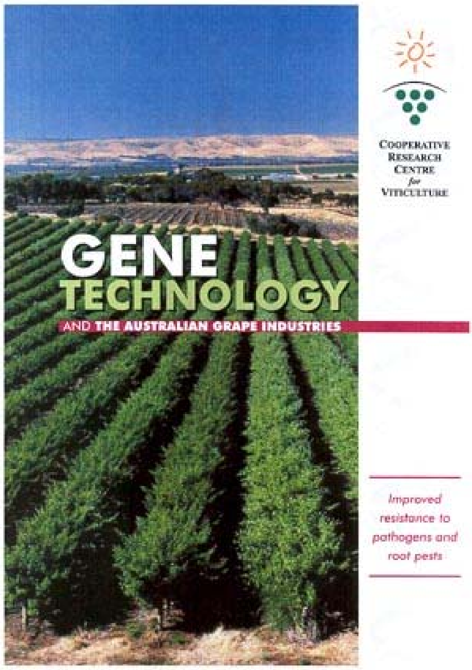
Cooperative Research Centre for Viticulture

Australian Government
Grape and Wine Research and Development Corporation

Adoption of genetically modified grapevines



FINAL REPORT to
GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **CRCV 99/18**

Principal Investigator: **Angela Gackle/Simon Robinson**

Research Organisation: **Cooperative Research Centre for Viticulture**

Date: **26/9/2003**

Project Title: **Communication to the Grape and Wine Industries**

CRCV Project Number: **3.5**

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The Cooperative Research Centre for Viticulture is a joint venture between the following core participants, working with a wide range of supporting participants

Executive Summary

The primary aim of Project CRCV99/18 - *Communication to the Grape and Wine Industries* - has been to inform industry and the public about the gene technology (GT) research carried out in CRCV Program 3 and to emphasise that this work is entirely experimental at this time.

Our approach has been to keep industry stakeholders up to date with progress, to offer our presence at any meeting possible and accept every opportunity for direct contact. The fact that this project has been staffed in-kind by a number of senior researchers indicates our belief that face-to-face discussion is a powerful communication mechanism.

Vehicles for delivery in this project included written material for a variety of audiences and participation in wine industry-specific events such as annual general meetings, discussion fora, field days and the 2000 Wine Industry Technical Conference. Perhaps most significantly we were able to help the Australian wine industry to develop and articulate a policy relating to research using GT for the industry.

Whilst there were more goals identified at the beginning of this project, it was necessary to adjust our ambitions to keep pace with the gradual development of industry awareness and acceptance of this issue. We are satisfied that this project has achieved good results for both the research program and the industry. Significantly, in June Nigel Scott and Peter Hayes delivered papers at the OIV meeting in Paris. Feedback suggests that the possible future use of gene technology, in one application or another, is now on the international agenda and Australia is seen as having a clear and open position.

Introduction and Objectives

It has been clear in the past decade that gene technology promises – and in many cases is already delivering - some very great benefits to the biological sciences, health, industry and the environment.

When this project began there was no GT legislation in place in Australia but GMAC (the Genetic Manipulation Advisory Committee) had been operating on a voluntary basis for some years. The establishment of an Act and guidelines had also been foreshadowed.

A number of other agencies, with a brief to provide information to various sectors of the Australian community, were established within the period of this project. It was felt that to put the Australian wine industry and its leaders in the best position to make decisions about the use of gene technologies we should focus effort on the wine industry sector.

Gene technology is a complex and relatively new area of scientific effort with many apparent contradictions. Whilst its use has been embraced without a whimper by the pharmaceutical and medical industries there is still much suspicion and resistance to food-based uses.

The project team was aware that this is a difficult subject to communicate. Our task was to make it as accessible as possible, try to convey the excitement of the research and to encourage engagement of stakeholders in any way. It had also become clear during the first couple of years that some parts of the industry were more ready or interested in hearing what we had to say than others.

Primary staff of this project have been Angela Gackle, Communicator with CSIRO Plant Industry and Simon Robinson, Leader of Program 3 and Principal Researcher at CSIRO Plant Industry. Significant contributions have been made by Nigel Scott, Peter Høj and researchers in Program 3.

The following broad objectives were defined to cover the major issues for the industry.

Project Objectives

- **Reassure consumers on *non-use* of GMO's in Australian wine**
- **Assure the industry the research is being carried out responsibly**
- **Communicate the research and its benefits to the industry**
- **Promote understanding of the technology**
- **Monitor and manage intellectual property**
- **Communicate to consumers the research benefits & timeframes**

Results/Outcomes

1. One of the first actions was to initiate a process of consultation with industry representatives to agree upon a position statement **(see Appendix 1)**. This industry statement is clear and unambiguous and has been important as a reference point for the industry, media and international community. It is currently being revised and updated.
2. Two eight page full colour brochures describing the research in Program 3 have been produced and a third is in draft form **(Attachment 1)**. The third brochure will be designed to be placed on relevant web pages but is unlikely to be printed in hard copy.
3. We wrote to the Committees of major Australian wine grape growing regional associations, offering to attend meetings to present information about the research and discuss issues with members. Most South Australian and some Victorian grower organisations have taken up the offer of a speaker **(see table 1 below).**
4. Media releases were issued highlighting research progress where appropriate **(see Appendix 2)**. The April 2002 release about a *Nature* paper on the Pinot Meunier mutant attracted by far the most interest, with numerous requests for newspaper and radio interviews and enquiries from wine and science writers both within Australia and internationally.
5. An issue management plan **(Appendix 3)** was produced at the request of the CRCV Board to guide staff actions in the event of an unintended breach of security involving GM plants. Whilst the risk and incidence of such an event, for example breakage to a PC2 glasshouse or accident to vehicle transporting GM plants, is extremely low (no such recorded events to date), it was felt that an emergency procedure would ensure that all bases are covered and risk of GM escape into the environment is minimized.
6. Following discussions at a meeting of the CRCV Industry Reference Group (IRG) it was suggested that a Frequently Asked Questions (FAQ) brochure be produced to address some concerns about gene technology that relate specifically to grapevines. A brochure

was produced **(Appendix 4)** and input sought from the IRG. One difficulty identified with this document is that some of the issues are not exhaustively explored. Agrifood Awareness Australia was established around the time this project began (1999) and they very quickly wrote some brochures on many of the same topics. These are readily available on the AFAA website, and provide much more detail about these subjects. The current plan is to put the FAQ sheet on the CRCV website with links to other sites with more information.

7. The research in this project has been publicised via commissioned television programs including cross country, and a short video was produced for use by Ross Skinner at a Dried Vine Fruits Conference in the UK in October 2002.

Discussion

It is difficult to judge the impact of this communication effort on the Australian wine industry or sectors of it. An overriding feature of the project has been an the low level of debate within the industry. On the face of it, it has seemed that the growth of understanding about GT in the wider community has been painfully slow (not just in the wine industry) despite a few quite vocal anti-GM groups. Results from Biotechnology Australia's second 'Biotechnology Public Awareness Survey' suggest that there is still much uncertainty and misconception surrounding gene technology and the use of genetic manipulation in plants and food in this country. There is obviously still much work to be done in communicating the benefits of this technology to the community.

There is certainly a significant core of industry leaders who have shown great support for CRCV Program 3 and have been public advocates for the research. They are generally industry personnel who have had greater exposure to information about the progress of this science and sought discussions with the researchers.

Having spoken to quite a number of community groups in the past few years my impression is that many people, whilst not well-informed about the mechanics and applications of GT, are certainly aware of issues relating to control of technology, cost of patents and use of patented technology and the uncertainty surrounding containment of GM crops. There is also quite good, if qualified, support for the potential environmental benefits such as crop protection, drought tolerance etc. If these benefits can be clearly demonstrated in the near future it will go a long way to building acceptance. With respect to grapevines, an acid test for Australia – and the world - will be a GM vine that is resistant to powdery mildew.

