

Horticulture Innovation Australia

Final Report

WA Strawberry Improvement Program

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Western Australian Agriculture Authority (WAAA)

Project Number: BS10004

BS10004

This project has been funded by Horticulture Innovation Australia Limited with co-investment from the Strawberry Growers Associations of Western Australia Inc., Western Australian Agriculture Authority (WAAA), The Department of Agriculture and Fisheries (DAF) the strawberry levy, and funds from the Australian Government.

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ISBN 978 0 7341 3905 4

Published and distributed by:
Horticulture Innovation Australia Limited
Level 8, 1 Chifley Square
Sydney NSW 2000
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Summary

This project comprised part of the national strawberry breeding program which also has breeding projects located in Queensland (northern node) and Victoria (southern node).

New seed was imported annually into Western Australia (WA) from each of the northern and southern node breeding projects, germinated at South Perth and subsequently planted in the field at Wanneroo to evaluate under local growing conditions.

This project's concept, to grow and evaluate seedlings in the location where new selections would be used for commercial strawberry production, seemed logical and simple. However, the reality was much more challenging due to peaks in labour requirements not accommodated easily by reduction of available technical support, and the project's location over two sites – the nursery with glasshouses in South Perth and the trial site on a commercial property at Wanneroo, about 32km north.

The project began in early 2011 and was concluded in January 2015, reduced by a year due to severe over-summering casualties and labour issues.

The fruiting pattern in many of the selections from the southern node was unfavourable in Western Australia. Typically, the plants had barely any fruit until September, then produced a huge burst of undersize fruit. Seedlings from the northern node had a much better spread of flowering and wide variation in how the fruit was displayed.

Most of the southern node fruit lay flat on the black plastic whereas the fruit on a large proportion of the northern node plants was held aloft. These characteristics will be important considerations if robotic harvesting is introduced which relies on the majority of fruit hanging down.

In 2014, the southern node fruit size and shape changed dramatically for the better, but flavour and softness were disappointing. In that season the northern node presented three promising lines, but disappointingly most were lost over the hot summer period.

There were real signs of progress with several lines consistently outperforming Albion (our comparator) in terms of flavour. If the problem of over-summering could be solved and yields evaluated we might have some winners. However, each year when promising lines were carried forward we saw a major decline in fruit size and shape in the following season. This is a concern and may indicate more work is required to determine if this is simply the result of heat stress over summer or if some other processes or conditions are required for successful vegetative propagation.

Keywords

Strawberry; breeding program; variety selection; northern node; southern node; short-day; day-neutral; robotic harvesting; seedlings; runnering; tipping; advanced lines; heat stress; flavour; *Fusarium*; *Gnomoniopsis*.

Introduction

Western Australia has the third largest strawberry industry in Australia by volume and value after Queensland and Victoria, with about 270ha grown commercially. Camarosa has been the dominant variety for several years but its share is declining in favour of Festival. These are both short-day varieties. Day-neutral varieties have changed from a mix of Selva, Diamante and Aromas in 2004 to a combination of Albion and San Andreas in 2014, almost all grown in the Albany/Mount Barker area.

All of these varieties are products of the University of California (UC) or University of Florida (UF) breeding programs and are well adapted to production locations near Perth (32 degrees south latitude) and near Albany (35 degrees south). There has been almost no penetration of Australian-bred varieties in WA since Kiewa in 2004 despite WA being a regional evaluation site for the Temperate (Victorian Department of Primary Industries) breeding program since 1992.

Possible reasons for this low level of adoption of Australian-bred varieties include:

1. UC varieties are well adapted to WA's Mediterranean climate due to breeding and selection in a similar climate in California.
2. The population of new short-day (SD) selections evaluated annually from the former Temperate breeding program was too small at 40–80 annually to identify superior material.
3. New short-day selections from the former Temperate program for evaluation in WA were derived from a population of 250 plants that had already been selected from a mass population of 7000 seedlings in Victoria. It is likely that this first selection rejected many that may have been well adapted to a Mediterranean climate.
4. Runners of new short-day selections almost always arrived too late (May) for fair comparison with UC commercial varieties in field evaluation plots.
5. The evaluation process for day-neutral (DN) varieties in WA tested even fewer selections than the SD program, relying on the assumption that advanced selections that performed well in Victoria would do so also in Albany. This may have been false, given the relative success of Albion in Albany compared with Victoria.

This project aimed to address these weaknesses by growing seed directly from both the northern and southern node breeding projects at Wanneroo, the major strawberry Western Australian growing area, and selecting and evaluating progeny at an early stage.

Methodology

All seed received for germination from Queensland (northern node) and Victoria (southern node) was scarified prior to planting by immersion in concentrated sulphuric acid for 8 minutes followed by rinsing with water. About 500 seeds (maximum) per tray were planted by scattering on the surface of the soil-less media (peat/sand/perlite).

To be ready for planting out at the appropriate time, seed was sown in early to mid-January each year. Seedlings were progressively pricked out into 42-cell plug trays when they had a minimum of two true leaves and grown on in the DAFWA South Perth nursery before planting out in the field at Wanneroo in April/May.

Each year seedlings were evaluated for a range of parameters including plant vigour, disease susceptibility and the fruiting characters of productivity, flavour, shape, firmness and colour. Fruit was assessed weekly and superior plants tagged using bamboo stakes. Plants that were obviously inferior were removed as the season progressed for easier management.

Each year some lines did not flower at all and were also removed. At the end of each season the best performing seedlings were held over for runnering, so approximately five plants of each could be planted out for more detailed assessment the following season.

