

**DIGESTIVE AND FEEDING
PHYSIOLOGY OF GRAPE
PHYLLOXERA (*DAKTULOSPHAIRA*
VITIFOLIAE FITCH)**

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B. Sc (HONS)

**A THESIS SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY OF
THE AUSTRALIAN NATIONAL UNIVERSITY**

SCHOOL OF BOTANY AND ZOOLOGY

FACULTY OF SCIENCE

THE AUSTRALIAN NATIONAL UNIVERSITY

CANBERRA, ACT

AUSTRALIA

FEBRUARY 2007

This thesis does not contain any material that has been accepted for the award of any other degree or diploma at this or any other University. To the best of my knowledge, this thesis does not contain any material that has been published previously, except where due reference is made in the text. The research described in this thesis is my own original work, except where due acknowledgement has been made in the text.

Part of the content of Chapters 2 and 5 are currently *in press* for publication for *Proceedings of the Third International Phylloxera Symposium* in *Acta Horticulturae*. For both articles I am the principle author and contributor to the work.

Kim Bernadette Kingston

01 February 2007

ACKNOWLEDGEMENTS

I would like to thank my supervisors for their continued support, guidance, and encouragement throughout my PhD studies. Dr Kevin Powell (Department of Primary Industries; DPI) originally offered me this fantastic opportunity, and I must thank him for allowing a 'soil microbiologist' to endeavour into the world of entomology and host-plant interactions. Dr Paul Cooper (Australian National University; ANU) has provided continual strength to me both personally and academically, I always felt refreshed and revitalised after our conversations. Both supervisors brought different attributes to my PhD journey, and I knew from early on in the project that I was in a fortunate situation.

Going back to the start of this endeavour, I also wish to thank Angela Avery (DPI) for initially planting the seed of thought in my mind that perhaps it was time to 'think outside the square' for the future direction of my career. Without that late night chat, I would never have gone down this path. I also need to thank the Department of Primary Industries for allowing me four years leave without pay to complete my PhD studies. My scholarship and the funds for the project were generously provided by the Grape and Wine Research Corporation.

During the course of the PhD I have been a part of '*team phylloxera!*' My workmates have made my task very enjoyable, and I have benefited from the professional relationship and social developments that have come from being part of this team. Therefore acknowledgment must be made of the assistance and support provided to me by past and present colleagues of the grape phylloxera research team at DPI-Rutherglen, particularly: Anna Burns, Annette Blanchfield, Carolyn Trethowan, Ginger Korosi, Karen Herbert, Rob Bederian and Sarah Brown.

I would also like to acknowledge the psychological assistance that has been provided to me by my workmates at DPI-Rutherglen. It is true that the “people make the workplace”, and the friendships that I have established here have been critical the completion of this research. A general thank you for all of the chats, both in and outside of the tea room. The pub lunches were pretty good too! A special thank you to Kyra-Jane Huhn for offering assistance with the formatting of this thesis.

Now to the first of a list of professional thankyoues ...

The statistical analysis presented throughout the thesis has been performed in consultation with Dr Alvin Milner and Sorn Norng (DPI). Thank you to for your direction, and most importantly, your patience. I may not share your passion for biometrics, but I certainly appreciate your support. Special thanks to Sorn for reviewing the final chapters.

The microscopy research presented in chapter 2 could not have been performed without the direction and assistance of Neda Plovanic (ANU). Neda, a ‘master’ at sectioning, provided technical support and training for the light microscopy sectioning. A number of sections presented in this thesis were cut by her steady hand. The electron microscopy images presented were captured with the use of the facilities at the ANU Electron Microscopy Unit under the direction and experience of Dr Roger Heady. All scanning electron microscopy images in this thesis were taken by Dr Roger Heady and Dr Paul Cooper.

The molecular symbiont research presented in chapter 3 was assisted by a number of people. An initial refresher course in the skills of molecular biology was provided by Dr Lyn Cook (ANU); I was appreciative of the opportunity to regain some confidence in this area. Further assistance in field of molecular biology was provided by Dr Daryl Nelson, Dr Andrew Oxley and Annette Blanchfield (DPI). I especially need to thank

Andrew and Annette for assistance in the laboratory and great discussions about the best approach to take. Finally, I need to thank Dr Trudy Wharton (ANU) who provided me with the Monterey pine aphids used as a positive PCR control. The DNA sequencing presented in this thesis was completed by Saturn Biotech, Murdoch University.