A significant recent development has been the International Grapevine Genome Project, in which Australian researchers are playing an integral role. Within a very short time all major wine producing countries have become aligned behind this goal. Despite the debate surrounding the use of GT in the wine industry (among others) that encompasses political issues, speculation about potential but so far unrealized negative effects on marketing, health and the environment, the research community and wine industry decision makers have put aside concerns to pull together in this quest.

In the past two years the establishment of the Office of the Gene Technology Regulator, following new legislation governing GT research, has seen the advent of large amounts of paperwork to certify existing research work. At this moment there is no cost to organisations for this process, however there is discussion about implementation of a cost recovery system for the OGTR. The impact of such charges cannot be predicted, but might lead to a rationalization of research projects involving GM plants and field trials.

Conclusions

There are a few 'take home' messages from this project.

1. **Gene technology has the potential to revolutionise agriculture, but there is no indication that GM crops are being embraced wholesale by consumers at this stage.** On the other hand, there has been steady growth of around 12% per annum in the hectarage of broadacre GM crops. For these crops (corn, canola, cotton and soybean) more than 20% of the world area is GM and in the case of soy more than 50% is GM.

2. **Communication of such a complex technology with many unresolved social and ethical issues is going to be a long term process.**

3. **There has been a significant shift in rhetoric and motivation over ten years from GM products to the non-GM benefits of gene technologies and information.** At the outset of this Program industry (and researchers) were keen to speculate on the many useful modifications that might be possible using GT. Early success in grapevine transformation also encouraged a perception that GM grapevines for industry were imminent. In Australia public and market forces have not shut down research but seem to be encouraging a 'take it slow' approach to development of GM products. Many State governments seem to be pouring money into Biotech enterprises and setting up specialist offices to monitor the domestic and international situation for GT.
4. **Response to a PM resistant vine will be crucial.** In the public mind, both here and overseas, there are a number of obstacles to be resolved for a GM crop to be acceptable and live up to promises for clean and green and 'natural'. (For some people these issues will never be satisfied though gene technology) The response to success in the Run1 project will be most interesting.

Industry Communications

Robinson, S.P. (2000) A Toast to Biotechnology…with GM Wine? Innovate Australia Issue 3, February.

Robinson, S.P. (2000) Gene Technology and Viticulture Research. The Wine Contact. August.

Gackle, A.G., Scott, N.S. and Robinson S.P. (2000) Gene Technology and Viticulture – in the mainstream. Australian & New Zealand Wine Industry Journal Vol 15 No 4.

Gackle, A S. and Robinson, S.R. (June 2000) Gene Technology and the Australian Wine Industry Number 1. (8 page colour brochure)

Gackle, A S. and Robinson, S.R. (June 2002) Gene Technology and the Australian Wine Industry Number 2. (8 page colour brochure)

Gackle, A S. and Robinson, S.R. (June 2002) Gene Technology and the Australian Wine Industry Number 3. (8 page colour brochure - DRAFT)

Scott, NS, Hayes, P and Gackle, A The Current Status of Biotechnology and its Outcomes in Agribusiness and its Particular Relevance to Vitivinicole. OIV, Paris, June 2003

Scott, NS, Hayes, P and Gackle, A Managing Biotechnology in Agribusiness: Practice and Problems. OIV, Paris, June 2003

Table 1 Presentations to Grower meetings, Field Days, Community groups

• Sanitarium International Nutrition Symposium Sydney	16th March 2000
• Clare Valley Vine Improvement Association AGM	22nd May 2000
• Victorian & Murray Valley Wine Grape Growers Council, Mildura	31st May 2000
• SA Farmers Fed Winegrape Section McLaren Vale Growers Day	7th June 2000
• Coonawarra Grapegrowers Association AGM	5th July 2000
• Biotechnology Australia Regional Community Forum, Horsham	25th July 2000
• Coonawarra TAFE Viticulture students, Adelaide	3rd August 2000
• Waikerie/Loxton Field Days	13th/14th Sept 2000
• Biotechnology Australia Regional Community Forum, Tamworth	10th November 2000
• University of the Third Age (U3A), Stawell	23rd February 2001
• Eden Hills Probus Club	9th July, 2001
• McLaren Vale Vine Improvement Society AGM	23rd May 2001
• Eden Hills Probus Club	9th July 2001
• Community Forum on GM Crops, Leeton NSW	18th July 2001
• Murrumbidgee Shire Council, Darlington Point, NSW	19th July 2001
• Over 60s Education Association Inc	15th August, 2001
• CRCV Board Presentation, Knoxfield VIC	5th September 2001
• Dried Fruits Forum, Merbein VIC	14th September 2001
• Winemakers Federation Technical Committee	6th November 2001
• University of the Third Age, Victor Harbor	13th November 2001
• Community Forum on GMOs, Mt Gambier SA	21st November 2001
• Iain Evans Electorate Office	30th November, 2001
• GWRDC Board presentation	5th February 2002
• Mitcham Hills Combined Probus Club	25th February 2002
• GT Forum, Perth WA	20th May 2002
• Elders Grapegrowers group (Urrbrae)	21st May 2002
• Mary McKillop College, Adelaide	26th May 2002
• SA Parliamentary Briefing on GT	15th July 2002
• Langhorne Creek Grapegrowers Association	24th July 2002
• Clare Valley VIA, (Urrbrae)	19th August 2002
• Wine Technologist, Marks & Spencers UK	20th August 2002
• Dried Vine Fruits industry briefing, Merbein VIC	27th September 2002
• LM Training Specialists GM discussion with ESL class	4th November 2002
• American Vineyard Foundation briefing, Adelaide	5th November 2002
• Chinese delegation, Adelaide	26th November 2002

- Victorian Teachers Association, Melbourne 2nd December 2002
- GT Forum, Mildura 9th December 2002
- Mornington Peninsula Vignerons Association, Moorooduc VIC 11th December 2002
- Mornington Peninsula Shire Council, Rosebud VIC 11th December 2002
- GMO Forum, Barossa 12th December 2002
- BRL Hardy Winemakers & Viticulture managers 15th January 2003
- Lockleys Combined Probus Club 10th April 2003
- GT Forum, Shepparton 20th May 2003
- Brahma Lodge Weightwatchers 23rd July 2003

Appendix 1

The Australian Wine Industry's Position on Gene Technology

Cooperative Research Centre for Viticulture

Grape and Wine Research and Development Corporation

No genetically modified organisms are used in the production of Australian wines.

There will be no consideration of use of genetically modified organisms to produce Australian wine unless both consumers and the industry are satisfied that they are safe, of high quality and beneficial.

The Australian wine industry produces some of the best wines in the world. It is a vibrant, efficient and forward-looking industry, with a strong interest in remaining at the forefront in a very competitive world market. Its success has been built through cooperation, determination and focus on quality and efficiency.

Underpinning this success is a culture of innovation and willingness to improve the way we grow grapes and make wine. The industry will continue to explore new developments in all areas of science and apply these where there are clear benefits to consumers and acceptance by society.

As part of this endeavour, Australian scientists are using gene technology in research to advance our knowledge of how both microorganisms and grapevines function. These efforts form part of an ongoing, long-term program of scientific research and are not unique to Australia, or to the wine industry. Research organisations in France, the USA, Israel and South Africa are also investigating the use of gene technology for potential application in the food industry, including grape and wine production.

