

Final Report

Evaluation of new citrus varieties 2017-2022

Project leader:

Dave Monks

Delivery partner:

New South Wales Department of Primary Industries

Project code:

CT17006

Project:

Evaluation of new citrus varieties 2017-2022 (CT17006)

Disclaimer:

Horticulture Innovation Australia Limited (Hort Innovation) makes no representations and expressly disclaims all warranties (to the extent permitted by law) about the accuracy, completeness, or currency of information in this Final Report.

Users of this Final Report should take independent action to confirm any information in this Final Report before relying on that information in any way.

Reliance on any information provided by Hort Innovation is entirely at your own risk. Hort Innovation is not responsible for, and will not be liable for, any loss, damage, claim, expense, cost (including legal costs) or other liability arising in any way (including from Hort Innovation or any other person's negligence or otherwise) from your use or non-use of the Final Report or from reliance on information contained in the Final Report or that Hort Innovation provides to you by any other means.

Funding statement:

This project has been funded by Hort Innovation, using the citrus 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:

ISBN 978-0-7341-4881-0

Published and distributed by: Hort Innovation

Level 7

141 Walker Street

North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

© Copyright 2022 Horticulture Innovation Australia

Contents

Final report	1
Evaluation of new citrus varieties 2017-2022	1
Contents.....	3
Public summary.....	4
Keywords.....	4
Introduction.....	5
Methodology	5
Results and discussion	6
<i>An account of new budwood released to the program for evaluation and varieties that are exiting the program upon completed evaluation.....</i>	<i>6</i>
<i>An update on results presented to industry during the period through farm walks, field days, fruit variety displays, seminars and conferences in collaboration with variety managers, Citrus Australia Ltd and Hort. Innovation.</i>	<i>7</i>
<i>An update on the independent and objective horticultural performance of new citrus varieties.</i>	<i>8</i>
<i>An update on the information sheets developed on each new variety.</i>	<i>9</i>
<i>Photos/images/other audio-visual material.....</i>	<i>9</i>
Outputs	10
Outcomes	13
Monitoring and evaluation	15
Recommendations	16
Refereed scientific publications	16
References.....	16
Intellectual property	16
Appendices	17

Public summary

The citrus industry identified the independent evaluation of new varieties as a priority through their Strategic Investment Plan (SIP) as a way 'to remain a world-class industry' and 'to build on the significant gains that the industry has made over the last five years to ensure its ongoing viability and sustainability' (Citrus SIP, 2017).

This project delivered to industry independent and objective horticultural performance data from the evaluation of new citrus varieties between 2017-2022 through information sheets describing the horticultural performance of the varieties. The project outcomes were delivered through field walks and fruit variety displays as well as seminars and conference presentations to citrus industry stakeholders and value chain members.

New varieties that entered the program were assessed for their 'trueness-to-type' by growing them in the glasshouse and comparing the fruit produced with images and notes from the variety in the country of origin. The budwood produced by that glasshouse tree was topworked in an established Valencia orange block for detailed field evaluation. Our evaluation program included defining the timing of phenological development (e.g growth stages) and key physical traits of the fruit and juice. The weight, diameter, number of seeds and rind thickness of the fruit and the brix, acid and juice % were recorded through its development and used to define a maturity period for each variety.

The inclusion of each new variety in the evaluation program is advertised through wide-reaching industry publications and presentations, and individual and small group tours are held for those interested in viewing and discussing the fruit in the field. This information is then developed into publicly available information sheets that are used by industry members to assess the suitability of each variety to their enterprise. This forms part of their decision-making process – to plant, to market, to sell, or to support a new variety. Through the term of this project, approximately 1000 people have visited the site with specific intention to view the outputs from the variety evaluation program, and a similar number were exposed to presentations at forums and seminars.

Keywords

Mandarin, navel orange, Valencia orange, grapefruit, common orange, lemon, pummelo

Introduction

The citrus industry identified the independent evaluation of new varieties as a priority, through their Strategic Investment Plan, as a way 'to remain a world-class industry' and 'to build on the significant gains that the industry has made over the last five years to ensure its ongoing viability and sustainability' (Citrus SIP, 2017).

The Australian citrus industry stakeholders and value chain members compete on an international market. New markets for our citrus are emerging (e.g. Korea, China, Thailand, Philippines) and other markets are maturing. The consumers in these markets are becoming more educated and more discerning and are seeking better quality citrus products to buy and consume (Graham Barry, 2017 and John Chavarria, 2017 pers. comm.). The development of new citrus varieties to meet these consumer demands is a priority in many countries including South Africa, Israel, Spain, USA and Australia. Their breeding and selection programs have set criteria for assessment including seedlessness, easy peel characteristics, high sugar content, specific maturity period and intense skin colour. Australia now has access to the best material being developed overseas through international commercial relationships. A range of new citrus varieties will assist the diversification of the Australian citrus industry and provide new domestic and international market opportunities. Australian citrus growers need to make informed decisions on new investments and cannot afford to be left behind with new variety developments.