The EPG analysis of grape phylloxera feeding behaviour would not have been possible without the training and assistance provided by Dr Freddy Tjallingii (Wageningen University, The Netherlands). Freddy is considered in many circles as the 'godfather' of EPG, and the insight that he brought to the analysis of the grape phylloxera waveforms was critical for the development of my knowledge in this area. I have also been rewarded by meeting a number of researchers undertaking EPG based studies. Various members of the EPG community have provided support and guidance to me for the development of an EPG system for a tiny, root-feeding insect, and inspired me along the way into the belief that everything was possible.

A professional thank you must also be extended to the providers of the grapevine root material that is essential for maintaining the grape phylloxera populations in the laboratory, and was also utilised for the EPG studies. In particular, thank you to Peter Clingleffer (CSIRO, Merbein) for continuously allowing the phylloxera research team to 'harvest' the root system of the vineyard planted grapevines. And a special thank you to the vineyard manager in the King Valley, Victoria, who has managed to keep grape phylloxera out of his vineyard, but still lets the phylloxera research team enter to collect root material. The Börner rootstock material was used in agreement with Professor Ernst Ruhl (Geisenheim Research Institute, Germany).

Back to a personal level ...

I would sincerely like to acknowledge my parents, Rex and Joy Andrews, who have always supported me in my endeavours and ambitions. They mightn't understand the 'nut and bolts' of what I do, but they have provided encouragement ever since I decided (half a lifetime ago) to pursue a career in science. Coming from a small country town, not everyone thought that "girls did science". I share in the pride that mum and dad display for all of their children, and for that I am grateful.

And finally my eternal gratitude to my husband and best friend, Merrick Kingston. Without Merrick's continual belief in me, and support for my periods of absence from our family home, I would not have been able to complete this journey. I don't think that either of us really knew what we were getting ourselves into to, but I thank Merrick for his patience and exceptional personal qualities. Merrick's perceptiveness always brings reality to my life, and for that I am extremely grateful.

This thesis has been completed in loving memory of Anya.

ABSTRACT

Grape phylloxera (*Daktulosphaira vitifoliae* Fitch, Hemiptera: Phylloxeridae) is a worldwide pest of the viticulture industry due to damage caused to the root system of the European grapevine, *Vitis vinifera* L. (Vitaceae). The main management option for radicicolae grape phylloxera is the use of resistant rootstocks, however due to the success of this management option a range of questions relating to the biology, nutrition and feeding behaviour of the pest insect remain unanswered. This thesis addressed a number of these questions in order to extend the current knowledge of the biological characteristics of grape phylloxera and the possible influences on host-plant responses.

The internal morphology of grape phylloxera was dominated by a large, non-coiled midgut, and developing eggs in adults. The midgut was compartmentalised by an atypical junction with the hindgut. The hindgut extended to the posterior end of the insect, and although an anus was present, no waste excretion was observed in live insects. Parthenogenetic production of relatively large eggs may compress the digestive system, increasing pressure in both the midgut and hindgut chambers. The evolution of the compartmentalised midgut is suggested to permit the storage of food and ensure the continual supply of food to grape phylloxera during periods of egg production and during dispersal to new *Vitis* plants.

Molecular and microbiological evidence showed that radicicolae grape phylloxera has a transient association with an undefined bacteria species. The association appeared to be related to the health of the grapevine root and the insect population, and may influence the variable survival rates of insects observed in laboratory controlled experiments. The bacteria species differed from a bacterial association identified in

gallicolae grape phylloxera, and unlike the endosymbiotic relationship of Aphididae, was not essential.

The development of an artificial feeding system for radicolae grape phylloxera was complicated by the size of the insect, the extended survival of 'control' insects, and a lack of detail regarding the composition of the natural food source. Due to the sedentary feeding behaviour of grape phylloxera, the design of the diet chamber was modified to allow renewal of the artificial diet solution with minimal disturbance to the insect. The survival time of grape phylloxera was significantly extended by two diet formulations, however neither result was reproducible. Insect probing activity was generally stimulated by acidic diet formulations containing sucrose and amino acids, indicating that grape phylloxera were attracted to the artificial feeding system although the diet formulation was not optimised.

