Sustainable protection of grapevines from garden weevil





FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

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Contents

	Page
Abstract	1
Executive Summary	2
Background	3
Project Aims and Performance Targets	5
Objective 1: Develop standardised assessment protocols for in-field demonstrations of comparative garden weevil management aspects.	8
Objective 2 – Establish and implement a framework for reporting results of garden weevil related research and demonstration activities to the Australian viticulture industry.	9
Objective 3 – Develop and test economic action thresholds for garden weevil infestation in winegrapes.	11
Objective 4 - Assess the potential to explain the variability in garden weevil distribution within vineyards based on spatial environmental data.	15
Objective 5 - Assess new methods of physical exclusion carriers and inert surface coatings e.g. kaolinite clay products to reduce garden weevil damage.	20
Objective 6: Produce an Integrated Pest Management (IPM) package to control garden weevil in grapevines.	35
Outcome/Conclusion	
Recommendations	
Appendix 1: Communication	
Appendix 2: Intellectual Property	
Appendix 3: References	
Appendix 4: Staff	
Appendix 5: Raw data/miscellaneous attachments	
Appendix 6: Budget reconciliation	

1. Abstract

This project investigated a number of aspects in relation to the sustainable management of garden weevil in grapevines.

The project developed a program for vignerons to assess any new management aspects they consider could reduce weevil damage. A web site was established at the Department of Agriculture and Food Western Australia (DAFWA) internet address whereby aspects of garden weevil could be posted. A prototype canopy damage scoring system was developed to help vignerons quantify the abundance of garden weevil through feeding effects. This system was examined for rigor and while it had advantages over earlier monitoring methods, had some limitations.

Vineyards infested with garden weevil were selected as sites to test a range of “soft” options for management. Variable results were obtained when assessing the effect of kaolin clay on reducing weevil damage. Artificial fibre bands suppressed weevil damage rather than giving a consistent, high degree of control. Their effectiveness as a barrier was improved when sprayed with chilli. A grease developed in South Africa gave good exclusion of weevils from the vine canopy, but problems with application would limit its adoption. Repellent sticky trunk bands were the most effective exclusion agent, but are time consuming to apply.

The results of these studies and other investigations were used to produce an outline of an Integrated Pest Management package for managing garden weevil in grapevines.

Areas considered worthy of further study are recommended.

2. Executive Summary

Garden weevil is one of the key insect pests of grapevines in Western Australian vineyards. It is also a pest of concern in some winegrape areas of Tasmania, South Australia and Victoria. Insecticides have been relied upon for protecting vines from garden weevil. The products available have limitations in terms of their selectivity and time of application to avoid residues in wine. This project investigated a number of aspects in relation to the sustainable management of garden weevil in grapevines to reduce the reliance on insecticides for control.

The project developed a set of recommended steps that vignerons could use to assess any new management aspects they considered could reduce populations of garden weevils.

A web site was established at the Department of Agriculture and Food Western Australia (DAFWA) internet address whereby aspects of garden weevil could be posted for public access.

A prototype canopy damage scoring system was developed to help vignerons quantify the abundance of garden weevil through feeding effects. This system was examined further to determine whether it could be used to define an economic injury level for vignerons to decide whether intervention was justified to prevent vines suffering economic loss. Results obtained showed that the system was of limited value in some situations because yield level was not always related to the damage score. However the system was considered to be an improvement compared to the previous trunk band based monitoring system in being more flexible and less time consuming to allow monitoring across a vineyard. It also meant it was more likely that hot spots of weevil infestation would be identified.

Vineyards infested with garden weevil were selected as sites to test a range of “soft” options that would have minimal adverse effects in vineyards. A major part was assessing the effect of kaolin clay on reducing damage caused by garden weevil. Variable results were obtained and the use of this material is recommended for larger scale investigations by vignerons where weevil numbers are moderate rather than high, until the material can be used with more confidence. Artificial fibre bands, both bonded and unbonded suppressed weevil damage rather than giving a high degree of control. From a laboratory study it was found that their effect could be enhanced when sprayed with a chilli compound that is available commercially. A grease developed in South Africa as a weevil barrier resulted in exclusion of weevils from entering the vine canopy, but problems were experienced with maintaining a complete band because of the substrate used to which the material was applied. As found in previous studies, sticky trunk bands based on polybutane were the most effective exclusion agent, but are time consuming to apply.

The results of these studies were used in conjunction with information from earlier work in WA and at other locations where garden weevil occurs, to produce an outline of an Integrated Pest Management package for managing garden weevil in grapevines.

Areas considered worthy of further study on garden weevil management are recommended.

This project would not have been possible without the co-operation of many people associated with the vineyards where field studies were conducted, including the Swan Valley, Margaret River, Manjimup/Pemberton, Frankland and Porongorups. We thank them.

We would like to express our sincere appreciation for the financial support for this research project provided by the Grape and Wine Research Development Corporation and the Australian Government, Curtin University of Technology and the Department of Agriculture and Food, Western Australia.

3. Background

Garden weevil (*Phlyctinus callosus*) is indigenous to South Africa. Garden weevil was accidentally introduced into Australia more than 50 years ago. In South Africa it is considered an economic pest to apples, nectarines and table grapes and is becoming an increasingly serious global phytosanitary pest in export fruit consignments as a result of its pest status.

In 2004 priority setting meetings in Western Australia, garden weevil was consistently rated as the highest priority tactical issue for viticultural research. It has been an important pest in WA vineyards for around 30 years. It is also a significant pest in some areas of South Australia, Victoria and Tasmania. Feeding by adults can kill newly planted vines, reduce yield in mature vines by up to 70% and increase propensity for secondary pest infestations and disease infection such as botrytis. Also, they can have long term effects on vine structure and bud development. The larval stage of garden weevil also has been implicated in adversely affecting the vigour and health of newly planted grapevines. This has been evident where the insect has built up in numbers due to the occurrence of favourable alternative food plants (weeds) in the previous land use such as pasture.

Broad-spectrum insecticides are available as trunk drench or foliar sprays. These give temporary protection but at the cost of potential for build up of secondary pests, most notably longtailed mealybug. Mealybug infestations from vines treated for garden weevils have resulted in rejection of winegrapes. Monitoring guidelines for strategic use of insecticide to control garden weevil have been developed for vignerons. The emphasis on insecticide use has been to apply a butt drench in an attempt to lessen the possible undesirable side effects of canopy spraying.

Management of garden weevils is primarily through the application of insecticide either to the vine trunk or canopy (Fisher and Learmonth, 2009). Synthetic pyrethroid insecticides are available under both a minor use permit for this. This group of insecticides has been implicated in outbreaks of secondary pests, most notably mealybugs and the sooty mould their feeding is associated with can lead to the downgrading or rejection of fruit. More recently, the insecticide Avatar (indoxacarb) which is from a different activity group, the oxadiazines, has been registered. This insecticide is not as broad spectrum as the synthetic pyrethroid group and has a shorter withholding period which allows more flexibility in its use.

A range of cultural and physical control methods are available to either control weevils or help to reduce weevil abundance (Fisher and Learmonth, 2003). Recommendations for softer approaches have been made to industry and include: removing favourable alternative plants such as some broadleaf weeds on the vineyard floor, retain water shoots as diversionary feeding and monitoring sites during the spring emergence period, introduce predatory birds such as guinea fowl and chickens, timely interrow cultivation to kill garden weevil pupae and use of trunk barriers such as sticky bands and material bands to exclude weevils from entering the vine canopy. Despite the availability of these recommendations, not all of which are commercially viable in larger vineyards, garden weevil continues to be a major problem in Western Australia and an emerging problem in some areas of other states. Management protocols remain contentious among vignerons with a wide variety of ‘best guess’ treatments. Clearly there is the need to either develop additional management regimes and/or further extend the current systems to foster grower adoption.

Garden Weevil workshop and review

In August 2005 a workshop and review were conducted (separately funded) to summarise the existing data from Department of Agriculture and Food Western Australia trials and the national and international knowledge base related to garden weevil control.

The review and workshop engaged local and international authorities and local producers to formulate a research and development plan. Project areas were given a rating in a workshop format and then prioritised by the expert (visiting and local) panel.The research priorities could be readily divided into three main areas:

A) Priorities that related to overriding issues:
   Development of a standard method of assessment of weevil populations and weevil damage;
   Development of a reporting and extension system;
   Determination of the economic costs of garden weevil to the wine industry.
B) Priorities that relate to determination of pest pressure:
   Role of ground covers;
   Potential for biocontrol;
   Pest genetics;
   Phenomenon of population autodecline;
   Pheromones.
C) Priorities that relate to managing the impact of garden weevil on production:
   Exclusion (physical and chemical);
   In-canopy control (chemical and non-chemical);
   Secondary infections (interaction between garden weevil and *Botrytis* infection).

In addition to the three main areas of research the workshop also identified the need to fill in strategic gaps in knowledge of the biology and life cycle of garden weevil, and develop a predictive model and a greater understanding of the environmental factors which influence weevil emergence to facilitate the development of more targeted management controls.

The review of literature on garden weevil was reported by Michael (2005) and a report on a seminar that reviewed the garden weevil issue and considered future research directions prior to the commencement of the current project was presented by Gibberd & Learmonth (eds.) (2005).

Project aims and performance targets.

Planned project outputs

There were a total of eight research objectives listed in the original project submission to meet in this research:

- Objective 1 – Develop standardised assessment protocols for in-field demonstrations of comparative garden weevil management aspects.
- Objective 2 – Establish and implement a framework for reporting results of garden weevil related research and demonstration activities to the Australian viticulture industry.
- Objective 3 – Develop and test economic action thresholds for garden weevil infestation in winegrapes.
- Objective 4 – Determine the relationship between garden weevil abundance and ground cover species composition in vineyards.
- Objective 5 – Assess new methods of physical exclusion carriers for garden weevil.
- Objective 6 – Assess the potential to utilise environmental and spatial data to predict the timing and pattern of emergence of adult garden weevil.
- Objective 7 - Assess the potential of inert surface coatings (e.g. kaolinite clay products) to reduce garden weevil damage.
- Objective 8 – Collate results from this project and other sources to produce an IPM package for garden weevil management in vineyards.

Objectives 4 and 6 were considered sufficiently similar to merge to from one objective:

- Objective 4 - Assess the potential to explain the variability in garden weevil distribution within vineyards based on spatial environmental data.

Objectives 5 and 7 also were considered to be sufficiently similar to merge to form one objective:

- Objective 5 - Assess new methods of physical exclusion carriers and inert surface coatings (e.g. kaolinite clay products) to reduce garden weevil damage.

With these revisions, the initial number of objectives has been reduced by two and the numbers of the last two objectives changed accordingly.

Outputs and Performance Targets 2005-06

Outputs	Performance Targets
1. Standardised protocols for assessment of garden weevil damage	Protocols developed and distributed to researchers and made available to industry by 1 January 2006
2. Model to predict weevil emergence and spatial variation.	Initial data set on weather and weevil abundance parameters collected and reviewed by June 2006.
3. Economic action thresholds for garden weevil damage	Set up and complete preliminary field experiments and surveys on garden weevil thresholds and management by June 2006.
4. Framework for reporting results of garden weevil research and demonstration activities	Weevil Watch website set up and functional by 1 January 2006
5. Assessment of inert surface coatings and alternative physical barriers	Initial assessment of Kaolinite clay products and alternative physical barriers for the reduction of garden weevil impact completed by 30 June 2006
6. Extension of research outcomes	Seminar to industry on outcomes of Garden weevil review complete by 1 January 2006.
7. Determination of the impact of cover crops on garden weevil density.	Initial survey and commence field trial on impact of ground covers on garden weevil density.

Outputs and Performance Targets 2006-07

Outputs	Performance Targets
1. Standardised protocols for assessment of garden weevil damage	Testing of standard protocols by researchers and revisions to protocols complete by 1 January 2007
2. Model to predict weevil emergence and spatial variation	Second set on weather and weevil abundance parameters collected and reviewed by June 2007. First year's data on spatial variation of garden weevil emergence collated by June 2007
3. Economic action thresholds for garden weevil damage	Complete field experiments and test economic threshholds for garden weevil management by June 2007.
4. Framework for reporting results of garden weevil research and demonstration activities	Weevil Watch website maintained and updated bimonthly.
5. Assessment of inert surface coatings and alternative physical barriers	Commercial field trials of kaolinite clay products and alternative physical barriers for the reduction of garden weevil impact completed by 30 June 2007
6. Determination of the impact of cover crops on garden weevil density.	Complete first trial on cover crops; review and incorporate in second trial. Field surveys relating garden weevil population density with cover crop species distribution completed by 30 June, 2007

Outputs and Performance Targets 2007-08

Outputs	Performance Targets
1. Model to predict weevil emergence and spatial variation	Model of the influence of environmental parameters on weevil abundance emergence validated under field conditions by June 2008. Second year's data on spatial variation of garden weevil emergence collected and analysed by GIS by June 2008
2. Economic action thresholds for garden weevil damage	Complete second year of field experiments to test economic thresholds for garden weevil management by June 2008.
3. Framework for reporting results of garden weevil research and demonstration activities	Weevil Watch website maintained and updated bimonthly.
4. Assessment of inert surface coatings and alternative physical barriers	Commercial field trials for the demonstration of kaolinite clay products and alternative physical barriers for the reduction of garden weevil impact completed by 30 June 2008
5. Determination of the impact of cover crops on garden weevil density.	Recommendations for cover crop species for weevil completed – definition of weevil-prone areas formulated by 30 June, 2008
6. Produce an IPM package for garden weevil	Collate information from this project and other sources into an IPM package for garden weevil management in vineyards
7. Final report	Final report presented to GWRDC by 30 September 2008

Extensions on the project were granted with the Final Report due in September 2011.

Objective 1: Develop standardised assessment protocols for in-field demonstrations of comparative garden weevil management aspects.

Introduction

Vignerons manage their winegrapes with individualism and the way pests are managed is no exception. The diversity in approaches can be summarised to some extent by the broad classifications of organic pest management and conventional pest management. Within each of these groups, theories abound as to how garden weevil may be managed to minimise its impact on vine health and yield.

The objective of this aspect of the current project was to describe practical guidelines that vignerons could access as a basis for assessing new techniques for managing garden weevil within the constraints of commercial operation.

Methodology

Guidelines that could form the basis to allow objective comparison of new techniques for managing garden weevil, or other pests, were produced based on sound experimental technique (see Appendix 5 for details). These guidelines were posted on the DAFWA web site at http://www.agric.wa.gov.au/PC_92726.html and vignerons of WA were advised of this through the DAFWA industry magazine *Wine Industry Newsletter*. This information was first placed on the website on 31 May 2007 and is due for revision.

Results

To date, there has been no feedback from industry on the use or therefore value of this information.

Conclusion

The value of the garden weevil web site will be maintained through regular updates. This website forms part of the DAFWA project - Premium Wine Production.

Objective 2 – Establish and implement a framework for reporting results of garden weevil related research and demonstration activities to the Australian viticulture industry.

Introduction

Garden weevil is an important pest of the Western Australian wine industry. This insect is also an important pest in winegrapes of other states especially South Australia, Victoria and Tasmania. The insect is also a pest of table grapes, mainly in Western Australia. Therefore, any new information related to improved pest control of garden weevil is of interest to grapevine growers across southern Australia. Garden weevil is a pest of other horticultural crops such as deciduous tree fruit, strawberries, potatoes and floriculture. It can also be a pest in the home garden.

To enable ready access to results from this project and associated publications, information is posted on the DAFWA website - http://www.agric.wa.gov.au/. Such information is an adjunct to other means of disseminating results, but forms the basis for ease of access both to updating information by researchers and industry personnel, and disseminating such information to industry and other researchers and interested parties.

Methodology

In the early years of the current project, an initiative to assist vignerons achieve timely control of garden weevil and coined ***GARDEN WEEVIL watch*** was undertaken and results posted on the DAFWA website. This service was based on vignerons across the garden weevil susceptible part of WA volunteering to receive weevil trunk monitoring bands and reporting weevil abundance and any management actions undertaken. An example of the information and advice given is displayed in Appendix 1 for **Issue No. 6, 17** November 2006. This service was discontinued in the 2007/08 season.

Other information was posted on the web site as it came to hand.

Results

There has been no record kept of “hits” on the DAFWA garden weevil web site to quantitatively gauge its success or frequency of use by interested parties.

The usefulness of ***GARDEN WEEVIL watch*** declined over time for a number of reasons outlined below. In its early years it helped industry in WA to focus on the need to time application of insecticide for best effect – this was particularly relevant for the application of trunk drenches which need to be applied in the early stages of weevil emergence. This timing was achieved by vignerons examining their own pest abundance information and also by checking their situation with vignerons in the same and other districts.

Conclusion

The DAFWA web site has been a useful repository for information on garden weevil given the high percentage of vignerons that have access to web based information. The challenge for web based information is to maintain the relevance of the website through regular review of the information posted including the approaches for pest management.

For garden weevil, this was seen in the move away from recommending industry use trunk bands to assess garden weevil numbers as the basis for deciding on whether and when management practices need to be applied. This was the case for ***GARDEN WEEVIL watch*** (Learmonth 2011). The aim of this service was to assist vignerons time their insecticide application to control garden weevil. The use of the trunk bands was seen as time consuming and a constraint to the effective monitoring of commercial vineyards, especially the larger vineyards. This approach is gradually being replaced by a system of scoring canopy feeding by garden weevil adults. This approach suits the more recent

registration of indoxacarb insecticide for control of garden weevil adults.(Avatar). Because this insecticide has a withholding period later in the season than other available insecticides, vignerons are able to implement a canopy damage score system as the basis for deciding on the need for action against garden weevil. Also, they able to more accurately pinpoint those parts of the vineyard and even within vineyard blocks where action is required.

The garden weevil web site information will be reviewed on a regular basis to be a site where industry can browse in the knowledge that the information is current and relevant.

Objective 3 – Develop and test economic action thresholds for garden weevil infestation in winegrapes.

Introduction

One of the high priority recommendations of the review of literature on garden weevil by Michael (2005) was to determine losses caused by garden weevil and an economic injury level (EIL). The basis for this recommendation was the paucity of data on losses caused by garden weevil in grapevines. Garden weevil adults are present in large numbers at times where damage to the structure and yield potential of vines is unquestioned. But there are many other instances where the range in timing of occurrence of phenological stages through varietal variation and season conditions superimposed on variations in weevil numbers both temporally and spatially that have not been taken into account when making decisions on the need to take action against this insect.

The most assured means of protecting vines form damage by garden weevil is the use of synthetic insecticides. Issues relating to outbreak of secondary pests and fear of developing insecticide resistance through the over reliance on the insecticide approach for pest control give weight to the need for ensuring that insecticides are only used where the adverse economic impact of the pest is likely. Such information on pest abundance and crop damage has only been available for trial areas where high pest numbers have been required.

Studies were undertaken to gather information that would assist vignerons justify decisions on the need to use insecticide based on the abundance of garden weevil adults and/or their feeding effects.

Methodology

To develop a decision tree for garden weevil management, information is required on vine stage, weevil abundance or damage level and resultant yield loss for a given scenario of a combination of these parameters. Descriptions of the stages of vines is widely accepted as those provided by Coombe (1995). After a number of systems for scoring vine damage by garden weevil were considered, the system summarised in Table 3.1 was adopted.

Table 3.1. Garden Weevil Damage Scoring System in Grapevines

VINE PART	STAGE	E-L NUMBER	DAMAGE DESCRIPTION	DAMAGE SCORE	ACTION
Bud	1st leaf separated from shoot tip	7 to 9	No Damage	B0	none
			< 5% buds chewed/killed	B1	none
			> 5% buds chewed/killed	B2	Trunk/foliar
Canopy	4 leaves separated	10 to 31	No damage - but signs of weevil feeding could be present at a low level.	0	None
	Inflorescence developing		Minor - leaf damage easily seen, no apparent bunch damage.	1	None/trunk
	80% capfall		Obvious - leaf damage obvious and **low** level of bunch damage.	2	Trunk/foliar
	Berries up to pea size (7 mm diam)		High - leaf damage obvious and **high** level of bunch damage.	3	foliar
	Note: EL 31 = for spray	stage limit options	Severe - heavy leaf and bunch damage.	4	foliar
Water shoot	Any stage of canopy development up to berries pea size	Up to 31	No damage - but signs of weevil feeding could be present at a low level.	W0	none
			Minor – obvious but low level scalloping	W1	None/trunk
			Major – Severe scalloping	W2	trunk/foliar

This scoring system was applied within commercial vineyards where hand harvest were undertaken to examine different levels of weevil damage scores and associated damage.

(a) Replicated small plot trials 2005/06 and 2009/10

Replicated small scale field trials consisting of the same a range of garden weevil control treatments were undertaken in blocks of Chardonnay grapevines in two vineyards in the Pemberton region in 2005/06. In these trials, six treatments including a second untreated treatment were compared, the other treatments being: polybutene sticky trunk band; pyrethrum trunk drench applied twice; Dominex trunk drench and Avatar foliar spray applied once each (see Table 5.1 for details) using a Hardi back pack. Treatment plots consisted of one panel (four vines) and two half panels at either end – the half panels acting as buffers to the adjacent treatment along the vine row. There were six replications for the two trials in 2005/06. The sticky trunk bands were applied before the commencement of weevil emergence. When the start of weevil emergence was indicated by weevil numbers in the monitoring bands, the trunk drenches were applied. The Avatar foliar spray was applied after weevil emergence was underway.

In 2009/10, two series of twelve paired plots in two nearby blocks of Chardonnay grapes in the same vineyard were either untreated or sprayed with Avatar using the vigneron's commercial air blast machine.

The abundance of garden weevil adults was monitored using a cardboard trunk band placed just below the crown of the vines and above any exclusion treatment. As well as monitoring numbers of adult weevils, canopy feeding damage was scored as per Table 3.1 and yields assessed by hand harvests.

(b) Comparisons of yield and garden weevil treatments across a number of locations

Yield data gathered at a number of locations across south western Western Australia comparing various garden weevil treatments and untreated areas during this project were collated to quantify and clarify its pest status. This data was obtained from plot hand harvests.

Results

Data obtained form these experiments were analysed with ANOVA. In the following figures, bars represent $LSD_{0.05}$ for each sampling occasion and where significant differences among means of treatments were obtained, the level is represented as *** = $P<0.001$; ** = $P<0.01$; and * = $P<0.05$; ns = no significant difference found.

(a) Replicated small plot trials 2005/06 and 2009/10

The abundance of garden weevil adults (square root transformed), canopy feed score and yield for the two 2005/06 trials are given in Figs. 3.1 a, b, c and Figs. 3.2 a, b, c respectively.

In the first trial, weevil numbers were not significantly different for the two untreated treatments and the pyrethrum trunk drench treatment for most of the trial duration. Numbers of garden weevil adults were reduced significantly for the sticky band and Dominex trunk treatments and the foliar application of Avatar. These effects were similar with respect to garden weevil canopy feed score. There was reasonable variation in yield within treatments which may explain the unexpected result that there was no significant difference among treatments for yield.

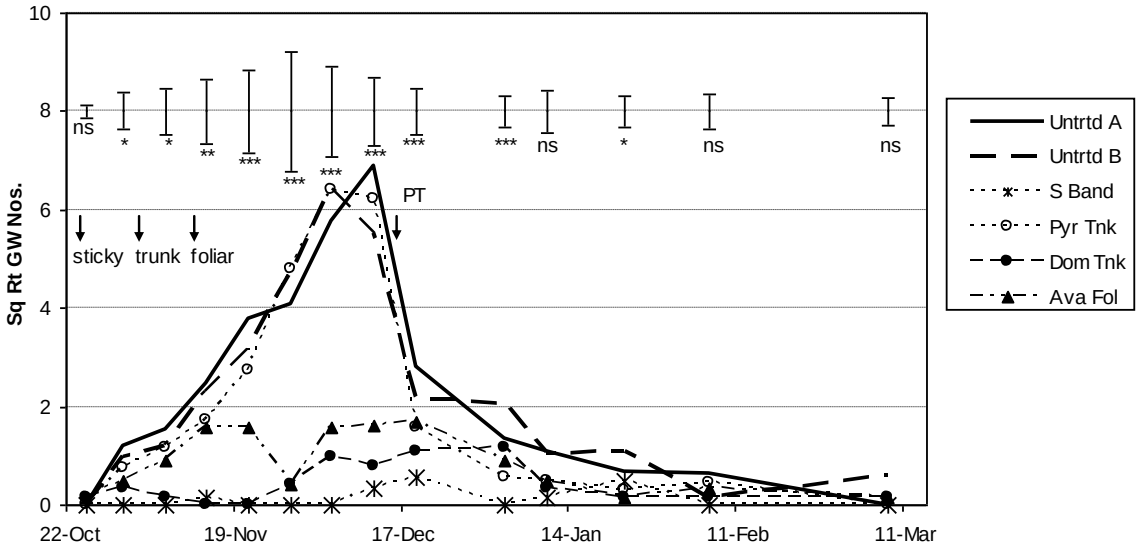


Fig. 3.1a. Average number of garden weevil adults in monitoring bands on two series of untreated vines or with either exclusion barriers: S Band = polybutane trunk band, DOM Tnk = Dominex insecticide trunk drench, Pyr Tnk = natural pyrethrum + piperonyl butoxide trunk drench; or foliar application of Avatar (Ava Fol) in the 2005/06 season – first trial, Pemberton, WA.

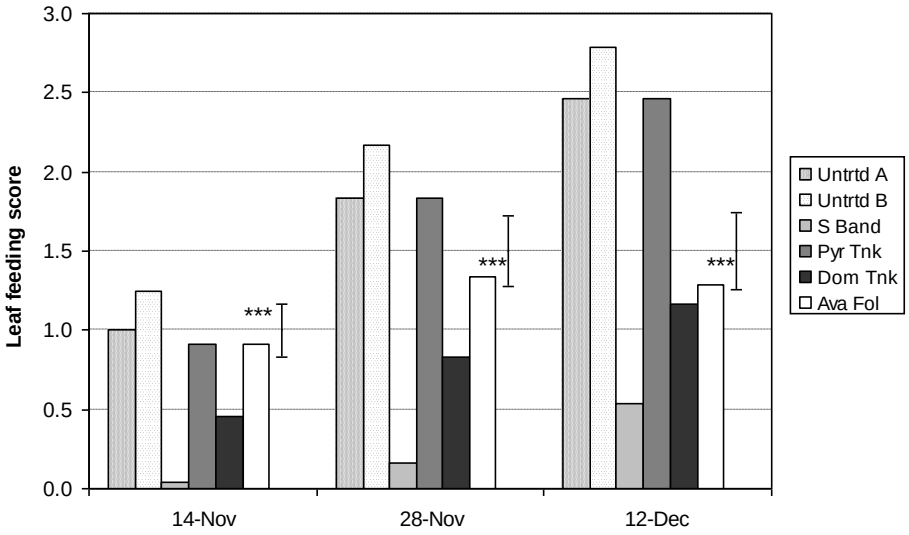


Fig. 3.1b. Canopy damage rating for treatments described in Fig. 3.1a.

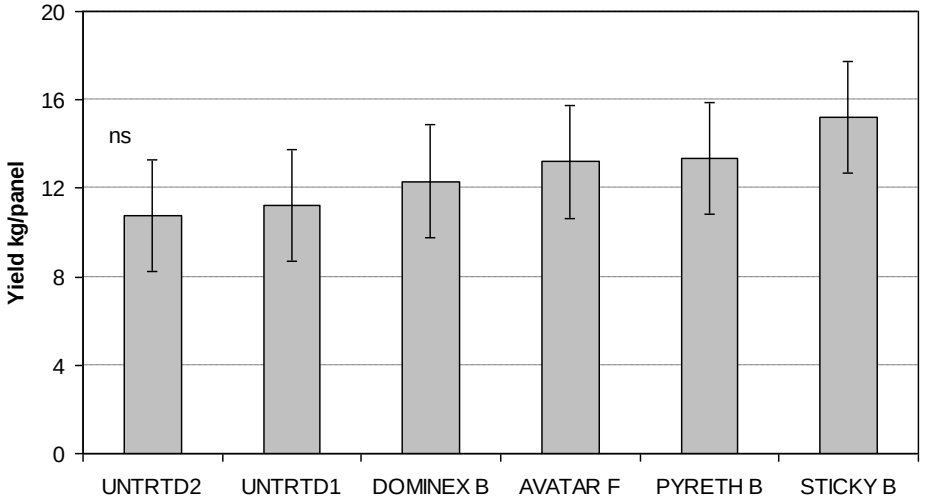


Fig. 3.1c. Yield of vines for treatments described in Fig. 3.1a.

In the second trial during 2005/06 involving the same treatments, the abundance of garden weevil adults (square root transformed), canopy feed score and yield are given in Figs. 3.2 a, b, c respectively.

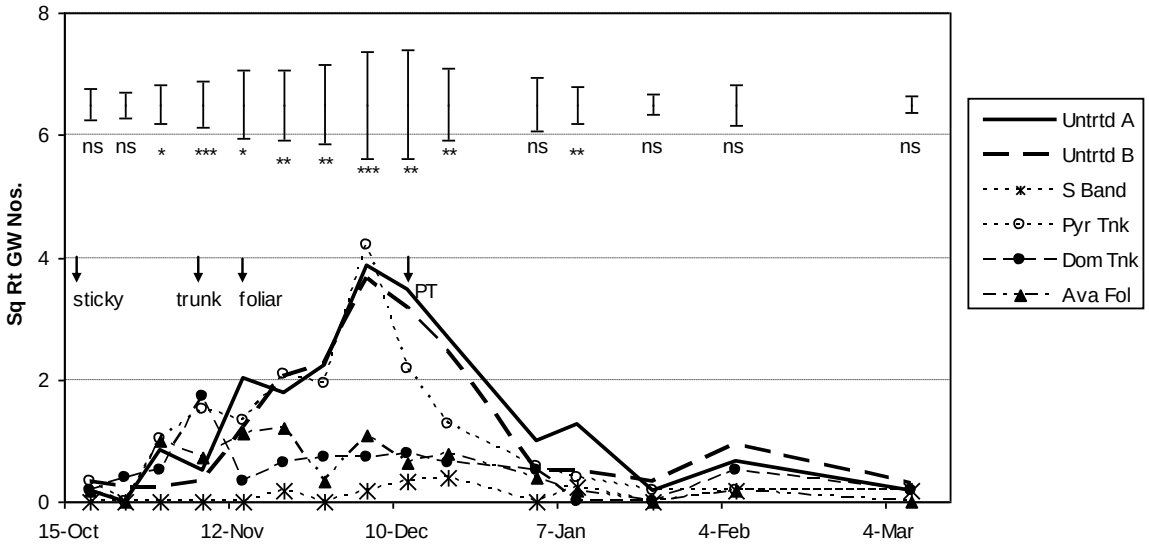


Fig. 3.2a. Average number of garden weevil adults in monitoring bands on two series of untreated vines or with either exclusion barriers: S Band = polybutane trunk band, DOM Tnk = Dominex insecticide trunk drench, Pyr Tnk = natural pyrethrum + piperonyl butoxide trunk drench; or foliar application of Avatar (Ava Fol) in the 2005/06 season – second trial, Pemberton, WA.

