Grape and Wine Research and Development Corporation

Final Report

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ADOPTION OF STRATEGIES TO REDUCE THE USE OF PESTICIDES IN WINE GRAPE PRODUCTION

DAN 92/4

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(ii) NON TECHNICAL SUMMARY

Project Title: Adoption of Strategies to Reduce Pesticide Use in Wine Grape Production

The reasons for reducing pesticide use

The project was an initiative designed to sustain both the domestic and the rapidly growing export market image of Australian wines being of good quality, value for money and very importantly being perceived to have a very low chemical residue status. Some large wine purchasing groups such as British supermarkets have requested that the wine marketeers furnish lists of agricultural chemicals used in the production of wine grapes and have indicated their preference for very low residue wine. Lowering chemical pesticide use in the vineyard also has the very important advantage of reducing environmental contamination.

Australian white wine exports have increased from 6 million litres in 1985/86 to 77 million litres in 1996/97 while red wine exports have also grown rapidly with an increase from 4 million litres to 68.8 million litres in the same period. The present volume of exports and further growth are sustainable only if the quality, good value and low residue image is maintained and enhanced.

Potential for reducing pesticide use

An analysis of agricultural chemicals registered in Australia for the control of pests and diseases in the vineyard showed that a small proportion of them were capable of doing the job in the Riverina area of NSW and wine grape growing areas of similar climates. Chemical spray could be reduced by,

- The use of weather data to estimate the occurrence of pests and diseases to enable better planning for control.
- Thorough inspections of vineyards for occurrence of pests and diseases to facilitate good timing of control measures when necessary.
- Use of biological agents to control grapevine pests, which would favour the build up of natural predators and parasites in the vineyards.
- Good planning to ensure the availability of biological agents and preferred pesticides during the vine growing season.
- Efficient application of pesticides to eliminate the need for respraying to gain adequate control of pests and diseases.

"Riverina Clean"

The first draft of an operation plan for growers to lower pesticide use was titled "Riverina Clean" and was completed in September 1993 by NSW Agriculture and the Wine Grapes Marketing Board. The "Riverina Clean" Quality Management program included objectives, allowable products and practices code, vineyard pest/disease/weedicide and soil management strategy list, a management calendar for mature vineyards and a vineyard log for agricultural chemicals used.

Demonstration areas were developed to build industry confidence in "Riverina Clean" as a Low Chem Management program. At several of these locations a weather recording station was used to assist with disease prediction and prevention programs. Vineyard inspections were conducted at these sites to assist growers with pest and disease control programs.

"Low Input Viticulture - A Whole Vineyard Model"

After gaining experience in operation of the pest and disease section of the plan "Riverina Clean" it was refined and presented to industry as part of a vineyard development and management system titled "Low Input Viticulture - A Whole Vineyard Model" at a major field day held at Riverina Wines on 2nd May 1995. It had become obvious during project demonstrations that effective pest and disease control was reliant on a whole vineyard planning and management system.

The vineyard model was presented in a paper (Appendix ii) and includes comments on production and marketing wine from Australia, as well as a comprehensive explanation on establishing and operating a Low Input Vineyard. Importantly for pest and disease control there are sections on

- Irrigation and drainage
- Controlled use of fertilisers and management of vigour.
- Reduced use of pesticides and preferential use of soft pesticides.

At the field day, trial participants and associates related their experiences in operation of the model and other relevant work. The field day publication has been in demand from MIA wine grape growers unable to attend the field day and from other wine grape growers of inland NSW.

Succeeding at reducing chemical pesticide use

Winegrape growers involved in the project to promote Low Chem Management and Low Input Viticulture commented at the major field day;

- Weather monitoring helped planning and decision making in the pest and disease control program
- Using oats as a winter cover crop minimised the likelihood of Light Brown Apple Moth infestation in summer
- Cover cropping improved water infiltration from both irrigation and rain
- Adoption of Low Input Viticulture made significant savings in water, fertiliser and pesticide use
- The Low Input management exercise has been a good introduction to AusVit, which is a comprehensive aid in vineyard management
- After using Low Input Management we will be using deficit irrigation in our vineyards for both winegrape quality and good pest and disease management

Irrigation Policy a Factor in Disease Control

At Ballingal Vineyards the major trial site, soil moisture monitoring was carried out with EnviroScan equipment to enable irrigations to be minimised on the heavy soils to firstly prevent raising the saline water tables into the rootzone and secondly to allow Regulated Deficit Irrigation to be used. The aim was to grow smaller berries in which fruit flavours were not diluted and colour was improved in the wine made from red wine grape varieties. At the major trial site this involved allowing the soil water available to the vines to be depleted by,

- Up to 75% in the budburst to early ripening period.
- 50% during the ripening period

The Regulated Deficit Irrigation management and application of water to only the vine row area contributed a less favourable environment than routine flood irrigation for diseases such as Phomopsis, botrytis, downy mildew and perhaps powdery mildew. No preventative or curative

sprays to control botrytis were applied during the trial years in the Riverina. The irrigation practices followed also allowed better access to the vineyard for application of pesticides when required.

Advantages of maintaining soil condition and using efficient irrigation

The use of winter cover crops improved the condition of the heavy soil thus allowing improved water infiltration from rain and irrigation which helped lessen the risk of disease infection and also contributed to suitable vine growing conditions.

The irrigation technique used at the major trial site at Ballingal Estate Vineyards was Riverina Twin Furrow, which employs narrow irrigation furrows on both sides of the vine bank. This helped in reducing the water applied compared to the commonly used inter row flood and broad based furrow techniques. Drip irrigation used at the Corbie Hill site was even more effective than Riverina Twin Furrow. The use of irrigation techniques that minimised surface water in the vineyard also lessened the risk of disease infection.

Favourable vineyard climate for production of quality wine grapes facilitated the reduction of pesticide use

The project showed that the creation of a favourable vineyard climate for the production of quality wine grapes lessened the risk of disease infection and facilitated the reduction of pesticide use in the vineyard. Wines made from trial vineyards involved in the project were always rated well above district average. Wines made from the major demonstration vineyards (vines on own roots) by Riverina Wines have been very successful in international, Australian capital cities and regional wine shows. Residue testing of the wines is expected to further confirm success of the project.

(iii) BACKGROUND TO THE PROJECT

In 1991 consumption of wine in Australia was declining and it was believed that increasing exports should generate expansion of the industry. Exports of Australian wine were increasing rapidly,

growing by 30% to 65.3 million litres worth $200 m in the 1991 calendar year. The strong growth seen in the export market was then based on Australian wines being of good quality, value for money and perceived as having a low pesticide residue status. The maintenance and growth of exports were seen to be sustainable only if this image was maintained and enhanced.

The importance of maintaining and enhancing the 'clean green, value for money' image was well recognised by industry with the formation of the Co-operative Research Centre for Viticulture (CRCV) and other industry groups such as the Riverina Standing Committee on Viticulture (RSCV) and the Riverland Organic Grape Growers Association (ROGGA). In a joint address to growers by the chairman of both the WGMB and the MIA (Murrumbidgee Irrigation Area) Winemakers Association in the Riverina, they were urged to take every step to ensure that hard won export markets were retained. Part of the region's strategy to achieve this was to produce grapes and wine that conformed to international maximum residue limits (MRL) of pesticides. The growers were also advised that increasingly overseas buyers were seeking assurances that the product in the bottle conformed to international MRL standards, and were requesting written evidence that it did.

Good progress had been made prior to the commencement of this project with reduction in the use of chemicals in controlling individual pests and diseases through better understanding of their life cycles, improved canopy management and availability of new effective chemicals and rootstocks. While further research was required it was important that a start be made on the evolution and adoption of Low Chem Management practices for commercial vineyards with the information available.

iv) OBJECTIVES OF THE PROJECT

The hypothesis is, that the provision of accurate information on the development of grape pests and diseases to wine grape growers would enable them to implement LCM programs from a short list of agricultural chemicals and together with the use of biological control agents would lead to reduced levels of chemical residues in wine for both domestic and export markets.

- The objective is to successfully demonstrate to wine grape growers the efficacy, practicality and economics of no risk LCM programs on a commercial scale and have them adopt such programs for use in their vineyards.

(v) INTRODUCTORY TECHNICAL INFORMATION CONCERNING THE DEVELOPMENT NEED

In the fourteenth edition (July 1995) of PESKEM, a compilation of agricultural chemicals registered in Australia, there were one hundred and eighteen registrations of twenty eight fungicides, eighty

nine registrations of twenty six insecticides and sixty nine registrations of twenty weedicides plus three wetting agents registered for use on grapevines. That was a total of seventy-four agricultural pesticides. There is a risk that the use of a wide range of agricultural chemicals in production of wine grapes will lead to undesirable residue pollution in the view of consumer standards organisations.

Some of the problems associated with pest and disease control programs using a very wide range of the registered agricultural chemicals are;

- There is an increased risk of misuse because of lack of familiarity with mode of chemical operation, spray preparation and application requirements.

- It often results in long storage time of chemicals, reduced efficacy and then the need to respray with newly purchased chemicals to control the problem.

- Long storage time of agricultural chemicals on farm increases the risk of on site and near site pollution with the deterioration of pesticide containers.

Further technical information relating to the development need;

- The inefficient application of pesticides results in unexpected infections/infestations that often necessitates the reapplication of pesticides increasing the likelihood of excessive chemical residues in wine.

- Where vineyard managers have poor knowledge of the nature of disease infection and pest infestation it results in poorer decision making and increased use of pesticides to control the problem.

- As biological pest and disease control agents become available there is a strong need for training to familiarise managers with the products and mode of operation.

- The importance of using suitable soil and water management to favour good vine health, winegrape quality and minimisation of conditions which favour pests and diseases needs to be emphasised to industry viz. create a suitable vineyard climate for production.

- Consideration of the problems associated with pesticide residues, current pest and disease control with the wide range of pesticides available and the technical information available resulted in the development of the “Riverina Clean” concept in winegrape quality assurance as outlined here;

Riverina Clean

The Riverina Clean concept, as other clean agriculture programs, developed out of increased consumer awareness about pesticide residues in foodstuffs. Riverina Clean is a quality assurance program to produce winegrapes under a fully

documented management protocol that minimises the use of pesticides in the vineyard and allows the production of quality wines that easily meet internationally specified MRL's. The program has recognised the grapegrowers' obligation to consumers, winemakers and a cleaner environment and has been very largely based on the principles of organic biodynamic viticulture.

In the Riverina Clean quality assurance program there are only seven fungicides listed - three of these are copper based, two insecticides listed - these being *Bacillus thuringiensis (Bt)* for the control of larvae of moths and butterflies and petroleum oil for the winter control of scale and only two weedicides listed. In addition to the insecticide sprays allowed, biological controls have also been recommended such as the release of predatory mites for the control of various mite pests.

There are only a total of eleven agricultural pesticides available in the program of which three have been acceptable in organic viticulture. While organic and mineral fertilisers have been accepted in the program, operators have been advised to avoid excessive use, especially of nitrogenous fertilisers.

(vi) THE DEVELOPMENT METHODOLOGY - INCLUDES DESCRIPTION AND JUSTIFICATION

Program Management

The 'best bet' LCM program for each site was determined in consultation with plant pathologists, entomologists, district horticulturists and a management committee including growers and

winemakers. Inclusion of the latter group was to ensure the programs were practical and to give other growers, besides the cooperator, early involvement and a sense of 'ownership' of the program, to facilitate its eventual extension to all growers.

A comprehensive procedure manual drafted in September 1993 was prepared for growing wine grapes in a LCM management program for the Riverina Clean marketing plan. The procedure manual included;

- Objectives of Riverina Clean.

- Application for accreditation of grapes which includes items on vineyard inspection, statutory declarations, certification, penalties and audits and a section on winery procedures.

- An appendix which includes forms for grape accreditation application, grower authorisation for inspections, a disclaimer regarding possible losses from implementation of Riverina Clean, a log for chemicals used during the season, chemical application equipment details, grower declarations regarding vineyard management records and a record log for inspections.

- An appendix which lists the Riverina Clean allowable products and practices code for pest and disease control, weed control, vineyard nutrition and soil amelioration.

- Procedures for vineyard and winery inspections.

- A management calendar for mature vineyards.

The program was to be modified by the management committee, if necessary, as further results of research on the pests and diseases of grapevines became available. Extension of the results of the program was to be facilitated to enable other wine grape growers to utilise the information available in their management.

Management costs and production outcome for each site (LCM and standard) was to be monitored and analysed. Distribution of the proceeds of sale of the grapes and wine was to be a matter for normal commercial negotiation between grower and winemaker.

The program has incorporated;

- Commercial lots of wine made from LCM and standard grapes from each site and a sample analysed for residues.

- Soil moisture monitoring was to be carried out where possible on the demonstration blocks to assist in irrigation and drainage management and to minimise the risk of disease infection and pest infestation.

- Soil management practices that minimise the likelihood of disease infections and pest infestations. Soil management systems were modified to minimise cultivations and herbicide use.

- Canopy management practices that minimise the likelihood of pest and disease infections. Where possible a range of canopy management systems was to be assessed in each district.

- The use of pheromone traps and port wine traps for Light Brown Apple Moth (*Epiphyas posttivana)* to be monitored by growers and supervised by NSW Agriculture staff to develop criteria on the need for vineyard inspection.

- Vine inspection and larval counts to determine the need for spray control.