Electrical penetration graph (EPG) studies identified that the apterous life stages of radicolae grape phylloxera exhibit differential feeding behaviour on *V. vinifera* root material. The first application of EPG to grape phylloxera research identified 14 waveforms associated with probe penetration and continual feeding activity, with the two most common waveforms anticipated to represent salivation and ingestion. The restrictions of working with a root-feeding insect were overcome by the use of excised root pieces and tissue culture grapevines. Both root systems produced the same EPG waveforms.

The content of this thesis lays the ground work for further research into grape phylloxera host-plant interactions with susceptible and resistant *Vitis* species. The long-term aim of this research is the development of alternative management options for the pest insect, and to ensure the sustainability of resistant rootstocks as the main management option for the viticulture industry.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION.....	1
1 HISTORICAL BACKGROUND	2
1.1 TAXONOMIC CLASSIFICATION.....	2
1.2 GEOGRAPHICAL DISTRIBUTION	4
2 INTERACTIONS OF THE HOST-PLANT MODEL	5
2.1 THE INSECT MODEL – GRAPE PHYLLOXERA	6
2.2 THE PLANT MODEL – GRAPEVINES.....	10
3 GRAPE PHYLLOXERA MANAGEMENT OPTIONS	15
3.1 QUARANTINE MANAGEMENT	15
3.2 CHEMICAL CONTROL	16
3.3 CULTURAL CONTROL.....	16
3.4 BIOLOGICAL CONTROL.....	17
4 GRAPE PHYLLOXERA DIGESTION.....	18
4.1 STRUCTURE OF THE DIGESTIVE SYSTEM.....	18
4.2 ENDOSYMBIONTS	20
5 GRAPE PHYLLOXERA NUTRITIONAL REQUIREMENTS	21
5.1 GRAPEVINE CHEMISTRY	22
5.2 ARTIFICIAL DIET DEVELOPMENT.....	22
6 GRAPE PHYLLOXERA FEEDING BEHAVIOUR	24
6.1 FEEDING LOCATION.....	24
6.2 PROBING ACTIVITY	25
7 OUTLINE OF EXPERIMENTAL RESEARCH	26
8 REFERENCES	28

CHAPTER 2

STRUCTURE OF THE DIGESTIVE SYSTEM OF GRAPE PHYLLOXERA.....	41
1 SUMMARY	42
2 INTRODUCTION.....	43
3 MATERIAL AND METHODS.....	46
3.1 INSECT MATERIAL	46
3.2 OVIPOSITION DURATION	46

3.3	EXTERNAL MORPHOLOGY	47
3.4	INTERNAL MORPHOLOGY	48
3.5	VOLUME CALCULATIONS.....	50
3.6	STATISTICAL ANALYSIS.....	50
4	RESULTS	51
4.1	EXTERNAL MORPHOLOGY	51
4.2	INTERNAL MORPHOLOGY	61
5	DISCUSSION.....	76
5.1	FEEDING SITE LOCATION	77
5.2	WASTE EXCRETION	78
5.3	INSECT DISPERSAL ADAPTATIONS.....	82
5.4	REPRODUCTIVE IMPACTS ON FOOD INTAKE	83
5.5	COMPARISON WITH PREVIOUS RESEARCH	84
6	REFERENCES	86

CHAPTER 3

INVESTIGATING BACTERIAL SYMBIOTIC RELATIONSHIPS IN GRAPE PHYLLOXERA		89
1	SUMMARY	90
2	INTRODUCTION.....	91
3	MATERIAL AND METHODS.....	94
3.1	INSECT MATERIAL	94
3.2	CULTURING OF INTERNAL BACTERIA	95
3.3	DNA EXTRACTION.....	95
3.4	PCR CONDITIONS AND PRIMER COMBINATIONS	96
3.5	CLONING AND SEQUENCING.....	98
4	RESULTS	99
4.1	BACTERIA CULTURE	99
4.2	PCR AMPLIFICATION	101
4.3	BACTERIAL DNA SEQUENCE.....	106
5	DISCUSSION.....	107
5.1	CULTURAL IDENTIFICATION OF GRAPE PHYLLOXERA BACTERIA.....	107
5.2	MOLECULAR IDENTIFICATION OF GRAPE PHYLLOXERA BACTERIA.....	109
5.3	MOLECULAR CONTROLS	111
5.4	IMPACTS OF FEEDING LOCATION.....	111
5.5	COMPARISON WITH PREVIOUS RESEARCH	113
6	REFERENCES	115

