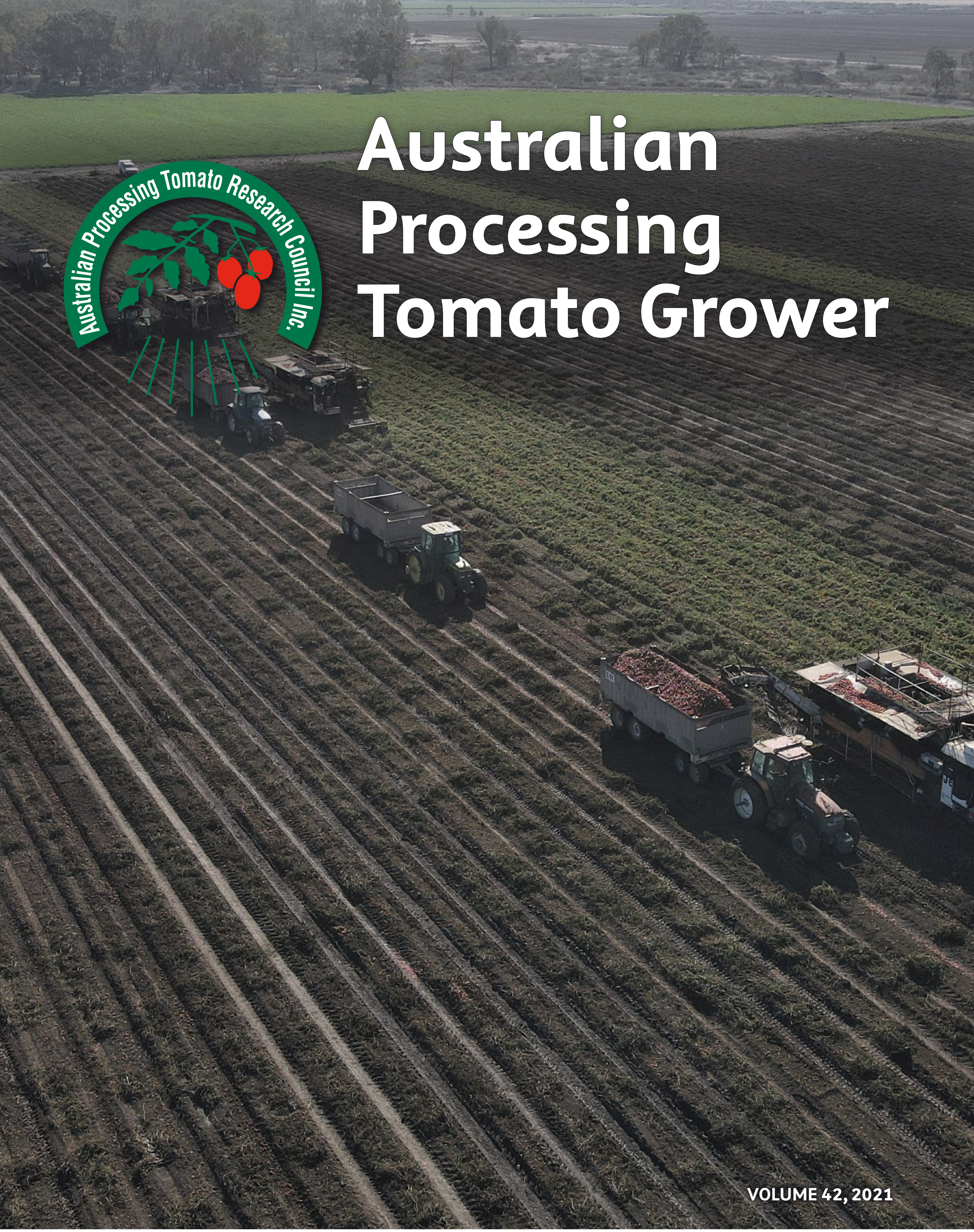
Australian Processing Tomato Grower



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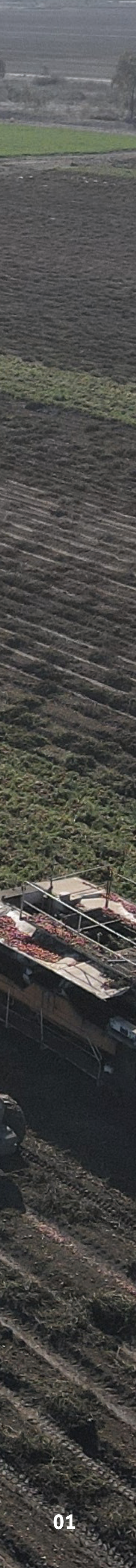
Hort Innovation
Strategic levy investment

PROCESSING TOMATO FUND

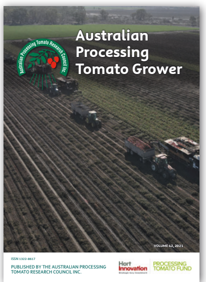


AUSTRALIAN PROCESSING TOMATO GROWER

ISSN 1322-8617 VOLUME 42, 2021

APTRC members and guests, meeting in Echuca

FINANCE REPORT - 2020/21	APTRC Account (Audited)	Hort Inn Account (Unaudited)
INCOME		
Processor (APTRC) and Grower (HI) levies	114,914	114,914
Interest	5,691	10
Total Income	***120,605***	***114,924***
EXPENDITURE		
Hort Innovation		106,245
Membership - Plant Health Australia	1,500	
Biosecurity costs	31	
University of Melbourne - Honours project	10,744	
NSW DPI Yield Variability project	34,860	
Deakin University - Irrigation project	15,000	
APTRC Operating Expenses	1,800	
Depreciation	12,286	
Total Expenses	***76,221***	***106,245***
Net Surplus/(Deficit)	***44,384***	***8,679***



Cover Photo

Hamish Lanyon's drone photo of the crop harvest on Tony Sawers property near Boort.

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INTRODUCTION

In a season overshadowed by COVID lockdowns and border closures, the processing tomato industry achieved its highest average field yield on record, a testament to the skill and resilience of our growing and processing community. The APTRC is once again pleased present this publication as a record of the industry's research and development program and major events. We also thank all the businesses and agencies that support these activities, particularly in such challenging times.

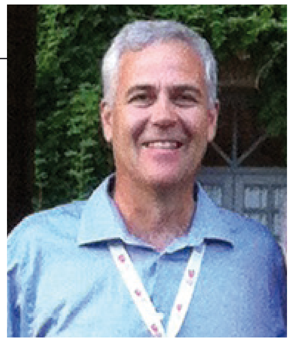
Editors Bill Ashcroft and Matthew Stewart
APTRC Inc
Design and Printing
Willprint Shepparton

The project [Australian Processing Tomato Industry Capacity Building Program (TM17000)] which includes the production of this magazine has been funded by Horticulture Innovation Australia Limited with co-investment from Australian Processing Tomato Research Council Inc. and funds from the Australian Government.

Notice to Contributors:

Authors wishing to contribute articles to the next 'Australian Processing Tomato Grower' should submit copy to APTRC Inc., PO Box 547, Echuca Victoria, 3564 NO LATER THAN June 30, 2022. Where possible, photographs should be supplied as hi-res digital images on disk or email. Graphs, charts, tables, etc. should be submitted electronically, with an accompanying print-out for confirmation of data.

APTRC – Chairman's Report 2021



Charles Hart, Chair, Australian Processing Tomato Research Council Inc.

For the second season running, the processing tomato industry, like many others, experienced difficulties with a year of Covid lockdowns and border closures, enhancing issues with labour shortages for growers and processors alike.

The 2020/21 season saw growers deliver a total of 232,562 tonnes of processing tomatoes, which is a reasonable increase on the 2019/20 season. The average yield was the highest ever recorded in Australia at 106.13 t/ha, which is very impressive considering that the area of production, and with it the increased challenges of logistics for growers and processors, increased by over 200 hectares. This yield average was slightly above the Californian yields for the season, which highlights the high standard of our growers to keep pace with the world's best practices and top producers.

We were fortunate this season to host both the Boort/Boga and Rochester District crop inspection days, which were very well attended by growers, processors, and industry stakeholders. The accompanying dinner events were as always a great opportunity for many in industry to catch up after a year of much isolation and the January event allowed inclusion of partners and children.

Once again, due to state government restrictions, we regrettably were unable to conduct our Annual Tomato Forum. Our new IDM Matt Stewart, successfully managed to take several of the planned forum sessions online and help keep momentum going on several key priority areas in our Research and Development portfolio. We all look forward to an 'in person' 2022 forum event.

The industry delved deeper into some unanswered questions regarding drip irrigation on the two major soil types in our area. This work is being done with assistance from Sam North, NSW DPI and Lloyd Chua of Deakin University. The results of these studies have been of interest to growers and irrigation supply companies alike.

Our continued studies into soil-borne disease conducted by Melbourne University were unfortunately delayed due to the international PhD student conducting the work not being able to return to Australia. Prof Paul Taylor has been extremely supportive of our industry and we plan to continue with the work in 2022, subject to travel restrictions.

In another project, the Australian National University has been progressing its work on tomato vine gasification, following on from the compelling study undertaken by Andre Henry during his Nuffield scholarship in 2018/19. With rising fuel and fertiliser costs on the industry we are keen to pursue this work in 2022.

Adequate seed to plant the required hectares this season was obtained only through the persistent efforts of processors and Australian seed company representatives, with assistance from the APTRC. It is imperative that seed is secured well in advance to ensure that the industry has sufficient seed to meet its requirements.

The relationship with Biosecurity Australia has strengthened over the last two seasons and we are grateful for all the assistance they provide in securing seed entry into Australia. Unfortunately, due to issues with viroid detection overseas, not all the varieties requested for planting could be delivered and hence some new varieties were fast tracked into commercial production, due to their availability and pre-identified productivity data that was gathered through the APTRC trial program.

This year saw the end of our 3-year TM17000 Capacity Building project and APTRC delivered a final report covering all the great work delivered by APTRC during this period. The APTRC were required to tender for, and were successful in obtaining the contract to undertake the ongoing research. I wish to thank Matt, Peter, Ann and Bill for the work they did in winning the tender for the new 5-year contract. The increased term from 3 to 5 years provides us with greater certainty and gives us the confidence to take a long term view on research we undertake.

A facilitated meeting was held on 5th of May 2021 with Sam North from NSW DPI, at which industry representatives (growers, processors, researchers, agronomists, sales agents) reviewed past strategic plans and project findings; set a vision and goals for the coming five years; and discussed future actions under each goal. A draft plan produced from this meeting was circulated across the industry and feedback received was incorporated into a new strategic plan; finalised and agreed to by the industry in August 2021. The outcome of this work has been that the industry identified the need for a farming systems-based approach to addressing disease risk and the need to develop a more profitable and sustainable crop rotation practice.

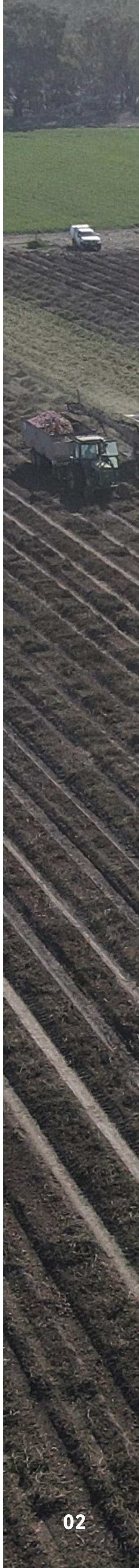
It was welcome news to hear that a new grower, Andrew Stott, had entered the industry this season in NSW. Although Stott's have a past pedigree in processing tomato growing in NSW, it will be Andrew's first season growing and we wish him all the best in this endeavour.

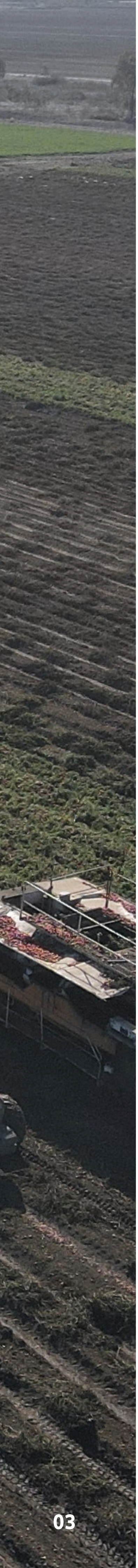
I would like to thank the growers and processors again for their assistance and cooperation in facilitating the APTRC trial program. I also wish to thank Matt and Ann for their ability to keep the APTRC activities on track and progressing under challenging conditions. Thanks to Peter and Bill for their stellar support as always.

This year also marks the end of a very long relationship between Peter Gray and the tomato industry. Peter has held various roles within the APTRC and APTG over a period of more than 25 years. Peter's financial prowess and his calm well considered opinions on virtually every aspect of the industry will be sorely missed. We wish Peter and Jenny all of the very best in their transition to retirement.

Sadly 2021 saw the passing of Geraldine Chirnside, a much loved member of the world tomato growing and processing family. Geraldine epitomised the can do attitude of the Australian tomato industry. She was a true industry leader in that she was actively involved in the family farming operation and participated in all aspects of the industry. Geraldine will be greatly missed.

Finally, I would like to thank all the volunteer committee members as well as the grower group committee for their dedication and commitment to the industry. Despite the challenges of 2020 and 2021, the committee and I look forward to working with our members to continue advancing our industry in 2022.





Update from Hort Innovation

Adrian Englefield – Regional Extension Manager, South-East

On behalf of Hort Innovation, I would like to congratulate the Australian Processing Tomato Research Council (APTRC) project team of Matt Stewart, Ann Morrison and Bill Ashcroft on the successful completion of the *Processing Tomato industry capacity building* (TM17000) project. In September 2021, a new five-year processing tomato project delivered by the APTRC started, titled *Processing Tomato industry development and extension* (TM20000).

The *Processing Tomato industry development and extension* (TM20000) project is funded by Hort Innovation, using processing tomato research and development levy funds from the Australian Government and in-kind contributions from the APTRC. The *Processing Tomato industry capacity building* (TM17000) final report and *Processing Tomato industry development and extension* (TM20000) description are available on the Hort Innovation website.

During 2021 Hort Innovation liaised with stakeholders from 37 levy-paying industries (including Processing Tomatoes) to create five-year industry specific Strategic Investment Plans (SIPs). The SIPs identify Research, Development, Extension, Marketing and Trade investment priorities for 2022–26. I encourage all Horticulture producers to visit the Hort Innovation Strategic Investment Plans on our website, including the Processing Tomato Strategic Investment Plan 2022–26.

The 2020–21 Processing Tomato Annual Report is also available on the Hort Innovation website. The report contains project information, a case study from Johanna Morgan, agronomist with Kilter Rural, and the Processing Tomato 2020–21 financial operating statement.

Fingers crossed, COVID-19 disruptions are now behind us; and I look forward to attending grower field days, the 2022 industry forum, the regular pest and disease updates via workplace and other resources produced within TM20000 for the benefit of the Processing Tomato industry.

If you have any questions or would like to discuss anything with Hort Innovation, please feel free to call me on 0427 143 709 or email Adrian.englefield@horticulture.com.au.

Processing Tomato Fund (collective) Financial operating statement 2020/21

	R&D ($)	Total ($)
	2020/21 July – June	2020/21 July – June
OPENING BALANCE	**(45,990)**	**(45,990)**
Voluntary levies from growers	106,245	106,245
Australian Government money	91,071	91,071
Other income*	–	–
TOTAL INCOME	**197,316**	**197,316**
Project funding	160,102	160,102
Consultation with and advice from growers	–	–
Service delivery	22,039	22,039
TOTAL EXPENDITURE	**182,141**	**182,141**
Levy contribution to across-industry activity	–	–
CLOSING BALANCE	**(30,815)**	**(30,815)**

* Interest, loyalties

Levy collection costs – These are the costs associated with the collection of levies from industry charged by Levy Revenue Services (LRS)
Service delivery – Also known as Corporate Cost Recovery (CCR), this is the total cost of managing the investment portfolio charged by Hort Innovation

Annual Industry Survey 2021

Matthew Stewart

Executive Summary

During the 2020/2021 season, eleven growers produced 232,562 tonnes of processing tomatoes, an increase on the volume grown in 2019/20, and the crop was again processed by three companies.

Approximately 2,215 hectares were planted, with total use of sub-surface drip irrigation for the third time. The use of transplants increased slightly to 90% of the total area under production, with seeded tomatoes making up the remaining 10%.

In 2020/21, the Australian processing tomato industry achieved their highest ever average yield of 106.13 tonnes per hectare. The record was achieved on the back of a relatively dry and uninterrupted planting/sowing period, a mild summer and only two major rain events during the harvest period. 100% of planted area was harvested, which was an ideal outcome for industry.

Soluble solids averaged 5.01%, which continues the trend in recent years where solids have been consistently above the 5.00% benchmark.

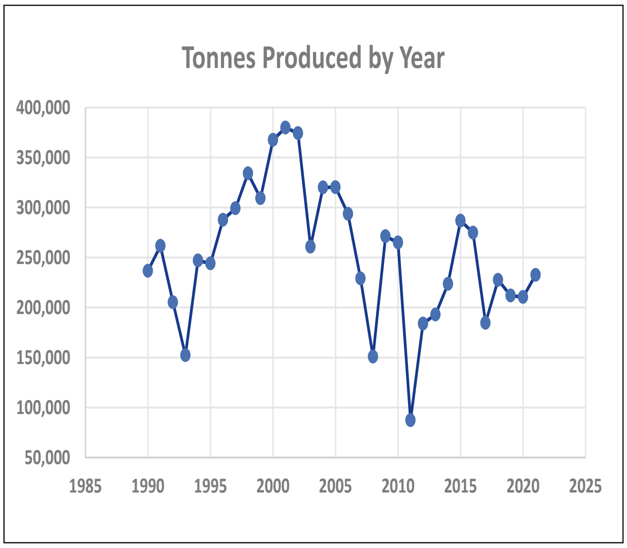
Imports of processed tomato products, in equivalent raw tonnes, increased significantly during the 2020 calendar year, to levels not seen since 2011. Exports almost doubled compared to the previous year, at yet again higher price points for the fifth successive year.

Domestic demand was supplied by a slightly increased percentage of imports; although the 5-year average remains fairly stable at about two thirds imported to one third local product.

Australians increased their average consumption of processed tomato products from 23 to approximately 25 kilograms per capita in equivalent raw weight. The higher consumption of tomato products has been linked most significantly to a change in consumer trends resulting from the pandemic, which started in early 2020; this trend has also been observed in other regions around the world.

1 Industry Size

1.1 Volume

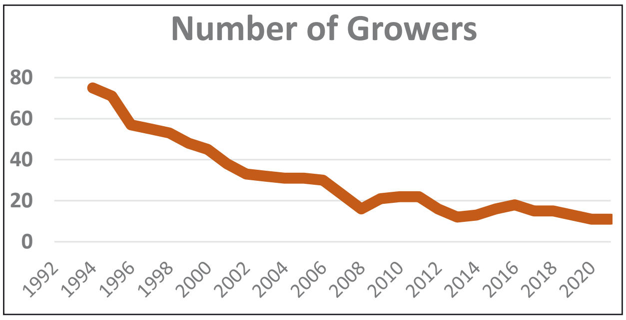


Graph 1-1: Paid tomato volumes delivered (tonnes)[1]

Growers produced 232,562 tonnes of processing tomatoes during the 2020/21 season, approximately 10% higher than the figure for the 2019/20 season of 210,477 tonnes. This reflected increases in demand from the two major processing operations in Australia. It is also worth noting that contained in the total production figures are the organically grown tomatoes, which contributed 2,731 tonnes of produce, with an average yield of 55.4 t/ha.

No fresh market tomatoes contributed to the processing industry tonnage during the 2020/21 season.

1.2 Producers



Graph 1-2: Number of growers[1]

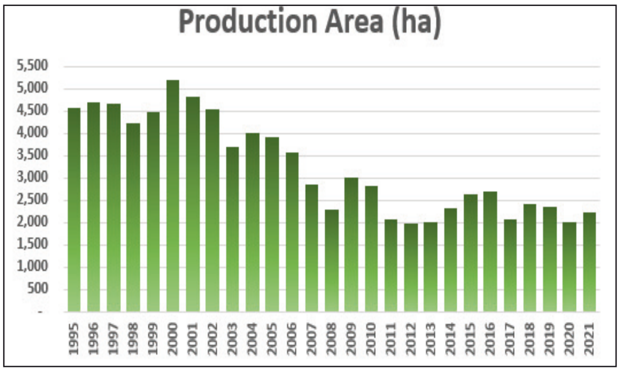
The grower number remained at 11 specialist growing businesses for the 2020/21 processing tomato season.

1.3 Processors

As in the previous season, the crop was processed by three businesses, with Kagome and SPC taking most of the harvest.

2 The Crop

2.1 Area and management



Graph 2-1: Planted production area (ha)[1]

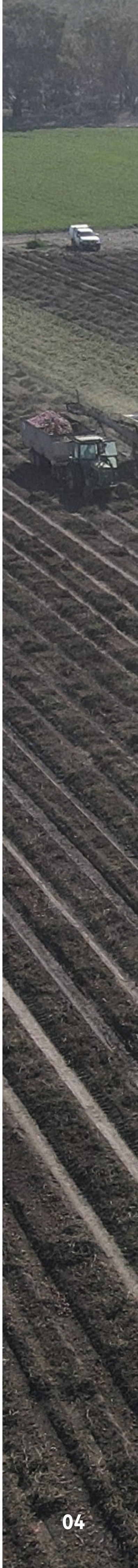
The area under production increased to 2,214 hectares, of which 100% was harvested. The larger area planted may reflect both an increased capacity of processors as well as additional demand from export markets in response to global consumer trends during the pandemic.