Gene technology is giving researchers and the industry a better understanding of plant processes, and may one day help in developing better varieties and more effective vineyard techniques. If genetic modification were to be used in the future, possible outcomes of such research could be to modify grapevines, or their management, to make them resistant to diseases, and to improve berry quality.

At present this work is at the research stage and much further development and testing is needed before any commercial adoption could be considered.

The wine industry is monitoring progress in this research with interest. Whilst there are potentially great benefits in employing gene technology—particularly in areas where conventional methods have failed—we are also conscious of the need for safety, openness and quality assurance. Adoption of this research would only occur after a thorough assessment of consumer acceptance, the technology and its products.

For further information please contact: Simon Robinson at CSIRO Plant Industry on 08 8303 8600 or Peter Høj at the Australian Wine Research Institute on 08 8303 6600.

Or visit the following websites:
http://www.crcv.com.au/
http://www.gwrdc.com.au/

CSIRO

ADELAIDE UNIVERSITY AUSTRALIA

The Australian Wine Research Institute

March 2002

App

endix 2

CSIRO MEDIA RELEASE 96/145
11 December 1996

CSIRO RESEARCHERS ACHIEVE GRAPE BREAKTHROUGH

CSIRO researchers have achieved a scientific advance of international significance with the creation of what may be the world's first gene-modified grapevine.

The vine, which paves the way for major gains in both productivity and quality for the $1.5 billion a year wine, grape and dried fruits industries, was developed at CSIRO Horticulture in Adelaide, by Dr Tricia Franks, Dr Mark Thomas and Dr Nigel Scott.

The team employed a special bacterium as a "taxi" to transport a novel gene into the DNA of grapevine cells and then demonstrated that it worked in its new setting.

Their achievement comes part of a neck-and-neck race between Australian, French and American horticultural researchers, who are also claiming to have developed the world's first genetically transformed vine.

"Using this technology, we can create grapevines with enhanced flavour, improved colour development and increased disease resistance," team leader, Dr Scott says.

"We have already identified the gene that causes sultanas to turn dark brown when they are dried. We believe we will soon be able to turn off this gene and produce superb golden-coloured sultanas."

"We have the genes and all the tools we need to go ahead and produce superior performance out of the existing elite grapevine varieties. That's where Australia's advantage lies."

Former president of the Australian Winemakers Federation, Mr Brian Croser said the team's achievement represented a large gamble which had paid off for the Australian wine industry

"The industry invested in this blue-sky project, recognising that the returns were potentially enormous even though the chances of success were low. This is a major victory for the industry," he said.

"The opportunity to introduce disease resistance and other valuable characteristics into grapevines without changing the essential quality of varieties offers Australia its biggest potential gains in the winery and the vineyard," Mr Croser says.

Working with the Co-operative Research Centre for Viticulture, CSIRO scientists are presently investigating genes which control the sweetness, flavour and colour development in grapes.

More information: Dr Nigel Scott 07 3377 0263 (bus. hours) 041 9838 626 (mobile) or Katrina Nitschke 08 8303 8605 (bus.) 08 8303 8344 (a/h)
Media vision opportunity: scientists with gene-modified grapevine.

CSIRO MEDIA RELEASE 97/39
6 March 1997

WINE SCIENCE YIELDS VINTAGE CROP

Australia's wine industry is having a world-wide impact on wine-making and wine styles, thanks to a major investment in science and technology.

Experts at a National Science Briefing in Parliament House today told parliamentarians that the art of wine-making had been transformed by good science and technology, setting the industry on track for $4.5 billion in annual sales by 2025.

One of the most spectacular recent advances had been CSIRO's production of Australia's first genetically transformed grapevines.

"It is probably impossible to over-estimate how important molecular technologies are going to be in plant production - the potential is staggering," Dr Elizabeth Heij, Chief of CSIRO Horticulture, said.

"By understanding the processes controlled by DNA, we can now manipulate the production of chemicals by the plant. This will enable us to produce grapes and other foods with or without seeds, with more or less sugar and flavour, with in-built resistance to pests, diseases and fungi, with better or different colour, with a different nutritional profile, with improved ability to take up soil nutrients.

"Even now we are starting to see the impact throughout the world, with the first genetically engineered foods already in the marketplace. Australia is part of the global research effort to use these new technologies to produce better crops, more quickly and with less damage to the environment," she said.

Among recent major advances are:

- mechanical harvesters reducing the cost of harvesting by as much as $175 per tonne
- trellis designs that allow mechanical pruning and improve light and air penetration of the crop and lower the risk of disease
- salinity management and irrigation systems tailored specifically to soil, region and grape varieties
- new low-pressure subsurface irrigation to halve water application and save waste through evaporation and run-off
- computer-based decision support systems for crop management - CSIRO is developing a model for vine growth based on weather data, soil profile, trellis, canopy particulars and irrigation data
- a new study using multiple data sources will improve early crop forecasting, allowing better decision-making from vine to wine
- a new DNA fingerprinting technique which will help verify grape varieties to ensure Australian quality standards. Each grape variety has a distinctive genetic profile and this can be identified by comparing DNA grape, leaf or other plant material with a database of over 200 varieties

Contact : Wendy Parsons (06) 276 6615 or 0419 208 194

Wine For The New Millennium

Research has played a major role in helping the Australian wine industry in its quest for $1B in exports by the turn of the century, South Australian parliamentarians were told at a Science Briefing in Parliament House, Adelaide today.

"Australia's drive to turn winemaking into a multi-billion dollar export industry in the new millennium will not succeed without increased spending on research," said Professor Peter Hoj, Director, Australian Wine Research Institute.

Professor Hoj says research and development will be responsible for half of all growth in the industry's year 2025 Strategy to produce annual sales of $4.5 billion.

"Scientific developments and breakthroughs have already played a significant part in putting the industry ahead of target in its goal to generate $1 billion in Australian wine exports by the turn of the century," he said.

"We've passed the $790m mark with just a relatively small R&D outlay of $16m," said Professor Hoj, "so we're getting good value out of research and development, but we need to find more money to keep up and ahead of the rest of the world."

His comments were endorsed by Dr Nigel Scott, a senior executive with CSIRO which sponsored the SA Science Briefing.

"CSIRO has worked with the viticulture industry since 1917 and in more recent times the relationship has grown closer, with industry making direct contributions through financial support and planning," said Dr Scott, Assistant Chief, CSIRO Plant Industry.

He told MPs and other invited guests that scientific research has already produced many new techniques to reduce winemaking costs and improve quality.

"At the research level, we are now using new technologies, such as gene technology, which opens up many new possibilities in viticulture, to advantage Australia's wine industry," he said.

"Using this technology, we can create grapevines with enhanced flavour, better quality and increased disease resistance," said Dr Scott.

Fellow speaker Philip Laffer, director of Viticulture and Winemaking at Orlando-Wyndham, agreed that science and the industry must work closer together in order to maintain and enhance Australia's position as a fine wine-producing nation.

More information from:

Peter Hoj, Aust Wine Research Institute, 03 8303 8660
Dr Nigel Scott, CSIRO, 08 8303 8600 or 0418 626 860
Phillip Laffer, Orlando-Wyndham, 08 8521 3111

Tassie wine industry needs local research, MPs told

The premium Tasmanian wine industry has demonstrated world standard quality and must achieve a world reputation for the Pinot Noir variety, based on local research, Tasmanian MPs have been told.

"A major impediment to most growers in achieving good fruit quality is difficulty in predicting fruit yields and managing these for optimum quality economic returns - this is where we need the local research, " Andrew Hood, of Hood Wines, told a CSIRO Science Briefing in Parliament House, Hobart.

