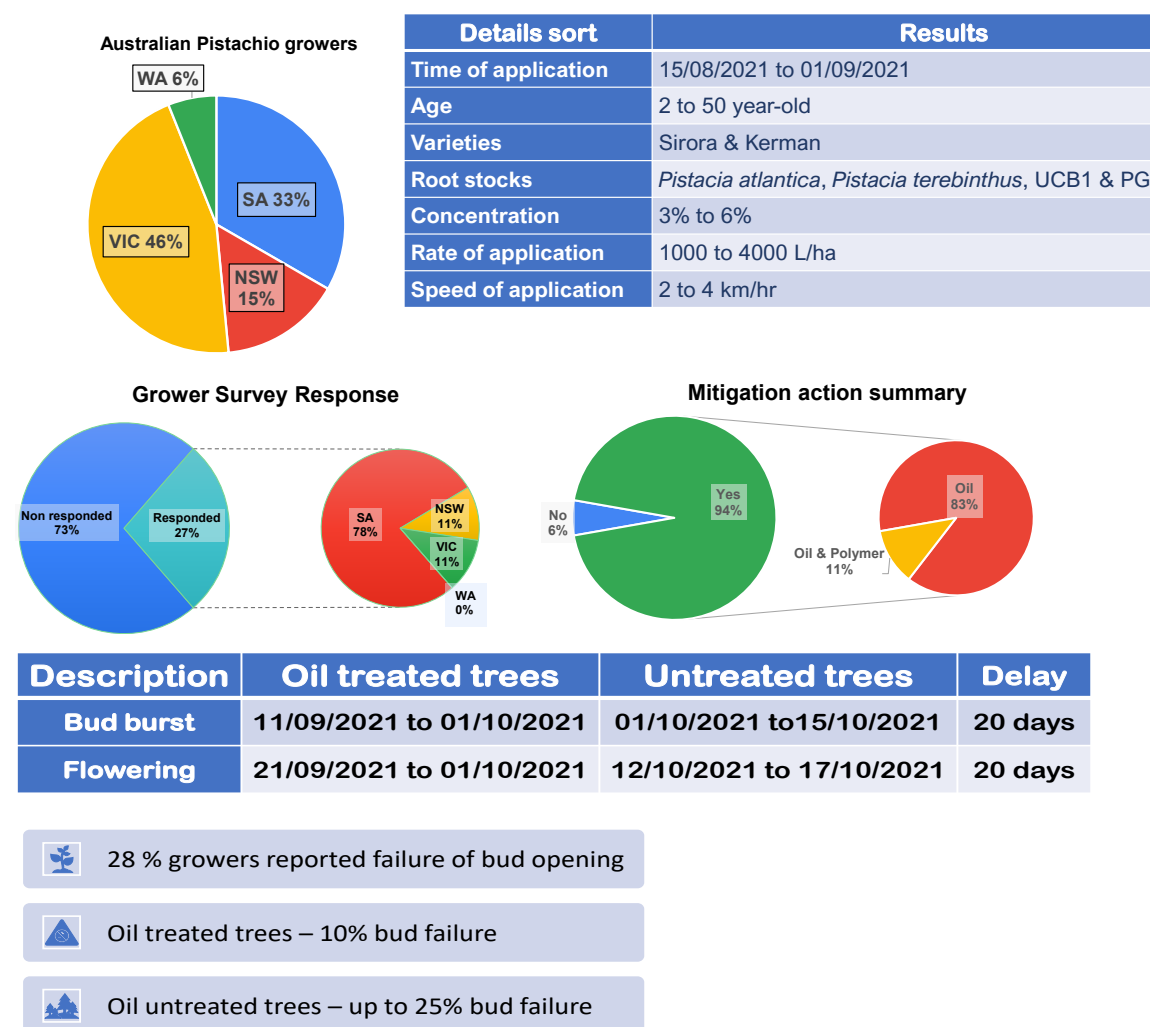
Objective: Survey growers for information on actions to mitigate the issue, phenological responses and draw overall picture on present strategies to help future research area (s).

Materials & methods: Designed an online survey for the growers to collect and collate information on

1. Grower details (orchard location, area, rootstock),
2. Mitigation action (s) taken (oil/polymer),
3. details on date, concentration, rate and speed of application,
4. Phenology responses (bud burst and flowering: time & uniformity) on treated and untreated trees,
5. Follow up questions on percentage of bud burst and flowering, bud failure, observations on nut set for uniformity.

Observations: Information on the items listed above were collected from the online survey, tabulated and preparation of appropriate charts to present the data.

Results & discussion: There were 18 responders for the survey and the following are some of the results.



4. Pistachio shoot dieback

Background: The Australian pistachio industry is currently expanding in area at more than 10% per annum. The total area under pistachio cultivation is about 2500 ha with about 60% of the plantation yet to reach economical yield. Pistachio cultivation is faced with a minor yet a significant disorder that causes branch dieback. The aetiology still being unclear and given the rate of expansion of the pistachio industry in Australia, it is critical to investigate the issue for a reliable and sustainable production of quality pistachio nuts.

Objective: The research proposal aims to elucidate pistachio branch dieback in a broader sense,

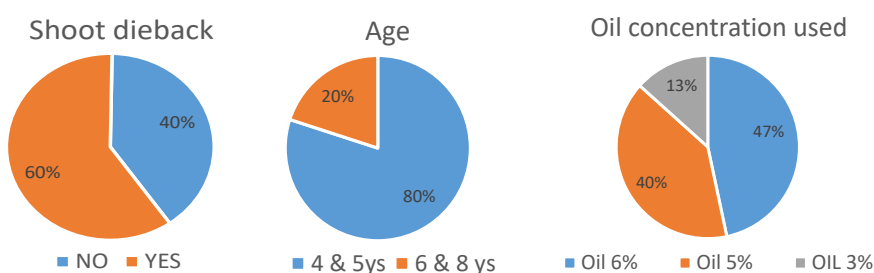
1. Abiotic factors including but not limited to weather, soil, water, topography, and geographical location.
2. Plant orchard management components; variety, root stock, training and pruning, irrigation and nutrient management and other orchard practices.
3. Pathological cause: investigate on possible pathological reasons for the branch die back disorder.

Materials & methods:

A short grower survey with yes/no answer for the presence of dieback was conducted. This was further used for a detail survey of the growers who identified them as being affected by shoot dieback to investigate, identify or narrow down the cause of the growing issue of pistachio branch dieback. Simultaneously, investigate on possible pathological reasons from analysis of the affected tissues.

