Developments in the Australian Table Grape Breeding Program

Peter Clingeleffer, Belinda McCarthy, Colin Gordon, Ian Cameron, David Oag, Cameron McConchie and Rob Walker

7th International Table Grape Symposium, November 2014
National project: working with industry to develop new varieties since 1998

National Industry Steering Committee
# Table Grape Varieties grown in the Murray Valley (80% of Australia’s production)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crimson Seedless</td>
<td>3377</td>
</tr>
<tr>
<td>Thompson Seedless</td>
<td>1848</td>
</tr>
<tr>
<td>Red Globe</td>
<td>1042</td>
</tr>
<tr>
<td>Menindee Seedless</td>
<td>899</td>
</tr>
<tr>
<td>Autumn Royal</td>
<td>355</td>
</tr>
<tr>
<td>Ralli Seedless</td>
<td>210</td>
</tr>
<tr>
<td>Flame Seedless</td>
<td>170</td>
</tr>
<tr>
<td>Calmeria</td>
<td>105</td>
</tr>
<tr>
<td>PBR varieties</td>
<td>597</td>
</tr>
</tbody>
</table>

Source: *SunRISE* Mapping and Research 2014
To remain competitive in international and domestic markets, industry require new varieties.

Increasing difficulty to access overseas varieties.

Alternatives to Thompson Seedless (susceptible to berry collapse).

Key criteria for new varieties:

- Extend season
- Storage, transport and shelf life
- Large seedless
- Flavour
- Disease resistance to reduce chemical use
- Low input
Project components

Developing seedless types by conventional breeding
• In-ovulo embryo rescue for seedless x seedless crosses
• Understanding seedlessness
• Inheritance of key characteristics
• Disease resistance
• Identification of potential types

Evaluation of best selections
• Regional adaptation
• Management practices
• Consumer acceptance
## Stages of evaluation

<table>
<thead>
<tr>
<th>Stage</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single vine seedlings</td>
<td>1000’s</td>
</tr>
<tr>
<td>Multiplied and top-worked</td>
<td>300</td>
</tr>
<tr>
<td>Regional sites (6-8)</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Semi-commercial</td>
<td>3</td>
</tr>
</tbody>
</table>
National evaluation of promising selections

Regional adaptation
- variation in management, fruitfulness, seedlessness
- market requirements and availability
Multiplying and top-working

- Multiply promising selections into own-rooted replicates
- Top-working onto older grafted vines
  - Rootstocks include 1103 Paulsen, Freedom, 140 Ruggeri, Ramsey and Schwarzmann
Assessment and evaluation (multiplied and regional sites)

Management techniques
- pruning
- bunch and berry thinning
- hormone application (GA, CCPU)
- cincturing

Harvest
- maturity date
- yield
- fruit characteristics (approx. 20)
- sugar and titratable acidity
- sensory evaluation

Post-harvest storage
- rots, shatter
- storage and shelf life
Grower field days

Murray Valley

Western Australia
Grower and industry displays
Sensory evaluation

Conducted by Ian Cameron AgWA & Dr Vijay Jayasena of Curtin University, WA.

Visual evaluation

Taste (eg. sweetness)

Evaluation booths
Conventional breeding
Optimising *in-ovulo* embryo culture for (seedless x seedless crosses)

- varieties where seedless characteristic is stemospermocarpic, not parthenocarpic
- maximum 5 generations, David Ramming USDA

Ovule culture
- embryo recovery

Embryo culture
- embryo survival

Conversion
- acclimatisation

Parental selection

Date after flowering

Media manipulation
- Calcium
- Organic Substances
- Activated Charcoal

Growth conditions

Liu, Sykes and Clingeleffer 2003, 2008
## In-ovulo rescue outcomes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. crosses</td>
<td>45</td>
<td>78</td>
<td>89</td>
</tr>
<tr>
<td>No. cultured ovules</td>
<td>2141</td>
<td>8422</td>
<td>13424</td>
</tr>
<tr>
<td>No. rescued embryos</td>
<td>645</td>
<td>763</td>
<td>3224</td>
</tr>
<tr>
<td>Mean recovery rate (%)</td>
<td>30.0</td>
<td>9.1</td>
<td>24.0</td>
</tr>
<tr>
<td>No. survival embryos</td>
<td>176</td>
<td>694</td>
<td>3125</td>
</tr>
<tr>
<td>Mean survival rate (%)</td>
<td>27.0</td>
<td>91.0</td>
<td>96.9</td>
</tr>
<tr>
<td>No. plants</td>
<td>83</td>
<td>469</td>
<td>1200 +</td>
</tr>
<tr>
<td>Mean conversion rate (%)</td>
<td>47.2.</td>
<td>61.5</td>
<td>&gt;50?</td>
</tr>
</tbody>
</table>