- The use of biological control agents of pests and diseases where possible eg *Bt* sprays and Trichogramma wasps to control Light Brown Apple Moth (LBAM) larvae and the release of the predatory mite "Doreen" (*Typhlodromus doreenae)* to control mite pests.

- The use of 'soft' chemical options to control pests and diseases in the program by the LCM list.

- Improvement of the efficacy of any necessary pesticide applications.

- Planned fungicide and insecticide applications. The decision to apply pesticides was to be based on on-site monitoring of climatic conditions and insect pest and disease build up.

The LCM program used a protective fungicide approach for the control of downy mildew, powdery mildew and Phomopsis. Applications were timed in response to weather events and previous infections to ensure the vines were protected from potential new infection. While the program allowed for the use of the curative fungicide, potassium phosphite, its use was restricted to occasions when the vines may not have been adequately covered by a protective fungicide at the time of a recorded infection period.

Conditions in all locations were suitable for the development of various fungal diseases in the first two years as attested by disease development in vineyards neighbouring the trial plantings. However, there was less pressure from infective conditions in the third season in the Riverina where the program was continued.

Irrigation

The winegrape growers cooperating with provision of vineyard sites for LCM demonstration purposes were encouraged to install soil moisture monitoring devices to assist in vineyard management. Riverina Wines cooperated by having EnviroScan soil moisture monitors installed at their Ballingal Estate Vineyards in the Chardonnay planting, the major demonstration site, in the first year. Sets of soil moisture sensors from the EnviroScan were placed at 20, 40, 60 and 80 cm depth at numerous locations throughout the demonstration vineyards. Computer printout graphs of a

composite soil moisture availability to the vines from various soil depths for a variety block in the vineyard were made available to assist in irrigation management.

The aims were to

- Irrigate more efficiently to minimise the amount of water used
- Avoid accession of irrigation water to saline water tables
- Avoid waterlogging which would adversely affect photosynthesis and new root development and conversely to avoid under irrigation.
- Help predict irrigation times to assist in management operations such as the timing of pesticide applications
- Facilitate the use of Regulated Deficit Irrigation (RDI) practices to improve grape quality.

Early work at Griffith Viticultural Research Station (now Griffith Centre for Irrigated Agriculture) indicated that irrigation policy was important in developing high quality winegrapes.

In district surveys on winegrape quality conducted by H. Creecy it was found that the growers who flood irrigated Shiraz vines only four times per year compared to eight to ten times, which was more typical in district management, had much higher quality grapes. Generally, winemakers had not associated high quality winegrapes with better irrigation management in the warm Riverina climate.

Nutrition

Restricting the application of nitrogenous fertilisers to approximately 30-40 kg/ha per season helps to reduce vine growth so that "the right style of growth" is achieved for quality wine grape production. The "right style of growth" constitutes approximately 7-8 mature leaves per bunch on the holding cane. According to Rowe 1993 " 7-8 leaves/bunch in my opinion represents the balanced plant we hear so much about when discussing vine vigour and wine quality".

Surveys conducted by H. Creecy in the Riverina indicated that typical nitrogen use in vineyards was 75 - 100 Kg/ha with some applications reaching 200 kg/ha. In those surveys, the growers who winemakers recognised as having top quality Shiraz fruit were those who applied 30 - 40 Kg/ha and had a conservative irrigation policy which resulted in low to moderate vigour vines. The less vigorous growth gave high quality red wine grapes and appeared easier to manage for pest and disease control. In the demonstration vineyards at Tharbogang nitrogen application was restricted to 60 Kg/ha.

Diseases

As vineyard soils in the MIA range mostly from loams to clay loams and have shallow grades for irrigation and surface drainage it was not possible to have a strictly reactive program to the occurrence of vine diseases. This was due to the risk of bogging spray machinery after significant rain, which could also stimulate infection of vine diseases such as downy mildew. Also, there are significant diseases such as Phomopsis for which there are no curative fungicides.

Consequently, protective spray programs were planned for spring when growth was rapid and rainfall was common. To minimise the use of fungicides, opportunities were sought to miss a routine cover spray in the spring period. When recorded weather conditions indicated an infection of a major disease was possible the spray record was reviewed to decide whether a curative fungicide spray was necessary. The objective was to minimise the number of sprays required but also to increase the efficiency of the protection program by choosing the most appropriate chemical and timing its application well.

Pests

In LBAM control the importance of using *Bt* sprays during the first and second instar stages of larvae growth was emphasised to cooperating growers. A change in formulation of *Bt* products to increase concentrations occurred at the end of the second year of the formal trials (products now are Dipel-Forte, Thuricide, Biobit, Delfin). In the final year of the trials the application of copper based fungicides for protection of bunches and foliage was delayed until the major LBAM hatching in late November/early December to avoid any affect of copper on performance of *Bt*.

Vineyards were regularly inspected for pests especially egg masses, hatching and first and second instar larvae of LBAM. Inspection frequency was increased when numbers of female LBAM's increased to significant levels in a biweekly moth count from port wine/water (1: 9) traps placed within each winegrape variety in the main demonstration vineyard. Initially it was thought that a moth count over ten per trap warranted vineyard inspections. When vineyard inspections revealed significant levels of LBAM larvae then a decision to spray with *Bt* could be made.

Weather Stations

On-site monitoring of climatic conditions is essential to account for variations in weather, especially rainfall to enable prediction of vine diseases, which are sensitive to specific infection conditions. Weather monitoring was via nine 'Environdata' automatic weather stations, provided under a NSW State Development Grant (in association with CRC for Viticulture) and installed in each district. Monitoring was performed was performed by a NSW Agriculture District Horticulturist in association with the vineyard manager.

The stations were located in vineyards in the Upper Hunter Valley, Mudgee, Cowra, Tumbarumba, Charles Sturt University (CSU) Wagga and the Riverina. The remote stations were accessible by telephone modem. In addition data was accessed from another Riverina 'Environdata' weather station and six data loggers in the Hunter Valley.

The weather stations for each test district were read regularly by the grower cooperators during the growing season and pesticide application decisions were made on the basis of these weather readings, LBAM recordings and vineyard observations.

District selection

Four districts were chosen to cover the range of climates and pest and disease pressures likely to be experienced in NSW vineyards. LCM test sites of about 1 hectare were established in vigorous commercial vineyards in the Hunter Valley, Mudgee, Cowra and Griffith districts. Griffith in the Riverina was selected because of the low incidence of pests and diseases and industry interest in adopting a LCM program. Each vineyard site included an adjacent area of the same variety managed according to the grower's standard practice.

Soil management

Prior to the cover crop trials (GWRDC project DAN 92/2) and associated publicity in relation to nematode control, growers commonly maintained an indifferent attitude to the usefulness of vineyard cover crops. In the cover crop trials conducted by R McLeod in the MIA and other locations the nematode count was reduced significantly by the use of cover cropping with Cooba or Coolabah oats or Rangi rapeseed. The use of Rangi rapeseed in the MIA demonstration vineyards was not popular with the growers because of the difficulty in moving pneumatic power lines for power assisted hand pruning equipment through the cover crop. There was also fear that rapeseed would favour the unknown insect carrier of Australian Grapevine Yellows.

The use of vineyard cover crops also improves soil stability, water infiltration and vineyard access. To improve the heavy soils in some demonstration vineyards, oat cover crops were recommended and used in the third and fourth year of demonstrations.

Canopy management

Canopy management was listed in the methodology as a tool that should be investigated for its potential to minimise disease infection and pest infestation. Also, there was a real need to analyse the various canopy management systems that were being recommended or used by growers to determine which systems were most productive and convenient to manage and were able to produce quality suitable for bottle wine exports. Consequently, trials were commenced at three different properties in the Yenda district of the Riverina in the 1994/95 growing season in cooperation with the Wine Grapes Marketing Board (WGMB), the South Australian Department of Agriculture and CSIRO.

At the main demonstration site Farm 803 Yenda of G & P Raccanello a vineyard planted to Shiraz/Ramsey was used to compare a Minimal Pruning Canopy Treatment (MPCT) to Standard Machine Hedging (SMH) and Smart-Dyson Ballerina (S-DB).

- The MPCT treatment involved training canes to a foliage wire above the cordon and then using a declining amount of machine pruning of dormant annual growth on the sides of the vine canopy over three years. The pruning was then simply a tidy up of a minor amount of growth projecting beyond the bulk of the canopy sides and some growth trailing close to the ground.

- The SMH treatment involved machine pruning of the dormant annual growth close to the cordon with circular saws in both the vertical and horizontal planes.

- The S-D B treatment involved pruning the dormant annual growth as in the SMH treatment and training the new season growth inclined to grow upwards in the vertical plane.

Associated activity

The coordinator was to maintain regular contact with the following personnel, outside NSW Agriculture

<u>Co-operative Research Centre for Viticulture</u>
Dr. B.M. Freeman Associate Professor of Viticulture, Charles Sturt University, Wagga Wagga, Leader Program 4. - technology transfer.

<u>Pathology</u>
R. W. Emmett, Sunraysia Horticulture Centre, Mildura

P. Magary, Department of Agriculture, Loxton South Australia

Entomology
G. A. Buchanen, Sunraysia Horticulture Centre, Mildura

Canopy management
P. R. Clingeleffer, Division of Horticultural Research, CSIRO, Merbein
R. E. Smart, Smart Viticultural Services

Staff and facilities (NSW Agriculture)

Coordinator: Mr. C. R. Turkington, previously Special Horticulturist, Citrus and Vines, Gosford, coordinated the program. He was familiar with all aspects of the viticultural and wine industries and had an excellent working relationship with NSW Agriculture staff and other personnel associated with the project. As part of his programs he has conducted research on grapevine pruning, trellising, irrigation, clonal selection, rootstocks and initiated the concept of mechanical hedge pruning. He established the MIA Vine Improvement Society (MIAVIS) and was a former member of the Wine Grapes Marketing Board. He was a Chairman of the NSW Winegrape Processing Industry Negotiating Committee and played a role in negotiations that led to its authorisation by the Trade Practices Commission. He was also Chairman of the Assessment Panel for the Hunter Valley Wine Accreditation Scheme.

Mr. Turkington was one of the instigators of the vine mite research program that was successfully conducted by Dr. David James, Yanco Agriculture Institute. In a joint paper with Mr Somers he developed and proposed a LCM program for Hunter Valley vineyards at the 1990 Spring Vineyard Seminar. In November 1990 he convened a workshop to coordinate the future of the NSW Agriculture vine LCM program. He developed computer spreadsheet budgets for establishment and operation programs for citrus orchards and wine grape vineyards to assess the economic merits of the differing management systems.

As coordinator he was to consult regularly with all participants in the proposed program to consolidate information from the four sites and other sources.

Collaborators

Advisory
Mr. H. Creecy, District Horticulturist (Viticulture), NSW Agriculture, Griffith.
Mr. Creecy is a District Horticulturist, with experience in the Hunter Valley, NSW Sunraysia and the MIA. He was also involved in the establishment of MIAVIS and has conducted research on control of Phomopsis and Black Spot of grapevines and evaluation of vineyard spray machinery in dried vine fruit programs. He is a member of the Riverina Standing Committee on Viticulture.

Mr. A. Boys, previously District Horticulturist, NSW Agriculture, Griffith.
Mr. Boys initiated an organic viticulture demonstration at the Horticulture Research and Advisory Station, Griffith

Mr. C. R. Beckingham, NSW Agriculture, Bathurst (including. Cowra).
Mr. Beckingham has extensive viticultural experience in Mudgee and the Hunter Valley, where he organised many successful viticultural seminars and small farm field days. He compiled the first vineyard spray guides for the Hunter Valley and Central Tablelands.

Mr. B.C. Browne, previously District Horticulturist, NSW Agriculture, Mudgee.
Mr. Browne after taking over responsibility for the vineyard spray guide has developed it into a more comprehensive vineyard management guide and incorporated a section on organic grape growing. He has been successful in improving trickle irrigation systems and had a canopy management program aimed at reducing the incidence of botrytis.

Mr. A. Somers, previously District Horticulturist, NSW Agriculture, Maitland.
Mr Somers cooperated with Dr Nair in his field research on botrytis in the Hunter Valley, he is now in the position of Special Horticulturist (Viticulture) based at the National Wine and Grape Industry Centre, Wagga Wagga.

Co-operative Research Centre for Viticulture
Dr. C.D. Green, previously Director of Plant Pathology, Biological & Chemical Research Institute, Rydalmere, NSW, Dr. Green, an experienced nematologist, was leader of program 2, - Low Input Viticulture

As an adjunct to the CRC for Viticulture program, joint application with Charles Sturt University was made to the NSW State Development Department for the purchase of computerised weather monitoring equipment for installation in the Hunter Valley and at Griffith. These were used to develop general disease warning services, which were used as a backup to the specific site monitoring for this program.

Pathology
Dr. N.G. Nair, previously of the B. & C. R. I , Rydalmere, NSW
Dr. Nair has extensive experience in research on botrytis bunch rot on grapes. He has also begun research on cane blight or Phomopsis (GWRDC DAN 8 funded). Currently he is a lecturer in plant pathology at Western Sydney University.

Entomology
Dr. D.G. James, previously of the Yanco Agricultural Institute, NSW.
Dr James conducted extensive research on biological control of vine mites (GWRDC DAN 4 GW and DFRC funded).

Dr. S. Goodwin, Horticultural Research and Advisory Station, Gosford, NSW.
Dr. Goodwin has researched the borers afflicting grapevines in the Hunter Valley, particularly the fig longicorn beetle (GWRDC DAN5 and Hunter Vineyard Association funded).