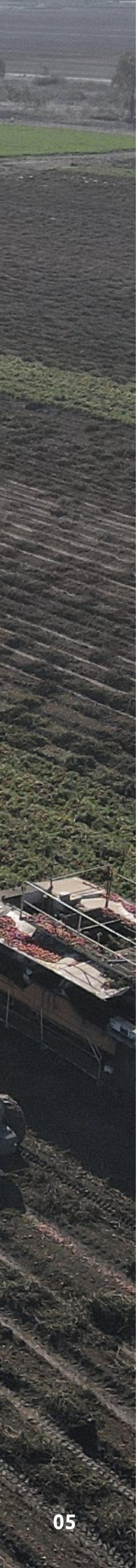
Season	Drip Irrigation	Transplanted	Seeded
2010/11	88%	79%	21%
2011/12	90%	81%	19%
2011/13	98.5%	72%	28%
2013/14	95%	59%	41%
2014/15	99.9%	68%	32%
2015/16	98.3%	69%	31%
2016/17	99.6%	86%	14%
2017/18	99.3%	88%	12%
2018/19	100%	91%	9%
2019/20	100%	86%	14%
2020/21	100%	90%	10%

Table 2-1: Proportions of drip and transplants Vs seed[2]

This season, the crop was again fully grown under sub-surface drip irrigation.

The trend toward higher percentages of transplants Vs seeded crop was observed again this season, with the Boort growing region in Victoria accounting for all seed-grown tomato production. The seed-sown crops represented 10% of the total industry by area in 2020/21.



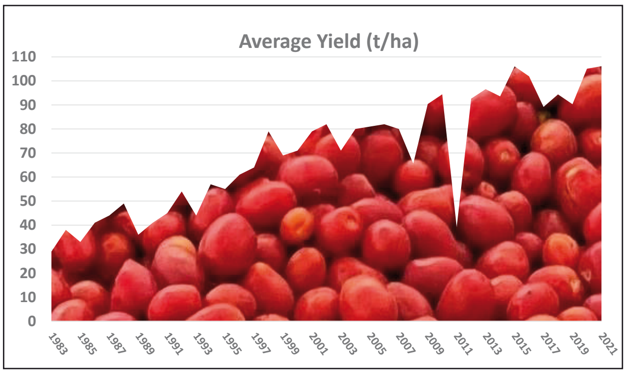


2.2 Yield - *(Note: all yields are expressed in metric tonnes per hectare)*

Season	Area (ha)	Area (ha)	Harvested	Average Yield	Seasonal Comments
	Planted	Processed	Area %	t/ha	
2009/10	3443	2806	81%	94.4	Wet harvest
2010/11	2850	2074	73%	39.2	Flooded crops
2011/12	2366	1962	83%	92.6	Wet harvest
2011/13	1999	1998	100%	96.6	Wet, late harvest
2013/14	2386	2330	98%	93.6	Wet, late harvest
2014/15	2700	2635	98%	106.10	Early crop failure
2015/16	2782	2697	97%	101.9	Poor crop stand, delayed harvest, over-contract fruit
2016/17	2183	2071	95%	89.2	Delayed harvest due to rain
2017/18	2457	2407	98%	94.4	Abandoned due to factory power outage and resulting delay
2018/19	2347	2347	100%	90.3	Extreme bacterial speck, high temperatures
2019/20	2073	2003	97%	105.1	Hot and windy during growing; late harvest rains
2020/21	2215	2215	100%	106.13	Dry start, strong winds mid spring, some hail, mild summer

Table 2-2: Historical Average and Harvested Yields with seasonal conditions (t/ha)[2]

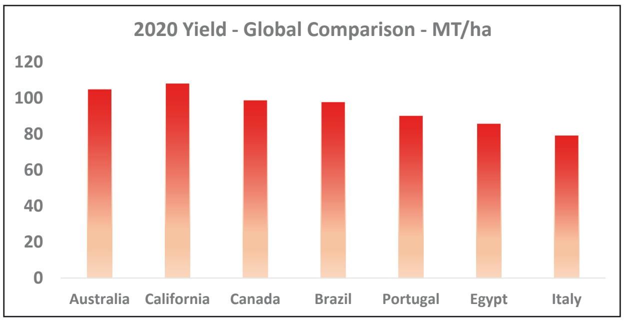
The 2020/21 season saw an increase in overall average yield to a record for the Australian industry of 106.13 t/ha. Although assisted by a reasonably moderate season this is a testament to the skill of the growers, and when considered with the fact that a significantly greater area was also planted; (which generally invites more risk) this record yield is an even more impressive result.



Graph 2-2: Average yield (t/ha)[1]

Additionally, the success of achieving 100% harvested area (or close to it) in recent years is in part a result of the move by processors to shift the harvest schedule to earlier in the season, which helps avoid harvest delays and minimises the chance of abandoned crops due to overripe fruit or poor paddock conditions.

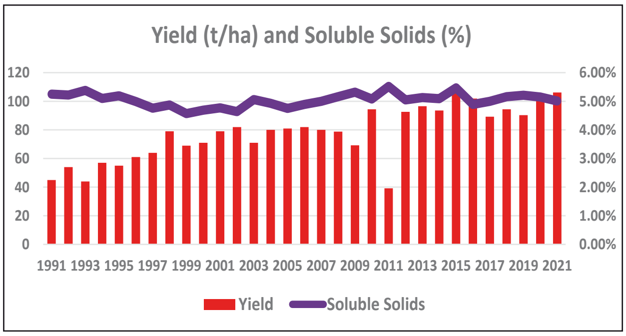
The industry is focussed on ever higher yields and solids to stay competitive internationally and to improve grower viability. The annual industry cultivar evaluation trials and research into irrigation optimisation, based on soil type, are just some of the current actions the Australian processing tomato industry are undertaking to achieve ever higher yield outcomes.



Graph 2-3: 2020 average yield (t/ha), by country[3]

Graph 2-3 presents the 2020 average yields for major producing countries from which relevant data is available. California at 108.33 tonnes achieved slightly higher averages than Australia at 105.1 tonnes per hectare. Canada and Brazil were also close behind. The result in 2020 emulates previous seasons, where Australia has been one of the leading countries in the world for yield averages.

2.3 Soluble Solids



Graph 2-4: Soluble solids (%) and yield (t/ha)[1]

Average soluble solids for the season were 5.01%, above the minimum industry benchmark of 5.00% preferred by processors. The recent history of soluble solids indicates that benchmark is being attained in most seasons.

2.4 Varieties

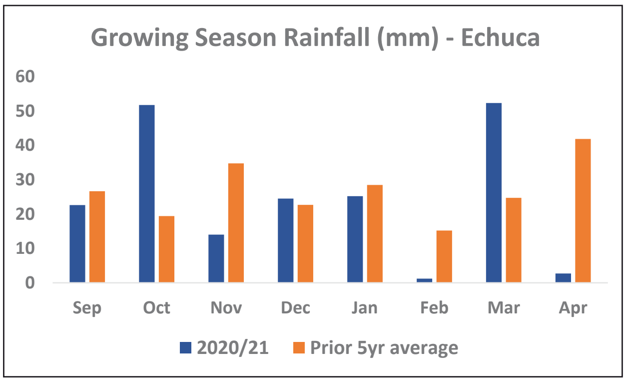
VARIETIES	PERCENTAGE OF TOTAL AREA GROWN	
	2020/21	***2019/20***
H3402	**18.5%**	*11.0%*
H3402/H1311	**16.7%**	*3.8%*
H3402/H2401	**17.0%**	*18.6%*
UG19406/UG16112	**14.6%**	*9.3%*
H3402/H1175	**7.8%**	*21.5%*
H1311	**5.6%**	*5.0%*
H1015	**9.0%**	*11.2%*
H1014	**5.6%**	*0%*
H4401	**3.3%**	*4.8%*
SVTM9000	**0.5%**	*0%*
UG16112	**0.6%**	*0.9%*
UG4014	**0.3%**	*0%*
H1428	**0.3%**	*0%*
UG19406/18806	***0%***	*9.7%*
UG19406	***0%***	*1.9%*
H1301	***0%***	*1.5%*
H1307	***0%***	*0.6%*

Table 2-3: Variety by proportion of total area

When comparing 2019/20 to the 2020/21 season, there were some significant shifts in the balance of varieties grown by area. Many factors influence the mix of varieties being grown from season to season and they may reflect a change in bias toward customer requirements, upgrading of processing infrastructure, new market access or loss of previous markets, seasonal harvesting logistics and/or agronomic suitability of varieties to growing regions and soil types.

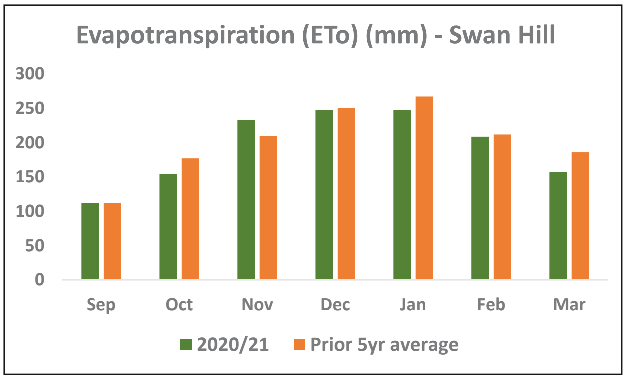
The industry is still being heavily challenged by seed availability. The main issues are related to unwanted viroids being detected in seed destined for Australia and related import biosecurity protocols. Apart from the added expense involved, inspection and laboratory testing can significantly delay the release of seed shipments even if it is found to be free of viroids. Seed shortages of certain cultivars have influenced the balance of crop area grown by variety and this is reflected in the table above.

3 The Season



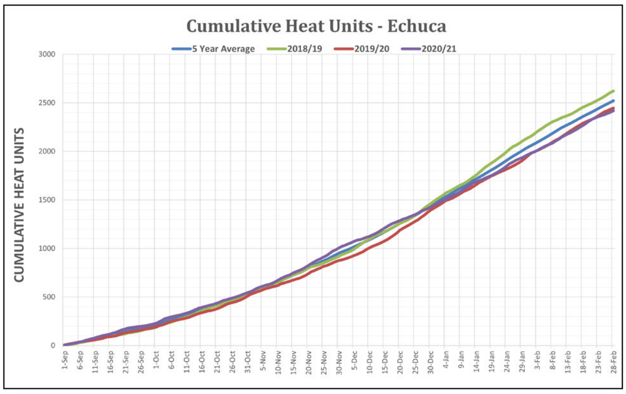
Graph 3-1: Rainfall at Echuca (mm)[4]

The relatively dry winter and planting period in 2020 meant there was little delay in planting schedules. Some high wind events in November caused damage on a few properties, however the impacts were not widely felt. As seen in 'Graph 3-1', there was almost no rainfall in April, which helped growers and processors to finish up without any losses of area or major delays in harvesting.



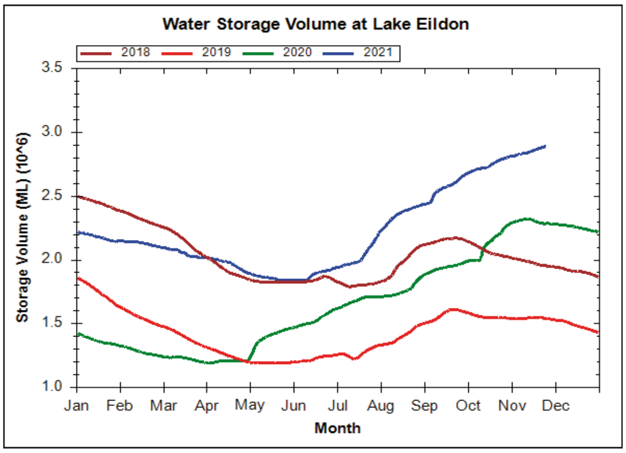
Graph 3-2 Evapotranspiration (ETo), Swan Hill (mm)[4]

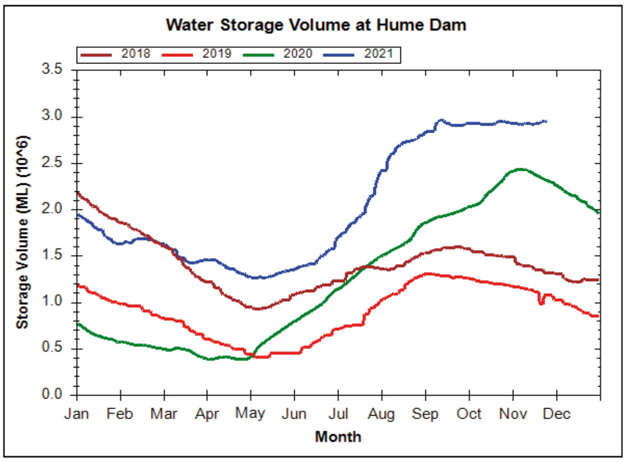
The evapotranspiration levels were lower in every month of the 2020/21 growing season versus the 5-year average, except for November, where a few spikes in temperature contributed to a higher ETo.



Graph 3-3: Heat units – Echuca[5]

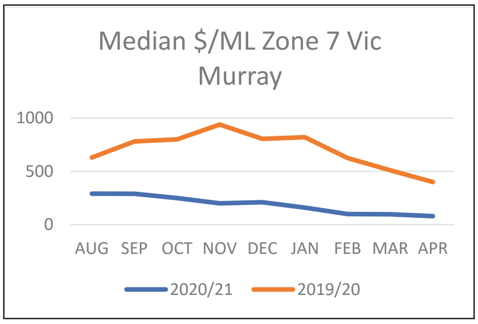
The heat units recorded during the major crop growth period demonstrate that the season was cumulatively milder than the previous 5-year average. This mild weather did cause some delays in ripening and hence minor disruptions to processor harvest schedules.

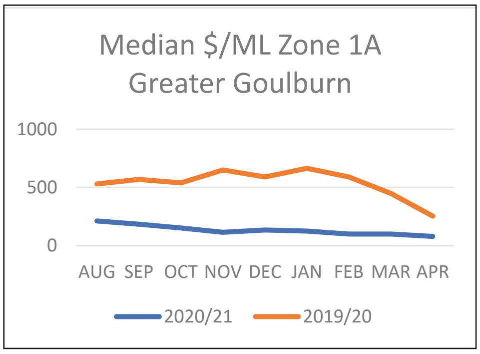




Graph 3-4: Storage Volume, Lake Eildon, and Hume Dam[6]

Water storage at both Eildon and Hume reservoirs increased in the early part of the 2020/21 season. It has continued to improve throughout the 2021 calendar year and indeed leading into the 2021/22 season.

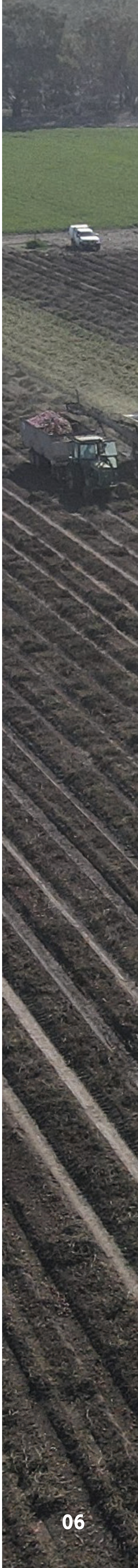


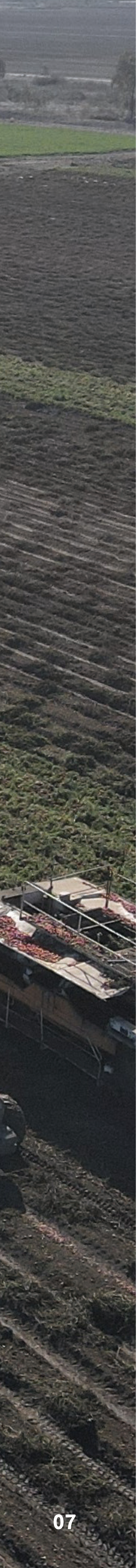


Graph 3-5: Zone 1A and Zone 7 median water price ($/ML)[7]

The price of water during 2020/21 was substantially lower than 2019/20, directly reflecting the higher inflows into major water storages for Victoria and New South Wales during this period.

The outlook for the 2021/22 season is for higher rainfall and lower temperatures, so water prices are predicted to remain suppressed for another season.





4 Trade

4.1 Imports

Product	Factor	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dried/powder	20	54,358	39,155	39,125	35,940	26,875	34,506	37,934	37,660	34,880	28,017
Whole/pcs <1.14L	1.1	50,371	49,173	48,060	42,660	45,222	40,965	43,354	42,683	41,799	51,121
Whole/pcs >1.14L	1.1	19,445	18,661	18,911	28,402	28,088	22,997	24,002	24,275	22,369	21,129
Paste/puree<1.14L	6	64,835	73,484	80,602	83,976	153,210	102,733	107,923	109,578	110,328	159,447
Paste/puree>1.14L	6	242,310	148,728	145,214	109,242	102,866	130,171	140,532	144,906	133,524	143,118
Juice	1.1	143	264	137	116	75	83	38	75	50	30
Sauce/ketchup	2	26,760	28,902	33,633	38,628	39,276	38,462	45,705	45,946	47,050	48,375
Total Tomato		**458,222**	**358,367**	**365,682**	**338,964**	**395,612**	**369,917**	**399,488**	**405,123**	**389,999**	**451,236**

Table 4-1: Imports of Tomato Products[8] (equivalent raw tonnes)

The volume of imports increased significantly during 2020, with most of the increase coming from the paste/puree categories.

The largest supplying countries, sorted by category, were as follows; (Note - where the major supplier provides less than 90% of the total import, the next most significant supplier is also listed).

- **Dried/powder** – Turkey 47%, New Zealand 17%
- **Whole/pcs <1.14L** – Italy 97%
- **Whole/pcs >1.14L** – Italy 97%
- **Paste/puree<1.14L** – Italy 80%, China 17%
- **Paste/puree>1.14L** – USA 45%, China 20%, Italy 19%
- **Juice** – USA 60%, Germany 19%
- **Sauce/ketchup** – Italy 40%, New Zealand 18%

At 70% of total volume (last year 71%), Italy remains the dominant source of imported processed tomato products into Australia. The next largest suppliers were China and the USA, who made up approximately 10% each of total product into Australia.

Product	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Dried/powder	3.86	5.11	5.37	5.75	6.36	5.61	5.79	5.84	5.67	6.22
Whole/pcs <1.14L	1.11	1.07	1.11	1.25	1.24	1.28	1.13	1.18	1.26	1.39
Whole/pcs >1.14L	0.83	0.82	0.93	1.07	1.05	0.97	0.91	0.98	1.00	1.00
Paste/puree<1.14L	1.25	1.20	1.25	1.46	1.45	1.41	1.31	1.28	1.40	1.56
Paste/puree>1.14L	0.97	0.96	0.96	1.13	1.35	1.20	1.12	1.16	1.23	1.31
Juice [1]	1.59	1.13	1.01	1.32	1.63	0.93	2.45	1.82	1.86	3.09
Sauce/ketchup	1.27	0.56	1.60	1.75	1.82	1.82	1.80	1.81	1.90	2.19
Total Tomato	**1.11**	**1.03**	**1.21**	**1.37**	**1.40**	**1.38**	**1.31**	**1.34**	**1.41**	**1.54**

Table 4-2: Average import prices ($/kg), in 2020 monetary values[8]

Correlation of Imports and Price

- The Australian data indicates that there is a strong negative correlation between imported dried/powdered products and price. Unsurprisingly, this means that as import prices drop, volumes increase (and vice versa).
- The other correlations for imported product are quite varied and swing from moderately positive to moderately negative. They also deviate within different package sizes and category groups. This suggests that overall, the variability in imported volumes does not appear to be strongly price driven for most categories.

4.2 Exports

Product	Factor	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Whole/pieces	1.1	1035	1581	1075	2552	746	461	133	62	139	623
Paste/puree	6	3248	11492	14987	33800	43747	104518	21852	16402	11695	32766
Sauce/ketchup	2	9334	4134	3218	3524	8196	4039	8799	11636	13227	14788
Juice	1.1	201	237	224	195	131	57	50	80	106	52
Total Tomato		**13818**	**17444**	**19504**	**40070**	**52819**	**109075**	**30834**	**28180**	**25167**	**48228**

Table 4-3: Exports of tomato products[8] (equivalent raw tonnes)

The volume of exports almost doubled in 2020, which may reflect the global consumer trend to consume more processed tomato products across the board.

The largest export markets, sorted by category and then by country were:

- **Whole/pieces** – Thailand 79%, New Zealand 7%
- **Paste/puree** – Japan 47%, Vietnam 23%
- **Sauce/ketchup** – New Zealand 45%, China 25%
- **Juice** – New Zealand 52%, Singapore 13%, USA 12%

At 32% of all products, New Zealand is the largest export destination for Australian processed tomato product, with Japan close behind at 28% and China at 14% of total exports.