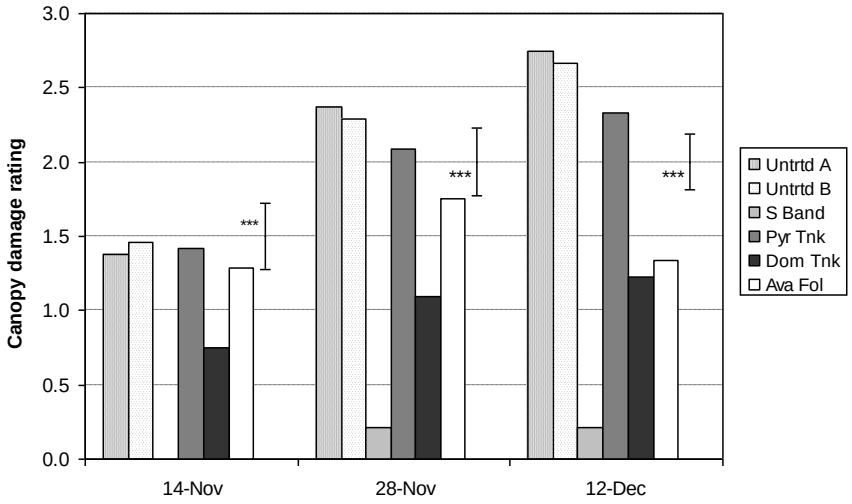


Fig. 3.2b. Canopy damage rating for treatments described in Fig. 3.2a.

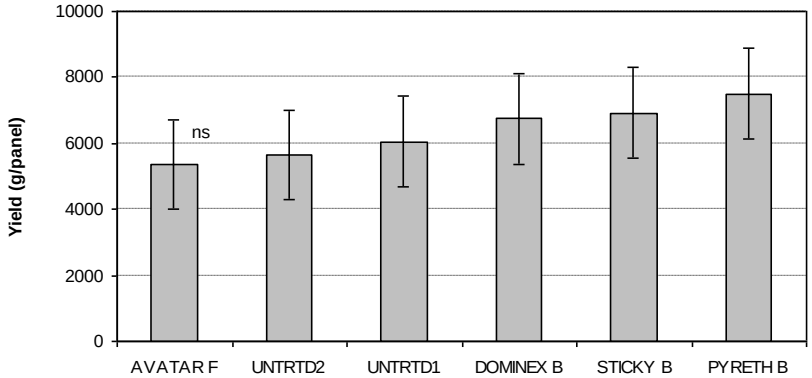


Fig. 3.2c. Yield of vines for treatments described in Fig. 3.2a.

Results in this trial were very similar to those obtained from the first trial discussed above, though weevil abundance was lower in the second trial (Figs. 3.2 a, b, c).

The abundance of garden weevil adults (square root transformed), canopy feed score and yield for the two 2009/10 trials are given in Figs. 3.3 a, b, c and Figs. 3.4 a, b respectively.

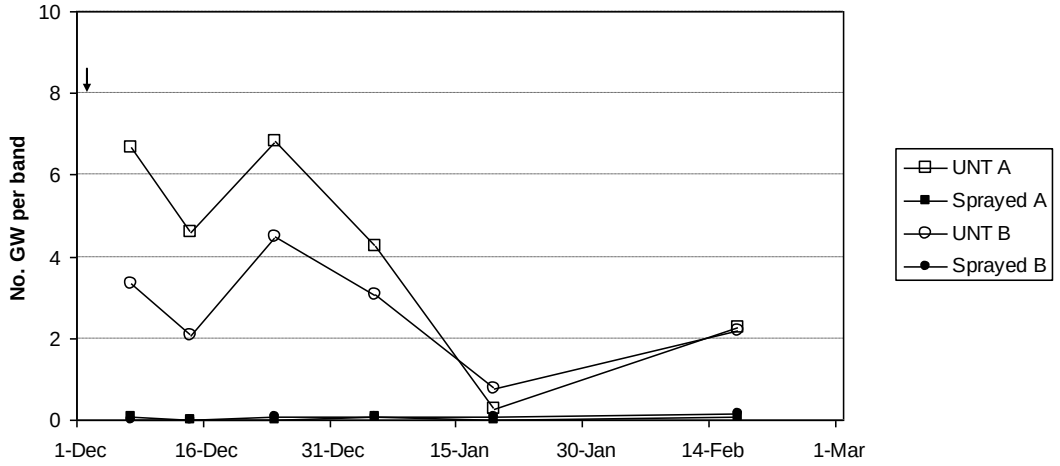


Fig. 3.3a. Average number of garden weevil adults in monitoring bands on untreated vines or vines sprayed with Avatar in two Chardonnay grapevine blocks in the 2009/10 season, Pemberton, WA.

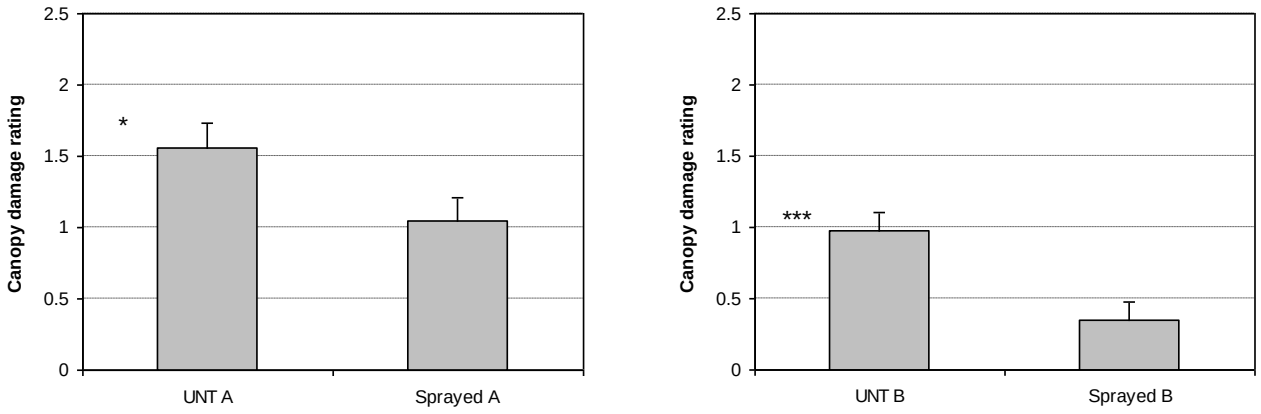


Fig. 3.3b. Canopy damage rating on 17 Feb 2010 for garden weevil feeding in untreated and sprayed plots in two Chardonnay grapevine blocks at Pemberton, WA.

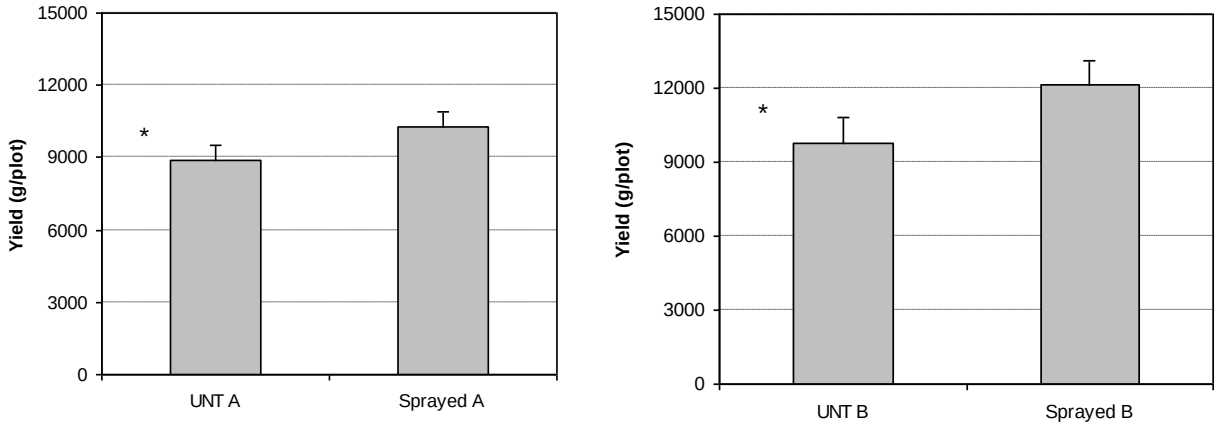


Fig. 3.3c. Hand harvest plot yields on 15 March 2010 in untreated plots and plots sprayed to control garden weevil in two Chardonnay grapevine blocks at Pemberton, WA.

While the abundance of garden weevil adults was relatively low in both vineyard blocks, significant differences were recorded for both canopy feeding score and yield between untreated and sprayed plots in both blocks. In Chardonnay block A, the yield in treated pots was on average 116% of that for untreated plots. In Block B, the average yield for treated plots was 124% of that for untreated plots. This occurred despite the higher number of garden weevil and feeding damage score in Block A.

Also the average feeding score for untreated plots in Chardonnay Block B was near 1. Given that the yield difference was significant, this low level of canopy feeding indicates that at least on this occasion the damage potential for garden weevil was not related to the canopy damage level based on the proposed scoring system. As stated elsewhere, a canopy feeding score of between 2 and 3 was proposed as an economic injury level. This recommendation requires further assessment.

(b) Comparisons of yield and garden weevil treatments across a number of locations

Across a total of seven vineyards where field trials and demonstrations on garden weevil management were conducted in the 2006/07 season, the effect of a range of treatments as a percentage of the yield in untreated vines is given in Fig. 3.4. In two of the vineyards, applying treatment did not appear to be justified in terms of yield improvement.

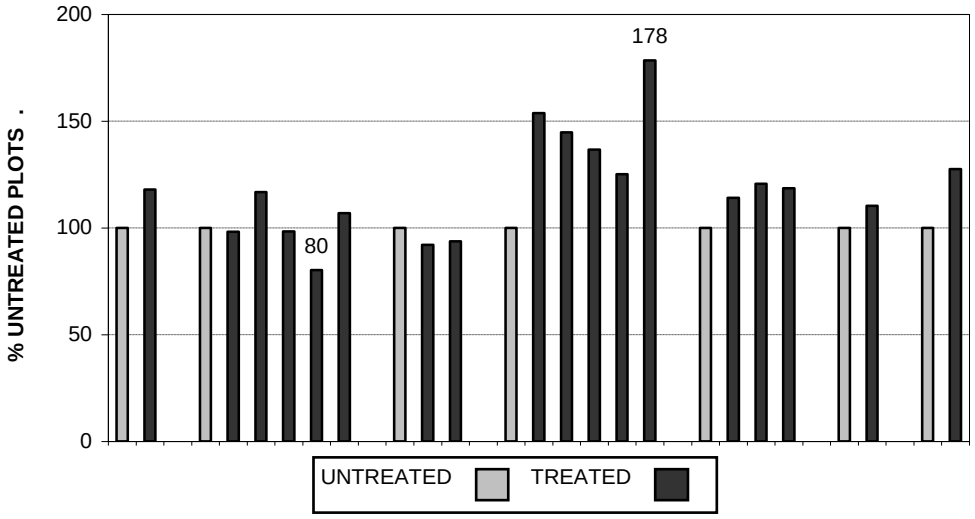


Fig 3.4. The yield of grapes as a percentage of that for untreated plots across seven vineyards where various treatments were applied for control of garden weevil during the 2006/07 season in south west Western Australia.

Examples of the use of the scoring system in Table 3.1 are presented in Figs 3.5 to 3.5, where the results of yield of grapes are plotted against feeding scores. Figs. 3.5 and 3.7 show that in general terms, the greater the feeding score the lower the yield.

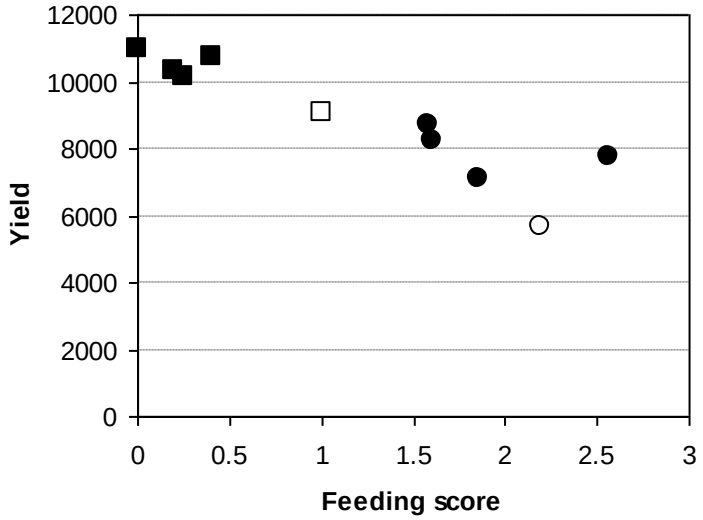


Fig. 3.5. The yield of grapes in two vineyards represented by the circles and squares across a range of treatments to control garden weevil versus the weevil feeding score in the vine canopy using the system explained in Table 3.1. In each vineyard the open symbols are data from untreated plots.

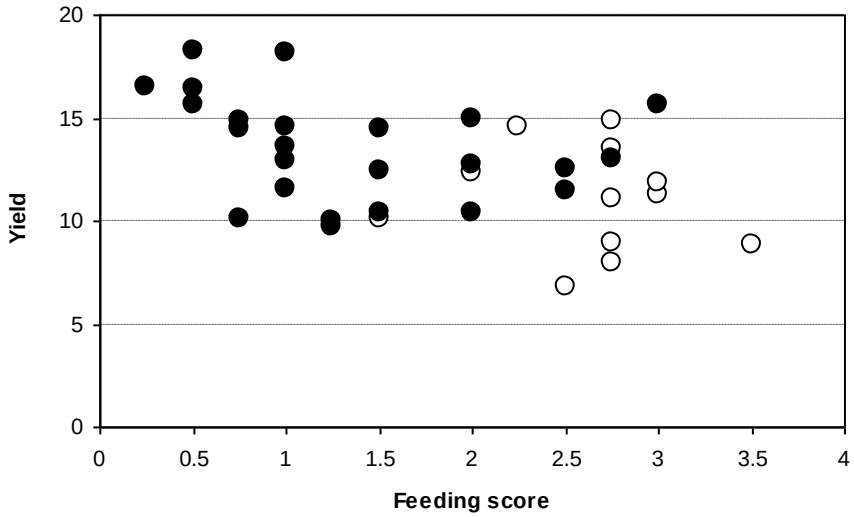


Fig. 3.6. The yield of grapes in a vineyard versus the garden weevil feeding score in the vine canopy using the system explained in Table 3.1. The treatments included untreated controls represented by the open circles.

The situations represented in two other vineyards indicate that even at relatively modest levels of garden weevil damage, the justification for applying a treatment to control garden weevil is not always justified – see Figs. 3.7 and 3.8. At this level of weevil feeding in the vine canopy, there was no clear relationship between weevil feeding and subsequent yield.

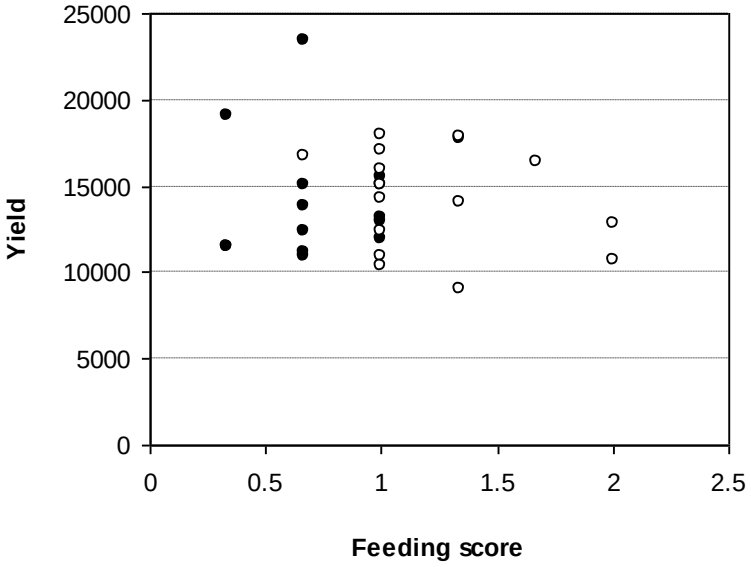


Fig. 3.7. The yield of grapes in a vineyard where one series of panels received a butt drench with synthetic pyrethroid to control garden weevil (dark circles) and another adjacent series were untreated (open circles) versus the weevil feeding score in the vine canopy using the system explained in Table 3.1.

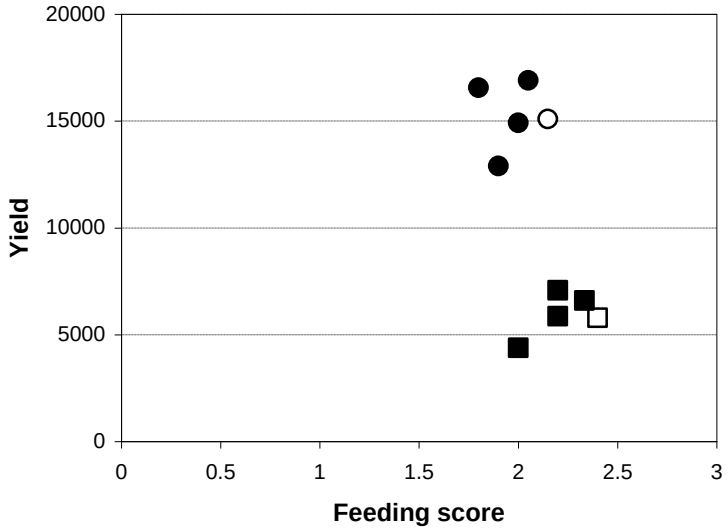


Fig. 3.8. The yield of grapes in two vineyards represented by the circles and squares across a range of treatments to control garden weevil versus the weevil feeding score in the vine canopy using the system explained in Table 3.1. In each vineyard the open symbols are data from untreated plots.

Conclusion

The data collected to date as demonstrated here with some examples indicate that it may be possible to incorporate a rapid assessment system to help decide whether a given garden weevil infestation requires intervention. While some of the vineyards where assessments were undertaken showed variable results, some indication that the system may prove useful were seen.

The variability in damage in terms of reduced yield from garden weevil infestations shows that presence of garden weevil is insufficient justification for applying insecticide. Even though there are reliable insecticides to control garden weevil, they are very limited in

activity groups and there is concern that resistance to insecticides may develop. The judicious use of insecticides demands that they be used with caution and only where infestation must be controlled in order to protect vines from significant yield loss or adverse effects on vine structure. This objective will only be achieved by vignerons having the confidence in a monitoring system that allows them to assess the potential for damage based on early levels of canopy feeding.

The relationship between garden weevil abundance, a scoring system to interpret those numbers in terms of a canopy feeding and the justification for intervention on economic terms has yet to be fully developed.

Objective 4 - Assess the potential to explain the variability in garden weevil distribution within vineyards based on spatial environmental data and to determine the relationship between garden weevil abundance and ground cover species composition in vineyards.

Introduction

Four vineyard sites were chosen each in a sub-region of the greater Margaret River wine region. Vineyard 1 in the northern sub-region of Cowaramup; Vineyard 2 situated in the Willyabrup region; Vineyard 3 in Margaret River and Vineyard 4 in the southern region of Karridale.

Vineyard 1

Vineyard 1 is located in the Cowaramup sub-region of the Margaret River Wine region. The block of research vines are own rooted chardonnay comprising 2.84 Ha planted in 1998. The block consists of 19 rows running north south. The 4,743 vines are spur pruned on a VSP trellis. The vines have one cordon arm on a 1.2 m high cordon wire. Vine spacing is 3 m x 2 m, with 3 vines per panel; each row contains approximately 84 panels. The block is cropped at 10 t/Ha.
The block is south facing on a gravel rocky ridge. The soil at the northern (elevated) end of the rows consists mainly of sandy loam, the southern end of the rows in close proximity to the creek line and dam are heavy clay.

The mid-row consists of indigenous species with alyssum sown in every 5th row to encourage lacewing wasps and ladybirds to breed keeping the mealy bug population in check. The mid-row is mown during the growing season and chemical weed killer is used under vine. The vineyard has a flock of guinea fowl to reduce the grasshopper population. Over winter sheep are allowed to roam the vineyard.

Vineyard 2

Vineyard 2 is a registered biodynamic producer. The vineyard is located on the western side of Caves Road in the Willyabrup sub-region of Margaret River. The block of research vines are own rooted chardonnay vines comprising 4.75 Ha planted in the late 1980's. The block consists of 71 rows running east west. A total of 6,828 vines are cane pruned on a VSP trellis with two arm cordons at 1.2 m with 3 vines per panel; vine spacing is 3.8 m x 1.8 m. The block is cropped at 4 t/Ha.

The block is flat with fairly consistent soil of sandy loams with the southern section tending to have higher clay content.

Every second mid-row is sown with a mix of sweet pea, clover and rye grass which is mown to form mulch during the summer growing months. The under vine area is cultivated, mounding soil up under the vine reducing the weed population.

Vineyard 3

Vineyard 3 is located in the Margaret River sub-region. The research vines are own rooted chardonnay comprising 1.52 ha planted in 1997. The block consists of 51 rows running north south. The 2,556 vines are cane pruned on a VSP trellis. The vines have two cordon arms at a height of 750 - 900 mm with 4 vines per panel; vine spacing 3 m x 2 m. The vineyard is cropped at 8 t/Ha (4.5 kg per vine).

The block is positioned on a ridge that slopes west and south into a creek line. The soils at the elevated row ends are gravelly, sandy loam with the row ends closest to the creek line tending to gravelly, heavy loam and clay.

The mid-row consists of mainly self-sown annual species, although previously every fourth row was seeded with lupin, and every second row with rye grass and clover. The mid-row and under vine

area is mown during the growing season to form a mulch layer. Over winter sheep are allowed to roam the vineyard.

The block of vines were sprayed for garden weevil on 21/11/2009 using Avatar® at a rate of 17 g/100 L at a volume of 17 L/100 m or 566 L/Ha. The spraying was undertaken as garden weevil damage to the canopy on row ends nearest the creek line was deemed unacceptable by the vineyard manager.

Vineyard 4

Vineyard 4 is located in the Karridale sub-region. The block of research vines are own rooted chardonnay comprising 2.08 Ha planted in 1998. The block consists of 29 rows running north south. The total of 2,968 two arm cordon vines are cane pruned on a VSP trellis with the cordon at 1 m, vine spacing is 3.5 m x 2 m, with 4 vines per panel. In 2009 the vineyard was cropped at 4 t/Ha and 2010; 6 t/Ha.

The block is on an elevated ridge with consistent sandy loam over clay soils. The mid-row cover crop is sown – alternate rows of Swan Oats and Cereal Rye which is mown to form mulch. Under vine is kept weed free with chemicals.

Materials and methods

One hundred vines were chosen via spatial representation throughout a block of chardonnay vines at each of the four vineyard sites. Each vine was monitored for number of garden weevils, damage to canopy and soil type. Forty sites within each vineyard site were monitored for cover crop / mid-row species. See **Error! Reference source not found.** which shows the spatial position of each of the study vines in relation to row and panel, and highlighted in blue are the cover crop monitoring sites.

A corrugated cardboard band was placed around the trunk of each of the 100 test vines per vineyard site. The band was placed as close to the canopy of the vine as possible with the rough (corrugated) side of the cardboard facing towards the vine trunk. This gave the weevils a place to hide during the daytime enabling an approximation of the number of weevils travelling up the trunk into the canopy to feed at night. To count the number of weevils ‘hiding’ in the band a canvas sheet was placed around the base of the vine trunk. The band was removed and shaken dislodging weevils onto the canvas sheet. The number of weevils was counted and recorded during the growing season

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Canopy Scoring

A visual assessment of each test vine was undertaken as per Table 3.1.

Soil Analysis

Soil was taken near each of the 100 test vines per vineyard site. Each sample was analysed for soil texture via the ribbon method (Ramsey, 2007); and soil colour, value and chroma determined using Munsell charts.

Cover crop / mid-row

The species within the mid-row was determined using a 760 mm x 760 mm, 9 square grid, each square measured 245 mm x 245 mm. This was placed in the centre of the mid-row in front of selected test vines. Note if the test site was a double site i.e. two test vines side by side then the grid was placed in the centre of the mid-row at a central point between the two vines. A total of 40 test points per vineyard site were chosen through spatial representation.

Results

Weevil numbers

The number of weevils counted in each vineyard in the growing season of 2 years are shown in Figure 4.1. The graphs show high weevil numbers in spring, the initial weevil hatching. The numbers then seem to reduce until the second hatching midsummer.

The total number of weevils increased in Vineyards 1, 2 and 4 from year one (2008/09) of the study to year two (2009/10). There was no increase in weevil numbers at Vineyard 3 this is not unexpected as this vineyard was sprayed for garden weevil in December 2009. Interesting to note is that weevil numbers were significantly higher at the second hatching in midsummer in Vineyard 1 and 2, consistent in Vineyard 3 but significantly lower in Vineyard 4.

Figure 4.2 below shows that the average number of weevils at each individual study vine in Vineyard 1, 2 and 4 increased from 2008/09 to 2009/10 but was consistent in Vineyard 3.

Figure 4.1 Total number of weevils counted at each site over 5 visits during the two growing seasons, 2008/09 and 2009/10.

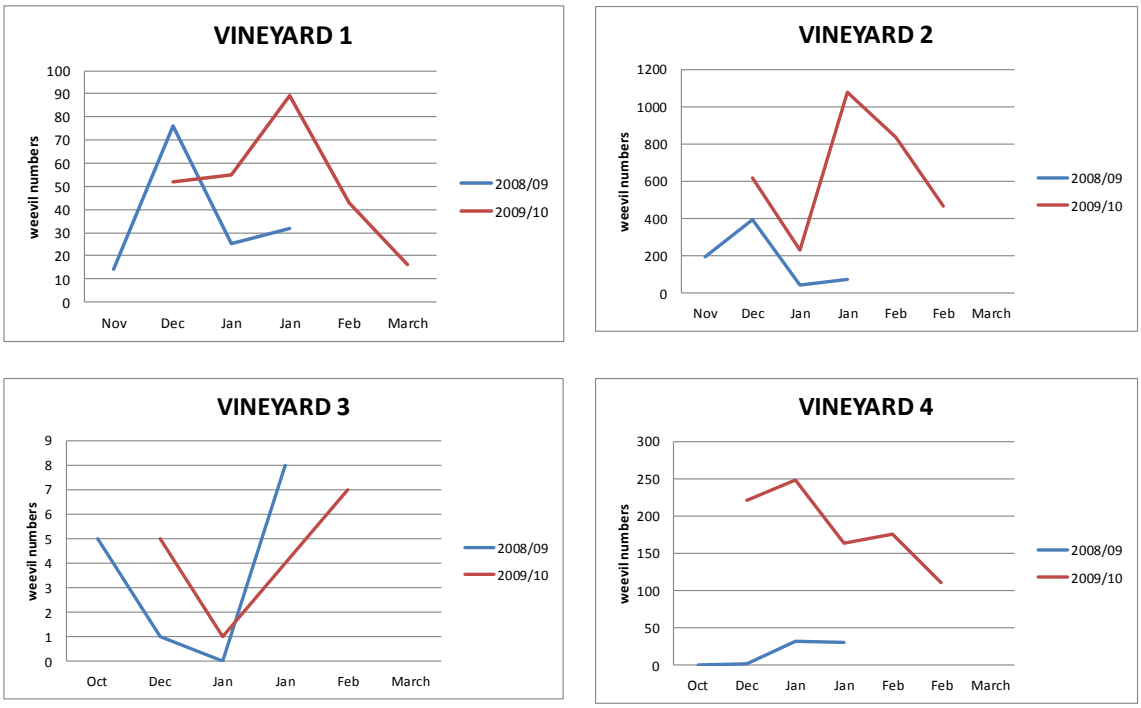
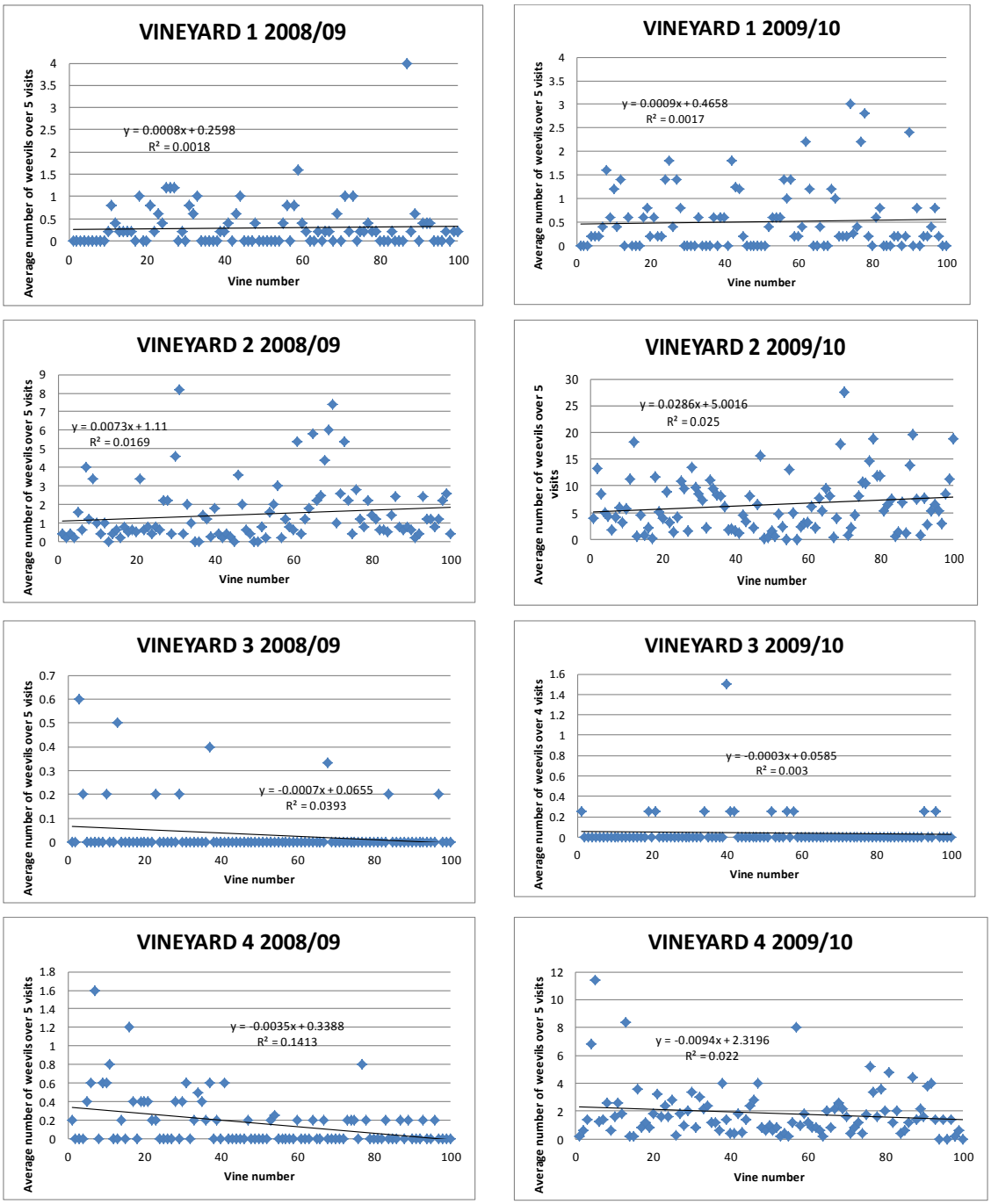


Figure 4.2 Comparison of the average number of weevils present at individual study vines in the two growing seasons 2008/2009 and 2009/2010 at the four vineyard sites.