The project team for 'CT17006 Evaluation of new citrus varieties 2017-2022' brings together highly experienced researchers and industry communicators who have international renown in citrus variety evaluation. The team has extensive technical knowledge and strong linkages with industry stakeholders and has been involved directly with the delivery of citrus variety evaluations continuously since 1996. The majority of variety evaluation is carried out on site at the Dareton Primary Industries Institute with further, small-scale evaluation carried out at sites in Western Australia.

This project, in direct response to a call from industry (Outcomes 1 and 3 Citrus SIP, 2017), delivered to industry independent and objective horticultural performance data from the evaluation of new citrus varieties between 2017-2022. It leveraged considerable financial contribution and organisational capability from the New South Wales Department of Primary Industry (NSW DPI) and a smaller contribution from the Department of Primary Industries and Regional Development (DPIRD) in WA through managing small satellite evaluation sites.

The project outcomes were delivered through field walks and fruit variety displays as well as seminars and conference presentations to citrus industry stakeholders and value chain members. These activities were supported by information sheets describing the horticultural performance of the varieties.

As such, the objectives of the project were to:

Objective 1: Measure and evaluate the horticultural performance of new citrus varieties

Objective 2: Test new citrus varieties for trueness-to-type by growing them rapidly in the glasshouse

Objective 3: Establish new citrus varieties in the field and grow them to a high standard

Objective 4: Deliver outputs to industry

Methodology

Fruit Quality

This involved the repeated testing of each variety on a 10 - 14 day schedule over the maturity period of the variety - beginning before the fruit is palatable to when it is over mature. Where available, a 10-fruit sample size was used for each test. Criteria assessed included: Juice %, Brix (sugar), Acid %, Brix to Acid ratio and calculated BrimA, and external colour development. Occasionally, the number of seeds per fruit, rind thickness (mm), and fruit diameter (mm) were also recorded.

Maturity Period

Sequential fruit quality testing defines the maturity period for each variety and its potential marketing 'window'. A

comparative table is produced and updated at regular intervals as more data becomes available. Several seasons of testing is needed to account for seasonal variability and tree age to confidently predict the maturity period for each variety. A review of the method used to determine the maturity window for new varieties was presented for the mandarin variety M4 (91-0304) in Milestone 106 and for a package of Valencia oranges in Milestone 105.

Phenology

Phenology recording was done each year to capture the major developmental stages of each variety. These major stages are based on the 'Key Phenology Stages for Citrus' poster developed by Dr Tahir Khurshid, NSW DPI. More detailed recording is also done through the flower development to fruit set period and is based on a modified flower/fruit development key developed by G. Sanderson, NSW DPI. The detailed phenology recording period begins in early July with bud swell through to full fruit set in late January.

Specific management requirements

The evaluation program aimed to identify any specific management issues, such as a tendency to alternate bearing, a sensitivity to chemicals or nutrients, susceptibility to pest or disease and fruit load and cropping characteristics. This is done on an *ad hoc* basis, based on the project team's observations, and is reported in the variety information sheets at the end of their evaluation.

Results and discussion

An account of new budwood released to the program for evaluation and varieties that are exiting the program upon completed evaluation.

Between 2017 and 2022 (CT17006 term) 50 new varieties produced fruit in the evaluation block for the first time, and an additional 16 new varieties have entered the program but have not fruited yet (Appendix 1). Those pre-fruit varieties range from being recently budded to trees growing in the glasshouse for bud-multiplication and trueness-to-type evaluation. Varieties marked as having 'glasshouse fruit' have, as described in the methods, been proven to be true-to-type in our glasshouse, with fruit appearing to be in line with that seen in the country of origin. Varieties marked as having 'Field fruit' have been established in a field evaluation block and produced fruit at least once. When growers and industry representatives visit the site to view fruit, these are the pool of varieties they may view.



Plate 1. Varieties recently released from Post-Entry Quarantine and offered to the evaluation program are budded to a range of rootstocks and multiplied to provide budwood for field grafting. Five new varieties budded in spring 2021 are seen here.

As mentioned in the Milestone 106 report (2021), all mandarin budwood received out of Post-Entry Quarantine last year (2021/22) was small, and multiplication is proceeding slower than normal. Some buds have been cut in early August, before bud break, to attempt to establish a small number of trees in the evaluation block. Additional buds may be required from AusCitrus, the Australian citrus industry's clean budwood supply scheme, if they have had success in multiplying better budding and grafting material.

Sixty-six new varieties entered the evaluation program between 2017 and 2022 and 19 varieties exited (Appendix 2). Several of varieties exiting the project were withdrawn from evaluation at the request of the variety manager – three afourer mandarin types and two Star Ruby grapefruit selections – two at the request of the variety owners and three for not conforming to the variety manager's expectation for that fruit. Those not conforming to expectations were true-to-type but were deemed to be not meaningfully different/better than what exists on the market. This is a good result, minimising the resources used to evaluate varieties that will not be made available to Australian growers.