OBSERVATIONS: i) Conducted a short survey for the yes/no answer, ii) Extensive survey by interviewing growers with and without dieback issues, iii) collect affected tissues and tested for the presence of pathogens (SARDI) that could possibly cause the symptoms, iv) Study collected information- determine commonalities and or differences between orchards that show and that do not show the symptoms.

RESULTS & DISCUSSION: The results of the short survey are as follows:

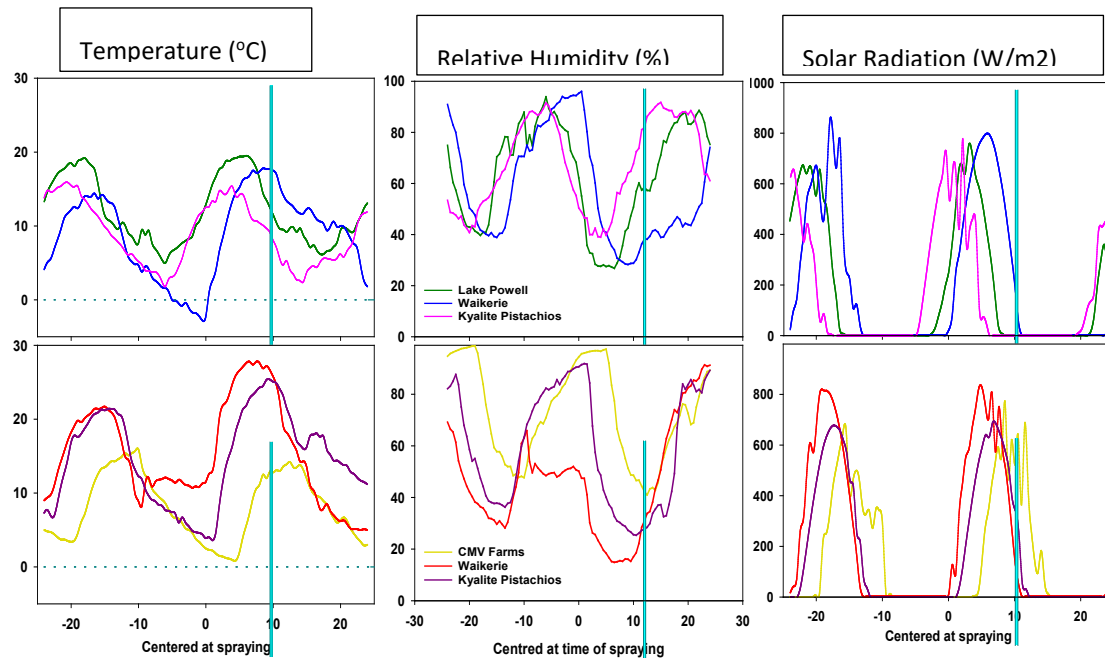


Based on the short survey, few growers were selected for detailed survey. Survey results led to getting the focus on oil application. Shoot dieback started appearing since 2017 when oil application became prevalent. Survey results showed non oiled orchards or non-oiled blocks in the same orchard did not exhibit symptoms and that the oil sprayed at different date/time showed difference in the occurrence of shoot dieback. Integrating the discussions and the chill mitigation survey indicated that the shoot dieback is a result of a combination of events resulting in tissue death. Narrowing down on conditions of oil application that were common between orchards that showed dieback symptoms showed that oil sprayed at low temperatures and high relative humidity, post application spike in temperature and increased solar radiation. Further research investigations are required to confirm the occurrence of shoot dieback in similar conditions narrowed down. Also, the investigations are to be integrated with other plant physiological status and orchard conditions that might add to the expression and manifestation of the symptoms and its severity.

5. Establishment of a temperature and relative humidity sensors installation

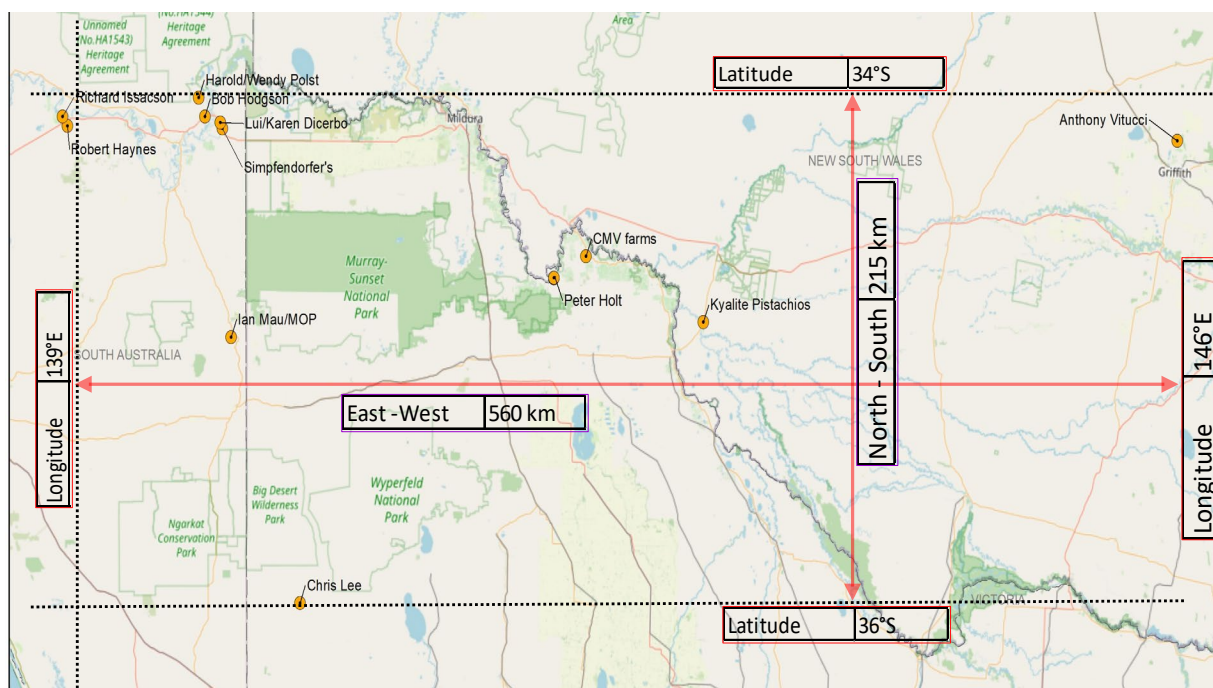
Background: Performance of pistachio tree revolves around temperature, whether it being winter chill accumulation or spring-summer heat units for the physiological responses, growth and development, yield and quality. It is imperative to record & monitor real time temperature that will be a great asset to PGAI for any research or investigation works in future and build temperature records for the years to come.