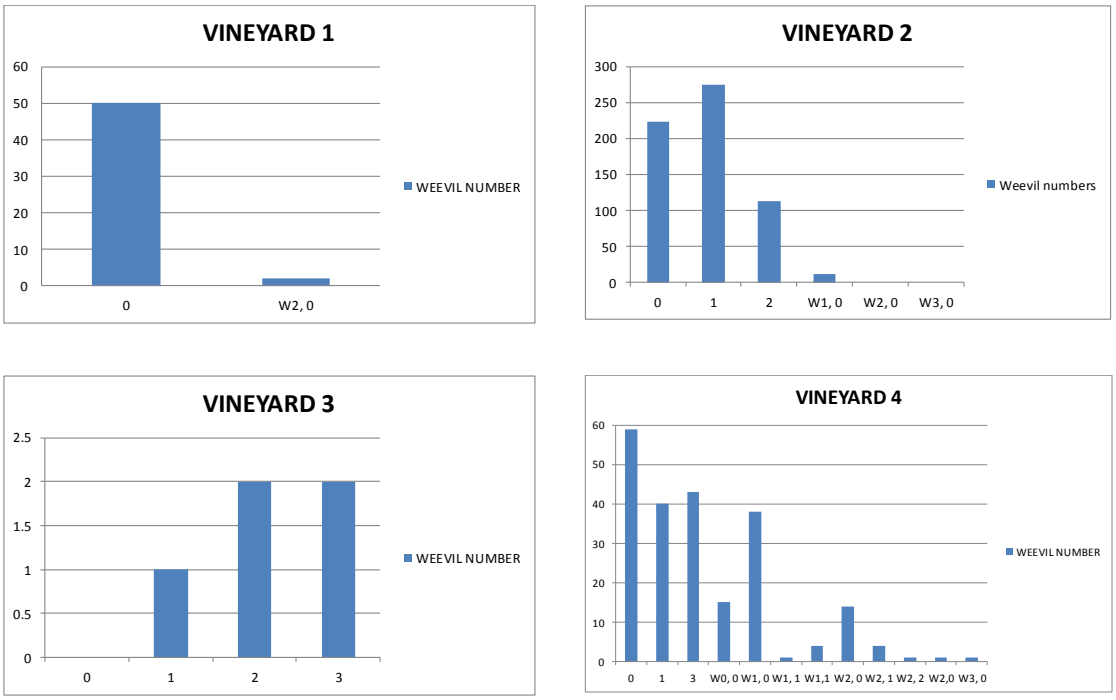


Canopy score

A significant percentage of weevils across the four vineyards were found on vines with no obvious canopy damage see Figure 4.3 below. Therefore a purely visual assessment of a vine does not necessarily reveal the number of weevils that may be present.

It has been suggested that the presence of a watershoot reduces the canopy damage of a vine. This is largely supported by the graphical representation below as high watershoot damage resulted in less canopy damage (see Vineyard 4 in Figure 4.3 below) but only a small percentage of weevils were found on these vines.

Figure 4.3 Comparison of canopy score (damage to canopy) and number of weevils present, December 2009.



Soil type

For ease of presentation the common soils found in the four vineyards (as described by Ramsey (2007)) were truncated into the four groups; sand, sandy loam, loam and clay loam, see Table 4.1.

Figure 4 shows the percentage of each soil type found at the 100 test vines in each of the four vineyards. The frequency of the (truncated) soil types in the vineyards was very similar with the exception of Vineyard 3 which had sandier soil types than the other three vineyards.

Figure 4.5 shows the number of weevils found in each of the four combined groupings. These graphs show that a higher percentage of weevils were found in the clay loam and loam groupings which represent the soil groups of light sandy clay loam, loam, sandy clay loam, clay loam and sandy clay. From these results it can be said that higher numbers of weevils were found in the heavier soil classes.

Table 4.1 Soil textures as described by Ramsey (2007) and truncated groupings.

Sand Loamy sand	SAND
Clayey sand Sandy loam	SANDY LOAM
Light sandy clay loam Loam Sandy clay loam	LOAM
Clay loam Sandy clay	CLAY LOAM

Figure 4.4 Percentage of soil type found in each vineyard at the 100 test vines sites.

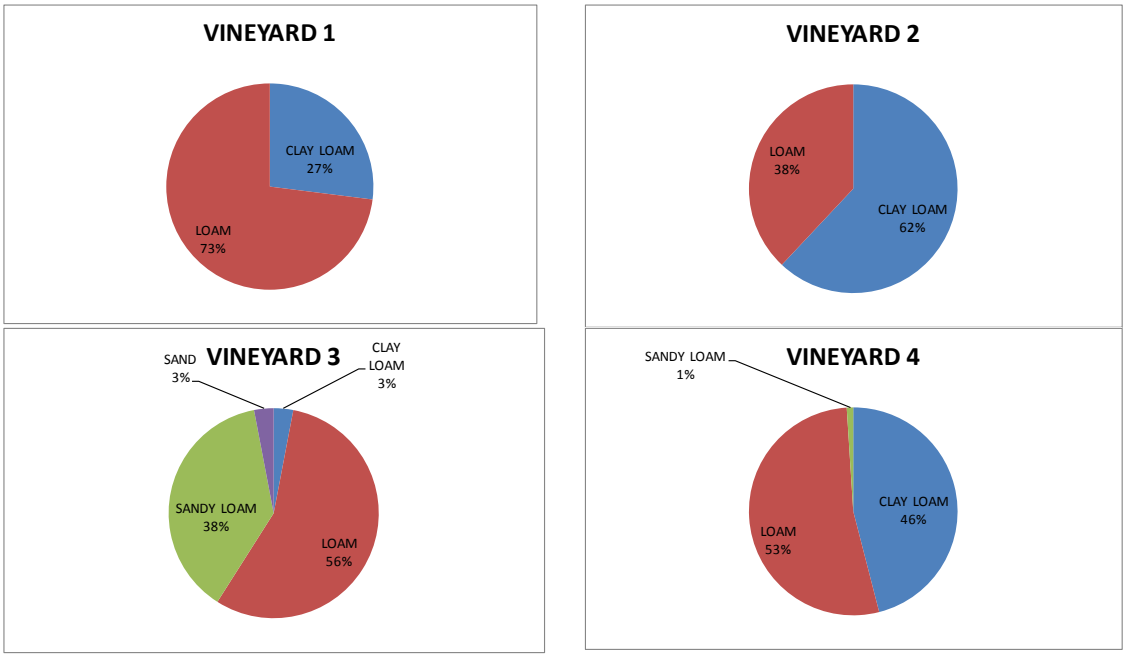
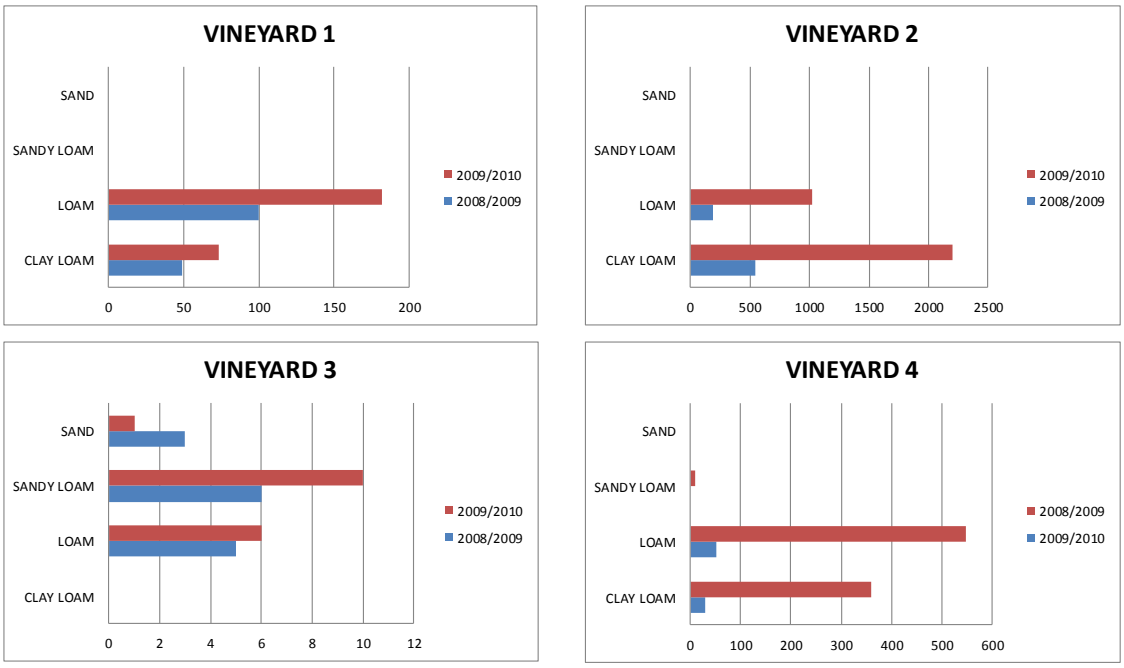


Figure 4.5 The total number of weevils found in each soil type (truncated as per Table 4.1 above) in the four vineyards.



Mid row cover crop

There was no significant correlation between weevil numbers and mid row cover crop

Vineyard 1

Table 4.2 below shows the percentage of each species of cover crop found in Vineyard 1. There is no consistency in results from 2008 to 2010, even though the mid-row management was unchanged. The December 2009 results show a high percentage of mulch as the mid-row was mown to form a mulch layer to reduce water loss over summer.

Table 4.2 Vineyard 1 - Frequency of mid-row cover crop species in two growing seasons (2008/2009 and 2009/2010).

	Barley grass	Capeweed	Clover (all types)	Dandelion	Dock	Four leaf allseed	Kikuyu	Lesser broomrape	Medic burr	Mulch	Peppermint weed	Perennial rye	Small leaf mallow	Soil	Swan oats	Wild oats	Winter grass
Nov-08	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.8	35.9	29.8	13.1	0.0	0.0
Dec-09	7.5	1.6	10.4	3.8	0.1	0.5	19.9	0.1	25.3	30.5	0.0	0.3	0.1	0.0	0.0	0.0	0.0
Aug-10	0.0	0.8	52.6	0.3	1.9	5.5	18.9	0.0	0.0	0.0	14.8	0.0	2.5	0.0	0.5	0.3	2.1

Figure 4.6 Vineyard 1 - Frequency of cover crop species November 2008.

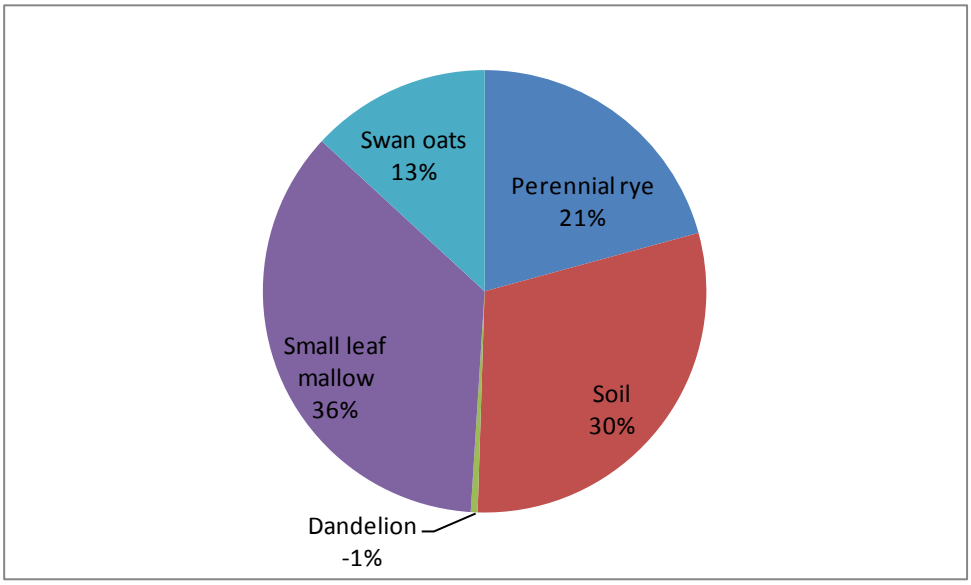


Figure 4.7 Vineyard 1 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, November 2008.

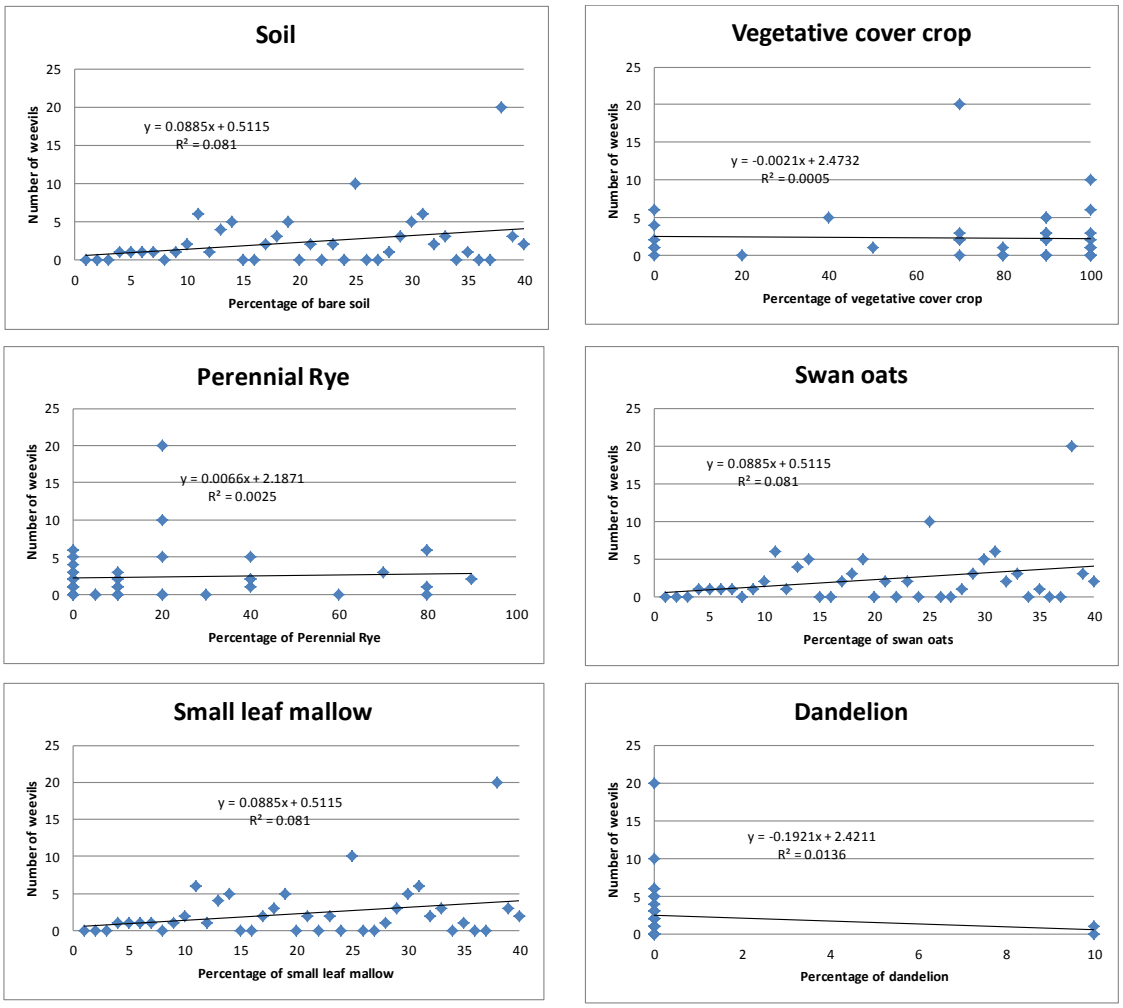


Figure 4.8 Vineyard 1 - Frequency of cover crop species December 2009.

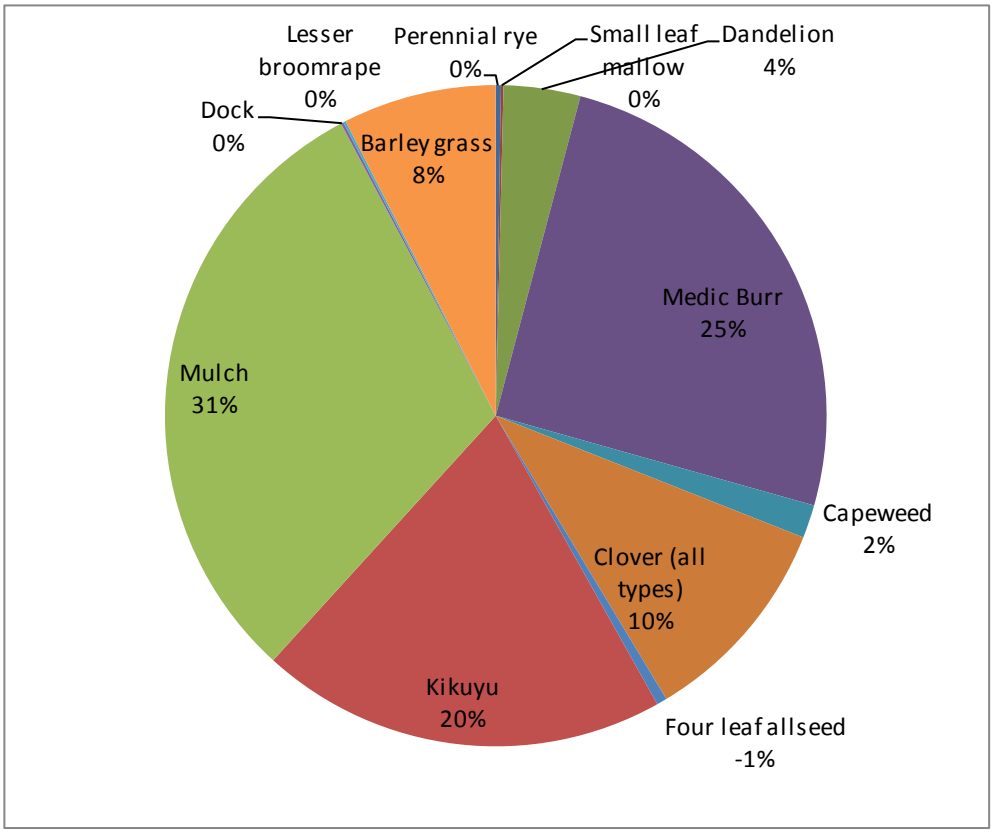
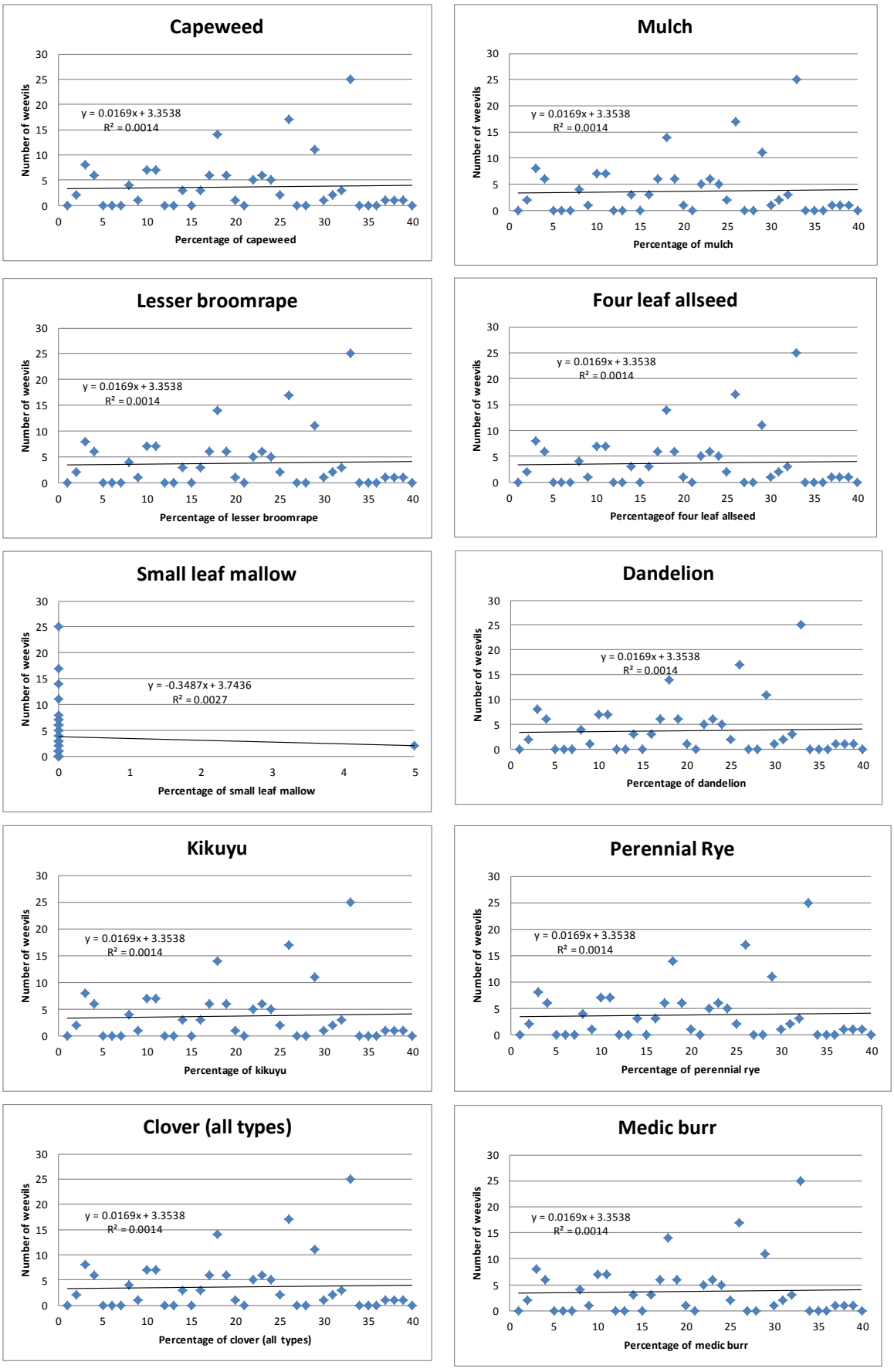


Figure 4.9 Vineyard 1 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, Dec 2009.



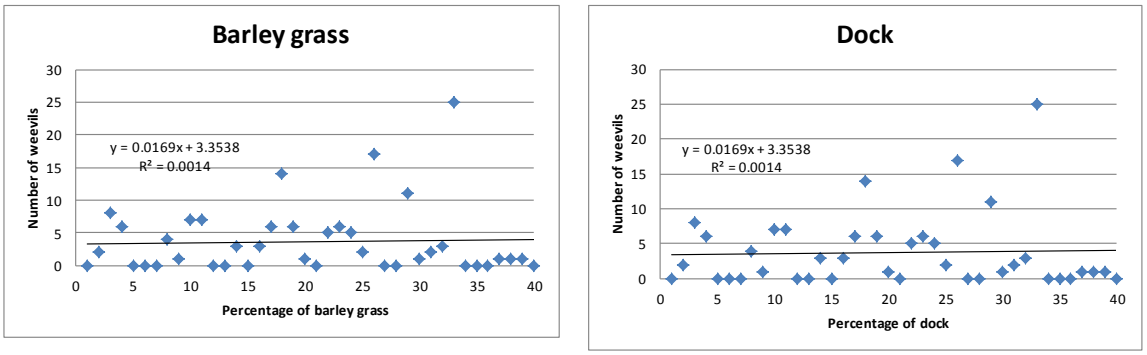


Figure 4.10 Vineyard 1 - Frequency of cover crop species August 2010.

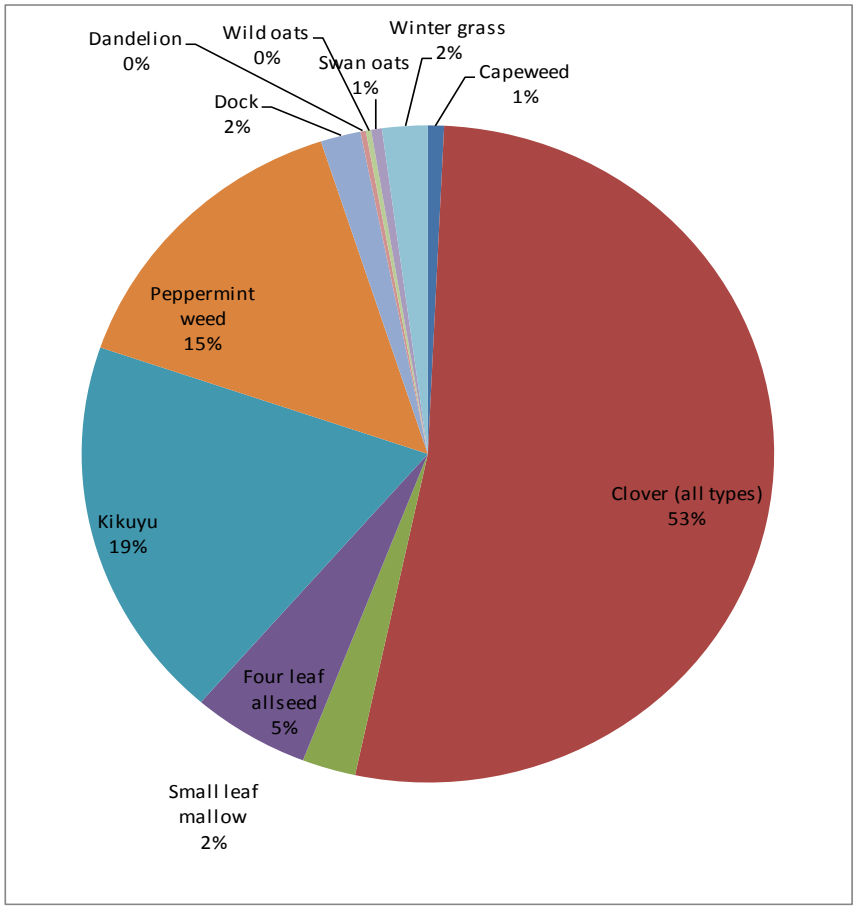
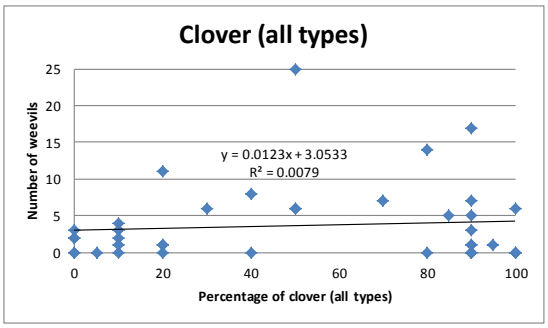
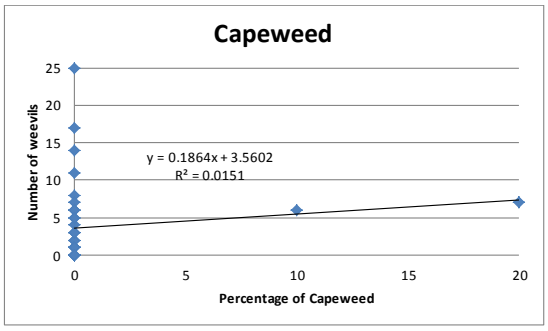
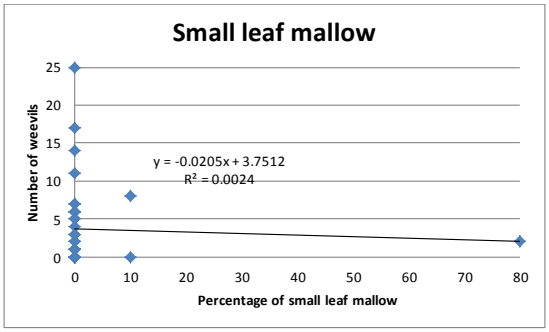
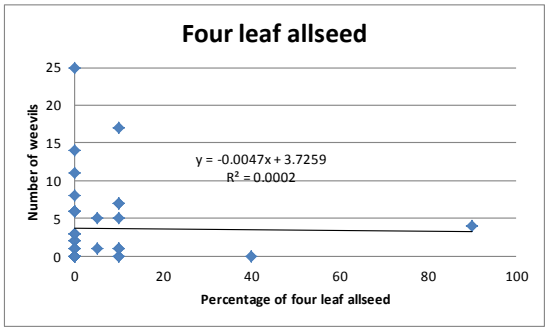


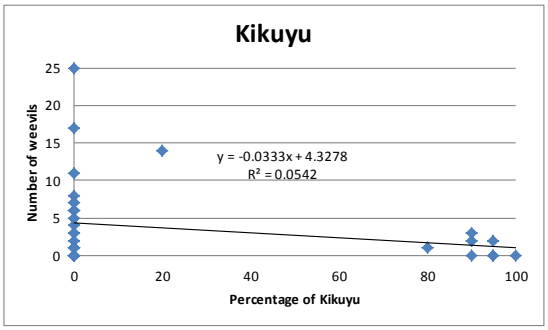
Figure 4.11 Vineyard 1 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, August 2010.