Product	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Whole/pieces	3.16	2.97	3.33	1.31	4.10	5.10	6.64	4.72	2.59	1.67
Paste/puree	2.16	1.41	1.41	1.40	1.28	0.99	1.18	1.40	1.78	2.23
Sauce/ketchup	2.53	2.89	2.76	2.62	2.58	2.72	1.94	1.97	2.01	2.31
Juice [1]	1.20	1.46	1.22	1.23	1.28	1.60	1.13	1.72	1.04	1.06
Total Tomato	**2.55**	**2.35**	**2.17**	**1.59**	**1.87**	**1.25**	**1.66**	**1.81**	**1.96**	**2.25**

Table 4-4: Average export prices ($/kg), in 2020 monetary values[8]

The real price of 2020 exports increased for the fourth year running – a welcome trend for the industry.

The data suggests a moderate to weak negative correlation between average export price and volume variability, meaning that as price goes up, volume goes down. This applies to all product categories, except for Juice, which appears to have no correlation whatsoever to export price.

It's worth noting that there is a moderate, but not a strong, negative correlation between export volumes and the USD exchange rates across the last 10 years, meaning that as exchange rates decrease, exports increase and vice versa. The fact that it is only a moderate correlation may suggest that exports from Australia aren't heavily dictated by exchange rates and that other market forces are having more influence on annual export opportunities.

4.3 Market Demand

Calendar Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	5 Yr	7 yr
Imports	458,223	358,367	365,682	338,964	395,613	368,918	399,488	405,123	389,999	451,236	**391,828**	**380,541**
Net Australian	71,465	179,090	171,491	181,561	234,007	165,773	153,848	199,456	185,310	184,334	**187,679**	**184,492**
Dom Demand	529,688	537,457	537,173	520,525	629,620	534,691	553,336	604,579	575,309	635,570	**579,507**	**565,033**
Imported %	87%	67%	68%	65%	63%	69%	72%	67%	68%	71%	**68%**	**67%**
Local %	13%	33%	32%	35%	37%	31%	28%	33%	32%	29%	**32%**	**33%**
Per capita (kgs)	24	24	23	22	26	22	22	24	22	25	**23**	**24**

Table 4-3: Apparent domestic market demand[2] (equivalent raw tonnes)

Table 4-3 shows apparent Australian market demand for processed tomato products and how it is being met (I.e., through local or overseas suppliers).

For individual years, combining data can produce non-matched results; ABS data is based on a calendar year, rather than a seasonal year, and this survey is unable to account for year-end stocks. However, these factors should tend to be mitigated when viewed over time, such as through the 5-year or 7-year averages.

Considering this data, the following observations can be made:

- **Imports:** Imports increased significantly in the 2020 calendar year.
- **Net Australian production:** Net Australian production equates to tomatoes processed less exports. The net Australian figure was almost identical to the previous calendar year; this suggests that almost all the additional demand for processing tomato products in Australia has been met by imported produce (and that the increase in domestic production from the previous year was balanced by an increase in exports).
- **Domestic Demand:** The sharp increase in domestic demand of processing tomato products in the 2020 calendar year is a direct result of the pandemic on consumer trends. Many studies globally have reviewed this effect and in broad terms, the rise in consumption of these products has been driven by demand for processed tomatoes for use in home cooking.
- **Imported %:** The imported percentage of processed tomato products slightly increased in 2020. Since a very wet season caused a major loss in production capability for the Australian industry in the 2011 season, the local demand for processed tomato products has stabilised at around 30% of total consumption.

There is no clear indication that this trend is changing – if anything the last calendar year may suggest that when demand rises for processed tomato products, retailers look to increase imports before sourcing local product.

- **Local %:** Although the percentage of local product demand decreased in 2020, the total equivalent raw tonnes of Australian local product was about the same as for 2019.
- **Per Capita kgs:** The Australian 7-year average per capita annual consumption rate has remained stable, at about 24 kilograms of equivalent raw tomatoes. Although the spike in consumption in the last calendar year was significant (25 kg/person in 2020 Vs 22 kg/person in 2019), the interesting question will be whether this trend continues.

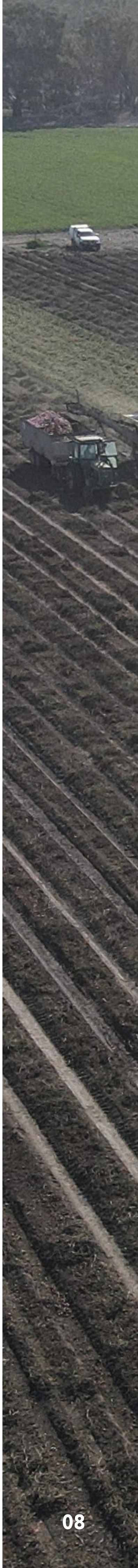
By comparison, in 2019/20 US consumption per capita was about 24 kilograms and Western EU consumption was about 18 kilograms[10].

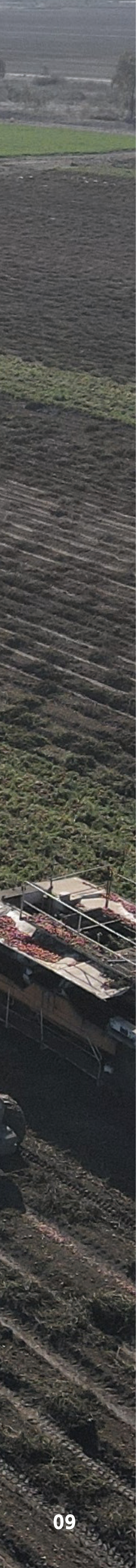
For a detailed report on global consumption and stocks – please follow the link below.
https://www.tomatonews.com/en/2020-tomato-news-online-conference-francois-xavier-branthome_2_1227.html

5 Global Production and Outlook

5.1 Production

- In 2020, recorded global production totalled 38.402 million tonnes, an increase of 3.2% compared to 2019. It is anticipated that production will only increase in 2021 by 0.8%.
- Australia is anticipating a reasonable rise in 2021-22 production: with the most recent estimate of 267,974 tonnes produced from 2488 ha planted, which includes 3000 tonnes of organic and 280 tonnes of cherry tomatoes. This represents an estimated increase of approximately 15% on the 2019/20 production level.
- In 2021, Australia contributed 0.55% of global production and increased its ranking from 20th to 18th in terms of industry volume.





Country	Season	2019	2020	*2021E*	% Change 2020-21	Ranking 2020	% Total 2020
USA	Jul-Dec	10,514	10,721	10,112	-6%	1	27.9%
China	Jul-Dec	4,600	5,800	4,800	-17%	2	15.1%
Italy	Jul-Dec	4,801	5,166	6,050	17%	3	13.5%
Spain	Jul-Dec	3,200	2,650	3,185	20%	4	6.90%
Turkey	Jul-Dec	2,200	2,500	2,200	-12%	5	6.51%
Brazil	Jul-Dec	1,200	1,421	1,350	-5%	6	3.70%
Iran	Jul-Dec	1,650	1,300	1,300	0%	7	3.39%
Portugal	Jul-Dec	1,410	1,262	1,596	26%	8	3.29%
Tunisia	Jul-Dec	815	961	938	-2%	9	2.50%
Chile	Jan-Jun	1,100	907	1,174	29%	10	2.36%
Algeria	Jul-Dec	800	800	820	3%	11	2.08%
Ukraine	Jul-Dec	720	800	800	0%	12	2.08%
Russia	Jul-Dec	552	515	523	2%	13	1.34%
Argentina	Jan-Jun	395	454	595	31%	14	1.18%
Canada	July-Dec	434	438	433	-1%	15	1.14%
Egypt	Jul-Dec	400	420	440	5%	16	1.09%
Greece	Jul-Dec	400	420	420	0%	17	1.09%
Australia	**Jan-Jun**	**212**	**210**	**233**	**11%**	**18**	**0.55%**
Israel	Jul-Dec	200	200	200	0%	19	0.52%
Dominican Republic	Jul-Dec	258	181	227	25%	20	0.47%
Poland	Jul-Dec	175	175	175	0%	21	0.46%
India	Jan-Jun	154	152	155	2%	22	0.40%
South Africa	Jan-Jun	140	150	125	-17%	23	0.39%
France	Jul-Dec	154	136	164	21%	24	0.35%
Morocco	Jul-Dec	130	100	100	0%	25	0.26%
Peru	Jan-Jun	100	100	120	20%	26	0.26%
Hungary	Jul-Dec	100	82	90	10%	27	0.21%
Senegal	Jan-Jun	77	73	73	0%	28	0.19%
New Zealand	Jan-Jun	50	50	50	0%	29	0.13%
Syria	Jul-Dec	42	42	40	-5%	30	0.11%
Thailand	Jan-Jun	43	40	40	0%	31	0.10%
Mexico	Jan-Jun	40	40	40	0%	32	0.10%
Bulgaria	Jul-Dec	40	40	40	0%	33	0.10%
Czech Republic	Jul-Dec	25	25	25	0%	34	0.07%
Japan	Jul-Dec	27	23	30	30%	35	0.06%
Venezuela	Jan-Jun	20	20	20	0%	36	0.05%
Slovakia	Jul-Dec	20	20	20	0%	37	0.05%
Malta	Jul-Dec	8	8	8	0%	38	0.0%
Total		**37,206**	**38,402**	**38,711 E**	**1%**	**38**	**100.0%**

Table 4-1a: World Production by Country ('000 tonnes)[3]

6 References and Sources

1. Previous survey data, B Horn and L Mann
2. Previous survey data, APTRC
3. World Processing Tomato Council
4. Bureau of Meteorology
5. Bureau of Meteorology, and previous survey data, APTRC
6. Goulburn-Murray Water
7. Victorian Water Registry
8. Australian Bureau of Statistics, and previous survey data, APTRC
9. Australian Bureau of Statistics
10. 2020 Tomato News Online Conference: François-Xavier Branthôme - Tomato News

TM17000: Processing Tomato Industry Capacity Building

Matthew Stewart, Industry Development Manager

Introduction – Industry Strategic Plan

TM17000 concluded its final year of activity in the 2019/20 season. It continued a long-line of capacity-building projects that have brought immense benefit to the industry. Acknowledged in a number of strategic plans, these projects provide a key platform for producers to consider and implement tested technologies, products and practices, the combination of which has maintained the Australian processing tomato industry's competitive position.

The 2018-2023 Strategic Plan identified three key actions for the processing tomato industry. These were to:

- Build skills, capacity and knowledge in the industry so that the capability exists to implement Research, Development and Extension (RD&E) and marketing outcomes and deliver the supply and quality improvements needed by the industry.
- Provide support for new or enhanced market opportunities, both domestically and increasingly for export, to increase demand and support processing tomato prices; and
- Undertake RD&E to improve product quality (including new varieties) and increase productivity/reduce yield variability in order to support the industry's future viability and sustainability.

Commencing during the 2018/19 season, TM17000 was jointly funded by levy funds from the APTRC and Commonwealth funds through Hort Innovation. It was the key industry strategy to deliver most of the outcomes described above. Specifically, its objectives were to:

- Co-ordinate information delivery to the industry to support innovation, enhance the skills of existing participants and encourage new entrants;
- Undertake R&D and increase industry understanding of the latest relevant R&D outcomes and encourage the adoption of R&D by processing tomato businesses;
- Increase the reach of the industry R&D program by engaging stakeholders in the R&D process, including on-farm trials;
- Collect industry benchmark data and statistics to help identify gaps and direct industry development efforts;
- Provide an accurate representation of the industry with stakeholder groups, such as Plant Health Australia; and
- Identify and secure other funding sources to support RD&E aimed at industry development.

The processing tomato industry, like most, has been challenged by global pandemic influences, including labour shortages, changes in consumer buying trends and a need for increased production. The capacity building project and the R&D and extension it offers can assist industry to meet these challenges and promote rapid practice change through demonstrated agronomic improvements and forward momentum in Knowledge, Awareness, Skills & Attitudes (KASA).

TM17000 activities and outcomes

Capacity Building

The project reach for agronomic trials and farm-based extension activities, including field days, was primarily focused on the processing tomato growers, processors, and technical advisors within industry, with the aim of encouraging practice change. As appropriate, industry researchers, product manufacturers or university representatives were proactively invited to participate in field-based extension, where it was considered advantageous to the topics being discussed or demonstrated.

Matt at Kagome Site

To help develop the capacity of industry, the methodology employed was focused on activities that bring growers together as this has been a very successful approach in previous capacity building projects.

The publication materials, including the quarterly Tomato Topics newsletter and the annual Processing Tomato Grower magazine, invited a broader, national audience to industry activities.

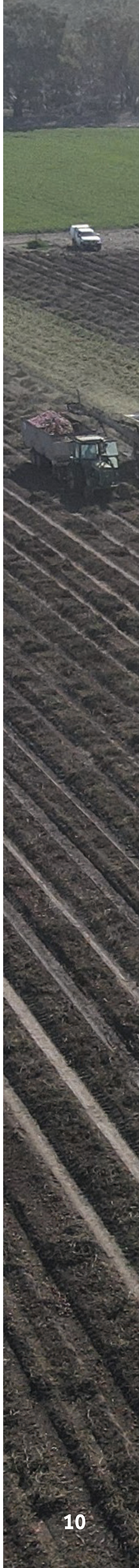
The TM17000 project delivered capacity building outcomes to industry as well as scientifically based trial programs and therefore employed several different methodologies, tailored to the delivery of these components and with the aim of achieving the best outcome as outlined below:

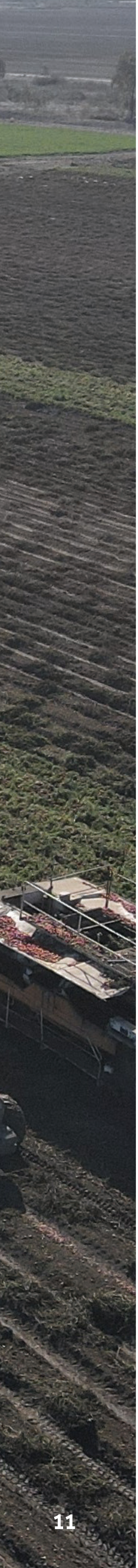
Processing Tomato Cultivar Evaluation

With the risk of seed viroid detection in shipments from international seed suppliers, the industry has been looking at cultivar evaluation criteria more closely than ever. If one of the mainstay varieties comes under supply pressure, the processors and growers need confidence in selecting alternative varieties from a range of different suppliers that have been proven to perform in Australia's challenging climate and soils.

Cultivar selection criteria are developed in consultation with the Australian processing tomato industry, taking into consideration the preferred attributes for both the paste and peeling sectors as well as grower requirements.

New cultivars to Australia are first included in small plot screening trials in several locations across northern Victoria and southern NSW. These are assessed on a range of vine and fruit characteristics at the end of the season, with input from seed providers, the local growers, and processors. The most promising selections then advance to larger scale, replicated trials which are machine harvested to provide comparative yield and fruit quality information.





Results for each trial are presented in table form to growers, processors, and seed suppliers as soon as practicable. For example, several promising new 'mid-season' varieties are identified from the most recent trials reported herein.

Industry Publications

The industry newsletter "Tomato Topics" has been a long-standing feature of capacity building projects delivered by the APTRC and issues are available via the APTRC website; aptrc.asn.au. Also available online are the past "Processing Tomato Grower" Magazine editions, which provide a detailed account of APTRC work during each season.

The online R&D database, established and maintained by Ann Morrison; continues to provide a searchable platform where industry researchers, growers and service providers can review past findings and help streamline investigations into previous R&D.

Field Days

During the 2020/21 season, both scheduled field days were successfully held and on December 17th at Boort, 45 participants took part in crop inspections, whilst 22 participants continued on for dinner at Boort Tennis Club. On January 15th at Rochester, there were 60 participants and afterwards, 63 members (including kids) attended an Industry Dinner at Moama Bowling Club 'Greens'.

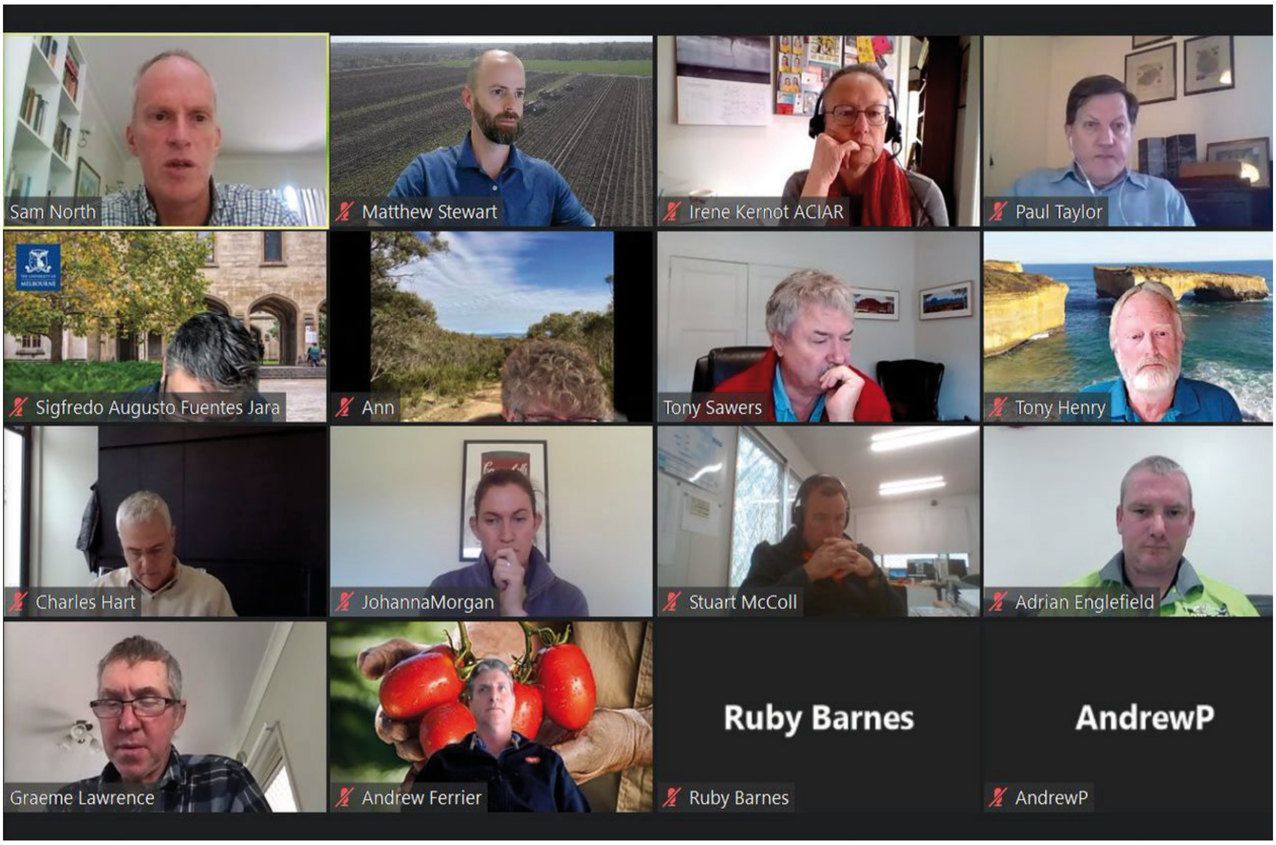
Annual Processing Tomato Forum

The forum was scheduled and cancelled 3 times for 2021, due to state government Covid-based restrictions. Not to be deterred however, the APTRC utilised modern video conferencing capabilities, via the Zoom platform, to hold several 'virtual' conference sessions. Although they can't compare to the 'real' experience of meeting face-to-face, they allowed some time sensitive presentations to reach their audiences and continued forward momentum on strategic planning as well as collection of feedback from industry members.

IPM training day

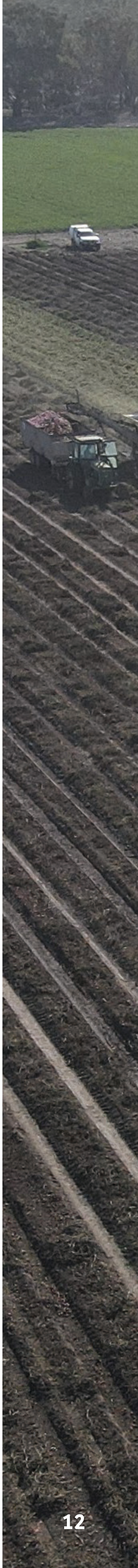
On December 10th, 9 crop advisors took part in an Integrated Pest Management (IPM) workshop with Australia's leading IPM experts, Jessica Page and Paul Horne from 'IPM Technologies'. The day was fully funded by FMC and hosted by their Area Business Manager, Greg Bennett. The APTRC facilitated the running of the event.

Jessica Page IPM Workshop 2021



Zoom Conference

IPM Training Day



Bacterial Speck online Training Session "Control of Bacterial Diseases with Copper Fungicides" – GroChem

Ben Coombe from GroChem recorded an online training session on best management use of copper to control bacterial diseases, which was distributed to growers, advisors, and farm managers. The session was recorded live and had 12 key industry participants. Given predictions of a wet season ahead, this will hopefully assist growers in managing these potentially damaging diseases and help improve resilience in a high disease pressure season.

Annual Industry Statistics

The data that is generated for the annual report serves as an industry survey for monitoring and evaluation purposes and for project planning based on local and world trends.