Nematology
Mr. R.W. McLeod, previously Nematologist, B & CRI, Rydalmere.
Mr. McLeod an experienced nematologist and has had a lengthy involvement in the study of nematology in NSW vineyards.

Soil management

Mr. P.J. Sinclair, previously Research Horticulturist, H R & A S, Griffith, NSW.
Mr Sinclair conducted research on vineyard soil management at Griffith (GWRDC DAN 7 funded).

Messrs. R. E. Davidson and G. P. Sanderson, District Horticulturists, H R & A S, Dareton.
Messrs Davidson and Sanderson are studying cover crop soil management at Dareton and have published promising results in the Australian Grapegrower and Winemaker, July 1991.

(vii) DETAILED RESULTS - INCLUDING ANALYSIS

The project, commenced in the 1992/93 season was continued with collaborator teams of District Horticulturists and cooperating growers for two years in the Hunter Valley, Cowra and Mudgee and for three years in the Riverina.

The LCM program, developed in 1992/93 under the auspices of Riverina Clean was used as a basis for the LCM program in the districts. The program benefited from regular liaison and coordination-ordination between NSW Agriculture staff, Charles Sturt University staff as well as Greg Buchanan and Bob Emmett of the Victorian Department of Agriculture. The District Horticulturists were equipped with notebook computers to facilitate data access and their involvement in the development and adoption of 'AusVit'.

Teething problems were experienced when beginning operation of the modems and the loggers that prevented regular access to the data after installation in the second season and thus pest and disease control management decisions in the first two years were made largely on the basis of vineyard

monitoring, manual weather readings, satellite map data (accessed by polling fax) and weather forecasts. The data logger programs and modems were successfully modified and the weather stations along with 'AusVit' played a key role in the 1993/94 disease control program.

As the weather data from recording equipment was available in the third season and could be transmitted to remote locations for use in decision making for disease prevention a vital part of the objective had been achieved. The outcome was that use of the weather recording program has been largely successful in preventing pest and disease damage with better timing of sprays, use of fewer sprays, use of 'soft fungicides' and use of *Bt* sprays to manage LBAM larvae infestations.

In the fourth year of demonstrations to develop the LCM the opportunity to release the predatory mite "Doreen" to control various mite pests at the major demonstration site was taken. The predatory mite was re-released in the same season after the management chose to use two unlisted chemical insecticides in an attempt to control LBAM infestations that had progressed beyond the second instar stage. An opportunity to release Trichogramma wasps that parasitise LBAM egg rafts was also taken for the Riverina in November 1996.

RIVERINA

In the first year when difficult weather conditions favoured disease development, prediction of disease infection and timing of fungicide applications was hampered as weather recording stations were not yet available to the program. However, the program was still successful in the Riverina, partly due to the careful monitoring for pests and diseases and sound spray control advice provided by the District Horticulturist. Some details from the first three years of the development work follow.

- 1992/93

The three cooperating-operating growers, with vineyards at Griffith, Stanbridge and Leeton, successfully controlled fungal diseases to the point of harvest throughout the first season, using only copper based fungicides and wettable sulphur. The only insecticide used was *Bt.* The spray programs used in Shiraz and Chardonnay plantings met the requirements of the Organic Vignerons Associations of Australia.
Some crop losses occurred in two out of the three Chardonnay plantings because of significant LBAM infestations of bunches which commenced in late December 1992 after bunch closure. The pheromone traps gave no warning of this infestation and it was picked up through regular crop monitoring. The Shiraz planting remained free of any apparent pest and disease throughout the growing season.

The Chardonnay wines made by Riverina Wines and De Bortoli's Wines from the trial grapes were successfully launched and publicised at the Annual Meeting of the Standing Committee on Agriculture at Griffith in June 1993.

-1993/94

The program was expanded in the 1993/94 season to take in two additional cooperators, covering a vineyard area of nearly 200 ha. One of the original cooperators, Riverina Wines adopted the program for all of its 150 ha of vineyards after the first year of trials.

Significant spring rain in 1993/94 led to severe infection of Phomopsis in some district vineyards. There was a severe outbreak of rust mite in January 1994 throughout the Riverina but it was brought under control by the activity of predatory mites with very few growers applying miticides.

The six cooperators successfully completed the LCM program in the 1993/94 season with the incidence of pest and disease damage being minimal in their vineyards. The cooperating growers in the 1993/94 season used a total of 5-6 sprays comprising early season mancozeb with sulphur sprays, then including a *Bt* component to control LBAM where required and finally copper based fungicides with sulphur sprays. Two cooperators deviated from the recommended pesticides to control heavy outbreaks of LBAM and mealy bug, but still restricted their applications to six compared with up to fourteen by some district winegrape growers.

-1994/95

The program work in the Riverina was concentrated on the Riverina Wines, Ballingal Estate Vineyards in the 1994/95 season, however growers from the other vineyards continued similar vine protection work. While there was potential for Phomopsis, downy mildew, powdery mildew and botrytis infection and LBAM and vine moth infestation only 4-5 sprays were applied to the vineyard depending on the maturity time of the variety.

Port wine traps were used to obtain evidence of LBAM activity in the vineyards to prompt more intense inspections for egg masses, larval hatchings and the presence of first and second instar larvae to assist in decision making on the need for *Bt* spray application. Tables listing the numbers of LBAM trapped by variety and planting area at Riverina Wines, Ballingal Estate Vineyards are provided in the next subsection.

There was a problem with identification of LBAM from port wine traps by new vineyard staff from late October to mid November. When this was cleared up it was found that the female LBAM numbers from the twice weekly counts were moving into double figures for Shiraz, Semillon, Chardonnay and Traminer in late November. The moth count remained below ten for Merlot, Merlot/Cabernet Franc, Ruby Cabernet, Barbera and Sauvignon Blanc.

Where the moth count was above ten in late November it was considered sufficient indication for closer vine inspections. The vine inspections showed only 2-3 live larvae/500m of vineyard row and dead larvae cases where predation by spiders had taken place. Close inspection of LBAM egg rafts showed some parasitisation of eggs. The schedule in Riverina Clean suggests an infestation of 2 larvae/vine is sufficient to initiate a vineyard spray thus no spraying was conducted in late November.

The LBAM trappings showed significant increases in early December for Semillon with 32 and 20 female moths in successive recordings, 14 and 6 for Sauvignon Blanc, 13 and 2 for Traminer and 10 and 2 for Pinot Noir. All other varieties were significantly lower. The varieties with double figure recordings warranted vine inspections and these showed 7-8 larvae/500m of vineyard row inspected. This was not considered sufficient infestation to warrant spraying *Bt* for control purposes.

A section of the Semillon planting near a neighbouring citrus orchard was not adequately inspected for LBAM larvae and some significant infestation did take place resulting in some bunch rot and crop loss. The moth trapping figures indicated that infestation was likely in the Semillon and the weather monitoring model indicated that moth activity and larval infestations were likely to occur. A more thorough inspection of the vines should have been carried out - more attention was being paid

to the Chardonnay vineyard, which was the location of the weather station, as Chardonnay was believed to be a more susceptible variety to infestation.

The weather recording graphs were also observed to determine the likelihood of disease occurring according to infection models eg at least 10 °C and at least 10 mm of rain in a twenty four hour period on unprotected susceptible foliage for a primary infection of downy mildew to take place. A copy of a weather recording graph taken from a trial site in November 1994 and transmitted to a remote computer for centralisation of information has been provided for observation in Graph No. 2 on page 28. The weather characteristics recorded are dry temperature, relative humidity, leaf wetness, millimetres of rain, solar radiation and wind velocity.

No significant Phomopsis, downy mildew or powdery mildew infections resulted in the demonstration vineyards but some significant infections of botrytis resulted in a minor area of Semillon where high infestations of LBAM occurred as previously explained.

An infestation of vine moth larvae in parts of the vineyard that occurred in late April was not considered worth an insecticide spray so late in the season after the harvest of all varieties despite some significant vine defoliation.

Light Brown Apple Moth traps - monitoring records

The LBAM monitoring records for male and female moths from port wine traps used in the vineyard during the 1994/95 season for ten winegrape varieties have been provided for examination in the following pages.

Table 1

LIGHT BROWN APPLE MOTH TRAPPING RECORD - Ballingal Estate, Block No. 3

VARIETIES							NOTES
'94 Date	Chardonnay		Traminer		Pinot Noir		
	M	F	M	F	M	F	
31/10	1	2	1	2	0	1	Cedar moth not
3/11	0	1	0	0	3	2	LBAM recorded

7/11	10	5	20	14	16	19	here (not used in totals).
10/11	3	2	11	16	6	4	
14/11	12	6	20	7	2	1	
18/11	13	7	6	6	3	1	
21/11	8	12	3	5	2	2	Trappings occasionally into double figures. Very low caterpillar count in vineyard.
24/11	10	10	9	20	3	12	
28/11	2	2	2	4	3	4	
1/12	5	4	8	15	8	5	
5/12	5	3	6	13	4	10	
9/12	3	9	2	2	2	2	
12/12	7	3	5	4	4	4	
15/12	13	13	5	5	4	6	
19/12	4	5	4	3	2	4	
Totals	**57**	**61**	**44**	**71**	**33**	**49**	Attractant Used Port Wine : Water 1 : 9
21/11 to 19/12	**118**		**115**		**82**		

NB 0 ..... no moths recorded
- ..... trap not inspected

M ..... Male moth
F ..... Female moth

Table 2

LIGHT BROWN APPLE MOTH TRAPPING RECORD - Ballingal Estate, Block No. 2

VARIETIES					NOTES
'94 Date	**Semillon**		**Sauvignon Blanc**		
	M	**F**	**M**	**F**	
31/10	1	2	0	2	Cedar moth not LBAM recorded Here (not used in Totals).
3/11	1	1	0	0	
7/11	10	6	11	4	
10/11	2	2	8	7	
14/11	3	4	8	6	
18/11	15	12	4	4	
21/11	9	14	3	1	Trappings Frequently into
24/11	7	17	3	4	
28/11	7	10	2	3	
1/12	2	4	2	1	

5/12	15	32	7	14	Double figures for Semillon. Significant vineyard Infestation near Citrus.
9/12	15	20	5	6	
12/12	5	2	1	1	
15/12	7	15	7	7	
19/12	7	6	1	1	
Totals 21/11 to 19/12	74	120	31	38	Attractant Used Port Wine : Water 1 : 9
	194		**69**		

NB 0 ..... no moths recorded
\- ..... trap not inspected

M ..... Male moth
F ..... Female moth

Table 3

LIGHT BROWN APPLE MOTH TRAPPING RECORD - Ballingal Estate, Block No. 1

VARIETIES											NOTES
'94 Date	**Shiraz**		**Ruby Cabernet**		**Barbera**		**Merlot**		**Merlot/ Cab. Franc**		
	M	F	M	F	M	F	M	F	M	F	
31/10	0	0	0	0	1	0	0	1	1	0	Cedar moth not LBAM recorded here (not used in totals)
3/11	0	0	0	0	0	0	0	1	0	0	
7/11	1	0	0	1	0	0	0	0	6	0	
10/11	2	1	3	0	0	1	6	1	3	1	
14/11	2	3	4	1	1	0	2	5	5	4	
18/11	1	2	-	-	0	3	3	3	1	1	
21/11	0	3	1	1	1	0	-	-	0	7	Trappings rarely into double figures. Very low caterpillar count
24/11	0	1	2	9	-	-	1	2	4	4	
28/11	2	10	3	3	8	7	6	7	6	6	
1/12	2	2	-	-	0	2	4	1	1	9	
5/12	2	2	4	4	4	6	5	6	4	4	
9/12	1	0	1	4	2	2	3	3	3	2	

12/12	-	-	2	2	0	1	1	2	1	2	In vineyard.
15/12	2	0	0	2	2	3	6	6	10	9	
19/12	-	-	-	-	0	2	2	4	2	4	
Totals	**9**	**18**	**13**	**25**	**17**	**23**	**28**	**31**	**31**	**47**	Attractant Used Port Wine : Water 1 : 9
21/11 to 19/12	**27**		**38**		**40**		**59**		**78**		

NB 0 ..... no moths recorded
\- ..... trap not inspected

M ..... Male Moth
F ..... Female Moth

Planning protective spraying

As the winter and early spring of 1994 were very dry a decision was made not to apply a budburst spray for protection against Phomopsis. As mites were not reported to be a significant problem in previous years then there was no need for a dispersible sulphur spray at budburst. When both these protectants chemicals are required then they are applied together - as they were judged to be unnecessary, a budburst spray was avoided.

As protection from pests and diseases was essential, a spray program was commenced for the large planting approximately two weeks after budburst. The nine varieties were protected with a mancozeb and dispersible sulphur spray against Phomopsis, downy mildew, powdery mildew and mites by the 24/10/94. Heavy rainfall (totalling 29.6 mm) was received in early November and it was calculated from temperature, rainfall and leaf wetness sensor data that the conditions were suitable for a primary infection of downy mildew on the 3 rd and 4 th of November.

Some varieties had been sprayed as early as the 19/10/94 and had up to 15 days growth since that time and there were inflorescences, shoot and leaf growth that were susceptible to downy mildew. A decision was made to apply a downy mildew eradicant, downy mildew and Phomopsis protectant and a powdery mildew protectant to the whole vineyard, as soon as ground spraying was possible, to cope with the situation. No downy mildew or powdery mildew infection was viewed in the vineyard during inspections in the weeks following the rainfall event, however, some downy mildew infections were noted in the district.

