Horticulture Innovation Australia

Final Report

Evaluation of CSIRO table grape breeding material in the Murray Valley, Queensland, Western Australia and the Northern Territory

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TG13001

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Summary

The project aimed to identify selections with potential, if released as varieties, to enable the industry to meet future challenges associated with production in a variable and changing climate and overcome problems/deficiencies of existing standard varieties. A particular focus was the identification of selections as potential alternatives to Thompson Seedless that are not prone to berry collapse; fruitful varieties with good budburst to address problems in tropical /sub-tropical regions and varieties that ripen early and late to extend the season of availability. Conducted over two seasons, the project completed the initial evaluation of CSIRO breeding lines located in the Murray Valley that were generated in previous projects and identified selections with potential for further development by research collaborators and industry. It also continued the evaluation of irradiated Red Globe mutants in the Murray Valley and a small number of selections planted at regional sites in Queensland and Western Australia.

Material under evaluation included 1000 seedling genotypes derived from seedless x seedless and disease resistance crosses; 210 multiplied selections and 45 irradiated Red Globe mutants selected, in the previous project, for a range of varying berry characteristics (i.e. seedlessness, reduced seed number, large berry size and attractive colour). In most cases, the management of the selections included bunch thinning, trimming and positioning in both seasons. GA treatments to enhance fruit quality were applied in season 2014-15. Although some selections cropped for the first time during the project, significant culling was undertaken with numbers reduced to approximately 200 seedlings and 100 multiplied selections. Overall, the project has identified 45 seedling genotypes (36 white and 9 dark) for propagation and establishment as own rooted vines in multiplied plots. A further 17 multiplied selections (i.e. 15 white and 2 red genotypes) were identified and propagated for evaluation as grafted plants on Ramsey and 1103 Paulsen rootstock. Fifteen high priority selections from the previous project have also been propagated as grafted vines on Ramsey and Freedom rootstock, for establishment in the Northern Territory in spring 2015. None of the seeded irradiated Red Globe selections appeared to offer significant advantages over Red Globe while the seedless and near seedless types displayed poor fruit quality.

Three seedless selections, i.e. early ripening black and red selections and a mid-late white seedless selection were identified in the previous project for assessment at regional sites and under semi-commercial conditions in the Murray Valley. The early ripening red selection continued to show promise under sub-tropical conditions in Queensland and at a semi-commercial grower site in the Murray Valley but produced unsatisfactory fruit quality at the more southern, Wokalup site in Western Australia. Despite development of small bunches, the very early ripening black selection continued to display positive attributes under semi-commercial conditions in the Murray Valley. However its performance was unsatisfactory in regional sites in Queensland and Western Australia. The mid-late ripening white was only evaluated in the Murray Valley. It produces reasonably large, Thompson Seedless like berries without application of GA treatments and displayed positive quality attributes which would enable the availability of a Thompson Seedless like product to be extended to a later period in the season.

Keywords

table grapes, gibberellic acid (GA), berry size, grape flavour, grape colour, seedlessness, berry collapse

Introduction

The Australian table grape grower is faced with new and evolving challenges surrounding production in a changing and highly variable climate, imported fruit, limited water supply and increasing consumer and regulatory demands with respect to product integrity and environmental responsibility and a need to maintain international competitiveness. The significant production losses associated with heat stress and berry collapse in Thompson Seedless (e.g. A loss of $100 million in season 2008) and related problems in other varieties such as Crimson Seedless and losses associated with wet climatic conditions in seasons 2011 and 2012, highlight the need for more robust varieties to meet these challenges. Low fruitfulness of key varieties in subtropical areas of northern Australia and highly variable yield from year to year, has a massive impact upon vineyard productivity and the profitability of businesses. New table grape varieties for the Australian industry are required to address these issues. The development and release of new table grape varieties aligns with the Industry Strategic Investment Plan (2012-2017), Strategy 2.2 (Establish options for access to & evaluation of new and improved varieties).

Since 1998, the table grape industry, CSIRO, State Departmental collaborators and Horticulture Australia have provided significant input to table grape breeding and evaluation. Projects included, 'Table Grapes for the New Millennium' (FR 97407) which was supported by voluntary industry contributions and the levy funded, 'Table grapes for the 21st Century' (TG03008) and 'Table grapes for the changing and variable Australian environment that address marketing needs (TG09003). To date, three varieties have been released. They include the early ripening white seeded variety with distinct muscat flavour, M 51-18Ⓟ, with grapes that meet specifications marketed under the Millennium Muscat™ trademark. This variety has been important for the Gascoyne region in Western Australia. The second variety is a black seedless variety, M 13-01Ⓟ, with grapes that meet specifications marketed under the Magic Seedless® trademark which is being planted in a number of regions in all production states. The third variety is a mid-late season, white seedless type, M 44-14Ⓟ which matures slightly later and has better storage characteristics than Thompson Seedless and does not appear to be susceptible to berry collapse. Grapes of this variety that meet specifications are marketed under the Mystic Seedless® trademark.

This project completed the initial evaluation of table grape material developed in previous projects located on the CSIRO property in the Murray Valley; continued the evaluation of advanced selections established at regional sites in the Murray Valley, Queensland and Western Australia and facilitated the establishment of further selections at regional sites. It aimed to identify alternative varieties to Thompson Seedless which are not prone to berry collapse; varieties that ripen early and late to extend the season of availability; seedless varieties with enhanced quality characteristics (i.e. improved berry size, texture and flavour); varieties with good long term storage and transport characteristics; low input varieties to reduce production costs and disease resistant types to facilitate 'low chemical' production and varieties with increased and consistent fruitfulness under subtropical growing conditions.

Material available for evaluation included, seedling populations produced from seedless x seedless and disease resistance crosses; multiplied selections of promising types; advanced selections established as grafted vines or top-worked onto existing vines; irradiated Red Globe mutants produced with the aim to induce seedlessness; and selections with significant potential established at regional sites in Queensland, Western Australia and semi-commercial sites in the Murray Valley.

Methodology

The project completed the initial evaluation of table grape material developed by CSIRO in the projects listed above, located on the CSIRO Irymple property in the Murray Valley; continued the evaluation of advanced selections established at regional sites in the Murray Valley, Queensland and Western Australia and facilitated the establishment of further selections at a regional site in the Northern Territory.

Material available for evaluation included:-

1. Remnant seedling populations produced from seedless x seedless and disease resistance crosses located at the CSIRO Irymple site (<1000 genotypes).

2. Multiplied selections of promising types identified in seedling populations located at the CSIRO Irymple site (210 genotypes). These included some more advanced selections that had been established as grafted vines or top-worked onto existing vines.

3. Irradiated Red Globe mutants (45 genotypes) selected for a range of varying berry characteristics (i.e. seedlessness, reduced seed number, berry size and colour) located at the CSIRO Irymple site.

4. Selections with significant potential established on grower properties for semi-commercial evaluation in the Murray Valley. These include red and black early ripening seedless types, a mid-season white seedless type which produces reasonably large berries without GA treatments and 12 irradiated Red Globe selections.

5. Selections established at regional sites in Queensland and Western Australia. Field research in Queensland and Western Australia concentrated on finalising evaluation and development of three highly promising selections for release to industry as potential new varieties (i.e. a highly promising early red seedless, an early black seedless and a mid-season white seedless types) when managed under different climatic conditions.

Evaluation of the listed material included assessment of budburst, bud health (an emerging issue in recent seasons in subtropical production districts) and fruitfulness to facilitate management, routine sampling of fruit prior to harvest for berry weight and maturity (total soluble solids); harvest and assessment of key fruit characteristics; cleaning and packing of fruit of the most promising types and conduct of long term storage assessments (i.e. at -1.0 ^{O}C). Where appropriate for selected seedling lines and multiplied and advanced lines, management techniques were applied to enhance fruit quality and optimize production. These included application of GA for inflorescence stretching, berry thinning and sizing; bunch thinning and trimming and leaf removal. Key tasks associated with maintenance of the above material were undertaken by CSIRO at the Irymple site included routine farm activities (ie. pruning, fungicide control, herbicide application, irrigation, cultivation) and culling of poor performing material, in consultation with the project team.

Furthermore, when dormant in winter, cutting material of targeted selections was collected for:-

1. Establishment of a new regional site in the Northern territory. This material was supplied to licensed nursery for grafting in winter 2014. The vines will be planted in spring 2015.
2. Establishment of the most promising selections as grafted vines on Ramsey and 1103 Paulsen rootstock. This material was supplied to a licensed nursery for grafting in winter

2015 and will be planted on the CSIRO Irymple site, as recommended by the Steering Committee in May 2015.
3. Establishment of multiplied plots of promising seedling selections on the CSIRO Irymple site. This material has been propagated for planting in late spring, 2015.
4. Distribution to collaborators in Queensland and Western Australia, if a new project is approved.

The project was overseen by the Unique Australian Table Grapes Steering Committee involving key industry stakeholders, the ATGA, CSIRO, HIA and regional collaborators (i.e. DAF Q, DAFWA and NTDPI).

Output

1. Evaluation of seedling populations

The key quality traits of more than 1000 single vine seedlings were evaluated at harvest, in seasons 2013-14 and 2014-15. The seedlings which had been planted in the 2008-2012 period on the CSIRO Irymple property included consolidated seedless selections transferred from the ex CSIRO Merbein property and seedlings produced from seedless x seedless crosses in 2007, using *in-ovulo* embryo rescue techniques and trained on a single wire trellis. No treatments were applied in the 2013-14 season. In season 2014-15, for the most promising selections identified in the previous season, bunch positioning, trimming and thinning was undertaken with a 30 ppm GA sizing treatment applied to some bunches when the developing berries were 4 - 9mm in size.

In the 2013-14 season 630 seedlings were found to be either seedless or had acceptable seed traces for table grape production while 215 seedlings, with unacceptable fruit quality traits were culled in winter. In that season almost one quarter of the seedling population (i.e. 230) were not in bearing and did not produce a crop. Fruit was harvested from about 200 seedling and evaluated in detail for yield components and fruit quality traits. A number of rain tolerant white seedless types showed potential as alternatives to Thompson Seedless. In total, 16 white and 4 red selections showing potential were identified for multiplication. Cutting material was collected in winter 2014 and propagated as own rooted vines at the CSIRO site. These vines will be planted in spring 2015.