This is published as a stand-alone document, loaded onto the website, and included in the annual Processing Tomato Grower magazine (see further article).

Evaluate New Crop Threats and Inform Industry

Arguably the biggest biosecurity issue for the processing tomato industry at present is that related to seed importation. The delays in importation due to testing requirements and the risk of not obtaining desirable varieties due to viroid detection is very real. As well as liaising with regulatory authorities, the APTRC committee are working together with processors, growers and Hort Innovation to help find a way to manage these risks and improve our national seed security.

The industry continues to monitor the emerging threats of Fall Army Worm and the Serpentine Leaf Miner as well as the recent detections of Silverleaf White Fly and Tomato Yellow Leaf Curl Virus in Victoria. At the time of writing, none of these new threats have been identified in the processing tomato industry.

Pest & Disease Updates

During 2020 the APTRC developed a Pest & Disease update system, via the 'Workplace' app. Using information provided by a network of crop scouts and agronomists, this service delivers regular updates for growers and advisors throughout the season on regional crops and pest/disease observations, thereby assisting with on-farm pest management as well as local and national biosecurity programs.

The app is subscription based and has a closed group of 30 members, including growers, farm managers, their advisors, and some key industry personnel. The posts are seen by an average of 20 people per weekly post.

Raising Awareness of the Australian Processing Tomato Industry locally and internationally

The IDM role acts as a central contact point for the processing tomato industry, consolidating relevant information, coordinating industry activities, and facilitating innovation.

Locally, this meant being involved in relevant industry networks, such as the Horticultural Industry Network (HIN), APEN (Austral-Asia Pacific Extension Network) and Plant Health Australia (PHA). APTRC staff also actively engaged with researchers from several Australian universities, including The University of Melbourne, Swinburne University, Deakin University, Australian National University (ANU) and Latrobe University. The APTRC maintains strong linkages with departmental institutions, including state Departments of Primary Industries (DPIs) and Biosecurity Australia.

Projects extended during TM17000 but funded by the APTRC

Although much of the RD&E conducted in the processing tomato industry was directly through APTRC committee-funded projects, the extension of information from them was vital to industry development and formed a major part of the TM17000 activity. These important projects would not have been possible without the Hort Innovation TM17000 capacity building project.

Extension activities covered results from the following projects:

University of Melbourne – 2019 Honours – "Efficacy of a plant bio stimulant to control soil borne pathogens causing root decline in processing tomato plants"

University of Melbourne – 2019 Honours – "The effects of soil pH on infection of tomato by *Fusarium oxysporum* (crown and root rot) and *Pythium spp*".

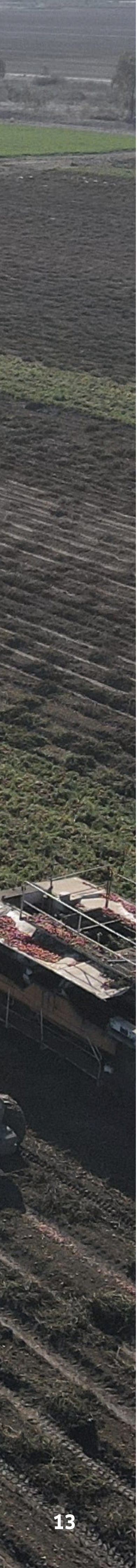
NSW DPI – 2020 – "Improving yields and yield stability in the Australian processing tomato industry"

University of Melbourne – 2020 PhD – "Root and collar rot pathogens associated with yield decline of processing tomatoes in Victoria, Australia".

NSW DPI – 2021 – "Strategic RD&E Planning Workshop"

NSW DPI – 2021 – "Moisture characteristics of two soils"

Deakin – 2021 – "Modelling Sub-Surface Drip (SSD) irrigation in two soil types"



University of Melbourne – 2021 (ongoing) – "Integrated disease management of poor root growth in processing tomato plants"

University of Melbourne – 2021 Honours – "Interactions between waterlogging and a novel *Fusarium oxysporum* disease in Australian processing tomato plants"

Strategic Planning

On the 5th of May, the APTRC in conjunction with Sam North from NSW DPI conducted a 'group workshop', focusing on growers, key advisors and processor representatives and industry stakeholders. The entire industry was represented on the day, except for 1 processor and 2 growers.

The growers were verbally consulted to confirm whether they still agreed with the mission statement from the 2018-2023 draft strategic investment plan, which was:

"To efficiently deliver innovative and effective research, development and capacity building solutions to support a sustainable and profitable processing tomato industry from producer to processor."

Participants at the Echuca meeting felt there was no reason to change this. Growers also indicated that the best part of the workshop was working in a collective, group environment.

Monitoring and Evaluation - Overall Project Performance

During the term of this project, various forms of monitoring and evaluation have been engaged to determine the effectiveness of the individual components that make up the overall project. The required key evaluation components, as outlined in the initial 'M&E Plan' were evaluated as follows.

Annual Activities – Trials, Field Days, Forums

The trials (see related articles herein) were all conducted to a high standard and published for industry. The field days had strong attendance (as seen in outputs) and peer-to-peer reviews suggest these remain an effective method for sharing information knowledge and maintaining aspirations of growers.

In 2019 the annual APTRC R&D forum format was modified after direct industry feedback requests to include more 'broad' categories of presenters and topics, including re-sellers and a keynote address. Verbal feedback from stakeholders was very positive about the new format, and attendees were keen to see it continue in the future.

Unfortunately, the 2020 and 2021 Forums could not proceed due to state government lockdowns. The APTRC used their initiative and capability to take the presentations virtual where possible.

Outputs – Topics Newsletter, APTG Magazine, Annual Survey

At the start of the 2019 season, peer-to-peer reviews confirmed that all publications were of importance to growers, and they found them to be a valuable information transfer tool. It was noted that more photographs and simpler/less scientific language, where possible would help to make the publications more widely readable and assist the knowledge transfer process. All publications were completed to a high standard (as specified under the project requirements).

Changes in KASA as a result of project – Questionnaires, Observation, Interviews, Annual Survey

Tomato industry participants are relatively small in number and as such questionnaires are typically taken verbally and often one-on-one. The main thrust of questionnaires in the tomato industry and TM17000 was around keeping growers current with appropriate outputs and activities, but also the cultivar trial program and annual industry survey. The trial program continues to be of high interest to growers and processors, as demonstrated by the fact that most growers take part each season with trials on their properties.

The Annual Survey was initiated after a benchmarking study of the industry in 1996 and is still conducted today under the capacity building project. The survey was modified in 2019 to include several additional categories, including weather and water trends and insight into consumption and import/export statistics. This continued to build on a strong history of evaluation and the co-operation of processors and growers in supplying their information is still considered a major strength for industry evaluation and monitoring today.

End of Program Outcomes

Average industry yield is perhaps the most astute figure for tracking agronomic progress, and Australian growers achieved the highest tonnage on record (106.13 t/ha) for the 2020/21 season, during the TM17000 project period.

Additionally, the unanimous support of growers and processors for the APTRC as their RD&E provider for the next 5-year project (TM20000) gives the council confidence that its projects are still delivering relevant and useful outcomes.

The end of TM17000 and beginning of TM20000

During 2020/21 the development of the Processing Tomato Strategic Investment Plan (SIP) 2022-2026 was undertaken by Hort Innovation, the APTRC committee and industry at large. The SIP recommended that the next project phase for industry follow a very similar format to the previous capacity building projects conducted by APTRC in conjunction with Hort Innovation's support. This was endorsed by growers and processors, suggesting that the current model is achieving a satisfactory level of success and therefore should be supported.

The 2022-2026 SIP identified the following key outcomes:

Outcome 1: Extension and capability

Achieving this outcome will involve:

- Increased KASA and practice change to support grower/industry profitability and sustainability through the adoption of best practice and innovation.
- Growers, value chain, media and governments being well informed of industry initiatives and achievements as a vital part of regional communities and networks.
- Improved networks and cross-industry collaboration to increase on-farm use of R&D outputs and to build a stronger, more resilient industry
- Proactive strategic and evidence-based decision-making in businesses and for industry on investment, priorities, and risk management.

Outcome 2: Industry supply, productivity, and sustainability.

Achieving this outcome will involve:

- Supporting activities to maintain or increase quality and reliability of processing tomato seed genetics and ensuring a sustainable seed supply chain underpinned by trials to identify improved varieties, and to refine production best practice growing methods.
- Striving to further identify and adopt environmentally sustainable practices.

Acknowledgements

The APTRC would like to thank the processing tomato growers and the processors for the support they give freely and unreservedly to the APTRC, its employees, and its volunteer committee members. The APTRC would also like to acknowledge Liz Mann, who commenced this project in 2018 and Peter Gray, Bill Ashcroft, and Ann Morrison, as well as the APTRC committee members who helped continue the TM17000 project during the period of transition from the previous IDM to the current appointment. Their willingness to step forward and take on the many and varied duties required by the project undoubtedly assured its success.

The author would like to acknowledge the support of Hort Innovation and in particular, the regional extension manager, Adrian Englefield. The APTRC look forward to working with Hort Innovation to deliver effective and relevant projects in the future together.

Modelling Sub-Surface Drip Irrigation to Optimise Tape Design

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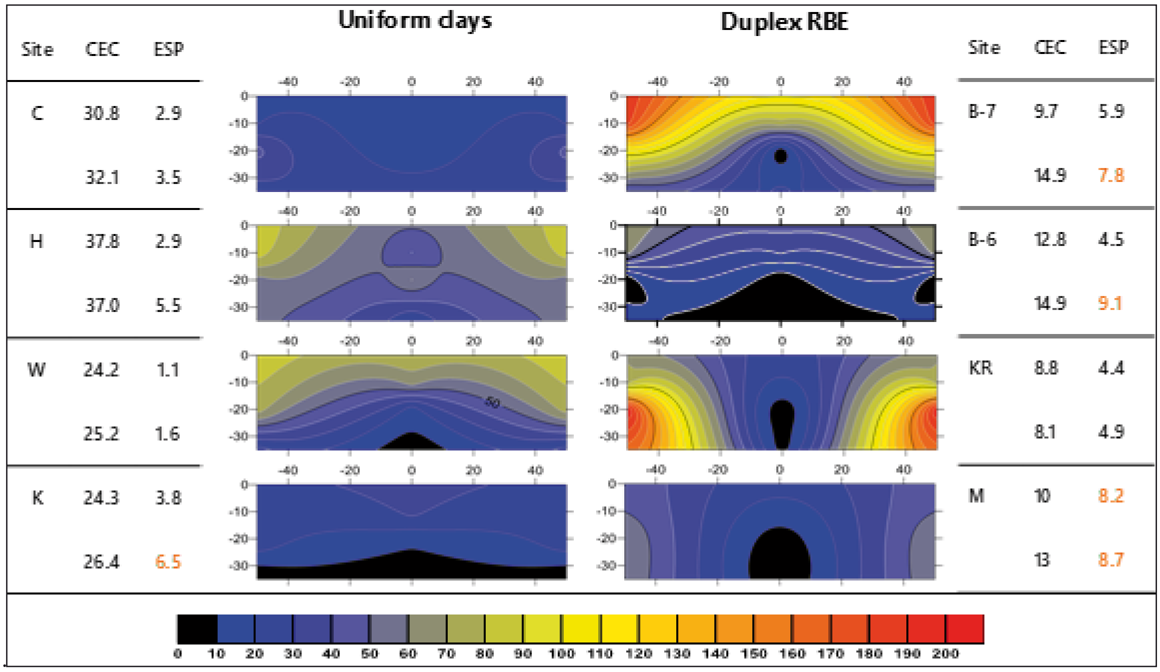
Introduction

Tomatoes for processing in Australia are grown in the irrigation areas of northern Victoria and southern NSW using sub-surface drip irrigation on three major soil types. On the Riverine plains of the Loddon, Campaspe and Murray valleys, crops are grown on uniform clays (vertosols; Isbell & NCST 2016) and duplex red brown earths (chromosols and sodosols; Isbell & NCST, 2016), while on the Colbinabbin range south-east of Rochester, crops are grown on calcarosols (Isbell & NCST 2016). Average yields are around 100 t/ha, but the industry wishes to lift production levels and there is a perception that yields from duplex RBE soils are lower than those from the uniform clays and the calcarosols.

A field study in the summer of 2019-20 (North 2020), which monitored soil water under commercial crops, found that there were consistent differences between the uniform clays and the duplex red brown earths (RBE) in the patterns of wetting around drip lines. In the four uniform clays in the study, high clay content (indicated by high cation exchange capacity) facilitates upward and lateral wetting by capillarity ("subbing"). This ensures the soil within the raised beds is relatively evenly wetted by the sub-surface drip lines (Figure 1 left). In contrast, the RBE soils have a coarser texture (lower cation exchange capacity) and do not "sub" as readily. This results in a smaller wetted zone around and below the tape; drier soil at the surface in the centre of the bed under the crop; and very dry zones on the shoulders of the beds (Figure 1 right), with variations in this pattern dependent on soil texture (cation exchange capacity) and sodicity (exchangeable sodium percent).



KEY - water (matric) potential (kPa suction)

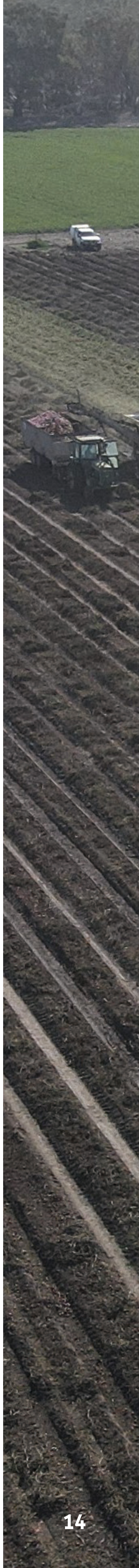
Figure 1. Average matric potential (kPa) through a cross-section of the beds at eight sites monitored in 2019-20. Zero on the X-axis of each plot indicates the bed centre and on the y-axis the soil surface, with distances measured in cm. The cation exchange capacity (CEC; cmol+/kg) and exchangeable sodium percent (ESP; %) at the surface and at 25 cm depth at each site is shown alongside the plots for each site.

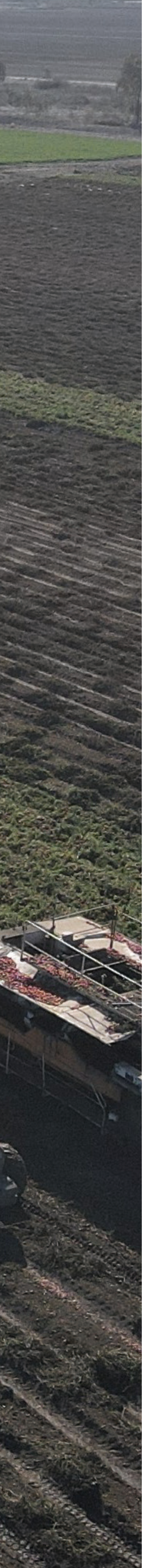
The 2019-20 study found there was a strong negative correlation (R2 = 0.81) between yield and the number of days in January and February that the soil in the centre of the bed was either too wet (waterlogged) or too dry. The strong patterns of wet and dry soil in the beds in the RBEs was a key factor in this. Given that similar amounts of water (≈8 ML/ha) and nitrogen (≈350 kg/ha N) were applied to the study crops, the lower yields in the RBE soils were attributed in-part to the loss of water and nitrogen in drainage below the root zone. As a result of these observations, it was recommended that sub-surface drip irrigation design be examined to see if there was potential to improve water and fertiliser efficiencies in the duplex RBE soils used by the processing tomato industry in northern Victoria and southern NSW.

Rather than do this using field trials, a computer modelling approach was adopted as a first step to better understanding the issue. Computer modelling offers a pragmatic approach to irrigation design as it allows repeat testing of configurations and design variables in a low-cost desktop approach. It has the advantage of being able to assess differences between multiple combinations of parameters (e.g. emitter delivery rate, spacing and depth) in a cost-effective way. "Best bet" outcomes from the simulation modelling can then be tested in later field trials in a more targeted fashion.

This work was conducted by NSW DPI and Deakin University, with NSW DPI collecting the soil data to inform the model, and Deakin University conducting the scenario modelling. This article provides a summary of these two activities and discusses the relevance of the findings to tomato growers.

Two sites were selected out of the nine previously used in the 2019-20 study: a uniform clay (site W; Figure 1) at Strathallan, Victoria; and a duplex RBE (site M; Figure 1) at Bunnaloo in NSW. The particle size distribution (i.e. texture) and dry bulk density of the surface soil (0-5 cm) and the sub-soil at the level of the drip tape (20-25 cm) had been determined in December 2019. Saturated hydraulic conductivity at the depth of the drip





tape was determined in May 2020 using constant head well permeameters (Amoozegar 1989). The water content-matric potential relationships in the wet range (0 to 180 kPa suction) for these two soils were found from paired measurements of volumetric water content and matric (water) potential at 10, 20, 30, 40 and 50 cm depths (Figure 2). Measurements of water content were made using EnviroPro® capacitance sensors (https://enviroprosoilprobes.com) calibrated for soil type. Measurements of matric potential were made using Irrometer® Watermark™ sensors (https://www.irrometer.com).

Soil data for modelling

Figure 2. Photographs showing site layout and instrumentation at the uniform clay site at Strathallan (top left) and the duplex RBE site at Bunnaloo (bottom left), and the arrangement of the sensors installed at each of the seven sample locations at each site (right).

These paired measurements were input into the computer program RETC (van Genuchten *et al.* 1998) to estimate the moisture characteristic and hydraulic conductivity functions (North 2021), from which the model parameters for each soil were obtained (Table 1).

Table 1. Soil hydraulic parameters obtained from RETC using paired water content and matric potential readings in the duplex RBE and uniform clay. Θ_s and Θ_r are saturated and residual soil water contents respectively; α and n are curve shape fitting parameters; and Ksat is saturated hydraulic conductivity.

Parameter	Units	Duplex RBE		Uniform clay
		0 – 15 cm	15-50 cm	0-50 cm
θ_s	*(m/m)*	0.38	0.35	0.38
θ_r	*(m/m)*	0	0	0.09
α	(cm^{-1})	0.011	0.006	0.009
n		2.4	2.2	1.1
K_{sat}	*(cm/day)*	12*	12	46
R^2		0.86	0.93	0.56

* this Ksat value is assumed the same as that measured for the sub-soil

The model

HYDRUS (https://www.pc-progress.com/en/Default.aspx?support-hydrus) is a Microsoft Windows based modelling environment for the analysis of water flow and solute transport in soil. HYDRUS has been used to evaluate sub-surface drip irrigation systems internationally (e.g. Simunek *et al.* 2012) and nationally (e.g. Cote *et al.* 2003). For the duplex RBE, two layers were modelled: an A horizon in the top 15 cm (silty loam) and a B horizon at depths greater than 15 cm (clay loam). For the uniform clay, one homogeneous layer (medium clay) was assumed from the surface to 50 cm depth.

The HYDRUS model was run in two dimensions (2-D). This assumes the emitter is discharging uniformly along the drip tape as a line source, rather than as a point source. Soil wetting is thus modelled in a vertical plane perpendicular to the drip line. The assumption of 2-D flow has been validated in field studies (Skaggs *et al.* 2004), and modelling in 2-D is widely reported (Provenzano 2007; Kandelous *et al.* 2012). The model soil domain was a vertical (x-z) plane measuring 75 cm wide (i.e. half a 1.5 m bed width) by 80 cm deep. The boundary conditions of this domain were free drainage for the bottom boundary (i.e. 80 cm depth), variable flux for the emitter, and zero water flows across the left- and right-hand boundaries (assuming symmetry and adjacent drip lines also operating) and across the soil surface (i.e. no plant water use).

Model validation

Validation is needed to develop confidence in the model and ensure that the model is reasonably capturing the flow within the modelled soil domain. To validate the model, emitters with radius of 1 cm, spaced 50 cm apart and discharging at 1.05 L/hr for 4 hours, once per day, were input to simulate the wetting patterns observed in 2019-20 at the two sites. The model was run with the emitter at a depth of 20 cm to approximate actual depths at the 2019-20 sites. The initial matric potential was estimated by trial. The HYDRUS model results were compared with the average January matric potential data from under the beds at the two sites (Figure 3; *NOTE – the colour scale was changed from Figure 1 to match the HYDRUS model output).*

For the uniform clay, the model showed a similar pattern of wetting within the beds once they had been wet up as was measured in 2019-20, with contour lines approaching horizontal and matric potentials close to field measured values and relatively uniform (Figure 3a). The almost homogeneous wetting pattern observed in the field data (Figure 3c) was thus well depicted by the model.

For the duplex RBE, the wetting up period took longer (14 days compared to 7 for the uniform clay), reflecting the lower Ksat. The model showed a wetter zone close to and below the emitter, with vertical contours indicating a lesser tendency to wet sideways resulting in progressively drier soil away from the centreline (Figure 3b). This is consistent with the field observations (Figure 3d). The modelled dry zone at the bed shoulder was not observed at site M but was observed at site B-7 (see Figure 1). The other feature of note in the duplex RBE is the steepness of the gradients at the edge of the wetted zone. This was noted in these soils in 2019-20, with very wet and dry zones adjacent each other potentially creating difficult conditions for optimum crop growth.