Objective: Install Tinytag sensors in pistachio orchards spread across a wide range of growing locations in Australia and set up to record real time temperature, relative humidity and dew point and use the data to interpret and investigate when required for research or other purposes, to be able to determine chill accumulation at specific locations and apply them for future phenological studies



Materials and methods: Two Tinytag sensors (TGP-4500) were installed; one at lower canopy level and the other at upper canopy level in 12 selected grower locations, stretching 215km North-South (34 to 35°South Latitude: Renmark to Telopea Downs) and 560km East-West (139 to 146°East Longitude: Renmark to Griffith). The sensors were set up to record temperature, relative humidity and dew point every 30 minutes. Stevenson type screen protector (ACS-5050) was used to protect the outdoor sensors from direct contact with rain, irrigation water and solar radiation that may off-set the records. A steel post was designed to take two sensors that were fitted on a steel holder and could be slid along the main post for ease of raising and adjusting them while downloading data. The steel post was fitted to the grown to stand sturdy and strong to withstand wind and outdoor conditions. The data are constantly downloaded at 3-to-4-month intervals by personally travelling to the locations and collated for future use.

RESULTS & DISCUSSION: First Tinytags were installed in SA, in Waikerie and continued through to Peebinga in December 2021. After the state borders opened, installation was taken up in VIC and NSW and was completed in August 2022. Seven locations in SA, two locations in NSW and three locations in VIC, making up 12 sites with 24 sensors in total are now in place. The data is being constantly downloaded at 3-to-4-month intervals, collated and maintained for future use.



Tinytag : temperature / RH / dew point Lower & Upper Canopy levels



6. 2022/23 season trials

Oil-Polymer trial

Background: Oil-polymer trial in 2021/22 indicated that polymer applications can complement oil application in improving the yield. Decision was made to investigate further on the time of polymer application before, after or both oil application.

Objective: Determine the environmental effects on time of application of polymer in combination with oil, its influence on phenology, with focus on productive bud and yield and quality.

Materials & methods: Trial was conducted on 11- to 12-year-old Sirora, in two pistachio growing regions (Simpfendorfer's orchard, Paringa, Renmark and CMV Farms, Robinvale, Sunraysia) which are apart at a straight-line distance of 200km. Experiment was laid out as CRBD with four treatments replicated five times. Treatment consisted of polymer application (0.5%) two weeks before, two weeks after, two weeks before and after and no polymer application. All treatments received oil application as standard orchard management practices. 300 shoots were selected and tagged with data matrix code on colour coded tags, at each site, for phenology, bud count, yield and yield component estimates. Treatment trees or treatment rows were harvested separately using machines to determine yield and subsampled to estimate quality as per industry standards.

Oil-Polymer application	
Experimental Design	CRBD (Completely Randomised Block Design)
No. of treatments	4
No. of replications	5
Treatments	No. & time of polymer applications
T1	One: 2 weeks BEFORE oil application
T2	One: 2 weeks AFTER oil application
T3	Two: 2 weeks before + 2 weeks after oil application
T4	No Polymer: Oil only
Polymer concentration	0.5% (5L/1000L)
Oil concentration	Orchard's decision
Locations	Two
	1 CMV Farms, Bannerton, VIC
	2 Simpferdorfer's Orchard, Wouararra, SA



Simpfendorfer's Orchard / Block P3 / Planted 2010				Block 1 (Rep 1)		Block 2 (Rep 2)		Block 3 (Rep 3)		Block 4 (Rep 4)		Block 5 (Rep 5)	
No. of rows	No. of trees / row	spacing	Plant density /ha	T1	T2	T2	T4	T2	T3	T1	T4	T2	T1
24	10	7.32 x 6.1 m	224	T4	T3	T3	T1	T1	T4	T2	T3	T4	T3

CMV Farms / Block 11 / planted 2011				Block 1 (Rep 1)				Block 2 (Rep 2)				Block 3 (Rep 3)				Block 4 (Rep 4)				Block 5 (Rep 5)			
No. of rows	No. of trees / row	spacing	Plant density /ha	T3	T1	T2	T4	T4	T3	T1	T2	T4	T3	T2	T1	T3	T4	T2	T1	T1	T4	T2	T3
59	80	6 x 3.5m	476																				

OBSERVATIONS

- Phenological response:** Bud burst (%), flowering (%); and bud count to estimate bud failure %
- Yield & Yield components:** Determine no. of bunches at shoot and tree level and no. of nuts at shoot and tree level, establish relationship within hull yield per tree to identify significant yield contributing traits.
- Yield & quality:** Marketable yield & Quality with focus on blank nuts (%), estimated based on industry standards.

RESULTS & DISCUSSION: Statistical analysis is in progress for results.

7. Case study on juvenile shoot die back with reference to oil application.

Background: Survey and preliminary investigation on juvenile shoot dieback showed that juvenile shoot dieback symptoms appeared with oil application at low temperature with high relative humidity followed by a spike in temperature and solar radiation.

Objective: Attempt a case study to observe the development of shoot dieback by targeting different concentration oil spray at specific temperatures.

Materials & methods: The case study on juvenile shoot dieback was conducted in two geographically different regions at 332km straight line distance: -

1. Paul Wurst's orchard, Waikerie, Riverland region, on six-year-old Sirora on UCB1 and PG1 and
2. Kyalite pistachios, Kyalite, Sunraysia region, on five-year-old Sirora on UCB rootstock.

Two oil concentrations; 3% and 6% were sprayed at the two targeted temperatures; less than 5°C and at more than 6°C. Eight trees in each location were covered with tarpaulin to avoid oil application, served as control. Temperature at the time of spray were monitored and best efforts were made to spray oil. Two sprayers for each oil concentration were used in Paul's orchard while, 6% oil was diluted to 3% after 6% spray at Kyalite. Five trees were tagged to score and for observations.

OBSERVATIONS:

Juvenile Shoot Dieback Studies	
Location	2
	Kyalite Pistachios (on UCB)
	Paul Wurst's orchard (on UCB & PG1)
Age	4 & 5 yrs
Time of spray (two)	Temperature at application
	T1 At temperature < 5°C
	T2 At Temperature > 10°C
Oil Concentration (3)	Concentration
	O1 3%
	O2 6%
	O3 0%



Observations on dieback shoot development; count and score, tree girth, no. off buds were taken on all tagged trees.

RESULTS & DISCUSSION: The trees did not respond to the oil concentration and temperature at the time of oil spray as expected. The reason could be that the weather conditions could not be simulated as targeted; lower temperature at spray followed by spike in temperature and increased solar radiation. Oil sprayed at 3% and 6% in Waikerie and 6% oil in Kyalite, showed dieback symptoms when sprayed at temperature more than 10°C. Eight to 10 showed dieback symptoms in a tree with about 30 to 40 shoots.