Spray diaries

As the part of the objective of the development project was to successfully demonstrate the efficacy, practicality and economics of LCM programs it was important that spray records of the participant be examined. Spray diaries issued by the WGMB together with the MIA Winemakers Association and NSW Agriculture were used in the last year of formal trials at Riverina Wines Ballingal Estates Vineyards and are shown in Tables 4, 5 and 6 on the following three pages.

The 1994/95 season entries for Pinot Noir were used in the major field day publication to encourage use of the diaries for both grower and winery benefit to review the season's pest and disease control program. The 1994/95 Chardonnay spray program shown here is representative of that used for Pinot Noir and Traminer (Table 4). The 1994/95 Semillon spray program is representative of that used for Sauvignon Blanc (Table 5). The 1994/95 Shiraz spray program is representative of that used for Cabernet Franc/Merlot, Barbera and Ruby Cabernet (Table 6).

Table 4 1994/95 SPRAY DIARY - RIVERINA WINES - BALLINGAL ESTATE - CHARDONNAY

DATE 1994/95	VARIETY/BLOCK/AREA ("ALL" IF APPLICABLE) BLOCK 3	REGISTERED PRODUCT	GROWTH STAGE, A,B,C,	AREA SPRAYED	AMOUNT OF PRODUCT USED gm/100L	TARGETED PEST/ DISEASE	COMMENTS EG RAINFALL, WIND & TEMPERATURE
2/10	Chardonnay		B	20 ha			Budburst record
19/10	Chardonnay	Thiovit (Sulphur)	C		330	Powdery Mildew	Fine, light wind, max. temperature 24°C
		Dithane M45			300	Downy Mildew	
8/11	Chardonnay	Thiovit (S)	D/E		300	Powdery Mildew	Fine, windy, max. temperature 30°C
		Dithane M45			250	Downy Mildew	Primary infection calculated 2/11, 4/11
		Foli - R – Fos				Downy Mildew	
27/11	Chardonnay	Thiovit (S)	F/G		250	Powdery Mildew	Bunch protection spray
		Kocide			250	Downy Mildew	Fine, hot, max. temperature 32°C
6/12	Chardonnay	Thiovit (S)	G		250	Powdery Mildew	Hot, windy, max. temperature 34°C
		Kocide				Downy Mildew	
5/1	Chardonnay	Kocide	H/I		250	Downy Mildew	Hot, max. temperature 32°C

A Dormancy	B Budburst	C Shoot 10 cm long	D Pre-Flowering	E Full bloom 80% cap fall	F Fruit Set	G Berries Pea Size	H Bunch Closure	I Veraison (Colouring)	J Post Harvest

Table 5 1994/95 SPRAY DIARY - RIVERINA WINES - BALLINGAL ESTATE - SEMILLON

D ATE 1994/95	VARIETY/BLOCK/AREA ("ALL" IF APPLICABLE) BLOCK 2	REGISTERED PRODUCT	GROWTH STAGE, A,B,C,	AREA SPRAYED	AMOUNT OF PRODUCT USED gm/100L	TARGETED PEST/ DISEASE	COMMENTS EG RAINFALL, WIND & TEMPERATURE
8/10	Semillon		B	28 ha			Budburst record
21/10	Semillon	Thiovit (Sulphur)	C		330	Powdery Mildew	Fine, cloudy, max. temperature 18°C
22/10		Dithane M45			300	Downy Mildew	Fine, windy, max. temperature 24°C
24/10							Fine
9/11	Semillon	Thiovit (S)	D		300	Powdery Mildew	Fine, max. temperature 32°C
		Dithane M45			300	Downy Mildew	
		Foli - R – Fos			300	Downy Mildew	Primary infection calculated 2/11, 4/11
9/12	Semillon	Thiovit (S)	G		250	Powdery Mildew	Fine, mild max. temperature 26°C
		Kocide			250	Downy Mildew	Bunch protection spray
7/1	Semillon	Kocide	H		250	Downy Mildew	Hot, max. Temperature 34°C

A Dormancy	B Budburst	C Shoot 10 cm long	D Pre-Flowering	E Full bloom 80% cap fall	F Fruit Set	G Berries Pea Size	H Bunch Closure	I Veraison (Colouring)	J Post Harvest

Table 6 1994/95 SPRAY DIARY - RIVERINA WINES - BALLINGAL ESTATE - SHIRAZ

DATE 1994/95	VARIETY/BLOCK/AREA ("ALL" IF APPLICABLE) BLOCK 1	REGISTERED PRODUCT	GROWTH STAGE, A,B,C,	AREA SPRAYED	AMOUNT OF PRODUCT USED gm/100L	TARGETED PEST/ DISEASE	COMMENTS EG RAINFALL, WIND & TEMPERATURE
9/10	Shiraz		B	10 ha			Budburst record
21/10	Shiraz	Thiovit (Sulphur)	C		330	Powdery Mildew	Fine, cloudy, max. temperature 18°C
		Dithane M45			300	Downy Mildew	
8/11	Shiraz	Thiovit (S)	D		300	Powdery Mildew	Fine, windy, max. temperature 30°C
		Dithane M45			250	Downy Mildew	
		Foli - R – Fos			300	Downy Mildew	Primary infection calculated 2/11, 4/11
11/12	Shiraz	Thiovit (S)	G		250	Powdery Mildew	Bunch protection spray
		Kocide			250	Downy Mildew	Fine, max. temperature 26°C
8/1	Shiraz	Kocide	H		250	Downy Mildew	Fine, max. temperature 30°C
10/2	Shiraz	Kocide	I		250	Downy Mildew	

A Dormancy	B Budburst	C Shoot 10 cm long	D Pre-Flowering	E Full bloom 80% cap fall	F Fruit Set	G Berries Pea Size	H Bunch Closure	I Veraison (Colouring)	J Post Harvest

Operation of weather data loggers for LCM

Vital equipment for success in LCM is the weather data loggers. The trial experience showed that there were technical problems with the weather data loggers following installation, which affected the transmission of data and required correction. Also problems developed in operation like dust accumulation on solar power units, spiders webs in automatic rain gauges and deterioration of wet bulb wicks used for recording humidity, all of which may have affected satisfactory recording of the data.

During the first season of operation the technical problems with transmission of data to remote computer recorders was largely overcome allowing satisfactory operation in the second season and thereafter.

An example of a computer weather chart from Riverina Wines is provided here for the period 4-5/11/94. The recordings charted are; Time, Dry Temperature °Centigrade, Relative Humidity %, Time/Leaf Wetness %, Rain mm, Solar Mj/m^2, Wind k/hr. In the graph provided, rain had commenced prior to 5.20 a.m. and had continued until approximately 8.50 am however the sensor remained wet until 11.30 a.m. This is confirmed by the Relative Humidity graph, which shows around 100 % until that time. The subsequent high humidity, until approximately 12.10 p.m., appears to have been caused by application of a protective spray which commenced immediately after the leaf wetness declined to zero.

The weather data can now be used in the AusVit computer program in models for downy mildew infection, some aspects of powdery mildew infection and for LBAM hatching. The downy mildew infection model takes into account the growth stage of the vines, the rainfall received and whether the rain will result in primary or secondary infections or both. The powdery mildew model will assist by calculating the rate of spread of ascospore infection. The LBAM infestation prediction is from a day/degree model used to calculate moth flights, hatching and potential parasitisation of eggs. The occurrence of diseases and pests from model calculations needs to be confirmed by vineyard inspections.

Graph 1 Computer Weather Chart, Ballingal Estate Chardonnay, 4-5/11/94

Efficiency of vineyard spray equipment

In the season following the LCM demonstrations, problems developed with the control of LBAM infestation because of late discovery of the larvae (3rd and 4th instar) and the difficulty of applying insecticide to them in rolled leaves or bunches. Consequently an evaluation of spray machinery was commenced at the Riverina Wines, Ballingal Estate Semillon vineyard to compare the efficiency of various spray equipment and the effect of using faster than recommended speed of operation. The demonstration was attempted because high efficiency in application is considered basic in Low Chem Management of vineyards and "improvement of the efficacy of any necessary pesticide application" was part of the methodology. The vines were considered to be of medium vigour.

The more efficient spray units or set-ups had noticeably good coverage of the rachis or bunch stems. Coverage of backs of leaves was mentioned because this is a major site for downy mildew infection. It appeared that excessive spray coverage of the waxy berries caused run off resulting in accumulation of the fluorescent dye at the base of the berry. In protection programs this would amount to insufficient coverage of the berry with the fungicide being applied.

The airblast units when operated at recommended ground speed (very close to 6 k/hr) and with nozzles properly fitted and adjusted were only reasonably efficient in leaf and bunch coverage. When operated at faster than recommended speed (8 k/hr) the efficiency of spray distribution was reduced by an estimated 33%.

It seemed that the efficiency of distribution by the Turbomister operated on a two row set up might be improved by better adjustment, however, it did seem to be more efficient than the airblast units.

The most efficient spray unit was the "Electromiser" which was scored 9/10 when used on moderate vigour Semillon on the 23/11/95, which was just beyond fruit set time. The Electromiser showed very good spray distribution over both leaves and bunch stems and was around 50% more efficient than the airblast machines operated at recommended speeds and almost 30% more efficient than the Turbomister in this exercise. However the "Electromiser" had the disadvantage of being set up to spray only two half rows compared to the "Turbomister" which was set up to spray two rows of vineyard. The results are provided here in Table 7;

Table 7 Evaluation of Spray Machinery for Foliage & Bunch Coverage - Ballingal Estate Block 2, Thursday 23/11/95

Trial carried out in Semillon vineyard .

Spray Machine	L/Ha	Spray Pressure	Operating Speed K/hr	PTO rpm	Comments – Score based on observation of fluorescent dye
Electromiser	280	276 kpa (40 psi)	7	540	Even, fine deposit on tops and backs of leaves and bunches. **9/10**
Turbomister	250	207 kpa (30 psi)	6	540	Even, fine deposit on leaf tops - backs of leaves and bunches not as good. **7/10**
Airblast	990	1724 kpa (250 psi)	6	440	Leaf tops evenly covered. Bunches - sometimes only part of berries covered. **6/10**
Airblast	1170	2413 kpa (350 psi)	8	480	Leaf tops evenly covered plus run off. Bunches poor coverage. Commonly only part of berries covered. **4/10**
Airblast -Nozzle mount varied to suit canopy shape	(est. 1100)	2068 kpa (300 psi)	5.25	460	Leaves fairly even. Bunches fairly even. **6.5/10**

Soil Moisture Monitoring in Vineyards

Soil moisture monitoring was carried out with EnviroScan equipment at 20, 40, 60 and 80 cm depth at many locations for each variety examined. As previously explained the monitoring was carried out to enable suitable irrigation timing to avoid excessive soil moisture that would favour root disease and favour development of diseases of aerial vegetation. Importantly, the monitoring would enable the use of the RDI technique to assist in the development of quality winegrapes and prevent unnecessary stressing of the vines.

The EnviroScan equipment was able to produce a composite graph of the availability of soil moisture as measured by monitors at the four depths used at all locations in the trials. A graph that depicts those soil moisture measurements for the 1995/96 season for the bottom end of the Semillon vineyard is provided on the following page in Graph 2. The soil moisture content in mm is shown on the Y axis and the date is shown on the X axis together with irrigation and rain events with their values noted.

The irrigation provided in September was to ameliorate any effect of potential frosts. No further irrigation was applied until early December and there were two significant rain events in that period totalling 65 mm. For a 75% deficit the Readily Available Water calculation was 90 mm. Available water was allowed to decline to approximately 65-75% in the period early September to mid January. From early December to mid January there were two significant rain events totalling 88 mm. In the ripening period from mid January to late February the soil moisture was only allowed to decline to approximately 50-55 %. There was no significant rain event from mid January until mid March. Post harvest in mid March the deficit was allowed to decline to approximately 75%.

Graph 2

HUNTER VALLEY, COWRA & MUDGEE

As in the Riverina, a low chemical seminar was held in conjunction with industry in the Hunter Valley at Cessnock in October 1992. This seminar was also well attended.

Two Hunter Valley winegrape growers successfully followed the low chemical program in their vineyards through to harvest in the 1993/94 season in a joint program with the plant pathologists' strategic management trial. At the McWilliams Mt. Pleasant vineyards, Pinot Noir and Shiraz were the varieties used. Of great interest was the success of the program on a minimal pruned Chardonnay vineyard. A detailed assessment, just prior to harvest, showed that despite heavy disease pressure in the later part of the season, the incidence of botrytis bunch rot was minimal. Similar results were experienced in the Mudgee district with appropriate pruning/training techniques that exposed developing bunches from early in the growing season

In the Cowra demonstrations, differences in the performances of Foli-R-Phos and Ridomil as post downy mildew infection control sprays were examined, with Ridomil being found able to control the disease from the time infection had developed to the first appearance of oil spotting on leaves. However, Foli-R-Phos needed to be applied between infection taking place and prior to the appearance of spotting for effective control.

However, the trials/demonstrations in the Hunter, Cowra and Mudgee areas were abandoned because of lack of funding resources when the original request was reduced.

(viii) DISCUSSION OF RESULTS - ANALYSIS OF DEVELOPMENT/EXTENSION OUTCOMES COMPARED WITH THE OBJECTIVES

Weather data loggers important for LCM

The weather data loggers, once adequately installed, were largely successful in aiding the prediction of diseases, particularly downy mildew one of the major diseases affecting production in SE Australia.