2011

The project was offered a small amount of seed from the northern node for a 'practice run' at the end of 2010. That seed was germinated, grown on and planted out on 7 April 2011. The total planting comprised 362 seedlings from this seed plus an additional 75 plants, also from the northern node, grown from seed supplied in 2009 (see Appendices, Table 1). The additional plants had been grown in pots at DAFWA Albany during 2010 and then moved to South Perth for propagation and planting out with the other seedlings in 2011. These seedlings were from crosses of 04.290 x 06.219, 06.219 x 06.262, 07.295 x 06.019 and 06.079 x 04.097.

We provided detailed feedback on each line to help guide the breeders. The date of first flowering was recorded and fruit was assessed at least twice before any line was discarded.

2012

Seed from both the northern and southern nodes was sown on 9 January 2012. The northern seed was slower to germinate and some lines had very low germination rates.

The trial experienced an outbreak of fungus gnats followed by some damping off which was treated with Vecto-Bac[®] and Banrot[®], but plant losses meant numbers were down on expectations. To increase numbers we supplemented with seedling plugs sent from the southern node in March (Appendices, Table 2).

A total of 2662 seedlings were planted out (885 from the southern node, 192 from the northern node and the balance of 1585 seedlings sent direct from the southern node) on 2–3 May 2012 under Haygrove tunnels (Appendices, Table 3).

Assessments for the 2012 season concluded on 6 November as all fruit was then small and there was a very high incidence of damage from western flower thrips.

2013

Seed was received as indicated in Tables 4 and 5 (Appendices) from the southern and northern nodes and planted out in the week beginning 14 January.

Seedlings were planted out (3875 from the southern node and 3022 from the northern node) on 18–19 April 2013 and left uncovered. The incidence of *Botrytis* and rain proved quite damaging in the early part of the growing season, not helped by the wettest September in 90 years.

Three advanced lines bred by Bruce Morrison, the previous breeder, were also planted, together with 16 lines carried forward from 2012.

2014

Seed was received as indicated in Tables 6 and 7 (Appendices) from the southern and northern nodes. Seed from the southern node arrived in two batches and was planted out in the weeks beginning 6 and 20 January.

Germination was good and 4875 seedling lines (3386 plants from Strawberries Australia Incorporated (SAI), Victoria, and 1489 plants from Department of Agriculture, Fisheries and Forestry (DAFF), Queensland, were planted out on 29 April 2014. After our experiences with problems from not using cloches in 2013, cloches were placed over the plants as soon as flowering and fruiting commenced. Assessments started at the end of July.

Survivors among the seedlings selected during 2013 were planted back into the field for the 2014 season. In addition, a few plants had runners that had been potted up, and these were also planted out (Appendices, Table 8). Any mother plants big and healthy enough were split into two (Appendices, Table 9).

Outputs

2011

Overall plant performance was satisfactory. There were some very prolific lines and generally fruit display and productivity were acceptable. Excessive berry softness and poor flavour were responsible for most discards. Some lines proved extremely susceptible to powdery mildew, and *Gnomoniopsis* and *Fusarium* also caused plant losses.

At the end of the 2011 season there were no suitable plants from the 2009 seed batch to go forward. Six seedlings, two each from families 3065, 3071 and 3229 from the 2010 seed, rated an average of 3 or higher (on a scale of 1–5) for flavour over the season and scored reasonably well on other parameters. As a 'practice run' for the next season, the plants were transferred from the field into pots in late November for runnering and tip propagation. They were very slow to produce runners and we considered whether it might be worth taking the best lines out earlier in the season to try and get better runner production. None of these vegetatively-propagated plants was intended to be assessed the following year.

2012

Many lines were again late to fruit. The season was largely disappointing as there were no seedlings close in flavour or other quality characteristics to current commercial lines. A summary of results can be found in Table 10 (Appendices). From the progressive comments it can be seen that for some lines flavour improved as the season progressed, while for others it declined. One line had some interesting flavours but the berries were small. Given the poor start to the season, we shortlisted the best 20 lines for further evaluation in 2013. Unfortunately, fusarium crown rot was suspected as killing some plants, including both selected northern lines, so there were only 16 lines (Appendices, Table 11) from the southern node remaining. Each plant was dug out and taken back to the South Perth nursery for runnering and tip propagation for the 2013 season.

Each plant was divided into three to five crowns, transplanted into pots and placed under fog until recovered. They were then moved out to the climate-controlled nursery under overhead watering until the canopy covered the pot area, when they were placed on drippers and kept in the nursery for tipping. This worked well, but even with the few lines we had, nursery space was becoming scarce as the plants need to be spaced widely for runnering.

Advanced lines

The project received two batches of 30 plants each of 10 advanced lines from the southern node which were being evaluated in all states using the same scoring system. One batch was planted at Wanneroo and the other at Albany.

At Wanneroo, three lines (BM1201, BM1202 and BM1203) started fruiting early with excellent berry size and flavour – close, if not equal to Albion, the comparator, but soon became misshapen with poor taste. This tends to indicate that they are unsuited to the warm WA climate. Several other lines were late to fruit but improved as the season progressed.

We selected three lines (BM1202, BM1203 and BM1209) for further evaluation at Wanneroo in 2013. Those were taken to the greenhouse at South Perth for propagation by tips to avoid the problem of late arrival, which may have affected their productivity in 2012.

None of the Albany lines showed enough promise to be worthy of further evaluation. The weather was wet early in the season then very hot in January, so growing conditions overall were difficult there.