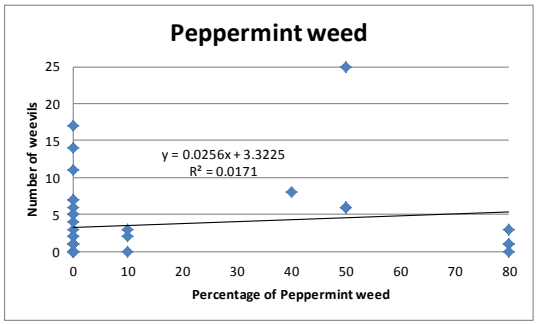


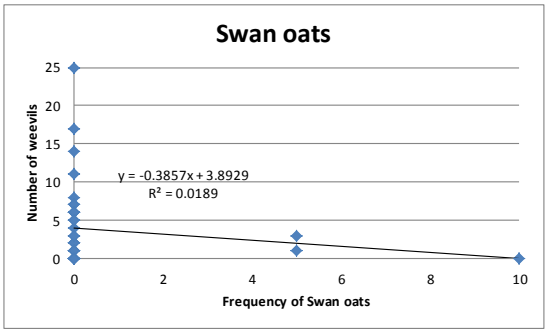


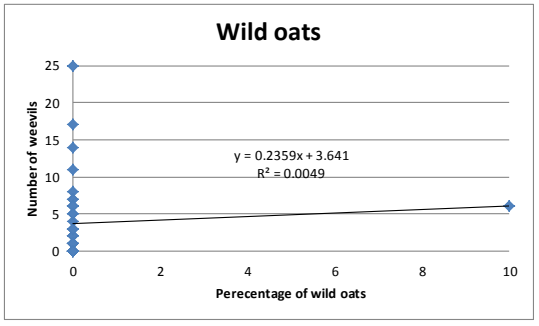


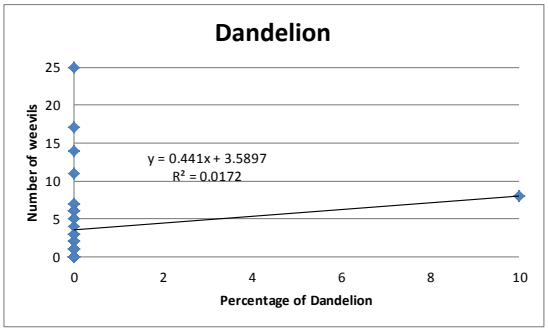


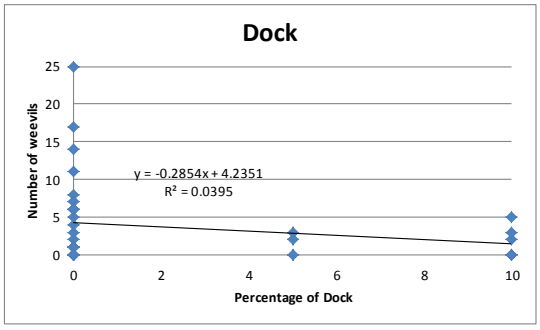


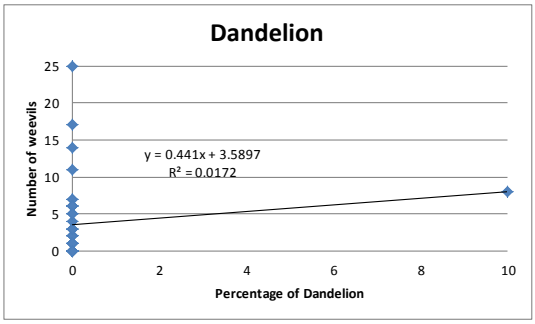












Vineyard 2

Table 4.3 below shows the percentage of each species of cover crop found in Vineyard 2. There is no consistency in results from 2008 to 2010, even though the mid-row management was unchanged. The December 2009 results show a high percentage of mulch as the mid-row was mown to form a mulch layer to reduce water loss over summer.

Table 4.3 Vineyard 2 - Frequency of cover crop species over two growing seasons.

	Perennial rye	Soil	Capeweed	Small leaf mallow	Dandelion	Clover (all types)	Wireweed	Peppermint weed	Cretin plantain	Kikuyu	Sorrel	Nightshade	Dock	Medic burr	Wild radish	Wild oats	Swan oats	Creeping oxalis	Winter grass	Mulch
Nov-08	36.4	35.6	10.1	17.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dec-09	13.5	18.5	2.0	0.1	0.1	6.0	0.4	5.8	2.4	6.3	0.4	0.1	0.1	0.5	0.0	0.0	0.0	0.0	0.0	43.9
Aug-10	7.0	0.0	32.3	0.0	0.0	31.1	0.0	17.0	1.8	0.0	0.0	0.0	0.1	0.0	0.1	0.6	0.1	2.3	2.1	5.6

Figure 4.12 Vineyard 2 - Frequency of cover crop species November 2008.

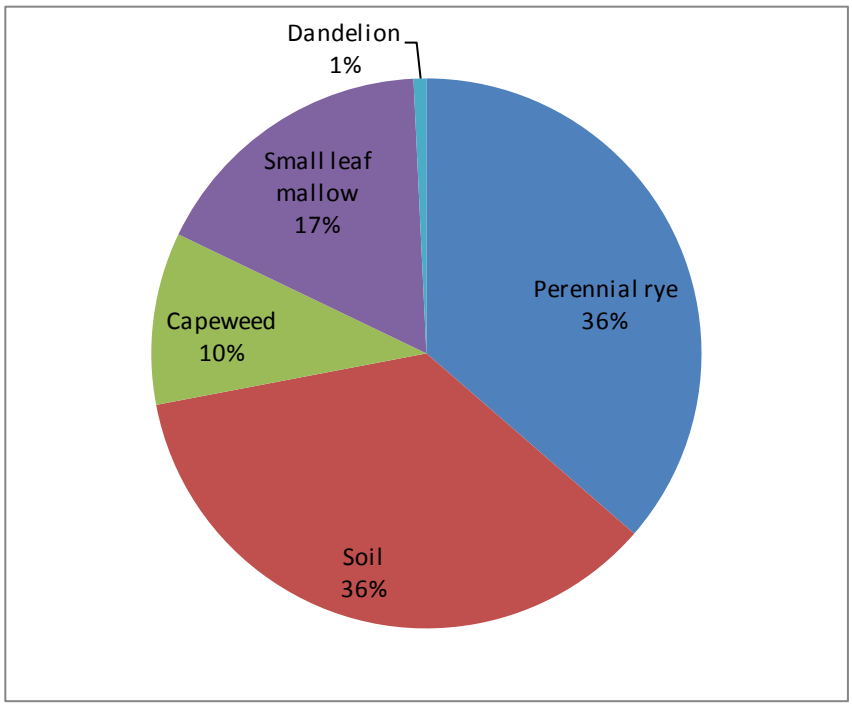


Figure 4.13 Vineyard 2 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, November 2008.

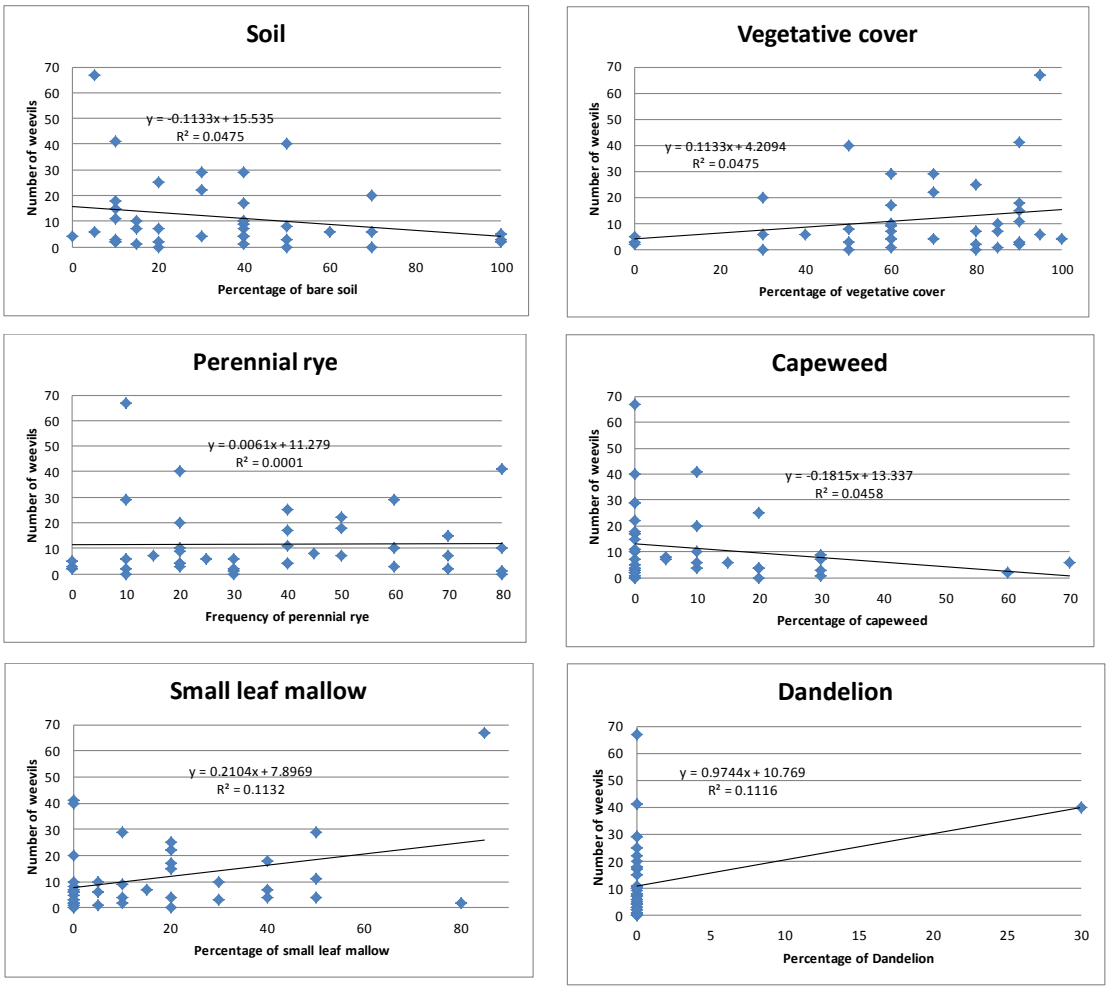


Figure 4.14 Vineyard 2 - Frequency of cover crop species December 2009.

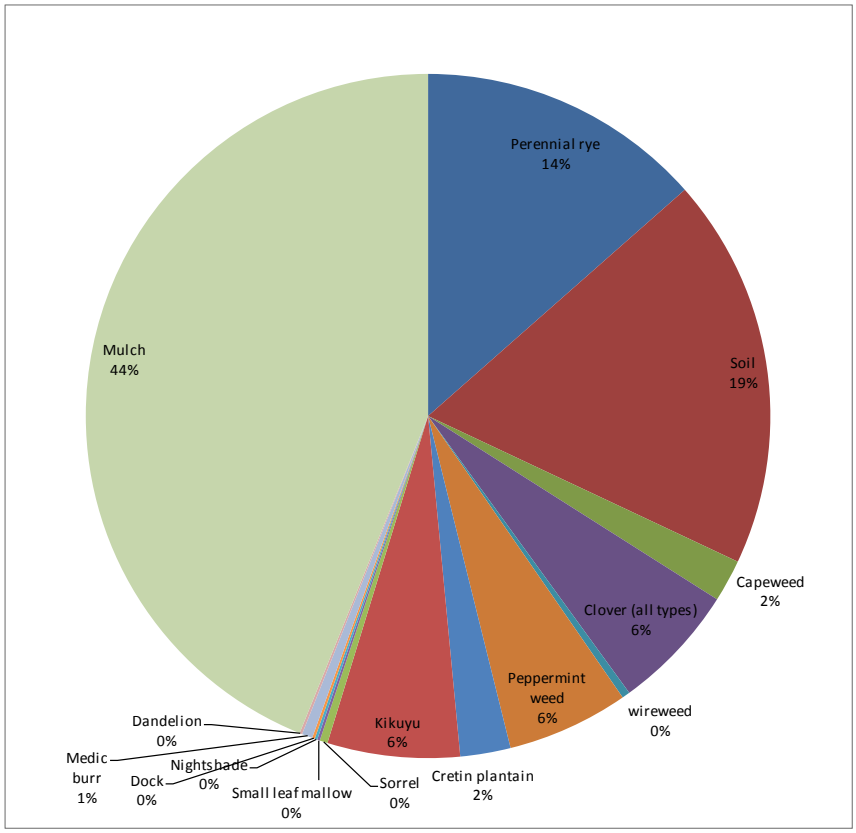
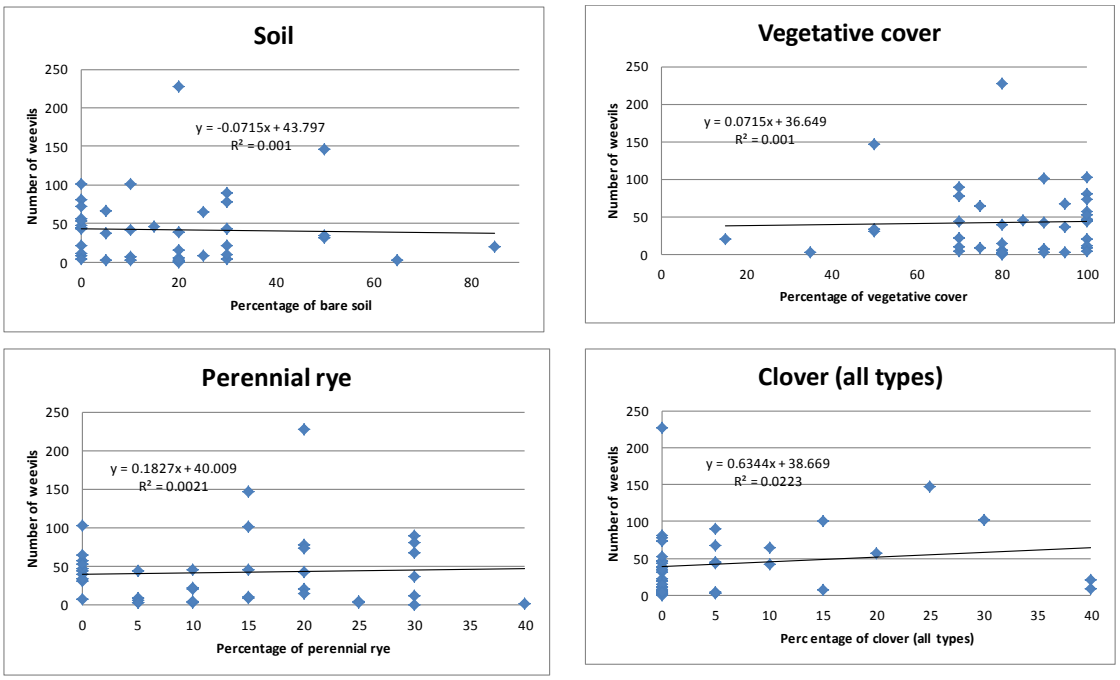
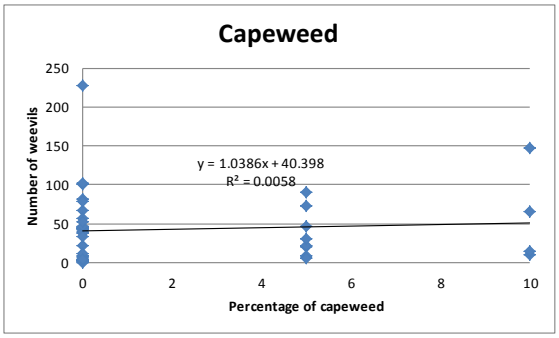
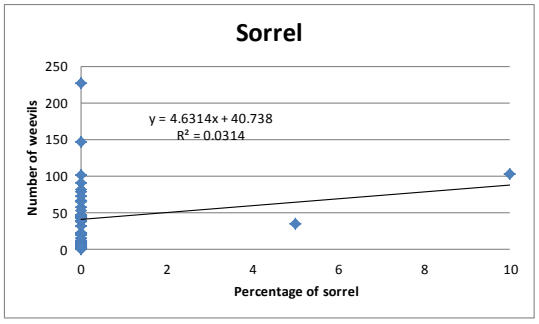
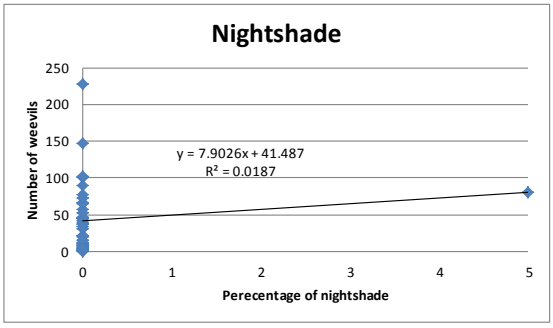


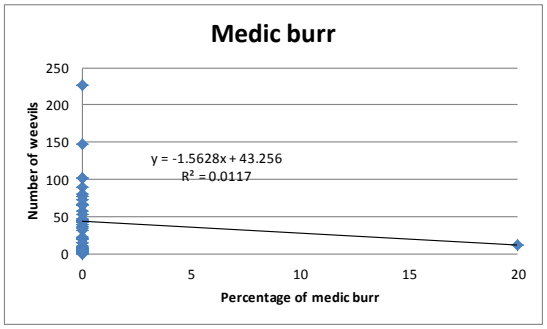
Figure 4.15 Vineyard 2 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, December 2009.

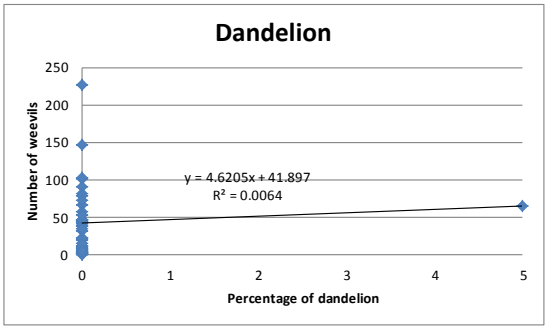


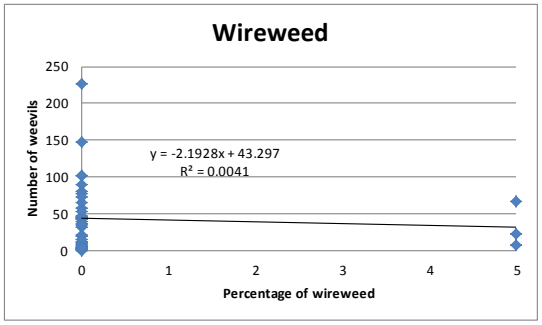

Capeweed
Number of weevils
y = 1.0386x + 40.398
R² = 0.0058
Percentage of capeweed

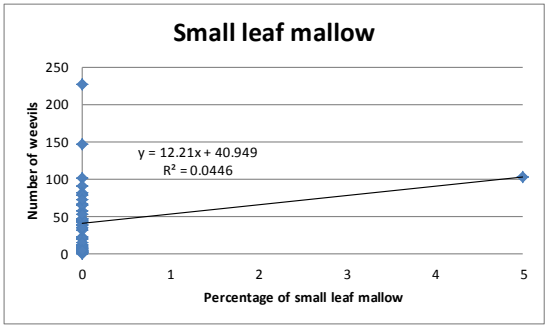

Sorrel
Number of weevils
y = 4.6314x + 40.738
R² = 0.0314
Percentage of sorrel

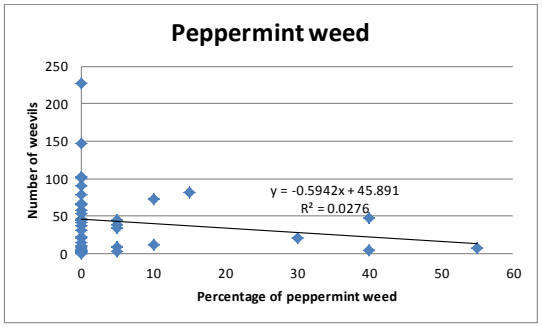

Nightshade
Number of weevils
y = 7.9026x + 41.487
R² = 0.0187
Perecentage of nightshade

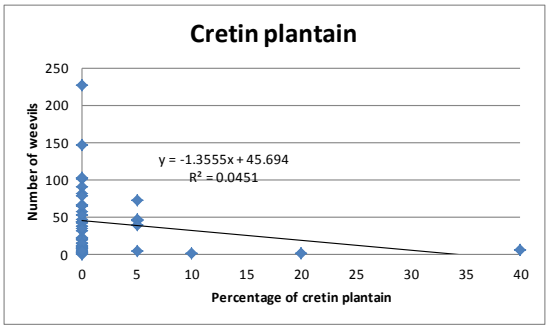

Medic burr
Number of weevils
y = -1.5628x + 43.256
R² = 0.0117
Percentage of medic burr

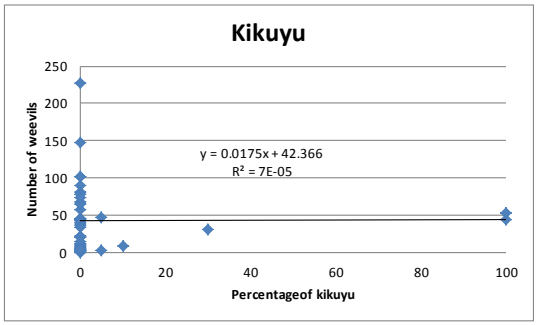

Dandelion
Number of weevils
y = 4.6205x + 41.897
R² = 0.0064
Percentage of dandelion

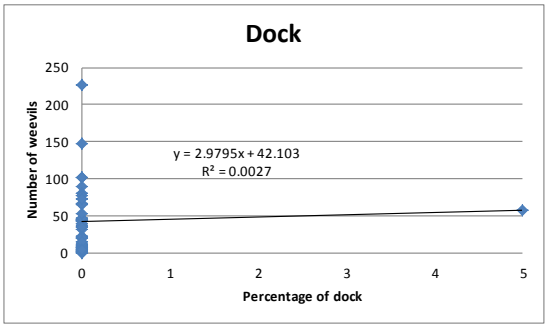

Wireweed
Number of weevils
y = -2.1928x + 43.297
R² = 0.0041
Percentage of wireweed


Small leaf mallow
Number of weevils
y = 12.21x + 40.949
R² = 0.0446
Percentage of small leaf mallow


Peppermint weed
Number of weevils
y = -0.5942x + 45.891
R² = 0.0276
Percentage of peppermint weed


Cretin plantain
Number of weevils
y = -1.3555x + 45.694
R² = 0.0451
Percentage of cretin plantain


Kikuyu
Number of weevils
y = 0.0175x + 42.366
R² = 7E-05
Percentageof kikuyu



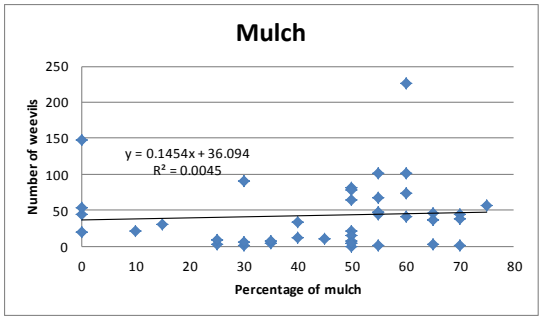


Figure 4.16 Vineyard 2 - Frequency of cover crop species August 2010.

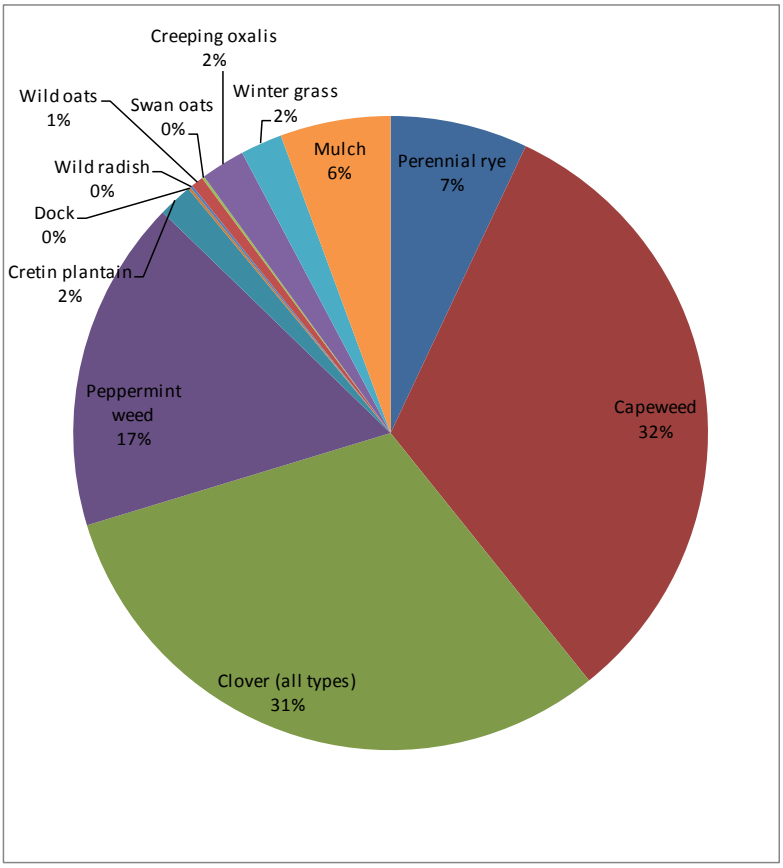
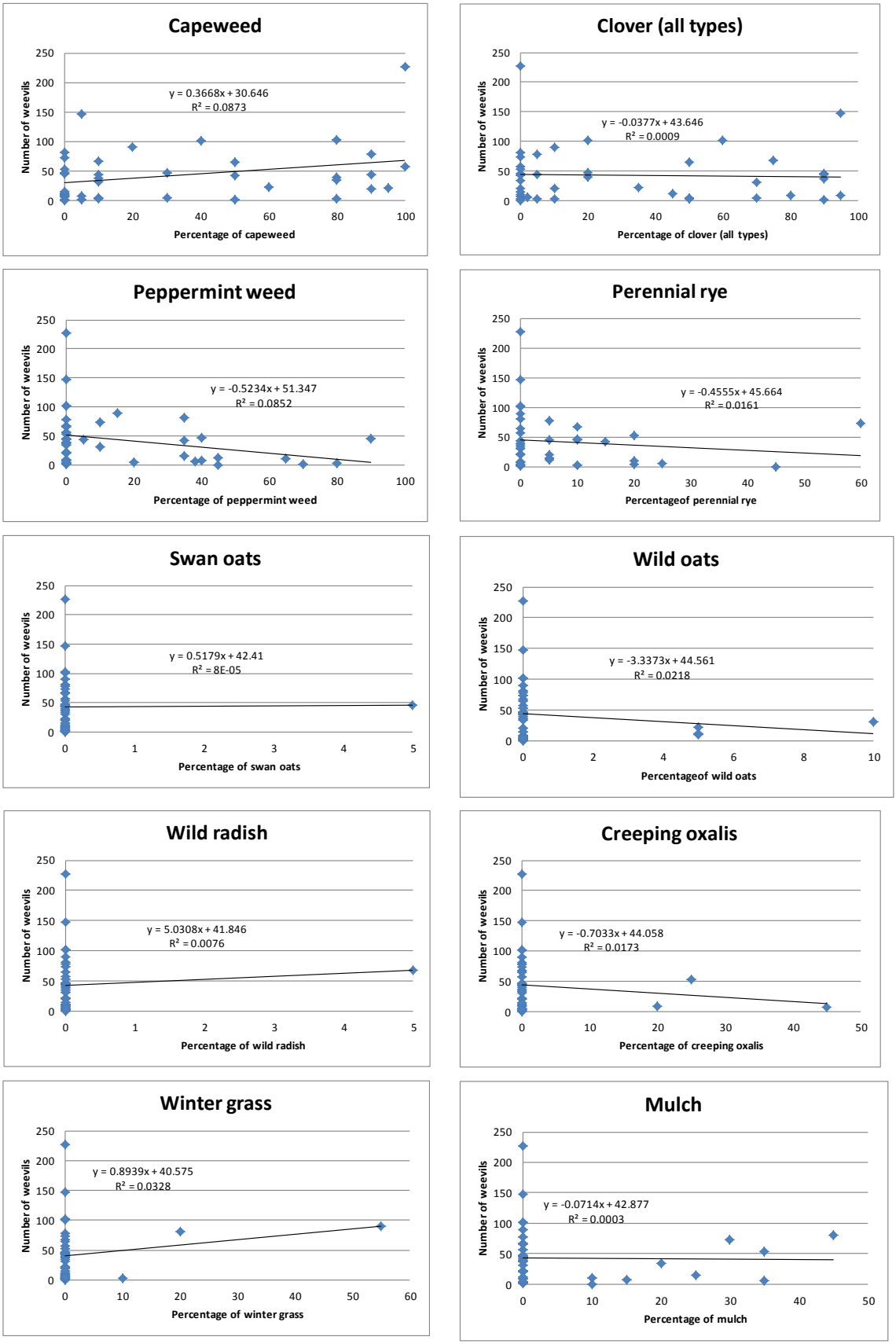
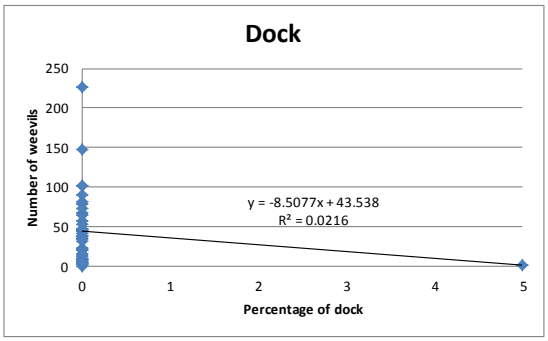
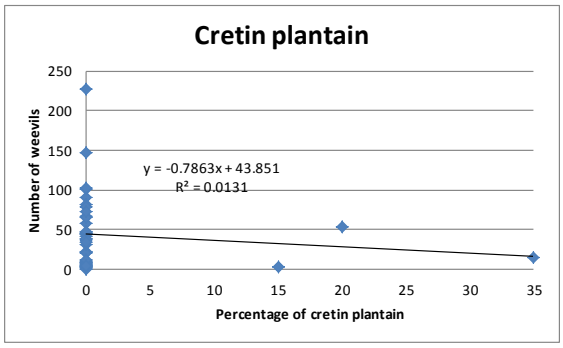


Figure 4.17 Vineyard 2 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, August 2010.







Vineyard 3

Table 4.4 below shows little consistency in cover crop species over the two growing seasons.

Table 4.4 Vineyard 3 - Frequency of cover crop species over two growing seasons.

	Wild oats	Perennial rye	Soil	Small leaf mallow	Lupin	Dandelion	Medic burr	Capeweed	Clover (all types)
Oct-08	44.3	3.5	12.0	2.8	21.4	16.1	0.0	0.0	0.0
Dec-09	1.9	67.6	0.0	0.0	0.0	24.9	3.0	0.1	2.5
Aug-10	0.0	24.8	0.0	0.0	0.0	2.6	0.0	0.0	72.6

Figure 4.18 Vineyard 3 - Frequency of cover crop species October 2008.