The most important observation was that the uncoiled trees (control) in the same row did not develop dieback symptoms.

6. OUTPUTS

The following is a summary of the project's outputs: -

Table A. Output summary

Output	Description	Detail
Establish a program logic framework	As part of the acceptance of the Pistachio Growers' Association Inc (PGAI) as the service provider was required to establish a Program Logic Framework.	The Project Logic Framework was established and included the following: • Full Project Work Plan. • PGAI Communications and Engagement Strategy. • Project Monitoring and Evaluation plan. • Initial 3-year set of KPI's.
Communications and Engagement Plan	As part of the acceptance of the Pistachio Growers' Association Inc (PGAI) as the service provider was required to prepare a Communications and Engagement Plan	The Project Communications and Engagement Plan was prepared and submitted as an Appendix to Milestone 102.
Monitoring and Evaluation Plan	As part of the acceptance of the Pistachio Growers' Association Inc (PGAI) as the service provider was required to prepare a Monitoring and Evaluation Plan	The Project Monitoring and Evaluation Plan was prepared and submitted as an Appendix to Milestone 102.
Project Work Plan		The Project Work Plan was prepared and submitted as an Appendix to Milestone 102.
6-monthly KPI Reports		6-monthly KPI Reports were prepared and submitted as an Appendix to each of the Milestone Reports.
Retention of Dr Jianlu Zhang	To assist in a smooth transition Dr Jianlu Zhang, the retiring Pistachio Researcher, was retained by the PGAI.	Dr Zhang was engaged to: - • Continue the appropriate components of the new project from June to September 2018 until a new Pistachio Researcher was engaged, and • Mentor and assist the new Pistachio Researcher, and • as a Pistachio Emeritus Research Fellow to undertake specific programs through the life of the project.

Engagement of a Pistachio Researcher	Undertaking a selection process and the appointment of a Pistachio Researcher.	After an extensive selection process Dr Subhashini Abeysinghe was appointed to the position of Pistachio Researcher and commenced employment on the 1st of September 2018. Dr Abeysinghe resigned on the 20th of May 2021 to take up an appointment with the Department of Agriculture, Water and the Environment (DAWE) in Canberra. After an extensive selection process Dr Maha Mahadevan was appointed to the position of Pistachio Researcher and commenced employment on the 12th of August 2021. Dr Mahadevan still holds the position as of the 30th of June 2023.
Initial Planning meeting	With the employment of a new Pistachio Researcher, it was necessary to undertake planning and establish relevant commencement activities.	An initial planning meeting with the Pistachio R&D Committee was held in September 2018 to: - Establishment of an initial research priority list. Review of the first 5-month KPI's and implementation of the work plan for the next six-months.
Chill hour data collection and reporting.	Collection of Bureau of Meteorological data from weather stations across the growing regions and preparing reports for all Australian Pistachio growers.	Data was received on a weekly basis from the Bureau of Meteorological from 12 weather stations across South Australia, Victoria and New South Wales. That data was placed into the appropriate spreadsheets and collated so that reports could be prepared and sent to the growers. A Chill Newsletter was prepared at the end of June, end of July and the 15th of August in each of the years from 2018 to 2022. A total of 15 newsletters across the life of the project. <i>A copy of the 2022 Chill Newsletter No 3, 15th August 2022 is attached as Appendix A to this Final Report.</i> The Chill Newsletters for 2023 will be prepared by the PGAI either as part of the next project or through the utilisation of other research funds held by the PGAI. This Chill Hour activity has continued to be an 'extension' part of this Project and has been an integral part of the Communications and Engagement Program.
Benchmarking data collection and reporting.	Collection of Benchmarking data from the Australian Pioneer Pistachio Company (APPC) and preparing reports for individual	Harvest data was collected from the Australian Pioneer Pistachio Company and collated so that both industry and individual grower reports could be prepared. The information included data on: - • Merchantable yield • In hull yield • Count size • Percentage Dark Stain

	Australian Pistachio growers.	• Percentage Close Shell Each graph contained the following: - • Maximum result (top grower) • Median • Minimum result (worst grower) • Individual Orchard. From these graphs each grower could then see where their particular results compare with others in the industry. The Benchmarking reports were prepared and distributed to the relevant growers in June/July of 2018, 2019, 2020, 2021 and 2022. <i>A copy of a 2022 Benchmarking Report is attached as Appendix B to this Final Report.</i> The Benchmarking Reports for 2023 will be prepared by the PGAI either as part of the next project or through the utilisation of other research funds held by the PGAI. This Benchmarking Report activity has continued to be an 'extension' part of this Project and has been an integral part of the Communications and Engagement Program.
Project Team meeting. Pistachio R&D Committee meetings.	Project Team meetings were conducted at the same time as the Pistachio R&D Committee meetings.	Project Team Meetings were held in the following months: - ○ September 2018 ○ February, May, June and September 2019 ○ February, June and September 2020 ○ February, June and September 2021 ○ February, June and September 2022 ○ February 2023 At these meeting Project PS17003 was reviewed, adjusted (where necessary) and research priorities were adopted.
PR Reports to the Pistachio R&D Committee.	The PR, both Dr Abeyasinghe and Dr Mahadevan, at the appropriate times presented their research reports to the Pistachio Committee	The PR presented reports to the Project Team and the Pistachio R&D Committee at the following meetings: - ○ September 2018 ○ February, May, June and September 2019 ○ February, June and September 2020 ○ February, June and September 2021 ○ February, June and September 2022 ○ February 2023 <i>A copy of the most recent report prepared and tabled by Dr Mahadevan is attached as Appendix C to this Final Report.</i>
PR Reports to the Pistachio PIT Group sessions.	As part of the role of the PR they were required to present reports on their research to the growers as part of the PIT Group sessions (Project	The PR presented reports to the PIT Group sessions conducted on the following dates: - ○ September 2019 Spring Symposium ○ November 2019 meeting(s) ○ September 2020 Spring Symposium ○ December 2020 meeting(s) ○ November 2021 meeting(s)