Key characteristics of the white and red selections, collected in the 2013-14 season, are provided in Tables 1.1. and 1.2 respectively. There was a diverse range in potential harvest dates across the 16 white seedless selections, based on the actual harvest date and the maturity level at harvest in 2013-14 (Table 1.1). A number of the white selections, with high total soluble solids, could have been harvested earlier in the season. The mean natural berry weights of the white selections ranged from 1.28 g to 4.09 g. The weight of the largest berry, ranged from 1.49 - to 7.56 g, an indication that most selections have potential to produce large berries if management practices had been applied. Harvest dates of the red selections ranged from 6th February to the 7th of April (Table 1.2). The mean natural berry weight of the red selections ranged from 2.6 to 5.92 g. The weight of the largest berry, ranging from 2.60 - to 8.66 g, indicates potential to produce large berries if management practices had been applied.

Table 1.1. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of promising white seedling selections in season 2014.

Selection	Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
		(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
SdW1	6-Feb	17.1	3.69	4.92	18.1	23.6
SdW2	6-Feb	22.4	2.68	3.21	15.3	20.6
SdW3	12-Feb	22.2	1.97	2.64	15.1	18.9
SdW4	20-Mar	22.2	3.91	5.15	19.0	23.5
SdW5	26-Mar	23.0	3.60	5.65	18.3	22.9
SdW6	3-Apr	17.3	2.79	3.82	17.9	19.0
SdW7	3-Apr	21.0	3.16	4.45	17.1	23.9
SdW8	3-Apr	19.4	3.98	6.02	20.6	23.9
SdW9	3-Apr	23.3	2.91	4.25	16.5	22.3
SdW10	3-Apr	21.0	3.24	4.84	18.2	23.8
SdW11	3-Apr	19.3	2.07	5.24	20.0	22.2
SdW12	7-Apr	22.3	2.31	3.58	15.3	20.1
SdW13	7-Apr	24.6	2.37	3.83	15.6	22.7
SdW14	7-Apr	23.5	2.58	3.31	15.7	20.2
SdW15	7-Apr	25.6	1.28	1.49	12.0	15.7
SdW16	7-Apr	22.0	4.09	7.56	21.4	27.4

Table 1.2. Harvest date, berry colour, total soluble solids, mean and largest berry weight and berry dimensions of promising dark coloured seedling selections, season 2014.

Selection	Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
		(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
SdD1	6-Feb	22.3	3.43	4.28	16.7	22.2
SdD2	26-Feb	24.8	2.21	2.60	13.7	18.4
SdD3	20-Mar	20.5	5.92	8.66	21.9	29.7
SdD4	7-Apr	22.7	4.35	5.15	19.9	23.2

In season the 2014-15 season, 600 seedlings were evaluated. One hundred and fifty seedlings were harvested and the fruit evaluated. Approximately 400 seedlings were identified for culling. Twenty five of the most promising selections were identified for establishment in multiplied blocks on the CSIRO property for further detailed evaluation when managed on a larger, V-shaped table grape trellis. These included 20 white seedless and 5 red, purple and black seedless types. Key characteristics of the white and darker selections are provided in Tables 1.3. and 1.4, respectively.

There was a diverse range in potential harvest dates across the 20 white seedless selections, based on harvest date and the maturity level at harvest (Table 1.3). A number of the late harvested selections, with high total soluble solids could have been harvested earlier in the season. Overall there were 4 early ripening selections harvested in January (highlighted in yellow), potentially 7 mid-season selections which could be harvested in late February to March (highlighted in blue) and 9 late ripening selections to extend the season with potential for harvest in April (highlighted in green). Most of the white selections displayed potential to respond to GA treatment to increase berry size, with approximately half producing berries greater than 5 g. Harvest dates of the darker coloured selections ranged from the 12th March through to the 21st of May, although based on their maturity, the 2 very late selections could have been harvested earlier (Table 1.4). Berry colours of these dark selections varied from red, purple and black. While none of the selections were treated with GA to increase berry size, both the mean berry weight and the largest berry weight values indicate potential to produce large seedless berries. Views of some of the white and red seedling selections prior to harvest are provided in Figures 1.1 (white) and 1.2 (red) below.

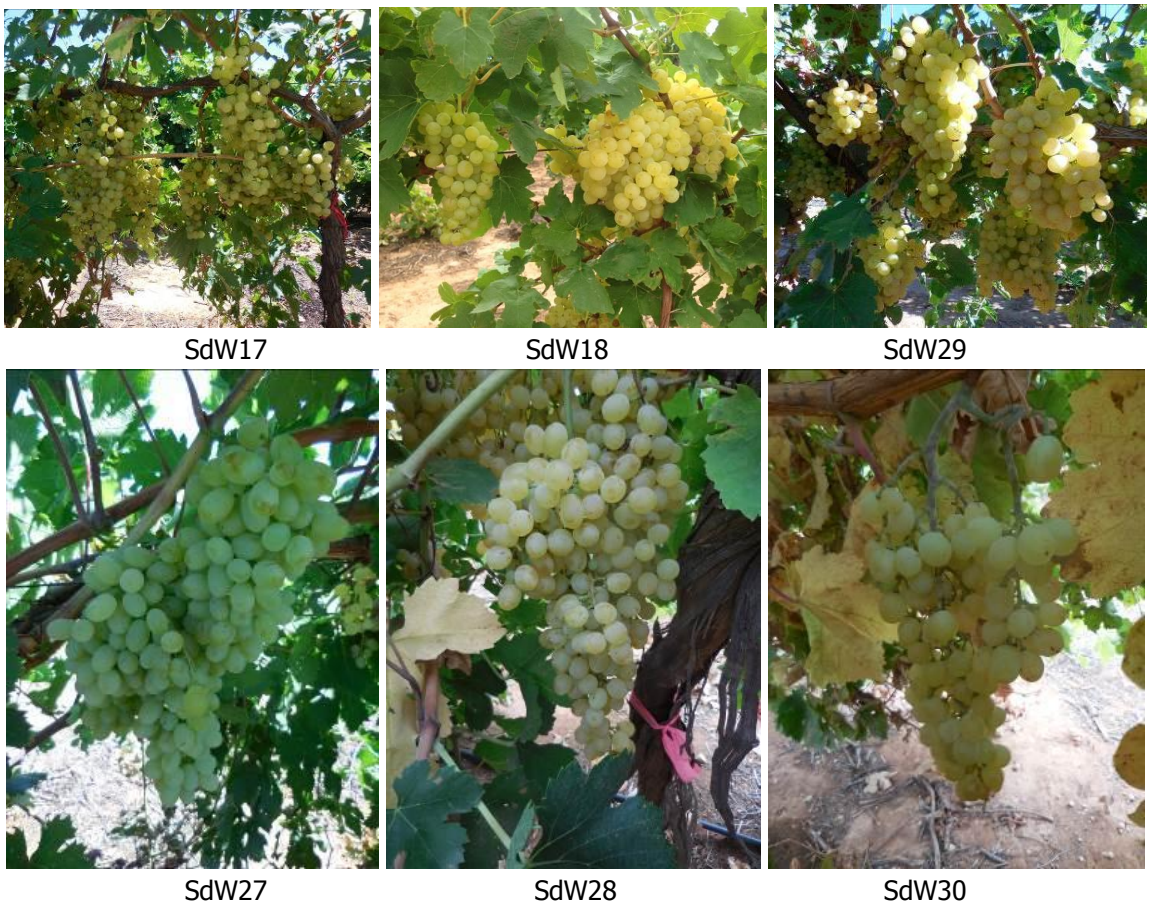


Figure 1.1. Views of fruit of white seedling vines prior to harvest.

Table 1.3. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of promising white coloured seedling selections, with and without a 30 ppm GA treatment in season 2015.

Selection	GA	Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
SdW17	-	22-Jan	18.7	2.6	4.5	15.6	16.4
SdW17	+	22-Jan	16.4	3.9	5.1	18.3	20.0
SdW18	-	23-Jan	21.3	2.6	3.3	15.4	2.1
SdW19	-	23-Jan	18.8	3.1	3.8	16.8	18.8
SdW19	+	23-Jan	16.8	4.4	6.2	16.9	22.7
SdW20	-	23-Jan	19.6	3.0	4.1	15.1	19.1
SdW20	+	23-Jan	18.4	5.2	6.8	18.1	22.8
SdW21	-	16-Apr	24.5	2.3	3.1	14.4	15.9
SdW11*	-	10-Mar	22.0	3.5	4.4	16.9	19.8
SdW11	+	21-Apr	24.1	3.2	4.3	16.4	20.6
SdW22	-	21-Apr	25.0	2.9	na	15.8	20.4
SdW22	+	21-Apr	24.1	3.4	5.4	16.3	21.2
SdW12*	-	21-Apr	23.6	2.8	3.3	14.9	18.5
SdW12	+	21-Apr	26.6	3.0	4.2	15.6	20.2
SdW23	-	23-Apr	24.4	3.9	5.0	17.7	21.2
SdW23	+	23-Apr	23.5	4.3	5.5	17.9	21.2
SdW24	-	23-Apr	23.5	2.8	3.9	15.1	18.1
SdW24	+	23-Apr	23.4	3.3	5.1	18.0	20.5
SdW25	+	16-Apr	22.3	4.2	5.0	17.2	22.4
SdW26	-	16-Apr	22.7	2.3	3.0	14.5	18.5
SdW26	+	16-Apr	17.3	5.4	7.3	21.1	23.2
SdW27	-	16-Apr	21.3	3.1	4.2	15.5	19.0
SdW27	+	16-Apr	19.0	4.7	6.8	19.1	21.2
SdW28	-	16-Apr	20.4	3.1	5.2	18.7	3.2
SdW29	-	16-Apr	21.3	2.2	3.6	17.2	1.8
SdW15*	+	21-Apr	22.7	2.1	2.4	14.4	16.5
SdW30	-	23-Apr	27.5	1.3	2.1	13.2	15.9
SdW30	+	23-Apr	18.8	2.7	4.1	15.3	18.9
SdW16*	-	23-Apr	22.4	4.6	7.2	17.4	23.1
SdW16	+	23-Apr	20.1	5.4	7.2	19.9	22.4
SdW31	-	23-Apr	18.8	3.9	4.9	20.4	3.6
SdW32	-	23-Apr	20.5	2.5	3.2	16.6	2.9

* Note: Selections marked with asterisk were propagated in 2014, based on results from that year.

Table 1.4. Harvest date, berry colour, total soluble solids, mean and largest berry weight and berry dimensions of promising darker coloured seedling selections, season 2015.