The project team thought it might re-evaluate all 10 lines at Manjimup (slightly colder climate) in 2013 with runners to be supplied from Wandin, Victoria, however after discussion with the breeder decided not to proceed.

2013

The pattern of fruiting from most southern node lines was again late, with most ripening in a small time window. Presumably due to the volume of fruit, they were mostly small. Most fruit lay flat on the plastic unlike northern node fruit that tended to be held in the air, above the plastic. The northern node lines, in general, fruited earlier and more steadily, but some did not fruit at all and were culled.

Table 11 (Appendices) shows the status of all lines as at 4 October 2013 where SAI indicates Strawberries Australia Incorporated as the source and DEEDI refers to the former Department of Employment, Economic Development and Innovation in Queensland, later the Department of Agriculture, Fisheries and Forestry (DAFF) and now the Department of Agriculture and Fisheries (DAF).

Only one of the northern subtropical lines was discarded, whereas most of the higher chilling lines were not performing well enough to be retained. As at 4 October 2013, the selection rate for seedlings from the southern node was 0.9%; for the high chill varieties from the northern node 1.5%; and for the subtropical node varieties 3.3%. If the higher chill seedlings had been raised in Victoria they might have performed better, however the aim of this project was to produce seedlings that could be propagated under WA conditions.

Some lines (all from SAI) from 2012 were also planted out for further assessment. While they had no outstanding features they were better than the rest and due to the poor start of the previous season it was felt worthwhile at least to test the protocol for holding lines over the summer period.

They proved to be highly susceptible to the prevailing weather conditions and virtually no marketable fruit was harvested from any of them. A summary of the results is shown in Table 12 (Appendices).

Overall, 2013 was a better season than 2012, although in hindsight, planting without weather protection was not wise. The results raise the question of whether it is worth persevering with high chill lines. Germination was good and 4875 seedling lines (3386 plants from the southern node and 1489 plants from the northern node) were planted out on 29 April 2014. After our problems from not using cloches in 2013, cloches were placed over the plants as soon as flowering and fruiting commenced. Assessments started at the end of July.

Seedlings carried forward from 2013

There was significant attrition among the seedling lines that were held back at the end of 2013. We did expect to lose some to *Fusarium* as the season advanced, but heat may have been the major factor. We had intended to leave the seedlings in place for tipping, but the owner of the Wanneroo site had leased much of the property to another grower which meant the plants had to be moved to one end.

Given that about 90 plants were involved it would have been beyond our capacity to move them all to the nursery at South Perth as we had done in 2011 and 2012, due to space constraints. Instead, the seedlings were dug up on 17 December, transferred to pots and placed on pallets under trees in shade. They were not divided. After initial hand-watering they were placed under very low pressure overhead sprinklers to settle them in, and after a few days moved onto newly-formed beds on black plastic with one dripper per pot.

By that stage we had already lost about 25 lines in the field and losses continued. Table 13 in the Appendices shows about half the number of lines originally staked survived the summer and few were healthy enough for tipping.

2014

The pattern of fruiting from most of the southern node lines was again late with most available over a short period. Most of the fruit lay flat on the plastic unlike the northern node fruit that tended to be in the air, off the plastic. The northern node lines in general fruited earlier and more steadily. The selection rate for seedlings from the southern node was 1.18%, and for the subtropical node varieties, 4.43% (Appendices, Table 14).

The lines from 2013 that were planted out for further assessment were generally of poor size and shape. However, given the heat stress these lines suffered in January 2014 it may be that they were not performing as well as they could and it was intended to re-propagate and plant out again in 2015.

For the 2014/15 summer, the staked seedlings were left in situ, however over that period we again experienced heavy losses. By 20 January 2015 all of 3845, the most promising line, had been lost as had substantial amounts of 3758 and 3764. (Figure 1 shows two of these lines in September 2014.) Given this, we decided to terminate the project and not proceed with tipping and the 2015 season evaluation.



Figures 1. Examples of fruit from promising lines 3845 (left) and 3758 (right) at 11 September 2014

Outcomes

For reasons not yet determined we consistently had disappointing performance from lines staked as promising in the previous year, that is in 2011, 2012 and 2013. Over the summer periods in 2012/13 and 2013/14 we also had significant attrition from lines that had been staked in the previous season.

Over the 2014/15 summer we lost all of the best line and about half of all the others so it was decided to terminate the project one year early. Therefore, there are no lines remaining from this project for further evaluation.

Evaluation and Discussion

Some valuable lessons were learnt in terms of both the experimental outcomes and the logistics of running this project, especially within the changing bureaucratic environment. These issues will require consideration by anyone continuing this project or a similar one in Western Australia.

Experimental

Fruit from the **southern node** achieved a consistently lower rate of staking (denoting superior potential) throughout the project.

Fruiting occurred in a dramatic peak and in all years except 2014 the fruit was small. In 2014, fruit size and appearance were much better, in fact excellent, but were let down badly in terms of taste and firmness.

Lines from the **northern node** had a much better spread of flowering and wide variation in how the fruit was displayed. Where most of the southern node fruit lay flat on the black plastic, for many of the northern node plants a large proportion of fruit was held aloft (Figure 2).

These characteristics will be important considerations if robotic harvesting is introduced as it relies on most fruit hanging down.



Figure 2. Examples of the range of fruit display characteristics showing plants with all fruit lying on the plastic from the southern node (left) compared to plants with fruit held aloft from the northern node (right)

Firmness was a positive feature of several northern node lines, and in general, flavour was better. The 2014 season showed one outstanding line, 3845, which had superb flavour and was relatively firm.