Approximate total plants produced: **1,800 +**
## World comparison

<table>
<thead>
<tr>
<th></th>
<th>Number of cultured ovules</th>
<th>Embryo recovery rate (%)</th>
<th>Plant conversion rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSIRO (02)</td>
<td>13424</td>
<td>24.0</td>
<td>≈ 50.0 (exp.)</td>
</tr>
<tr>
<td>France</td>
<td>15610</td>
<td>22.1</td>
<td>36.7</td>
</tr>
<tr>
<td>Florida, USA</td>
<td>5755</td>
<td>23.4</td>
<td>44.5</td>
</tr>
<tr>
<td>Spain</td>
<td>14698</td>
<td>18.1</td>
<td>26.0</td>
</tr>
<tr>
<td>Fresno, USA</td>
<td>37360</td>
<td>23.4</td>
<td>31.0</td>
</tr>
<tr>
<td>Japan</td>
<td>6232</td>
<td>18.1</td>
<td>41.0</td>
</tr>
</tbody>
</table>

(From published sources)
Disease resistance

**Screening populations for:**
- Powdery Mildew
- Downy Mildew
- (Botrytis rots)

(Laboratory, glasshouse, unsprayed field sites, and long-term storage of fruit)

Liu, Sykes and Clingeleffer 2003, 2008
Disease resistance

A diverse range of disease resistant parents used including:

- *V. rotundifolia*
- *V. cinerea*
- *V. caribaea*
- *V. longii*
- *V. aestivalis*
- *V. labrusca*
- multispecies complexes
Disease screening

Genotypic differences in response to downy mildew inoculation (6 days after incubation)
M 48-42 (syn. Black Gem)  
Released in 2011  
*Early ripening disease resistant currant*

- Potential for organic production (dried, juice, table, wine?)
- High antioxidant levels
- Provisional PBR granted
- US Plant patent obtained
Black Gem – disease resistance (field)

- no problems with downy & powdery mildew and botrytis in unsprayed site, 2011 which received 924 mm over the growing season
- hypersensitive reaction to downy mildew
- some minor berry splitting
- cross between Beauty Seedless x Seyve-Villard 39-639

Beauty Seedless

Black Gem
Conclusions: *Inheritance of vine resistance to mildews*

Resistance to mildews was governed by limited number of loci (genes) indicating potential to develop molecular markers for rapid screening of seedlings.

Powdery mildews differ in genotype response in Sunraysia and Queensland.

No line completely resistant to powdery mildew, but some to downy mildew.

Breeding grapevines resistant to both mildew diseases is achievable.
Identifying new seedlings

Screening new hybrids
• Identify promising material
• Provide data for inheritance studies

Unmanaged or minimal input
• Single wire
• Own roots
• Close planted
• Targeted management on some selections
• Best selections are multiplied and/or top-worked
Inheritance of key characteristics

Experimental details

Bi-parental progenies

- 40 female parents
- 60 male parents

Conventional and in-ovulo embryo rescue breeding

Planted as family groups

1.5 x 2.4m vine x row spacing

Cane pruned (2-4 canes)

(N = 5500), seasons x 2

Wei, Sykes and Clingeleffer 2002, 2003a, 2003b
Variation in four key grape berry traits

- **Yield (kg/vine)**: The graph shows the frequency distribution of yield per vine, with a peak around 15 kg/vine.
- **Seediness**: The bar chart illustrates the frequency of seediness categories, with a significant number of berries being seedless.
- **Berry weight (g)**: The histogram displays the distribution of berry weights, with a peak around 25 g.
- **°Brix**: The bell-shaped curve represents the frequency distribution of sugar content, with a peak around 20°Brix.
## Estimates in narrow-sense heritability

<table>
<thead>
<tr>
<th>Yield Characteristics</th>
<th>pooled $h^2 \pm \text{s.e.}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigour</td>
<td>0.22 ± 0.05</td>
</tr>
<tr>
<td>Yield per vine</td>
<td>0.18 ± 0.04</td>
</tr>
<tr>
<td>Bunch number</td>
<td>0.41 ± 0.08</td>
</tr>
<tr>
<td>Bunch weight</td>
<td>0.23 ± 0.05</td>
</tr>
<tr>
<td>Bunch length</td>
<td>0.28 ± 0.07</td>
</tr>
<tr>
<td>Bunch size uniformity</td>
<td>0.10 ± 0.04</td>
</tr>
<tr>
<td>Bunch density</td>
<td>0.14 ± 0.05</td>
</tr>
</tbody>
</table>

Generally low heritability (except bunch number)
Estimates in narrow-sense heritability