Selection	Colour	Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
SdD5	red/purple	12-Mar	16.6	3.95	5.45	17.5	20.8
SdD6	black	21-Apr	24.0	4.37	6.27	18.7	22.4
SdD7	red	23-Apr	19.5	1.98	3.2	13.6	18.7
SdD8	purple	21-May	23.5	3.68	5.44	18.0	22.1
SdD9	black	21-May	25.6	2.30	3.54	14.6	21.3

SdD5 SdD6 SdR9

Figure 1.2. Views of fruit of dark seedling vines prior to harvest.

2. Evaluation of multiplied selections located at CSIRO Irymple

Approximately half of the 210 multiplied selections, maintained on the CSIRO property in the Murray Valley, were evaluated in detail in 2013-14. However, due to the late commencement of the project, it was not possible to implement a GA treatment program for berry thinning and sizing while bunch thinning and trimming treatments were only applied to the most promising selections identified in the previous project. A number of multiplied selections established in the latter years of the previous project did not produce a crop. The evaluation process identified 33 selections with high potential and 20 selections for culling in winter due to poor production or fruit quality characteristics. In season 2014-15 detailed management practices were also applied to 70 multiplied selections which were evaluated for production, fruit quality and storage characteristics. Sixty multiplied selections were identified for culling.

Based on the preliminary evaluations conducted in 2013-14 and the more detailed evaluations conducted in 2014-15, 15 white selections and 3 red selections have been identified with high potential. These are currently being propagated as grafted vines on Ramsey and 1103 Paulsen rootstocks, as recommended by the Steering Committee in May 2015, for more detailed assessment under modern management practices in multiplied plots, which will be established at the CSIRO Irymple site. These selections will also be established in regional sites if a new project is successful. Key berry characteristics of the white and red selections, determined in season 2014-15 are provided in Tables 2.1. and 2.2, respectively.

There was a diverse range in potential harvest dates across the 15 white seedless selections, based on harvest date and the maturity level at harvest, ranging from late January through to the late May (Table 2.1). A number of the selections, with high total soluble solids could have been harvested earlier in the season. Overall there were 3 early ripening selections harvested in January (highlighted in yellow), potentially 3 mid-season selections which could be harvested in late February to March (highlighted in blue) and 9 late ripening selections to extend the season and harvest in April/May (highlighted in green). Berry weights of the untreated selections ranged from 1.92 g, similar to Sultana, to 4.04 g. Where applied, the GA sizing treatment tended to reduce the total soluble solids, leading to a delay in harvest in some cases. Most of the white selections responded to GA treatments, with increases in mean berry weight and the weight of the largest berry. In all cases these responses were due to an increase in both the diameter and the length of the berry. Mean berry weight of the GA treated selections ranged from 3.40 g to 7.38 g. Views of some of the white seedling selections prior to harvest are provided in Figure 2.1.

Table 2.1. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of the largest berry for promising white selections established on their own roots in multiplied plots, with and without a 30 ppm GA treatment, in season 2015.

Selection	GA	Harvest Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
MuW1	-	20-Jan	18.8	2.48	3.26	16.3	21.3
	+	20-Jan	19.0	2.53	3.82	17.3	21.9
MuW2	-	23-Jan	21.2	2.63	3.10	16.4	8.6
	+	23-Jan	18.9	3.53	4.52	18.4	23.3
MuW3	-	24-Feb	25.2	3.14	2.07	16.7	24.7
	+	24-Feb	23.8	3.73	3.57	17.8	27.5
MuW4	-	26-Mar	20.0	2.73	3.85	17.3	20.6
	+	na	-	-	-	-	-
MuW5	-	26-Mar	20.0	2.73	3.85	17.3	20.6
	+	26-Mar	17.1	4.16	5.00	19.1	21.9
MuW6	-	12-Jan	18.0	2.39	2.87	19.4	22.9
	+	31-Mar	20.6	4.29	5.48	19.8	24.4
MuW7	-	8-Apr	27.2	3.66	5.21	17.9	25.6
	+	8-Apr	25.4	5.11	7.00	19.7	28.9
MuW8	-	31-Mar	26.6	2.42	3.00	16.0	18.7
	+	21-Apr	24.8	3.97	5.41	20.0	23.0
MuW9	-	20-Jan	19.2	2.39	3.54	17.0	21.3
	+	2-Apr	20.4	3.22	4.62	18.5	21.7
MuW10	-	16-Apr	21.0	1.92	2.53	14.8	17.9
	+	16-Apr	22.1	2.58	3.40	16.9	20.0
MuW11	-	16-Apr	20.7	3.23	4.74	19.0	22.7
	+	23-Apr	19.1	5.22	7.20	21.2	24.5
MuW12	-	23-Apr	21.7	3.45	3.70	17.3	20.3
	+	16-Apr	21.9	3.67	7.38	21.2	25.9
MuW13	-	21-May	26.4	2.80	3.63	15.7	21.0
	+	na	-	-	-	-	-
Muw14	-	21-May	22.7	4.04	5.52	19.4	22.5
	+	na	-	-	-	-	-
MuW15	-	21-May	24.1	2.98	4.45	17.8	23.7
	+	21-May	23.9	3.75	4.92	18.0	23.9

MuW1 MuW5 MuW6

MuW8 MuW9 MuW10

Figure 2.1. Views of fruit of white multiplied selections prior to harvest.

The 3 red selections were harvested in late May although harvest dates could have been earlier for 2 of the selections, based on their total soluble solids values, above 20 ^{o}Brix (Table 2.2). Both the mean berry weight values and the value for the largest berry indicate that at least 2 of the red selections have potential to produce large seedless berries. Mean berry weights of the untreated selections ranged from 2.42 g to 4.94 g while with the GA treatment, mean berry weights ranged from 2.93 g to 6.55 g associated with an increase in both the diameter and the length of the berry. Views of some of red multiplied selections prior to harvest are provided in Figure 1.2.

Table 2.2. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of the largest berry for promising red selections established on their own roots in multiplied plots, with and without a 30 ppm GA treatment, in season 2015.

Selection	GA	Harvest Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
MuD1	-	21-May	21.8	4.94	6.17	18.8	28.0
	+	21-May	19.6	5.92	8.32	21.3	30.7
MuD2	-	21-May	24.9	2.42	3.62	15.9	23.4
	+	21-May	24.9	2.93	3.29	16.1	21.5
MuD3	-	21-May	22.3	3.57	5.45	19.5	23.3
	+	21-May	23.1	6.55	9.90	23.6	30.1

MuD1 MuD2 MuD3

Figure 2.2. Views of fruit of red multiplied selections prior to harvest.

3. Evaluation of the priority selections identified in TG09003

The evaluation of the twenty five highly promising multiplied selections, located at the CSIRO Irymple site which had been identified in the previous project (TG09003) was continued in this project. A full description with photographs is reported in TG09003 final report. Due to the delayed commencement of the project, in the first season (2013-14) management treatments to enhance fruit quality were limited and GA treatments were not applied. In contrast, in the 2014-15 season the full suite of practices to enhance fruit quality were imposed including bunch thinning and trimming, leaf removal and GA treatments. In general, the results confirm the previous assessments and the responses of these selections to imposed management treatments. However, based on the recent results, 8 selections have been eliminated for a number of reasons including flower sex, small berries or small bunches, poor fruit set and the existence of large, lignified seed traces. Those eliminated included 3 white selections, 2 red selections and 2 red/purple selections. The remaining 17 selections have been identified for regional evaluation. A summary of the results from season 2013-14, and when best practice was applied in 2015 is provided for the white selections in Tables 3.1 and 3.2 respectively and the dark selections in Table 3.3 and 3.4 respectively.

There was a wide range in harvest dates for the priority white selections, from early January through to April and May for seasons 2013-14 and 2014-15 respectively (Tables 3.1 and 3.2). Based on the total soluble solids values, above 20 ^{o}Brix, a number of the late maturing selections may have been harvested earlier in the 2013-14 season. Similarly, in the 2014-15 season, many of the selections could have been harvested earlier. Both the mean berry weight values and the value for the largest berry indicate that most of the white selections have potential to produce large seedless berries. Mean berry weights of the untreated selections ranged from 2.12 g to 5.59 g in season 2013-14 and from 2.48 g to 6.54 g in 2014-15 (Tables 3.1 and 3.2). All of the white selections responded to GA treatments in 2014-15, with increases in mean berry weight and the weight of the largest berry. In most cases these responses were due to an increase in both the diameter and the length of the berry. Mean berry weight of the GA treated selections ranged from 3.46 g to 6.54 g.

Table 3.1. Harvest period, total soluble solids, mean and largest berry weight and berry dimensions of the promising priority white coloured selections, season 2014.

	Selection	**Harvest period**	**Total Soluble Solids**	**Mean Berry Weight**	**Largest Berry**		
			(^{o}Brix)	**(g)**	**Weight (g)**	**Diameter (mm)**	**Length (mm)**
PrW1	M 74-44	January	16-17	3.98	6.41	24.1	28.8
PrW2	M 54-49	February	17-24	3.56	4.70	17.6	25.9
PrW3	M 58-61	March	16-17	5.59	6.92	21.0	26.2
PrW4	M 45-15	March	16-17	2.80	3.61	16.8	20.2
PrW5	M 46-20	March	19-21	2.12	3.18	15.0	21.1
PrW6	M 48-46	March	19-23	2.70	3.66	16.5	19.1
PrW7	M 47-63	March	21-23	3.23	4.58	19.1	17.3
PrW8	M 81-47	March/April	19-24	4.66	7.04	21.1	24.9
PrW9	M 08-13	April	21-24	3.68	5.12	18.3	23.6
Prw10	M 47-52	April	19-21	3.73	4.78	18.2	23.3

Table 3.2. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of the promising priority white coloured selections, with and without a GA treatment program in season 2015.