Dr Stephen Wilson, from the University of Tasmania's School of Agricultural Science told the MPs that this most pressing industry problem could be better understood with more research into vine growth rhythms.

"Tasmania has a long history of research into tree fruit, and local research and development on vines has relied on lessons learned mainly from the apple industry," he says.

"In fact, much of the viticulture research to date has been embedded in, or developed from, research programs that include crops.

"If we can understand grape growth systems for specific varieties in Tasmania, the gains may be beneficial across different crops and many years into the future.

"While future research will need to concentrate on grapes as the wine industry expands, the payoffs are likely to extend beyond viticulture," he says.

Dr Nigel Scott, CSIRO Plant Industry told the Briefing that strategic research has resulted in a new irrigation technique where vines use 50 per cent less water, have similar or higher yields and produce better quality wines.

He says that new genetics should be used to understand precisely how grapevines and other crops develop and function.

"With genetic advances it is possible to either breed by conventional methods or to manage grapevines in a different way based on the new knowledge," Dr Scott says.

"CSIRO and the CRC for Viticulture are collaborating with INRA (Institute Nationale Recherche Agronomique) in France to study the resistance of grapevines to fungal diseases such as powdery mildew and botrytis.

"We have known for a long time that American grapevines are resistant to powdery mildew, so they have been crossed into some European wine varieties in an attempt to make them resistant also.

Ongoing studies of this gene will map and define it so it can be used to produce grapevines resistant to powdery mildew either by conventional breeding or using GM techniques.

"It will be many years before such vines are available for use in industry and we cannot predict now whether they will be conventionally bred or GMO.

"It is clear that once this knowledge becomes available there will be the potential for greatly reduced input of chemicals into the vineyard," he says.

More information:

Dr Nigel Scott, CSIRO Plant Industry 08 8303 8626 nigel.scott@pi.csiro.au

Dr Stephen Wilson, University of Tasmania 03 6226 7469 s_wilson@utas.edu.au

Mr Andrew Hood, Hood Wines 03 6248 5844 hoodwine@bigpond.com

CSIROnline
Commonwealth Scientific & Industrial Research Organisation
Media Release - Ref 2002/81 - Apr 30 , 2002

Quirk of nature shows bunch of promise

A naturally occurring dwarf grapevine may be the key to vines producing more fruit for less cost.

The Pinot Meunier mutation is only half a metre in height and has hairy leaves, but its grapes are normal size.

Pinot Meunier, along with Pinot Noir and Chardonnay are the three grape varieties used to make Champagne-style sparkling wines.

Pinot Meunier itself is a mutation that arose in Pinot Noir at least 400 years ago.

Dr Mark Thomas and his research team from CSIRO Plant Industry and the CRC for Viticulture have been trying to determine the exact nature of the gene that has caused hairiness in the Pinot Meunier.

The team's findings are published in the latest issue of Nature.

"Our primary interest in this is what it reveals about gene function and the role of the plant growth hormone – gibberellic acid (GA) – in grapevines," says Dr Thomas.

"But looking much further ahead it may well have implications for the possible control of grapevine vigour and fruitfulness."

In many vineyards grapevines produce a lot more vegetative growth than is needed to support the growing and ripening of the crop.

This means some growers prune during summer to open up the vine canopy and help ripening. A less vigorous vine will need less water and nutrients.

Dr Thomas says earlier research by the team showed that the mutation responsible for the altered form of Pinot Meunier arises from one of the two cell layers from which the whole grapevine develops.

"When we went on to grow new vines from each of the two separated layers we found that the outer layer – known as the L1 layer contains the mutated gene which is called GAI.

"GAI stands for 'gibberellic acid insensitive', and its effect is to stop the vine responding to gibberellic acid.

"The resulting vine is very much smaller than usual, and this feature is already known – in fact it is one of the 'green revolution genes'" says Dr Thomas.

"But the really interesting thing that we observed is that where most grapevines grow tendrils, this vine forms bunches of grapes.

"The grapes themselves are not smaller than usual so the overall visual effect is of a dwarf vine loaded with bunches."

Many organisms undergo natural mutations, which can result in a variety of changes to the original form.

Mutations have long been recognised as a valuable source of diversity, particularly in food plants.

Some well-loved mutations are the sultana, seedless grapes, navel oranges, Granny-Smith apples and ornamental plants with different colouring or shape to the normal or 'wild' type.

Plant breeders actively seek these different plants for breeding and developing new varieties.

Molecular researchers can gain more knowledge of plants by examining the differences in the genes of these variants.

Dr Thomas and the team are growing a small number of the dwarf vines to get a better idea of actual yield and grape quality.

"There is much more work to be done before any of these attributes can be properly assessed," he says.

This research is funded by CSIRO, the Cooperative Research Centre for Viticulture, the Grape and Wine Research and Development Corporation and the Dried Fruits Research and Development Council.

More information from:

Mark Thomas, 08-8303 8624

Angela Gackle, 08-8303 8630

Appendix 3

DRAFT

CRCV ISSUES MANAGEMENT

Unintended spread of genetically modified grapevine material

1. Background

All CRCV staff should be aware of potential issues and sensitivities in their research – for both the industry and the wider community. This includes any kind of problem, real or perceived, relating to CRCV programs. We have a responsibility to identify and evaluate emerging issues, consult with our stakeholders, and put in place procedures which will allow us to respond quickly and minimise any potential impact.

- Bear in mind that the Australian Grape and Wine industry's interests are paramount.
- We need to demonstrate a commitment to openness and honesty.
- Procedures should be in place to minimise all foreseeable major issues.
- An action plan should be prepared to anticipate each issue and deal with it effectively.
- There should be a nominated contact person, normally the CRCV Program Manager.
- Any potential issues should be reported to the CRCV Program Manager.
- It is wise to use the most senior/expert spokespersons available for each issue.
- Legal and commercial advice should be sought where necessary.

2. Nature of the Issue

The use of gene technologies in agriculture has recently become a controversial issue. This relates to perceived safety issues surrounding the use of genetically modified organisms (GMOs) in food production, moral and ethical issues over the technology and possible environmental consequences following its adoption.

The CRCV research in Program 3 involves the use of genetically modified (GM) grapevines in laboratory and field situations. Unintended spread of GM grapevine material may occur by theft, unintended removal or inappropriate disposal of GM plant material from laboratories or field stations. It could also arise following dispersal of fruit or pollen from GM grapevine plants in planned release field trials. All reasonable precautions need to be taken to ensure that no opportunity exists for unintended spread of GM grapevine material from any experimental sites.

3. Those Affected

In the first instance, the unintended release of GM material is likely to impact on the agencies involved (CSIRO & Adelaide University) and subsequently on the CRCV and GWRDC. There would be a loss of confidence in the regulatory procedures employed, which would impact on future research and development using these technologies. The issue may impact on the grape and wine industries and their peak bodies such as WFA and WGGC, which would be seen to have fostered or at least condoned the research. Although considered unlikely, this issue could ultimately affect the marketability of Australian wine and grape products in both domestic and export markets, and so impact all producers including the major wine companies.

4. Assessment of the Level of Risk

Unintended spread of GM material is unlikely to pose a significant material risk to the grape and wine industries but there could be a perceived risk. It is highly unlikely that unintended spread of GM material would result in any physical risk to existing production and there is a very low chance of GM grapes or yeast being used for commercial production of wine, dried fruit or table grapes. The perceived risk would be that Australia's 'clean and green' image would be threatened and its competitors would use this to their advantage.

It should be noted that GM grapevines and yeasts have been developed in most of the major wine producing countries, including the USA, France, Germany, Italy, Israel and South Africa. In some instances, containment procedures are much less stringent than in Australia.