<table>
<thead>
<tr>
<th>Quality Characteristics</th>
<th>Pooled $h^2 \pm \text{s.e.}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ripening date</td>
<td>0.35 ± 0.03</td>
</tr>
<tr>
<td>Berry weight</td>
<td>0.63 ± 0.04</td>
</tr>
<tr>
<td>Berry width</td>
<td>0.69 ± 0.04</td>
</tr>
<tr>
<td>Berry length</td>
<td>0.68 ± 0.04</td>
</tr>
<tr>
<td>Berry size uniformity</td>
<td>0.12 ± 0.06</td>
</tr>
<tr>
<td>Seediness</td>
<td>0.58 ± 0.07</td>
</tr>
<tr>
<td>oBrix</td>
<td>0.48 ± 0.06</td>
</tr>
<tr>
<td>Acidity</td>
<td>0.36 ± 0.08</td>
</tr>
</tbody>
</table>

Generally high heritability (except berry size uniformity)
Heritability and expected genetic gain

Heritability ($h^2$)

- °Brix
- Seediness
- Berry weight
- Yield / vine

Genetic gain (%)

- 0.0
- 10.0
- 20.0
- 30.0
- 40.0
- 50.0
- 60.0
Genetic correlations between three key grape berry traits

Berry weight

Seediness

$\rho_g = 0.46 \pm 0.12$

$\rho_g = -0.31 \pm 0.04$

°Brix
Conclusion

3 Major findings

Characteristics under medium to strong genetic control

No significant seasonal effects

Need to consider correlations when selecting for multiple traits

Parent selection based on “breeding values”
Three varieties released with PBR protection. Variety information leaflets

M 51-18

Description:
M 51-18 is a medium early vinifera-based grape variety with strong performance and potential for high-quality wine production.

Commercialisation:
M 51-18 is available for purchase from the licensed commercialiser, GrapesWA. For further information, contact GrapesWA on 08 9274 333 or grapeswa@grapeswa.com.au.

M 44-14

Description:
M 44-14 is a medium late season grape variety with excellent flavor and high-quality wine production potential.

Commercialisation:
Table Grape Vine Vines (TGW) Ltd. is the licensed commercialiser of M 44-14. For further information, contact TGW at 08 9313 4444 or sales@tablegrapevinevines.com.

M 13-01

Description:
M 13-01 is an early mid-season black seedless variety with excellent flavor and high-quality wine production potential.

Commercialisation:
M 13-01 is available for purchase from the licensed commercialiser, Black Seedless. For further information, contact Black Seedless on 08 9313 4444 or sales@blackseedless.com.au.
Released Varieties

M 51-18

- Creamy golden colour
- Strong muscat flavour
- Early ripening and seeded
- Suited to Carnarvon
- Launched November 2005
- Fruit meeting specifications is marketed as Millennium Muscat™ by licensed agents
Released Varieties

M 13-01

- Black berries
- Bright green stems
- Seedless
- Easy to grow – No GA
- Suited to most regions
- Launched January 2007
- Fruit meeting specifications is marketed as Magic Seedless® by licensed agents
Released Varieties

**M 44-14**

- Mid/late season white seedless
- Fruitful – can be spur pruned
- Large crisp berries
- Responds to GA and Sitofex®
- Oblate berry shape
- High acid
- Excellent for storage
- PBR
- US patent granted
- Fruit meeting specifications is marketed as Mystic Seedless™ by licensed agents

Mystic Seedless™
Current status (no new breeding since 2008)

- 630 seedless single vine seedlings
- 210 multiplied selections
- 22 seedless selections identified for evaluation at regional sites, with natural berry weights between 4-6 g
  - 12 white (one with strong muscat character)
  - 6 red
  - 1 black
  - 3 purple
- 3 selections on semi-commercial grower sites
Semi-commercial selection X

- Late white seedless
- Elongated berry shape
- Naturals (no GA) are crisp and long
- Sun exposure and browning
Semi-commercial selection Y

- Early red seedless
- Very crisp and fruitful
- Potential to fill supply gap between Flame Seedless and Crimson Seedless
- Bright colour
Semi-commercial selection Z

- Early black seedless
- Requires GA for sizing
- Low vigour with short cane length
- Requires vigourous rootstock
- Small bunch does not require trimming
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Bianca Schreiber
Karen Connolly
Phil Cupper
George Morris
Richard Fennessy
Chris McMullan
Amanda Annells
Raghu Sagumathy
Martin Hidalgo
Sue Wills
Geoff Kenna
Farm staff

Industry Support
Steering Committee members
Industry organisations
Growers for trial sites
Licenced propagators/nurseries/agents

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Grower stakeholders & levy payers
Horticulture Australia
CSIRO
DAFWA
QPIF
NT DPIFM
Thank you