Logistical factors

This project required relatively large amounts of labour at discrete points in time – something that was difficult to accommodate at DAFWA in the current economic climate. Sowing seed is not difficult, although stratifying seed in concentrated sulphuric acid requires use of a fume cupboard and protective equipment under occupational health and safety (OHS) regulations.

A relatively large irrigated greenhouse was required for the seedling trays and additional space (outside) once they were pricked out into cell trays. Ideally, the reticulation on those areas should be monitored, if not controlled remotely, in case of breakdowns on weekends and after hours. This may be accomplished more easily in a commercial setting.

Pricking out was a time-consuming exercise over several weeks, ideally requiring more than one person. Planting was another major operation, needing a team of people with strong backs.

Once flowering started and then fruiting, assessment could begin, and was done weekly. Over this time plants needed to be clean and tidy and all over-ripe fruit removed. This became extremely onerous as the weather warmed up in September and October.

The resources allocated to this project were 30% of one professional officer and 20% of one technical officer. Given the technical officer had ongoing commitments to two other projects, it was virtually impossible and in any case impractical, to accommodate the labour peaks in an ideal manner. Holidays and compulsory training, over which we often had little or no control, were also issues that affected timing of operations.

Basing the project at two locations also presented difficulties. With the nursery operations at South Perth and the trial site at Wanneroo, all seedlings had to be transported to the trial site for planting. This required hiring a suitable truck (and having a driver with the appropriate licence) and the use of racks on which to put the trays.

Fortunately, we were able to borrow the picking racks from the trial site owner – so two trips were required to Wanneroo and back on that day, one to pick up the racks and the other to deliver the trays and unload.

At the end of each season the dilemma was what to do with the staked plants to carry forward. Three choices were:

1. Leave them in the ground. This meant a large area was essentially removed from production, could not be fumigated and had to be irrigated and fertilised as before, as the staked plants were dotted over the whole planting area.
2. Transplant the staked plants into large pots and leave in situ.
3. Take the staked plants back to South Perth where they could be maintained and allowed to runner. With up to 100 plants staked by the end of the year, transplanting and then transporting them was a major exercise – and removed a significant amount of soil from the trial site. Once the plants started to runner in the nursery they needed a lot of space or became tangled and unmanageable, especially at tipping time. One square metre per plant was probably a minimum requirement.

Over the term of the project we tried all three options:

1. Leaving in the ground was judged as inefficient and impractical.
2. Leaving them in the field over summer in pots (regardless of irrigation), was disastrous.
3. Uprooting plants and returning them to South Perth was the only one that was moderately successful.

Clearly, they were unable to withstand the heat when they carried so much leaf area, especially on black plastic or in black pots sitting on black plastic.

When this project was conceived, it included a component that involved screening lines for *Fusarium* tolerance. In the first year we assumed the losses in the field after the end of the season were due to root or crown rot but later experience suggested heat stress may have been the primary cause of death. In any event, the *Fusarium* screening activity was not required and was removed from the project.

Later examination of temperatures over summer in each of the three project nodes (Appendices, Tables 16 and 17) did not show consistent significant differences in either average daily maxima or in the maximum monthly temperature recorded, so some clarification of the reasons for the high failure rate over summer may be needed.

Recommendations

If WA growers decide to continue to support the national breeding program decisions need to be made with respect to staff, facilities and funding. It is likely a new location for the work will need to be found in WA and that location will need nursery facilities as well as land for growing on the lines each season.

A grower's property would be ideal as the systems are in place for commercial crop husbandry. Dedicated staff would be needed, as well as the flexibility to cope with peak workloads. It is unlikely that DAFWA staff will be available in future.

Given the above conditions of dedicated nursery space and adequate staff, the carryover of lines from one year to the next should not be so problematic, which was a major reason for ending the project a year ahead of schedule.

Scientific Refereed Publications

None involved.

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Intellectual Property/Commercialisation

No commercial IP generated.

Acknowledgements

This project was initiated by the Department of Agriculture and Food, Western Australia in conjunction with the Strawberry Growers Association of Western Australia Inc.

The project was jointly funded by:

- The Department of Agriculture and Food, Western Australia;
- Horticulture Innovation Australia;
- Strawberries Australia Inc; and
- the Agricultural Produce Commission Strawberry Producers Committee (which imposes a fee for service on fruit sold).

Special thanks are due to Gerry Verheyen, on whose property the field trials were located and who provided the day-to-day management of the site, and to DAFWA technical officers Tony Shimmin and Chris McMullan.

The support, advice and cooperation from interstate collaborators including Mark Herrington, Bruce Morrison, Hinga Marsh, Patricio Brevis, Karen Spencer and Louella Woolcock is also greatly appreciated.