CHAPTER 4

DEVELOPMENT OF AN ARTIFICIAL FEEDING SYSTEM FOR GRAPE PHYLLOXERA	119
1 SUMMARY	120
2 INTRODUCTION	121
3 MATERIAL AND METHODS.....	124
3.1 INSECT COLLECTION	124
3.2 ARTIFICIAL DIET CHAMBERS	125
3.3 ARTIFICIAL DIET FORMULATION.....	130
3.4 ARTIFICIAL DIET MONITORING.....	135
3.5 STATISTICAL ANALYSIS.....	136
4 RESULTS	138
4.1 ARTIFICIAL DIET CHAMBER DESIGN.....	138
4.2 ARTIFICIAL DIET SURVIVAL TIME	142
4.3 STYLET INTERACTIONS	159
5 DISCUSSION.....	169
5.1 ARTIFICIAL DIET CHAMBER DESIGN.....	170
5.2 SURVIVAL RATES ON CONTROL DIETS.....	172
5.3 ARTIFICIAL DIET FORMULATION.....	174
5.4 COMPARISON WITH PREVIOUS RESEARCH	177
6 REFERENCES	181

CHAPTER 5

APPLICATION OF ELECTRICAL PENETRATION GRAPH TO GRAPE PHYLLOXERA FEEDING

BEHAVIOUR STUDIES	185
1 SUMMARY	186
2 INTRODUCTION	187
3 MATERIAL AND METHODS.....	190
3.1 INSECT AND PLANT MATERIAL.....	190
3.2 PLANT ELECTRODE AND EPG RECORDING SYSTEMS	191
3.3 INSECT ELECTRODE AND EPG RECORDING POSITIONS	194
3.4 EPG EQUIPMENT	196
3.5 WAVEFORM CHARACTERISATION	196
3.6 WAVEFORM ANALYSIS	199
3.7 WAVEFORM NON-SEQUENTIAL PARAMETERS	201
3.8 WAVEFORM SEQUENTIAL PARAMETERS	203

4	RESULTS	204
4.1	EPG RECORDING SUCCESS RATE	204
4.2	WAVEFORM CHARACTERISATION	207
4.3	CONTINUAL FEEDING RECORDING ANALYSIS	219
4.4	PROBE RECORDING ANALYSIS	229
4.5	TISSUE CULTURE RECORDING ANALYSIS	235
4.6	RESISTANT ROOTSTOCK RECORDING ANALYSIS	237
5	DISCUSSION	241
5.1	GRAPE PHYLLOXERA CONSTRAINTS	241
5.2	INSECT AND PLANT ELECTRODE DESIGN	243
5.3	GRAPE PHYLLOXERA EPG WAVEFORMS	244
5.4	INTERPRETATION OF CONTINUAL FEEDING WAVEFORMS	246
5.5	EVIDENCE FOR FEEDING SITE LOCATION	251
5.6	RESISTANT ROOTSTOCK SCREENING	253
6	REFERENCES	256

CHAPTER 6

	GENERAL CONCLUSIONS AND FUTURE DIRECTIONS	262
1	SUMMARY OF DATA	263
1.1	CHAPTER 2: STRUCTURE OF THE DIGESTIVE SYSTEM OF GRAPE PHYLLOXERA	263
1.2	CHAPTER 3: INVESTIGATING BACTERIAL SYMBIOTIC RELATIONSHIPS IN GRAPE PHYLLOXERA	263
1.3	CHAPTER 4: DEVELOPMENT OF AN ARTIFICIAL FEEDING SYSTEM FOR GRAPE PHYLLOXERA	264
1.4	CHAPTER 5: APPLICATION OF ELECTRICAL PENETRATION GRAPH TO GRAPE PHYLLOXERA FEEDING BEHAVIOUR STUDIES	264
2	IMPLICATIONS OF RESEARCH	267
3	FUTURE DIRECTIONS	271
3.1	GRAPE PHYLLOXERA BIOLOGY	271
3.2	GRAPE PHYLLOXERA NUTRITIONAL REQUIREMENTS	272
3.3	GRAPE PHYLLOXERA FEEDING BEHAVIOUR	274
4	GENERAL CONCLUSION	278
5	REFERENCES	279