Selection	GA	Harvest Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
PrW1	-	16-Jan	17.5	3.97	6.05	20.2	24.3
	+	16-Jan	16.8	5.57	7.39	19.5	30.4
PrW2	-	3-Mar	23.8	3.70	4.43	18.1	23.6
	+	3-Mar	26.4	4.67	6.17	19.5	27.2
PrW7	-	3-Mar	24.5	3.47	4.59	19.1	20.4
	+	3-Mar	22.8	4.82	6.62	21.0	24.2
PrW8	-	10-Mar	25.7	3.46	6.20	19.9	26.2
	+	10-Mar	15.8	4.99	6.82	20.5	25.6
PrW10	-	12-Mar	17.9	4.05	4.76	18.4	24.0
	+	12-Mar	19.7	4.71	6.69	17.8	23.4
PrW9	-	26-Mar	23.1	4.34	5.50	19.0	24.1
	+	26-Mar	22.3	5.54	8.98	20.5	33.0
PrW3	-	26-Mar	18.8	4.96	6.00	20.1	24.6
	+	1-Apr	15.6	6.54	8.43	22.2	30.1
PrW5	-	1-Apr	21.0	2.48	3.24	16.1	20.8
	+	1-Apr	19.9	3.46	4.46	17.2	26.2
PrW6	-	21-May	22.0	3.63	4.55	18.0	19.4
	+	21-May	21.7	4.44	5.36	19.6	21.6
PrW4	-	21-May	16.5	2.96	4.26	17.8	21.5
	+	21-May	17.5	4.28	5.93	20.4	24.0

Harvest dates of the priority dark coloured selections, ranged from February through to April and May for seasons 2013-14 and 2014-15 respectively (Tables 3.3 and 3.4). Based on the total soluble solids values, above 20 °Brix, many of the selections could have been harvested earlier in both seasons. Both the mean berry weight values and the value for the largest berry indicate that most of the dark selections have potential to produce large seedless berries. Mean berry weights of the untreated selections ranged from 3.10 g to 4.78 g in season 2013-14 and from 3.14 g to 4.73 g in 2014-15 (Tables 3.3 and 3.4). All of the dark selections responded to GA treatments in 2014-15, with increases in mean berry weight and the weight of the largest berry. In all cases these responses were due to an increase in both the diameter and the length of the berry. Mean berry weight of the GA treated selections ranged from 4.25 g to 7.33 g. These dark coloured selections offer potential for use by industry to extend the product range available at specific times in the season.

PrW1

PrW7

PrW3

PrW9

PrW8

PrW4

Figure 3.1. Views of fruit of white priority selections prior to harvest.

Table 3.3. Harvest date, berry colour, total soluble solids, mean and largest berry weight and berry dimensions of priority coloured selections, season 2014.

Selection	Colour	Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
PrD1	red/purple	Feb	17-21	5.80	6.98	29.5	19.6
PrD2	red/purple	Feb	19-22	4.66	6.26	26.7	20.1
PrD3	black	Feb	19-22	3.81	5.88	19.8	22.76
PrD4	red	Feb/Mar	19-23	3.10	4.16	16.6	24.99
PrD5	red	March	17-21	4.78	6.59	20.4	26.00
PrD6	red	March	17-21	4.63	6.19	19.9	24.93
PrD7	purple	April	20-21	4.54	6.85	20.2	27.08

Table 3.4. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of the promising priority dark coloured selections, with and without a GA treatment program, season 2015.

Selection	Colour	GA	Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
				(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
PrD3	black	-	24-Feb	21.6	4.29	2.96	19.5	22.2
		+	20-Jan	15.9	6.38	8.24	23.3	26.6
PrD5	red	-	24-Feb	22.2	4.33	3.82	19.7	25.3
		+	24-Feb	22.4	4.70	5.36	21.5	26.8
PrD6	red	-	24-Feb	23.3	3.31	3.59	20.4	25.1
		+	24-Feb	21.2	5.75	5.46	21.9	27.4
PrD1	red/purple	-	26-Mar	20.7	4.73	6.64	18.9	26.5
		+	24-Feb	18.5	7.30	8.90	23.3	32.2
PrD2	red/purple	-	26-Mar	28.1	4.40	5.84	19.5	22.5
		+	26-Mar	24.3	7.33	10.46	24.1	28.9
PrD7	purple	-	2-Apr	24.2	3.81	5.30	18.8	23.3
		+	2-Apr	18.6	5.90	8.67	22.4	28.0
PrD4	red	-	21-May	25.3	3.14	3.75	16.8	21.3
		+	21-May	24.8	4.25	5.66	18.1	2.7

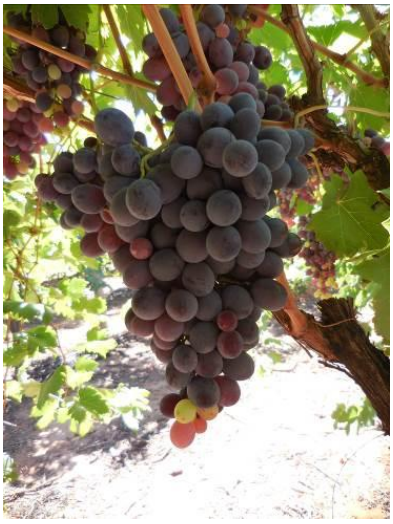
PrD1

PrD6

PrD2

PrD3

PrD5



PrD7

Figure 3.2. Views of fruit of red priority selections prior to harvest.

4. Evaluation of advanced selections planted on semi-commercial sites

Three of the most promising advanced selections were established on grower properties for semi-commercial evaluation in the Murray Valley in the previous project (TG09003). These included the red and black early ripening seedless types and a mid-season white seedless type which produces reasonably large berries without GA treatments. Data for all three selections were collected from multiplied plots established on the CSIRO site with support data obtained from the grower site for the early ripening black and red selections planted with Flame Seedless as a comparator variety (Tables 4.1, 4.2, 4.3). Unfortunately, the semi-commercial site for the white selection was lost due to redevelopment of the vineyard to a red variety. Views of these selections are shown in Figure 4.1.

Ad1 Ad2 Ad3

Figure 4.1. Views of fruit of advanced selections prior to harvest (season 2015).

The very early maturity of the black seedless selection (Ad1) was confirmed at the commercial site, as the level of total soluble solids was around 6 ^{o}Brix higher than Flame Seedless, at all sampling dates in both seasons (Table 4.1). The selection had very high levels of total soluble solids when samples were collected at the CSIRO site from different rootstocks in late February. At the CSIRO site, natural berry size appeared to be influenced by rootstock, being smallest on own roots, 3.42 g (2014-15) and largest on Ramsey, 4.53 g and 4.8 g in season 2013-14 and 2014-15, respectively. The selection responded to GA sizing applications when applied to own rooted vines and to vines on Schwarzmann rootstock in 2014-15, producing berries that were greater than 5.4 g, and larger than Flame Seedless berries. The major issue noted on the commercial site with the selection was the development of small bunches. However, because of its very early ripening, Ad1 could be developed as a useful black variety, particularly for niche markets and packaging in smaller plastic containers.

Table 4.1. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of the advanced early ripening, black selection (Ad1) from both the CSIRO site, with different rootstocks and the semi-commercial site in seasons 2013-14 and 2014-15. A GA sizing treatment was applied at the CSIRO site where indicated in 2014-15.

Source	GA	Harvest Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
2014							
1103 Paulsen	-	26-Feb	26.1	4.39	7.43	22.8	22.8
140 Ruggeri	-	26-Feb	22.3	4.21	6.03	20.8	23.4
Ramsey	-	26-Feb	24.3	4.53	7.29	21.4	26.1
Commercial		5-Feb	22.7	2.90	5.52	20.4	22.8
Flame Seedless	GA	5-Feb	17.0	3.46	5.10	24.0	20.1
2015							
Own roots	-	20-Jan	19.3	3.42	5.27	19.5	21.7
Own roots	GA	20-Jan	20.7	5.49	7.78	22.5	25.3
Ramsey	-	24-Feb	28.0	4.81	4.47	20.8	24.4
Schwarzmann	GA	24-Feb	28.4	5.35	4.75	21.1	25.0
Commercial		21-Jan	20.2	3.52	5.66	21.2	20.3
Flame Seedless	GA	21-Jan	15.2	5.01	7.11	22.7	23.0
Commercial		29-Jan	25.9	3.72	4.32	17.8	19.5
Flame Seedless	GA	29-Jan	15.3	3.60	4.38	18.2	19.5

Note: Vines on the semi-commercial site were top-worked onto Flame Seedless grafted on 1103 Paulsen. Bunches on all vines were routinely trimmed and thinned.

At the commercial site, the red selection (Ad2) appeared to ripen at the same time as Flame Seedless, in both seasons (Table 4.2). However at that site in 2015, a significant rain event in early January caused significant splitting in Flame Seedless, despite it being covered by plastic. As a consequence, the crop was of no commercial value and trellis dried for raisin production. In contrast, the advanced red selection (Ad2) had almost no rain damage although it was not protected by plastic covers. The major problem with Ad2 was uneven colour development, particularly where the crop load was high. As a consequence, to allow full colour development, it is likely that the fruit would be harvested later and have a higher maturity than Flame Seedless. Small differences in maturity, attributed to rootstock effects at the first sampling in 2013-14 (20th January), showing delayed maturation with 1103 Paulsen and advanced maturation with Ramsey, had largely disappeared at the second sampling (26th of February). In season 2014-15, AD2 on all rootstocks had similar levels of maturity when assessed in late March. Natural berry weight was affected by rootstock, with own rooted vines, Freedom and Ramsey producing the smallest berries and 140 Ruggeri the largest berries in 2014 (Table 4.2). Own rooted vines also produced the smallest berries in 2015. In general, the berry size responses to GA treatments in 2014-15 were small with own rooted vines showing a small, 11% increase to GA sizing treatment. Largest berries were produced with GA treatments applied for thinning at flowering on 1103 Paulsen and Freedom rootstock. The largest berries produced by Ad2 under commercial management in the 2014-15 season (i.e. 5.34 g), were slightly larger than produced by Flame Seedless (5.01 g). More detailed replicated studies are required to optimize GA treatments for this red selection (Ad2) in combination with crop load studies to enhance berry size and fruit colour development.

Table 4.2. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of the advanced early ripening, red selection (Ad2) from both the CSIRO site with different rootstocks and the semi-commercial site in seasons 2013-14 and 2014-15. GA treatments were applied at flowering (F) and at berry sizing (S) or in combination (F, S) at the CSIRO site as indicated, in 2014-15.