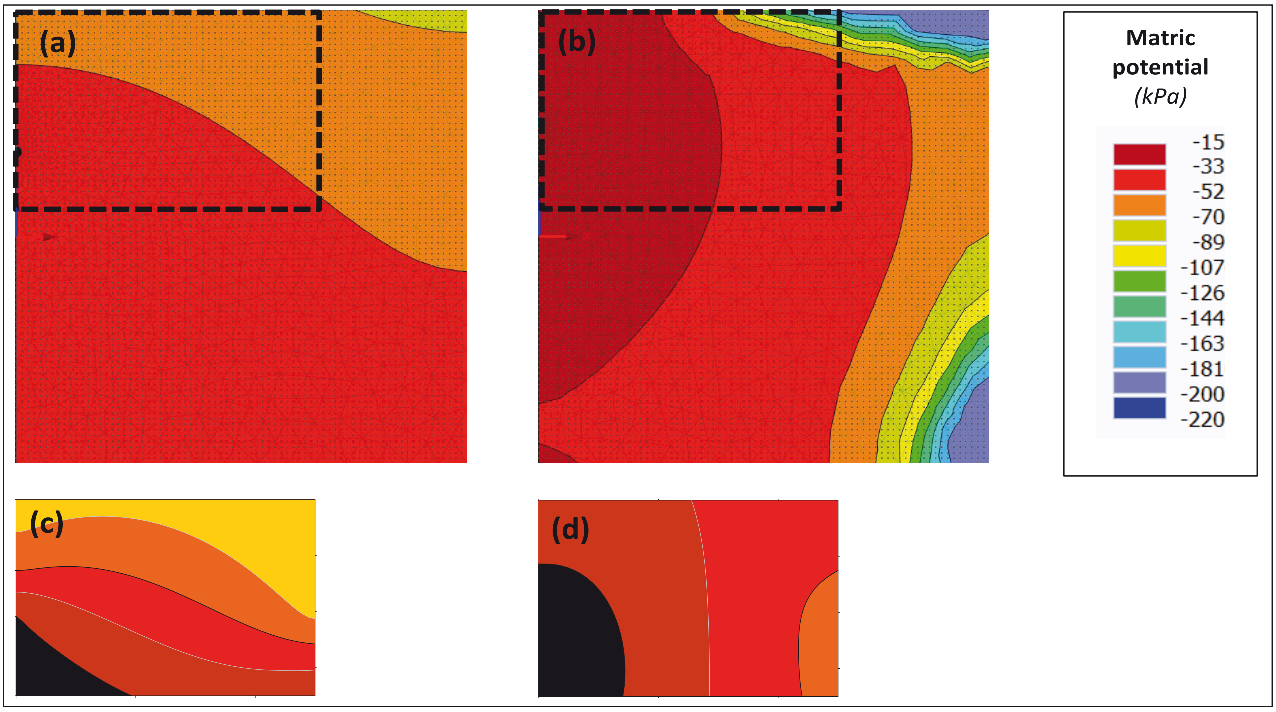


Figure 3. Matric potential contours in the model soil domain for the uniform clay (a) and the duplex RBE (b) and the corresponding measured average January 2020 matric potential contours from uniform clay site W (c) and duplex RBE site M (d). The dashed rectangle in the modelled contour plots delineates the area corresponding to the measured profiles.

Optimisation

After validating the model, a series of modelled experiments were run to investigate the effect of emitter flow rate, emitter spacing and tape placement depth on water distribution within the model domain. After consulting Netafim and growers, the following design variables were modelled in a system with drip lines spaced 1.5 m apart delivering 12 mm per day:

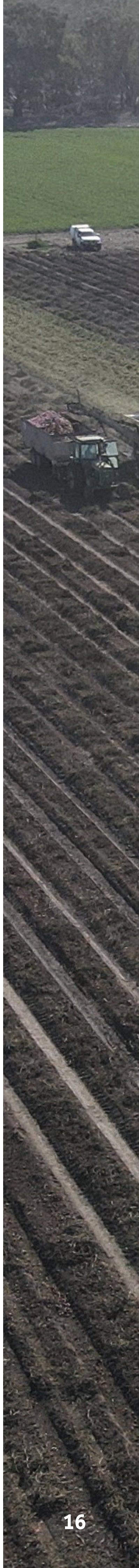
- Emitter flow rate: 0.5, 1.05 and 1.5 L/hr in both soils with extra runs at 0.75 L/hr in the RBE
- Emitter spacing: 0.3, 0.4 and 0.5 m
- Tape depth: 10 cm and 25 cm

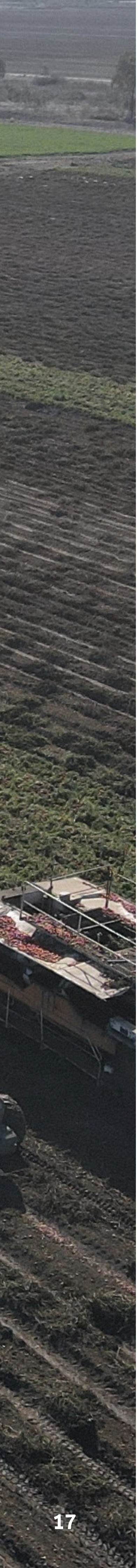
Given that the target irrigation depth was fixed (i.e. 12 mm/day), emitter flow rate and spacing dictate the daily irrigation run time (duration) through the equation:

This set of variables resulted in 18 model runs for the uniform clay and 24 model runs for the duplex RBE, with watering times ranging from 3.5 hrs to 18 hrs and effective application rates from 0.7 mm/hr to 3.3 mm/hr (Table 2). The set of runs at 0.75 L/hr in the duplex RBE were added because the trends in this soil were not as clear, most likely because of the two layered soil profile and the proximity of the emitter to the horizon boundary.

Table 2. The experimental matrix of model runs (numbers 1 to 24) to investigate the effect of tape depth, emitter flow rate and emitter spacing on modelled water distribution in a sub-surface drip irrigation system delivering 12 mm/day through lines spaced 1.5m apart.

Model Run # *10 cm depth*	**Model Run #** *25 cm depth*	**Flow rate** *(L/hr)*	**Spacing** *(cm)*	**Duration** *(hrs)*	**Irrigation** *(mm/day)*	**Delivery Rate** *(mm/hr)*
1	4	0.5	50	18	12.0	0.7
2	5		40	14	11.7	0.8
3	6		30	10.5	11.7	1.1
7	10	1.05	50	8.5	11.9	1.4
8	11		40	6.75	11.8	1.7
9	12		30	5	11.7	2.3
13	16	1.5	50	6	12.0	2.0
14	17		40	4.75	11.9	2.5
15	18		30	3.5	11.7	3.3
19	22	0.75	50	12	12.0	1.0
20	23		40	9.5	11.9	1.3
21	24		30	7	11.7	1.7





Individual configurations were compared by quantifying the daily loss of water as drainage below the bottom boundary (i.e. 80 cm depth) once the model soils had been wet up. This drainage loss was calculated as a percentage of the daily irrigation application depth ('Irrigation' in Table 2) for each model run. This was plotted against the irrigation duration, which is a function of emitter flow rate and emitter spacing. The results (Figure 4) showed the following general patterns:

1. **Soil type** – drainage loss was around 10% higher in the uniform clay than in the duplex RBE. This reflects the higher Ksat used for the uniform clay: 46 cm/day compared to 12 cm/day for the RBE.
2. **Depth of tape** – In the uniform clay, there was no difference in drainage loss between the two depths. This also is likely an effect of the higher Ksat used to model this soil. In the duplex RBE, drainage loss was around 2% higher for the deeper drip tape.
3. **Emitter flow rate and spacing** – these two variables are linked, with higher flow rates at a given spacing resulting in shorter irrigation run times and vice versa. In the uniform clay, deep drainage loss increased with emitter flow rate or with decreasing emitter spacing (i.e. as irrigation run times got shorter). Drainage loss in the uniform clay was minimised when irrigation run times were greater than 12 hours. The picture was less clear-cut in the duplex RBE, with drainage loss increasing with decreasing spacing at the two higher flow rates (1.5 and 1.05 L/hr), decreasing with spacing at 0.75 L/hr, and static at 0.5 L/hr. Additionally, reducing emitter flow rates from 1.5 to 1.05 L/hr at the same spacing (i.e. longer irrigation run times) reduced drainage loss, but reducing flow rates below 1.05 L/hr did not reduce drainage loss.

The other measure used to gauge the suitability of each tape design combination was the occurrence of saturated soil at the surface. Once an irrigation ceases, water redistributes through the profile along hydraulic gradients. The contour plots (Table 3) of the modelled soil profile matric potentials at the end of the redistribution period show there is greater surface wetting:

1. in the duplex soil;
2. with emitters placed at 10 cm; and
3. with longer irrigation times (i.e. emitters are either further apart or with a lower flow rate).

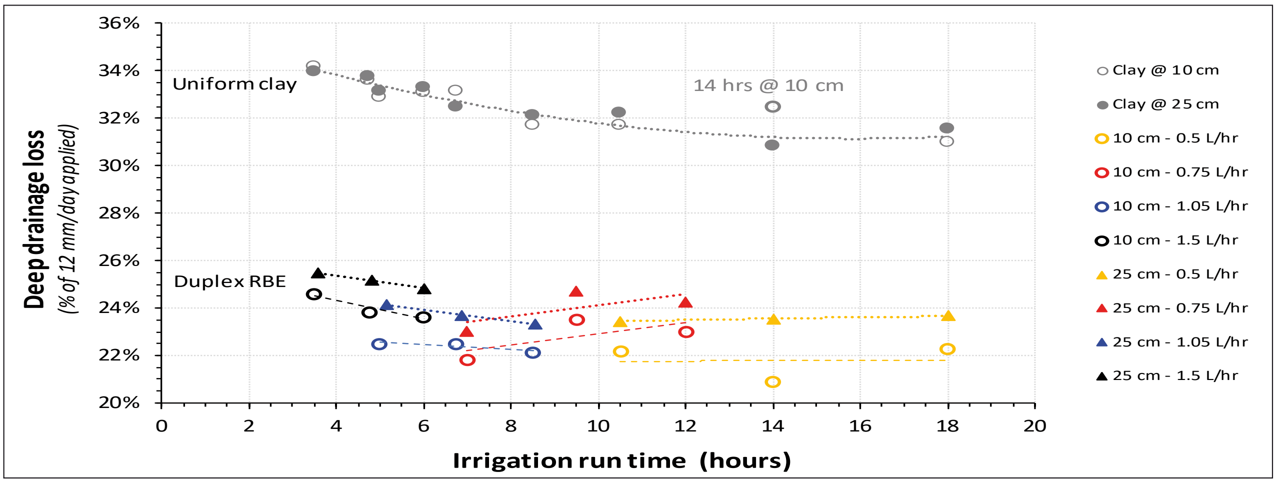
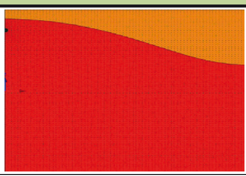
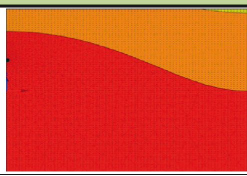
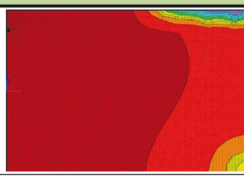
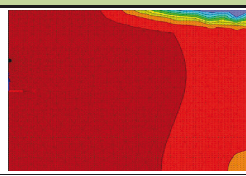
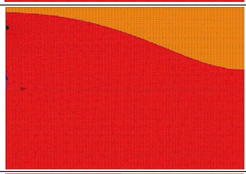
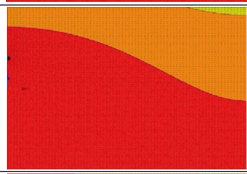
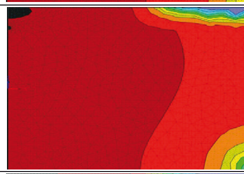
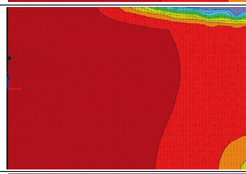
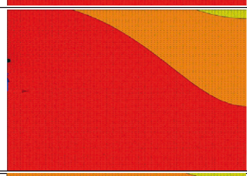
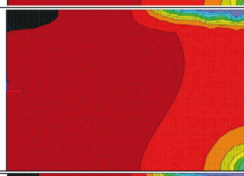
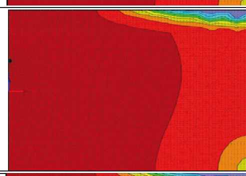
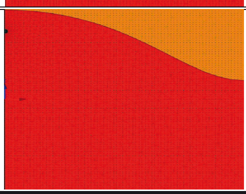
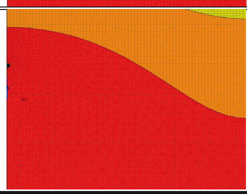
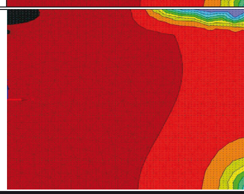
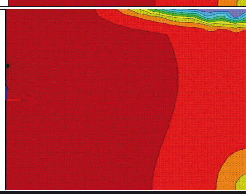


Figure 4. Modelled deep drainage loss as a percentage of the daily irrigation application depth plotted on irrigation run time, which is a function of emitter flow rate and spacing. Results are shown separated on soil type (uniform clay; duplex RBE); drip tape depth (10 cm - open symbols; 25 cm - closed symbols); and, for the duplex RBE, emitter flow rate (1.5, 1.05, 0.75 and 0.5 L/hr).

Table 3. Contours plots of matric potential (kPa) within the soil profiles of the uniform clay and duplex RBE at the end of the redistribution period for emitters at two depths (10 cm and 25 cm), flow rates of 1.5, 1.05 and 0.5 L/hr at a spacing of 50 cm and 0.5 L/hr at a spacing of 30 cm.

Spacing Rate	Uniform clay		Duplex RBE	
	10 cm	25 cm	10 cm	25 cm
50 cm 1.5 L/hr				
50 cm 1.05 L/hr				
50 cm 0.5 L/hr				
30 cm 0.5 L/hr				

Discussion

The HYDRUS model was used to evaluate the effect of emitter flow rate, emitter spacing and tape depth, yet soil type may have a far larger influence on deep drainage loss. The model estimated losses of 31% to 34% in the uniform clay and 21% to 25.5% in the duplex RBE. The range in these percentage losses within the two soil types (i.e. 3 to 4.5 %) reflects the influence of the three parameters examined using HYDRUS, with tape depth having the greatest influence. However, this influence is minor compared to the 10 % difference in drainage losses between the two soil types. This difference is considered to have been driven predominantly by Ksat, which was set to 46 cm/day in the uniform clay and 12 cm/day in the duplex RBE.

The question arises as to how realistic these estimates of deep drainage are. The on-line irrigation scheduling tool IrriSAT (https://irrisat-cloud.appspot.com/#) allows estimation of crop water use based on potential crop evapotranspiration (Allen *et al.* 1998) and crop canopy density assessed from satellite imagery. Apart from the crops at sites B-6 and B-7, where weeds affected the estimates of canopy cover, deep drainage can thus be estimated by subtracting in-crop rainfall and irrigation application depths from the IrriSAT estimation of crop water use. The results (Table 4) show that the proportionate deep drainage losses in the modelled soils are of the same order of magnitude (i.e. 20%-35%), which gives confidence in the HYDRUS model estimates of deep drainage and indicates there is potential for water savings in sub-surface drip systems.

The HYDRUS results indicated that drainage losses under the duplex RBE may be lower than under the uniform clay, whereas the IrriSAT derived data in Table 4 indicates that losses under the duplex RBE are higher. Both HYDRUS and IrriSAT are models and they have different underlying assumptions as they have been designed to do different things. While the deep drainage numbers obtained using IrriSAT support the conclusions from the 2019-20 study (North 2020) that excessive drainage loss under the duplex RBE soils was a factor in the lower yields on that soil type, without verification it is not possible to categorically assert that this was in fact the case.

As previously stated, the HYDRUS results are driven by the Ksat measurements and these may not truly reflect field conditions during the irrigation season for a number of reasons.

1. Ksat was not measured in the A horizon of the duplex RBE so the value from the B horizon was used. Measurements in northern Victorian irrigation districts determined an average Ksat of 65 cm/day for the A horizon of Group 2 (duplex) soils (Mehta and Wang 2005). Changing the Ksat value of the A horizon in the RBE however is unlikely to have increased modelled drainage loss because the B horizon of these soils exerts the greatest influence on deep drainage (van der Lelij and Talsma 1978). Such a change would have only affected surface wetting and water distribution in the A horizon.
2. The Ksat measurements were made in May, after crops had been picked. Soil bulk density has a large influence on Ksat, so compaction from picker traffic may have led to a reduction in Ksat by the time the measurements were made. Furthermore, soil conditions in May are different to those during the peak irrigation season and soil consolidation in duplex RBE following repeat irrigations is well known (Cockroft and Olsson 2000; Murray and Grant 2007).
3. Alternatively, there may be a horizon in the sub-soil below the drip tape which has a lower Ksat but this was not ascertained. If present, this horizon would determine deep drainage loss once the soil above this layer filled up after the start of the irrigation season.

Table 4. Crop water use data for the tomato crops monitored in 2019-20, with rain (R) and irrigation (I) obtained from grower records, crop water use (ETc) estimated from IrriSAT, and deep drainage (DD) calculated from DD = R + I – ETc.

SOIL GROUP	Uniform clays				Duplex RBE		Calcarosol
SITE	**W**	**C**	**H**	**K**	**M**	**KR**	**MW**
Plant / emergence date	**13 Nov**	5 Nov (s)	8 Nov (s)	9 Oct	**9 Oct**	14 Oct	12 Oct
Hand pick date	**16 Apr**	23 Mar	23 Mar	26 Feb	**18 Feb**	10 Mar	10 Mar
In-crop rain (mm)	**185**	85	80	120	**60**	155	155
Total irrigation (mm)	**n/r**	700	795	500	**800**	840	665
Crop water-use (mm)	**660**	610	610	450	**570**	480	510
Est. deep drainage (mm)	**-**	**175**	**265**	**170**	**290**	**515**	**310**
Drainage loss (% of total)	**-**	22%	30%	27%	**34%**	52%	38%

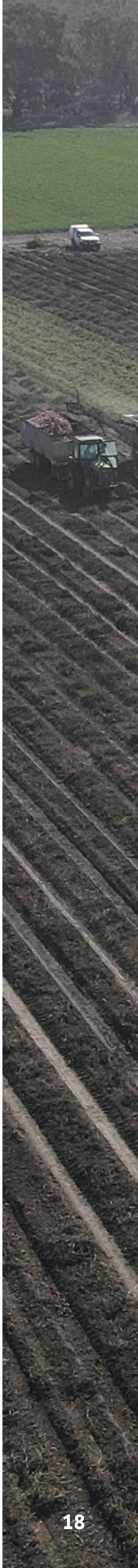
Conclusions

Paired measurements of soil water content and matric potential from readily available soil sensors provided a convenient method of collecting the data needed to determine the soil moisture characteristics of two contrasting soil types. Input of the soil hydraulic parameters obtained from this field data into HYDRUS allowed model comparisons of the effect of emitter flow rate, emitter spacing and drip tape depth to be assessed. The following general conclusions are made based on the modelled results:

1. Shallower placement of drip tape may reduce deep drainage losses in duplex RBE soils but may not have any effect in uniform clays.
2. Emitter flow rates lower than 1.5 L/hr should be beneficial in reducing deep drainage losses in both soil types.
3. Irrigation run time is proportional to emitter spacing and inversely proportional to emitter flow rate. Combinations of emitter flow rate and spacing that provide for irrigation run times around 8 hours in the duplex RBE and 12 hours in the uniform clay resulted in the lowest deep drainage.

Soil hydraulic conductivity may have a larger influence on deep drainage than the tape design parameters investigated. While there are questions around the Ksat data used in this study, the estimates of deep drainage obtained via modelled water balance were in general agreement with the results obtained from the HYDRUS modelling. Investigations to confirm the scale of deep drainage losses under sub-surface drip tape and to assess options for saving water are strongly recommended. If deep drainage losses are in fact in the order of 20-30%, then reducing such losses may provide considerable savings to growers. Given the proportionately lower response of deep drainage to tape design, then monitoring soil water to schedule irrigations and better match irrigation applications to crop water use may provide the best option for finding water savings if the modelled results are confirmed.

The sharp boundary between wet and dry soil modelled for the duplex RBE agrees with field observations in this soil type. Root growth is likely to be compromised in such soil profiles, potentially limiting water and nutrient uptake. The presence of such conditions and the effect on root and plant growth needs



confirming. If confirmed, then options for ameliorating these soils to facilitate better lateral movement of water may assist to overcome constraints to higher yields in these soils.

This study was a first effort. While much has been learnt, there is room for refinement and further work is needed to build on this to develop tools and techniques to assist the industry in better matching tape design and irrigation scheduling to soil type and crop water use.

References

Allen, RG, Pereira, LS, Raes, D, Smith, M (Eds) (1998) 'Crop evapotranspiration: guidelines for computing crop water requirements.' In 'FAO Irrigation & Drainage Paper'. (Food & Agriculture Organisation of United Nations: Rome). Available at http://www.kimberly.uidaho.edu/water/fao56/

Amoozegar, A (1989) A compact constant-head permeameter for measuring saturated hydraulic conductivity of the vadose zone. *Soil Science Society of America Journal* **53**, 1356-1361.