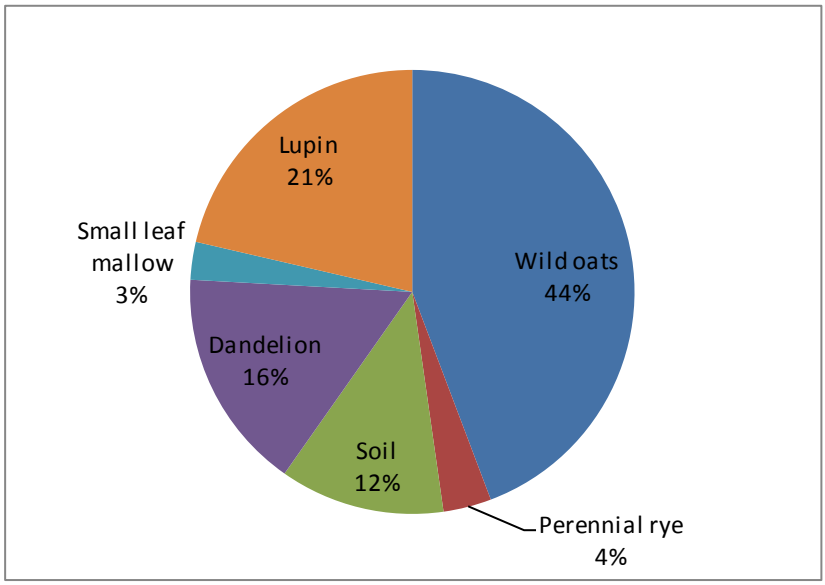
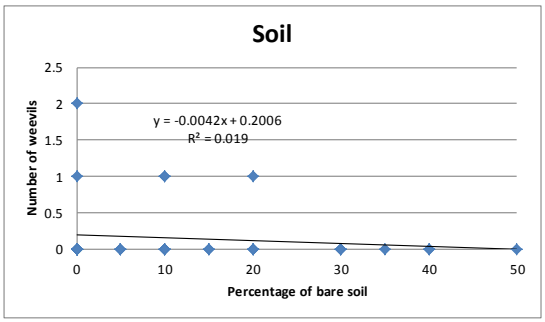
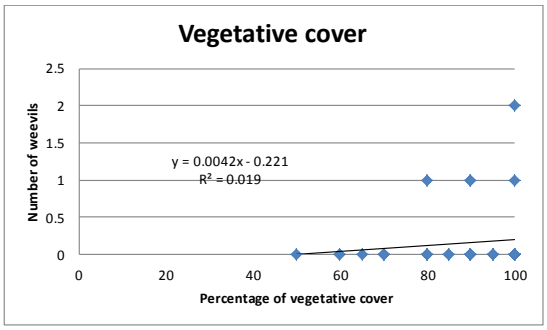
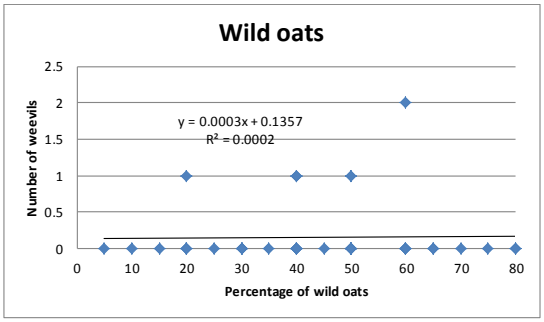
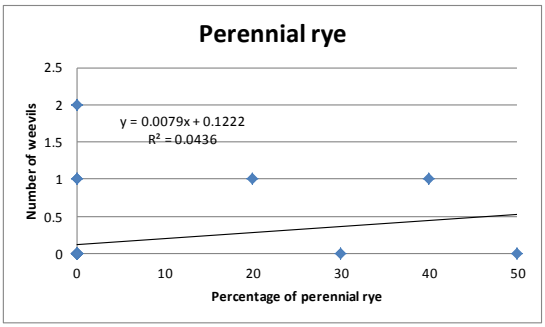


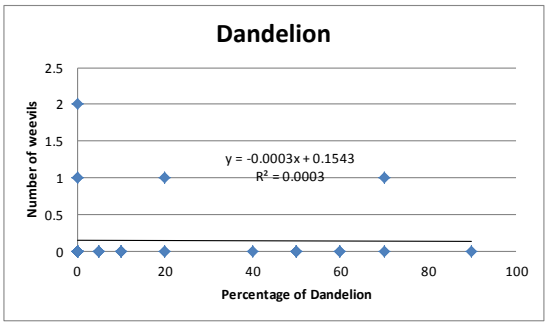
Figure 4.19 Vineyard 3 – Number of weevils versus the percentage of each cover crop species found at each monitored vine, October 2008.

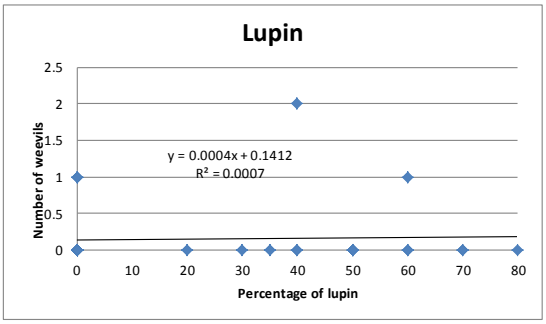












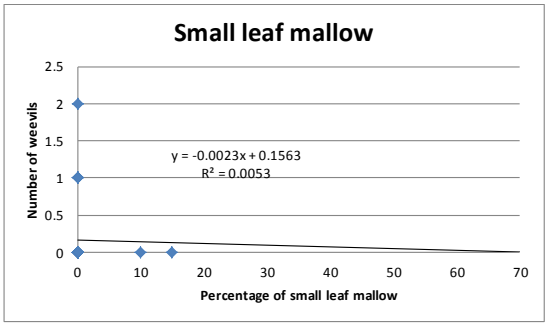


Figure 4.20 Vineyard 3 - Frequency of cover crop species December 2009.

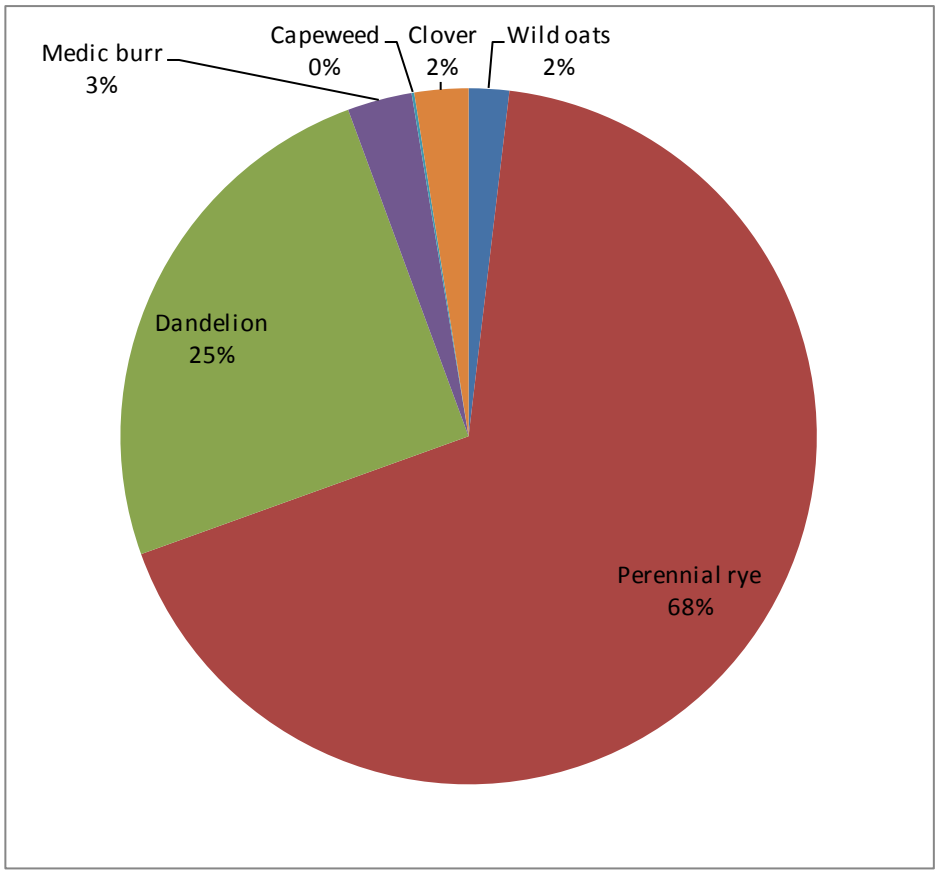


Figure 4.21 Vineyard 3 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, December 2009.

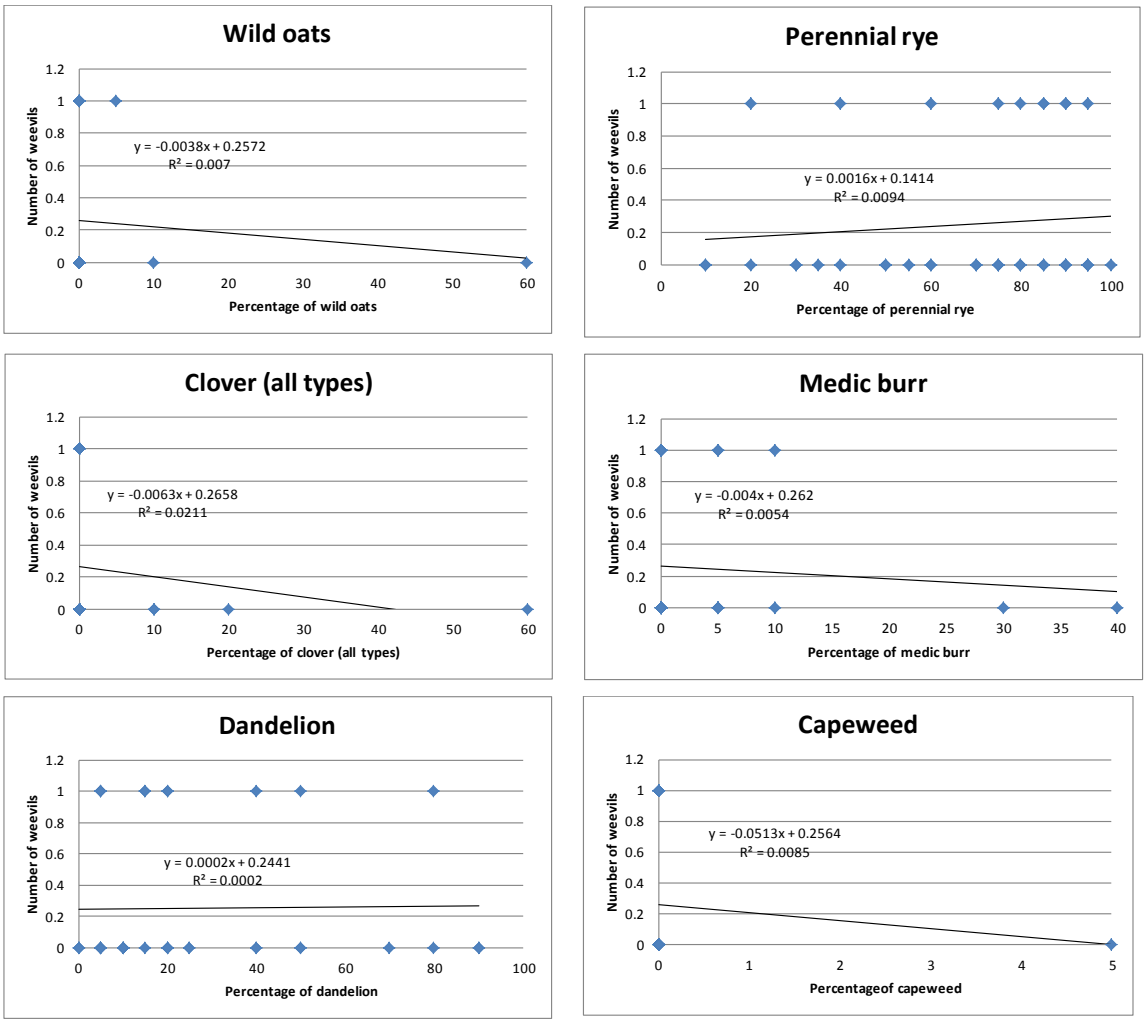


Figure 4.22 Vineyard 3 - Frequency of cover crop species August 2010.

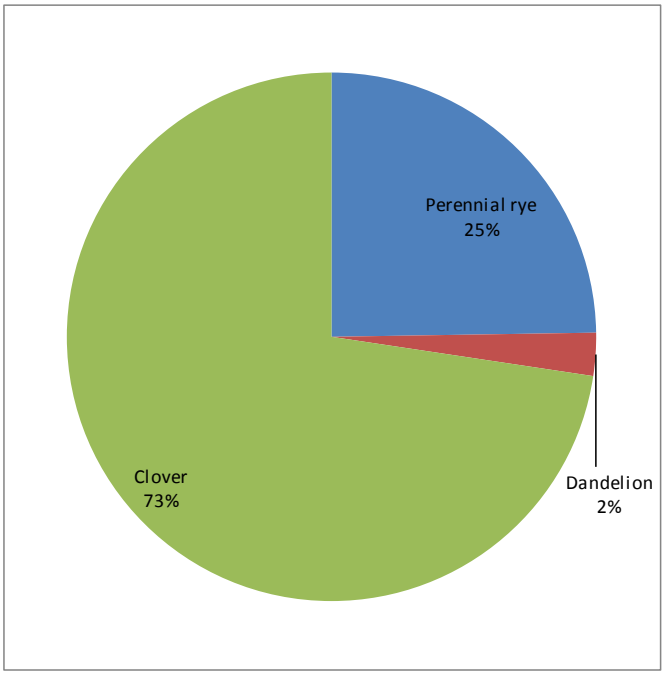
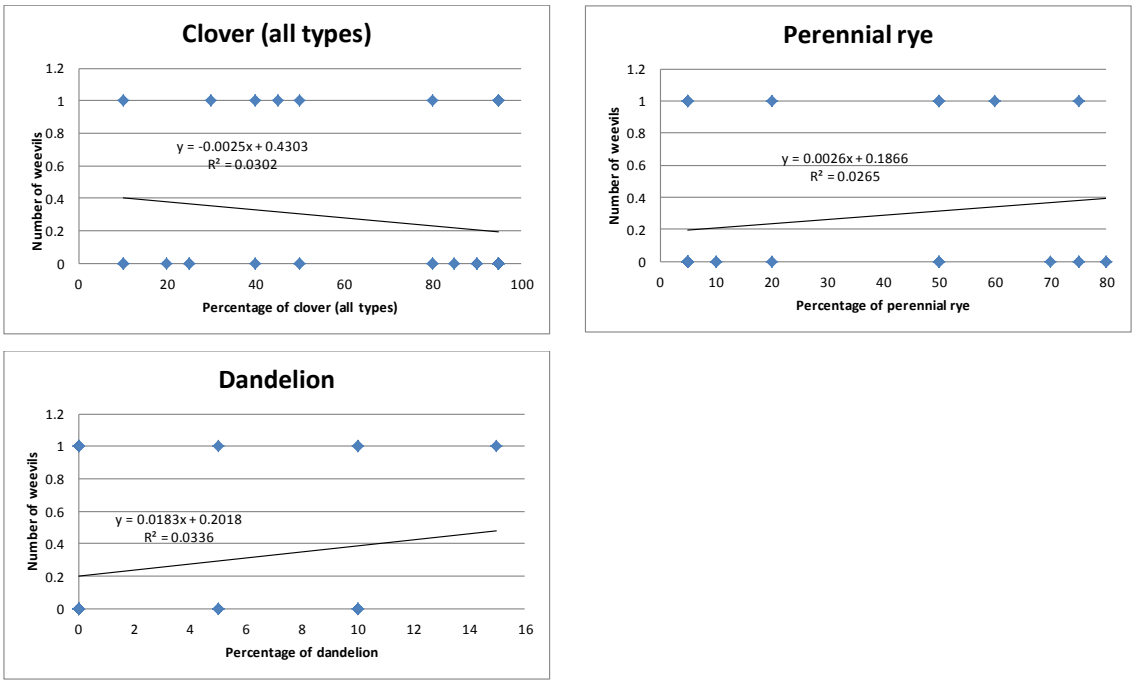


Figure 4.23 Vineyard 3 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, August 2010.



Vineyard 4

Table 4.5 below shows that cereal rye and a high percentage of bare soil are the most frequent cover crop in the mid-row.

Table 4.5 Vineyard 4 - Frequency of cover crop species over two growing seasons.

	Perennial rye	Cereal rye	Soil	Capeweed	Small leaf mallow	Cretin plantain	Wireweed	Sorrel	Four leaf allseed	Dandelion	Kikuyu	Creeping oxalis	Medic burr	Crabgrass	Swan oats	Clover (all types)	Mulch
Oct-08	10.5	37.6	27.4	5.6	0.4	8.1	0.0	0.0	0.0	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dec-09	7.5	59.0	4.9	0.0	0.0	0.0	0.6	13.9	6.3	3.4	1.9	0.5	0.6	1.5	0.0	0.0	0.0
Aug-10	0.0	30.5	33.9	0.3	0.0	0.0	0.0	3.1	1.0	1.7	0.0	4.9	0.1	0.0	18.1	5.9	0.6

Figure 4.24 Vineyard 4 - Frequency of cover crop species October 2008.

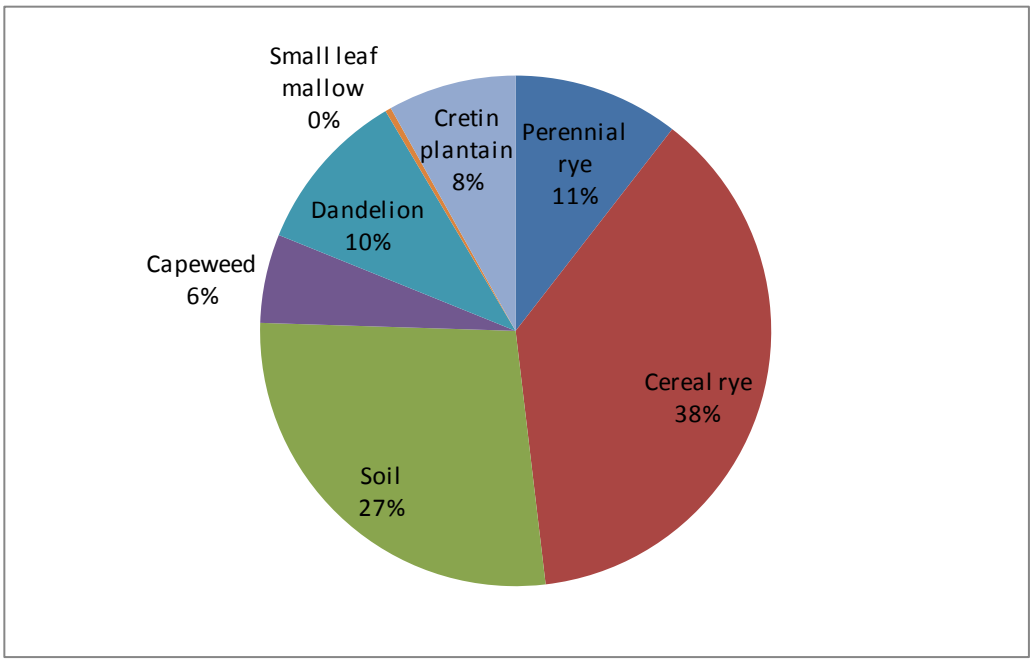
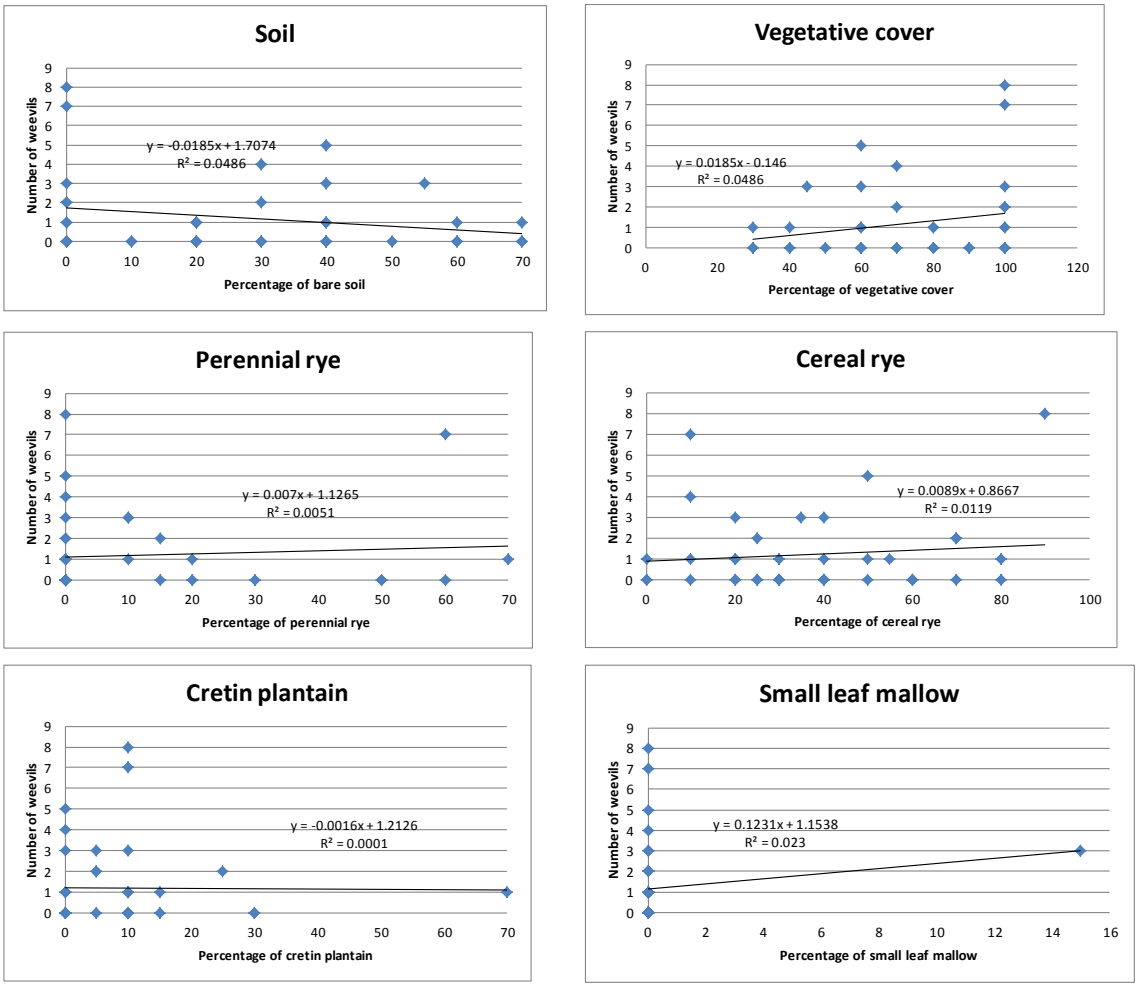
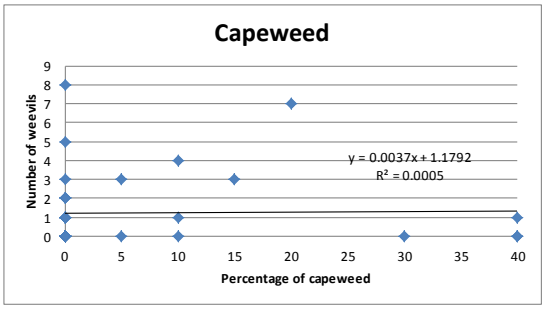


Figure 4.25 Vineyard 4 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, October 2008.





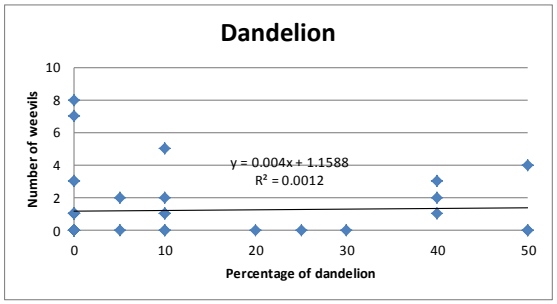


Figure 4.26 Vineyard 4 - Frequency of cover crop species December 2009.

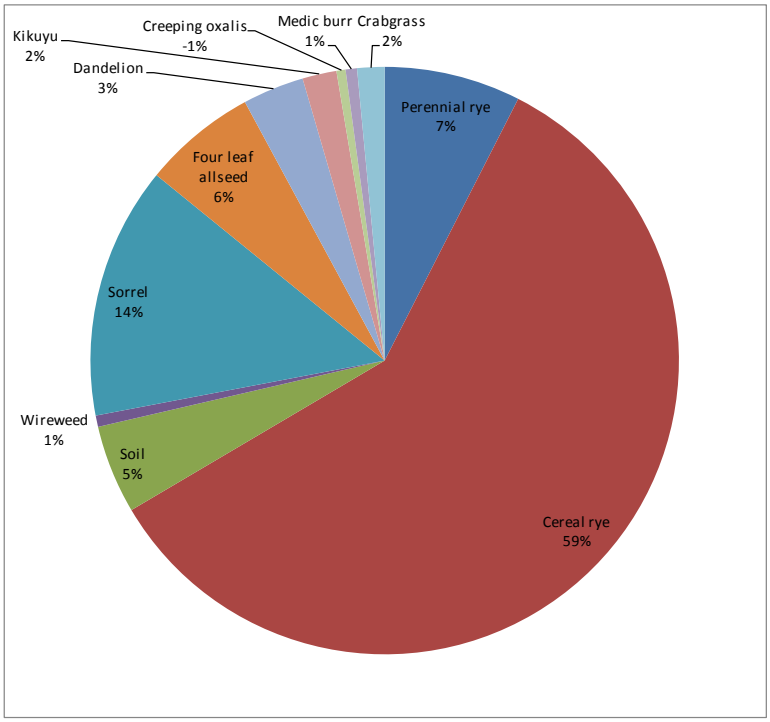
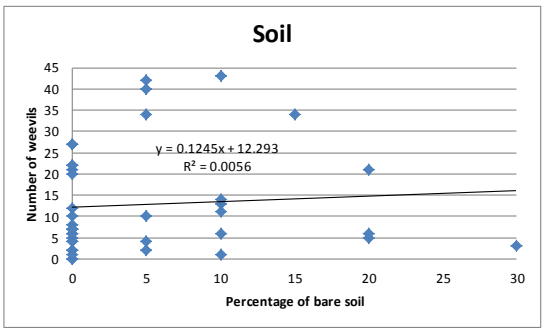
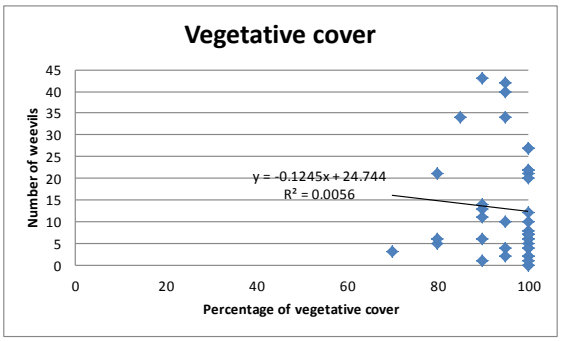
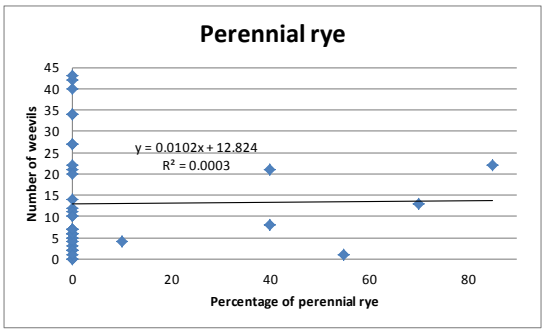
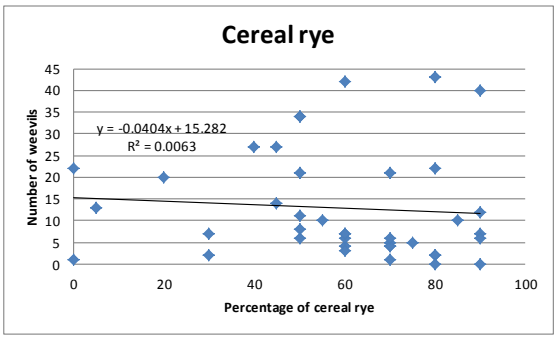


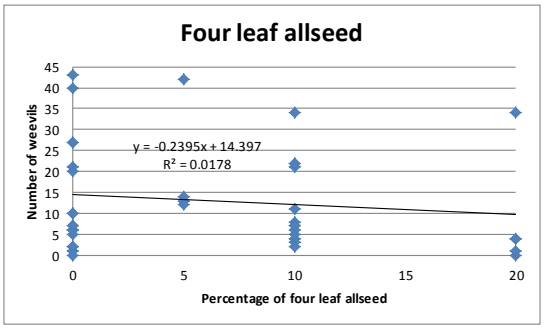
Figure 4.27 Vineyard 4 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, December 2009.