	GA	Harvest Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
2014							
Own roots	-	5-Mar	21.1	2.52	3.55	16.9	20.1
1103 Paulsen	-	20-Jan	14.9	3.02	4.20	17.8	21.2
140 Ruggeri	-	20-Jan	16.3	3.40	4.29	18.4	21.0
Freedom	-	20-Jan	17.7	2.49	3.02	16.0	19.0
Ramsey	-	20-Jan	19.1	2.47	3.87	18.0	19.9
1103 Paulsen	-	26-Feb	19.3	3.06	4.42	17.9	27.5
140 Ruggeri	-	26-Feb	18.5	3.72	4.83	19.3	22.1
Freedom	-	26-Feb	20.6	3.09	4.41	17.9	21.3
Ramsey	-	26-Feb	19.9	2.60	2.90	14.9	20.9
Commercial		21-Jan	14.7	3.14	4.15	18.0	20.8
Commercial		29-Jan	16.2	3.03	3.63	17.2	20.1
Commercial		5-Feb	17.2	4.00	5.05	17.9	23.5
Flame Seedless		5-Feb	17.0	3.46	5.10	24.0	20.1
2015							
Own roots	-	3-Feb	19.2	3.60	5.00	20.0	23.0
Own roots	S	23-Feb	18.7	4.01	5.67	20.0	23.4
1103 Paulsen	-	31-Mar	20.6	4.30	4.75	18.7	23.7
1103 Paulsen	S	31-Mar	22.9	4.07	5.00	18.8	24.3
1103 Paulsen	F, S	31-Mar	23.1	4.48	6.39	20.1	27.3
140 Ruggeri	-	31-Mar	22.9	4.07	5.00	18.8	24.3
Freedom	2F	31-Mar	21.2	4.69	5.40	20.2	23.7
Ramsey	S	31-Mar	20.6	4.30	4.75	18.7	23.7
Commercial		21-Jan	15.1	5.34	7.73	22.2	25.3
Flame Seedless		21-Jan	15.2	5.01	7.11	22.7	23.0

Note: Vines on the semi-commercial site were top-worked onto Flame Seedless grafted on 1103 Paulsen. Bunches on all vines were routinely trimmed and thinned.

Studies with the advanced seedless white selection (Ad3) show that it was later ripening than Sultana (Table 4.3), an indication that it could be useful to extend the season with a product similar to Thompson Seedless. In both seasons, total soluble solids of the Ad3 when grafted on 140 Ruggeri were delayed compared to own roots. In season 2014-15, highest total soluble solids were achieved with vines grafted on Ramsey rootstock (i.e. 25.6 °Brix) compared to own roots (19.5 °Brix). Natural berry weights of untreated bunches of Ad3 were 2-3 times larger than Sultana berries (Table 4.3). GA treatments, applied in 2014-15, had little impact on berry weight. The results confirm the ability of the white selection to produce large berries without the use of GA sizing sprays as the untreated bunches produced larger berries than the GA treated vines in 2014-15. However, it may be necessary to use GA treatments during flowering to reduce bunch compactness, a problem with the selection.

Table 4.3. Harvest date, total soluble solids, mean and largest berry weight and berry dimensions of the advanced mid-season, white selection (Ad3) from both the CSIRO site with different rootstocks and the semi-commercial site in seasons 2013-14 and 2014-15. GA treatments were applied at flowering (F) and at berry sizing (S) or in combination (F, S) at the CSIRO site as indicated in 2014-15.

	GA	Harvest Date	Total Soluble Solids	Mean Berry Weight	Largest Berry		
			(°Brix)	(g)	Weight (g)	Diameter (mm)	Length (mm)
2014							
Own roots	-	15-Apr	19.0	4.40	6.38	18.1	27.3
140 Ruggeri	-	15-Apr	13.9	3.97	5.59	18.2	27.2
Sultana	-	19-Mar	23.3	1.59	2.34	14.5	17.4
2015							
Own roots	-	3-Mar	19.5	5.49	6.48	17.0	35.6
Own roots	S	3-Mar	18.0	5.52	8.46	20.9	31.8
Own roots	2S	3-Mar	15.7	4.93	7.46	18.6	32.8
Ramsey	-	1-Apr	25.6	4.58	6.06	18.2	28.4
Ramsey	S	1-Apr	22.8	4.98	6.13	17.3	29.1
Ramsey	F,S	1-Apr	21.9	4.46	6.03	16.9	32.0
140 Ruggeri	F	2-Apr	na	4.14	5.68	18.8	26.2
Sultana	-	3-Mar	24.3	2.53	3.14	15.9	20.0
Sultana	S	3-Mar	23.1	4.24	5.23	17.8	26.8

Note: Bunches on all vines were routinely trimmed and thinned.

A sensory evaluation study with the early ripening red selection (Ad2) and with Flame Seedless as a comparator was also undertaken with 240 high school students and teachers at a local high school in Sunraysia. Two samples of the red selection were included in the study, i.e. berries from bunches with good colour (sample X) and less well developed colour (sample Y). Each participant scored the fruit for visual, texture and taste characteristics on a 9 point hedonic scale, determined the total soluble solids of each sample using a digital refractometer, and were requested to indicate if they had sufficient interest to purchase the fruit (i.e. equivalent to repeat sales).

Figure 4.2. Examples of participants involved in assessment of total soluble solids and berry sensory characteristics of the early ripening red seedless selection.

The maturity results across the samples showed that the total soluble solids of the Flame Seedless control (i.e. mean 18.1 ± 1.4 °Brix, range 11.8 - 20.6 °Brix) fell between the well coloured sample (X) (i.e. mean 18.6 ± 1.51 °Brix, range 13.7 to 22.6 °Brix) and the uneven coloured sample (Y) (i.e. 17.3 ± 1.60 °Brix, range14.0 - 20.9 °Brix) of the advanced red seedless selection (Ad2). They also highlight the wide variation in maturity of individual berries on bunches of Flame Seedless and the advanced red selection. For the red selection, there was a definite preference for the well coloured, more mature fruit sample based on visual, texture and taste characteristics across the participants compared to the less mature, uneven coloured sample (Figure 4.3). Compared to Flame Seedless, the well coloured Ad2 red selection was preferred on visual and textural properties while Flame Seedless was preferred on taste. A high percentage of participants indicated that they would purchase the well coloured, mature fruit of the Ad2 and Flame seedless, with a slight preference for Ad2 (Figure 4.4).

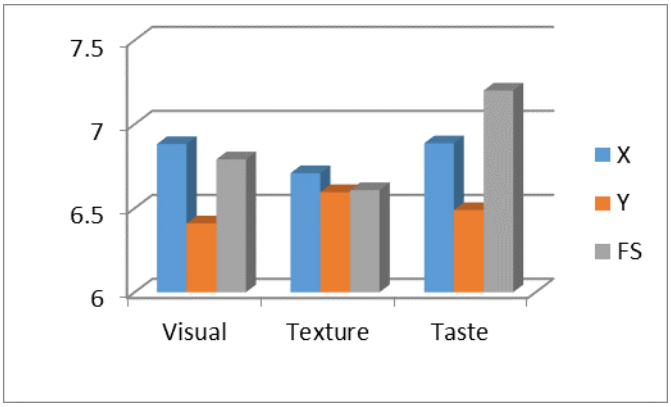


Figure 4.3. Mean score of visual, texture and taste characteristics of the well coloured (X) and uneven coloured samples of the early ripening red selection and Flame Seedless (n=240).

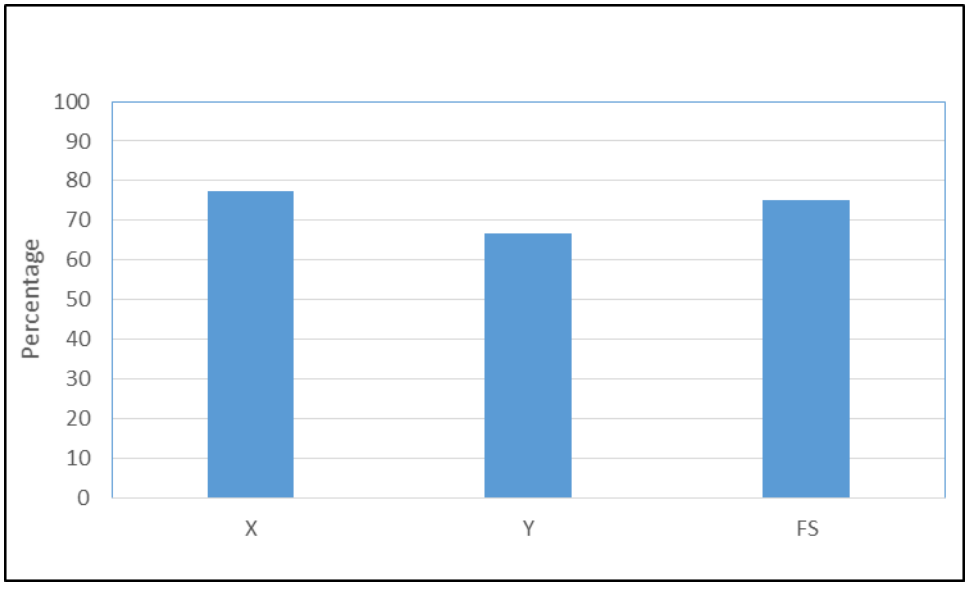


Figure 4.4. Percentage of particpants likley to purchase fruit of the well coloured (X) and uneven coloured samples (Y) of the early ripening red selection and Flame Seedless (n=240).

5. Evaluation of irradiated Red Globe

Red Globe mutants, selected in the previous project with varying levels of the seedless trait, seed number, berry colour and size and established at the CSIRO property in the Murray Valley (35 selections) and on a commercial property (10 selections) were assessed in both seasons. Data collected at the CSIRO site in season 2015, for irradiated mutants managed on a large Y-trellis, are presented in Table 5.1. The visual appearance of 22 mutants was considered to be poor based on a range of characteristics including bunch shape, colour uniformity, fruit set, uniformity of berry size, berry splitting and soft flesh. In particular, the seedless mutant RG 46.4 displayed very poor fruit quality as it had very poor bunch structure due to issues at flowering and fruit set. It also had a very low level of total soluble solids compared to the seeded mutants. At harvest, there were varying degrees of maturity across the mutants, with total soluble solids ranging from 18.0 - 25.6 ^{o}Brix compared to Red Globe with 22.5 ^{o}Brix (Table 5.2). Such differences in maturity could be exploited under commercial conditions to extend the harvest period for Red Globe. Berry weights of the seedless Red Globe mutant, RG 46.4 was 0.89 g. Berry weights of the seeded mutants ranged from 3.95 g to 10.5 g compared to Red Globe with 8.15g. Four mutants, all with similar seed numbers to Red Globe had larger berries than Red Globe. Across the data set, there was a strong correlation between berry weight and seed number ($r = 0.66$).