Cockroft, B, Olsson, KA (2000) Degradation of soil structure due to coalescence of aggregates in no-till, no-traffic beds in irrigated crops. *Australian Journal of Soil Research* **38**, 61-70.

Cote, CM, Bristow, KL, Charlesworth, PB, Cook, FJ, Thorburn, PJ (2003) Analysis of soil wetting and solute transport in subsurface trickle irrigation. *Irrigation Science* **22**, 143-156.

Isbell, RF, National Committee on Soil and Terrain (2016) 'The Australian Soil Classification.' (CSIRO Publishing: Australia)

Kandelous, MM, Kamai, T, Vrugt, JA, Simunek, J, Hanson, B, Hopmans, JW (2012) Evaluation of subsurface drip irrigation design and management parameters for alfalfa. *Agricultural Water Management* **109**, 81-93.

Mehta, B, Wang, QJ (Eds) (2005) 'Soil Hydraulic Properties of the Shepparton Irrigation Region.' (Department of Primary Industries: Tatura, Vic.). Available at http://vro.agriculture.vic.gov.au/dpi/vro/gbbregn.nsf/pages/soil_hydraulic_pdf_sir/$FILE/shp-sir_fp_toc.pdf

Murray, RS, Grant, CD (2007) The impact of irrigation on soil structure. Land and Water Australia, Canberra, ACT.

North, SH (2020) Investigation of factors limiting processing tomato yields. *Australian Processing Tomato Grower* **41**, 10-15.

North, SH (2021) Optimising sub-surface drip irrigation design for the Australian processing tomato industry: moisture characteristics of two Riverine plains soils. NSW Department of Primary Industries, Orange, NSW.

Provenzano, G (2007) Using HYDRUS-2D Simulation Model to Evaluate Wetted Soil Volume in Subsurface Drip Irrigation Systems. *Journal of Irrigation and Drainage Engineering (ASCE)* **133**, 342-349.

Simunek, J, van Genuchten, MT, Sejna, M (2012) HYDRUS: Model use, calibration and validation, Special issue on Standard/Engineering Procedures for Model Calibration and Validation. *Transactions of the ASABE* **55**, 1261-1274.

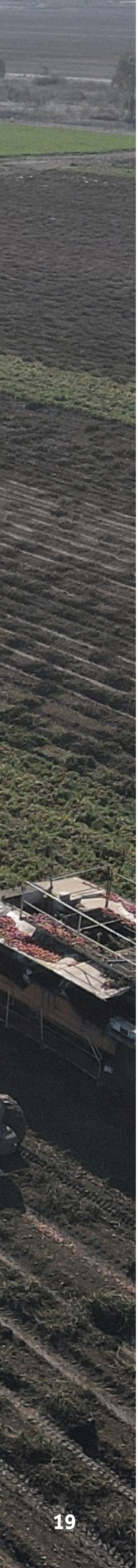
Skaggs, TH, Trout, TJ, Simunek, J, Shouse, PJ (2004) Comparison of HYDRUS-2D simulations of drip irrigation with experimental observations. *Journal of Irrigation and Drainage Engineering (ASCE)* **130**, 304-310.

Skene, JKM, Harford, LB (1964) Soils and land use in the Rochester and Echuca Districts, Victoria. Melbourne.

van der Lelij, A, Talsma, T (1978) Infiltration and water movement in Riverine plain soils used for rice growing. In 'Proceedings of a Symposium of the Australian Society of Soil Science Inc., on Hydrogeology of the Riverine Plains of South-East Australia, 28-29 July 1978. Griffith, NSW', 1978. (Eds RR Storrier, ID Kelly) pp. 89-98. (Riverina Branch, Soil Science Society of Australia:

van Genuchten, MT, Simunek, J, Leij, FJ, Sejna, M (1998) 'RETC version 6.02. Code for quantifying the hydraulic function of unsaturated soils.' (PC-Progress: California, USA)

Sam North promoting the findings of his research into soil/water management at the Rochester Field Day.



Australian Processing Tomato Cultivar Trials 2020-2021

Ann Morrison and Bill Ashcroft

Introduction

The Australian Processing Tomato Research Council's cultivar improvement program continued over the 2020-2021 season. Field trials were set up to compare prospective new cultivars with current industry standards (H1015 for early season trials and H3402 for mid-season) and to identify equivalent or improved lines for commercial use. The screening process involves two stages, with preliminary "observation" trials used to identify promising lines which may then be promoted to larger-scale replicated machine harvest plantings.

Two early season and eight mid-season machine harvest trials were established along with two early and three mid-season preliminary screening trials. Four of the mid-season machine harvest trials (around Boort) were direct seeded and the rest were transplanted with seedlings.

A total of thirty-nine cultivars were included in the preliminary screening and machine harvest trials, and some were restricted to certain sites by the quantity of seed available.

Materials and Methods

Cultivars

The cultivars (or mixes) assessed in the screening and machine harvest trials are listed in *Table 1*. Cultivars of interest for further evaluation are highlighted light green.

Table 1. Cultivars evaluated during the 2020-21 growing season

		Early		Mid-season			Early		Mid-season				Mid-season			
		Screening		Screening			Transplants - Machine Harvest		Transplants - Machine Harvest				Direct seed - Machine Harvest			
		Kilter	Kagome Hibma	Kilter	Kagome Danckerts	Weeks	Kilter	Kagome Hibma	Kennedy	Kilter	Kagome Timmering	Weeks	Chirnside	Sawers	Lehmann	Henry
Heinz	H1014	✔														
	H1015	✔	✔				✔	✔								
HM Clause	HM Pumatis	✔	✔													
	HM Encina	✔	✔													
	HM Zafra	✔	✔													
South Pacific	SPS 270-6	✔	✔													
Seminis	SVTM9000	✔	✔				✔	✔								
Heinz	H1307			✔	✔	✔										
	H1311 Mix			✔										✔	✔	
	H1428			✔	✔	✔						✔				
	H1884				✔	✔										
	H3402			✔	✔	✔			✔	✔	✔	✔	✔	✔	✔	✔
	H3402 Mix										✔					
	H3406			✔	✔	✔										
	H3406 Mix												✔	✔		✔
	H5408			✔	✔	✔										
HM Clause	HM4885					✔										
	HM6175				✔	✔										
	HM Enotrio				✔	✔										
	HM Nava				✔	✔										
	HM58811 (HMX58811)			✔	✔	✔			✔	✔	✔	✔	✔	✔	✔	✔
Seminis	SVTM9016			✔	✔	✔										
	SVTM9019			✔	✔	✔										
	SVTM9023			✔	✔	✔				✔		✔				
	SVTM9024			✔	✔	✔				✔						
	SVTM9025			✔	✔	✔				✔		✔				
United Genetics	UG19406 Mix				✔											
	UG16112			✔	✔	✔			✔	✔	✔	✔	✔	✔		✔
Lefroy Valley	TOP 95412				✔											
	TOP 95420				✔											
	TOP 95900				✔											
	TOP 95901				✔											
	TOP 95910				✔											
	TOP 95928				✔											
	TOP 95929				✔											
	TOP 95930				✔											
	TOP 95931				✔											
	TOP 95932				✔											
	TOP 95933				✔								—			

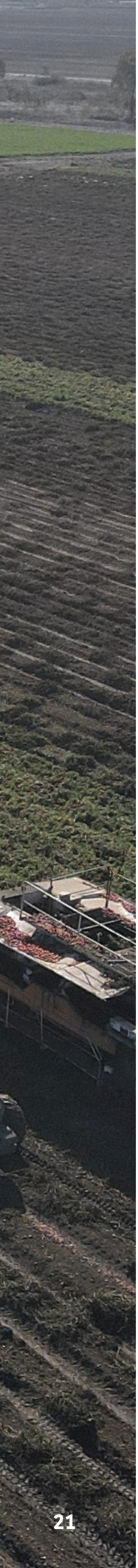
Breakdown of the mixes in the trials were as follows:

H3402 Mix = H3402:H2401 60:40

H1311 Mix = H3402:H1311 70:30 at Boort, 60:40 elsewhere (in transplant crops)

H3406 Mix = H3406:H1311 70:30

UG19406 Mix = UG19406:UG16112 60:40



Trial Design and Assessment

Machine harvested trials

The machine harvested trials were laid out in randomised complete blocks (RCB). This is a standard design for agricultural experiments used to help mitigate the impact of variations in trial results due to spatial effects in the paddock e.g., soil type or irrigation.

Where possible, trials were set out with five replicates (blocks) repeating along the rows. All trial sites had drip irrigated single row beds ranging from 1.52 to 1.67 metres in width, and the cultivars were assigned at random across each block.

A hand-held GPS unit was used to measure and peg out the machine harvest trial rows. During planting, cultivars were swapped at each peg in accordance with the trial plan. The weight of harvestable fruit produced from each trial plot was measured using load cells on the bulk harvester trailers.

As a measure of site variability, plant counts were performed on all machine harvest trials within a month of crop emergence or transplanting. The number of plants within a two-metre section was counted at five locations spread evenly across each trial plot. These figures were then used to estimate the plant population within that plot.

All machine harvested cultivars were visually assessed prior to harvest (see *Tables 13 and 14*). Twenty healthy red fruit were randomly sampled from each trial plot and taken to the Kagome Laboratory for °Brix, pH and colour testing. A pureed sample of raw fruit was used for °Brix and pH testing using a refractometer for the former and pH meter for the latter test. A hand diced fruit sample was also tested for colour, using a Hunter Lab Colorimeter.

Colorimeters provide numerical colour values along the black to white axis (colour L), the green to red axis (a) and the blue to yellow axis (b). The higher the value for the individual colour axis, the lighter the colour (higher L), the more red (higher a) and the more yellow (higher b) the fruit sample.

The preferred raw fruit pH is around the 4.3 - 4.4 range or lower, and a desirable a/b colour score (obtained by dividing colour a by colour b) is 1.9 or higher.

Red fruit yields (tonnes per hectare) from trial plots were calculated using trial plot weights together with the row length and width.

Yield and °Brix results were multiplied together to determine the tonnes per hectare of soluble solids (labelled as soluble solids (t/ha)).

Statistics

Trial results were analysed using the ARM 9 statistical program to perform analysis of variance (ANOVA), comparing the differences between group means. Whether the difference between means was significant or not was determined using Tukey's HSD (honest significant difference) P = 0.05.

Preliminary Screening trials

Two early and three mid-season transplanted screening trials were established, with each consisting of at least two ten metre plots per cultivar. These trials were visually assessed and rated prior to the paddock being harvested. Indicative °Brix readings were obtained for promising mid-season varieties by testing ten intact red fruit randomly selected from sites at Rochester and Deniliquin.

Results and Discussion

Cool weather persisted through the harvest period with maximum temperatures recorded in Echuca for February and March 2021 being 36.7 and 33.8 °C respectively and averages of 30 and 25.9 °C. These milder growing conditions may not have fully tested the trial varieties with respect to field holding capacity and resistance to sun bleach.

The early season trials were machine harvested after 124 days in the field for Kagome Hibma and 141 days for Kilter. The mid-season trial harvests ranged from 126 to 164 days after planting, which is shorter than the previous season (152 to 170 days).

Early Season Trials

Unfortunately, only two cultivars were available for replicated assessment in the early planting window, and one of these (H1015) is the industry standard. Two trials were transplanted in late September/early October, one at Kagome Hibma (Mathoura) and one at Kilter (Winlaton). ANOVA results from these trials are shown in *Table 2* and *Table 3* where average values followed by same letter do not significantly differ (P=.05, Tukey's HSD).

Table 2. ANOVA results for Kagome Hibma (Mathoura, NSW) early season transplant trial

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H1015	19573	a	113.87	a	6.42	a	7.26	a	4.50	a	2.40	a
SVTM9000	19079	a	118.42	a	5.79	a	6.84	a	4.57	a	2.44	a
Tukey's HSD (P=.05)	523		22.42		0.87		2.09		0.15		0.23	
Treatment Prob (F)	0.0577		0.6025		0.1111		0.600		0.272		0.615	
Replicate Prob(F)	0.082		0.020		0.575		0.152		0.905		0.783	

Excluded replicate 4 from Colour a/b to correct kurtosis.
Excluded replicate 2 from data pH to correct heterogeneity of variance/skewness/kurtosis.
Excluded replicate 2 from Colour L to correct skewness.

Table 3. ANOVA results for Kilter (Winlaton, Vic) early season transplant trial

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H1015	18947	a	106.30	a	5.80	a	6.15	a	4.66	a	2.46	a
SVTM9000	19605	a	105.33	a	5.56	a	5.86	a	4.63	a	2.49	a
Tukey's HSD (P=.05)	1156		10.61		0.63		1.17		0.06		0.35	
Treatment Prob (F)	0.1890		0.8230		0.3718		0.554		0.203		0.799	
Replicate Prob(F)	0.802		0.126		0.318		0.804		0.209		0.877	

Excluded replicate 1 from Plants/ha to correct heterogeneity of variance.
Excluded replicate 6 from Colour L to correct skewness/kurtosis.
Excluded replicate 4 from Colour a to correct heterogeneity of variance/skewness/kurtosis.
Excluded replicate 4 from Colour a/b to correct kurtosis.

There were no significant differences between any of the parameters measured in either of the early season trials. Both trial sites had good plant populations and the average gross red fruit yields were over 105 tonnes per hectare at Kilter and 113 tonnes at Hibma. There was greater variation in yield between plots of the same cultivar at Hibma (which ranged from around 80 to 160 tonnes per hectare for each cultivar) than in the Kilter trial where the individual cultivar plot yields ranged from around 94 to 130 tonnes per hectare (data not shown).

SVTM9000 had lower °Brix in both trials but had higher yields at the Kagome Hibma trial site. The calculated tonnes per hectare soluble solids was lower for both cultivars at the Kilter site compared to the Kagome site.

Average raw fruit pH values of both cultivars were higher than the preferred maximum of 4.3 at both sites, and the colour a/b values of both were over the minimum acceptable level of 1.9.

Mid-Season Trials

Eight mid-season trials were established and successfully harvested this season, with the first mid-season transplant trial being planted on 14th October and first direct seeded trial on 16th October 2020. Due to limited seed availability some varieties were only included in a restricted number of transplant trials.

Analysis of Variance Tables

In the ANOVA results tables, letters highlighted in red are significantly worse than the mid-season industry standard cultivar (H3402) and green highlighted letters significantly better for that parameter. Data which has been excluded from analysis is highlighted grey and the reason for exclusion is listed below the table.

Table 4. ANOVA results for Chirnside (Leaghur, Vic) direct seeded trial (5 replicates).

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H3402	86108		144.78	a	5.66	a	8.37	a b	4.37	a	2.34	a
H3406 Mix	85509	a	123.61	b	5.54	a	6.88	b	4.42	a	2.45	a
HM58811	77964	a	152.27		5.90	a	8.99	a	4.32	a	2.30	a
UG16112	87425	a	136.87	a b	5.49	a	7.53	a b	4.36	a	2.31	a
Tukey's HSD (P=.05)	15102.50		19.089		0.749		1.920		0.119		0.0416t	
Treatment Prob (F)	0.2277		0.0369		0.3945		0.033		0.136		0.512	

NB. Missing data in replicate 3, H3402, °Brix & Soluble solids (t/ha).
Applied automatic data correction transformation 'Log(n+1)' to Colour a/b to correct skewness.
H3402 was excluded from Plants /ha to correct heterogeneity of variance
HM58811 was excluded from Yield (t/ha) to correct skewness.

Table 5. ANOVA results for Henry (Appin South, Vic) direct seeded trial (5 replicates)

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H3402	43593	a	114.32	a	5.69	a	6.47	a	4.56	a	2.26	a
H3406 Mix	37725	a b	110.47	a	5.92	a	6.53	a	4.41	a	2.24	a
HM58811	34132	a b	117.53	a	6.30	a	7.38	a	4.40	a	2.17	a
UG16112	30180	b	136.62	a	5.69	a	7.77	a	4.46	a	2.29	a
Tukey's HSD (P=.05)	10735.61		0.1135t		1.081		0.1117t		0.168		0.354	
Treatment Prob (F)	0.0182		0.1371		0.3365		0.226		0.068		0.807	

NB. Automatic data correction transformation 'Log(n+1)' was applied to Yield (t/ha) to correct skewness/kurtosis.
Automatic data correction transformation 'Log(n+1)' was applied to Soluble solids (t/ha) to correct skewness.

Table 6. ANOVA results for Kagome Timmering (Nanneella, Vic) transplant trial (5 replicates)

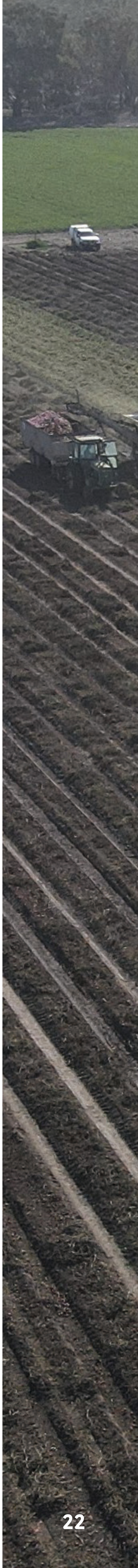
Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H3402	19342	a	127.39	a	4.97	a	6.30	a	4.54	a	2.16	a
H3402 Mix	18816		131.08	a	5.17	a	6.76	a	4.50	a	2.05	a
HM58811	19342	a	130.85	a	5.02	a	6.56	a	4.45	a	2.06	a
UG16112	19211	a	132.64	a	4.95	a	6.56	a	4.43	a	2.15	a
Tukey's HSD (P=.05)	1074		15.36		0.61		1.20		0.13		0.27	
Treatment Prob (F)	0.9224		0.7785		0.7143		0.734		0.115		0.536	

NB. H3402 Mix excluded from Plants/ha to correct heterogeneity of variance/skewness/kurtosis.

Table 7. ANOVA results for Kennedy (Burramboot, Vic) transplant trial (5 replicates)

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H3402	19737	a	55.58	a	6.05	a	3.28	b	4.49	a	2.28	a
HM58811	19244	a	69.35	a	6.60	a	4.50	a	4.36	a	2.28	a
UG16112	19408	a	63.20	a	5.78	a	3.63	b	4.36	a	2.21	a
Tukey's HSD (P=.05)	1091		15.22		1.41		0.07278t		0.14		0.28	
Treatment Prob (F)	0.4219		0.0874		0.2869		0.008		0.049		0.695	

NB. Automatic data correction transformation 'Log(n+1)' applied to soluble solids (t/ha) to correct skewness.
UG16112 excluded from Colour L to correct skewness/kurtosis.
Replicate 1 excluded from Plants/ha to correct heterogeneity of variance/skewness/kurtosis.



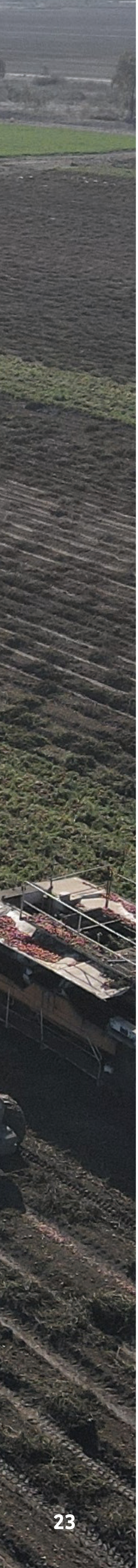


Table 8. ANOVA results for Kilter (Fish Point, Vic) transplant trial (5 replicates)

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H1311 Mix	19342	a	141.27	b	5.46	a	7.74	a b	4.48	a	2.28	a
H3402	18158	a	145.08	b	5.19	a	7.54	b	4.48	a	2.05	a
HM58811	19211	a	153.91	a b	5.31	a	8.16	a b	4.44	a	2.01	a
SVTM9023	18158		167.42	a	5.81	a	9.71	a	4.44		2.20	a
SVTM9024	19079	a	149.76	a b	5.19	a	7.77	a b	4.39	a	2.14	a
SVTM9025	18553	a	151.49	a b	5.30	a	8.02	a b	4.41	a	2.04	a
UG16112	19079	a	142.31	b	5.09	a	7.22	b	4.46	a	2.01	a
Tukey's HSD (P=.05)	2464		20.66		1.16		2.07		0.11		0.49	
Treatment Prob (F)	0.6504		0.0077		0.5311		0.021		0.075		0.499	

NB. SVTM9023 excluded from Plants/ha to correct skewness/kurtosis.
SVTM9023 excluded from pH to correct heterogeneity of variance.
SVTM9023 excluded from data kg/plant to correct skewness/kurtosis.