An update on results presented to industry during the period through farm walks, field days, fruit variety displays, seminars and conferences in collaboration with variety managers, Citrus Australia Ltd and Hort. Innovation.

Site visitors

Through the term of this project, approximately 1000 people have visited the site with specific intention to view the outputs from the variety evaluation program. They are made up primarily of small groups with a specific interest in making an on-farm business decision to plant a new variety. In other cases, they are larger groups not shown the evaluation block but presented with a table-display of mature fruits coupled with an open discussion on their merits.

In 2018 the project hosted 246 people representing more than 30 major citrus industry groups. Most of these visitors came to see the performance of specific varieties or sub-class (e.g. processing oranges, late navel oranges etc.). Visitors came from all over Australia, including a group of 20 from the Riverina, and others from Queensland, WA, South Australia, Victoria and NSW. Several non-citrus growers visited the site to discuss their intentions to enter the industry. In 2019 the project hosted 296 people.

In 2020 and 2021 COVID19 pressures limited the number of visitors to the site to 85 and 137, respectively. During this time, a digital outreach program allowed presentations to be made to industry from Sunraysia, Riverina and Western Australia. An example of the presentations delivered was included in the Milestone report and included video footage of varieties on trees and juice quality metrics at maturity.

In 2022, to August, the project has hosted 191 people across 28 groups.

We have also noticed a small but growing synergy with the co-location on site at Dareton Primary Industries Institute of the Hort Innovation co-funded Frontiers project AS18000 National Tree Crop Intensification in Horticulture (Citrus). A large field day was coordinated by Citrus Australia last year and Dareton was selected to host a major field day on the back of our portfolio of citrus research projects. We foresee people visiting the site to see the work conducted in all our industry-focused programs. In 2023, Dareton will host one leg of NSW DPI's Citrus Roadshow grower outreach program where both the Variety Evaluation program and the Tree Crop Intensification project will be featured prominently. The evaluation program will be represented at each of the other Roadshow events with presentations and discussions.

Technical presentations

Fourteen major invited technical presentations were made to more than 1000 industry members during the term of the project (locations listed in the Output Summary, Table 1). These included two presentations at Citrus Australia's biennial National Technical Forums in Adelaide, SA to 430 people in 2019, and Maroochydore, QLD to 350 people in 2021, the premier national citrus forum for researchers and growers to interact, share ideas and discuss issues. Presentations were

also made to the Citrus Australia Juice Forum and Regional Forums, NSW DPI Citrus regional Roadshows as well as regional citrus grower groups.

Industry publications

Forty-three new and updated variety information sheets were released during the term of the project (described in a following section).

Project leader Dave Monks provided editorial assistance in the final stages of production of the Australian Mandarin Production Manual (Hardy *et al.* 2017). Dr. Monks was also lead author on NSW DPI Primefact 20/919, titled 'Orange scions and varieties' giving an overview of navel, common and Valencia oranges available in Australia and their maturity timing to interested industry members. It can be accessed online, at https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0005/1290182/Orange-scions-and-varieties.pdf.

A number of articles were published in Citrus Australia' Citrus News magazine, highlighting new varieties entering the program or advertising the release of variety information sheets (Citrus News, Winter, 2020). In addition, comments were commissioned by the editor to prepare a list of important things to think about when planning to plant a new variety and is available via the Hort Innovation website.



Plate 2. A broad selection of citrus fruit presented as a table display at an industry forum hosted at the variety evaluation site, Dareton Primary Industries Institute.

An update on the independent and objective horticultural performance of new citrus varieties.

A summary of the average diameter, rind thickness and number of seeds per fruit for varieties evaluated in the project between 2017 and 2022 is presented below (Appendix 3). This is new data, presented here in summary form for the first time, and includes some varieties that have only been evaluated for one season. Across all mandarin varieties tested, the average fruit diameter was 65mm compared with 74mm and 75mm for navel oranges and Valencia oranges respectively. Rind thickness was, on average, 2.7mm, 4.2mm and 5.3mm for mandarins, navel oranges and Valencia oranges respectively. Average juice quality metrics, including brix, acid, calculated BrimA and juice %, are made available in the published information sheets once the evaluation is complete – these data are used to define the maturity window (as described for the mandarin variety M4 (91-0304) in Milestone 106, and for a package of Valencia oranges in Milestone 105) and requires multiple seasons to determine. These juice data often form a part of presentations delivered to

industry; an example of which can be seen in Milestone 103 for the red fleshed navel oranges Cara Cara and Villa 11, and in Milestone 106 for early- and mid-season navel oranges. The presentation appended within Milestone 103, describing red-fleshed navels, is available via the Hort Innovation website.