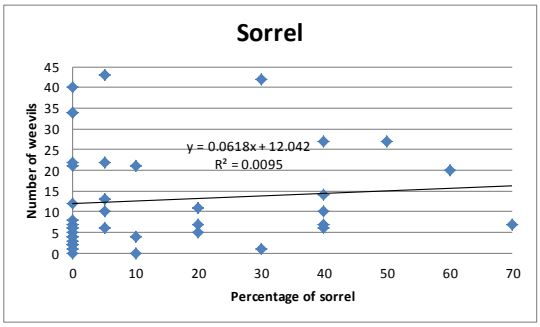


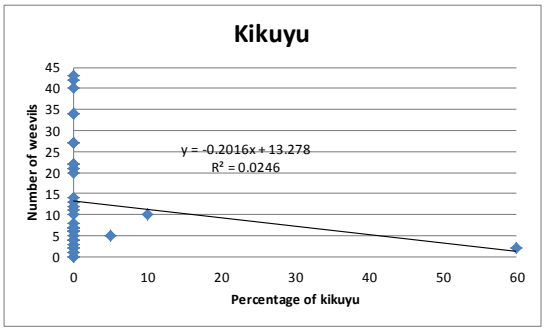


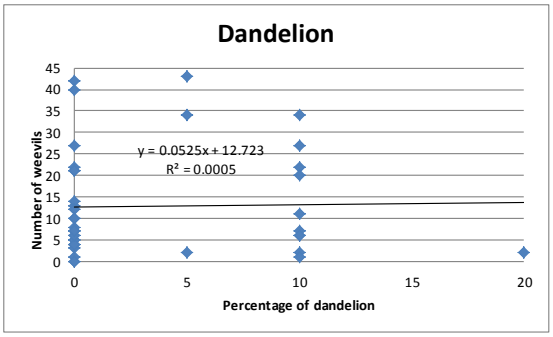












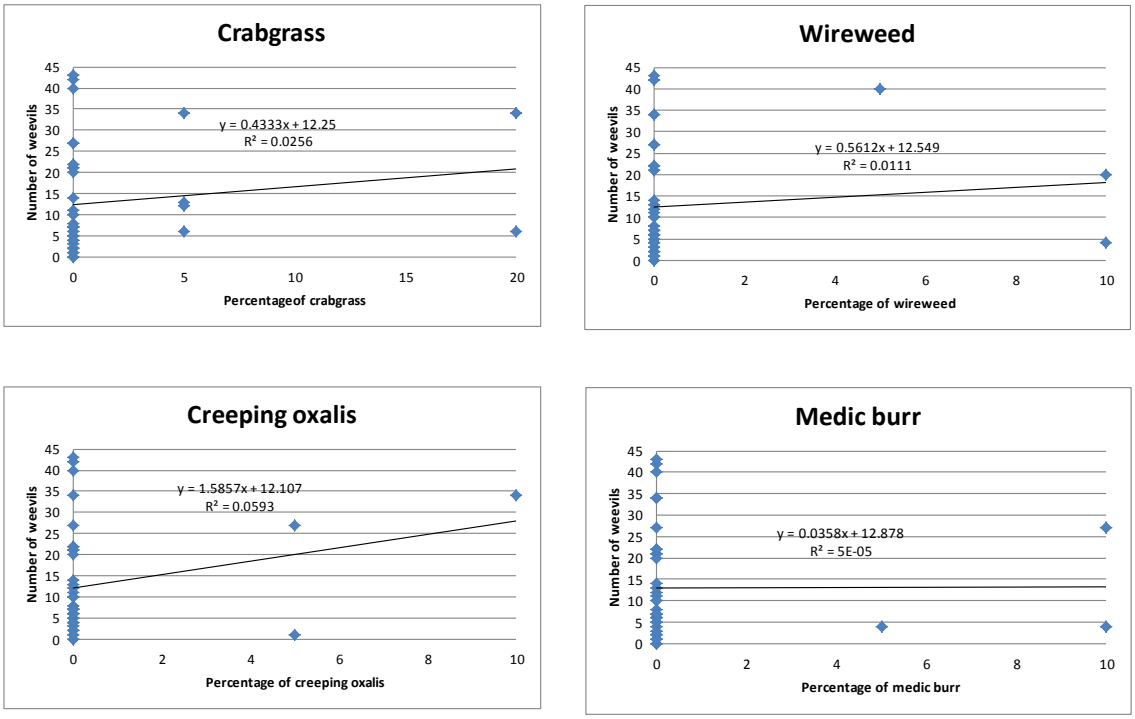


Figure 4.28 Vineyard 4 - Frequency of cover crop species August 2010.

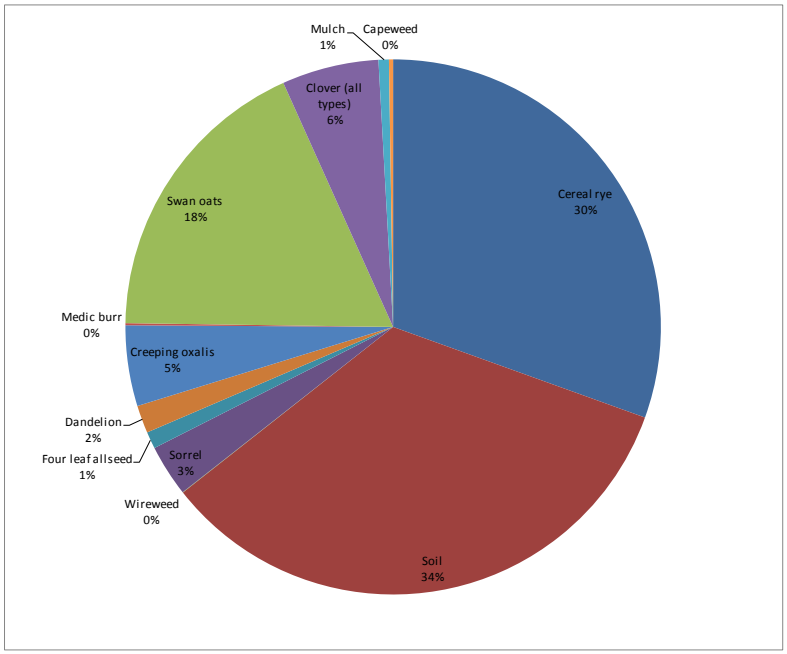
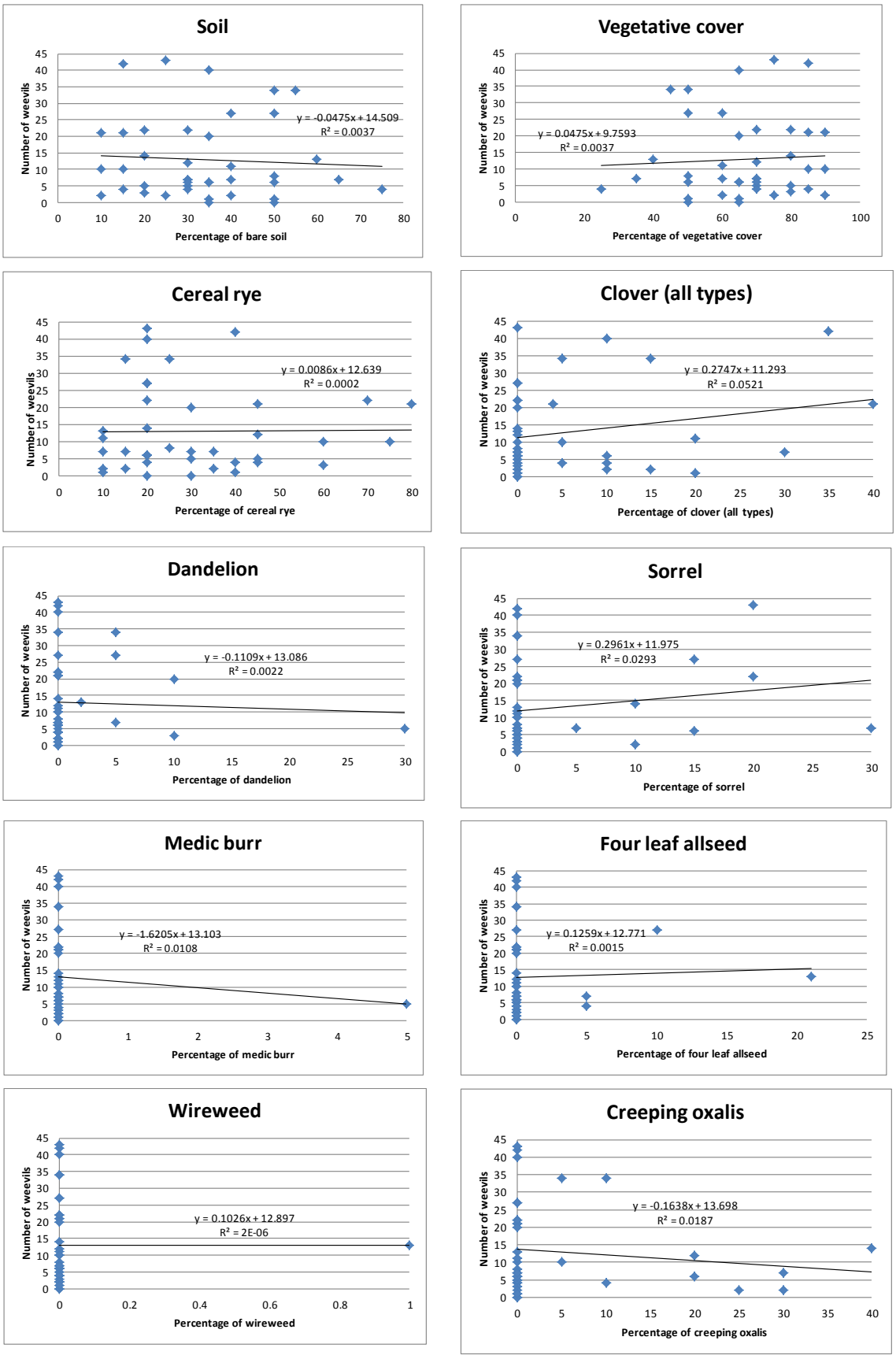
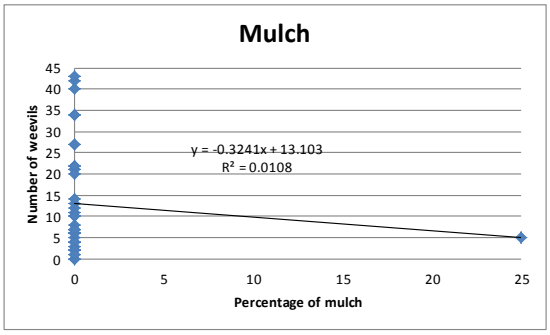
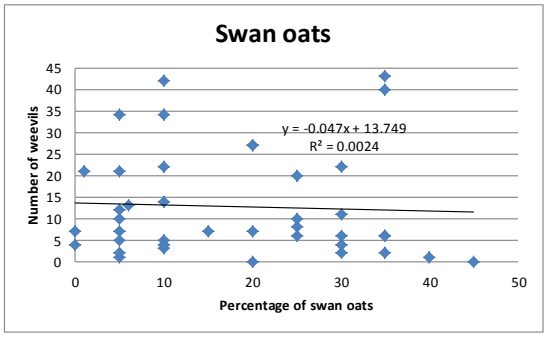
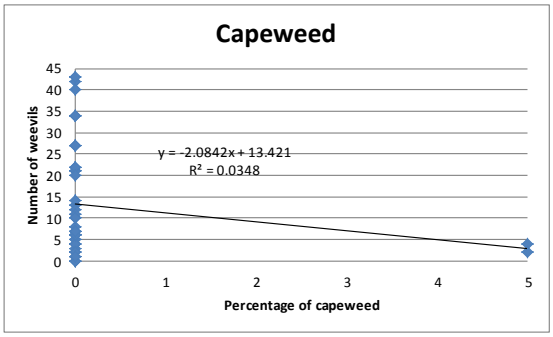


Figure 4.29 Vineyard 4 - Number of weevils versus the percentage of each cover crop species found at each monitored vine, August 2010.









Discussion

Weevil numbers were higher in vines gown on heavier soil types but the results are slightly skewed as there was a higher frequency of vines grown in heavier soils in the test vineyards. The soil type affects the soil temperature which may affect the garden weevil hatching and larvae growth. However, this was not tested in this study.

The results did not show any correlation between mid-row species and weevil numbers. It has been said that Capeweed provides an overwintering support for garden weevil but there was no evidence to support this statement in this study.

The Garden Weevil canopy scoring system gives the viticulturist an indication of the damage in the vineyard canopy but does not necessarily give a true indication of the number of weevils present.

Objective 5 - Assess new methods of physical exclusion carriers and inert surface coatings e.g. kaolinite clay products to reduce garden weevil damage.

Introduction

The main means of protecting grapevines from attack by garden weevil is with the application of synthetic insecticides. Total reliance on such an approach has long term adverse implications such as the possibility of such products being rendered ineffective through the development of insecticide resistance, the possibility of outbreak of secondary pests, potential contamination of the crop and the environment and health risks to personnel who handle pesticides.

Any replacement for synthetic pesticides must be effective and economically and environmentally sustainable. Because garden weevil larvae develop in soil and adults are flightless, the option of trunk exclusion is a possibility for crop protection. One such exclusion method that involves the use of sticky polyethylene bands on the trunk has been used successfully in South Africa for many years. Unfortunately the material is labour intensive to apply and does not usually last longer than one season without further attention. Another option that has been considered is the base chemical used for the coating of non-stick cooking equipment – “Teflon”. When dry, this material produces a very smooth surface which insects are unable to climb over. Setting up such a barrier is very expensive – the “Teflon” requires a smooth substrate such as plastic film and the material itself is reasonably expensive.

The fact that one particular type of trunk band can successfully prevent garden weevil adults from accessing the vine canopy provides encouragement to investigate other more cost effective options. Two options suggested for investigation were the use of artificial fibre trunk bands which may physically impede and possibly trap weevil adults as they ascend the vine trunk or vineyard posts. Also, a material used on windscreens to prevent accumulation of water may act in the same way as “Teflon” but at much lower cost. Further to these possibilities are reports that a very highly refined form of kaolin clay has shown activity against some insect pests. Kaolin has the added advantage of being acceptable for organic agriculture. One such commercial product based on kaolin clay is Surround, formulated in the USA. Finally, a compound with the consistency of automotive grease has been developed and used successfully in South Africa for weevil exclusion when the material is applied as band around the trunk; this material is called Barrier Glue.

These options were investigated in field experiments.

Studies involving another species of non-flying weevil pest had demonstrated that a liquid form of chilli extract when applied to fibre bands prevented entry to tree canopies. This product was tested against garden weevil in a laboratory experiment.

Methodology

(i) Field studies

Assessment was made of a range of alternative physical barriers and kaolinite clay products when applied to vine trunks and support posts and for kaolin to the vine canopy for the reduction of garden weevil impact. This range of treatments was tested in both replicated small scale experiments and larger scale demonstration plots in a number if vineyards in the southwest region of Western Australia.

The details of treatments are given in Table 5.1. The exclusion treatments, including the application of alpha-cypermethrin insecticide as a trunk drench were applied during spring either before weevil emergence was detected or in the early stages of weevil emergence. The time of application of the latter treatments and foliar spraying was determined by the abundance of garden weevil adults and were made when reasonable numbers of adults were present. Any follow up applications were made on the basis of continuing presence of reasonable numbers of weevils, or applied according to a pre-determined interval.

Table 5.1. Details of treatments used in exclusion experiments to protect grapevines from damage by garden weevil adults.

Product (Company)	**Active ingredient (concentration)**	**Rate applied**	**Comments**
Surround WP (Engelhard)	refined kaolin (950g/kg)	Foliar spray: 5kg/100L; then 2.5kg/100L	For trunk drenching, the higher rate was used for all applications. Spray solution requires continuous agitation to maintain a suspension.
Avatar (Du Pont)	indoxacarb (300g/kg)	17g/100L	Foliar application can be applied up to barrier 1mm size(EL31)
“Fluffy” synthetic fibre (Tontine)	Unbonded fibre	-	Applied to the vine trunk as a complete band 150mm wide and attached with electrical tape.
“Grey” synthetic fibre (Tontine)	Bonded fibre	-	As above.
Barrier glue (Piston Power, South Africa)	Unspecified; has the consistency of automotive grease	-	Applied as a band 20mm wide on “Silo tape” wrapped around the vine trunk.
Tac gel (Garrards P/L)	polybutane (912g/kg)	-	Applied as a band 20mm wide directly to the vine trunk after removing loose fibrous outer bark.
RainX	polysiloxanates	-	Water repellent material. Applied as a trunk band over black plastic to prevent weevil traction across the band.
Chilli Plus (Organica Aust P/L)	na	10ml/L	Applied to synthetic fibre trunk band. This product contains natural pyrethrum.
Chilli Wax (Organica Aust P/L)	na	10ml/L	Applied to synthetic fibre trunk band.
Pyrethrum SF Insecticide (Kendon)	pyrethrins (75g/L) and piperonyl butoxide (300g/L)	2ml/L	Spray solution applied as a trunk and post drench. Half to 1 L applied per vine and post.
Dominex Duo	alphacypermethrin (100g/L)	100ml/100L	Spray solution applied as a trunk and post drench. Half to 1 L applied per vine and post.

The abundance of garden weevil adults was assessed using single faced corrugated cardboard monitoring bands. The bands were coated in wax which made them waterproof. Hook and loop Velcro strips were stapled to each end of the bands that allowed them to be attached to the vine trunk. These bands were placed just below the

crown of vines. A calico groundsheet was spread under the band before it was removed to ensure all weevils hiding under the band were counted. Weevils left on or in the band were also dislodged onto the groundsheet. After identifying and counting the number of garden weevil adults, they were flicked off the sheet near the base of the vine.

Garden weevil damage to grapevines was assessed by a general canopy score based on the extent of leaf scalloping and general damage to grape bunches (see Table 3.1).

Yield was assessed on a per panel basis by hand harvesting.

(a) Large plot demonstration of kaolin

A block of Chardonnay grapes was used for a demonstration study on the efficacy of kaolin clay to protect grapevines from garden weevil during 2005/06. Four treatments were applied: untreated; Surround; Avatar and Dominex (see Table 5.1 for details). Single treatment plots were used and consisted of 6 panels with 4 vines per panel in 8 adjacent rows. The central two panels of the central two rows, that is four sites in each treated plot, were monitored for garden weevil adults at roughly weekly intervals during the growing season.

Dominex trunk drenching was undertaken when weevil emergence commenced and was applied using a HARDI backpack and single nozzle hand lance.

Avatar and Surround were applied to the vine canopy after significant numbers of weevils had emerged signalling the main emergence of weevils. Two follow-up applications of Surround were made up to early summer. The foliar applications were made using a vehicle mounted spray rig.

As well as monitoring numbers of adult weevils, canopy and bunch damage was noted and yields assessed.

(b) Replicated plot trials on physical exclusion

A small scale replicated field trial comparing a range of physical exclusion methods was undertaken in a block of Chardonnay grapevines in 2005/06. Six treatments were compared: untreated, fluffy and grey synthetic fibre trunk bands, Barrier Glue, RainX and Surround as a trunk drench (see Table 5.1 for details). Treatment plots consisted of one panel (four vines) and two half panels at either end – the half panels acting as buffers to the adjacent treatment along the vine row. There were six replications.

The abundance of garden weevil adults was monitored using a cardboard trunk band placed above the exclusion treatment on the vine trunk. When the start of weevil emergence was indicated by weevil numbers in the monitoring bands, the exclusion treatments were applied: 17 and 18 October for the grey synthetic fibre bands and Barrier Glue and RainX treatments, 21 October for the fluffy synthetic fibre band and 4 November for the Surround trunk drench.

As well as monitoring numbers of adult weevils, canopy and bunch damage was noted and yields assessed.

A second small scale replicated field trial comparing three physical exclusion methods was undertaken in a block of grapevines in 2007/08 in the Porongorups region of WA. Treatments compared were: untreated, grey (bonded) synthetic fibre trunk bands, Barrier Glue (grease), and repellent (polybutane) sticky trunk bands. Treatment plots consisted of four vines, two either side of the vine support post. The first and last vines in the series of four acted as buffer vines between treatments. All measurements of weevil abundance, canopy damage and yield were made on these two vines adjacent to the support post. There were four replications.

(c) Replicated plot trials on kaolin applied to the vine canopy

Two replicated field trials with the same treatments were undertaken in the Pemberton and Margaret River regions in 2006/07. Kaolin was applied as a foliar spray and compared with the insecticide indoxacarb (Avatar) applied as a foliar spray at different times in relation to the emergence pattern of garden weevil adults. These treatments were compared with untreated vines and vines protected with a repellent sticky trunk band (polybutane). Treatment plots consisted of one panel (four vines) and two half panels at either end – the half panels acting as buffers to the adjacent treatment along the vine row. There were six replications.

(d) Demonstration of trunk drench application of kaolin

The effect of trunk drench application of kaolin on protecting vines from garden weevil damage was assessed in a demonstration study in a vineyard in the Margaret River region in the 2006/07 season. Vines and vine posts in two series of three adjacent rows of grapevines were sprayed with kaolin clay as Surround at 1L of a 5kg/100L spray solution. A further two series of three adjacent rows between and next to the Surround treated rows acted as untreated controls. Vines in the central row of the three adjacent rows were monitored for weevil numbers, foliage feeding level and yield assessment. In addition to whether Surround was applied, in each treatment row the vine trunks and posts in alternating panels received a sticky trunk band (polybutane) as a further comparison to the effect of the trunk drench with Surround. There were six paired adjacent panels along each measurement row – paired with respect to the sticky band treatment.

(e) Replicated plot trials on kaolin – trunk drenching

Two small scale replicated plot trials were undertaken in the Pemberton and Margaret River regions in 2007/08 to assess the ability of kaolin used as a trunk drench to protect grapevines from garden weevil infestations. Treatments were: untreated; kaolin at two rates – 2.5 and 5 kg/100L – applied either on a fortnightly schedule or on demand depending upon weevil numbers; and sticky trunk bands (polybutane). Treatment plots consisted of one panel (four vines) and two half panels at either end – the half panels acting as buffers to the adjacent treatment along the vine row. There were six replications.

At both trial sites, the different timing of kaolin application was not able to be executed because weevil numbers were high enough during the weevil emergence period of spring to early summer to require both rates be applied at fortnightly intervals. The trial undertaken in the Pemberton region was subjected to a heavy infestation of garden weevil that caused a high level of damage to untreated vines and some of kaolin treated vines. In mid December given the high numbers of weevils across the trial site and damage level to the vine canopy, the trial site was over sprayed with Avatar insecticide. Measurements of weevil numbers and damage continued to crop maturity and yield for each treatment was assessed.

(ii) Laboratory study

Replicated pot trial on physical exclusion

This experiment was conducted in the laboratory using plant pots filled with crushed metal to 20mm from the top, which supported a pine rod 25cm long, 19mm diameter. A rolled up fresh grapevine leaf was fixed to the top of the rod with a drawing pin. The exclusion treatments listed in Table 5.2 were placed on the pine rod approximately 10cm above the crushed metal. The inside edge of the plant pot above the layer of stones was painted with liquid Teflon, a material on which weevil adults are unable to gain footholds. Ten garden weevil adults were introduced into the pots and the rolled leaf was checked for the presence of weevils at 24 and 48 hours after they were introduced. The experiment was

repeated 28 days later without renewing any of the treatments and weevils again checked 24 and 48 hours after introduction. Each treatment was replicated 5 times.

Table 5.2. Treatments applied to pine poles in the laboratory to compare their ability to prevent weevils climbing them.

Treatment
Untrtd
grey (bonded) dacron flat
grey (bonded) dacron with skirt
grey (bonded) dacron flat + Enviro Spray Ultrawax @ 10ml/1L
grey (bonded) dacron flat + Enviro Spray Barrier Plus @ 10ml/1L
grey dacron (bonded) skirt + Enviro Spray Barrier Plus @ 10ml/1L
fluffy (unbonded) dacron
fluffy (unbonded) dacron + Enviro Spray Ultrawax @ 10ml/1L
fluffy (unbonded) dacron flat + Enviro Spray Barrier Plus @ 10ml/1L
Surround @ 5kg/100L

Results

(i) Field studies

Data obtained form these experiments were analysed with ANOVA where the number of garden weevil adults required transformation to square roots to normalise the data. In the following figures, bars represent LSD $_{0.05}$ for each sampling occasion and where significant differences among means of treatments were obtained, the level is represented as *** = P<0.001; ** = P<0.01; and * = P<0.05; ns = no significant difference found.

(a) Large plot demonstration of kaolin

The abundance of garden weevil adults, canopy damage scores and plot yields are given in Figs. 5.1a, b and c respectively. All treatments reduced the abundance of garden weevil adults compared to untreated areas with a greater reduction by Avatar and Dominex treated areas. This was reflected in the feeding damage scores but there was no significant difference in yield among the treatments.

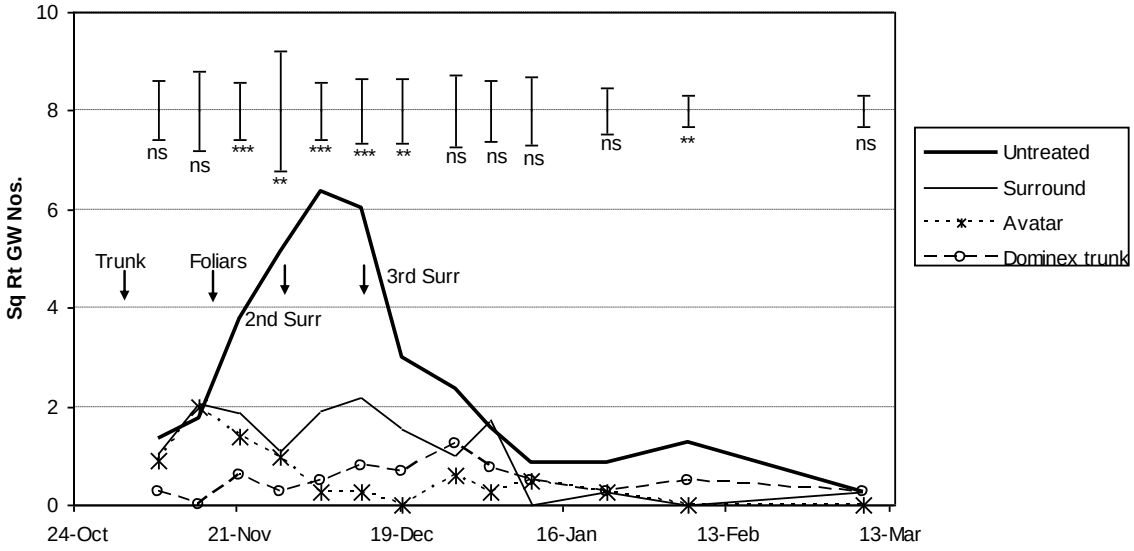


Fig. 5.1a. Average number of garden weevil adults in trunk monitoring bands on untreated vines, foliar applications of Surround (kaolin clay) or Avatar insecticide, or where trunks were drenched with Dominex insecticide. Vineyard unreplicated demonstration 2005/06.

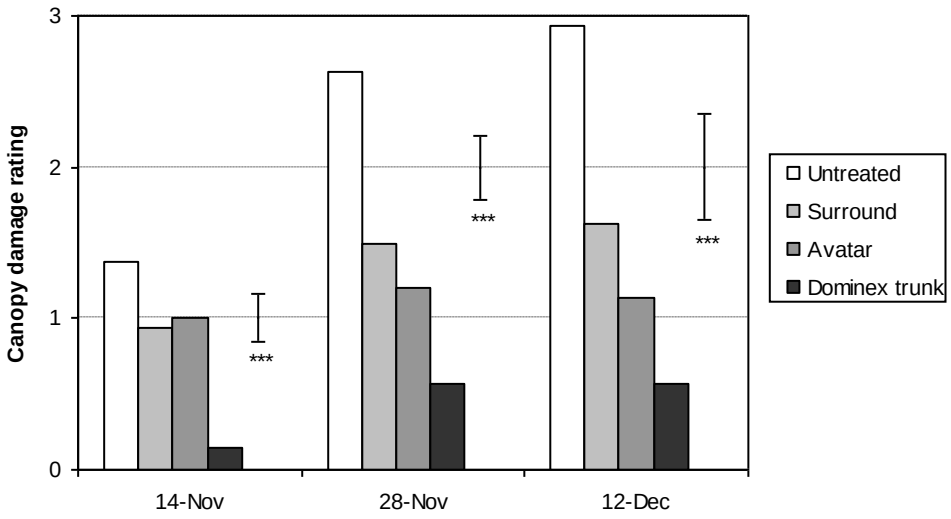


Fig 5.1b Canopy damage rating on untreated vines, foliar applications of Surround (kaolin clay) or Avatar insecticide, or where trunks were drenched with Dominex insecticide. Vineyard unreplicated demonstration 2005/06.

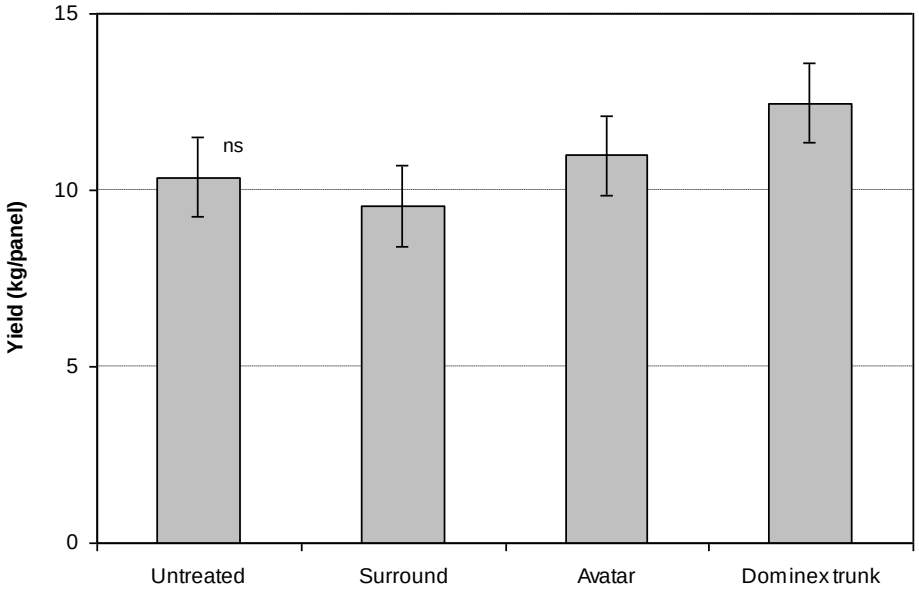


Fig.5.1c. Average yield per panel from blocks of vines either untreated, or canopy or vine trunks treated with products to assess their ability to reduce the impact of garden weevil adults as described in Fig. 1 a. Vineyard unreplicated demonstration 2005/06.

(b) Replicated plot trial on physical exclusion

The abundance of garden weevil adults, canopy damage scores and plot yields are given in Figs. 5.2a, b and c. The treatment resulting in a sustained reduction in weevil abundance was the South African grease. This result was achieved only after continual maintenance of the grease band. As the season progressed and the substrate band of sticky backed tape used as the substrate for the band “slipped” on the trunk of the vine, a strip of band without grease appeared. This strip was covered in grease by wiping grease over it from adjacent areas on the band. The artificial fibre trunk exclusion bands resulted in intermediate but not consistently significantly lower abundance levels in weevil

numbers. The trunk drench with Surround and RainX resulted in slightly lower numbers of weevil abundance in bands, but this was not significantly lower than untreated plots.

The result in weevil numbers was reflected in the canopy damage score with the lowest score achieved in vines protected from garden weevil with the grease.

Likewise for yield, only plots treated with the grease resulted in a significantly greater yield than both untreated plots and those receiving a trunk drench of Surround. Yields in the other trunk exclusion treatments were not significantly different to that for untreated plots.