	PS20000).	○ May 2022 meeting(s) ○ July 2022 meeting(s) ○ September 2022 Spring Symposium ○ November 2022 meeting(s) <i>A copy of the most recent report prepared and tabled by Dr Mahadevan is attached as Appendix E to this Final Report.</i>
Research Subsets (Dr Abeysinghe)	As major part of the project was the development, implementation and data collection on a range of research 'subsets'.	The following are the research and development project 'subsets' commenced, managed and continued by Dr Abeysinghe: - ○ Completion of the initial scoping polymer trial prepared and undertaken by Shane Phillips from Landmark in collaboration with Dr Subha Abeysinghe. ○ Collecting data for young Kerman trial. ○ Organising expanded polymer trials using multiple trial sites shoot dipping trails. ○ Collecting information on pollen and nut quality. ○ Establishing data on Australian male trees and looking to assess pollen from each of the male tree varieties. ○ Organising trial with the aim of increasing Zn absorption. ○ Expansion of polymer trials using multiple trial sites shoot dipping trails. This included the: ▪ collection of the season 1 results. ▪ presentation of the results to the Pistachio R&D Committee. ▪ implementation of season 2 trials. ▪ collection of the season 2 results and presentation of the results to the Pistachio R&D Committee.
Research Subsets (Dr Mahadevan)	As major part of the project was the development, implementation and data collection on a range of research 'subsets'.	The following are the research and development project 'subsets' commenced, managed and continued by Dr Mahadevan: - ○ Oil and polymer trials, ○ Bud opening and flowering study, ○ Chill mitigation survey, ○ Pistachio shoot die back. ○ Establishment of a temperature and relative humidity sensor grower network and the collection and collation of data.
Information sheets	Part of the Communications and Engagement program was the preparation of relevant 'tech sheets' that presented details on particular topics.	The following are the information 'tech sheets' that were prepared: - ○ Report on Mechanical Pruning (with the objective of producing a specific Technical Bulletin). ○ 'Fungi Newsletter' (relating to the current climatic variability and the potential for increased fungal problems within the 2021 crop). ○ Application of AF36.

Media articles		Preparation of a Polymer trial overview for the December 2020 edition of the Australian Nutgrower Magazine.
Grower visits		Throughout the life of the Project both PR's made numerous visits to growers, particularly those either involved in trials or having tree problems that required sampling and observation. Dr Mahadevan established a network of TinyTags on 12 growers' properties requiring regular visits to download relevant data.
Additional PR activities (Dr Abeysinghe)	Throughout the Project the Pistachio Researcher participated in a range of different activities as part of liaison with researchers and for professional development	The following are a range of activities undertaken by Dr Abeysinghe during her time as the PR: - ○ Virtual 'Advanced Pistachio Course', 2020 which was conducted by UC Davis, California. ○ Women & Leadership Australia (WLA) networking platform. ○ Australian Nut Industry Council (ANIC) Leadership Program. ○ Virtual 2021 State-wide Pistachio Day which was conducted by University of California. ○ ANIC Leadership Program webinar sessions and Face-to-face meeting.
Additional PR activities (Dr Mahadevan)	Throughout the Project the Pistachio Researcher participated in a range of different activities as part of liaison with researchers and for professional development	The following are a range of activities undertaken by Dr Mahadevan during her time as the PR: - ○ Attendance at the ANIC 2022 Nut Conference in Melbourne during March 2022. ○ Membership of the ISHS. ○ Attendance at the meeting of the Crop Reference Group for a number of Almond projects on the 11th of July 2022. This was followed by a 'Smart Farm' visit in Irymple, Victoria on the 12th of July 2022. ○ Attendance at the 'WeedSmart in Horticulture' workshop held on the 1st of September 2022. ○ Participation in the Victorian Horticulture Industry Network. ○ Participation in the inaugural Pistachio 'Chat Group' held in November 2022. ○ Attendance at the 2023 ISHS International Almond and Pistachio Congress in California, USA in May 2023.
International Almond and Pistachio Symposium.	As part of liaising with international researcher the PR was to be supported in attending the ISHS International Almond and Pistachio Symposium	In late 2020, Dr Abeysinghe prepared and submitted the following two Abstracts for presentation at the ISHS Almond and Pistachio Congress to be held in June 2022: - ● Effects of reduced bud temperature on pistachio phenology, yield and nut quality. ● Acid washing of leaves influences nutrient concentrations in Pistachio leaves. Due to COVID the 2022 Congress was cancelled and was postponed until May 2023. In the meantime, Dr Abeysinghe resigned from the PR position and while the abstracts were listed the papers were never presented.

		Dr Mahadevan with the assistance of Chris Joyce, Trevor Ranford and Prue McMichael prepared a research paper for presentation at the International Almond and Pistachio Symposium to be held in the USA in May 2023. Dr Mahadevan attend the Congress and presented a paper titled “Dynamics of chill accumulation in Australian pistachio growing regions”. Presenting Author: Dr. Maha Mahadevan maha@pgai.com.au Co-Author(s): Mr. Chris Joyce ckjoyce@ozemail.com.au, Mr. Trevor Ranford sahort@bigpond.com, Prof. Dr. Victor Sadras Victor.sadras@sa.gov.au <i>A copy of the initial report from Dr Mahadevan on her visit to the USA is attached as Appendix G to the Final Report</i>
Preparation of Research Papers	As part of the Communications and Engagement program if there is relevant material that has a level of scientific rigour it can be utilised in the preparation of a Research paper.	Dr Jianlu Zhang and Trevor Ranford prepared and published the paper titled “Identification of Key Periods of Temperature Influence on ‘Sirora’ Pistachio Nut Quality”. This research paper was published in Hort Technology, June 2021 31(3). Link: https://journals.ashs.org/horttech/view/journals/horttech/31/3/article-p266.xml <i>A copy of the published Scientific paper is attached as Appendix E to this Final Report</i> Dr Mahadevan prepared a paper titled “Dynamics of chill accumulation in Australian pistachio growing regions”. Presenting Author: Dr. Maha Mahadevan maha@pgai.com.au Co-Author(s): Mr. Chris Joyce ckjoyce@ozemail.com.au, Mr. Trevor Ranford sahort@bigpond.com, Prof. Dr. Victor Sadras Victor.sadras@sa.gov.au This paper was presented at the 2023 ISHS International Almond and Pistachio Congress held in California, USA in May 2023. The paper has NOT YET been published so is not for public distribution. <i>A copy of the unpublished Research paper is attached as Appendix F to this Final Report</i>
Stop/Go Milestone Report	As part of this five-year project there was a requirement to undertake a Stop/Go review and Milestone	As required within the Project the Pistachio Growers’ Association Inc (PGAI) conducted a mid-project evaluation to assess stakeholder satisfaction with the program. The processes that were undertaken include the following: - • A proposal was prepared in