It became obvious that there were some problems in maintaining weather data loggers such as the need to move the Leaf Wetness Sensor as the vine grew so that its position was a fair representation of the vineyard microclimate experienced by leaves. Also regular maintenance of weather data loggers was important to ensure they were in working order eg adequate water for the relative humidity recorders and no blockage of the rainfall recorders.

It is important that trained vineyard/winery staff, interested in the weather recording as it relates to pest and disease control be responsible for maintaining equipment and using the data for vineyard management purposes.

LCM needs soil moisture monitoring to guide irrigation decision making

The LCM exercise in the major trial vineyard at Riverina Wines, Ballingal Estate was linked to soil moisture monitoring, with RDI to improve vineyard manageability and winegrape quality. It became obvious after several years of trial operation that the occurrence of grapevine diseases was significantly affected by vineyard environment, particularly in marginal conditions for infection. For example, Phomopsis infections occurred in many district vineyards where unnecessary and inefficient flood irrigations in spring resulted in long damp periods which created an ongoing favourable vineyard climate for the development of the disease which is easily able to infect as new growth immediately becomes susceptible.

It has been noted that vineyards with heavy soils in poor condition and with consequent poor drainage do not favour vine varieties with roots of poor persevering character such as Merlot or Semillon. It appears that in the conditions described that Semillon vine roots are less successful in their biodynamics of growth and function thus weakening the vine and making it more susceptible to some pests such as borers. The solution is often to blame only the pest for the vine decline and attempt control by application of pesticides when changing the vineyard environment by improving soil conditions and irrigation management to suit the variety is also required.

The use of soil moisture monitoring helped gauge the real need for irrigation at the major trial site and avoid lengthy periods of above field capacity soil, which favours root decline. It also helped to employ the RDI technique to develop smaller than average berries that were less susceptible to disease infection. Both better irrigation timing and the use of RDI contributed to quality of the fruit for winemaking at Riverina Wines.

Soil management

Various articles were written on soil management and weed control during and soon after the formal trial period in publications with wide distribution to wine grape and dried vine fruit growers. An article "Soil management and weed control" by Phil Sinclair and Harry Creecy was published in the 1996/97 Grapevine Management Guide. This article included the use of cover crops in inter-row areas. In the same publication an article on "Interpreting soil test results" by Terry Abbott et al was presented for grape growers. Soil management articles presented by Phil Sinclair to Riverina growers during 1994/95 were "Soil and irrigation management studies in the MIA" and "Soil management regime and grapevine nutrition".

The importance of sustainable soil management practices for horticulture becomes appreciated more as time progresses. At a November 1997 conference on sustainable soil and water management for commercial horticulture hosted by NSW Agriculture and Department of Natural Resources and Environment Victoria at Barooga NSW most program items were relative to creation of a vineyard environment suitable for LCM. Examples of the relative program items were "Minimum tillage and irrigation practices in Sultana grapevines" presented by Graham Sanderson, "Sustainable soil management systems for horticulture" by Harold Adem and "Microbial response to increased organic matter in soils".

Success with LCM demonstrations

There was no significant Phomopsis, downy mildew or powdery mildew occurring in the Riverina Wines, Ballingal Estate Vineyards during the three year trial period however botrytis infections resulted on some Semillon fruit where infestations of LBAM had occurred and on some Chardonnay where there had been minor splitting of fruit immediately prior to harvest in late February 1995. While there were protective sprays applied for the prevention of Phomopsis, downy mildew and powdery mildew there were none applied for botrytis in the control period.

The decision to use port wine lures for LBAM traps appears justified as later advice from Agriculture Victoria Entomologist David Madge was that they were a more reliable indicator for potential infestation than hormone traps as the wine was more attractive to fertilised female moths which then gave a better guide to egg laying periods.

Occasionally LBAM larvae were discovered in broad leaf weeds in the vineyards or surrounds in spring which seemed to add support to the program recommendation of using oat cover crops in the autumn/winter/spring period to increase soil organic matter and also to compete with weeds likely to support the pest.

Control of LBAM has been a problem in district vineyards because of the inability of growers to appreciate the importance of early recognition of the infestation to allow biological or chemical spray control to succeed if populations warranted the effort. In the main trial vineyards the use of *Bt* to control LBAM, when required, instead of chemical insecticides did favour the build up of predators and parasites. Vineyard inspections revealed LBAM eggs that had been parasitised (possibly by lacewings) and LBAM larvae that had been predated on by spiders.

A release of Trichogramma wasps, a natural parasite of LBAM, was arranged in late November 1996 in a Shiraz vineyard at Griffith Centre for Irrigated Agriculture as part of the objectives to introduce biological controls of vineyard pests in the district. The wasp also occurs naturally in Australian vineyards but its survival in agricultural environments is dependent on the use of "soft insecticides".

The release of the predatory mite "Doreen" for demonstration vineyards during the trial period and later in district vineyards was reported by growers to be very successful in lowering vineyard mite problems. Dr David James Entomologist at Yanco Agricultural Institute who researched and developed "Doreen" for commercial release was the main speaker at two field days held in the Riverina during March 1996 for grower information and wider release of the predator in relation to this Low Chemical Management program. The predatory mite "Doreen" was released to 31 growers with wine grape plantings in Riverina districts, including a re-release at the main trial site at Riverina Wines Ballingal vineyards, during March 1996 in relation to this program.

The occurrence of mealy bug in some parts of demonstration vineyards was considered a problem worth more attention in research to assist in understanding of the pest.

Spray efficiency of machinery compared as part of program

With less departmental staff attention at the end of the formal trial period and loss of vineyard staff at Riverina Wines' Ballingal Estate, vineyard inspections were not as frequent or as thorough and a problem developed in control of LBAM with a significant outbreak occurring. In this situation *Bt* was not as effective because the LBAM larvae were above first and second instar stage of growth and the third and fourth instar larvae were able to roll tender young vine leaves into protective shelters. Eventually two pesticides unlisted in the LCM schedule were used in an attempt to control the infestation.

The situation was used to advantage by conducting a spray efficiency trial as the management were questioning the performance of their spray equipment and were keen to compare it to others being suggested by a sales company. The trial results tabled earlier in the report showed that there were significant differences in the performance of spray equipment commonly used, even if used according to manufacturer's instructions, with four of the treatments ranging in an efficiency of distribution score from 6/10 to 9/10.

Because of the large areas of vineyard involved at the main trial site at Riverina Wines' Ballingal Estate Vineyards there was sometimes difficulty in getting the vineyard sprayed and a tendency by some drivers to drive faster than recommended to get the job done. Consequently, a treatment that involved a ground speed of tractor drawing the airblast sprayer at 8 k/hr and approximately 2400 kpa instead of the maximum 6 k/hr and approximately 1700 kpa recommended by the manufacturer, was included. There was an estimated 33 % loss of efficiency in application resulting from increased speed of operation.

The trial provided a vivid demonstration of the importance of using high performance spray equipment efficiently to succeed in LCM pest and disease control and to avoid the need for respraying.

While not realised at the time of the trial it appears in retrospect that small droplet size that emanates from the "Electromiser" is very important in maintaining globules of spray on the waxy berries to enable adequate pesticide to be evenly placed on the berry surface. It became obvious that excessive spray or large droplet size caused spray to run to the base of the berry leaving the pesticide placed very unevenly which would result in poorer protection.

Spray efficiency in pest and disease control still appears to be an under-rated part of vineyard management by industry in inland areas with significant losses occurring when heavy pressure of

infestation/infection occurs. While the small trial reported here on spray efficiency was conducted in relation to LCM work and showed marked differences in the efficiency of spray distribution by the use of fluorescent dyes, the trial was not enough to fully evaluate the problem. The technology of use of surfactants in vineyard spraying also needs to be given more attention to improve efficiency in spray application.

In the coastal, Hunter and tableland districts where rainfall is much higher than the Riverina districts the risk of disease infection in particular becomes much greater and any inefficiency in spray application is more telling in fruit or foliage losses. Repeat spraying in attempts to correct unsatisfactory pest or disease control results in more chemical use than necessary and all the associated losses through time, machinery wear and soil compaction which results in a poorer environment for vine roots, vine health and performance.

Certainly, changes made in canopy management such as Scott-Henry and Minimal Pruning which improve the display of leaves and fruit to sunlight to create better conditions for ripening have allowed better access of preventative/protective sprays to their targets.

In both the Riverina and the Hunter Valley functions associated with LCM were organised to firstly initiate interest and later to report on trial work conducted. These functions have been well attended as growers seek to stay in touch with developments that may assist in preparation of winegrapes for marketing and increase their efficiency of operation. This has been achieved with grower cooperators who have helped arouse interest in the importance of good planning for pest and disease control programs, weather recording and efficiency in operation of spray machinery.

In the Cowra demonstrations the Ridomil curative was found able to control downy mildew up to the time oil spotting appeared on leaves however, manufacturers now recommend application before the appearance of oil spotting to minimise the risk of infections developing to the stage where they cannot be controlled. This information helps emphasise the need for weather recording to be an integral part of disease control to enable correct decisions to be made in relation to application of curative sprays and to maximise the time span available for spraying.

Greater care needs to be taken in the industry with the protection of inflorescences from downy mildew and botrytis infections as the inflorescences hold water from rain and dew a lot longer than leaves when separating prior to and during the flowering event. The weather recording instruments base the time of foliage wetness on a leaf simulation.

Extension

A well attended LCM regimes seminar was held in the Riverina at Griffith in May 1992 and winegrape growers were provided with a book (see Appendix i - Seminar and Field Day Programs) introducing the subject through articles by the major speakers. The concept of LCM and the program were expounded in the 1993-94 NSW Agriculture Vineyard Management Guide which was distributed to most NSW wine grape growers.

The draft procedures manual of Riverina Clean prepared in September 1993 was revised and presented at a major field day attended by 120 growers in May 1995 at the conclusion of the official

vineyard trials. The feature article "Low Input Viticulture - A Whole Vineyard Model" which included the revised procedures manual of Riverina Clean was presented by Ross Turkington the previous Program Leader for Viticulture in NSW Agriculture at the Low Input Viticulture field day. The article was well received by the wine grape industry as a major part of the May 1995 function.

The "Low Input Viticulture" field day book was advertised in the annually produced Grapevine Management Guide that has been widely distributed to growers in NSW and the field day book was in strong demand afterwards. The Grapevine Management Guide also contained articles and photographs of vineyard pests and diseases to assist growers in identification and help in decision making on control.

Pest and disease management using the Riverina Clean system at the major demonstration vineyard, Ballingal Estate of Riverina Wines, was the subject presented by Harry Creecy at the field day. The presentation included items on planning a pest and disease control program in which vineyard history, operation rules, weather guides, vineyard monitoring, biological insect control, spray machinery, tractors, pesticide requirements and spray recording needs were outlined. A plan for control requirements for typically occurring pests and diseases was listed for each month of the season and this included the essential monitoring requirements.

The 1994/95 season experience at Ballingal Estate was discussed in the article and this included spraying curative fungicide for protection against a primary infection of downy mildew judged by weather data and the recording of LBAM numbers in vineyards. The LBAM numbers were taken from port wine traps placed in ten variety locations to help in decision making on the need for control sprays. Some planning for future use of Riverina Clean was listed with pest and disease identification, vineyard monitoring and introduction of the predatory mite "Doreen" to the Chardonnay vineyards included.

An introduction to the AusVit computer listing of pesticides and processing of weather data for use in pest and disease control was provided for winegrape growers at the field day by Shayne Hackett who was a Technical Officer with the Cooperative Research Centre for Viticulture based at Charles Sturt University at Wagga Wagga .

As well managed irrigation program was shown to be a vital part in pest and disease management and the development of winegrape quality. Articles on the subject were presented at the field day by Robert Hoogers of NSW Agriculture who spoke on Riverina Twin Furrow of vines in the MIA and Evan Christian of CSIRO who spoke on Irrigation and Drainage Management for Horticulture. Also presented at the field day were introductory articles on marketing and industry status while articles on water /salt balance and canopy management were presented by a number of speakers.

The field day was organised by Ross Turkington and Harry Creecy of NSW Agriculture in cooperation with the Wine Grapes Marketing Board, the MIA Winemakers Association, CSIRO, Charles Sturt University and Riverina Wines who cooperated by providing demonstration vineyards and the field day site.

The field day was sponsored by MIA Rural Services a Griffith company which supplies Dipel-Forte a biological spray for control of *Lepidopteran* larvae and a range of agricultural pesticides as well as agricultural spraying equipment.

Comments from growers participating in "Riverina Clean" demonstrations

"After using Low Input Management we will be using deficit irrigation in our vineyards for both wine grape quality and good pest and disease management"

"Good contact with Wagga on weather monitoring, (CSU centralisation of weather recording data) helped planning and decision making on the pest and disease control program. Typically I contacted Wagga weekly to update on weather statistics and contacted the centre more often around rain events"

" Involvement in the LCM program resulted in me changing to using oats as a cover crop in winter to minimise the likelihood of LBAM infestation in summer - 8 months oats and 4 months bare ground worked well. The oat sward helped with vineyard access in winter for pruning and particularly in spring for vineyard access in the spray program."

"Cover cropping improved water infiltration from both irrigation and rain"

" The Low Input management exercise has been a good introduction to AusVit - a comprehensive aid in vineyard management"

Several growers commented that adoption of Low Input Viticulture made significant savings in water, fertiliser and pesticide use. While the crop was not quite as heavy, quality was higher resulting in bonus payments and there were less harvesting and freight costs.