5. The CRCV's Viewpoint

The CRCV has a responsibility to ensure that Australia maintains a competitive research capability in a wide range of viticultural areas. Research involving GM material has the potential to provide new knowledge, new technologies and ultimately improved planting material. The CRCV funds strategic research using this technology as a small part of its portfolio of projects which will maintain the competitive position of Australia's wine industry. Commercial adoption of the technology will not occur for at least ten years and the decision of whether to utilise GM material for production of wine will ultimately be made by the industry. The CRCV will take all steps necessary to ensure that the research is carried out in an open and transparent manner following all of the necessary regulatory procedures.

6. Policy

- No genetically modified grapes or yeasts are used in the production of Australian wines. GM grapevines and yeasts are being produced for experimental evaluation in most of the major wine producing countries around the world. In Australia, GM yeasts and grapevines are being produced and evaluated as part of the CRCV research programs. There will be no commercial use of GM grapes or yeast to produce Australian wine until it is clear that they are safe, of high quality and beneficial to consumers.
- Procedures have been developed to minimise any unintended spread of GM material.
- All GM plant material will be handled according to the guidelines developed by the Genetic Manipulation Advisory Committee (GMAC) and the Interim Office of the Gene Technology Regulator (IOGTR).

- All procedures involving GM material will be approved by the relevant Institutional Biosafety Committee (IBC) and, where required, by GMAC / IOGTR prior to deployment of the GM plant material.
- Accurate records will be kept for all GM plant material to establish an audit trail.
- A comprehensive QA manual (Appendix 1) has been developed outlining the procedures to be followed and establishing an audit trail for all GM plant material.
- All relevant staff will be fully trained in the procedures to be followed in handling GM plant material. They will be informed of their responsibility to comply with the procedures outlined in the QA manual and the GMAC / IOGTR guidelines and sign an acknowledgement that they have read and understand the manual.
- For GM grapevines planted in the field for experimental assessment, the potential for spread of GM material and the possible environmental ramifications are addressed in detail in each GMAC planned release proposal.
- In planned release experiments, the number of bunches will be limited to that required for experimental analysis by removal of all other bunches prior to anthesis. The remaining bunches will be bagged prior to anthesis to prevent the spread of pollen. Bunches will be netted prior to veraison to prevent fruit dispersal.
- A literature search on pollen dispersal and pollination of grapevines will be initiated and a report prepared of the current knowledge on pollen flow in vineyards.
- If required, an experimental plan will be developed to determine and quantify pollen flow in a vineyard environment.

7. Procedure

If unintended spread of GM material is detected, take the following steps :

1. ***Do not attempt to deal with the matter or incident on your own.***
   Stay calm, be polite, ask for and write down as much information as possible, take the name and phone number of any external witnesses, media, etc for follow up later. Do not offer an opinion or comment – refer all enquiries to the CRCV Program 3 Manager.

2. ***If contacted by the media, take down their details and tell them the spokesperson will contact them as soon as possible. Do not respond yourself.***

3. ***Notify the relevant CRCV Program Manager immediately***.
   If not available, ensure that the next available member of CRCV is contacted immediately (see list of Contact Details below).

4. After consulting with the relevant CRCV Program Manager, take steps to limit any further spread of GM material and recover any GM material where possible.

5. ***The CRCV Program Manager will notify the CRCV CEO immediately with briefing information to follow.***

6. ***The CRCV Program Manager will write clear and comprehensive notes including:***
   - time and date and place of occurrence
   - persons involved and contact details
   - extent of the problem – including media and industry awareness
   - steps needed to address the issue and public concerns
   - nomination of an interim spokesperson – with contact details
   - list of external stakeholders (govt depts, industry reps, etc) to be informed

7. The CRCV CEO will convene an Incident Management Committee within 12 hours to determine the appropriate course of action.

8. The Committee will include a nominated representative of the key industry bodies (Winemakers Federation of Australia, Winegrape Growers Council, GWRDC) and each of the parties involved (CSIRO, AWRI, Adelaide University).

9. The Committee will notify all relevant stakeholders within 24 hours.

10. The Committee will nominate an appropriate spokesperson and produce an agreed response to guide all public comment by the spokesperson within 24 hours.

11. A media statement will be prepared – obtaining PR and legal advice if required, within 24 hours.

12. The CRCV Program Managers will brief all relevant staff with a clear outline of the situation and actions to be taken.

13. The Committee will keep detailed records of all developments, contacts and interactions relating to the incident.

14. The Committee will carry out an investigation of the cause of the incident and identify procedures which would prevent it from happening again.

8. Contact Details

1. Dr Simon Robinson	Manager, CRCV Program 3
	(08) 8303-8611 (B)
	(08) 8271-8651 (H)
	0409-099-131 (M)
2. Dr Rob Walker	Manager, CRCV Program 2
	(03) 5051-3100 (B)
	(03) 5023-0095(H)

	0417-393-572 (M)
3. Dr Anna Koltunow	Program Manager, CSIRO Plant Industry (08) 8303-8610 (B) (08) (H) 0408-896-583 (M)
4. Angela Gackle	Communications, CRCV Program 3 (08) 8303-8630 (B) (08) 8345-5038 (H) 0410-585-038 (M)

9. Advice to Stakeholders
The following stakeholders will be advised, where appropriate :
CSIRO
University of Adelaide
GWRDC
DFRDC
WFA
AWBC
AWRI
Department of Natural Resources, Vic
Primary Industries, SA

10. Media Response
The Incident Management Committee, following consultation with the relevant stakeholders, will determine the appropriate media response. If necessary, additional advice will be sought from PR consultants with skills in this area. A list of key media contacts will be prepared, including those relevant to the industry such as wine writers. These will be contacted and briefed on the issue.

11. Public Response
The CRCV Program Manager will prepare a concise statement of the issue and what is being done about it for use by the spokesperson and other senior staff who may be asked to comment. All staff will be briefed and informed who the spokesperson for the issue is and their contact details as soon as possible. The Incident Management Committee will determine whether any additional public response is required.

Prepared by : Simon Robinson & Angela Gackle February 2001

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Appendix 4

Frequently Asked Questions (FAQs) about Gene Technology

No genetically modified organisms are used in the production of Australian wines. There will be no consideration of use of genetically modified organisms to produce Australian wine unless both consumers and the industry are satisfied that they are safe, of high quality and beneficial.

#1 Are there any GM grapevines in Australia?

- CSIRO was one of the first countries to produce a genetically modified grapevine for research purposes.
- CSIRO is conducting OGTR compliant, small-scale field trials of GM grapevines at the Merbein field station to assess their field performance. The grapevines being tested are low-browning sultanas and experimental winegrapes for research only.
- Experimental GM grapevines have been planted out in most of the major wine producing countries, including Germany, France, Italy, the USA and Canada.

#2 What about pollen flow in vineyards?

In the case of grapevines there have been questions raised about the effect that pollen from GM grapevines might have on surrounding non-GM vines, grapes - and wine.

- The trials are conducted under rigorous procedures. Flowers are bagged, fruit is netted and prunings are destroyed at high temperature. After laboratory testing all parts of the vine are eventually destroyed.
- From previous studies we know that under normal conditions grapevines are usually self-pollinating, or pollinated by other vines within one or two rows. It is possible for pollen to travel, or be spread, further and still be viable, but it rarely pollinates another grapevine over greater distances.
- There are a number of reasons that pollen flow is not an issue in grapevines. Different varieties are commonly planted next to each other, and this does not affect the fruit or the wine produced from them. Cabernet Sauvignon grapes would often be pollinated by white varieties, but this does not change the colour or characteristics of the fruit.
- The result of pollen mixing would only be seen if plants grew from seeds resulting from such an occurrence. This is extremely unlikely since vines are normally propagated vegetatively.
- Grapevine DNA is lost during winemaking - wine contains no detectable DNA.