	Report	conjunction with Adrian Hunt (Hort Innovation) and signed off. This was distributed to a number of recommended consultants. • Dr Kevin Clayton-Greene was engaged, as an independent consultant, to undertake the review. • All relevant project information was supplied to Dr Clayton-Greene. • Interviews, either via Zoom or face-to-face, were undertaken through May 2021. • A Final report was prepared and submitted to both PGAI (Trevor Ranford) and Adrian Hunt. • The report has been distributed to the R&D Committee and the Executive Committee Summary by Dr Kevin Clayton-Greene: “A mid-term review of the Program (PS 17003) has found it to be a highly effective R&D vehicle for the Pistachio industry and that it should continue. Through its structure it addresses many of the perennial issues of traditional R&D delivery of relevance and implementation. It is a model that would serve many horticulture industries.” PGAI Action: At a meeting of the Pistachio R&D Committee, held on Thursday 24th June 2021 (via Zoom) the full report was tabled and reviewed. In particular the summary and recommendations were considered in detail and the R&D Committee agreed to: - 1. <i>Adopt all of the ‘recommendations – general and project specific’ - and the ‘observations for PGA consideration’.</i> 2. <i>Recommend to the PGAI Executive Committee that Project PS17003 continue but with appropriate variations coming from the summary and recommendations.</i> 3. <i>Recommend to the PGAI Executive Committee that a new Pistachio Researcher be engaged and that the relevant work plans be developed to continue the project utilising the skills of the new Researcher.</i> <i>The report as prepared by Dr Kevin Clayton-Greene is attached as Appendix H to the Final Report.</i>
Milestone Reports	Preparation of 6-monthly project Milestone Reports.	The Pistachio Growers’ Association Inc as the service provider for Project PS17003 has prepared and submitted the following Milestone Reports on the required dates: - ○ 102 ○ 103 ○ 104 ○ 105

		○ 106 ○ 107 ○ 108 ○ 109 ○ 110 ○ 111. Each of the Milestone Reports were subsequently accepted and signed off by Hort Innovation and the milestone payments made.
Final Report	Preparation of a Final Report	The Pistachio Growers' Association Inc as the service provider for Project PS17003 has prepared and submitted a Final Report on the 9 th of June 2023.

7. OUTCOMES

Table B. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
Continuation and expansion of industry led and focused pistachio research, development and extension:	Maintenance of the direct linkages between the industry researcher and the network of growers within each region and across the regions.	There a number of methods used to communicate directly with growers including: - • Industry Newsletters • E-mail blasts • PIT Group Meetings • Surveys • Website All of these methods have been utilised during this milestone reporting period.	During the life of this Project the Project Researcher has undertaken the following: - Attendance at and presentations to the following PIT Group session: - ○ September 2019 Spring Symposium ○ November 2019 meeting(s) ○ September 2020 Spring Symposium ○ December 2020 meeting(s) ○ November 2021 meeting(s) ○ May 2022 meeting(s) ○ July 2022 meeting(s) ○ September 2022 Spring Symposium ○ November 2022 meeting(s) In addition, the following links with growers have commenced/continued: - • Installation of 24 Tiny Tag recorder on 12 Pistachio properties across a wide number of growing regions in New South Wales, Victoria and South Australia. Data has been and continues to be regularly collected from these units. • Continued grower visits and meetings Reported to the Pistachio R&D Committee at the following meetings: - ○ September 2018 ○ February, May, June and September 2019 ○ February, June and September 2020 ○ February, June and September 2021 ○ February, June and September 2022 ○ February 2023.

			Information relating to these activities have been consistently detailed in the relevant Appendices to each of the Milestone Report.
Continuation and expansion of industry led and focused pistachio research, development and extension:	Enhanced communication and sharing of knowledge and information of technical developments, with and amongst all sectors of the pistachio industry	There a number of methods used to communicate directly with growers including: - • Industry Newsletters • E-mail blasts • PIT Group Meetings • Surveys • Website All of these methods have been utilised during this milestone reporting period.	The Project Researcher has undertaken the following: - Attendance at and presentations to the following PIT Group session: - ○ September 2019 Spring Symposium ○ November 2019 meeting(s) ○ September 2020 Spring Symposium ○ December 2020 meeting(s) ○ November 2021 meeting(s) ○ May 2022 meeting(s) ○ July 2022 meeting(s) ○ September 2022 Spring Symposium ○ November 2022 meeting(s) In addition, the following links with growers have commenced/continued: - • Installation of 24 Tiny Tag recorder on 12 Pistachio properties across a wide number of growing regions in New South Wales, Victoria and South Australia. Data has been and continues to be regularly collected from these units. • Continued grower visits and meetings Reported to the Pistachio R&D Committee at the following meetings: - ○ September 2018 ○ February, May, June and September 2019 ○ February, June and September 2020 ○ February, June and September 2021 ○ February, June and September 2022 ○ February 2023.

			Preparation and distribution of the three Chill Newsletters. A Chill Newsletter was prepared at the end of June, end of July and the 15th of August in each of the years from 2018 to 2022. A total of 15 newsletters across the life of the project Preparation and distribution of grower benchmarking reports to each of the individual growers for which data is available. The Benchmarking reports were prepared and distributed to the relevant growers in June/July of 2018, 2019, 2020, 2021 and 2022. A total of 120 individual reports were prepared and distributed across the life of the project. Information relating to these activities have been consistently detailed in the relevant Appendices to each of the Milestone Report.
Continuation and expansion of industry led and focused pistachio research, development and extension:	Increased utilisation of the PR as the industry 'go to person' for technical and scientific information	The Researcher has a full range of activities as detailed within the project agreement. While not employed as 'technical officer' growers do reach out when they have specific issues. This is highlighted by the issue of Pistachio Shoot Die Back being raised by growers, brought to the Pistachio R&D Committee and then added as a priority topic to the Pistachio Researcher Work Plan. In addition, the Pistachio Researcher has proposed and initiated a number of activities that have enhanced the overall program.	The Pistachio Researcher continued to implement a number of activities as detailed in the R&D priority list. The following were built into her Work Plan and the results of the work regularly presented: - • Revised oil and Polymer trials • Bud opening and flowering study • Chill Mitigation Survey • Pistachio Shoot Die Back Study • Orchard visits with the objective of observation and data collection Temperature and relative humidity sensor network across SA, Victoria