Two collaborations have begun during the term of this project. One, with Dr Peter Prentis, Associate Professor of Genetics at Queensland University of Technology (QUT), Brisbane, and their Hort Innovation AS17000 National Horticultural Tree Genomics Program. Dr Prentis' contact described their interest in "[...] examining gene expression along a floral development time course in mandarin or another citrus [...]". I have since shared data with them on the timing of floral development, from budbreak through full flowering up to the time fruit are 'golf-ball size'. They are working to understand how different genes are expressed relative to the plant's phenological development stage through a sequence of plant material collections from varieties held in our arboretum.

Another recently formed collaboration is with Dr Craig Hardner, Associate Professor of Quantitative Genetics and Tree Improvement, QAAFI, at the University of Queensland (UQ) and their Hort Innovation AS17000 National Horticultural Tree Genomics Program. I have shared data with them on juice quality metrics collected on a range of varieties, de-identified where required, from the main evaluation program, as well as leaf samples for DNA extraction. Dr Hardner's contact explained that their aim "[...] for this information was to validate genomic prediction models for fruit quality in citrus [using] historical phenotypic data for fruit quality traits for the accessions selected [...]".

An update on the information sheets developed on each new variety.

During the project, a suite of 43 new and updated variety information sheets was released. The sheets, available to industry via NSW DPI's website, present the estimated maturity window in the Riverina and Sunraysia, internal quality in that maturity window (Brix°, acid %, ratios, skin thickness, number of seeds), general comments, and, in most cases, sequential juice results from representative seasons. An example of the information sheets was included in Milestone 104 report. These variety information sheets were advertised to industry in a Citrus News (Winter 2020) article titled "Citrus Variety information sheets". The article described the information sheets released and presented a list of recent varieties to enter the evaluation program. The information sheets are also advertised during presentations to industry.

Photos/images/other audio-visual material

Plate 1. Varieties recently released from Post-Entry Quarantine and offered to the evaluation program are budded to a range of rootstocks and multiplied to provide budwood for field grafting. Five new varieties budded in spring 2021 are seen here. Dave Monks, 20 July 2022, Dareton Primary Industries Institute.

Plate 2. A broad selection of citrus fruit presented as a table display at an industry forum hosted at the variety evaluation site, Dareton Primary Industries Institute. Dave Monks, 1 June 2022, Dareton Primary Industries Institute.

Outputs

A summary of the project's outputs should be completed using the table below, using monitoring data collected to provide evidence of outputs as per the project's M&E Plan (where applicable). Examples of the outputs must be supplied as an appendix and uploaded into the Delivery Partner Portal (where appropriate), and if the output is digital, a link to the output is also required.

Provide a detailed list of extension activities conducted over the project life and any associated links to other projects and documentation.

Table 1. Output summary

Output	Description	Detail
The monitoring and evaluation (M&E) plan.	Prepared for Hort Innovation as part of the project application and delivered in Milestone 102.	-
A project risk register	Prepared for Hort Innovation as part of the project application and delivered in Milestone 102.	-
A stakeholder engagement/communication plan.	Prepared for Hort Innovation as part of the project application and delivered in Milestone 102.	-
43 variety information sheets	Individual information sheets were prepared on varieties evaluated within the program and released to industry.	The sheets, available to industry via our website, present the estimated maturity window in the Riverina and Sunraysia, internal quality in that maturity window (Brix°, acid %, ratios, skin thickness, number of seeds), general comments, and, in most cases, sequential juice results from representative seasons. They are available here: https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus and navigating to the Rootstocks and Varieties drop-down section, or follow the clickable links below. These variety information sheets were advertised in a Citrus News (Winter 2020) article titled "Citrus Variety information sheets", written by Project Leader Dave Monks. It described the information sheets released this year and presented a list of recent varieties to enter the evaluation program. • African Sunset mandarin (PDF, 741.8 KB) • Alkantara mandarin (PDF, 781.8 KB) • Bintangcheng No 2 orange (PDF, 776.0 KB) • Bintangcheng Renbin No 5 orange (PDF, 725.9 KB) • C1829 mandarin (PDF, 796.4 KB) • Cami mandarin (PDF, 855.8 KB) • Dekopon mandarin (PDF, 785.2 KB) • Dolci navel orange (PDF, 687.1 KB) • Early Sicily (C1867) mandarin (PDF, 1.0 MB) • Earlygold orange (PDF, 768.3 KB) • Etna mandarin (PDF, 697.7 KB)