#3 Are GM grapes used to make wine?

- **No genetically modified grapes are used in commercial winemaking in Australia.**
- Experimental wine will be made in the future from GM grapevines to assess changes in quality. To taste test the wine will require Office of the Gene Technology Regulator (OGTR) and Australia New Zealand Food Authority (ANZFA) approval.

#4 Are there risks in eating genetically modified foods?

Some people suggest that introduced genes in GM foods could be a threat by becoming incorporated into, or in some way affecting, our DNA. There is no evidence that genes from any foods can become part of the human genome.

- Most food contains DNA and we eat and digest millions of genes in our food every day. When DNA is eaten, most of it is degraded in the digestive system, usually before it reaches the small intestine.
- GM foods entering Australia are evaluated by ANZFA, (the Australia New Zealand Food Authority) which is responsible for ensuring that GM foods are safe to eat[1].
- GM foods have been extensively tested during the research phase, in glasshouse experiments and in large scale field trials.
- In the US, where GM foods and ingredients have been eaten for at least five years, no adverse effects have been reported.
- **Current evidence indicates that there is no risk, over and above that which we currently accept every day, when we consume food.**

#5 Could GM foods contain allergic substances or toxins?

It has been suggested that genetic modification might result in a plant producing hazardous compounds that were not present before[2].

- Many plants produce compounds that are toxic or allergenic. Most of those that are a health problem are well known, and they are routinely tested for in new varieties.
- Many foods are already labelled if they contain known allergenic ingredients so that people sensitive to certain products can avoid them. This will also apply to genetically modified products.

#6 Could GM foods spread antibiotic resistance?

To transfer new genes into a plant's DNA, a gene for resistance to the antibiotic kanamycin is used to select GM plants. It is a quick and effective method, and the antibiotic resistance gene is known as a selectable marker. Some groups have suggested that the antibiotic resistance genes might transfer from GM plants to gut microbes, making diseases more difficult to treat.

- To date, extensive research on the topic has demonstrated that gut microbes don't incorporate these antibiotic resistance marker genes - even under optimal laboratory conditions.
- Researchers are now developing alternative techniques - different selectable markers or removing the extra genes once a plant is transformed.

#7 Do GM plants contain genes from viruses?

A part of one gene (the 'promoter') from the cauliflower mosaic virus (CaMV) is commonly used to "switch on" genes introduced into many GM plants. It has been suggested that the CaMV promoter may have health or ecological effects.

- The CaMV is a very common and benign virus. It is often found on green vegetables and most people eat millions of these viruses, over their lifetime, with no ill effects.
- In GM plants, only a small part of one gene is used, not the virus itself.
- The use of theCaMV promoter has been approved by a range of regulatory authorities in the USA and Europe.

#8 Could transferring new traits, such as herbicide resistance, to wild relatives of crop plants, produce super weeds?

People have suggested that genes from GM plants could be transferred to related weeds, and that this could have serious environmental consequences.

- To assess the likelihood of this happening, a case-by-case evaluation of crops is necessary. For example, corn has no sexually compatible relatives outside South America and so transfer of genes in other parts of the world is not a problem.
- In-breeding species, which are generally self-pollinating, such as cotton, do not transfer genetic material readily.
- Canola is an out-breeding plant with a number of wild relatives. The transfer of herbicide tolerance or other genes from either conventional or GM varieties is possible.
- In such a case herbicide tolerance would not provide any competitive advantage to the weed and may not survive in the population except if the specific herbicide is applied. In the unlikely event that gene transfer takes place, herbicide tolerant weeds can be managed with other herbicides.

#9 Can GM plants be dangerous to non-target insects and other organisms

Public concern was raised in North America that some crops with in-built insect resistance could pose a risk to non-target insects[3] such as Monarch butterflies.

- There can be little doubt that crops producing their own insecticide have a far lesser impact on non-target insects than indiscriminating sprayed insecticides.
- There are several studies being carried out to determine the effects of the breakdown of Bt-containing plant tissues on soil micro-organisms.

#10 Does GM pollen affect bees?

Beekeepers and honey producers have raised questions about the possible effects of GM pollen on both bees and honey.

- It is likely that bees foraging near GM crops will pick up GM pollen.
- Generally bees keep pollen separate from nectar, which is converted to honey. Most honey however does contain some pollen traces - it can be an accurate indicator of the proportion of crops from which the honey was sourced.
- Whilst this could be a problem for producers wishing to maintain GM free status, it is not a health risk. GM pollen is not dangerous for either bees or humans.

Notes

[1] For more information see Agrifood Awareness Australia paper #9 "*Regulating genetically modified food*" http://www.afaa.com.au/)

[2] For more information see Agrifood Awareness Australia paper #5 "*Rats and potatoes - toxicity studies with genetically modified foods*"

[3] For more information see Agrifood Awareness Australia paper #7 " *Butterflies, insects and genetically modified crops*"

Useful web sites:

Australia New Zealand Food Authority
http://www.anzfa.gov.au/

Office of the Gene Technology Regulator
http://www.health.gov.au/ogtr/

CRC for Viticulture
Http://www.crcv.com.au/

CSIRO Biotechnology
http://genetech.csiro.au

Australian Biotechnology Association
http://www.aba.asn.au

Biotechnology Australia
http://www.isr.gov.au/ba/

Biosafety Information Network
http://binas.unido.org/binas/

Appendix 5

THE CURRENT STATUS OF BIOTECHNOLOGY AND ITS OUTCOMES IN AGRIBUSINESS AND ITS PARTICULAR RELEVANCE TO VITIVINICOLE[1]

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Abstract

The use biotechnology and GMOs in modern biological science as tools for research, for development, for output and outcomes is the defining characteristic of the very best modern laboratories and industries. These qualities have been warmly embraced by the successful Australian grain, cotton and viticultural industries who look to the new sciences to provide the new knowledge with which to build their production base. This paper describes the main thrust and the main targets of biotechnology research in Australia aimed at growth of Australian viticultural industries.

Introduction

Biotechnology is a generalised description encompassing many of the most recent scientific advances in biology and how they are used and applied in our society. In medicine, the uses of biotechnology are widespread and generally accepted by the community. In accessing medical advice and treatment, most of us have experienced the benefits of knowledge gained through biotechnology or medicines produced by its use. Increasingly, these medicines are being produced by that branch of biotechnology which centres around genetically modified organisms (GMOs) and it is becoming ever more likely that specific human diseases will be treated by genetic modification (GM) techniques and their application to the somatic cells of humans.

In Agribusiness, and particularly Vitivinicole, the use of biotechnology for knowledge and outcomes is accepted in a similar fashion. However, the use of GM based biotechnology, particularly when it comes to the production of food and related products is by no means accepted around the world. This paper makes the distinction between the use of GMOs and biotechnology as tools to generate knowledge and practices that will result in improved vitivinicole technology and the possibility that in the future there may be strong reasons to use GM technology to genetically change the material used in the viticultural production chain.

In Australia, as in many parts of the world, the use of biotechnology to generate information and of the consequently derived non-GMO biotechnology to improve production and management practices is well established. Now and in the future, some of this knowledge and practice will continue to be generated by experiments involving the production of GMOs to test scientific theory. There are no plans to use GMO grapevines in vitivinicole in Australia.

The views expressed in this paper are those of the authors alone.

This paper will describe some of the biotechnology experimentation now carried out in Australia - much of it in collaboration with other viticultural research institutes around the world.