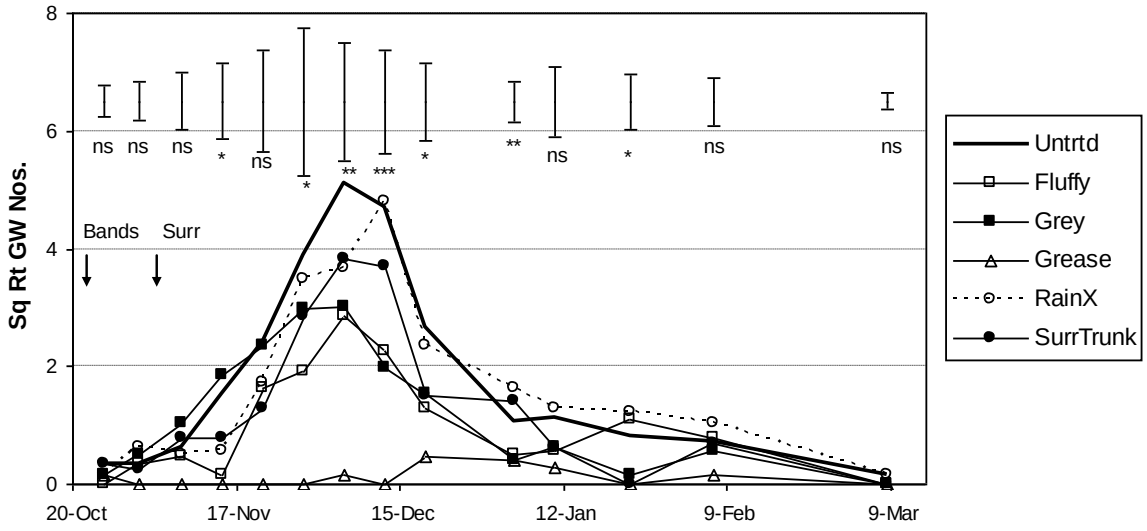


Fig. 5.2a: Average number of garden weevil adults in trunk monitoring bands on untreated vines or with exclusion barriers: Fluffy = unbonded artificial fibre band; Grey = bonded artificial fibre band; Grease = grease like material “Barrier Glue” ; RainX = solution; SurrTrunk = kaolin clay applied directly to the vine trunk. Vineyard replicated trial Pemberton region 2005/06.

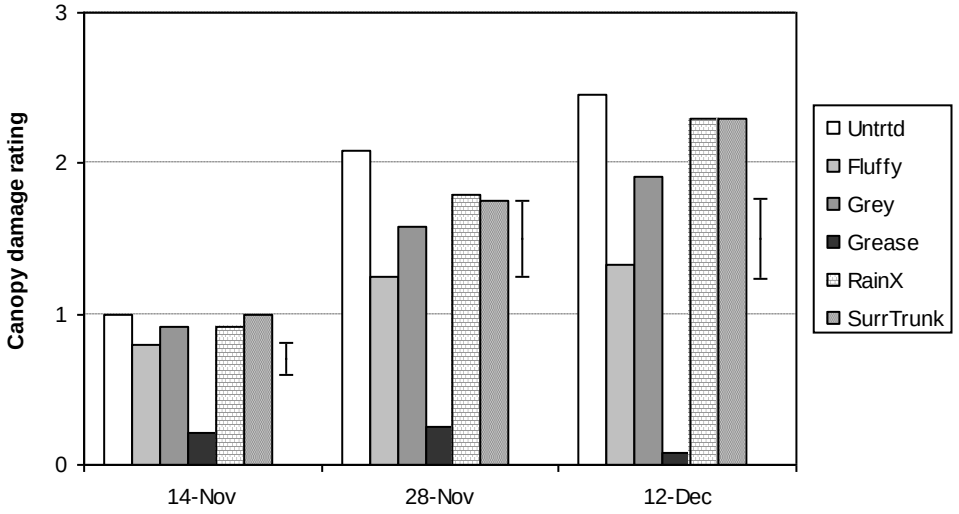


Fig 5.2b. Canopy damage rating for treatments described in Fig. 5.2 a.

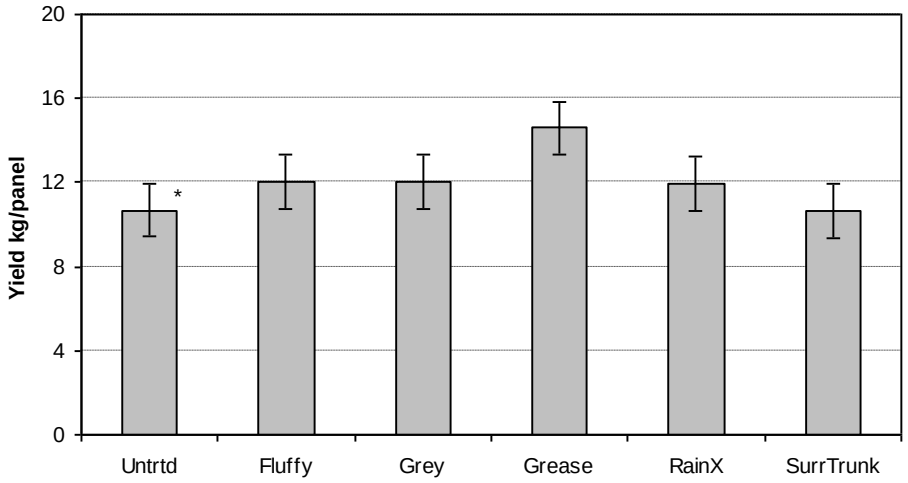


Fig. 5.2c: Average yield per panel from vines where exclusion barriers were placed on the trunks of vines to assess their ability to reduce the impact of garden weevil adults as shown in Fig. 2 a.

For the trial in The Porongorups region, weevil abundance, canopy damage score and yield are given in Figs. 5.3 a, b, c respectively.

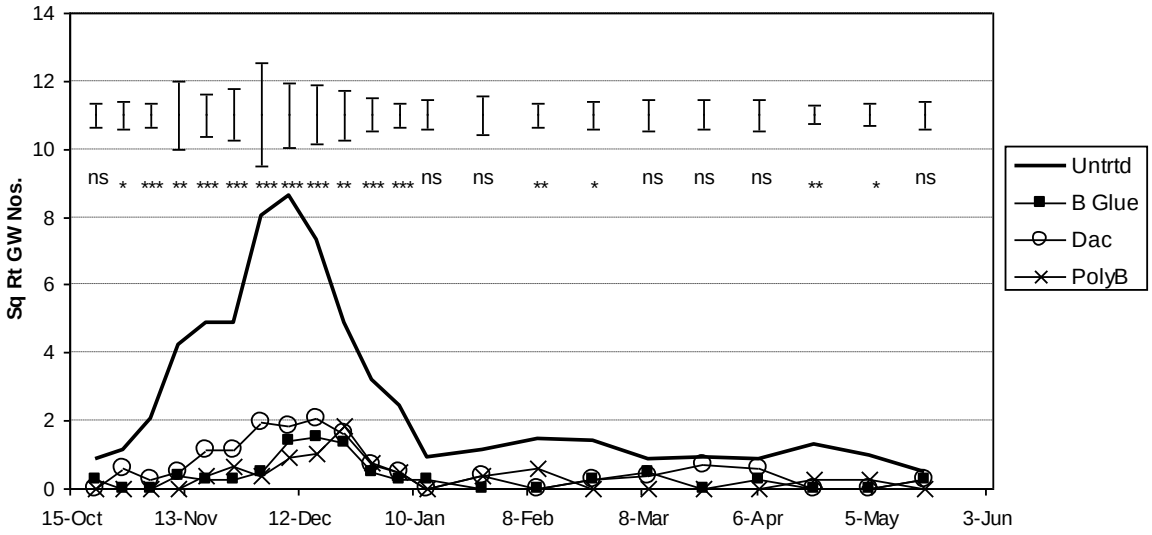


Fig. 5.3 a. Average number of garden weevil adults per trunk monitoring band on vines either untreated or with exclusion bands: B Glue = Barrier Glue; Dac = bonded artificial fibre band; Poly B = polybutane sticky band. Replicated trial 2007/08 in the Porongorups Region, WA.

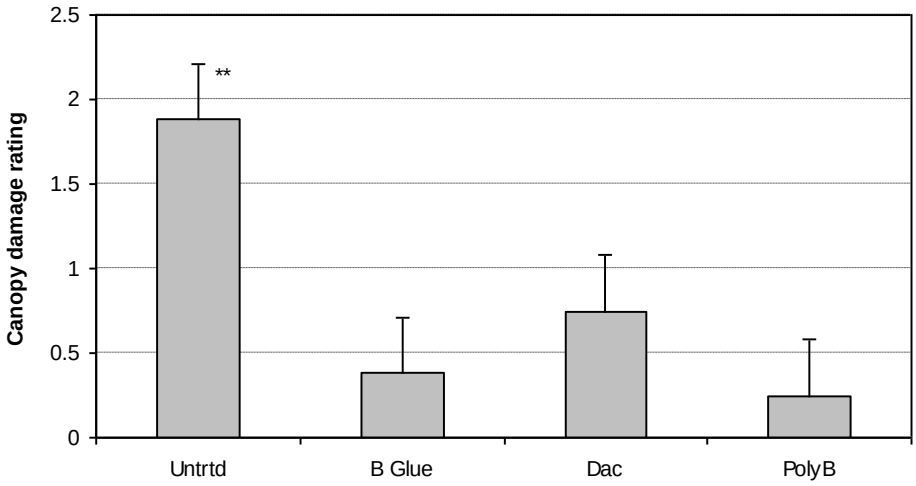


Fig 5.3 b. Canopy damage score for vines receiving treatments described in Fig. 5.3a.

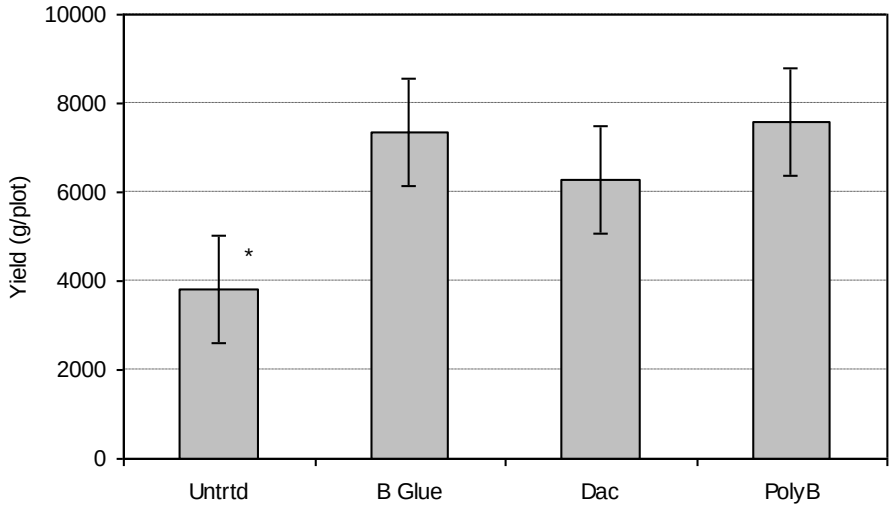


Fig. 5.3 c. Yield of vines for treatments described in Fig. 5.3a.

All trunk barriers resulted in significantly reduced weevil abundance in the vine canopy and a reduced canopy feeding score and an increase in yield. There was no statistically significant difference among the trunk barriers.

(c) Replicated plot trials on kaolin applied to the vine canopy

Two replicated field trials with the same treatments were undertaken in the Pemberton and Margaret River regions in 2006/07. The abundance of garden weevil adults, canopy damage scores and plot yields are given in Figs. 5.4a, b and c for the trial conducted in the Pemberton region and Figs. 5.5a, b and c for the trial conducted in the Margaret River region.

In the Pemberton region trial, the treatment involving sticky repellent trunk bands resulted in the greatest reduction in weevil numbers. The early application of Avatar resulted in the next most consistent reduction in weevil numbers. Vines sprayed with a foliar application of Surround and the two later application times for Avatar resulted in lower but not significantly different numbers of weevil compared to untreated plots.

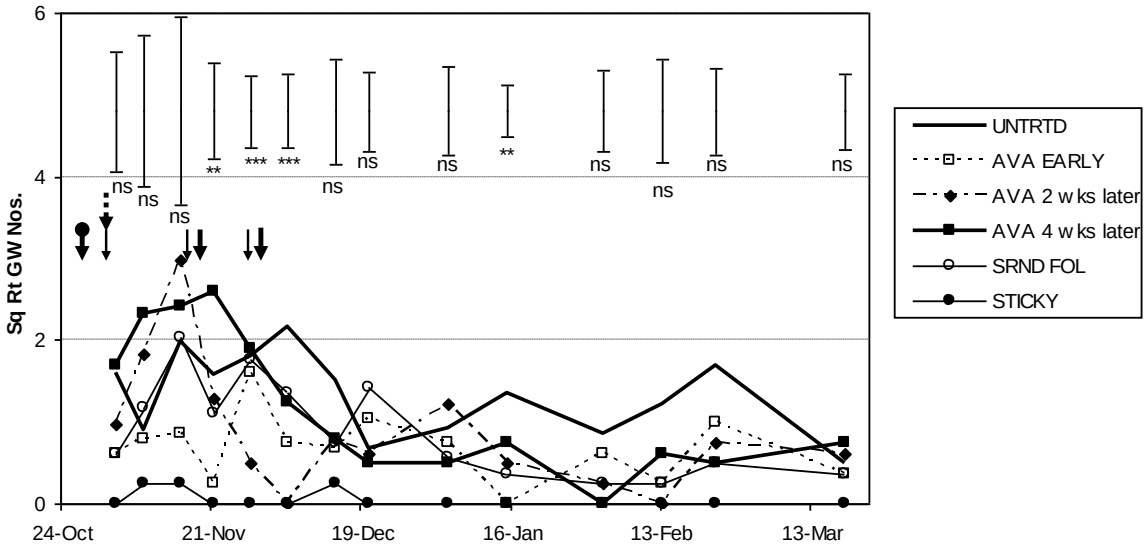


Fig. 5.4 a. Average number of garden weevil adults in trunk monitoring bands on untreated vines in the Pemberton region, where the canopy was treated with Avatar insecticide at different times or Surround (kaolin clay), or where a weevil-excluding sticky material was applied to vine trunks. Vineyard replicated trial 2006/07.

A significantly lower weevil damage canopy score was recorded for the vines treated with the sticky band only. With respect to yield, only the vines treated with sticky material and the first two times of application of Avatar resulted in higher yield than untreated plots. Plots treated with a foliar application of Surround were not significantly different from untreated plots or plots sprayed with Avatar.

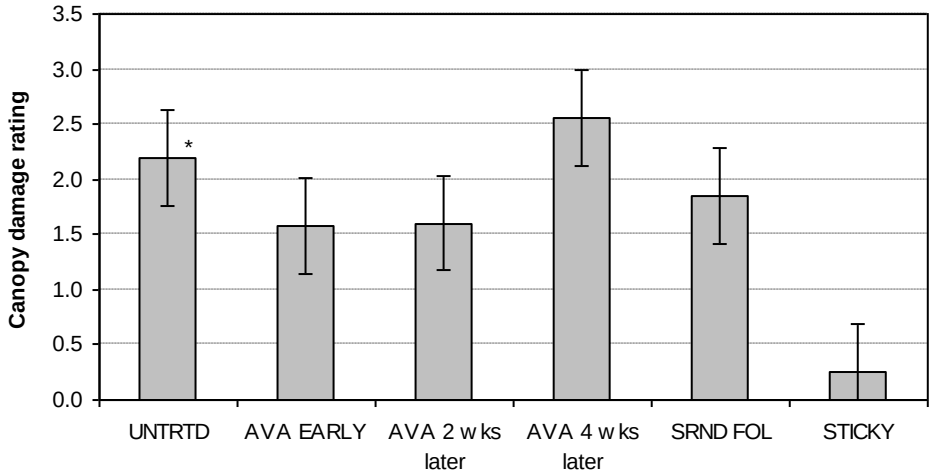


Fig 5.4b Canopy damage rating for treatments described in Fig. 5.3a.

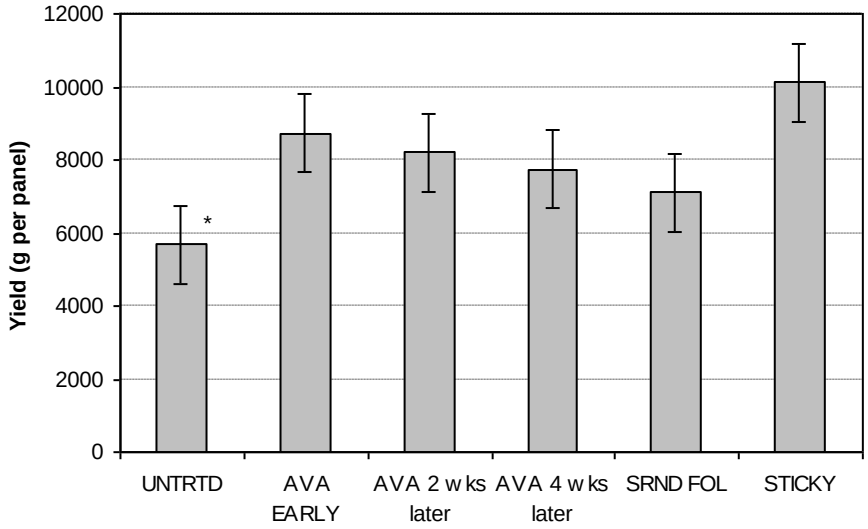


Fig. 5.4 c. Yield of vines for treatments described in Fig. 5.4a.

For the trial conducted in the Margaret River region (Figs. 5.5a, b, c), a similar trend in results was obtained to that found in the Pemberton region trial, with the exception that no significant difference in yield among treatments was found. This occurred despite the abundance of garden weevil being higher in the Margaret River region trial.

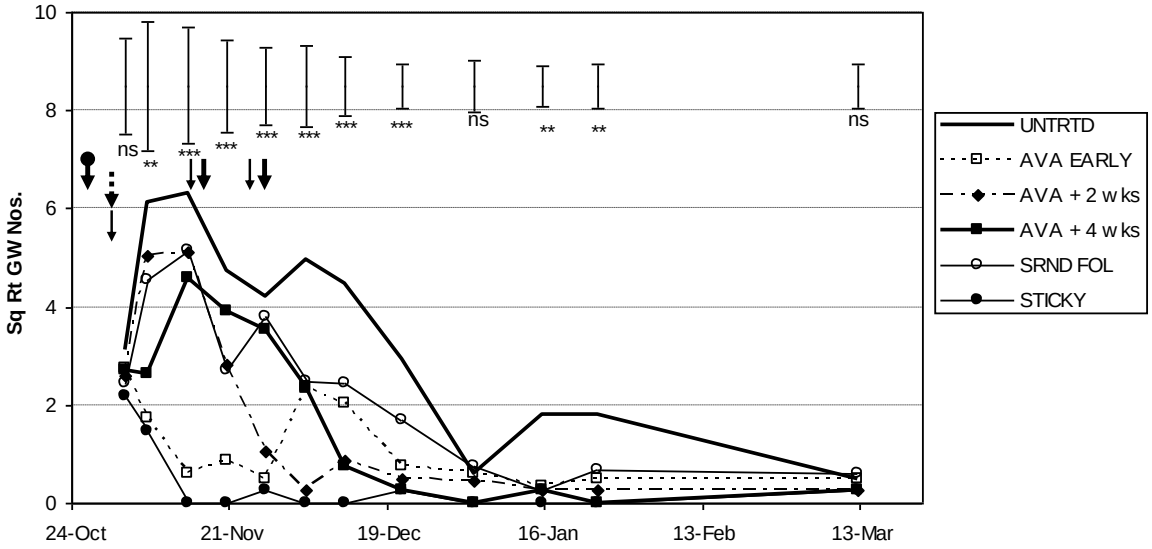


Fig. 5.5 a. Average number of garden weevil adults in trunk monitoring bands on untreated vines in the Margaret River region, where the canopy was treated with Avatar insecticide at different times or Surround (kaolin clay), or where a weevil-excluding sticky material was applied to vine trunks. Vineyard replicated trial 2006/07.

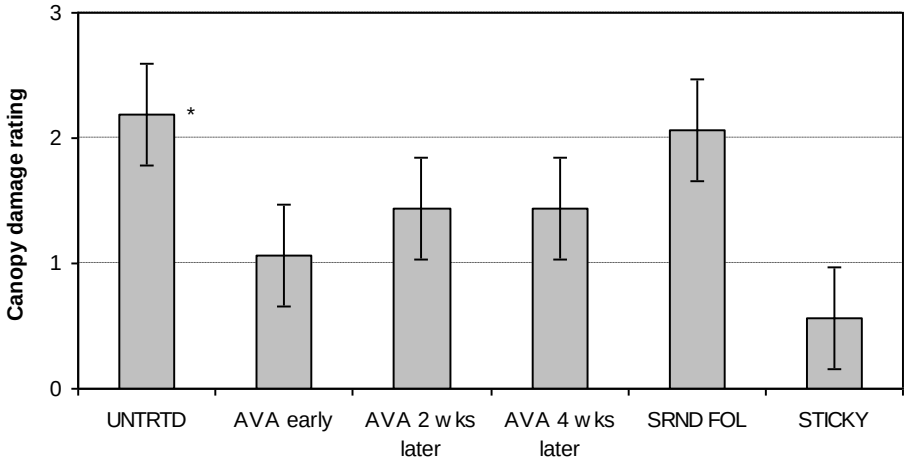


Fig 5.5 b. Canopy rating for treatements described in Fig. 5.4a.

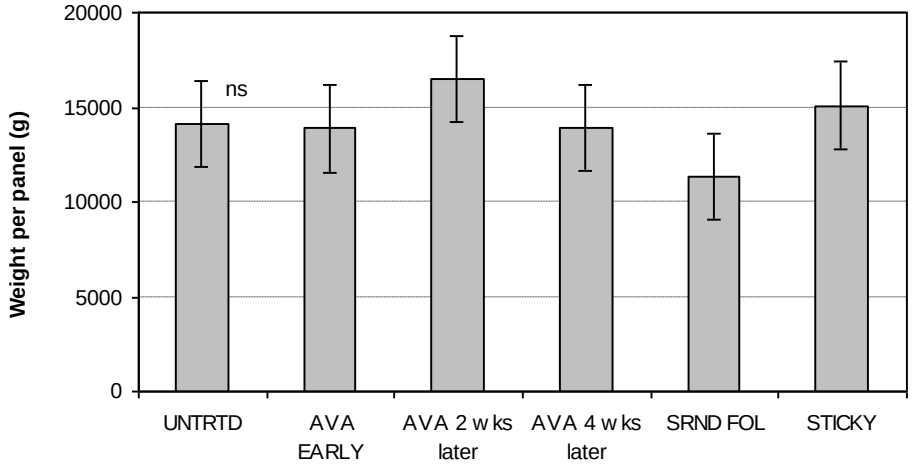


Fig. 5.5 c. Yield of vines for treatments described in Fig. 5.5a.

(d) Demonstration of trunk drench application of kaolin

The abundance of garden weevil adults in this trial was low, but where vine trunks were sprayed with Surround, there were fewer weevils recorded in the trunk monitoring bands (Fig 5.6a). This was reflected in the canopy feeding score, although the highest level was only a score of 1 (Fig. 5.6b). There was no significant difference in yield among the treatments (Fig. 5.6c).

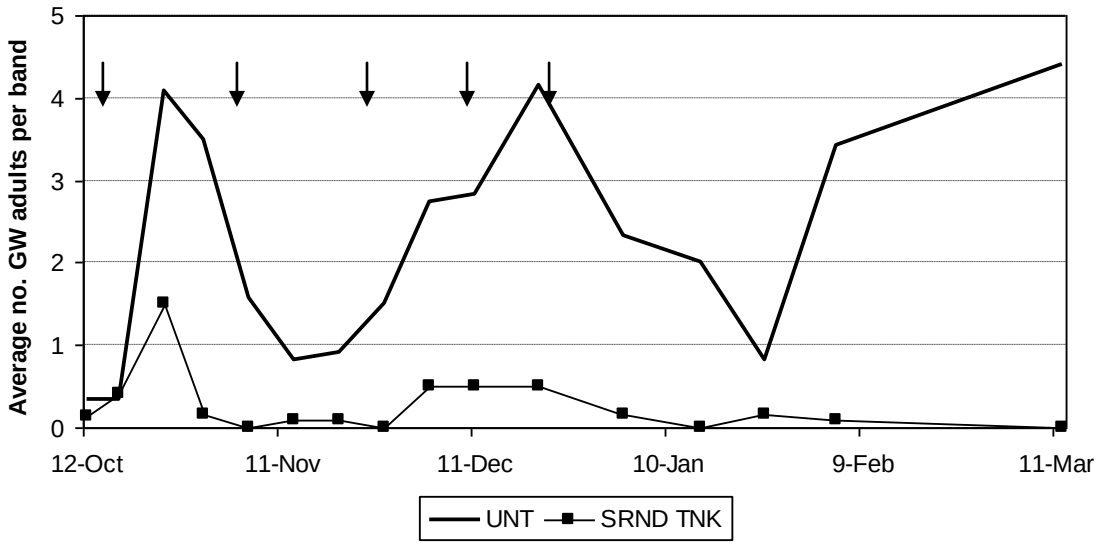


Fig. 5.6 a. Average number of garden weevil adults per trunk monitoring band on vines in the Margaret River region either untreated or where trunks were drenched with Surround (kaolin clay). Unreplicated demonstration 2006/07. Abundance of garden weevil adults was not monitored on vines where polybutene sticky bands were applied that were adjacent to the untreated and Surround treated vines. Unreplicated demonstration 2006/07.

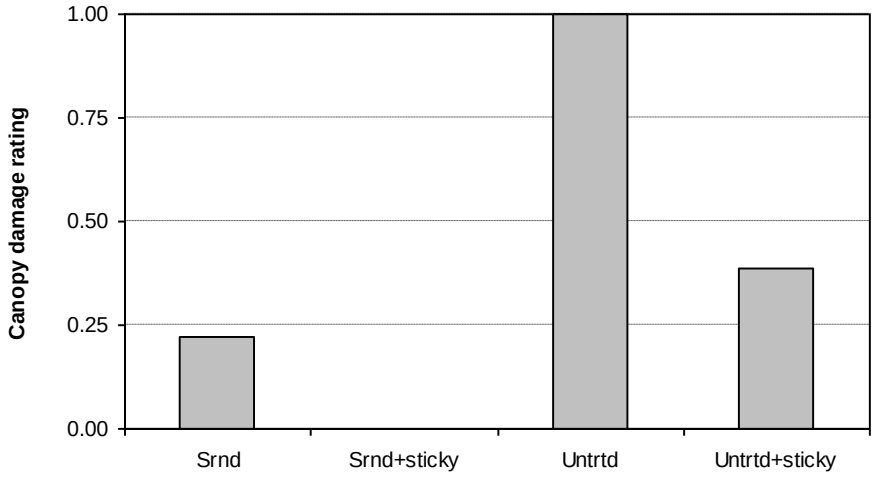


Fig 5.6b. Canopy damage score for vines where trunks were untreated or trunks drenched with Surround and in canopy of vines where a band of polybutane was applied to the trunks. Unreplicated demonstration 2006/07.

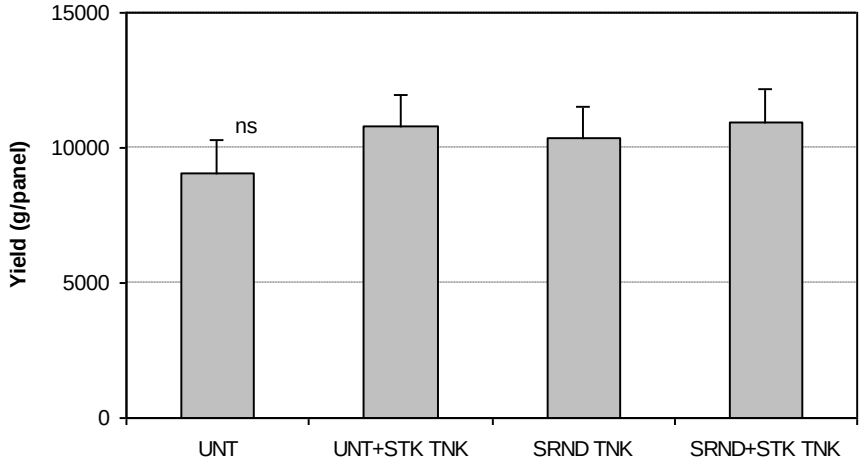


Fig. 5.6c. Average yield from 3 vine plots where trunks were untreated or where trunks were drenched with Surround (kaolin clay) or had a weevil excluding sticky material applied or where both the sticky material and Surround were applied. Unreplicated demonstration 2006/07.

(e) Replicated plot trials on kaolin applied to vine trunks

Two replicated field trials with the same treatments were undertaken in the Margaret River and Pemberton regions in 2007/08. The abundance of garden weevil adults, canopy damage scores and plot yields are given in Figs. 5.7a, b and c for the trial conducted in the Margaret River region.

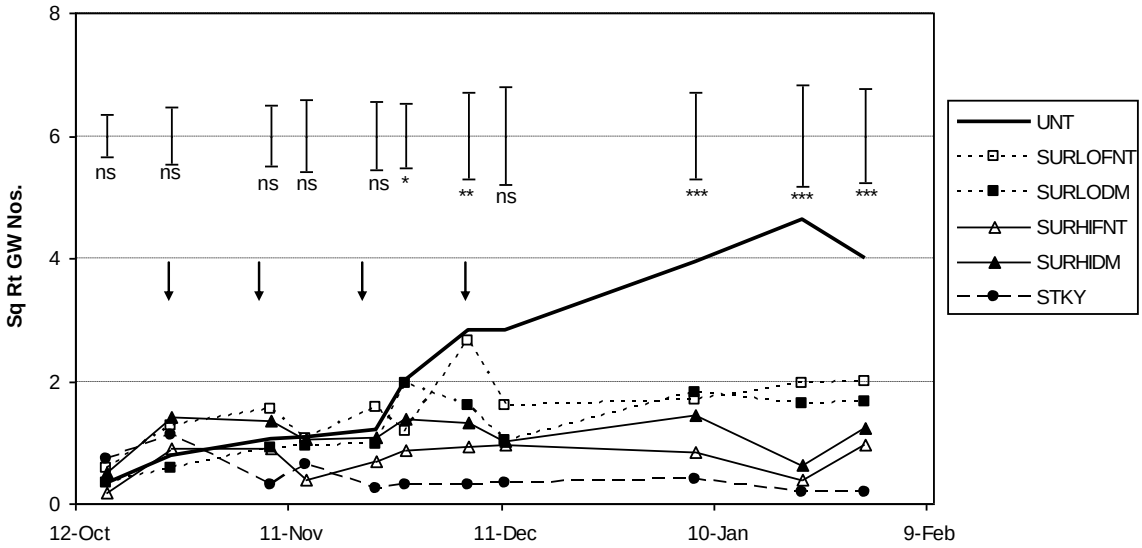


Fig. 5. 7 a. Average number of garden weevil adults per trunk monitoring band on vines either untreated or where trunks were drenched with Surround (kaolin clay) at a low = Lo (2.5kg/100L) or high = Hi (5kg/100L) rate either fortnightly = FNT or monthly = M, or to which a weevil excluding sticky band was applied. Replicated trial 2007/08, Margaret River region WA.