Conclusions

The trials and seminar raised awareness of low input management of vineyards for both wine companies' staff and wine grape growers who adopted features of it in their vineyard management such as; soil moisture monitoring, RDI, less nitrogen use, more confident use of *Bt* to control *Lepidopteran* larvae, a narrower choice of agricultural chemicals for pest control to preserve predators and parasites of vineyard pests and more thorough vineyard inspections for LBAM.

The use of soil moisture monitoring and deficit irrigation to ensure irrigation was only carried out when calculated to be really necessary appeared to be very useful in lowering the incidence of Phomopsis, downy mildew and botrytis diseases where surface irrigation was carried out. The use of Riverina Twin Furrow irrigation at the Riverina Wines Ballingal Estate trial site was a significant improvement on inter-row flood irrigation for both root and foliar environment and created a more favourable vineyard climate for vine health and quality production. The use of inter-row cover cropping with autumn/winter/spring oats also contributed to a favourable root environment for the vines.
The weather recording through rain and temperature monitoring enabled determinations on the occurrence of downy mildew infections to be made after rain events which assisted vineyard managers in deciding on the need for application of curative sprays. In vineyards, located on the slopes and Hunter Valley in particular, it appears important that an inflorescence simulation be used to judge vegetative wetness in addition to the leaf simulation to enable prediction for both downy mildew and botrytis infection of bunches.

The use of bio-controls such as *Bt* for control *Lepidopteran* larvae especially LBAM and the release of "Doreen" the predatory mite both favoured the build up of natural predators and parasites which eliminated the need for use of other insecticides during the formal trial period.

The spray diaries issued to growers by the WGMB and wineries should be renamed pest and disease control diaries so that entries regarding biological management to control pests and diseases besides sprays can be included and given credit eg release of the predatory mite "Doreen".

The statement that it was "essential that an immediate start be made to LCM" in the project application was fulfilled for industry by the lowering of vineyard inputs in the trials and then ongoing significant adoption of various aspects of the program by industry as outlined.

The practical experience in LCM management in the trials prompted the testing of efficiency of spray machinery and its operation soon after the conclusion of the formal trials to dispel arguments regarding efficacy of various units. The trials were very worthwhile in demonstrating the importance of operating well maintained and well adjusted equipment at recommended ground speed to obtain effective coverage of pesticides (organic or chemical) in protection programs.

The considerable bonus that came to LCM was that it benefited from use with Low Input Viticulture for the production of quality wine grapes. The efficient vineyard irrigation under Low Input Viticulture guidelines, assisted by soil moisture monitoring, together with low to moderate nitrogen fertilisation favoured moderate foliage growth that was suitable for production of quality winegrapes which were easy to spray and had very few disease problems under the sound prevention program.

The wines made from grapes grown under Low Input Viticulture incorporating LCM were high in taste quality and very low in chemical residues making the wines very marketable products. Wines made from grapes grown under the Low Input Viticulture policy were succeeding in the wine show circuit as demonstrated by the Riverina Wines 1995 Cabernet Merlot and 1995 Cabernet from the Ballingal Estate vineyards. These wines were involved in the taste-off for the Jimmy Watson trophy and the Chardonnay being awarded a gold medal at the 1996 Melbourne Show.

The techniques demonstrated and recommended in the Low Input Viticulture incorporating the LCM program have been adopted in part by many growers and particularly in vineyards owned by wineries. Many MIA growers are tending to use less agricultural chemicals in winegrape production because of success of the demonstrations in this program and the management format is now being demanded of growers by some wineries in order to meet low residue requirements for valuable export markets. Also soil moisture monitoring continues to be adopted in the Riverina to assist in irrigation management for the production of good taste wines.

While some growers are swinging to the use of AusVit as a comprehensive computer management tool for wine grape vineyards there are still good prospects that an updated Low Input Management scheme for vineyards will be used as a model for low cost production for high quality wine grapes.

(ix) IMPLICATIONS AND RECOMMENDATIONS

Costs/benefits to Australian industry of findings and/or future research needs

- Low Input Viticulture is a practical management system which can be adopted by winegrape growers in areas up to 500 mm average annual rainfall with a tendency to winter maximums.

- The wines from Low Input Viticulture management systems are low cost and high quality products that have impressive tastes and low chemical residues. The Low Input Viticulture management system has potential to be used as a base for a quality management model such as

ISO 9000. Widespread adoption of such standards would lift the percentage of the winegrape crop available for valuable export markets and importantly for long term success in marketing, would lift the reliability of quality production for wineries.

- While some wineries are requiring their growers to use a restricted list of chemicals to meet international marketing requirements and raise the image of their products, most do not have a quality management system for development of specific wine products in the vineyard.

- The pesticides listed in the Low Input Viticulture model comply with the allowed chemical use for wine exports to all major importing countries and use of the model, together with growers compliance with the chemical producers requirements in application, will enable the wine to be a very low residue product.

- The weather recording instruments used in vineyards should include a moisture sensor device that simulates a developing vine inflorescence and then bunch at susceptible stages of development so that the risk of botrytis and downy mildew infection there can be judged. The inability of the leaf simulation moisture sensor to reliably estimate infection risk in inflorescences and bunches is a weak point in the protection program.

- Weather station performance needs to be regularly reviewed and recommendations made to industry on operation, maintenance and improvements in design. New radio equipment for transmission of weather data for recording needs performance assessment before adoption by the winegrape growing industry.

- Soil moisture monitoring of vineyards is essential to assist in decision making on irrigation for production of high quality wine grapes and to avoid excessive application of water, that creates a suitable vineyard environment for infection of vine foliage and inflorescences by several vine diseases.

- The Low Input Viticulture system needs reviewing to assess the potential for resistance developing to fungicides from the short list especially for botrytis preventatives.

- The Low Input Viticulture quality wines are excellent products for blending with wines from other districts where more agricultural chemical use is necessary because of higher pest and disease pressure, so that MRL's can be kept within market expectations.

- Vineyard management systems such as the computerised AusVit package can be used for Low Input Viticulture management by inclusion of a categorised reduced pesticide list.

- An annual review of the pesticides allowed in Low Input Viticulture (including second options) would allow easy updating of that system in AusVit. There is also a need to assess the potential for new products to be included in the listing especially for biological pest and disease control.

- The promotion of sound soil management practice in Low Input Management vineyards will favour good drainage and healthy root growth of vines which would be another contribution by the scheme to stabilisation of the environment.

- Research on biological control of pests and diseases should be on going so alternatives to chemical pesticides are available to industry especially for Low Input Viticulture management.

An integrated pest and disease management system also lessens the likelihood of resistance developing in either chemical or biological control methods.

- Performance of biological control agents such as *Bt* on vine leaves also needs to be reviewed when updating Low Input Viticulture management guidelines. There also appears to be a good case for inclusion of "Trichodex", a biological fungicide useable in the protection program against botrytis bunch infection.

- There is also potential for the use of new modelling systems such as the CSIRO "Dimex" for calculating the likelihood of significant pest hatching at specific locations which could improve the present degree day accumulation prediction for hatching.

- The spread of the predatory mite "Doreen" introduced into pilot Riverina and upper Hunter vineyards should be examined as observation of some release sites has shown that it has survived for 4 years. If spread of the predator has been successful in the Low Input Management vineyards in the Riverina then introduction to other regions such as Sunraysia and the Riverland should be encouraged.

- Commercialisation of breeding of "Doreen" for releases and reintroductions where necessary can be encouraged by the development of a volume culturing system as recommended in GWRDC Project No. DAN 93/2. Also stated in that report "Commercial availability of *T. doreenae* is highly desirable and perhaps critical to adoption of biological control by the entire Australian viticultural industry."

- Further work needs to be done in the Riverina on the occurrence and evaluation of Trichogramma wasps as natural parasites of LBAM. Trichogramma wasps can reduce infestation pressure in vineyards and the need for further release of the wasp needs to be determined.

- Vineyard spray diaries should be retitled as pest and disease management diaries so that credit can be given for biological control efforts by growers such as release of "Doreen" the predatory mite and release of Trichogramma wasps. Advice could be given in the diaries on the pesticides that are not harmful to the parasites and predators of vineyard pests.

- Research and extension of efficient application of pesticides as attempted in this project should be on going as this is vital to success in Low Input Viticulture and all viticultural management systems.

(x) DESCRIPTION OF INTELLECTUAL PROPERTY

Not applicable as this is a development project using viticultural research information from various sources.

(xi) TECHNICAL SUMMARY OF ALL INFORMATION DEVELOPED

The Low Chem Management approach to pest and disease control was recognised as benefiting from use with a Low Input Viticulture program in which a considerable amount of existing technical information on vineyard management was coordinated to produce high quality wine grapes with very low chemical residues at a relatively low cost. The Low Input Management scheme is a practical use of technical information such as weather forecasts, weather records, vine fertiliser requirements, soil

and vine petiole tests, soil structure reports, soil moisture records, insect trapping records, lists of insect predators and parasites of vine pests and biological and chemical sprays for pest and disease control.

As the range of chemical sprays allowed is very small compared to the range of registered chemicals available for use on winegrapes the process of testing for residues by government authorities and purchasers is simplified.

In explanation of how the technical information listed was used to minimise the use of agricultural chemicals the following points are made.

- Examination of weather forecasts helped in spray planning to avoid the application of unnecessary pesticides and time essential sprays correctly to control the pest and/or disease being targeted.

- Examination of weather records enabled the prediction of some vine disease infections such as downy mildew and this helped in decision making on the need for application of curative fungicides and for further planning of preventative sprays.

- The use of both port wine and insect hormone traps for LBAM helped in determining the need for more intense inspections for egg masses, parasitisation of eggs, predation of larvae and larvae infestation to determine the need for and timing of the biological insecticide *Bt* application.

- The use of *Bt* instead of chemical insecticides favoured the build up of predators and parasites of LBAM the main pest of the mature vines. The most obvious predators were spiders that built up significantly in the vineyards involved.

- The use of autumn/winter/spring oat cover crops in trial vineyards helped improve soil structure for vine roots and created a firmer soil base for vehicle movement for spring application of pesticides in particular.

- The conduct of spray efficiency trials with the use of different machines and different modes of application showed significant variation in performance. This highlighted the importance of choosing suitable equipment and operating it efficiently to successfully apply the required pesticides to their vine targets.
- The use of soil moisture monitoring equipment capable of recording up to 400 kpa soil moisture tension at four depths at a large number of locations in the vineyards was very useful in determining the real need for irrigation. The low number of irrigations applied to the vineyards prior to harvest in the RDI program created a vineyard climate less suitable for many diseases of vines.

- The low moisture regime, useful in reducing the incidence of disease, created a vineyard climate which was very suitable for the production of high quality wine grapes as evidenced in the large number of wine medals awarded to made from grapes coming from the main trial vineyards.

- The introduction by NSW Agriculture of the predatory mite “Doreen” helped significantly in control of mite pests in many district vineyards where it was released especially those with an LCM pesticide schedule.

Appendices

i SEMINAR & FIELD DAY PROGRAMS

(a) Low Chemical Management Regimes in Viticulture, Hanwood, May 1992

(b) Low Input Vineyard Management Field Day,
Riverina Wines, Tharbogang, May 1995

(a) LOW CHEMICAL MANAGEMENT REGIMES IN VITICULTURE, MAY 1992

Seminar presided by - Harry Creecy, Special Horticulturist (Citrus & Vines)
NSW Agriculture, Griffith.

The seminar was opened by A. Cruickshank MLA.

An industry perspective on Low Chemical Viticulture

- Darren DeBortoli, Manager
DeBortoli Wines

Low Chemical Viticulture in Australia

- Stuart McGrath-Kerr, Secretary
  Organic Vignerons of Association of Australia

Marketing and Public Relations

- Robert Geddes, Executive Officer
  Wines of the Riverina Promotion Committee

"Born Clean" - A Growers View

- Dennis Murphy, Manager
  Yenda Estate Services

Nematode problems in Grape Production

- Rod McLeod, Nematologist
  NSW Agriculture
  Biological & Chemical Research Institute

Viticultural Management using Computer Based Decision Support Systems

- Neville Hermann, AusVit Computer Programmer
  Charles Sturt University

A Co-operative Research Centre for Viticulture - includes sections on meeting the challenge of reducing pesticide residue levels in Australian grape products

- Brian Freeman, Associate Professor
  Charles Sturt University

Canopy Management & Low Use of Chemicals in the Vineyard

- Ross Turkington, Special Horticulturist (Citrus & Vines)
  NSW Agriculture - Gosford

Management of Bunch Rot Disease of Grape Vines

- N G (Tan) Nair
  Principal Research Scientist, NSW Agriculture

Other speakers included:

- Phil Sinclair, Research Horticulturist (Viticulture),
  NSW Agriculture, Griffith.