Appendices

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Table 1. Lines grown from seed supplied from the northern node and planted for assessment in 2011

Line	No. planted	Line	No. planted
3059	5	3080	63
3064	5	3093	14
3065	13	3094	29
3069	7	3223	26
3071	95	3229	64
3072	33	3231	8

Table 2. Supplementary seedlings sent to WA in March 2012 from southern node

2011 short-day seedlings			2011 day-neutral seedlings		
Line	Cross	No.	Line	Cross	No.
11-036*	W7 x W13	168	11-042*	W3 x W2	42
11-037*	W9 x W10	168	11-043*	W4 x W1	84
11-038*	W10 x W5	168	11-044*	W12 x W5	84
11-001	W1 x W1	84	11-047	W2 x W17	42
11-002	W1 x W7	42	11-064	W17 x W19	84
11-003	W1 x W8	42	11-066	W17 x W21	42
11-004	W1 x W14	84	11-070	W18 x W19	42
11-005	W1 x W9	42	11-079	W19 x W12	84
11-006	W1 x W11	42	11-081	W20 x W21	42
11-007	W1 x W13	84	11-083	W20 x W12	42
11-008	W1 x W16	42	11-086	W21 x W12	42
11-009	W7 x W7	42	11-088	W22 x W12	42

* = speculative cross

Table 3. Numbers of seedlings planted out in 2012

Line/Cross	Alternate designation	No.	Line/Cross	Alternate designation	No.
29 (ex Qld 3071 from 2010)		2	W7 x W13	11-036	164
45 (ex Qld 2010 3229/61)		2	W7 x W7	11-009	41
155 (ex Qld 2010, 3229/9)		4	W8 x W2		24
3330		13	W9 x W10	11-037	151
3331		33	W10 x W5	11-038	61
3343		3	W11 x W5		223
3345		36	W11 x W6		89
3360		46	W12 x W5	11-044	142
3427		9	W12 x W8		26
3448		45	W13 x W1		23
3460		7	W13 x W11		81
W1 x W1	11-001	74	W13 x W9		9
W1 x W7	11-002	39	W14 x W13		18
W1 x W8	11-003	28	W17 x W19	11-064	69
W1 x W14	11-004	77	W17 x W21	11-066	76
W1 x W9	11-005	20	W18 x W19	11-070	75
W1 x W11	11-006	29	W19 x W12	11-079	36
W1 x W13	11-007	36	W20 x W12	11-083	160
W1 x W16	11-008	40	W20 x W21	11-081	21
W2 x W17	11-047	130	W21 x W12	11-086	67
W3 x W2	11-042	66	W22 x W12	11-088	129
W4 x W1	11-043	238			

* These lines were held over from the previous year.

Table 4. Seed received and seedlings planted in the field from southern node in 2013

Cross type	Female parent	Male parent	Notes	Approximate seed number	No. planted
DN	01-061-311	05-014-134	Cross ID 12-018	1000	68
DN	01-061-311	07-102-41	Cross ID 12-023	1000	320
DN	05-058-36	05-069-63	Cross ID 12-045	1000	445
DN	05-058-36	06-046-142	Cross ID 12-046	1000	170
DN	05-069-63	06-046-142	Cross ID 12-049	1000	670
DN	05-069-63	07-095-35	Cross ID 12-050	1000	0
DN	05-069-63	07-102-41	Cross ID 12-051	1000	10
DN	06-046-142	07-102-41	Cross ID 12-053	1000	472
DN	07-095-35	06-050-202	Reciprocal of 12-054	500	19
DN	07-102-41	06-050-202	Reciprocal of 12-055	500	100
DN	07-095-35	08-022-42	Reciprocal of 12-056	1200	811
DN	07-102-41	08-022-42	Reciprocal of 12-057	800	290
DN	07-095-35	08-029-80	Reciprocal of 12-058	800	300
DN	07-102-41	08-029-80	Reciprocal of 12-059	500	200
Total				12,300	3,875

Table 5. Seed received and seedling numbers planted in field from northern node in 2013

Line	Seed number (approx)	Number planted
3546A	150	21
3590A	50	70
3591A	125	140
3593A	75	112
3624A	150	32
3627A	50	55
3628A	200	160
3629A	125	80
3630A	250	91
3631A	125	227
3661A	20	17
3662A	125	125
3663A	100	87
3664A	50	100
3665A	125	170
3666A	75	72

Line	Seed number (approx)	Number planted
3667A	125	84
3668A	50	100
3669A	25	81
3670A	50	26
3679A	125	60
3507P	150	32
3515P	200	180
3516P	200	32
3517P	350	268
3680P	150	310
3695P	100	83
3696P	100	144
3698P	25	80
Total	3445	3022

Note: Numbers followed by A = higher chill
 Numbers followed by P = subtropical.

Table 6. Seed received from southern node for 2014 season

Crosses SD x SD	Approx seed no.	Crosses SD x DN	Approx seed no.
W13-1	500	W13-4	500
W13-2	500	W13-6	500
W13-29	1500	W13-8	300
W13-30	1000	W13-9	500
W13-31	1500	W13-10	500
W13-32	2000	W13-11	400
		W13-12	500
		W13-14	500
Crosses SD x DN			
W13-22	500	W13-15	500
W13-23	500	W13-16	500
W13-24	500	W13-17	500
W13-25	500	W13-18	500
W13-26	300	W13-20	500
W13-27	500	W13-21	300

Table 7. Seed received from northern node for the 2014 season

Cross	Approx seed no.
3758	250
3764	250
3765	250
3831	250
3832	250
3838	250
3842	250
3843	250
3845	250
3846	250

Table 8. Summary of tips planted May 2014

Cross	Seedling	Plant numbers at beginning of season	Plant numbers at end of season
R12-057	A	3	2
R12-058	C	3	2
R12-058	D	2	2
R12-058	A	4	1
R12-058	B	2	2
3517	A	3	2
3517	B	3	2
3628	A	2	2
3696		5	0

Table 9. Mother plants planted in May 2014 for second season assessment and runnering