		• Eureka SL lemon (PDF, 798.9 KB) • First fruit from new varieties and citrus variety evaluation research continues: March 2018 • FJ navel orange (PDF, 690.4 KB) • Gold Nugget mandarin (PDF, 605.5 KB) • Hadass mandarin (PDF, 709.8 KB) • IRM1 mandarin (PDF, 1.0 MB) • IRM2 mandarin (PDF, 841.7 KB) • Jincheng orange (PDF, 452.6 KB) • Kirkwood Red navel orange (PDF, 663.1 KB) • Mandalate mandarin (PDF, 726.8 KB) • Mandared mandarin (PDF, 690.2 KB) • Mor mandarin (PDF, 765.1 KB) • Nectar mandarin (PDF, 751.9 KB) • Nour clementine (PDF, 576.4 KB) • Nouvelle mandarin (PDF, 732.0 KB) • Orange scions and varieties • Orogrande clementine (PDF, 763.2 KB) • Orri mandarin (Or 4) (PDF, 480.7 KB) • Palmer navel orange (PDF, 751.3 KB) • Pomelit pummelo (PDF, 739.5 KB) • Primosole mandarin (PDF, 810.6 KB) • Royal Honey Murcott (RHM) (PDF, 685.8 KB) • Sidi Aissa clementine (PDF, 806.0 KB) • Summerina mandarin (PDF, 797.1 KB) • Tacle mandarin (PDF, 772.7 KB) • Tangold mandarin (PDF, 770.1 KB) • Tarocco Ippolito blood orange (PDF, 654.1 KB) • Tarocco Meli blood orange (PDF, 628.3 KB) • Tarocco Rosso blood orange (PDF, 731.9 KB) • TDE 2 (Shasta Gold) mandarin (PDF, 693.5 KB) • TDE 3 (Tahoe Gold) mandarin (PDF, 759.8 KB) • TDE 4 (Yosemite Gold) mandarin (PDF, 826.1 KB) • Turkey Valencia orange (PDF, 699.6 KB) • Winola mandarin (PDF, 706.9 KB)
Australian Citrus News (Winter 2020) article titled "Citrus Variety information sheets", written by Project Leader Dave Monks.	An article written for the leading citrus industry publication.	It described the information sheets released this year and presented a list of recent varieties to enter the evaluation program. https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/ct17006-citrus-news-winter-2020.pdf on page 23.
Australian Citrus News article advertising the re-contracting of the evaluation program for five more years.	"Citrus variety evaluation research gets the green light for 5 more years."	
Australian Citrus News (Winter 2020) article titled "Will you have a home for your future fruit?", written by Project Leader Dave Monks.		An article was commissioned by the Citrus Australia Variety and Rootstock Committee titled "Will you have a home for your future fruit?" (Citrus News, Winter 2020) that was prepared with heavy input from Project Leader Dave Monks. The article outlined many of the most important considerations when choosing a new variety to plant. Those considerations include horticultural performance, but also

		the capacity for your packhouse to take additional fruit in a different timeslot, which market you plan to send the fruit to – and if that market will exist and be profitable in 15 – 25 years' time. https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/ct17006-citrus-news-winter-2020.pdf on page 22.
An invited presentation was delivered to the Citrus Australia National Technical Forum in Adelaide (5-7 March 2019).	Presentation to industry	Presented in Milestone 104 as a representation of the style of presentation given at the time and available via the Citrus Australia website here: https://citrusaustralia.com.au/wp-content/uploads/Dave-Monks-Citrus-variety-evaluation.pdf
A poster was displayed at the Citrus Australia National Technical Forum in Adelaide (5-7 March 2019) outlining new varieties in the program and giving industry an update on outputs.	Presentation to industry	
Industry presentations	Travelled and presented variety information updates to industry in their location.	Each presentation was prepared to address specific questions or challenges faced in that area. In 2018: • Gunnedah, QLD • South Australia • Leeton, NSW • Dareton, NSW 2019: • Adelaide, SA • Griffith, NSW • Western Australia ○ Harvey (15 July 19) ○ Manjimup (16 July 19) ○ Gingin (18 July 19) 2020: • Mildura, VIC • South Australia (Non-travelling, video presentation) • Griffith, NSW 2021: • Dareton, NSW • Yanco, NSW 2022:

		• Maroochydore, QLD • Harvey, WA												
Field walks	Individual or small group walks with citrus growers and industry personnel.	Through the term of this project, approximately 1000 people have visited the site with specific intention to view the outputs from the variety evaluation program. They are made up primarily of small groups with a specific interest in making an on-farm business decision to plant a new variety. In other cases they are larger groups, not shown to the evaluation block but presented with a table display of mature fruits and an open discussion on their merits. <table><tr><td>2017</td><td>Not recorded</td></tr><tr><td>2018</td><td>246</td></tr><tr><td>2019</td><td>296</td></tr><tr><td>2020</td><td>85</td></tr><tr><td>2021</td><td>137</td></tr><tr><td>2022</td><td>191</td></tr></table>	2017	Not recorded	2018	246	2019	296	2020	85	2021	137	2022	191
2017	Not recorded													
2018	246													
2019	296													
2020	85													
2021	137													
2022	191													
CT17006 Milestone reports	MS102, MS103, MS104, MS105 and MS106	An account of new budwood released to the program for evaluation and varieties that are exiting the program upon completed evaluation. An update on the independent and objective horticultural performance of new citrus varieties. An update on results presented to industry during the period through farm walks, field days, fruit variety displays, seminars and conferences in collaboration with variety managers, Citrus Australia Ltd and Hort Innovation. An update on the information sheets developed on each new variety.												