- Alan Boys, District Horticulturist,
  NSW Agriculture, Griffith

- Lu Cremasco, Chairman MIA Vine Improvement Society &
  Wine Grape Grower, Yenda District

- David James, Entomologist,
  NSW Agriculture, Yanco Agricultural Institute

(b) LOW INPUT VITICULTURE FIELD DAY
Tuesday 2nd May 1994, Riverina Wines, Griffith

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The Changing Market for Riverina Wine	Darren De Bortoli, Chairman, MIA Winemakers Association
The Market for Riverina Wine Grapes	Stuart McGrath-Kerr, Executive Officer, Wine Grapes Marketing Board
Low Input Viticulture and 'Riverina Clean'	Ross Turkington, NSW Agriculture
Pest & Disease Management - 1994/95	Harry Creecy, NSW Agriculture
AusVit 1994/95	Shayne Hackett, Charles Sturt Uni, Wagga Wagga
Irrigation Management - Riverina Twin Furrow - 1994/95	Robert Hoogers, NSW Agriculture
Soil Water and Salt Balance	Warren Muirhead, CSIRO,

Division of Water Resources

Canopy Management and Shiraz quality Shayne Hackett, Charles Sturt Uni, Wagga Wagga

Poster Summaries

Clear Pocket 1. *Workshop Notes* - Strategies for production of low input quality wine grapes focussing on Shiraz and Semillon

Clear Pocket 2. *Diseases & Pests* - Advertisement for this comprehensive guide to diseases, pests and disorders of grapevines in Australia
ed, Phil Nicholas, Peter Magary & Malcolm Wachtel.

Clear Pocket 3. *Soil Management Regime & Grapevine Nutrition*
Phil Sinclair, Gary Osborne

Clear Pocket 4. *Subsurface Irrigation Trials*
Peter Clingeleffer
Salt Tolerant Rootstocks for Sultanas
Dr Rob Walker

Clear Pocket 5. *Spreading the Benefits of Minimal Pruning*
Peter Clingeleffer

ii "Low Input Viticulture - A Whole Vineyard Model"

This feature article was presented by Ross Turkington at a major field day titled "Low Input Viticulture" which was held towards the end of the industry funded program. It is an explanation and model of modern development in wine grape growing following a professional career in viticulture and oenology research with emphasis in the latter part on production of high quality fruit with low chemical residues suitable for consumer appeal at home and abroad.

The article has a major section on 'Riverina Clean' and is preceded firstly by an introduction that mentions the environmental and residue issues in winegrape growing that are important for the marketing image of Australian wine especially for the rapidly expanding export trade. He mentions the importance of Australian wine maintaining the edge in international trade with its "clean and value for money" image and how the Riverina needs to meet the challenge by taking advantage of its assets such as low cost gravity fed irrigation supply, low salinity water, availability of large blocks of suitable and easily managed soil, low pest and disease pressure and an already strong wine industry infrastructure.

There is an explanation provided on "Low Input Viticulture" in which minimum application of pesticides, with "soft" pesticides being preferred, is highlighted. The section in which "Riverina Clean" is incorporated is titled "Establishing and Operating a Low Input Vineyard". The ten key points are;

1 Site Selection

2 Pre-planting Site Preparation
3 Vineyard Layout
4 Irrigation and Drainage
5 Selection of Planting Material
6 Canopy Management System
7 Vineyard Floor Set Up and Management
8 Controlled Use of Fertilisers
9 Reduced Use of Labour and Substitution With Mechanisation
10 Reduced Use of Pesticides and Preferential Use of Soft Pesticides

Some important characteristics of "Low Input Viticulture" vineyards that relate more directly to "Reduced Use of Pesticides and Preferential Use of Soft Pesticides" are good surface drainage, minimum use of irrigation water, minimum accession of irrigation to the saline water tables, minimum use of fertilisers, minimum use of tillage, the development of vineyard floor mulches and infrequent trafficking of the vineyard. These points mostly relate to minimising moisture in the vineyard climate that is likely to contribute to vine disease or minimising other adverse conditions for the vine.

iii RIVERINA CLEAN

The *Riverina Clean* program is a good example of a reduced chemical program. It relies on:

- setting up the vineyard to reduce the incidence of pests and diseases;
- applying no more than 3 routine protective sprays in spring to protect young bunches;
- using a limited range of pesticides, including copper based fungicides, sulphur, predatory mites and *Bacillus thuringiensis,*.
- monitoring the weather and the vineyard and reacting to conditions inducing pest and disease incidence;
- recording spray applications.

Suitability of Riverina for low chemical vineyard management

The Riverina region of Australia is ideally suited to the low chemical production of grapes and wine. The warm and relatively dry summer climate means that there is minimal risk of fungal diseases - in many seasons, application of fungicides turns out to be unnecessary.

When conditions favour infection, copper based and sulphur fungicides can control diseases. Botrytis, by itself, is rarely a problem during the main part of the growing season, but reliably emerges late in the season (May-June after main harvest) to produce " Sauternes" -style or late harvested Semillon.

Mites controlled biologically with predatory mites, and vine moth is controlled biologically with shield bug predators. Monitoring and applying Bacillus thuringiensis sprays when necessary controls light brown apple moth.

To cap this off, the region has access to abundant supplies of low salt irrigation water from the Snowy Mountains electricity scheme.

OBJECTIVES OF RIVERINA CLEAN

Riverina Clean has been set up to capitalise on the natural advantages of the Riverina wine industry. The concept of "Clean" agriculture has developed out of increased consumer awareness and concerns about pesticide residues in foodstuffs.

Riverina Clean is a Quality Management Assurance program to produce winegrapes under a fully documented management protocol that minimises the use of pesticides in the vineyard and allows the production of quality wines that more than meet internationally specified MRLs.

The program recognises the grapegrowers' obligation to consumers, winemakers and a cleaner environment. While *Riverina Clean is* very largely based on the principles of organic/biodynamic viticulture, it differs from organic programs in that it permits the use of those manufactured products that do not appear as residues in the end product and which allow current production efficiency to be maintained.

It formalises the low chemical management regimes already being followed by some Riverina growers.

WHO OPERATES RIVERINA CLEAN?

Riverina Clean was developed by the Wine Grapes Marketing Board (WGMB)in conjunction with NSW Agriculture to take advantage of the low use of chemicals required for the production of Riverina grapes and wine. Procedures for growing *Riverina Clean* grapes are slightly restrictive than those set down by the Organic Vignerons Association of Australia. The procedures are designed to rationalise and reduce the use of pesticides in the vineyard but without placing the grape crop at risk and without reducing yield.

The Riverina Standing Committee on Viticulture, a representative body of winemakers, grapegrowers and government agencies has adopted Riverina Clean.

The program is designed to be administered through the WGMB in concert with NSW Agriculture and the MIA Winemakers Association. When and if *Riverina Clean* certification is sought by the market place, the program will be funded by industry. Inspection and certification fees will be based on the tonnages involved under each grower's program. The concept of *Riverina Clean* positions the Riverina wine industry to meet future (ISO) 9000 standards.

To quote from the article The Need to Manage Quality: Where to Begin ? The Institute's Perspective (Mark Gishen and Peter Leske, Australian Wine Industry Journal, February 1995)

"Growers must be aware of the principles of quality management as the pressure for certification will soon be passed onto them (Elder 1994). In order to develop a quality system, dialogue with winemakers on setting standards must take place . In many instances, this will be the most difficult

aspect to tackle as it requires a major change in approach. Handshake agreements for fruit procurements may have sufficed in the past where no quality criteria existed and rejection of goods was not even a remote possibility. Modern producers will need to move with these changes in attitude."

The following are a **draft** of records and procedures that growers may need to follow to be accredited for *Riverina Clean.* They are:

- a spray diary issued to Riverina grape growers for the 1994/95 season;
- a vineyard practices code and list of allowable products;
- a monthly management guide for mature vineyards.
- description of phenological or vine growth stages

1994 SPRAY DIARY

NAME ..... FARM NO ....

ADDRESS .....

.....

TELEPHONE .....

Australia now exports 30% of all wine produced, compared with only 3% a few years ago. It is therefore vitally important that we take every step to ensure that we retain our hard won export markets.

Part of the region's strategy to achieve this is to ensure that grapes and wine produced in the MIA conforms to international minimum residue limits. Increasingly overseas buyers are seeking assurances that the product in the bottle conforms with international standards, and seek in written evidence that it does.

As part of a joint program aimed at protecting and enhancing our export markets for wine, the MIA Winemakers Association, the Wine Grapes Marketing Board and NSW Agriculture are endorsing a standard record-keeping system on the use of sprays for pest and diseases in grapes.

This diary contains the following:

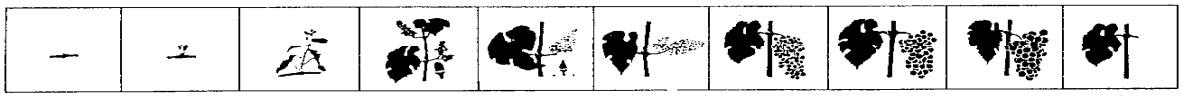
- A list of recommended spray products for use in MIA vineyards
- Blank record sheets for growers to enter details of each pesticide and fungicide spray applied to vines in their vineyard
- A list of winery contacts and telephone numbers.

If you require further information about the spray diary and how it should be completed, contact your winery or Harry Creecy of NSW Agriculture on 069 60 1300

John J Dal Broi
Chairman
Wine Grapes Marketing Board

Darren De Bortoli
Chairman
MIA Winemakers Association

Date	Variety/Block/Area ("All" If Applicable)	Registered Product	Growth Stage, A, B, C, etc.	Area Sprayed (Hectares)	Amount Of Product Used	Targeted Pest/ Disease	Comments E.G. Rainfall, Wind & Temperature



ALLOWABLE PRODUCTS AND PRACTICES CODE

Previous season

- Record incidence of pests and diseases and likelihood of carry over;
- Re-trellis or extend trellis height and retrain vines to develop an open vine structure.
- Use lighter pruning techniques to produce more but shorter shoots with smaller and looser bunches.

Preferred strategies and control agents for vineyard pest and disease management

Select a site with a dry summer climate. Select soil type and set up vineyard to facilitate early access after rain or and irrigation. Control excessive shoot growth and maintain an open foliage canopy, bearing small loose bunches.

Where feasible the non-chemical option or first listed chemical option (common name) option is preferred. Post bunch closure applications of pesticides should be avoided, unless the crop is genuinely at risk. All pesticides listed in the following table are registered in NSW for use in vineyards and should be applied at label rates. The agents and chemicals listed in bold type are permitted under the Riverina Clean protocol.

Use pesticides marked with a # only if the pest is causing significant economic damage. Use of these pesticides will make the vineyard ineligible for reduced pesticide certification for the current vintage and will decimate the population of beneficial predators.

Recommended withholding periods should be adhered to at all times. Winemakers may require longer withholding periods for pesticides than indicated by the manufacturer. The program below meets the pesticide residue requirements for exports to all major importing countries.

STRATEGIES AND CHEMICALS

FOR LOW INPUT PEST AND DISEASE MANAGEMENT

Pest or Disease	Strategy	Spray Timing	Chemical active ingredient	Chemical trade name	Withholding period (days)
Botrytis bunch rot	Use NSW Agriculture monitoring service at Flowering. Alternate use of different chemical groups to avoid resistance Problems. Dicarboximides promote less permanent resistance	Reactive	Carbendazim (Benzida-mazole group) Benomyl (Benzida-mazole group) Chlorothalonil (Subs -tituted aromatic) **Iprodione (Dicarb-oximide)** Vinclozolin (Dicarb-oximide)	Bavistin FL Spin Benlate Benlate DF Bravo 500, Bravo W750 Chlorothalonil 500 SC Rover 500 **Rovral** **Rovral liquid** Ronilan Ronilan 500	1 1 3 3 7-14 7-14 7-14 7 7 7 7
Downy Mildew		Routine Reactive	**Copper hydroxide** **Copper Oxychloride** **Bordeaux** **Potassium Phosphite**	**Kocide** **Cuprox** **Foli-R-Phos**	1 1 -
Elephant Weevil #		Reactive	Azinphos methyl # Methidathion #	Azithion 500W Supracide 400 #	14 14
Fig longicorn		Reactive	Azinphos methyl # Methidathion	Azithion 500W Supracide 400	14 14
Light Brown Apple Moth	Monitor with pheromone traps to time spray application of bio-agent	Reactive	***Bacillus thuringiensis***	**Dipel** **Novosol** **Thuricide**	-
Mites	Protect predatory mites - Don't use miticidal spray		***typhrosilia doreenae***		
Nematodes	Rootstocks Nematicidal cover crops				
Phomopsis		Routine	**Mancozeb**	**Various brands**	Before flowering
Phylloxera	Strict observance of Quarantine regs. - Rootstocks				
Powdery Mildew	Temp greater than 18°C Temp less than 18°C		**Sulphur, dispersible** Fenarimol Triadimefon	**Various Wettable** **Kumulus** **Lansul** **Thiovit** Rubigan Bayfidan	30 30 30 30 Before flowering Before flowering
Thrips	No Action Needed				
Vine Moth		Reactive	***Bacillus thuringiensis***	**Dipel** **Novosol** **Thuricide**	
Vine Scale	Dormant	Reactive	**Petroleum Oil**	**Various**	

PREFERRED STRATEGY FOR WEED MANAGEMENT.

RIVERINA CLEAN OPTIONS IN BOLD TYPE

Mechanical	Knockdown action chemical	Residual action chemical	Application method	Chemical trade name	Minimum age of vines (years)
	Glyphosate		CDA	**Glyphosate Roundup**	3
	Glyphosate-trimesi.		CDA	Touchdown	3
	Fluazifop		Jet	Fusilade	
	Glufosinate-ammonium		Jet	Basta	2
		Simazine	Jet before rain/irrigation	Simazine (various) Gesatop Lupizine Simatox Simagranz	2
		Diuron	Jet before rain/irrigation	Diuron (various) Aguron Karmex	3
		Oryzalin	Jet before rain/irrigation or incorporate mechanically	**Surflan 500**	Newly planted
		Norflurazon	Jet before rain/irrigation	Solicam	1.5
Slashing					Newly planted
Knifing					Newly planted

FERTILISERS

All types of fertilisers, whether mineral or organic accepted for Riverina Clean. Avoid excessive use, especially of nitrogenous fertilisers.