Cross	Seedling	Plant numbers at beginning of season	Cross	Seedling	Plant numbers at beginning of season
R12-023	A	2	3517	A	1
R12-023	B	2	3517	B	1
R12-049	A	2	3517	C	1
R12-049	B	2	3517	D	1
R12-049	C	2	3517	E	1
R12-053	A	2	3628	A	1
R12-053	B	2	3628	B	1
R12-053	A	4	3628	C	
R12-056	A	2	3629		
R12-056	B	2	3631		1
R12-057	A	2	3661		2
R12-057	B	2	3680	A	1
R12-057	C	2	3680	B	2
R12-058	B	2	3680	C	2
R12-058	C	2	3695	A	2
R12-058	D	2	3695	B	2
R12-058	E	2	3696		1
R12-058	F	2	3698		1
R12-058	G	2			

Table 10. Summary of fruit assessment over 2012 season

Line	Code	No. of stakes	Progressive comments
29 (ex Qld 3071 from 2009)		0	Large fruit, misshapen, flavour below-average, nice texture, a bit bland, below-average, watery, low sugar, no good, firm, colour good, shape good, sweetness, firm, average taste, fibrous
45 (ex Qld 2009 3229/61)		0	Long fruit, white shoulders, firm, taste below-average, no fruit ready to eat, maybe next week, bland, below-average, watery, low sugar, bland, tasteless, no good, firm, colour good, shape good, below-average
155 (ex Qld 2009, 3229/9)		1	Big white shoulders, bad shape, taste average, very firm, flavour no good, below-average, watery, low sugar, firm, acidic, some okay, close to average for taste and other qualities, sweetness and astringent, firm and fibrous
3330		0	No ripe fruit as at 11 Sept
3331		0	Poor watery taste, tasteless, watery, misshapen, bland, firm, sugarless, no good, bland, sugarless, firm and poor taste, bitter, no sugar, plenty of fruit now
3343		0	No ripe fruit as at 11 Sept
3345		0	One suspected <i>Fusarium</i> , firm, powdery mildew, pithy, floury, very poor, mealy, dry, tasteless, watery, some dry, prolific flowers and fruit, diseased leaves and fruit, bland, watery, plenty of fruit, misshapen fruit
3360		0	Two plants with <i>Fusarium</i> , watery, soft, no sugar, misshapen, bland, average flavour, firm, okay, sweetness, soft, bad taste, some firm, bland, no sugar, not good
3427		1	Watery, some flavour, some sugar, average taste, flowery, powdery mildew, sugar/acid balance, soft, taste okay
3448		2	Small amount flowering, no ripe fruit, plenty of fruit, firm, started out bland, sugarless, firm, tasteless, astringent, good shape, but taste improving with time
3460		1	Watery, fair taste, slightly soft, good flavour, small fruit, okay, about average sweetness & flavour
W1 x W1	11-001	0	No good, soft, bland, no sugar, misshapen, badly misshapen fruit, sugarless, misshapen, some sweetness in some, poor taste, misshapen
W1 x W11	11-006	0	First fruit colour below-average, taste, shape okay, a bit watery, some flavour, some no flavour, firm, flowery, watery, variable, good shape, conical firm, potential for good flavour, soft, watery, bland, soft, misshapen, bland, sugarless, watery, astringent

Line	Code	No. of stakes	Progressive comments
W1 x W13	11-007	3	First fruit orangey, globular, seedy, flavour below-average, texture soapy, below-average, texture good, tasteless, sour, watery, acidic, one has some sugar, flavour okay (one to watch), some good, some bad, bit soft, plenty of fruit, good shape, some no good, average taste, a bit soft, some good flavour, some ugly fruit
W1 x W14	11-004	7	Fruit, flavour, shape, colour all average, conical, some powdery mildew, some mealy some not, taste average, not very sweet, large fruit, wedge shape, prolific flowers, watery, soft, flavour below-average, some sweetness, bland, variable, mix of soft and firm fruit, watery, sugarless, misshapen, some are good, tasteless
W1 x W16	11-008	5	Small, globular, soft, tasteless, fruit some hidden, below-average flavour, mealy, poor taste, not good, soft, taste okay, soft, prolific flowers, some good, some bad, plenty of fruit, good shape, watery, some sugar in some, some okay, some misshapen, plenty of fruit, small fruit, soft, tasteless, misshapen
W1 x W7	11-002	0	One possible <i>Fusarium</i> , mealy, poor taste, not a good berry, no taste, soft, some firm, watery, no good, prolific flowers and fruit, watery, soft, bland, misshapen, soft, some flavour, tangy, sour, plenty of fruit, some poor, misshapen, watery, bland, a little bit of sugar in some, soft
W1 x W8	11-003	0	Poor shape, below-average taste, odd shape, unusual neck, taste okay, some good and some bad, misshapen shoulders, floury, sweet, firm, watery, soft, poor taste, prolific flowers and fruit, firm, watery, bland, plenty of fruit, misshapen, bland, sugarless, tasteless, plenty of fruit
W1 x W9	11-005	1	Firm, orange colour, poor flavour, tasteless, watery, no sugar, bland, watery, not good, not good, astringent, watery, tasteless
W10 x W5	11-038	0	Bad powdery mildew, poor taste, bland, watery
W11 x W5	11-039	1	Early fruit very soft, taste okay, floury, very pale, pink colouring, flavour below-average, many runners, no fruit, powdery mildew, one plant okay and tagged, no flowers, no fruit, no good, some okay, soft, no good, misshapen watery, bland
W11 x W6		0	Many runners, no ripe fruit at 11 Sept, powdery mildew
W12 x W5	11-044*	0	No ripe fruit as at 11 Sept