Under commercial conditions, the assessments in seasons 2013-14 and 2014-15 of the 10 mutants compared to two Red Globe samples located at either end of the planting indicated that 3 of the 10 mutants displayed poor fruit quality in each season, respectively (Table 5.2). Maturity levels ranged from 17.3 - 20.6 ^{o}Brix (Red Globe 17.5, 18.1 ^{o}Brix) in 2013-14 and from 18.0 - 22.3 ^{o}Brix (Red Globe 20.1, 19.5 ^{o}Brix) in 2014 -15. Berry weight of the seedless mutant (RG 46.4) was higher than that at the CSIRO site but still much smaller than the other selected seeded mutants, i.e. 2.00 and 3.3 g in season 2013-14 and 2014-15, respectively. Berry weights of the 9 selected seeded mutants ranged from 7.06 g to 14.46 g compared to Red Globe with 11.51 and 9.65 g in season 2013-14 and from 8.62 g to 13.15 g compared to Red Globe with 8.4 and 10.4 g in season 2014-15. Seed numbers across the mutants ranged from 1.2 - 4.0 in season 2013-14 and 1.2 - 3.4 in season 2014 -15. Interestingly, the mutant producing the largest berries had relatively low seed numbers in both seasons (i.e. 1.2 and 1.8 in 2013 -14 and 2014 -15, respectively). Views of the seedless mutant and two of the large seeded mutants are shown in Figure 5.1.

Based on the results, the project steering committee recommended that no more work be undertaken with the Red Globe mutants due to the poor fruit quality of the seedless mutant and the fact that none of the seeded mutants appeared to offer characteristics that would enable the product to be differentiated from standard Red Globe in the market place. The committee also indicated that the importance of Red Globe to the industry had diminished as it had largely been replaced by the seedless red variety, Crimson Seedless. The irradiated Red Globe mutants of interest will be retained by CSIRO for future research purposes.

RG 46.4 RG 327.8 RG 333.2

Figure 5.1. Views of the seedless Red Globe mutant (RG 46.4) and 2 large berried Red Globe mutants (RG 327.8 and 333.2) prior to harvest when managed under commercial conditions, season 2015.

Table 5.1. Appearance, mean total soluble solids, mean berry weight, weight of the largest berry and seed number of irradiated own rooted Red Globe selections, season 2015.

Mutant Selection	Appearance	Total Soluble Solids	Mean Berry Weight	Largest Berry weight	Mean Seed Number
		(°Brix)	(g)	(g)	
46.4	Poor	18.0	0.89	2.81	0.6
78.4	Poor	24.9	3.95	6.50	1.0
171.3	Poor	23.4	7.17	9.80	1.0
151.3	Poor	25.6	5.39	7.60	1.0
171.2	Poor	20.6	7.26	9.70	1.2
301.9	Poor	22.4	5.62	8.70	1.8
301.9	Poor	22.4	5.62	8.70	1.8
50.3	Good	21.3	6.67	8.50	2.0
84.9	Poor	24.7	7.03	11.40	2.0
420.1	Poor	21.9	4.76	6.00	2.0
127.2	Poor	24.6	6.88	9.70	2.4
355.1	Poor	22.3	6.33	10.90	2.4
355.8	Poor	22.3	6.11	7.90	2.4
147.2	Acceptable	22.8	6.47	10.10	2.6
37.8	Good	22.2	6.67	9.00	2.8
311.3	Acceptable	23.8	6.51	12.70	2.8
32.1	Acceptable	21.6	9.05	11.30	3.0
54.2	Poor	20.3	7.03	9.10	3.0
87.4	Poor	22.9	6.48	8.10	3.0
124.2	Poor	22.1	6.72	9.10	3.0
125.2	Poor	20.1	7.48	9.20	3.0
309.8	Poor	20.2	7.88	8.80	3.0
327.8	Acceptable	22.0	7.71	10.70	3.0
333.1	Good	20.9	7.62	10.10	3.0
413.1	Good	20.6	7.47	9.50	3.0
7.3	Good	18.1	6.58	8.60	3.2
95.5	Poor	23.9	10.51	14.50	3.4
7.1	Good	23.2	9.34	10.70	3.4
44.3	Poor	20.5	8.74	12.90	3.6
351.4	Good	21.0	9.18	12.40	3.6
47.3	Good	24.8	7.66	11.80	3.6
48.8	Poor	22.7	7.96	12.20	3.8
69.8	Poor	22.4	7.04	10.20	3.8
323.1	Poor	23.0	7.70	10.90	3.8
333.2	Good	22.7	8.25	10.40	3.8
Red Globe	Good	22.5	8.15	11.50	3.6

Table 5.2. Appearance, mean total soluble solids, mean berry weight, weight of the largest berry and seed number of irradiated Red Globe selections established on Ramsey rootstock on a commercial grower site in season 2013-14 and 2014-15.

	Appearance	**Total Soluble Solids**	**Mean Berry Weight**	**Largest Berry weight**	**Seed number**
		(°Brix)	**(g)**	**(g)**	
2014					
46.4	Poor	18.5	2.00	3.79	0
69.8	Poor	17.3	8.83	11.91	3.6
73.2	Good	20.2	8.09	16.35	1.8
84.9	Poor	18.3	14.46	15.32	1.2
124.1	Acceptable	19.8	7.06	9.45	1.8
127.2	Acceptable	20.3	11.20	16.24	2.4
327.8	Acceptable	18.3	12.00	15.55	3.4
333.2	Poor	19.0	13.86	18.68	3.8
345.3	Good	20.6	11.95	13.6	4.0
420.1	Poor	19.9	7.60	11.28	1.4
Red Globe	Good	18.1	11.51	13.25	3.8
Red Globe	Acceptable	17.5	9.65	11.83	4.0
2015					
46.4	Poor	18.0	3.37	6.6	0.4
69.8	Good	20.3	9.86	13.7	3.4
73.2	Good	21.3	8.91	11.9	1.4
84.9	Poor	18.7	13.15	18.4	1.8
124.1	Good	20.9	8.91	13.4	1.8
127.2	Good	20.6	10.40	11.3	2.4
327.8	Good	20.8	10.31	13.3	3.2
333.2	Acceptable	20.8	10.85	11.9	3.2
345.3	Good	19.1	10.01	12	3.4
420.1	Poor	20.9	8.62	8.8	1.2
Red Globe	Good	20.1	10.40	15	3.2
Red Globe	Acceptable	19.5	8.40	10.8	2.0

6. Evaluation at regional sites

Management practices to optimize production techniques were also applied to a number of the most advanced selections in the Murray Valley (2), Emerald in Queensland (2) and Wokolup in Western Australia (5). The advanced, early ripening red selection (Ad2), which ripens between Flame Seedless and Crimson Seedless not only continues to show promise in the Murray Valley (section 4 above) but also in Queensland. Arrangements have been completed to establish a further semi-commercial site of the early red selection in St George, to enable wider industry exposure to the selection. Fruit of this selection grown in the Murray Valley was sent for market testing in 2014 and 2015. The grower wishes to expand his planting to further assess the selection on rootstocks, rather than using top-worked vines. However, in Western Australia this selection (Ad2) displayed unfavourable production and fruit quality characteristics. In Western Australia it appears to be sensitive to gibberellic acid (GA) thinning sprays producing tight bunches at 1 ppm and had an excessive number of shot berries at 3 ppm. There was also an issue with excessive berry shatter. Compared to results in the Murray Valley (section 4 above), results from the evaluation of the early ripening black selection (Ad1) were unsatisfactory in both Queensland and Western Australia, due to its growth characteristics and aspects of fruit quality. There is still some interest in this selection in the Murray Valley.

Other selections evaluated at Wokolup in Western Australia included an early ripening red/purple selection harvested in early February which produced very loose bunches without any thinning treatment and a berry size of 6.2g, although the bunches were not large (i.e. 330g). The bunches were very attractive with bright green stems, similar to the released variety, M 13-01. The berries were very crisp when treated with GA and CPPU. The other selection was a mid - season white type, harvested at the end of February which produced crisp, 5.5g berries when treated with GA and CPPU although the small bunches (i.e. 330g) tended to be tight when treated with 1 ppm and 3 ppm GA thinning treatments. Some distortion of the bunch stems may have been due to GA treatments. The fruit had an excellent muscat flavour. Furthermore, in Western Australia, 2 other red/purple selections were released from quarantine and established at Wokolup.

Fifteen seedless selections have been identified for establishment in the Northern Territory, based on performance in season 2014 at the CSIRO Irymple site, time of fruit maturation and the previous information provided in the final report for TG 09003. The selections include 6 white, 3 red, 3 purple and 1 black selection. One of the white selections has strong muscat character. The material has been propagated by a commercial nursery on two rootstocks, Freedom and Ramsey. Three comparator varieties (M13-01, Menindee Seedless and Crimson Seedless) will also be included in the new planting. The trellis and irrigation has been installed and the vines will be planted in spring 2015, at a location near Alice Springs.

7. Communications

Scott, J. ATGA (2014) Chiefs Executive's report. Evaluation of promising new table grape selections resumes. The Vine, 10 (1), 15. (appendix 2)

Clingeleffer, P., McCarthy, B., Cameron, I., Oag, D., McConchie, C. and Walker, R. (2014) Developments in the Australian Table Grape Breeding Program. In Proc. 7th International Table Grape Symposium, Mildura, November 2014, 39-42. (appendix 1)

Price, A. (2015). CSIRO table grape varieties - update. The Vine, 11 (1), 19.

8. Industry Engagement

Project steering committee meetings were held by telephone conferencing with input from all stakeholders (industry, HAI, CSIRO and state departmental collaborators) on the 27th of May 2014 and the 4th of May 2015. Project updates, recommendations and future research requirements were discussed.

In Queensland, performance of 3 promising selections under evaluation at regional sites was reported to a meeting of GrapeConnect in February 2014. Fruit of the early red and early black selections was presented to growers in Emerald during the 2013 harvest season and through visits to individual growers in St George. A further progress report was provided to the Queensland industry in September 2014, highlighting the attractive fruit characteristics and potential of the early red selection. Arrangements have been completed to establish a further semi-commercial site of the early red selection in St George to enable wider industry exposure in Queensland to the selection.

Outcomes

The project, conducted over 2 seasons, continued the evaluation of table grape germplasm material, generated in previous CSIRO breeding projects. It aimed to identify selections with potential to enable the industry to meet future challenges associated with production in a variable and changing climate and overcome problems/deficiencies of existing standard varieties. A particular focus was the identification of selections not prone to berry collapse as potential alternatives to Thompson Seedless; fruitful varieties with good budburst to address problems in tropical /sub-tropical regions and varieties that ripen early and late to extend the season of availability.