PEST AND DISEASE MANAGEMENT FOR RIVERINA CLEAN

Pest or Disease	Vine strategy	Chemical strategy	Chemical (active ingredient)	Chemical (trade name)	Withholding period (days) & schedule
Botrytis	Monitor Inflorescences Bunches loose And accessible To spray. Control LBAM Min. N fert.	Apply direct to bunch before bunch closure, only if detected in inflorescence. Select chemical to manage resistance	Benomyl Chlorothalonil Iprodione	Benlate Bravo Rovral	3 S6 14 S6 7 -
Downy Mildew	Develop open Vine canopy. Avoid o'head Spray irrigation At night Prevent Primary Infection Producing Spores and Protect Inflorescences	Monitor vines for primary and secondary infection Monitor weather forecast and rainfall. Apply two or three protective sprays (2,4 and 6 weeks after budburst) to cover Inflorescence, depending on incidence of primary infection and weather pattern. Apply combined **reactive** and **protective** spray if conditions have favoured a primary or secondary infection and leaves and inflorescences not protected	**Protective** Copper hydroxide Copper oxychloride Bordeaux mix Mancozeb **Reactive** Potassium Phosphite + Copper Hydroxide	 Blue Shield Kocide Spectrum Brycop C.oxychloride 1 C.oxychloride 2 Cuprox Oxydul Bryzeb Dithane (var) Galben Mancozeb Manzate Pennecozeb Recoil Foli-R-Fos 200 Fungi-Fos 200	 1 U 1 U 1 - 1 U 2 U 3 U 4 U 5 U 14 S5 14 S5 14 S5 14 S5 14 S5 14 S5 14 S5 0 U 0 -
Phomopsis	Avoid suscept-Ible varieties Maintain good Surface Drainage Remove dead Wood	Apply protective spays **before** rain from budswell to first downy mildew spray	Mancozeb	Various - see Downy Mildew	
Powdery Mildew	Monitor vines For previous Season Infection and Early season Flag shoots.	Apply protective spray 4 and 6 weeks after budburst. If heavy previous season infection or flag shoots found apply spray 2 weeks after budburst	Sulphur	Brysulph, Kumulus DF Lansul Sulfine Thiovit Top wettable S Wettable Sulphur	0 U 0 U 0 U 0 U 0 U 0 U 0 U

SEPTEMBER

Routine measures (response to phenological or development stage) #

Phenological stages # = 1-15;

1-12 Apply under vine herbicide
7 Apply spray to control Phomopsis if symptoms observed in previous season
7 Slash cover crop before budburst
15 Apply routine protective fungicide spray for powdery mildew
15 Apply routine protective fungicide spray for downy mildew

Reactive measures (response to pest/disease build up and weather events)

Monitor vineyard, weather, soil moisture and insect pest traps daily and if

- Weather conditions indicate primary downy mildew infection, apply protective fungicide spray.
- Powdery mildew observed on flag shoots or heavy infection last season, apply protective sprays 2,4 & 6 weeks after budburst.
- Insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT at egg hatch.
- soil moisture 50% depleted, irrigate or fertigate

See **Appendix; GRAPEVINE PHENOLOGICAL STAGES**

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

OCTOBER

Routine measures (response to phenological or development stage) #

Phenological stages = 10-20;

1 Apply mancozeb if Phomopsis observed last season

10 Apply protective sulphur sprays 2,4 & 6 weeks after budburst if heavy infestation last season or powdery mildew seen on flag shoots

15 Apply routine protective fungicide spray for downy mildew.

15 De-sucker trunks and arms

Reactive measures (response to pest/disease build up and weather events)

Monitor vineyard, weather, soil moisture and insect pest traps daily and if;

- weather conditions indicate primary downy mildew infection, apply potassium phosphite spray if protective spray not applied in last 7 days.
- powdery mildew observed on flag shoots or heavy infection last season. apply protective sprays 2,4 & 6 weeks after budburst.
- insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT.
- soil moisture 50% depleted, irrigate or fertigate
- rain forecast apply nitrogenous fertiliser

See Appendix, GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

NOVEMBER

Routine measures (response to phenological or development stage)#

Phenological stages = 18-31;

18 Apply routine protective fungicide spray for powdery mildew
18 Apply routine protective fungicide spray for downy mildew
19 Shoot position or - see 29
19 Desucker and train vines to lay down cordon extensions where needed
23 Apply botrytis inflorescence spray
25 Apply under vine glyphosate
25 Apply row centre glyphosate
25 Train vines to lay down cordon extensions where needed
27 Apply routine protective fungicide spray for downy mildew
29 Shoot trim or leaf pluck
31 Apply protective botrytis spray

Reactive measures (response to pest/disease build up and weather events)

Monitor vineyard, weather, soil moisture and insect pest traps daily and if;

- weather conditions indicate downy mildew infection, apply Cu(0H)2.
- powdery mildew present and weather conditions favour powdery mildew infection, apply Sulphur.
- insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT.
- soil moisture 50% depleted, irrigate or fertigate

 # See Appendix; GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

DECEMBER

Routine measures (response to phenological and development stage)#

Phenological stages = 27-35;
27 Apply routine protective fungicide spray for downy mildew
29 Shoot trim or leaf pluck
31 Apply protective botrytis spray
32-33 Train vines to lay down cordon extensions where needed
35 Monitor vines for fig longicorn and if present apply azinphos methyl

Reactive measures (response to pest disease build up and weather events)

Monitor vineyard, weather, soil moisture and insect pest traps daily and if;

- weather conditions indicate downy mildew infection, apply reactive fungicide.
- powdery mildew present and weather conditions favour powdery mildew infection, apply Sulphur, observing withholding requirements.
- insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT.
- soil moisture 50% depleted, irrigate or fertigate

See **Appendix; GRAPEVINE PHENOLOGICAL STAGES**

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

JANUARY

Routine measures (response to phenological or development stage)#

Phenological stages = 34-35;

35 Shoot trim or leaf pluck
35 if monitoring indicates risk of botrytis infection, apply post bunch closure fungicide
35-38 Monitor ripening
35-38 Train vines to lay down cordon extensions where needed

Reactive measures (response to pest/disease build up and weather events)

Monitor vineyard, weather, soil moisture and insect pest traps daily and if;

- conditions indicate downy mildew infection, apply reactive fungicide
- insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT.
- soil moisture 50% depleted, irrigate or fertigate

 # See Appendix: GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

FEBRUARY

Routine measures (response to phenological or development stage) #

Phenological stages = 36-38;

36 Monitor ripening
38 Harvest grapes

Reactive measures (response to pest/disease build up and weather events)

Monitor weather, soil moisture and insect pest traps daily and if;

- weather conditions indicate downy mildew infection, apply reactive fungicide.
- insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT.
- soil moisture 50% depleted. irrigate or fertigate

Post harvest

 # See Appendix; GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

MARCH

Routine measures (response to phenological or development stage)#

Phenological stages = 36-41;

36 Monitor ripening
38 Harvest grapes

Re-active measures (response to pest disease build up and weather events)

Monitor weather, soil moisture and insect pest traps daily and if;

- weather conditions indicate downy mildew infection, apply Cu(OH)2.
- weather conditions favour powdery mildew infection, apply Sulphur.
- insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT.
- soil moisture 50% depleted, irrigate or fertigate

Post harvest

 # See Appendix, GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

APRIL

Routine measures (response to phenological or development-stage)#

Phenological stages = 38-42;

38 Harvest grapes
41 Sow or trigger germination of winter legume cover crop
41 Apply superphosphate with cover crop

Re-active measures (response to pest/disease build up and weather events)

Monitor weather, soil moisture and insect pest traps daily and if:

- weather conditions indicate downy mildew infection, apply Cu(OH)2.
- weather conditions favour Powdery mildew infection, apply Sulphur.
- insect trappings and vineyard monitoring indicate build up of vine moth or LBAM, apply BT.
- soil moisture 50% depleted, irrigate

 # See Appendix, GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

MAY

Routine measures (response to phenological or development stage)#

Phenological stages = 42-47;

Monitor weather, soil moisture and insect pest traps for information only

Re-active measures (response to pest/disease build up and weather events)
Service machinery and equipment

 # See Appendix; GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

JUNE

Routine measures (response to phenological or development stage)#

Phenological stages = 44-48;

48 Prune, train and tie vines

Re-active measures (response to pest/disease build up and weather events)

Monitor weather, soil moisture and insect pest traps for information only

 # See Appendix; GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARD (continued)

JULY

Routine measures (response to phenological or development stage)#

Phenological stages = 44-48;

48 Prune, train and tie vines

Re-active measures *(*response to pest/disease build up and weather events)

Monitor weather, soil moisture and insect pest traps for information only

- If vine scale infestation heavy apply winter oil spray

 # See Appendix, GRAPEVINE PHENOLOGICAL STAGES

MANAGEMENT CALENDAR FOR MATURE VINEYARDS (continued)

AUGUST

Routine measures (response to phenological or development stage) #

Phenological stage = 48;

48 Finish pruning
48 Restrain trellis wires
48 Apply fertiliser

Reactive measures (response to pest/disease build up and weather events)

Monitor weather, soil moisture and insect pest traps for information only

 # See Appendix; GRAPEVINE PHENOLOGICAL STAGES



Figure 7.4. Phenological stages recommended for German viticulture by Eichhorn and Lorenz (1977).
The stage descriptions are as follows:

01. Winter rest, buds 'Romanesque shaped', light to dark-brown and more or less closed, depending on variety.
02. Bud swelling, primordia enlarging inside.
03. Wool stage, brown wool clearly visible.
05. Bud breaking, .first green of shoot visible.
07. First leaf unfolded and separating from shoot tip.
09. Two to three leaves unfolded.
12. Five to six leaves unfolded, inflorescence clearly visible.
15. lnflorescence enlarging, single flowers in compact groups.
17. Inflorescence fully developed, single flowers separated
19. Beginning of flowering, first flower caps loosening from receptacles.
21. Early flowering, 25% flower caps detached
23. Full bloom, 50% of flower caps detached.
25. Ending of flowering, 80% of flower caps detached.
27. Fruit set, ovaries enlarging, undeveloped ovaries abscessed
29. Berries buckshot size, bunches begin to hang down..
31. Berries pea-size, bunches hanging down.
33. Beginning of bunch closure (berries touching).
35. Beginning of ripening, berries start to change colour.
38. Berries ripe (harvest ripe).
41. After harvest, wood maturation complete.
43. Beginning of leaf fall.
47. End of leaf fall.

iv REFERENCES

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Rowe R N, (1993), ' The Growth of Grapevines : The Role of Roots', The Australian and New Zealand Wine Industry Journal Vol. 8 No. 4

v PUBLICATIONS ARISING

The following publications are provided for GWRDC examination;

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Creecy H (1995), 'Pest and Disease Management - Riverina Clean', from Low Input Viticulture, field day publication

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Hackett S, (1995), 'Improvement of Red Wine Quality in the Riverina', from Low Input Viticulture, field day publication

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vi ASSOCIATED PUBLICATIONS

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'Effects of Cover Crops on Inter-row Nematode Infestations in Vineyards'

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McLeod R, Da Silva E, (1994), Annual Technical Issue '2 Effect of green material and of roots of cereal'

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vii TABLES

Tables 1 Light Brown Apple Moth Trapping Record – Ballingal Estate, Block No.3
2 Light Brown Apple Moth Trapping Record – Ballingal Estate, Block No. 2
3 Light Brown Apple Moth Trapping Record – Ballingal Estate, Block No. 1
4 1994/95 Spray Diary – Riverina Wines – Ballingal Estate – Chardonnay
5 1994/95 Spray Diary – Riverina Wines – Ballingal Estate - Semillon
6 1994/95 Spray Diary – Riverina Wines – Ballingal Estate – Shiraz
7 Evaluation of Spray Machinery for Foliage & Bunch Coverage 23/11/95

viii GRAPHS

Graphs 1 Computer Weather Chart, Ballingal Estate Chardonnay, 5/11/94
2 Riverina Twin Furrow, Soil Water Graph – Summed, Interpolated 1995/96

ix ACKNOWLEDGMENTS

I would like to thank the GWRDC and the NSW State Development Board for part funding of this program and for their recognition of the potential in the Low Chemical Management proposal which was presented by Ross Turkington the previous Program Leader (Viticulture). The Low Chemical

Management program evolved into Low Input Viticulture as the reduced use of chemicals in the vineyard was integral with sound irrigation, nutrition and soil management as recognised, developed and promoted by Ross Turkington.

Thanks go to all those in the industry for the support they provided for the program - to the Wine Grapes Marketing Board and the previous Executive Officer Stuart McGrath-Kerr who helped develop the concept of Low Input Viticulture through his interest in Organic Viticulture and its potential for marketing.

Thanks especially go to the support from Riverina Wines where a moderate demonstration area involving one variety quickly turned into 150 ha of demonstration vineyards to develop the Low Chem Management concept with ten varieties being used as the potential for quality production of low residue wine was recognised. The support at Riverina Wines came from the company principal Tony Sergi, the previous Executive Officer, David Hammond and the vineyard manager Angelo Pittari and staff, their cooperation was greatly appreciated.

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