LIST OF FIGURES

CHAPTER 1

INTRODUCTION.....	1
FIGURE 1. RADICICOLAE GRAPE PHYLLOXERA FEEDING SITE	3
FIGURE 2. HOLOCYCLIC LIFE CYCLE OF GRAPE PHYLLOXERA.....	8

CHAPTER 2

STRUCTURE OF THE DIGESTIVE SYSTEM OF GRAPE PHYLLOXERA.....	41
FIGURE 1. COMPARISON OF SEM PREPARATION TECHNIQUES	53
FIGURE 2. GRAPE PHYLLOXERA LIFE STAGES - SEM	57
FIGURE 3. POSTERIOR OPENING - SEM.....	59
FIGURE 4. ANTENNAE SENSORY PIT - SEM	59
FIGURE 5. FOURTH INSTAR INTERNAL MORPHOLOGY - LIGHT MICROSCOPY	62
FIGURE 6. ADULT INTERNAL MORPHOLOGY - LIGHT MICROSCOPY	65
FIGURE 7. ADULT INTERNAL MORPHOLOGY - LIGHT MICROSCOPY	66
FIGURE 8. ADULT INTERNAL MORPHOLOGY - SEM.....	69
FIGURE 9. ADULT INTERNAL MORPHOLOGY - SEM.....	70
FIGURE 10. FOURTH INSTAR INTERNAL MORPHOLOGY - SEM.....	71
FIGURE 11. GRAPE PHYLLOXERA DIGESTIVE AND REPRODUCTIVE FEATURES.....	75

CHAPTER 3

INVESTIGATING BACTERIAL SYMBIOTIC RELATIONSHIPS IN GRAPE PHYLLOXERA	89
FIGURE 1. MORPHOLOGY OF BACTERIA COLONY	100
FIGURE 2. GRAM-STAIN OF BACTERIA CELLS	100
FIGURE 3. PCR WITH SSU rDNA PRIMERS.....	103
FIGURE 4. PCR WITH 16S rDNA PRIMERS.....	104
FIGURE 5. PCR WITH PANTOEAE PRIMERS	105
FIGURE 6. DNA SEQUENCE OF BACTERIA ISOLATED FROM GRAPE PHYLLOXERA	106

CHAPTER 4

DEVELOPMENT OF AN ARTIFICIAL FEEDING SYSTEM FOR GRAPE PHYLLOXERA	119
FIGURE 1. ARTIFICIAL DIET CHAMBER DESIGNS	127
FIGURE 2. HUMIDITY ARTIFICIAL DIET CHAMBER	129
FIGURE 3. CONDENSED DROPLETS OF WATER ON THE DIET MEMBRANE	141
FIGURE 4. SURVIVAL ANALYSIS PLOT - DIET EXPERIMENT 4	150
FIGURE 5. SURVIVAL ANALYSIS PLOT - DIET EXPERIMENT 12	154
FIGURE 6. PROBING ACTIVITY - DIET EXPERIMENT 12	167
FIGURE 7. DIET SOLUTION CRYSTALLISATION	168

CHAPTER 5

APPLICATION OF ELECTRICAL PENETRATION GRAPH TO GRAPE PHYLLOXERA FEEDING

BEHAVIOUR STUDIES	185
FIGURE 1. DIAGRAM OF EPG SYSTEM	192
FIGURE 2. GRAPE PHYLLOXERA PLANT ELECTRODE	193
FIGURE 3. GRAPE PHYLLOXERA INSECT ELECTRODE	195
FIGURE 4. GRAPE PHYLLOXERA EPG SYSTEM	197
FIGURE 5. WAVEFORM CHARACTERISATION.....	198
FIGURE 6. GRAPE PHYLLOXERA CONTINUAL FEEDING WAVEFORMS.....	209
FIGURE 7. GRAPE PHYLLOXERA CONTINUAL FEEDING WAVEFORMS.....	210
FIGURE 8. GRAPE PHYLLOXERA PROBE WAVEFORMS.....	215
FIGURE 9A. FIRST INSTAR WAVEFORM DISTRIBUTION ON <i>V. VINIFERA</i>	222
FIGURE 9B. INTERMEDIATE INSTAR WAVEFORM DISTRIBUTION ON <i>V. VINIFERA</i>	223
FIGURE 9C. ADULT WAVEFORM DISTRIBUTION ON <i>V. VINIFERA</i>	224
FIGURE 10A. FIRST INSTAR 'CORRECTED' WAVEFORM DISTRIBUTION	226
FIGURE 10B. INTERMEDIATE INSTAR 'CORRECTED' WAVEFORM DISTRIBUTION	227
FIGURE 10C. ADULT 'CORRECTED' WAVEFORM DISTRIBUTION	228
FIGURE 11. PROBE WAVEFORM DISTRIBUTION ON <i>V. VINIFERA</i>.....	232
FIGURE 12. GRAPE PHYLLOXERA PENETRATION PATTERN	234
FIGURE 13. WAVEFORM DISTRIBUTION ON <i>V. VINIFERA</i> TISSUE CULTURE	235
FIGURE 14. WAVEFORM DISTRIBUTION ON RESISTANT ROOTSTOCKS	239
FIGURE 15. RESISTANT ROOSTOCK EPG PATTERNS	240