Outcomes

Table 2. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
At least 20 new varieties/rootstock evaluated for Australian conditions and accessible by growers.		Has the project begun evaluation on at least 20 new varieties for Australian conditions? Are 20 varieties, that “have been through” the project, accessible by growers?	Sixty-six varieties have entered the evaluation program between 2017 and 2022. Specific future commercialisation plans are not known to the evaluation program, but more than 20 varieties have been made available to growers to buy and plant from the pool of varieties evaluated between 2017-2022 as

			evidenced by known-plantings.
300 people/year being engaged (from Inform to Empower) through exposure to the evaluation of new varieties via field walks, fruit displays and seminars.		Did the project engage with industry levy payers through appropriate methods? How accessible were extension events and written outputs to targeted member of industry?	The project averaged 200 people/year visiting the site to view fruit and trees. More were reached with the biennial Citrus Australia Technical Forum in Adelaide 2019 was (attended by 430 people) and in Maroochydore in 2022 (350 people). The project delivered invited presentations to each of these forums. Approximately 20 people attended each of six regional forums in 2017/18, 20 attended each of the Citrus Australia Juice Forums in 2018 and 2020.
Inform and Consult with industry through 'issue-based' forums, e.g. 2018 Leeton Juice forum, to raise understanding and engagement of variety issues.		Did the project engage with industry levy payers through appropriate methods? How accessible were extension events and written outputs to targeted member of industry?	Hort Innovation project CT20001 Strategic review of investments in citrus breeding and evaluation reported our field walks, fruit displays, seminars, and presentations were "On-going and well received".
Rapid elimination of varieties from the program that do not have a future as commercial varieties in Australia.		Were varieties not deemed appropriate to continue in the evaluation program eliminated in a timely fashion?	Yes, for example one specific variety had only one full season's data collected before being scaled back and then eliminated. Preventing varieties with no evidence that they would succeed in our environment or markets from entering the project is an area that needs further attention to minimize wasted resources.
Measure and evaluate the horticultural performance of new citrus varieties.		Were fruit quality, including juice %, °brix (sugar), acid %, °brix:acid ratio and BrimA, number of seeds/fruit, rind thickness (mm), and fruit diameter (mm) measured for evaluated varieties?	Yes, data were collected for all evaluated varieties as evidenced by their inclusion in this final report and milestone reports as well as in information sheets produced after a variety has been

			evaluated.
Test new citrus varieties for trueness-to-type by growing them rapidly in the glasshouse.		Were fruit tested for trueness-to-type?	Yes. Trees were grown in the glasshouse and evaluated <i>in situ</i> for their fruit and growth characteristics and compared with evidence available in the country of origin.
Establish new citrus varieties in the field and grow them to a high standard.		Were new citrus varieties planted in the field and grown to a high standard?	Yes. During the 2017-2022 evaluation program, sixteen new varieties were planted on a range of rootstocks for evaluation. This spring 2022, ten more varieties will be planted out. The planted varieties form a subset of those topworked to the main evaluation block in Dareton and the satellite sites in Western Australia.

Monitoring and evaluation

Table 3. Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
This project was contracted prior to mandatory Key Evaluation Questions.	-	-

Recommendations

- That growers continue to engage with relevant national and international variety information before making a planting decision. Planting a new variety is a business decision and should be made with that in mind. More information is available in an article “*Will you have a home for your future fruit?*” via our December 2020 update on Hort Innovation’s website here: <https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/ct17006/>. A direct link to the article is available here: <https://www.horticulture.com.au/globalassets/hort-innovation/resource-assets/ct17006-citrus-news-winter-2020.pdf>.
- That growers access the published information sheets, made available after the evaluation is completed, for a broad range of modern varieties. They are available here: <https://www.dpi.nsw.gov.au/agriculture/horticulture/citrus> and navigating to the Rootstocks and Varieties drop-down section.
- That growers sign-up to Citrus Australia as levy-paying members and access their excellent industry-focused magazine, forums and workshops in your area. Many of our variety evaluation materials are shared with industry via these channels and they allow face to face discussions with like-minded people on the pros and cons of new varieties for your property.
- That growers seek out, call and arrange a visit to the variety evaluation site in Dareton, NSW, or in Western Australia to see these new varieties with fruit on the trees.

Refereed scientific publications

Nil.

References

Milestone reports referenced here are all outputs of this CT17006 project, delivered to and accepted by Hort Innovation.

Citrus SIP, 2017. Citrus Strategic Investment Plan, 2017-2022. Available online

<https://www.horticulture.com.au/globalassets/hort-innovation/levy-fund-financial-and-management-documents/sip-pdfs-new/hortinnovation-sip-citrus-2017-2021.pdf>

Intellectual property

No project IP or commercialisation to report

Acknowledgements

Graeme Sanderson, former research officer on the project, was supportive in their hand-over of responsibilities and provided continuity during the early part of this project. Graeme’s contribution to the Australia citrus industry cannot be understated in his role as a variety expert, having been involved in all the past guises of this evaluation work since its inception in 1998 (CT98033).