Line	Code	No. of stakes	Progressive comments
W12 x W8		0	Powdery mildew on a number of plants, very compact, protruding seed, perfumed, taste not good
W13 x W1		1	Watery, soft, tasteless at first but sugar and flavour improving over the season
W13 x W11		2	Plenty of powdery mildew, sour, misshapen, some flavour, good sugar, okay taste, some sweetness & flavour, average
W13 x W9		0	No ripe fruit as at 11 Sept
W14 x W13		0	No ripe fruit as at 11 Sept
W17 x W19	11-064	1	Late to fruit, firm, some sugar, average flavour, below-average taste
W17 x W21	11-066	2	<i>Fusarium</i> on one plant, tasteless, watery, some taste, okay, a little bit soft
W18 x W19	11-070	0	Fruit firm, seedy
W19 x W12	11-079	0	No ripe fruit as at 11 Sept
W2 x W17		1	Fruit watery, poor taste, tasteless, watery, soft, no sugar, some pale in colour, white inside
W20 x W12	11-083	0	Late to fruit, soft, watery, some sweetness, only one ripe fruit average, watery, firm
W20 x W21	11-081	0	No ripe fruit as at 11 Sept
W21 x W12	11-086	1	Late to fruit, sour, no taste, no good
W22 x W12	11-088	0	No ripe fruit as at 11 Sept
W3 x W2	11-042*	0	Late to fruit, watery, no sugar, acidic, tasteless
W4 x W1	11-043*	0	No ripe fruit as at 11 Sept, powdery mildew, <i>Fusarium</i>
W7 x W13		5	Early to fruit, conical, started out tasting good, firm but becoming watery later
W7 x W7	11-009	0	Conical, slightly floury/mealy, soft, watery, tasteless, misshapen, bland
W8 x W2		0	Late to fruit, early fruit seedy and tasteless, getting better
W9 x W10		1	Early to fruit, conical, orangey, average firmness, seed on fruit germinating and producing leaves. Generally bland/watery, couple of plants with <i>Fusarium</i> and powdery mildew

* = speculative cross

Table 11. Summary of lines retained to go forward to 2013 season

Cross	Alternate designation	No. of stakes
W1 x W14	11-004	4
W11 x W5	11-039	1
W13 x W1		1
W17 x W21	11-066	1
W20 x W12	11-083	1
W1 x W16		3
W7 x W13		5

Table 12. Status of lines as at 4 October 2013

Line (SAI)	No. planted	No. staked	Line (DEEDI)	No. planted	No. staked	Line (DEEDI)	No. planted	No. staked
12-018*	68	0	3507P	32	0	3663A*	87	0
12-023	320	5	3515P	180	4	3664A*	100	0
12-045*	445	0	3516P*	32	0	3665A*	170	0
12-046	170	0	3517P	268	14	3666A	72	1
12-049	670	3	3546A*	21	0	3667A*	84	0
12-051*	10	0	3590A	70	3	3668A*	100	0
R12-053*	472	0	3591A*	140	0	3669A*	81	0
R12-054	19	0	3593A*	112	0	3670A*	26	0
R12-055*	100	0	3624A*	32	0	3679A	60	3
R12-056	811	8	3627A	55	7	3680P	310	7
R12-057	290	9	3628A	160	7	3695P	83	2
R12-058	300	10	3629A	80	3	3661A	17	0
R12-059*	200	0	3630A*	91	0	3696P	144	3
			3631A	227	4	3698P	80	7
			3662A*	125	0			
Total	3875	34		1625	42		1397	23

* Lines culled for non-performance

Table 13. Assessment of lines held over from 2012

Line	No. berries picked	Weight (g)	Flavour	Firmness	Quality	Colour	Internal colour	Comment
BM1202	61	1146	1.3	2.5	1.0	1.5	1.8	<i>Colletotrichum, Botrytis</i> , unmarketable
BM1203	70	2008	2.4	3.2	1.9	2.6	2.4	Seedy, misshapen, firm, large, acidic, no sugar, tasteless, unmarketable
BM1204	119	2998	2.3	2.0	1.8	2.3	2.6	Seedy, misshapen, soft, <i>Botrytis</i> , unmarketable
W1 x W14	79	2088	2.0	3.3	2.0	2.5	2.5	First berry 20 June. Ugly fruit, firm with good taste early then becoming tasteless. <i>Botrytis, Colletotrichum</i> , unmarketable
W1 x W14 (1)	72	1642	2.2	2.1	1.8	2.5	2.4	Varied size and shape, pale in colour, acidic, soft, <i>Botrytis</i> , unmarketable
W1 x W14 (3)	66	1568	1.7	1.7	1.4	1.6	1.7	Elongated, big shoulders, <i>Colletotrichum, Botrytis</i> , unmarketable
W1 x W14 (4)	30	745	2.5	2.3	1.8	2.3	2.3	Misshapen, elongated ugly fruit, <i>Colletotrichum</i> , unmarketable
W1 x W16 (1)	120	1777	2.5	1.8	1.5	2.3	2.3	Sweet, good taste but soft, white shoulders, <i>Botrytis, Colletotrichum</i> , unmarketable
W1 x W16 (2)	77	1050	2.7	1.7	1.7	2.3	2.5	Mealy, soft, small, seedy, <i>Colletotrichum, Botrytis</i> , unmarketable. Started out sweet but became tasteless
W1 x W16 (3)	97	1620	2.4	2.1	1.9	2.8	2.5	Highly variable in size, misshapen, no sugar. <i>Colletotrichum, Botrytis</i> , unmarketable
W1 x W16 (3)	94	1809	1.8	1.7	1.3	1.5	1.8	Misshapen, no sugar, white shoulder, <i>Colletotrichum, Botrytis</i> , unmarketable