LIST OF TABLES

CHAPTER 1

INTRODUCTION.....	1
TABLE 1. GRAPE PHYLLOXERA ROOTSTOCK RESISTANCE RATINGS	14

CHAPTER 2

STRUCTURE OF THE DIGESTIVE SYSTEM OF GRAPE PHYLLOXERA.....	41
TABLE 1. EXTERNAL BODY MEASUREMENTS - LIGHT MICROSCOPY	52
TABLE 2. EXTERNAL BODY MEASUREMENTS - SEM.....	55
TABLE 3. EXTERNAL BODY DIMENSION AND VOLUME CALCULATIONS - SEM.....	60
TABLE 4. INTERNAL BODY DIMENSIONS - LIGHT MICROSCOPY.....	72
TABLE 5. INTERNAL BODY DIMENSIONS AND VOLUME CALCULATIONS - SEM.....	73
TABLE 6. INTERNAL BODY VOLUME CALCULATIONS - LIGHT MICROSCOPY	74

CHAPTER 3

INVESTIGATING BACTERIAL SYMBIOTIC RELATIONSHIPS IN GRAPE PHYLLOXERA	89
TABLE 1. SUMMARY OF PCR AMPLIFICATION RESULTS.....	102

CHAPTER 4

DEVELOPMENT OF AN ARTIFICIAL FEEDING SYSTEM FOR GRAPE PHYLLOXERA	119
TABLE 1. ARTIFICIAL DIET FORMULATIONS	131
TABLE 2. ARTIFICIAL DIET SURVIVAL RATE - FILTER PAPER CHAMBER	143
TABLE 3. ARTIFICIAL DIET SURVIVAL RATE - HUMIDITY CHAMBER.....	145
TABLE 4. SURVIVAL ANALYSIS - DIET EXPERIMENT 4	149
TABLE 5. GRAPEVINE PH VALUES	152
TABLE 6. SURVIVAL ANALYSIS - DIET EXPERIMENT 12	155
TABLE 7. PROBING ACTIVITY - FILTER PAPER CHAMBER	160
TABLE 8. PROBING ACTIVITY - HUMIDITY CHAMBER	162

CHAPTER 5

APPLICATION OF ELECTRICAL PENETRATION GRAPH TO GRAPE PHYLLOXERA FEEDING

BEHAVIOUR STUDIES	185
TABLE 1. GRAPE PHYLLOXERA EPG SUCCESS RATE.....	205
TABLE 2. EXCISED ROOT - ACTIVE FEEDING POSITION SUCCESS RATE	206
TABLE 3. GRAPE PHYLLOXERA CONTINUAL FEEDING WAVEFORMS	211
TABLE 4. GRAPE PHYLLOXERA PROBE WAVEFORMS	213
TABLE 5. WAVEFORM INCIDENCE	217
TABLE 6. LIFE STAGE WAVEFORM ANALYSIS ON <i>V. VINIFERA</i>	220
TABLE 7. PROBE WAVEFORM ANALYSIS ON <i>V. VINIFERA</i>	230
TABLE 8. SEQUENTIAL PARAMETER ANALYSIS ON <i>V. VINIFERA</i>	233
TABLE 9. WAVEFORM ANALYSIS ON <i>V. VINIFERA</i> TISSUE CULTURE.....	236
TABLE 10. WAVEFORM ANALYSIS ON RESISTANT ROOTSTOCKS.....	238