Research Structure
In Australia our focus is on the use of biotechnology to study important issues of berry and oenological quality as influenced by viticulture production. This work is carried out in the Co-operative Research Centre for Viticulture (CRCV) in the laboratories of CSIRO and the University of Adelaide. The research has strong international linkages with collaborating viticultural laboratories in other countries particularly those from France, Germany, Italy, United States and South Africa.

The Grapevine Genome

Of all of these projects, perhaps the most important and that with the highest profile is the International Grapevine Genome Project (IGGP). This project involves the collaborative efforts of fourteen laboratories around the world to develop a genetic map of the grapevine with the ultimate ambition of sequencing the entire grapevine genome. This latter outcome will require significant international funding but when achieved will be a major advance in viticultural science. It will provide a step change in the knowledge currently available for use in viticulture, which is obtained from the existing sequences of the Arabidopsis and rice genomes.

Grapevine Regeneration
Advances in methods for grapevine regeneration began in 1978 with the development, by Barlass and Skene in Australia, of micro propagation of grapevines through tissue culture techniques. These experiments opened the way for new methods of rapid grapevine propagation and generating clones of existing grapevines varieties free of virus diseases. Subsequently, the pioneering work of the LVMH laboratories in Paris and Epernay (Mauro et al 1999) and the CSIRO laboratories in Adelaide (Iocco et al 2001), established techniques for the insertion of new genes into grapevines to generate GMOs.

While these techniques were originally developed with the intention of generating GMO grapevines or grapevine rootstocks free of, or resistant to, disease there is now strong market signals world wide that the technology should not be used in viticultural production other than for the prime purpose of research. As will be discussed in an accompanying paper, market forces may change in the future but as yet there is no sign of such a shift in public opinion or demand.

Disease
The international collaborations involved in many projects of common interest, including grapevine mapping is exemplified by the large collaborative project between CSIRO, the CRC for Viticulture and INRA to characterise a major resistance gene to powdery mildew (Donald et al, 2002). Grapevine breeders at INRA have introgressed this gene from the American wild grape species *Muscadinia rotundifolia* into a succession of pseudo back crosses of *Vitis vinifera*. The gene has continued to segregate as a single gene, and the objective of this collaborative project is to map the gene to enable its more rapid and precise introgression into important viticultural varieties. Success in this characterisation would also provide an important candidate gene for production of a GMO grapevine, resistant to powdery mildew with the major benefits of

the reduction of costs and chemical residues associated with mildew control. The mapping and isolation of this gene is proceeding steadily.

Another important fungal disease of grapevines is *botrytis*. Unlike powdery mildew, there is no known resistance to this disease in any grapevines or related species available for introgression. However, the observation that open berry bunches substantially increases tolerance of the *botrytis* infection is well known to viticulturalists. The Arabidopsis genome sequencing project has shown that there are genes that control this important characteristic of bunch architecture. This has led to the development of a project looking specifically for these genes and practises that might modify grapevine cluster architecture, with a view to either introgressing these genes into grapevine varieties or developing ways of managing their expression in *botrytis* prone vineyards to ensure open bunch architecture is achieved. This project has already shown that such genes exist in grapevine populations and methods.

Possible resistance strategies to the root pests Phylloxera and nematodes for rootstocks are also being evaluated, and an important result for the management of Phylloxera in Australia has been the development of DNA typing procedures for identification of the biotypes that infest a small region of Australian viticulture (Corrie et al. 1998)

Berry quality

A major focus in the Australian research program has been to look at flavonoid biosynthetic pathways and the pathway genes in grapes/berries. This pathway is responsible for the synthesis of three important groups of compounds central to many of the organoleptic properties of wine - flavonoids, tannins and anthocyanins. While these three end products share common genetic and metabolic pathways, the expression of the relevant genes, the control of their relative importance and the timing of the production of each of three major component groups during berry development is quite different (Downey et al 2002). This study is expected to lead to improvements in management practices to allow winemakers to more precisely specify the amount and balances of these compounds in berries.

Genes and crop prediction

One of the most difficult issues facing viticultural production is the understanding and management of crop load and quality in the face of seasonal and environmental variation and change in market demand. This area has been the focus of viticultural study for over a century with some wonderful descriptions of floral bud development in grapevines (notably Barnard, 1932). Most recently, the identification of the genes involved in flowering and fruitfulness in Arabidopsis has led to a study of how related genes in grapevine are organised and interact. For example, the *chimera* that results in pinot meunier can be separated into a conventional pinot and a mutant pinot form in which fruitfulness is dramatically increased even in juvenile plants. This dramatic change is the result of a single DNA base change in a single gene affecting vegetative and floral development of the vine (Boss et al, 2002).

The importance of this family of genes suggests that the continued dissection of this flowering and fruiting pathway will lead to biotechnology-based methods of estimating and managing fruitfulness and production in a vineyard throughout seasonal cycles. The speed of such methods is likely to allow continuous updating of information and fine tuning of management.

Biotechnology and Bioinformatics is the future
This discussion has focussed so far on the genomics aspects of biotechnology. The sister biotechnology techniques of proteomics and metabolomics allow analysis and matching of genes and their products. The number of such analyses and the speed with which they can be performed means it will soon be possible to make this direct comparison between and within varieties, vineyards' management practices and oenological and market outcomes.

Combined with the rapidly growing power of bioinformatics it is likely that high quality information will become available to allow direct linkage of decision making with all stages of the viticultural, oenological and marketing activities of our industry.

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MANAGING BIOTECHNOLOGY IN AGRIBUSINESS: PRACTICE AND PROBLEMS[2]

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Abstract
The uptake of biotechnology in Agribusiness and viticultural industries has followed an entirely different pattern from that of the biology-based medical industries. While relatively slow compared to medicine, the uptake in field crop industries has been steadily increasing to the extent that in 2002 around 58.7 million hectares of genetically modified (GM) field crops were grown worldwide. Outside the field crop industries there has been very little uptake. This paper presents a case study of the introduction of insect resistant GM cotton in Australian and demonstrates how the scientific, agronomic, economic, social, marketing, intellectual property and ownership issues have been addressed to manage and achieve a successful outcome for all concerned.

Managing Biotechnology In Agribusiness: Practice And Problems

Biotechnology is a relatively young science and the production of Genetically Modified Organisms (GMOs) is the most powerful technique currently available to this science. In plants, the study and application of biotechnology began in the early 1970s and the first transgenic plants appeared in experimental laboratories around 1980. Within a few years there were tens of thousand of GMO field trials world wide and the first commercial release of a genetically modified plant was the FLAVR SAVR tomato in 1994. By 1995/96 releases of field crop plants had begun and by 1999, public concerns had been raised in many countries, largely centred around the use of GMOs as sources of food. This debate continues and is now coupled with two other issues namely; intellectual property and patenting and the

consequent licensing, costs and ownership requirements that this imposes and questions as to whether this material will be available to and of benefit for crop and food production in developing countries.

The International Service for the Acquisition of Agribiotech Applications (ISAAA) maintains a database of the global areas of transgenic crops and their uses. In its most recent report (January 2003) the IR database recorded 58.7 million hectares of transgenic crops around the world (http://www.isaaa.org/kc/Bin/gstats/index.htm) This is equivalent to more than 5% of the total land area of China or the United States and the area has been increasing at a constant rate of 10-12% per annum since 1996. While six countries grew transgenic crops in 1996, sixteen are growing them in 2002. The principal GM crops are soybean, corn (maize), cotton and canola.

The views expressed in this paper are those of the authors alone.

The United States accounts for 67% of the global total of transgenic crops and, together with Argentina, Canada and China, 99% of the global crop area is accounted for.