Troy Witte has provided technical assistance throughout the term of the project and continues to be a friend to the program.

Appendices

Appendix 1. Varieties evaluated at the Dareton Primary Industries Institute between 2017 and 2022.

		Origin	Variety Manager	Glasshouse fruit	Field fruit
Cambria	Navel orange	South Africa	ANFIC	Yes	Yes
FJ	Navel orange	Australia	Variety Access	Yes	Yes
Glen Ora	Navel orange	South Africa	Variety Access	Yes	Yes
Greenwood	Navel orange	Australia	APM	Yes	Yes
Kirkwood Red	Navel orange	South Africa	Variety Access	Yes	Yes
Palmer	Navel orange	South Africa	PUBLIC	Yes	Yes
Rayno	Navel orange	South Africa	Variety Access	Yes	Yes
Villa 11	Navel orange	Australia	Variety Access	Yes	Yes
Witkrans	Navel orange	South Africa	Variety Access	Yes	Yes
Benny	Valencia orange	South Africa	Variety Access	Yes	Yes
Gusocora	Valencia orange	South Africa	Variety Access	Yes	Yes
Lavalle	Valencia orange	South Africa	Variety Access	Yes	Yes
McClean	Valencia orange	South Africa	Variety Access	Yes	Yes
Midnight Imp	Valencia orange	South Africa	Variety Access	Yes	Yes
Ruby	Valencia orange	South Africa	Variety Access	Yes	Yes
Turkey	Valencia orange	South Africa	Variety Access	Yes	Yes
Weipe	Valencia orange	South Africa	Variety Access	Yes	Yes
Jackson	Grapefruit	South Africa	Variety Access	Yes	Yes
Star Ruby (A)	Grapefruit	South Africa	Variety Access	Yes	Yes
Star Ruby (B)	Grapefruit	South Africa	Variety Access	Yes	Yes
Red Ned	Grapefruit	South Africa	Variety Access	Yes	Yes
AC Afourer	Mandarin	Australia	Variety Access	Yes	Yes
African Sunset	Mandarin	South Africa	Variety Access	Yes	Yes
ARC Nardorcott	Mandarin	Israel	Variety Access	Yes	Yes
C4-15-19	Mandarin	USA	ANFIC	Yes	Yes
Daisy LS	Mandarin	USA	Nu Leaf	Yes	Yes
Early Sicily (C1867)	Mandarin	Italy	ANFIC	Yes	Yes
Gold Nugget	Mandarin	USA	Variety Access	Yes	Yes
Hadass	Mandarin	Israel	Variety Access	Yes	Yes
HC Afourer	Mandarin	Australia	Variety Access	Yes	Yes
Honeybee	Mandarin	Australia	Variety Access	Yes	Yes
Kinnow LS	Mandarin	USA	Nu Leaf	Yes	Yes
M4 (91-03-04)	Mandarin	Australia	CSIRO	Yes	Yes
M8	Mandarin	Australia	CSIRO	Yes	Yes
Mandalate	Mandarin	Italy	ANFIC	Yes	Yes
Mandared	Mandarin	Italy	ANFIC	Yes	Yes
Miho Wase	Mandarin	Japan	PUBLIC	Yes	Yes
MJR 11 (Mojo)	Mandarin	Australia	Variety Access	Yes	Yes
MJR 12 (Mojo)	Mandarin	Australia	Variety Access	Yes	Yes
Orah	Mandarin	Israel	Variety Access	Yes	Yes
Orri	Mandarin	Israel	Variety Access	Yes	Yes
Sonet	Mandarin	South Africa	Variety Access	Yes	Yes

Sugar Belle	Mandarin	USA	ANFIC	Yes	Yes
Summerina	Mandarin	Australia	APM	Yes	Yes
Tang-gold	Mandarin	USA	Nu Leaf	Yes	Yes
USDA 88-2	Mandarin	USA	Variety Access & Nu Leaf	Yes	Yes
Valley Gold (B17)	Mandarin	South Africa	Variety Access	Yes	Yes
Italian Lemon	Lemon	Italy	Variety Access	Yes	Yes
Pink Marvel	Lemon	USA	Variety Access	Yes	Yes
Sudachi	Yuzu/ <i>Papeda</i>	Japan	Variety Access	Yes	Yes
Cara Cara late	Navel orange	Australia	Variety Access	No	No
15C001	Mandarin	Australia	QDAF	No	No
Bingo	Mandarin	USA	Variety Access	No	No
CB Murrcott	Mandarin	Australia	QDAF	No	No
HBI 01	Mandarin	Korea	Variety Access	No	No
HBI 02	Mandarin	Korea	Variety Access	No	No
HBI 05	Mandarin	Korea	Variety Access	No	No
HBI 06	Mandarin	Korea	Variety Access	No	No
HBI 12	Mandarin	Korea	Variety Access	No	No
Premier	Mandarin	Australia	QDAF	No	No
Seedless Snack	Mandarin	USA	ANFIC	No	No
Shiranui	Mandarin	USA	PUBLIC	No	No
UF 900	Mandarin	USA	ANFIC	No	No
UF 950	Mandarin	USA	ANFIC	No	No
UF Sunrise	Mandarin	USA	ANFIC	No	No
BA001	Lemon	Australia	ACS	This season	No

Appendix 2. Varieties exiting the evaluation program at the Dareton Primary Industries Institute.