Line	No. berries picked	Weight (g)	Flavour	Firmness	Quality	Colour	Internal Colour	Comment
W1 x W16 (5)	58	973	2.0	3.0	2.0	2.0	2.0	Acidic, misshapen, <i>Colletotrichum</i> , <i>Botrytis</i> , white shoulder, unmarketable
W7 x W13 (1)	40	552	2.5	2.3	1.8	2.3	2.5	Elongated fruit, seedy, no sugar, <i>Colletotrichum</i> , unmarketable
W7 x W13 (2)	42	658	2.8	2.3	2.5	2.3	2.3	No sugar, <i>Colletotrichum</i> , <i>Botrytis</i> , unmarketable
W7 x W13 (3)	31	374	-	-	-	-	-	No sugar, <i>Colletotrichum</i> , <i>Botrytis</i> , unmarketable
W7 x W13 (4)	65	1333	2.3	2.3	1.9	2.5	2.8	Fruit hidden in canopy, seedy, medium size, <i>Colletotrichum</i> , unmarketable
W11 x W5 (1)	19	360	2.5	2.0	2.0	2.0	2.0	<i>Botrytis</i> , <i>Colletotrichum</i> , unmarketable
W17 x W21 (1)	22	196	-	-	-	-	-	Nothing near marketable, <i>Colletotrichum</i> , <i>Botrytis</i>
W20 x W12	64	954	1.5	3.8	1.3	2.2	2.3	<i>Colletotrichum</i> , firm, elongated, white shoulder, <i>Colletotrichum</i> , <i>Botrytis</i> , unmarketable

Table 14. Lines tagged as at 9 December 2014

Southern node			Southern node		
Line	No. plants in ground	No. plants staked	Line	No. plants in ground	No. plants staked
W13-1	52	1	W13-26	68	0
W13-2	36	0	W13-27	32	0
W13-4	76	0	W13-29	464	1
W13-6	56	0	W13-30	332	9
W13-8	40	0	W13-31	288	2
W13-9	140	0	W13-32	105	0
W13-10	104	1	Total		54
W13-11	101	1	Northern node		
W13-12	128	1	3758	148	15
W13-14	132	3	3764	288	20
W13-15	216	5	3765	132	0
W13-16	72	1	3831	29	0
W13-17	172	3	3832	292	5
W13-18	136	1	3838	24	1
W13-20	104	1	3846	212	8
W13-21	84	4	3843	80	5
W13-22	40	0	3845	256	19
W13-23	124	2	3842	28	0
W13-24	152	1	Total		66
W13-25	132	1			

Table 15. Status of lines held over from 2013 as at 26 February 2014*

Line (SAI)	No. staked	Line (DEEDI)	No. staked	Line (DEEDI)	No. staked
12-023	(5) 3	3515P	(4) 1	3666A	(1) 0
12-049	(3) 3	3517P	(14) 6	3679A	(3) 0
R12-053	(0) 2	3590A	(3) 0	3680P	(7) 3
R12-056	(8) 2	3627A	(7) 1	3695P	(2) 2
R12-057	(9) 3	3628A	(7) 3	3661A	(0) 1
R12-058	(10) 8	3629A	(3) 1	3696P	(3) 3
		3631A	(4) 1	3698P	(7) 2
Total	21		13		11

* Numbers in brackets are the original numbers of plants staked.

Table 16. Maximum monthly summer temperatures for each node of the national breeding program since December 2011 (highest temperature among the node locations for each month is shown in bold)

Month	2011/12			2012/13			2013/14			2014/15		
	Nambour Qld	Wandin Vic	Wanneroo WA	Nambour Qld	Wandin Vic	Wanneroo WA	Nambour Qld	Wandin Vic	Wanneroo WA	Nambour Qld	Wandin Vic	Wanneroo WA
Dec	37.8	39.2	33.3	37.2	38.4	33	38.7	38.5	39.3	39.7	37.7	37.5
Jan	42.4	38.8	36.5	40.1	42.0	39.4	42.7	38.9	41.8	40.2	40.2	42.2
Feb	36.0	38.8	36.3	38.1	41.7	36.7	41.3	37.4	38.1	40.2	34.7	37.9
Mar	32.2	31.7	31.3	36.2	34.1	33.5	39	35.8	39.2	34.7	37.7	37.7

Table 17. Average monthly summer temperatures for each node of the national breeding program since December 2011 (highest temperature among the node locations for each month is shown in bold)

Month	2011/12			2012/13			2013/14			2014/15		
	Nambour Qld	Wandin Vic	Wanneroo WA	Nambour Qld	Wandin Vic	Wanneroo WA	Nambour Qld	Wandin Vic	Wanneroo WA	Nambour Qld	Wandin Vic	Wanneroo WA
Dec	26.8	24.8	28.8	30.2	25.4	28.9	29.2	24.9	30.0	29.5	25.4	30.8
Jan	27.7	27.2	32.3	30.4	29.2	30.1	30.3	29.3	32.0	29.6	27.5	30.1
Feb	28.7	27.5	29.6	27.5	30.7	32.3	29.7	30.0	26.4	28.1	29.2	28.3
Mar	27.0	23.2	30.3	27.4	27.2	26.8	28.2	26.4	28.2	29.7	24.1	26.9