The most popular trait in transgenic crops has been herbicide tolerance, with Bt insect resistance the second most popular. Increasingly, stacked genes for both herbicide tolerance and insect resistance are being deployed in cotton and corn, and in 2002 for the first time more than half of the soybean crop grown worldwide was GM. In all four crops mentioned above, growth is continuing at a steady rate such that 21% of the global area occupied by these crops is transgenic.

The main GM traits in transgenic crops are those related to agronomic practice and thus the benefits are most obvious for farmers large and small. Around 6 million farmers planted GM crops in 2002 and more than three quarters of them were from resource poor countries. While the agronomic and financial benefits available to farmers and producers are attractive, the ongoing argument in the more general public and consumer domains shows that the benefits of these economic traits has little impact on the general public perception of the value or otherwise of GM crops. Currently there are few GM traits being offered in food plants in the market place that have clear consumer benefit.

Paradoxically, the first two GM food products offered in the market place did have consumer benefits, but failed for different reasons. The FLAVR SAVR tomato released in the United States offered a firm tomato with full flavour and good shelf life characteristics not otherwise available at that time. Unfortunately, it was not competitively priced and, due to production difficulties and changes in the management of conventional tomatoes, it failed for economic reasons. A similar product, sold as tomato puree in the United Kingdom, was extremely successful on the basis of price competitiveness and perceived consumer value. It became a victim of mounting pressures and discussion about the safety of GM foods in the market place combined with the inability to supply sufficient quantities to the market. The product was withdrawn in the general moratorium on the sale of GM foods in the United Kingdom. There are now a large number of new GM traits that could be incorporated into food products and if the trend in growth of acceptance of GM crop products as indicated in the ISAAA figures continues, it seems likely that more general public acceptance of GM food products will occur.

Over a century ago, the suggestion by Louis Pasteur that milk should be pasteurised was subjected to a large period of public argument and it was twenty or thirty years before this process was accepted throughout the world.

In this paper, we have chosen to describe the evolution and introduction of the GM cotton crop in Australia (Pyke 2001; Fitt 2003). Many of the issues raised above are addressed in the development of this crop and it offers a case history of how the science, commercial and community attitudes evolve and come together to create an acceptable result.

A universal plague of cotton crops is the cotton bollworm, *Helicoverpa spp* and around the world this has been dealt with by extensive spraying with expensive insecticides which require careful use to avoid both health risks to agricultural workers and communities in cotton growing areas - and to manage how rapidly the insects develop resistance. These two problems provided the major driver for seeking alternative solutions to *Helicoverpa* resistance in cotton crops (Roush 1994).

The toxicity to Lepidoptera of the insecticidal proteins generated by the bacterium *Bacillus thuringiensis* has long been recognised and the bacilli have been used in many agricultural applications as an insecticide. Thus it was natural, early in the discussion of the advantages of GM crops, to think about putting a gene to produce the toxic protein directly into host crop plants.

In the 1980s, scientists at Monsanto and associated laboratories had already worked out the active principals of the toxic protein and had a patent on some of the genes necessary for production of this protein in plants. At the same time, CSIRO scientists in Australia were working on a range of insect tolerance strategies for cotton including the introduction of transgenic insecticides into the cotton plant. The particular skills generated in CSIRO were those needed to introduce new genes into agronomically successful lines of cotton plants. CSIRO obtained the research licence from Monsanto which enabled them to show that Monsanto's gene is effective in CSIRO cotton varieties. .

The Australian seed company, Cotton Seed Distributors, was licensed by CSIRO to grow and sell the CSIRO cotton seed varieties containing the Monsanto gene. At the same time Cotton Seed Distributors was also licensed by Monsanto to sell the Monsanto gene in the CSIRO GM cotton varieties. The cotton growers in turn had to sign a license agreement to grow the seed according to Monsanto and CSIRO specifications. The licence fees then flow back to Monsanto and CSIRO. The price of the GM cotton seed was higher compared to conventional seed to incorporate the costs of these licence fees but was cheaper overall than the cost of the sprays which were avoided by using the GM cotton.

In agronomic terms, introduction of this material has resulted in a massive 50% reduction in the use of insecticide sprays in the GM cotton crops in Australia. There has been a second major collateral agronomic benefit as farmers who grow GM cotton are required to sign an agreement with Cotton Seed Distributors and Monsanto that they will comply with specific guidelines for crop management to minimise the chances of insects becoming resistant to the BT gene.. This type of enforceable contract for management of pest resistance has never been available before with conventional chemical insecticides (Fitt et al 1994, Roush 1997).

Overlaid on this process were the requirements of the Australian community as administered at that time by the then Genetic Manipulation Advisory Committee (GMAC). The initial experimentation was limited to controlled laboratories from which GM material was not released, but destroyed by autoclaving or similar procedures. Both laboratories and plant houses were rigorously controlled. To complete the experimentation, the material was field trialled under both experimental and commercial conditions. These trials required collection of extensive data about factors such as cross pollination, seed dispersal and plant residue management (Llewellyn & Fitt 1996; Brown et al 1997).

In 2003 in Australia and in 2004 in the United States, it is expected that new lines of cotton containing two separate insect resistance genes will be released, substantially reducing the risk of insects becoming resistant. Control of management procedures will ensure that the two-gene GM cotton is not grown in those areas where cotton with the single insect resistance gene is grown.

This example demonstrates how scientific, public and commercial arguments surrounding GM crops can be addressed. Importantly it shows, because of the large number of processes and organisations involved - both governmental and business, that it is highly unlikely for any single interest to dominate and difficult for any to operate without the cooperation of the others. In the case of cotton, while the main driver has been the agronomic outcomes and financial benefits, all the parties involved have come to an agreement. Overarching the purely economic issues are the clear environmental and health benefits of reducing chemical spraying that was once a dominant feature of cotton growing districts.

The first GM cotton releases in Australia were under the aegis of the (GMAC). This body has now been superseded by a statutory body; the Office of the Gene Technology Regulator (OGTR) (http://www.ogtr.gov.au).

Most countries have regulations governing the use of biotechnology that in general fall into two categories. The philosophy exemplified by the regulations of the United States, takes the view that each case of a GMO needs to be considered on its merit and there is no *a priori* reason to assume that the use of biotechnology or genetically modified plants is of itself more risky than conventional methods of introgressing new genes into plants and plant products. The arguments used in this approach are those of 'substantial equivalence', thus canola oil from GM canola or canola oil from non-GM canola are viewed as being substantially equivalent since no difference can be detected or predicted between them.

The second approach is exemplified by the European regulatory system that takes the view that GM plant material has an intrinsic level of risk beyond that accepted in non-GM plant material. The regulations are framed around this philosophy and the requirements to demonstrate the properties of GMO-based material are substantially more rigorous than those placed upon the introduction of food material bred by conventional genetic means.

The naming of varieties of plants carrying new genes is another issue which will probably be resolved on a crop by crop basis. . In cotton where the particular variety or cultivar has been genetically modified, the variety is offered under the same name, with indication of the genetic modification. For example, SICALA V-2 cotton with the addition of GM Bt insect (i) protection becomes SICALA V-2i. Such nomenclature parallels current practices with grapevine clones, where clones that have been selected in the field are accepted as being of the same variety and are identified by the addition of a clone number or name. This identification is irrespective of the changes that have taken place in generating those clones - which are often unknown. In one of the few cases where the origin of the clone has been identified it was recently shown that pinot meunier is a chimera of two grapevine genomes which differ by only one base in one gene (Boss, et al 2002).

The management of biotechnology in agribusiness is a constantly evolving process. There are no firm rules or practises in place as yet and each case needs to be considered on its merits. There are many social, agronomic, business and regulatory requirements to be met.

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