Information sheet		
Eureka SL	Lemon	Yes
Turkey	Valencia	Yes
Tarocco Ippolito	Blood orange	Yes
Dolci	Navel orange	Yes
FJ	Navel orange	Yes
Kirkwood Red	Navel orange	Yes
Star Ruby (A)	Grapefruit	Withdrawn
Star Ruby (B)	Grapefruit	Withdrawn
Red Ned (Star Ruby)	Grapefruit	In preparation
ARC Nadorcott	Grapefruit	Withdrawn
AC Afourer	Mandarin	Withdrawn
Dekopon	Mandarin	Yes
Gold Nugget	Mandarin	Yes
Hadass	Mandarin	Yes
HC Afourer	Mandarin	Withdrawn
M4 (91-03-04)	Mandarin	In preparation
Mandared	Mandarin	Yes
Orri	Mandarin	Yes
Summerina	Mandarin	Yes

Appendix 3. The average diameter, rind thickness and number of seeds per fruit for varieties evaluated during the term of the project. This is new data, presented here for the first time, and includes some varieties that have only been evaluated for one season. The data are subject to updates as more data is collected.

Mandarins	Fruit diameter (mm)		Rind (mm)		Seeds/fruit	
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
USDA 88-2	65	1.9	3.0	0.46	0.1	0.15
AC Afourer	62	4.5	2.8	0.61	0.0	0.02
African Sunset	83	4.0	3.3	0.42	0.1	0.10
C4-15-19	57	3.1	2.8	0.62	0.0	0.00
Daisy LS	70	4.0	2.4	0.47	0.4	0.60
Dekopon	89	2.4	4.7	0.34	1.0	1.16
Hadass	68	1.0	2.2	0.24	1.6	0.66
HC Afourer	61	3.0	2.9	0.25	5.6	3.17
Honeybee	69	2.7	2.2	0.40	1.9	0.49
Kinnow SL	56	3.2	2.3	0.40	0.1	0.20
Kishu	48	4.9	1.6	0.25	0.0	0.00
M4 (91-03-04)	52	4.0	1.6	0.30	0.5	0.64
M8	75	7.3	2.4	0.65	0.5	0.58
Mandared	71	1.0	2.4	0.25	0.2	0.16
MJR11 Mojo	64	4.8	2.8	0.43	2.3	2.75
MJR12 Mojo	64	12.9	2.4	1.15	1.1	0.87
Nadorcot SL	62	2.6	2.3	0.44	0.8	0.37
Orah	65	4.8	3.2	0.40	9.4	2.17
Orri	62	2.3	3.0	0.36	1.1	0.46
RHM	64	7.9	2.2	0.40	0.8	1.05
Ruby GS	67	5.1	3.9	0.71	0.2	0.15
Sonet	71	7.3	2.0	0.40	3.3	2.66
Sugar Belle	63	3.0	2.3	0.26	7.6	2.57
Summerina	61	3.0	3.8	0.33	0.0	0.00
Tango	64	3.1	2.9	0.95	0.0	0.08
Valley Gold	68	2.6	2.3	0.37	1.3	0.41

Grapefruit	Fruit diameter (mm)		Rind (mm)		Seeds/fruit	
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
Jackson	74.9	3.34	6.7	0.71	0.7	0.46
Late Star Ruby	100.4	7.78	9.5	2.12	0.4	0.30
Red Ned (Star Ruby)	97.6	7.27	8.3	1.24	0.2	0.35

Navels	Fruit diameter (mm)		Rind (mm)		Seeds/fruit	
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
Glen Ora	81	5.8	4	0.5	0	0.1
Greenwood navel	70	5.1	3	0.5	0	0.1
Palmer	81	-	5	-	0	-
Rayno	69	4.0	4	0.5	0	0.0
Villa 11	74	2.4	4	0.3	0	0.3
Witkrans	71	3.8	4	0.5	0	0.0

Valencias	Fruit diameter (mm)		Rind (mm)		Seeds/fruit	
	Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.
Benny	78	4.2	5	0.6	2	1.2
Gusocora	73	4.5	6	1.2	0	0.0
McClean	75	5.3	5	1.0	2	1.0
Midknight	76	4.6	5	0.8	0	0.1
Ruby	72	5.1	5	0.7	2	1.1
Turkey	77	5.5	5	1.0	2	0.7
Weipe	75	4.4	6	0.9	0	0.0