			and NSW.
Increased grower awareness and understanding of the latest R&D:	Increased utilisation of the PR through involvement with the 'PIT' Groups and the relevant technical pages of the web site.	One of the established mechanisms to communicate with growers has been through the activities of Project PS20000 – PIT Groups. The Pistachio Researcher is required to attend (either face-to-face or via Zoom) and made a presentation at each PIT Group meeting.	The Pistachio Researcher participated in PIT Group sessions held as face-to-face) meetings: - ○ September 2019 Spring Symposium ○ November 2019 meeting(s) ○ September 2020 Spring Symposium ○ December 2020 meeting(s) ○ November 2021 meeting(s) ○ May 2022 meeting(s) ○ July 2022 meeting(s) ○ September 2022 Spring Symposium ○ November 2022 meeting(s)
Increased grower awareness and understanding of the latest R&D:	Increased grower adoption of the full suite of best practice management information, data and systems	One of the integral parts of the Pistachio R&D program has been and continues to be the collection, collation and distribution of the annual chill hour data. The 2022 data has and continues to be collected and relevant reports will be prepared and distributed to the growers during the next milestone reporting period. From these reports growers undertook the appropriate chill mitigation programs. The results of this both in the commercial orchards and in the research trial plots will be assessed at the point of harvest. Individual grower benchmarking data files are prepared by the PGAI, with the grower's cooperation and the assistance of APPC, utilising complied yield and quality data from the last 21 years of Australian harvests.	Chill Newsletters 1, 2 and 3 were prepared and distributed via e-mail to over 90 growers and consultants on the PGAI e-mail list on the 30th of June, 30th of July and 15th of August each year from 2018 to 2022. In addition, the Chill Newsletters, when available, will be added to the Pistachio website – www.pgai.com.au The Annual Benchmarking reports for individual growers, utilising the harvest data collected by APPC were prepared and distributed to growers in July of each of the years 2018 to 2022. Both the Chill Newsletters and the individual Benchmarking reports for 2023 are currently being prepared and will be distributed at the agreed times either before the conclusion of this project on the 30th of June 2023 or in early July 2023
Increased grower awareness and understanding of the	Increase of plantings of pistachios by 5% per annum.	Recent data of new plantings were tabled in Milestone Report 109. The data for new	Data produced by Chris Joyce on behalf of the Pistachio R&D committee has been regularly

latest R&D:		plantings in 2022 will be reported in the December 2022 Milestone Report	presented to the industry as part of the PIT Group program. Information relating to these reports have been consistently detailed in the relevant Appendices to each of the Milestone Report.
Enhanced exposure to international R&D and technology expertise/information:	PR expanding the linkages and utilisation of specialist international researchers and/or scientists to obtain additional specific knowledge/information resulting in behavioural change.	The Pistachio Researcher has reached out to a number of Australian and International researchers particularly in the areas of: a. chill hour modelling b. pistachio shoot die back c. Kerman fertiliser programs in the USA Sensor equipment	The Pistachio Researcher has made contact with or continues to liaise with: - • Prue McMichael (Independent Consultant) • SARDI – pathologist and other researchers • Michael Treeby (AgVic Temperate Nut Officer) • Louise Ferguson (USA Extension Officer) • Dr Jianlu Zhang (PGI Emeritus Fellow) • Tim Pitt (Research Scientist, SARDI) • Darren Graetz, Research Scientist, SARDI) • Dr Victor Sadras (Crop Ecophysiologicalist, Climate application, SARDI) • Dr Michelle Wirthensohn (University of Adelaide) • Dr Gwen Mayo (Adelaide Microscopy Waite Facility, University of Adelaide) • Dr Zelmari Coetzee (Senior Research Scientist, Horticulture Production Sciences, Agriculture Victoria Research) Through the recent attendance at the ISHS Almond and Pistachio Congress the Pistachio Researcher was able to meet a number of International researchers and will look to develop linkages and

			collaboration with them in the future.
Program changes through continuous monitoring and evaluation:	Flexibility within the project that allows modifications and/or updating the program built on sound information gathered from informed M&E.	The Project has shown flexibility in that: - Utilising the information from growers the Pistachio R&D Committee has put a priority focus on the Pistachio shoot die back and have the Pistachio Researcher implement a study.	An important aspect of PS17003 is that the program has had a built-in flexibility in that it has been able to make changes to the project subsets when and if required. The Pistachio R&D Committee requested that the Pistachio Researcher add the Pistachio shoot die back problem into her Work Plan. Details of the project/study have been outlined both previous Milestone Reports and this Final Report.
Program changes through continuous monitoring and evaluation:		A R&D priority list was developed and adopted by the Pistachio R&D Committee in February 2022. This priority list has been utilised by a small working group of the Project Team and Dr Mahadevan to plan the relevant activities for 2022 and also prepare the 2022/23 Work Plan	Regular Work Plan document have been prepared throughout the life of the project and tabled as an Appendix to each of the relevant Milestone reports.
Australian Pistachio Growers understand and contribute to the Hort Innovation investment pipeline:	Recognition of Hort Innovation and the funding assistance for relevant projects at each PGAI event.	Those presentations, reports and documents that are presented to the Pistachio industry and those growers who contribute to the Pistachio voluntary contribution pool include the Hort Innovation/Pistachio Fund logo.	The Pistachio Researcher reports to PIT Group session, the September Spring Symposiums and the reports to the Project Team and Pistachio R&D Committee carry the Hort Innovation/Pistachio fund 'block'.
Australian Pistachio Growers understand and contribute to the Hort Innovation investment pipeline:	Collection and collation of topics/issues raised with or by the PR and the presentation of such information to the Pistachio R&D Committee and the Pistachio SIAP.	The Pistachio R&D Committee meets in February, June and September each year and at those meetings representatives from Hort Innovation attended (Brad Mills; Eloise Mason).	The Pistachio R&D Committee held meetings throughout the life of the project as detailed below: - - September 2018 - February, May, June and September 2019 - February, June and September 2020

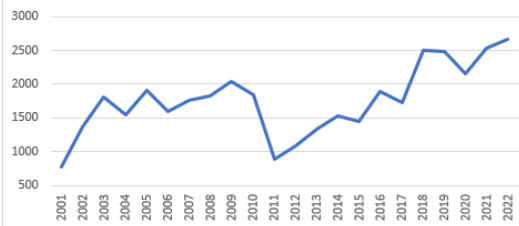
		The meeting papers and minutes are made available to the Hort Innovation representative. In addition, relevant Hort Innovation Project Managers participate in the discussions on specific projects at these meetings. The material collected and collated by the Pistachio R&D Committee and the Pistachio Researcher are reported on and recorded within the relevant documents.	○ February, June and September 2021 ○ February, June and September 2022 ○ February 2023 The following activities took place: - ● Report tabled by the Pistachio Researcher on the activities undertaken. ● The Work Plan document was reviewed and adopted. Reports on both of the above points have been included as Appendices to the relevant Milestone Reports. Dr Adrian Hunt from Hort Innovation has participated in the Pistachio R&D Committee meetings during the time when this particular project was discussed.
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8. MONITORING AND EVALUATION