Progress has involved the evaluation of a range of material located at the CSIRO Irymple site including 1000 seedling genotypes derived from seedless x seedless and disease resistance crosses; 200 multiplied selections of promising types and 45 irradiated Red Globe mutants selected for a range of varying berry characteristics (i.e. seedlessness, reduced seed number, berry size and colour). As a consequence of the evaluation and culling of the genotypes not meeting key criteria, approximately 200 seedlings and 100 multiplied selections have been retained for further evaluation in a future project. Twenty seedling genotypes (i.e. 16 white and 4 red genotypes) selected in 2014 have been propagated for planting in multiplied plots at the CSIRO site in spring 2015. A further twenty five seedling genotypes (i.e. 20 white and 5 red genotypes), identified in 2015 will be propagated for establishment in multiplied plots at the CSIRO site. Seventeen promising multiplied selections (i.e. 15 white and 2 red genotypes) have been targeted for evaluation as grafted plants on Ramsey and 1103 Paulsen rootstock. They are currently being propagated by a commercial nursery and will be planted on the CSIRO site for evaluation in a future project. Further evaluation of the 25 high priority selections from the previous project (TG09003) has reduced the number to 17 selections. Of these, 15 have been propagated as grafted vines on Ramsey and Freedom rootstock, for establishment in the Northern Territory in spring 2015.

In regard to evaluation of the Red Globe selections, none of the seeded irradiated Red Globe selections appeared to offer significant advantages over the existing material. The seedless and near seedless types displayed poor fruit quality. Industry feedback indicated that no further study of the irradiated Red Globe should be undertaken although the material will be retained by CSIRO for research purposes.

Selections established by top-working on grower properties for semi-commercial evaluation in the Murray Valley have continued to show promise. These include the red and black early ripening seedless types and a mid- late ripening white seedless type which produces reasonably large, Thompson Seedless like berries without GA treatments. The evaluation of selections planted at regional sites continued in Queensland and Western Australia. The research concentrated on finalising evaluation and development of the two promising selections, already established under semi-commercial conditions in the Murray Valley (i.e. the early red and black seedless types) when grown in different environments. The early ripening red selection continued to show promise under sub-tropical conditions in Queensland as well as in the Murray Valley but produced unsatisfactory fruit quality at the more southern, Wokalup site in Western Australia. Performance of the early ripening black selection was unsatisfactory in both Queensland and Western Australia.

Evaluation and Discussion

This project, conducted over two seasons, has completed the initial evaluation of CSIRO breeding lines located in the Murray Valley and has identified genotypes for further development by research collaborators and industry. In the longer term the outputs from the project should provide a direct benefit to Australian table grape growers as it will lead to improved table grape varieties with potential to enable the industry to meet future challenges associated with production in a variable and changing climate and overcome problems/deficiencies of existing standard varieties. These will include alternative varieties to Thompson Seedless which are not prone to berry collapse; fruitful varieties with good budburst to address problems in sub-tropical regions; varieties that ripen early and late to extend the season of availability; varieties with good long term storage and transport characteristics and low input varieties to reduce production costs. New varieties meeting key criteria will enhance opportunities to expand in existing markets and develop new export markets, particularly if suited to long term storage. Varieties which minimise product loss through shatter, desiccation and browning of berries and stems, development of moulds etc. will add value across the entire delivery chain.

The project evaluated table grape germplasm material established by CSIRO in previous projects at various stages of development ranging from single vine seedlings, multiplied selections established in larger plots, selections established at regional sites in Queensland and Western Australia and on a semi-commercial grower site in the Murray Valley. Although some selections cropped for the first time during the project, significant culling was undertaken with numbers reduced to approximately 200 seedlings and 100 multiplied selections. Overall the project has identified 45 seedling genotypes (36 white and 9 dark) for propagation and establishment as own rooted vines in multiplied plots. A further 17 multiplied selections (i.e. 15 white and 2 red genotypes), identified for evaluation as grafted plants on Ramsey and 1103 Paulsen rootstock are being propagated by a commercial nursery for establishment on the CSIRO site for evaluation in a future project. Furthermore, ongoing evaluation of the 25 high priority selections from the previous project (TG09003) has reduced the number to 17 selections. Of these, 15 have been propagated as grafted vines on Ramsey and Freedom rootstock, for establishment in the Northern Territory in spring 2015. Further evaluation of the retained material is required to complete the evaluation of the CSIRO table grape breeding lines and identify selections for release to industry with PBR protection.

The evaluation of 45 irradiated Red Globe mutants did not identify any promising selections for advancement leading to a recommendation from the steering committee that no further work be undertaken with this material. From an industry perspective, increasing adoption of Crimson Seedless is reducing the reliance on the seeded Red Globe variety. None of the seeded Red Globe mutants appeared to offer significant advantages over Red Globe while the seedless and near seedless types displayed poor fruit quality. The Red Globe mutants will be retained by CSIRO for research purposes.

While no new varieties have been released or selections identified for inclusion in PBR, DUS comparator trials in the short time frame of this project, it is likely that a number of the selections at various stages of development, will be adopted as commercial varieties in the longer term. To achieve this, further evaluation of the range of material established at the CSIRO site is required with the best selections also evaluated under regional conditions in key production regions. A new three project is proposed which will complete the evaluation of all CSIRO seedling genotypes and multiplied selections established in previous projects, establish multiplied plots for the most promising seedling selections identified in this project, establish grafted vines of highly promising selections identified in this project in multiplied plots, distribute and establish targeted selections for

evaluation in regional sites and conduct PBR, DUS comparator trials for selections identified with potential for release to industry.

Recommendations

It is recommended that a new 3 year project be developed for submission to HIA to:-

1. Complete the evaluation of the established CSIRO table grape germplasm material located at the CSIRO Irymple farm including 200 seedling genotypes and 100 multiplied genotypes.
2. Establish the 17 most promising selections, identified in this project, as grafted vines on Ramsey and 1103 Paulsen rootstocks in multiplied blocks, to assess their management characteristics and fruit quality characteristics under modern management practices.
3. Establish the 45 promising seedling selections identified in this project in multiplied blocks on the CSIRO property.
4. Facilitate the establishment and initial evaluation of selections identified for evaluation at regional sites. For material targeted for evaluation in Western Australia this will involve a period of a year in quarantine. Some initial evaluation of the selections established in regional sites in Queensland and the Northern Territory may also be conducted in year three of the project.
5. Complete the evaluation of the limited number of selections established on regional sites in previous projects in Queensland and Western Australia. This will involve imposition of advanced management practices to optimize production and fruit quality.
6. Establish further semi-commercial sites for the selections with the highest potential for industry adoption.
7. Establish PBR comparator trials, for the selections with the highest potential for industry adoption, to establish Distinctness, Uniformity and Stability. Once fully established, collect key data for PBR application when a decision is made to name and release to industry.
8. Establish mother vine plantings of the high potential selections to facilitate rapid industry adoption of new varieties, once a decision to release is made, to ensure that adoption is not limited by the supply of material.
9. Develop specific grower management information for new varieties released.
10. Assess in the 3rd year, further requirements to complete evaluation of selections established on regional sites in the Murray Valley including the CSIRO property, Queensland, the Northern Territory and in Western Australia.

After 3 years of further evaluation it is expected that the future project will deliver a range of material to industry at different stages of development. These would include:-

1. New varieties named and released with PBR protection for table grape production.
2. A small number of highly promising selections varieties, established in new PBR comparator trials and established in semi-commercial sites, with potential for naming and release. The plan would be to have no more than 10 selections in this category.
3. A limited number of promising selections, grafted on Ramsey and 1103 Paulsen rootstock established in multiplied blocks on the CSIRO property for assessment under modern management practices. The plan would be to have no more than 30 selections in this category.
4. A limited number of selections established for evaluation in regional sites across the country. The plan would be to have a total of no more than 20 selections in this category although this will vary depending on regional requirements and harvest date.
5. A limited number of multiplied selections, established as own rooted vines on the CSIRO property. The plan would be to have no more than 50 selections in this category.

Scientific Refereed Publications

Journal article

None to report

Whole book

None to report

Chapter in a book or Paper in conference proceedings

Clingeleffer, P., McCarthy, B., C., Cameron, I., Oag,D., McConchie, C. and Walker, R. (2014) Developments in the Australian Table Grape Breeding Program. In Proc. 7th International Table Grape Symposium, Mildura, November 2014, 39-42. (appendix 1)

Intellectual Property/Commercialisation

The key IP issue relates to the genetic material which has been evaluated in this project. CSIRO and HIA retain ownership of all genetic material which has been licensed to the project including seedlings, multiplied selections and selections identified or established in semi-commercial plantings. Conditions for access and use of the genetic material within the table grape breeding program were established through an agreement between CSIRO and ATGA with approval from HIA. For the purposes of this project, CSIRO made available to the project team all genetic material comprising the table grape breeding program including seedlings, parents and advanced selections. Selections, for establishment at regional sites and on semi-commercial grower sites are only made available with appropriate CSIRO Plant Evaluation agreements in place. New varieties will be protected by Plant Breeders Rights (Australia), and equivalent overseas mechanisms in the event of a recommendation for release. Other IP involves the creation of new knowledge and information on implementation of management practices, sensory evaluation and postharvest storage techniques.

While no new varieties have been identified for naming and release to industry in this project, a number of selections with high potential for naming and release have been identified. For PBR purposes, DUS comparator trials will be established as part of a new project on the CSIRO property. This is to avoid delays once a selection is identified for future release. The collection of comparator data will be included as part of a new project proposal submitted to HIA.

The project recognizes IP generated in the previous FR97047 and TG03008, TG09003 and CSIRO Food into ASIA projects including documented stakeholder inputs (i.e. industry bodies, CSIRO, HAL, and state departments).

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The project team also wish to acknowledge significant role of Arryn Clarke, the CSIRO Irymple farm Manager, who not only conducted the routine farm management activities (i.e. pruning, spraying for pest and diseases, irrigation and vine removals) but provided significant support over the harvest period with coordination of access to vehicles, cool room and laboratory facilities.

The contributions of growers providing semi-commercial sites for the most advanced selections has also been greatly appreciated. The input of Allan Price (TGWA) in the identification of promising selections, particularly with potential for adoption in Western Australia is acknowledged. The involvement of KC Nurseries in the propagation of grafted vines for the regional site in the Northern Territory and for establishment on the CSIRO Irymple farm has also been appreciated.

Input by industry members of the Steering Committee, Richard Lomman, Allan Price, Barry Pederson, David Smith and Werner Ullrich, is also gratefully acknowledged.

Appendices

Appendix 1.