Table 9. ANOVA results for Lehmann (Leaghur, Vic) direct seeded trial (5 replicates)

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H1311 Mix	70419	a b	142.00	a	5.84	a	8.29	a	4.33	a	2.42	a
H3402	74491	a	149.46	a	5.85	a	8.74	a	4.33	a	2.35	a
HM58811	68383	b	136.26	a	6.36	a	8.71	a	4.26	a	2.30	a
Tukey's HSD (P=.05)	4172		13.65		0.58		1.35		0.09		0.30	
Treatment Prob (F)	0.0088		0.0679		0.0516		0.592		0.077		0.533	

Table 10. ANOVA results for Sawers (Leaghur, Vic) direct seeded trial (4 replicates)

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H1311 Mix	59539	a	155.71	a	5.53	a	8.50	a	4.39	a	29.31	a
H3402	70395	a	164.29	a	5.22	a	8.57	a	4.45	a	28.42	a
H3406 Mix	67270	a	168.41	a	5.02	a	8.48	a	4.48	a	27.42	a
HMX 58811	53618	a	184.85	a	5.18	a	9.56	a	4.43	a	27.79	a
UG16112	64474	a	177.52	a	5.13	a	9.08	a	4.54	a	27.11	a
Tukey's HSD (P=.05)	17204.31		36.23		0.893		2.185		0.186		0.520	
Treatment Prob (F)	0.0621		0.1586		0.4923		0.465		0.185		0.640	

NB. Automatic data correction transformation 'Log(n+1)' applied to Kg/plant to correct skewness.

Table 11. ANOVA results for Weeks (Nanneella, Vic) transplant trial (5 replicates)

Variety	Plants/ha		Yield (t/ha)		°Brix		Soluble solids (t/ha)		pH		Colour a/b	
H1428	16315	a	180.50	b	5.76	a	10.34	a	4.24	b c	2.39	a
H3402	16447	a	196.63	a b	6.02	a	11.78	a	4.44	a	2.42	a
HM58811	16447	a	212.01	a	6.16	a	13.01	a	4.42	a	2.38	a
SVTM9023	16447	a	206.08	a b	6.16	a	12.64	a	4.35	a b	2.29	a
SVTM9025	16315	a	219.79		5.69	a	11.78	a	4.19	c	2.30	a
UG16112	16447	a	193.66	a b	5.79	a	11.39	a	4.40	a	2.31	a
Tukey's HSD (P=.05)	346		28.13		1.14		0.14875t		0.14		0.45	
Treatment Prob (F)	0.5878		0.0315		0.6518		0.471		0.0001		0.901	

NB. SVTM9025 excluded from Yield to correct heterogeneity of variance/skewness/kurtosis.
SVTM9025 excluded from kg/plant to correct heterogeneity of variance/skewness/kurtosis.

In the trial at Sawers, analysis of variance was only performed on four replicates due to a poor plant population of less than 20,000 plants per hectare in a single plot of HM58811 (labelled HMX58811 in earlier reports) in replicate 2 compared to the rest of the plots in that replicate which had over 53,000 plants per hectare (*Table 10*).

Plant density

Plant population was counted within 2 weeks of emergence/planting, and as such, does not take into consideration later plant losses due to wind or disease.

Across the trials, average plant density ranged from 16,300 to 19,700 plants per hectare for transplants and 30,200 to 87,400 for direct seeded crops. In six of the eight mid-season trials H3402 had the highest or equal highest plant population.

UG16112 appears to have lower seedling vigour (slower germination) than the other cultivars trialled. This cultivar had a significantly lower plant population in the direct seeded trial at Henry's, but it also produced nineteen tonnes per hectare more fruit than the next highest yielding cultivar, though this difference was not statistically significant (*Table 5*).

HM58811 at Lehmann's also showed a significantly lower plant density, although this did not result in a significantly lower yield of red fruit.

Figure 1 shows red fruit yield versus plant population for both the transplant and direct seeded trials. Whilst there is large variation in plant populations across the various trial sites, the trend line (blue dotted line) across the range of plant density is fairly level suggesting plant population is not the main driver of crop yields. Yields of red fruit per plant across the various trials ranged from 1.45 to over thirteen kilograms per plant (data not shown).

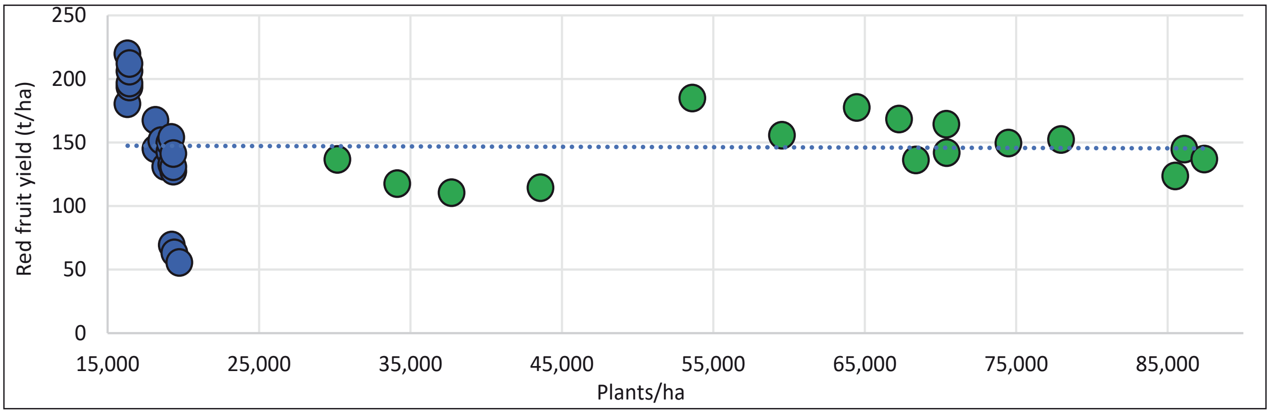


Figure 1. Red fruit yield versus plant population (blue dots - transplanted, green dots - direct seeded crops)

Yield and °Brix

In the bar graphs (*Figure 2* onwards), green indicates values which are significantly better than the industry standard, red significantly worse and data which has been excluded from analysis is coloured grey.

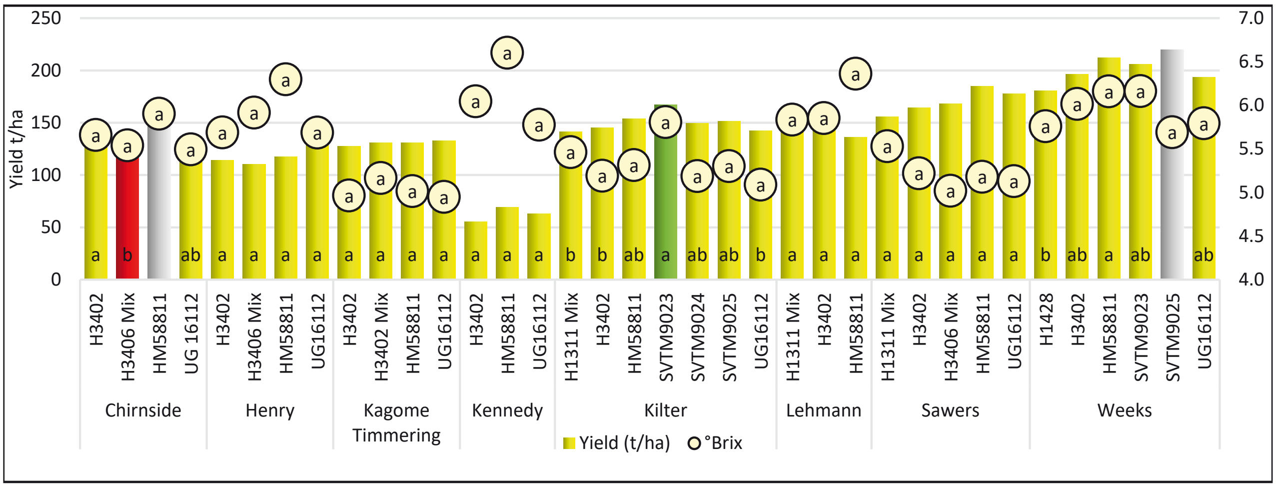


Figure 2. Mid-season trials average yield and °Brix compared to H3402

Yields

Red fruit yields across the mid-season trials ranged from 55 to 219 tonnes per hectare with both extremes occurring in transplant trials. There were statistically significant differences in red fruit yields compared to that of H3402 in two trials, with H3406 Mix having a significantly lower yield at Chirnside's and SVTM9023 with a significantly higher yield at Kilter (*Figure 2*).

The trial block at Henry's was impacted by tomato spotted wilt virus sometime in late January/early February. Of the cultivars in this trial, UG16112 and HM58811 both have some level of resistance to this virus. Both varieties showed slightly higher yields than the susceptible cultivars, but this difference was not significant.

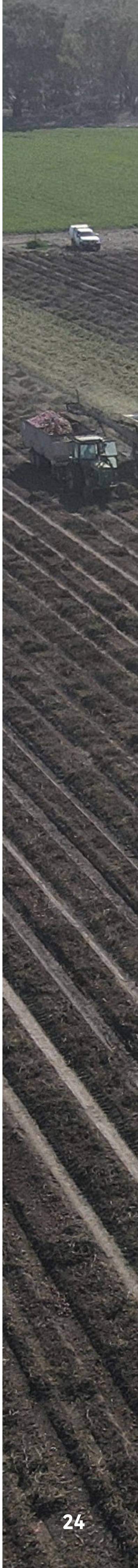
The ranking of cultivars across the different trials, while not statistically significant, show that HM58811, UG16112, SVTM9023 & SVTM9025 had higher yields than H3402 in a number of trials (*Table 12*), although some cultivars were only included in one or two trials.

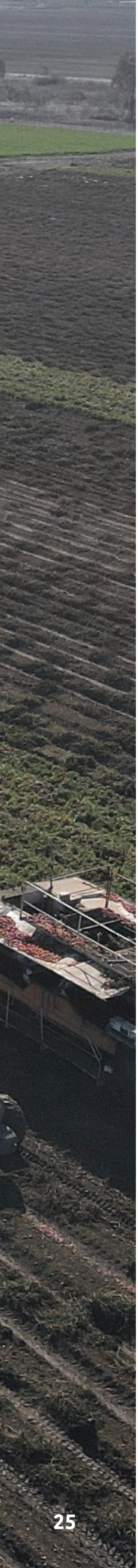
The highest yielding trial based on the average yield of red fruit from all plots in a trial was at Weeks with 201 tonnes per hectare followed by Sawers at 170 tonnes per hectare.

Plant growth across the paddock where the trial was planted at Kennedy's was uncharacteristically stunted with small plants and fruit resulting lower than average yields.

Table 12. Ranking of mid-season cultivars on average yield for each trial site

Yield (t/ha)	Highest						Lowest
Chirnside	HM58811	H3402	UG16112	H3406 Mix			
Henry	UG16112	HM58811	H3402	H3406 Mix			
Kagome Timmering	UG16112	H3402 Mix	HM58811	H3402			
Kennedy	HM58811	UG16112	H3402				
Kilter	SVTM9023	HM58811	SVTM9025	SVTM9024	H3402	UG16112	H1311 Mix
Lehmann	H3402	H1311 Mix	HM58811				
Sawers	HM58811	UG16112	H3406 Mix	H3402	H1311 Mix		
Weeks	SVTM9025	HM58811	SVTM9023	H3402	UG16112	H1428	





°Brix

There were no significant differences in °Brix readings across the trials (*Figure 2*), with average °Brix values ranging from 4.95 for UG16112 at Kagome Timmering to a high of 6.6 for HM58811 at Kennedy's. HM58811 had the highest °Brix values in four trials and the second highest in another three.

Tonnes per hectare soluble solids

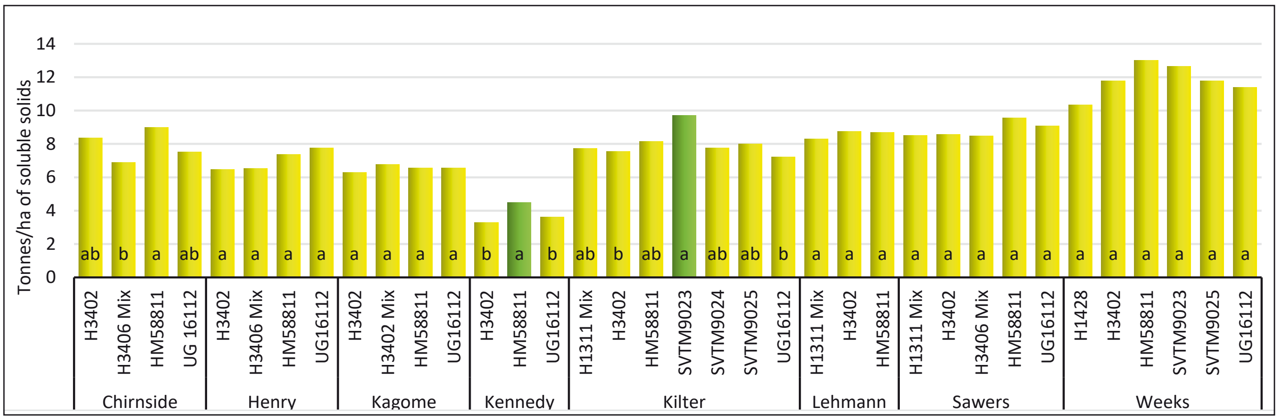


Figure 3. Mid-season trial average tonnes per hectare of solids compared to H3402

The average calculated soluble solids yield in this season's trials ranged from around three to thirteen tonnes per hectare. There were two statistically significant results across the trials, one at Kennedys where HM58811 showed significantly higher soluble solids and at Kilter where SVTM9023 also had significantly higher soluble solids than H3402 (*Figure 3*).

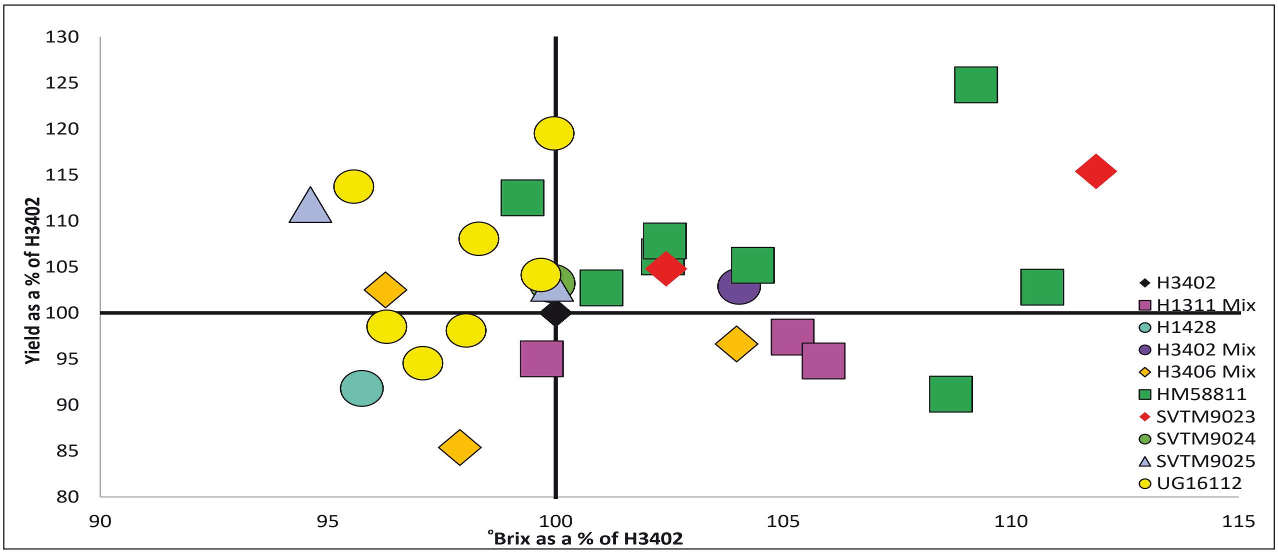


Figure 4. Average yields and °Brix as a percentage of H3402

Figure 4 compares the season's average trial red fruit yields and °Brix as a percentage of H3402 (represented by the black diamond in the cross hairs on the graph). The cultivars in the upper right hand quadrant of the graph showed both higher °Brix and yields than H3402.

HM58811 (green squares in *Figure 4*) showed both higher °Brix and yield in six out of eight trials. SVTM9023 and H3402 Mix also had higher yields and °Brix, but they were only included in a small number of trials.

H1428 had lower yields and Brix in the only trial in which it was included. Fruit size was also down for H1428 in both this trial and the screening trials.

pH

The highest average raw fruit pH across the mid-season trials was 4.56 for H3402 at Henry's site and UG16112 at Sawers'. Both SVTM9025 and H1428 had significantly lower pH than H3402 with pH values of 4.19 and 4.24 respectively in the trial at Weeks' (*Figure 5*). On ranking, HM58811 had the lowest pH in three trials and the second lowest pH in another three.

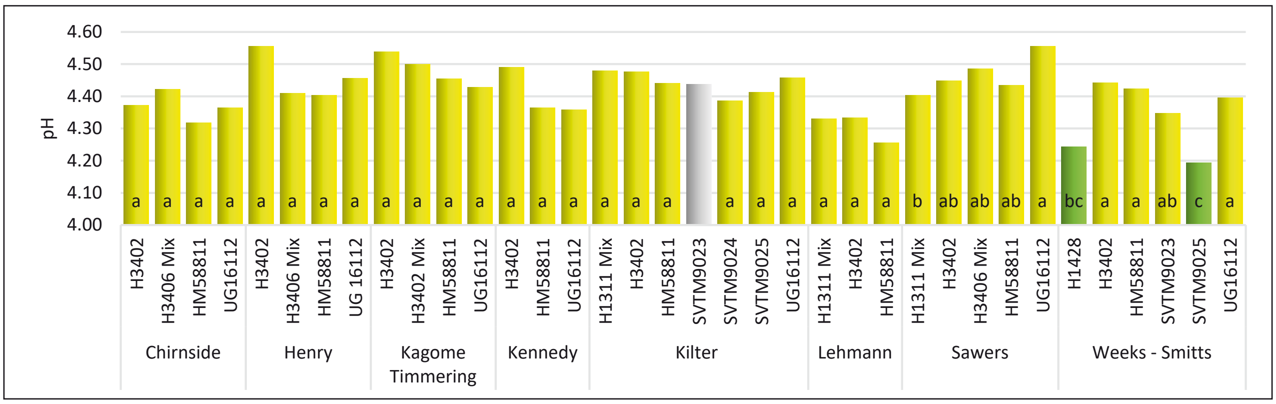


Figure 5. Mid-season trial pH values

Colour

There were no statistically significant variations in the average colour a/b scores across the mid-season trials. The colour scores across all mid-season trials ranged from a high of 2.45 from H3406 Mix at Chirnside's to 2.01 for both HM58811 and UG16112 in the Kilter trial.

H1311 is a high lycopene variety which was included in two mixes, H3406 Mix and H1311 Mix. These mixes had the highest a/b values in three trials.

Yield variation within cultivars

Differences in red fruit yields from various replicates within a single trial ranged from over sixty tonnes per hectare for UG16112 at Henry's to around twelve tonnes per hectare for H3402 in the trial at Kilter (*Figure 6*). In the trial at Henry's, plant populations were low for a direct seeded trial, with UG16112 having the lowest average of around 30,000 plants per hectare.

In the highest yielding trial at Weeks', the lowest replicate yield was 161 tonnes of red fruit per hectare for H1428 and the highest was 238 tonnes per hectare for SVTM9025.

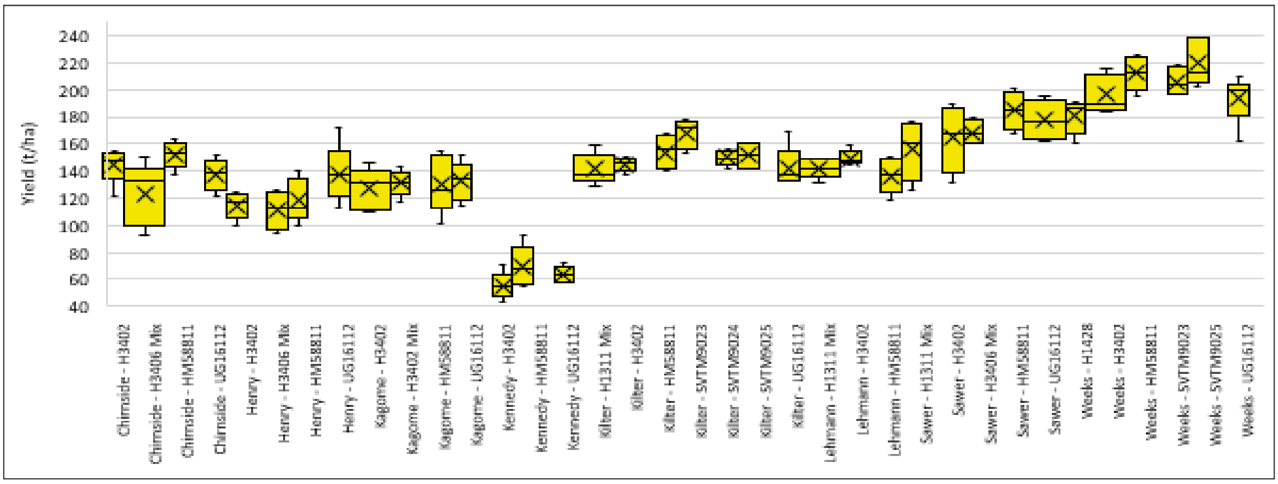


Figure 6. Box and whisker plot of mid-season replicate yields grouped by grower

Screening Trials

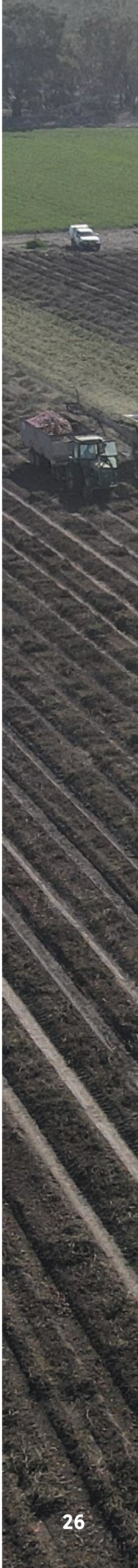
Two early screening trials were planted, one near Lake Boga and the second near Mathoura NSW. Both trials were visually assessed and rated in late January. The vine and fruit were given a score out of ten based on a range of characteristics including vine type, cover, severity of any plant or fruit disease, fruit holding, concentration and apparent yield (*Table 13*).