The following Monitoring and Evaluation was undertaken during the life of the project: -

Table C. Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
Stop/Go Review.	Review undertaken and report received and reviewed by the Project Team, Pistachio R&D Committee and the PGAI	The following were detailed as areas for improvement and/or future development: - • Development of a web-based chat room for use by members as part of PS 20000 • Develop a strategic plan for expanded R&D in the future with a view to having a dedicated orchard trial site and a place for the industry in State government planning and thinking. • Consider setting aside some funds for ‘over the horizon’ R&D to counter potential industry threats e.g., water availability and chill requirements against a backdrop of a warming climate. Precision agriculture is also an area which is rapidly developing and can offer significant benefits. • There may be increased scrutiny of nitrogen application in future and although not part of the brief it was noted that the levels and form of nitrogen application appear to be very high for tree crops and may exacerbate deficiencies in other elements, whilst UAN will accelerate soil acidification. Calcium nitrate may offer some advantages.”
Flexibility within the project to adjust based on input throughout the project.	Reviews regularly undertaken and reports received and reviewed by the Project Team, Pistachio R&D Committee.	Through the M&E process there have been a number of new issues raised and as a result changes to R&D subsets made as per the following change: - <i>The Pistachio R&D Committee requested that the Pistachio Researcher add the Pistachio shoot die back problem into her Work Plan.</i> This flexibility is essential within this type of program and allows modifications and/or updating the program built on sound information gathered from informed M&E.
Potential longer-term impacts on industry productivity, profitability,	Reviews regularly undertaken and reports received and	New pistachio plantings have been increasing over the last three years at over 10% of the existing orchards each year. For 2023 the nurseries report

environmental and/or social benefits	reviewed by the Project Team, Pistachio R&D Committee.	sales of young trees that will result in 700 ha of new orchards bringing the total to almost 3,000ha, a tripling of the total hectares in the last decade. Australian yields for the median grower over the two-year on/off cycle have improved 40% in the past decade to over 2,500kg/ha. The best orchards are achieving over 4,500kg/ha. The immediate objective is to improve the yield of the median grower of mature trees to over 3,000kg/ha. KG/ha for Median Grower 2-yr moving average <table><tr><th>Year</th><th>Yield (kg/ha)</th></tr><tr><td>2001</td><td>800</td></tr><tr><td>2002</td><td>1200</td></tr><tr><td>2003</td><td>1800</td></tr><tr><td>2004</td><td>1500</td></tr><tr><td>2005</td><td>1900</td></tr><tr><td>2006</td><td>1600</td></tr><tr><td>2007</td><td>1700</td></tr><tr><td>2008</td><td>1800</td></tr><tr><td>2009</td><td>2000</td></tr><tr><td>2010</td><td>1800</td></tr><tr><td>2011</td><td>1000</td></tr><tr><td>2012</td><td>1200</td></tr><tr><td>2013</td><td>1400</td></tr><tr><td>2014</td><td>1500</td></tr><tr><td>2015</td><td>1400</td></tr><tr><td>2016</td><td>1800</td></tr><tr><td>2017</td><td>1700</td></tr><tr><td>2018</td><td>2500</td></tr><tr><td>2019</td><td>2500</td></tr><tr><td>2020</td><td>2200</td></tr><tr><td>2021</td><td>2500</td></tr><tr><td>2022</td><td>2700</td></tr></table> Australian domestic consumption of all pistachios has plateaued at about 5,000 tonnes per annum over the last three years. This represents a compound growth of about 7% per annum since 2000. There is scope for continued growth. Australian production will exceed 5,000 tonnes for the first time in 2024 rising to 12,000 tonnes by 2030. Exports have already begun and will increase. This information highlights the progress and growth made by the Australian Pistachio Industry and the success can be in part contributed to the inputs and outcomes of Project PS17003.	Year	Yield (kg/ha)	2001	800	2002	1200	2003	1800	2004	1500	2005	1900	2006	1600	2007	1700	2008	1800	2009	2000	2010	1800	2011	1000	2012	1200	2013	1400	2014	1500	2015	1400	2016	1800	2017	1700	2018	2500	2019	2500	2020	2200	2021	2500	2022	2700
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9. RECOMMENDATIONS

“That the Pistachio Growers’ Association Inc seek to continue the ‘Pistachio Productivity Improvement Program’ for a further five years utilising funds from the Pistachio Collective Industry Fund.”

10. REFEREED SCIENTIFIC PUBLICATIONS

Journal article

Zhang, J., Ranford, T.M., 2021. Identification of Key Periods of Temperature Influence on 'Sirora' Pistachio Nut Quality. Hort Technology, June 2021 31(3).

11. REFERENCES

There are no specific references to list.

12. INTELLECTUAL PROPERTY

No project IP or commercialisation to report.

Notwithstanding that there is a Research Paper that has been prepared and present to the 2023 ISHS International Almond and Pistachio Congress in May 2023 but the paper is yet to be published in the International Society for Horticultural Science publication **Acta Horticulturae**[®].

As a result, the paper should not be publicly released.

13. ACKNOWLEDGEMENTS

The authors would like to acknowledge the

- Financial support by Horticultural Innovation Australia Ltd and The Pistachio Growers' Association Inc,
- Field and laboratory work support from APPC, CMV Farms and Kyalite Pistachios,
- Sharp critics and valuable suggestions by Dr Ben Robinson, Andrew Bowring, Prue McMichael, Chris Joyce and Trevor Ranford and the research committee members.
- Input from the many pistachio growers and members of the Pistachio Growers' Association Inc
- Agriculture Victoria and the research and office staff at the Irymple Research facility.

14. APPENDICES

Appendix A: Chill Newsletter No 3, 15th August 2022 (Sample)

Appendix B: 2022 Benchmarking Report (Sample)

Appendix C: Most recent report to the Project Team/Pistachio R&D Committee as prepared and tabled by Dr Mahadevan

Appendix D: Most recent report to a Pistachio PIT Group meeting as prepared and tabled by Dr Mahadevan

Appendix E: Published Research Paper “Identification of Key Periods of Temperature Influence on ‘Sirora’ Pistachio Nut Quality”.

Appendix F: Research Paper “Dynamics of chill accumulation in Australian pistachio growing regions” presented to the ISHS Congress (NOT FOR DISTRIBUTION AS NOT YET PUBLISHED.)

Appendix G: Report by Dr Mahadevan on her visit to the USA and attendance at the ISHS Congress.

Appendix H: PS17003: PISTACHIO PRODUCTIVITY IMPROVEMENT PROGRAM – Mid Project Report.