DEVELOPMENTS IN THE AUSTRALIAN TABLE GRAPE BREEDING PROGRAM

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Background and Aims

The Australian table grape grower is faced with new and evolving challenges surrounding production in a changing and variable climate, increasing consumer and regulatory demands with respect to product integrity and environmental responsibility and a need to maintain international competiveness. Table grape industries throughout the world are adopting new, deliberately bred varieties with a trend towards seedless types. The table grape industry, Horticulture Australia Ltd., CSIRO and collaborating research organisations have supported a national approach to table grape breeding and development since 1998 (Clingeleffer 2005, 2010, 2013). Breeding strategies have aimed to develop varieties to address specific market requirements in terms of key consumer based quality traits (seedlessness, berry size, texture and flavour), disease resistance, early and late maturity to extend the harvest season, long storage life to allow access to more distant markets and development of alternate varieties to Thompson Seedless that are not prone to berry collapse.

Modern management practices were applied to advanced selections grown in key regions with different climates and seasonality in a nationally coordinated approach with input from collaborating agencies in Queensland, the Northern Territory and Western Australia. These regional tests included application of various management techniques to enhance quality (eg. pruning regimes, bunch thinning and trimming, GA where appropriate) and visual, physical, chemical and sensory evaluation of fruit at harvest and after long-term storage.

This paper provides an overview of the program leading to the release of new table grape varieties

and to new knowledge incorporated into the studies.

Experimental Procedures and Results

Conventional hybridisation techniques between selected parents were used to produce new seedling progeny. The progeny were evaluated at different stages of development (i.e. as single vine seedlings, promising selections established in multiplied plots including grafted on rootstocks, advanced selections established in regional sites with different climate and management practices and, for near to release selections, established on semi-commercial grower sites to refine management practices and provide sufficient fruit for test marketing.

Key components of the program have been the improvement in embryo rescue techniques for crosses between seedless parents, the development of disease resistant screening techniques and application of modern quantitative genetic methods to understand the inheritance of key characteristics (Clingeleffer et al. 1999, 2003, 2009, Sykes et al. 2001).

1. Embryo rescue

In order to improve the efficiency of breeding seedless varieties, *in-ovulo* embryo rescue techniques were used to develop new hybrids from seedless x seedless grape crosses (Clingeleffer et al.1999). Under *in-vitro* conditions (i.e. in tissue culture), embryos which would normally abort, continue to develop and can be established as normal plants in the research vineyard. Over the course of the program more than 200 seedless x seedless combinations were tried, including 25% which were unsuccessful and produced no progeny. This this may be attributed, at least in some cases, to the fact that seedlessness can be due to pathenocarpy, where berry development occurs without fertilization and development of an embryo (Clingeleffer et al. 2003).

Investigations to improve the efficiency of the embryo rescue technique included effects of genotype; the culture medium, including supplements of various minerals, plant growth regulators and other organic substances; and the effect of ovule age at removal on ovule elongation, embryo recovery, embryo growth and plantlet formation (Liu et al. 2003a, 2008a). As a result, survival rates at all stages of culture improved (i.e. ovule culture, embryo rescue and plant acclimatisation), giving results comparable to overseas programs (Liu et al. 2003a).

2. Disease resistance screening

A major aim of the program was to develop disease resistant varieties to reduce usage of agrichemicals in the vineyard (Clingeleffer et al. 1999, Sykes et al. 2001). The main diseases targeted were botrytis bunch rot (*Botrytis cinerea*), powdery mildew (*Uncinula necator*) and downy mildew *(Plasmopara viticola)*, which originate from the American continent. A diverse range of disease resistant genotypes were used as parents. In some cases, crosses over a number of generations have produced complex pedigrees in the breeding lines. Parents used have included *V. rotundifolia*, *V. cinerea*, *V. caribaea*, *V. longii, V. aestivalis and V. labrusca* as well as hybrids with pedigrees incorporating many species. Rapid, leaf based laboratory screening protocols were developed for powdery and downy mildew (Sykes et al. 2001, Liu et al.2003b, Liu et al. 2008b) and used to assess hybrid populations for resistance (Liu et al. 2008). Among the hybrid populations there were no lines completely resistant to powdery mildew but some that had complete resistance to downy mildew (Liu et al. 2008). Correlations between powdery and downy mildew resistance were weak. For downy mildew resistance appears to be governed a limited number of recessive genes, indicating potential

to develop molecular markers to rapidly screen very young seedlings (Liu et al. 2008b).

The disease screening results show that development of varieties which are tolerant or resistant to both powdery and downy mildew is achievable. Indeed, CSIRO recently released a new, early ripening, disease resistant currant variety with small black berries, M 48-42 (syn. Black Gem)Φ which can be grown without the use of fungicides (Clingeleffer et al. 2011). Black GemΦ was selected from progeny of a controlled cross between Seyve-Villard 39-639, a complex multispecies, disease resistant hybrid and Beauty Seedless, a black, early ripening table grape variety. There has been limited niche marketing of Black GemΦ as a table grape in domestic and export markets.

3. Inheritance of key characteristics.

Genetic parameters including heritability and genetic correlations of production and fruit quality characteristics were investigated to enable effective selection of parents and to predict outcomes of crosses with greater accuracy (Wei et al. 2003a). Yield and quality characteristics were collected across a diverse range of complex bi-parental progenies comprising of more than 5000 seedlings involving combinations of 40 female and 60 male parents in 1999 and 2000 (Wei et al. 2002, Wei et al. 2003 a,b). Genetic parameters were estimated from data for each season separately and from data pooled over both years using advanced statistical methods (Wei *et al.* 2003a). Narrow-sense heritability estimates (h^2) provided a basis for selection of parents based on their estimated breeding values, which indicate how well they will transmit the characteristics they display to progenies.

Overall, there were three major findings applicable to table grape varietal development (Wei et al. 2002, Wei et al. 2003 a,b). First, most characteristics were generally under medium to strong genetic control and reasonable genetic gain could be expected from selection based on individual vine performances. This was particularly the case for quality traits where the estimates h^2 indicated that selection for ripening date, berry size, sugar content and acidity should be very effective. Second, there were no significant family by harvest season interaction effects. Hence, selection based on single year's data was as effective as that based on two years' data. Third, selection based on individual characteristics could be hindered by negative genetic correlations. Hence it would be unwise to select a vine based on only one or two characteristics as this may have unfavourable impacts on other traits. For example, berry weight was negatively with juice sugar concentration.

4. Varietal release

Three new varieties have been released with PBR protection (i.e. the early ripening white seeded Muscat, M 51-18Φ, the mid-season black seedless type, M 13-01Φ and the mid-late ripening white seedless, M 44-14Φ)(Figure 1). Marketing involves use of trademarks for fruit of the new varieties that meet quality specifications (i.e. Millennium Muscat™, Magic Seedless® and Mystic Seedless™ for the three new varieties, respectively).

M 51-18Φ produces very early ripening, white seeded grapes that develop a distinct muscat character. It is being grown in the sub-tropical Carnarvon region of Western Australia for domestic markets. M 13-01Φ produces very attractive loose bunches with green stems and large natural berries (5-7 g) and does not require GA treatments. It is grown in most regions for both domestic and export markets. The latest release, M 44-14Φ (Clingeleffer et al. 2011), produces large, crisp, seedless berries and is suited to long-term cool storage. It requires GA treatments for thinning and GA and

CPU treatments for berry sizing to give a 5-7 g berry.

Figure. Views of the varieties released from the program, i.e. M 51-18® (left) M 13-01® (middle) and M 44-14® (right)

5. Current status of the program

No new breeding has been undertaken since 2008. Material retained for evaluation includes 630 seedless single vine seedlings, 210 multiplied selections and 21 seedless selections identified with promise for evaluation at regional sites. The latter material includes 12 white (one with strong muscat character), 6 red and 1 black selection with natural berry weights ranging from 4-6 g without the use of GA. A further 3 early ripening selections (1 white, 1 red and 1 black selection) are established on grower sites for semi-commercial evaluation.

Discussion and Significance of the Study

A national table grape breeding and evaluation has been conducted for 16 years in Australia. New breeding has generated new genotypes which have been established in the field for evaluation. A number of seedless selections have been identified with significant potential for further evaluation and commercial development. The national evaluation of selections with high potential in the major growing regions has enabled assessment to be conducted in a diverse range of climates with varying seasonality and management practices. Three new varieties, the early ripening the white seeded muscat M 51-18®, the black seedless selection, M 13-01® and the white seedless M 44-14® have been released from the program. New knowledge concerning the inheritance of key characteristics, improvements for *in-ovulo* embryo rescue and rapid screening for disease resistance have been incorporated into the program.

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Appendix 2.

Evaluation of promising new table grape selections resumes

The Australian table grape grower is faced with new and evolving challenges surrounding production in a changing and variable climate, increasing consumer and regulatory demands with respect to product integrity and environmental responsibility and a need to maintain international competiveness. To compete in a difficult global environment Australia must differentiate its table grapes based on consistent high quality.

The previous national breeding and evaluation project (TG09003) was coordinated by CSIRO with input from collaborating research agencies in Queensland, the Northern Territory and Western Australia (TG09003). It aimed to identify selections that offer desirable characteristics such as early and late ripening, protection from berry collapse, good long-term storage, fewer inputs and disease resistance. Advanced selections were established and evaluated at 5 regional sites located at Emerald and St George in Queensland, at Ti-tree in the Northern Territory and at Carnarvon and Wokalup in Western Australia.

A new project, supported by voluntary contributions from industry will be coordinated by ATGA over the next 2 years to continue assessment of CSIRO table grape breeding lines, advanced selections currently established at regional sites and on semi-commercial sites. The material includes 1,000 seedlings, 210 promising multiplied selections, 60 Red Globe mutants, 7 advanced selections established on regional sites including three established on semi-commercial sites in the Murray Valley, 12 irradiated Red Globe on a commercial property and 25 advanced selections identified with potential for regional evaluation. The Red Globe mutants have varying levels of the seedless trait, seed number, berry colour and size.

Emphasis at the regional sites will be placed on optimising production techniques for three of the most promising advanced selections that are also established on semi-commercial sites on grower properties in the Murray Valley. These include an early ripening red selection which produces very attractive, red, crisp, seedless berries, selected because of its potential for marketing between Flame Seedless and Crimson Seedless (Figure 1), an early ripening black selection which produces large, black, crisp, seedless berries, very attractive bunches with green stems (Figure 2) and a mid-season white selection which produces crisp, large berries without the use of GA (Figure 3).

Figure 1. Early ripening red selection which produces very attractive, red, crisp, seedless berries.

Figure 2. Early ripening black selection which produces large, black, crisp, seedless berries, very attractive bunches with green stems.

Figure 3. Mid-season white selection which produces crisp, large berries without the use of GA.