Three mid-season screening trials were also established near Rochester, Lake Boga and Deniliquin. Assessment of these trials was completed in early March with fruit samples collected from promising varieties at Kagome Danckerts and Weeks Smitts sites to give indicative °Brix readings (*Table 14*).

An additional 16 Italian lines from Lefroy Valley were also planted at Danckerts. These varieties do not have extended field holding and consequently showed signs of fruit breakdown. However, three of these varieties (TOP 95412, 95931 & 95910) may have a fit as an early season option.

Table 13. Early season screening trial assessments

Cultivar	Comments	Rating (-/10)
H1014	Kilter site only. Small vine, rolled leaves, low on bed, dark foliage. Fruit firm, small-medium egg-plum shaped, thick-walled fruit with good colour. Good yield for vine. No bleach. Small fruit?	8
H1015	Hibma site only. Medium-vigorous vine on the bed with dark foliage. Medium sized, firm, plum-egg shaped fruit with good colour. Good yield and concentration.	9
HM Encina	Medium-vigorous vine on the bed with large, dark, rolled leaves. A few rogue plants noted at both sites. Large blocky plum-pear fruit, firm with good colour. Good concentration but question over holding – sunburn/scorch evident at both sites. Some patches of leaf disease also. Good yield for vine.	7
HM Pumatis	Medium/compact vine on the bed with some leaf roll. Bit of speck damage at Kilter, good cover at Hibma. Medium egg-plum fruit, firm with good colour although a little bleach, with shoulder discoloration and yellow-eye also noted. Good yield and concentration. Over-all not bad.	8
SPS 270-6	Trialled for low pH and proved to be not for early. Produced a vigorous vine, generally on the bed but flopping open in places to expose fruit. Light foliage. Fruit of variable size, medium firm, blocky eggs with some dimple, good colour. Holding ok but 15-20% green so not for early. Yield average.	5
SVTM 9000	Medium-vigorous vine, a bit ragged but on the bed with dark foliage – leaf disease noted at Kilter. Medium/large blocky egg-plum fruit with good colour. Firm with thick walls. Some good yield but second early (10-15% green) and question over holding, with some bleach and breakdown starting.	6.5
~~HM Zafra~~	Discontinued in Australia. Medium/vigorous on the bed with medium-dark foliage. Blocky elongated egg-plum fruit of good size (med). Medium firmness and colour also a bit variable – some very good. Hint of bleach coming in and concentration could be better with 10% plus green at both sites – probably second early. Yield good.	7
Two sites: Kilter GBra (Winlaton) and Kagome Hibma (Mathoura), both good trials. Compact vines with leaf damage/disease evident in patches at both sites. Both assessed on 27/1/21, within a week of projected harvest. Notes are compiled over both sites.		



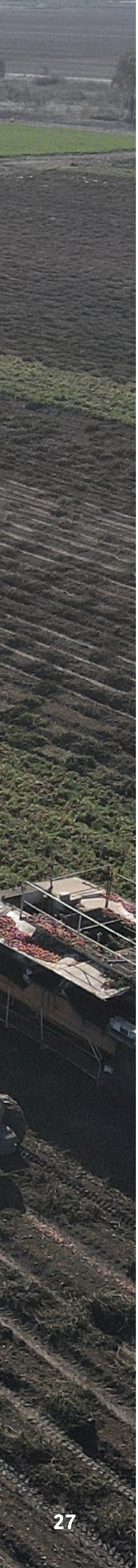


Table 14. Mid-season screening trial assessments (continued next page)

Cultivar	Comments	Rating (/10)
		Brix° [site1, site2]
H1307	Medium/vigorous vine on the bed with good concentration. Larger at site 2, where it grew into the furrows. Blocky egg-plums of medium size, firm with good colour – a few dimpled and a couple showing bleach/breakdown. Yield also good. Good yield and fruit size also at Site 3, although a concern about breakdown and bleach coming in.	7.5 / 7 / 6.5 (Avg 7) Brix° [6.0, 5.8]
H1311 Mix (H1311:H3402 40:60)	Standard Site 3 Hard to assess due to the two cultivars. Plots patchy with some bad areas for leaf loss. Overall, medium-vigorous vine on the bed with blocky plum-egg shaped fruit that were firm with good colour. Some patches showed breakdown and there was small fruit. Yield ok-good. Rating varied from 6-7.	6.5 (Site 3 only)
H1428	Medium/vigorous sprawling vine – again bigger at site 2, with rolled dark leaves. Very firm round-plum/egg fruit, many on the small side, but very firm with good colour. Concentration and cover ok, but lacking yield. Yield better at site 2 but poor concentration (too many greens) and small again. Yield also good at site 3, although variable size with smalls again an issue.	5.5 (small) / 6.5 / 6.5 (Avg 6.2)
H1884	A low, medium/vigorous vine on the bed with good fruit size, although 5-10% green (most large). Medium-dark foliage. Very firm blocky egg-plum fruit – a few dimpled. Very good colour also and yield good. Hint of bleach and breakdown at both sites.	8.5 / 7.5 / - (Avg 7.5) Brix° [5.9, 6.2]
H3402 Standard Site 2	Medium/vigorous vine on the bed providing good cover. Fruit firm with very good colour, egg-plum shaped but many smalls. Better size at site 2. Good yield. Concentration also OK at site 1 but a few greens at site 2. Some good yield also at Site 3, but fruit on the small side and a hint of bleach/break-down	6 (small) / 8 / 7 (Avg 7) Brix° [5.5, 5.1]
H3406	Medium sprawling vine on the bed with dark rolled leaves. Larger vine at site 2 with some leaf disease. Yield ok. Medium blocky plum-pear shaped fruit, firm with very good colour. Concentration ok, 5% small greens. Fruit a bit smaller at site 2. Earlier? Looked good at Site 3, with good yield and medium-small fruit. A hint of breakdown.	7.5 / 7 / 7.5 (Avg 7.3) Brix° [5.3, 5.8]
H5408	Medium/compact vine with dark rolled leaves. Small blocky plum-eggs with dimple, very firm and very good colour. Small greens <5%. Appears to lack yield. Better fruit size and yield at Site 2. Variable fruit size and a hint of breakdown at Site 3, where yield was ok.	6.5 / 7.5 / 6 (Avg 6.7) Brix° [5.7, 5.6]
HM Enotrio	Medium/vigorous vine spreading on the bed with dark foliage. Tall at site 2. Very firm blocky plum-egg shaped fruit with very good colour. Good size but yield only average – better at site 2. A bit of bleach and breakdown just coming in. Greens small and 5%.	6 (Yield and holding) / 7 / - (Avg 6.5) Brix° [6.2, 6.3]
HM Nava	Medium/vigorous vine on the bed – erect at site 2 - with medium foliage – cover ok. 5% (small) greens, Blocky plum- elongated egg fruit. Medium-large fruit at site 2. Firm with good colour and seem to be holding ok. Yield ok.	7 / 7.5 / - (Avg 7.3) Brix° [5.7, 5.9]
HM4885	Only grown at Site 2. Medium/vigorous vine – a bit upright - on the bed with medium-dark foliage. Medium egg-elongated fruit, firm with good colour but a hint of bleach showing. Yield ok. Greens >10%. Later?	- / 7 / - Brix° [--, 5.8]
HM58811	A rather upright spreading medium/vigorous vine with medium/dark small leaves and 5-10% green fruit. Medium-small (variable) elongated eggs, some pointed and some dimples. Very firm, a tad puffy, colour ok only. Yield ok. Medium sized blocky plum-pears at Site 3, good yield. Fruit again a bit puffy, with a bit of bleach and breakdown.	6 (concn) / - / 7 (Avg 6.5)
HM6175	Tall, spreading medium/vigorous vine on the bed with dark foliage with lots of big bud at site 1. Blocky, medium sized plum-pear fruit, very firm with good colour. Some dimpled. 5-10% green. Yield lacking, but hard to judge given other problems with plots. Yield better but a hint of breakdown and vine opening up at site 2.	5.5 / 6.5 / - (Avg 6)
SVTM9016	Couldn't rate at site 1 due to irrigation problems. Dark foliage, fruit firm with good colour. Lots of BER and greens. Good cover with leaf purpling at site 2, medium blocky plums, very firm, Yield ok. Green > 10%. Separation? Vigorous/medium vine at Site 3, may open up a bit. Fruit size and yield good, very firm and a tad puffy. Bleach could be an issue.	- / 6.5 / 7 (Avg 6.8)
SVTM9019	Rather vigorous spreading vine on the bed, with medium-dark foliage providing good cover. Firm plum-egg fruit with good colour. Variable size with some smalls. 5-10% green. Yield ok-good. Hint of bleach/breakdown. Did best at Site 3, where yield and fruit size were exceptional. Slight suggestion vine might open up and hint of bleach also.	6 (size and Conc)/ 6.5/7.5 (Avg 6.7)
SVTM9023	Vigorous spreading vine with dark leaves – some rolled. Taller and falling open at site 2. Blocky egg-pear fruit of variable size. Very firm, colour and yield ok, some dimples. Cover ok but might open up. 5-10% green. Later? Plot affected by water issue at Site 2. Opening up also at Site 3, with bleach/ break-down issues, green fruit and variable size also.	6.5/5.5/5.5 (Avg 5.8)

Table 14. Mid-season screening trial assessments

Cultivar	Comments	Rating (/10) Brix° [site1, site2]
SVTM9025	Medium spreading vine with light foliage (small leaves). Plum – round fruit – a few with points. Very firm with good colour. Plenty of small ones, medium yield, 5% green. Hard to rate due to irrigation issues. Better at site 2 – good yield. Fruit elongated plum-eggs. Some smalls still. Relatively large vine at Site 3, may fall over. Greens still suggesting later. Good size but medium yield and breakdown / bleach concerns.	- / 7.5 /5.5 (Avg 6.5) Brix° [--, 6.0]
UG16112	Medium/compact vine on the bed with large rolled purple leaves on top. Cover ok. Medium-large blocky egg-pear shaped fruit – slight dimple. Very firm, colour ok, a few puffy. Good concentration and yield. Holding. Still some leaf cover at Site 3, where fruit were a bit variable – most medium. Yield just ok and holding.	8 / 8 / 7 (Avg 7.7) Brix° [5.7, 5.3]
UG 16112:19406 Mix (40:60)	Standard Site 1 The 2 lines distinctly different, 16112 showing a compact vine with rolled leaves and larger fruit, 19406 a larger more vigorous vine with more greens. Good yield overall though, with all fruit firm with good colour.	7 (Site 1 only)
Site 1. Kagome Danckerts	Salty soil and a few root intrusion problems led to some blossom end rot and small fruit in some cultivars. Otherwise the site was fairly clean for weed and disease. Due for harvest within a week, most plots looked to have 5% or less green fruit. Quite a bit of big bud in some of the larger vines.	
Site 2. Weeks Smitts	A high yielding site despite some water issues leading to disease/leaf loss in a few plots. Vine training had also occurred in adjacent rows, affecting outer plots in the trial.	
Site 3. Kilter Tripcony	This block was largely defoliated (tomato russet mite?) and ready for harvest, with very few greens in evidence. Yields appeared moderate and some bleach and breakdown were clearly evident in some.	

Summary

Once again difficulties with seed importation restricted the range of varieties available for trial. In addition, this season's milder growing conditions may not have fully tested field storage, so it will be important to look at the more promising entries for at least another season.

Early Season

No significant differences were found between H1015 and SVTM9000 in the early season trials. Both varieties appear to have similar yield potential with the highest plot yield of either variety being around 160 tonnes per hectare. In general, this season SVTM9000 had a slightly lower °Brix but similar yield to H1015, which is the opposite to last season's trial results.

These two varieties have some differences in disease resistances with SVTM9000 having resistance to tomato spotted wilt virus and one of the causal agents of powdery mildew, whereas H1015 has resistance to bacterial speck, Alternaria stem canker, grey leaf spot as well as some tolerance to bacterial canker.

Mid-Season

Several varieties in this season's machine harvested trials showed promise. Once again UG16112 yielding well but tended to have slightly lower °Brix than H3402. During this season's cooler conditions its exceptional holding ability was not as critical as it has been in previous years.

HM58811 generally showed higher yields and °Brix than H3402 however its holding ability has not been fully tested by a hot season. The Seminis cultivars SVTM9023, 9024 and 9025 also look promising and have resistance to Fusarium wilt race 3 but were only included in a limited number of trials.

2021-2022 Season

Varieties of interest to the APTRC for continued assessment, subject to seed availability, are highlighted green in *Table 1*. In addition, four varieties in Heinz adaptor trials looked promising - namely H1996, H2020, H2010 and H2011.

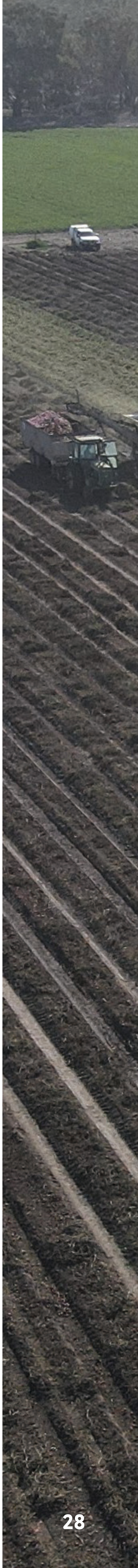
Other seed companies continue to support the APTRC's cultivar improvement program, putting new varieties up for quarantine testing each year. Difficulties with seed importation into Australia regularly delay or prevent seed arrival however, and the APTRC continues to work with seed companies and government authorities to address this problem, in the hope of obtaining this new material for testing under our challenging growing conditions.

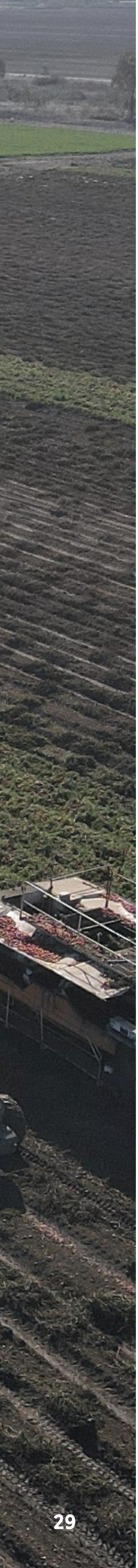
Acknowledgements

We are very grateful to participating growers, seed companies and processors for their co-operation and interest in the conduct of these trials.

Bill and Ann Screening Trials 2021

CV Trial Inspection 2021





2021 SPC Tomato Field Report

Andrew Ferrier, Field Manager, SPC

Although the end of 2020 saw two more grower retirements from the tomato industry, the improved canned tomato sales on the back of the COVID19 pandemic led to great optimism within SPC which resulted in a significant increase in contracted tonnage for the 2021 season. 46,500 tonnes were contracted with 5 growers across 407 hectares (71% transplant; 29% direct seed). For 2021; H3402 remained the main variety grown for SPC (357 Ha) with H1015 (37 Ha), UG16112 (4 Ha), and H1311 (9 Ha) making up the total area.

2020 included a more “normal” autumn, winter and spring, with much more favourable growing conditions for the 2021 crop. Transplanting began in the Rochester region at the end of September and continued through until the end of November, with direct seeding at Boort stretching from early October through until the end of November. Through September, October and into November, conditions were much milder than the previous year, however a run of 10-14 days in the mid to high 30’s in mid-November did cause some burn and sand blasting from high winds, even leading to one block requiring replanting as the young transplants suffered extreme damage in the conditions.

Whilst the beginning of the growing season appeared calmer than the previous year, November through December saw a return to the relentless windy conditions experienced in the season prior. This caused some physical damage to young tomato plants and contributed to areas of bacterial speck, while root disease issues also appeared across all growing regions. Apart from three days around 40°C in December, conditions remained mild throughout the summer. New Year’s Day saw storms across Victoria with one particularly bad one dumping 78mm and hail on SPC’s earliest paddock at Rochester, causing minor damage to the crop. Despite the lack of heat early and the constant wind, most tomato crops developed well, leading to quiet optimism of a good harvest.

Harvest began for SPC on the 8th of February, as scheduled, continuing through until the 16th of April. With perfect harvesting weather, a five-day delay whilst waiting for fruit to ripen in late February was the last thing that anyone wanted, but it was necessary. The first Boort paddocks were slow to ripen but after the break, harvest rates ramped up with yields matching or exceeding expectations. Harvesting conditions were exceptional until a rain event on the 20th of March, which dumped up to 50-60mm across all SPC areas over four days, delaying harvest for a week. The delay meant that, with Easter looming, growers were anxious about harvesting the remaining crop in a timely manner. As a result, harvesting and processing continued through the Easter weekend, (including Good Friday for only the second time in this author’s experience). Whilst conditions were difficult upon resumption, they did improve quickly, and harvest rates improved accordingly.

Due to material supply issues, SPC was forced to seek assistance from Kagome to complete the harvest, with the last 5,317 tonnes being processed at the Echuca factory. This meant that all remaining tonnes were able to be harvested and processed as close as possible to their ideal harvest window.

For season 2021; SPC processed 42,516 nett tonnes at the Shepparton plant and combined with the 5,317 nett tonnes processed by Kagome on SPC’s behalf, field yields averaged 118 MT/ha. Average brix for the season across all varieties was 4.980 Brix. ‘Culls’ were 2.3% with ‘regrades’ at 0.1% and ‘rejects’ at 0.5%. H3402 (87%) again accounted for the majority of tonnes processed, with H1015 (10%), UG16112 (1%) and H1311 (2%) making up the remainder.

The COVID19 threat remains a constant, and with further lockdowns predicted and stocks of canned tomato products expected to be exhausted by next season, SPC is looking forward to another strong season with an expected increase in contract tonnages for 2022. The future prosperity of the Australian Processing Tomato industry continues to rely on the support of the Australian public and their desire for locally produced tomato products. In a COVID affected world, this has never been more evident nor important.

Kagome Field Report – 2020-21

Chris Taylor: General Manager, Field Operations, Kagome

The 2020/21 tomato season started with some uncertainty for the industry, faced once again with significant issues relating to the importation of tomato seed. Such challenges have forced the industry to grow and put to trial some varieties it may not have previously considered, due to the dominance of the existing cultivars.

That said, we were able to fulfill our seasonal requirements using the main stayers we have become accustomed to; with Heinz H3402 still being the dominant cultivar with various mixing partners. United Genetics varieties UG16112 & UG19406 once again stood strong at the back end of the season, while Seminis SVTM9000 processed well for our early season cold break.

Kagome contracted 177,454 payable tonnes for the season and commenced planting on the 24th of September 2020, with its conventional grown tomato program in Northern Vic and Southern NSW. Organic tomatoes (H1014) were planted prior to the commencement of the conventional planting schedule with the expectation that they would ripen for harvest and processing first. Some minor delays occurred during the planting window with two main stoppages from rain, however wind also influenced planting efficiency through the duration of the planting period. Transplants again dominated (93%) the Kagome intake, with some direct seed grown produce (7%) coming from the Boort region.

COVID 19 played havoc through the entire tomato season from planting through to harvest. This added significant pressure and angst to an already stretched industry in terms of labour. While Kagome planned months ahead, we did face significant issues at the tail end of the harvest season to fill positions and source labour.

Processing started on the 2nd of February with conventional tomatoes from both NSW Kagome Farms and Kilter Rural (Lake Boga) to kick the season off. In a short, 5-day run, 12,000 conventionally grown tonnes were processed before stopping and allowing Kagome to process 2731 organically grown tonnes, then continuing with the remaining conventional crops. Strong crops and high factory efficiency saw Kagome harvest and process over 3,600 gross tonnes per day, before needing to stop on the 24th of February due to unripened fruit.

Recommencing on the 1st of March, Kagome experienced another solid run through to the 20th of March, when the industry received 25-50mm of rain across the growing regions. This significantly affected harvestability and throughput for both growers and processer and I thank everyone for their efforts to wrap the season up by the 19th of April.

Dice fruit quality was strong and in general fruit quality remained high for most of the season. Kagome finished with an average field brix of 5.04 and a grower yield range from 74 MT to 154 MT/ha.

It was great to see collaboration between Kagome and SPC, to enable the industry to harvest every hectare planted; with Kagome processing an additional 5,317 tonnes from SPC growers to make sure no fruit was left behind.

With the forecast of strong winter rains and storages filling in all exposed catchments, the industry can expect better water pricing for the coming 2021/22 season and hopefully some solid 2021 winter crop results.

I encourage everyone to stay safe and vigilant with our forever changing Covid situation and look forward to an even stronger 2021/2022 tomato season.