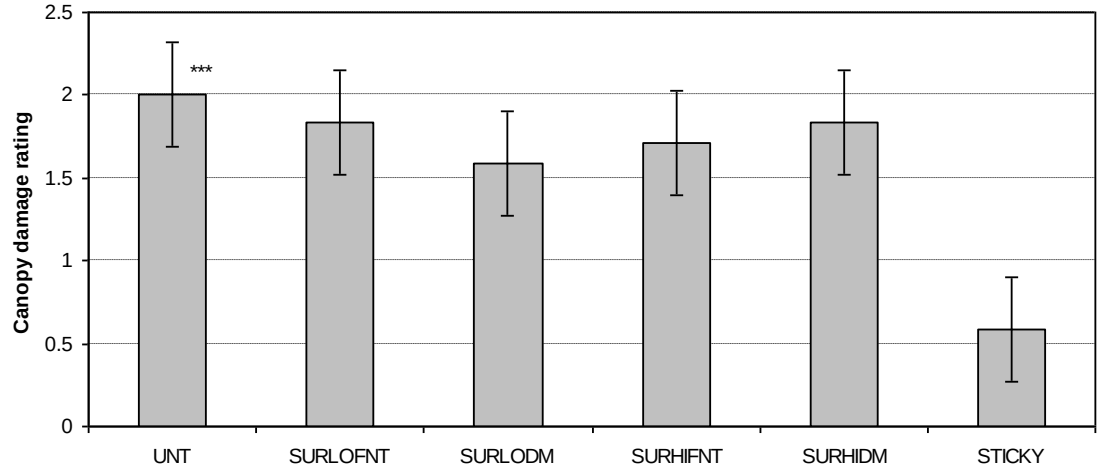


Fig 5.7 b. Canopy damage score for vines receiving garden weevil treatments descibed in Fig. 5.7a.

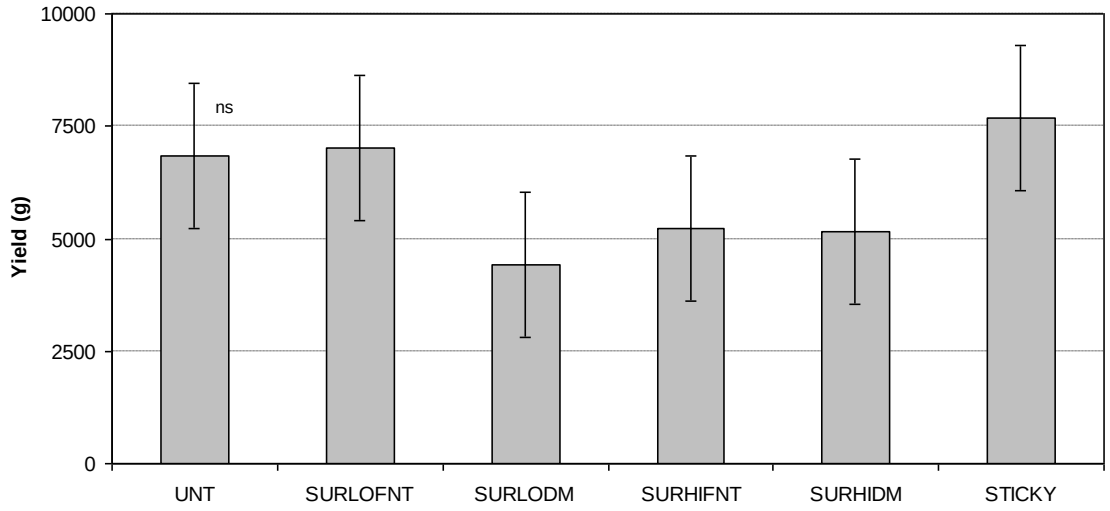


Fig. 5.7c. Yield per panel for vines receiving garden weevil treatments descibed in Fig. 5.7a.

The results of the trial in the Pemberton region on kaolin trunk drenching for garden weevil numbers, canopy damage score and yield are given in Figs. 5.8a, b and c. On three sampling occasion there were significantly fewer garden weevil adults recorded in vines where Surround had been applied. However there was no significant difference in canopy feeding score of Surround treated vines and untreated vines; only the vines with the sticky trunk band had a lower canopy feeding score compared to all other treatments. With respect to yield, both the vines with the sticky trunk band and one of the higher rates for Surround had significantly greater yield than untreated vines or other Surround treated vines.

As stated above, weevil pressure was such that all Surround treatments were applied fortnightly because of weevil pressure, and the trial area had to be oversprayed with Avatar in early December because damage levels in untreated vines and some of those treated with Surround was considered too high.

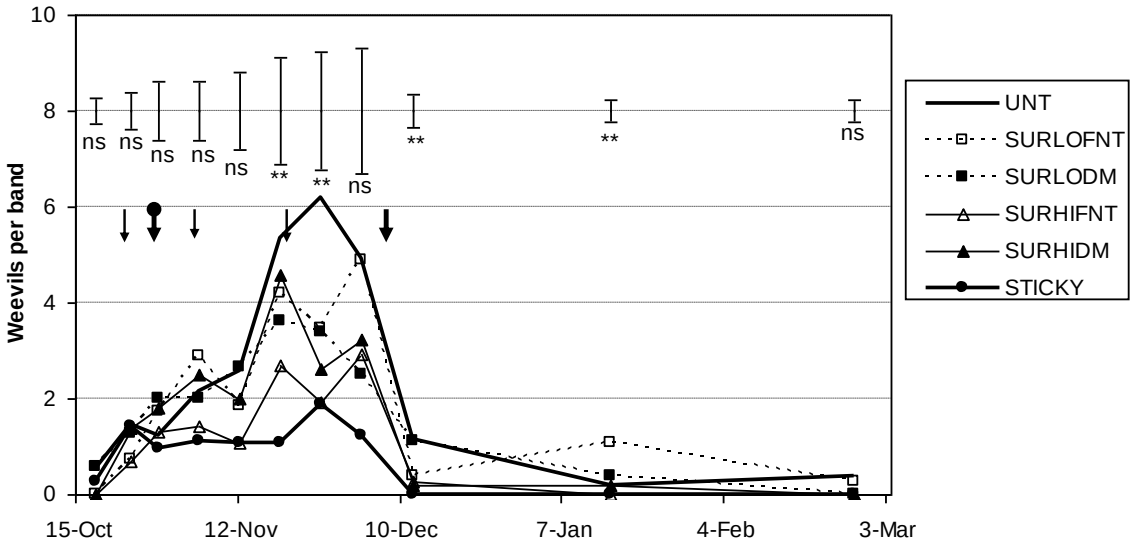


Fig 5.8 a Average number of garden weevil adults per trunk monitoring band on vines either untreated or where trunks were drenched with Surround (kaolin clay) at a low (2.5kg/100L) or high (5kg/100L) rate, or to which a weevil excluding sticky band was applied. Replicated trial 2007/08, Pemberton region, WA. Due to high weevil damage, the trial area was over sprayed with Avatar in early December.

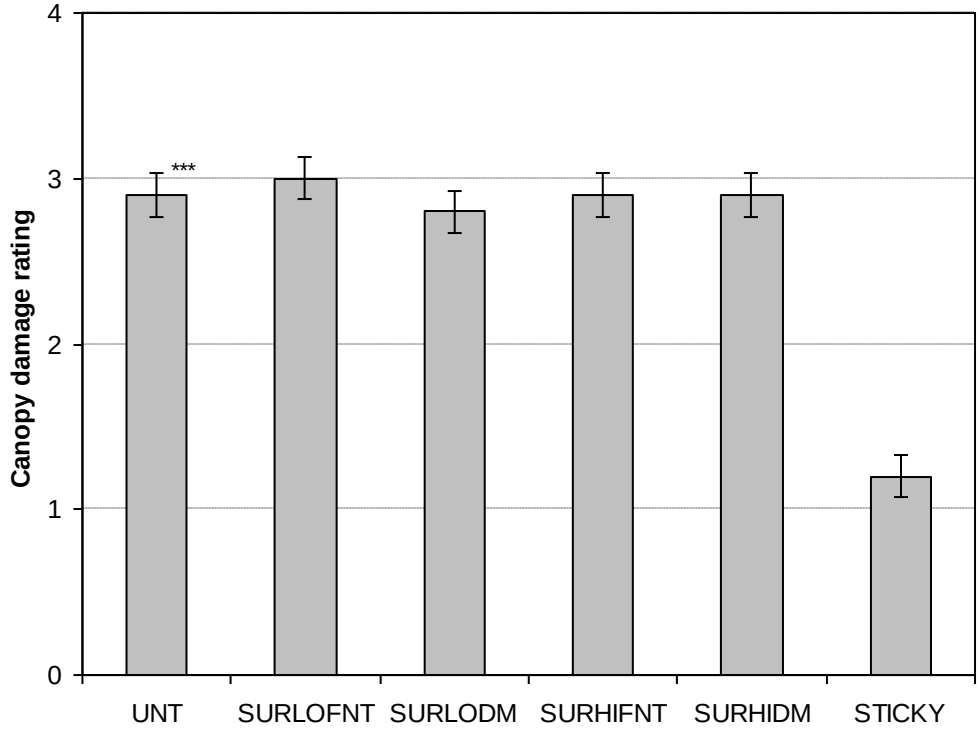


Fig 5.8 b. Canopy damage score for vines receiving treatments described in Fig. 5.8a.

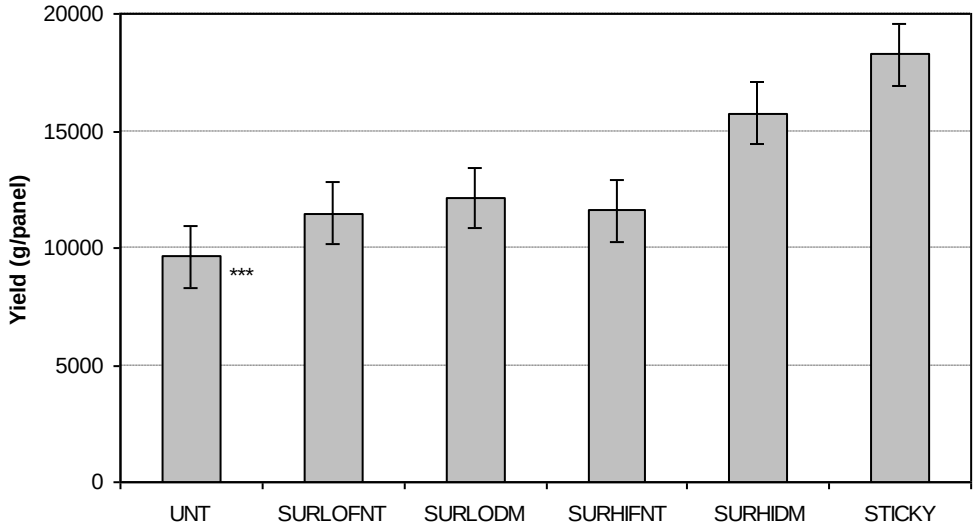


Fig 5.8 c. Yield of vines for treatments described in Fig. 5.8a.

(ii) Laboratory studies

Replicated pot trial on physical exclusion

The average number of weevils present in the leaf at the top of the pine poles is given in Fig. 9. In the first series of measurements in December 2008, the most effective exclusion treatments were those that included the application of “chilli plus” irrespective of whether the artificial fibre band was bonded or not. The “wax” formulation of the chilli was almost as equally effective. The use of unbonded fibre band (fluffy) resulted in fewer weevils gaining access to the top of the pole compared with bonded (grey) fibre bands. Poles treated with Surround allowed reasonable access of weevils.

When the treatments were compared at 28 days after initial application without refreshing any of the treatments and using a new set of garden weevil adults, only those artificial fibre bands treated with the “chilli plus” prevented weevil access.

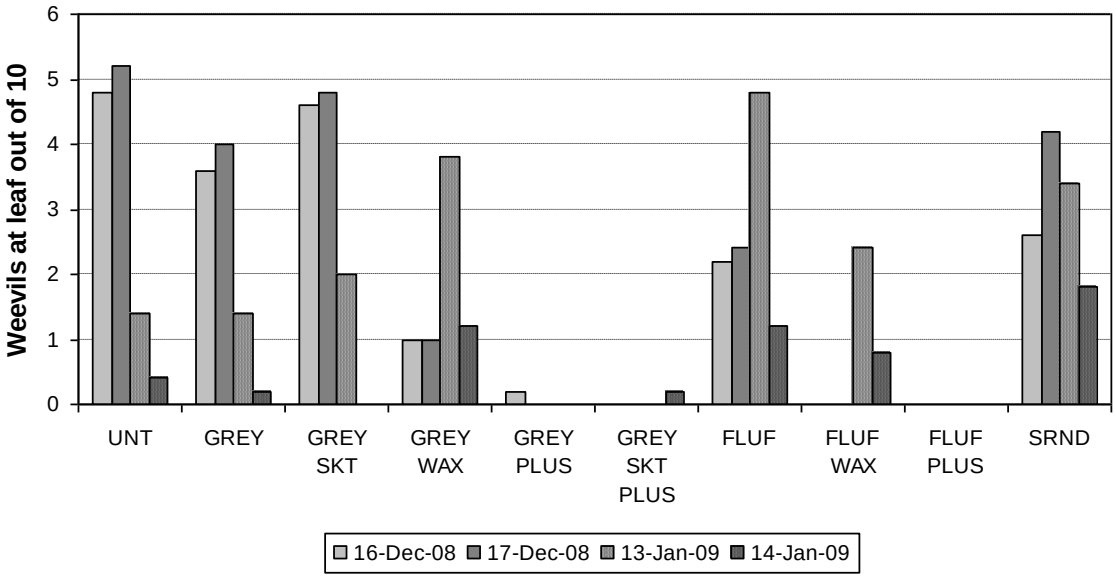


Fig. 5.9. The number of garden weevil adults from a total of ten able to cross various test exclusion treatments placed on a wooden peg on two test occasions in a replicated laboratory trial 2008/09. UNT = no exclusion barrier; GREY = bonded fibre band; FLUF = unbonded fibre band; SKT = fibre band made into an inverted funnel-like skirt; WAX = Type 1 chilli formulation; PLUS = Type 2 chilli formulation; SRND = Surround kaolin clay. See Table 5.2 for further details of exclusion treatments.

Conclusion

Polybutene sticky trunk bands were the most reliable means of excluding garden weevil adults from the vine canopy. This was reflected in higher yields compared to untreated vines.

A similar result was seen with the use of the South African Barrier Glue. A disadvantage of this product as used in the trials was the creation of a gap in the band when placed on silo tape. As the tape pulled back on itself during the season, a small channel of untreated tape appeared. This gap was bridged easily by spreading the glue on each monitoring occasion but the time required to check all bands on a regular basis if it were used commercially on many vines would make this treatment impractical. If it were acceptable to apply the grease directly onto the vine trunk as is the case for the polybutane sticky material, this disadvantage of the grease may be able to be overcome. The grease is easier to apply than the polybutane material. For machine harvested vines, the risk of contamination of harvest grapes with grease is probably too great.

The fibre bands proved very inconsistent – both the unbonded (fluffy) form and the bonded (sheet) form. In only one trial (Fig. 5.3, 2007/08) did this type of barrier demonstrate good ability to exclude weevils in a heavily infested site.

The effectiveness of the fibre bands was improved when they were sprayed with “chilli plus” – see Fig. 9. As would be the case for Barrier Glue, this treatment may have application in smaller vineyard blocks which are hand harvested.

Rain-X performed poorly in excluding weevils from the vine canopy and in any case requires the prior application of a smooth substrate such as silo tape which is a disadvantage over other products.

Surround (kaolin clay) either as a butt drench treatment or foliar application gave very inconsistent results. The reasons for this were unclear. Further studies on its use by either method as a treatment to protect vines from garden weevil attack would be beneficial. Such studies would yield the greatest clarification of the benefit of such products if they were conducted by its application over commercial (size) blocks.

Objective 6: Produce an Integrated Pest Management (IPM) package to control garden weevil in grapevines.

Introduction

This section of the project had the objective of drawing together the results of research in this project together with information derived previously in all regions where garden weevil is recorded as a pest to produce an Integrated Pest Management approach to control garden weevil in commercial vineyards.

Recommended IPM for control of garden weevil

The tenets of an IPM program to minimise the negative impacts of garden weevil on vineyards are based on:

- a monitoring program to assess the abundance of the insect
- recognition that the abundance of the insect will cause economic loss
- implementation of long term and therefore sustainable management options.

Assessing the abundance of garden weevil adults
Trunk bands are time consuming and fixed in locations. They may be acceptable to use if the location of the hot spots is known to time sprays, but inflexible and hot spots in new areas could be missed.

While there is limited experience in the canopy damage scoring system to assess the likelihood that garden weevil will cause damage (see Table 3.1), the system allows for rapid assessment across a large area. The system is flexible in that water shoots or the vine canopy can be used to assess the timing and numbers of garden weevils present in spring. It allows for weevil presence to be quantified and avoids the need to count actual weevils, which is time consuming and inaccurate.

Developing an economic injury level
There was no clear relationship established during this project between the canopy damage rating category and yield loss. However an interim economic threshold between a rating of 2 and 3 could be used as a staring point to develop confidence in such a system. By keeping records of canopy damage scores and yield within and between different blocks and varieties in vineyards, it may be possible to refine this system to confirm whether the system is practical.

Management options
The most effective and probably least disruptive method of protection from garden weevil attack is the use of sticky (polybutane) trunk bands. This material is very difficult and time consuming to apply. The more practical material used was the South African grease (Barrier Glue), but there are implications in using such a material in vineyards that are mechanically harvested because grapes may become coated with it. The artificial fibre bands gave inconsistent results and may best be used in situations of low to moderate pest pressure. Applying chilli to the bands improved their performance and may have reasonable duration of activity in the field. Likewise, kaolin clay gave inconsistent results and may also be best suited to situations where weevil pressure is low to moderate.

Other methods for longer term reduction in weevil abundance levels that should be incorporated in to a sustainable weevil management program include removing favourable (weed) plants; interrow ground cover composition that is a disadvantageous to weevil survival (favour grasses over broadleaved plants); poultry; retaining watershoots for diversionary feeding early in the season to help poultry control weevils and a target for pesticides to avoid their application to the vine canopy.

There are only three synthetic active ingredient insecticides available for control of garden weevil and two of these are in the same activity group. Because garden weevil is flightless, pest populations are largely resident within vineyards. With mechanical harvesting, there may be some movement among vineyards, but this would be minor compared to on-site breeding. Such a situation suggests a high chance for insecticide resistance to develop.

If insecticides are considered for use to control garden weevil, they should only be applied after monitoring the whole vineyard to identify insect pressure and that this is high enough to justify the use of insecticides. By careful monitoring and assessing the level of canopy damage it may well be that portions of a vineyard and portions of vineyard blocks only may require treatment. Because one of the insecticides has the witholding period of EL31 (berries pea size), vignerons can afford to watch and wait before application, to maximise the possibility that one well timed application only will be required for season long protection.

1. Research outcomes and implications

1.1 Research outcomes

Guidelines were outlined for vignerons to run their own demonstrations to compare conventional and new garden weevil control techniques.

A web site was established to post information on garden weevil management.

A prototype garden weevil canopy damage scoring system was developed to assist vignerons to quantify weevil abundance without having to count weevils.

The potential to reduce weevil numbers by manipulating the composition of cover crop swards has been ruled out.

Alternative “softer” options to the use of synthetic pesticides to control garden weevil were inferior to the effectiveness of these pesticides. However, Barrier Glue (grease), kaolin and artificial fibre trunk bands offer some possibility for weevil suppression to take the pressure off the use of synthetic insecticides. If overused development of insecticide resistance may result. These softer options would be most useful in situations of low to moderate garden weevil pressure. The use of polybutene sticky bands, assessed in much earlier research, again proved to be the yardstick in weevil control, but is time consuming to apply. It would have a role in protecting newly planted vines from weevil attack. The water repellent material Rain X was found to have no benefit in protecting grapevines from garden weevil and in any case would be impractical to apply.

1.2 Research practical implications

The canopy damage scoring system could be used by vignerons to assess and record weevil presence to compare between areas and seasons. Vignerons could use this experience as a base to quantify the pest status of garden weevil in their vineyard and record effects of new vineyard cultural and weevil management activities. It would also be useful in deciding if insecticide use was required and where on the vineyard it was required.

Where garden weevil numbers are considered to be low to moderate, the softer approaches such as kaolin clay and artificial fibre bands could be deployed and assessed for effectiveness. Vignerons should be encouraged to adopt the guidelines available for conducting their own comparison with either conventional control or more importantly, untreated areas for comparison to build up their experience in how important garden weevil is on their vineyard.

1.3 Limitations and further research

This study went only part way to developing an economic injury level for garden weevil. While there were some spectacular treatment effects on reducing weevil numbers this did not always translate to a significant difference in yield. We urge vignerons to employ monitoring techniques based on canopy damage assessment as detailed in this project to assess weevil abundance thoroughly before deciding to apply pesticides. While garden weevil is an important pest in newly planted vineyards, its pest status in mature vineyards is sometimes doubtful – “insect presence” does not always infer “pest presence”. More research in this difficult to study field is warranted.

The studies on various protection strategies were compromised by high variability in small plot yields. Larger demonstration sized areas would enhance the assessment process for these suggested options. For example, further research on the use of kaolin clay is

justified on the basis of the range of outcomes measured in this project – effective to poor control. The same applied to the use of artificial fibre trunk bands – vignerons who have tried them and others who continue to use them have a range of comments on how effective they are.

This project sought to include studies on the effect of ground floor management on garden weevil abundance. Vignerons in WA often plant alternate rows in alternate seasons to annual plant species. Therefore there is a real opportunity to assess the role of different plant composition on weevil abundance.

In quite a few of the trial sites used in this project, it was noted that weevil abundance declined in the season following the trial – even in plots receiving no treatment. Some studies could be undertaken to try to clarify what factors may be involved here and whether they could lead to novel approaches to weevil management.

12. Appendices

Appendix 1: Communication:

Learmonth, S., Hoyle-Mills, R., Stanaway, M. and Gibberd, M. (2005). Garden Weevil Field Walk. Smithbrook Vineyard, Pemberton, WA.

Learmonth, S. & Gibberd, M. (2006). Garden Weevil management – an update on a new research initiative. Viticulture Road Show, Margaret River. 25-28 July 2006.

Learmonth, S., Gibberd, M & Stanaway, M. (2006). Garden weevil management – progress on new research. *Australian Viticulture* **10** (6, Nov-Dec): 36, 38, 40, 42, 44, 46.

Learmonth, S., Gibberd, M & Stanaway, M. (2007). Where are we at with understanding and managing garden weevil (*Phlyctinus callosus*) in vineyards? Poster. 13th Australian Wine Industry Technical Conference, Adelaide, Australia. Jul/Aug 2007.

Learmonth, S., Stanaway M. and Gibberd M. (2007). Review of insect pests in Western Australian vineyards for season 2006/07. *Australian Viticulture*. **11**:6 (Nov. Dec.), Pp: 40, 42, 44, 46, 47, 48, 49.

Learmonth, S., Stanaway M (2009). Problem pests. Grape and Wine Updates: Margaret River, Manjimup & Mt Barker. 21, 22, 23 September 2009.

Learmonth, S. (2010). Workshop: Non traditional grapevine pests. 14th Australian Wine Industry Technical Conference, Adelaide, Australia July 2010.

An example of the information provided in the industry advice service ***GARDEN WEEVIL watch*** is provided on the next two pages.

GARDEN WEEVIL watch



Issue No. 6, 17 November 2006

Welcome to ***GARDEN WEEVIL watch***. This is a weekly report on the abundance of garden weevil adults in WA vineyards supplied to us by vignerons. The aim is to assist in the protection of grapevines from garden weevil.

If **butt drenching** is selected to control the weevil, it is most efficient to apply it in the early stages of the spring emergence of the weevil. This report is to encourage monitoring of garden weevil to get this timing right. Effective butt drenching should mean that subsequent foliar spraying won't be required, thereby reducing the chance of secondary pest outbreaks.

Monitoring is also applicable for **foliar application** to protect vines. It provides a standardised measure to check on the effectiveness of insecticide treatment and allows a comparison of weevil pressure between seasons. Vignerons can track the occurrence of the pest in a quantitative way.

We invite all vignerons to contribute to ***GARDEN WEEVIL watch*** with their observations and experiences with weevil management.

Editor: MARK STANAWAY (08) 9777 0000 E-mail: mstanaway@agric.wa.gov.au

GENERAL COMMENTS

Adult weevils are still emerging in large numbers in the Margaret River, Manjimup/Pemberton and Great Southern districts. There was a suggestion that there is a second emergence underway but this is most likely to be emergence reaching a peak after several weeks of more modest numbers emerging. An estimate of the numbers emerging can be seen where individual bands in blocks which may have had less than 10 for a few weeks in the space of a week can pick up 20, 30, or even 40 weevils.

Generally the time for control measures using butt sprays has now past and vignerons will need to check on damage levels to see if the application of a foliar spray is warranted.

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GARDEN WEEVIL COUNTS

The table is the average number of GW adults per 20 bands in the vineyards in the locations listed:

"b" indicates a butt drench; "f" indicates a foliar spray.

	OCT	OCT	OCT	Nov	Nov	Nov
VINEYARD LOCATION	**13**	**20**	**27**	**3**	**10**	**17**
SWAN DISTRICT						
West Swan	0.25	0.3"b"	0.2	0.3	0.1	0
MARGARET RIVER						
Boalia	0.2	0.6"f"	1.3	0.7	0.8	
Jindong	0.1	0.3	4.2	"b" "f"	2.6	5.2
Vasse	0.05	0	-	0.2	-	0.3
Carbanup	3.5"b"	-	-	5"f"	2	
South Carbanup	0	0	0.1	-		
Willyabrup	0.05	0	0.3	0.3	0.1	0.2
Margaret River	0	0	0	0		
South Margaret River	0	-	-	-	-	
Witchcliffe	0	0	0	0		
Rosa Brook	0	0.01	0.6	3.4	1.1	
Karridale	0	0.02	0.05	0.5		
Augusta	-	0.6	0	0.5	0.2	0
MANJIMUP/PEMBERTON						
West Manjimup	0	0	0.2	0.5	0.7	1.8
South Manjimup	0	0	0	0.1	0.1	0.3
Eastbrook	0	0.05	0.4	1.4		
Pemberton	0.1	0.3	0.7	1.1	2.4	3
Big Brook	0.2	0.1	0.6	1.7	0.5	1.5
Stirling	0	0.0	0.2	0.1	0.3	0.3
GREAT SOUTHERN						
Frankland	0	-	-	-	-	
North Frankland	0	0.05	0.2	2	2	3.4
Rocky Gully	0	0.05	0.05	0.5	0.4	0.5
Mt Barker	0	0	0	0.1	0.1	0.6
Denmark 1	1	2.2	1.2"b"	2.3	4	5
Denmark 2	0.2	1.2	0.3	0.1	0.3	0.8

NEXT ISSUE OF *GARDEN WEEVIL watch* – FRIDAY 24 NOVEMBER, 2006

GARDEN WEEVIL watch *ENQUIRIES:*

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or Stewart Learmonth slearmonth@agric.wa.gov.au

Tel (08) 9777 0000.

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Appendix 2: Intellectual Property:

No intellectual property was generated by this research project.

Appendix 3: References:

Coombe, B.G. (1995). *Growth stages of the grapevine: adoption of a system for identifying grapevine growth stages*. Aust. Journal of Grape and Wine Res. **1** (2):100-110.

Fisher, D.L. and Learmonth, S.E. (2003). *Garden weevil in vineyards.* Farmnote 60/03. Department of Agriculture, WA. 4pp.

Fisher, D.L. and Learmonth, S.E. (Editors). (2009). *Viticulture Spray Guide 2009/2010*. *Bulletin 4774. Department of Agriculture and Food, WA. 88pp.*

Gibberd, M.R. and Learmonth, S.E. (Editors). (2005). *Garden weevil management in vineyards – a workshop to identify research for the future*. Commissioned review and proceedings of a workshop held at the Margaret River Education Campus on 16 August, 2005.

Horne, P.A., Edward, C.L. and Curtis, J. (1997). *Control of garden weevil without insecticides*. Aust. Grapegrower & Winemaker. No. 142a. June: 109-10.

Learmonth, S. (2011).Improved management of garden weevil in WA – a warning service and assessing exclusion bands. Final report for Grape and Wine Research and Development Corporation Project RT04/07-2.

Michael, P.J. (2005). *Garden weevil management in vineyards - research for the future. Review of current knowledge and identification of research needs*. Sponsored by the Grape and Wine Research and Development Corporation, Project No. GWR02/02F. 25pp.

Appendix 4: Staff

DAFWA – Elizabeth Blincow, Helen Collie, Graziano Giadresco, Alby Horne, Jan Horne, Stewart Learmonth, Peter Needs, Mark Stanaway.

Curtin University of Technology – Hugh Lance, Ben Low, Jeanette Smith and Mark Gibberd.

Appendix 5:

Objective 1. Develop standardised assessment protocols for in-field demonstrations of comparative garden weevil management aspects.

HOW DO I ASSESS A NEW GARDEN WEEVIL CONTROL STRATEGY?

Here are some tips for vignerons who want to run their own trials to assess new strategies for controlling garden weevil.

A RECIPE

1. State the method you want to assess in the form a question.

2. Plan an experiment to answer your question.

3. Measure the effects of the new control strategy

4. Tell others about what you've found

5. Review what you have done before you move forward

6. Contacts in case you need some help with this

HOW DO I ASSESS A NEW GARDEN WEEVIL CONTROL STRATEGY?

THE DETAIL

1. State the new control strategy you want to assess in the form a question.

For example, Will the use of dacron bands tied to the trunks of grapevines protect them from damage by garden weevil adults?

At least initially, it's best to ask one question at a time until you get the feel of how much effort is involved in being able to prove to others that what you are looking at does work.

Before you start your trial, ask around to see if others have tried the new method or something similar. This might save you a lot of time and assist in how you go about your investigation.

2. Plan an experiment to answer your question.

Limit the scale of the experiment to an area you can handle (see section on measurements below to know what you are committing yourself to).

A minimum size would be one full panel and half a panel either side so that posts are included in the treatment. Garden weevil adults like hiding during the day and a lot of damage can occur to vines near posts because of this behaviour.

A larger area could include increasing the width to three vine rows and two inter-rows - the outside vine rows act as a buffer on each side of the central vine row where assessments are made.

Small areas for the first time also help keep the infestation uniform and so make your comparison more valid.

Have untreated areas for comparison of what would happen if you do nothing. This is essential to show that a damaging population of the pest was present. An option would be to include a known effective treatment, either based on insecticide or a physical barrier such as sticky bands or the new product Barrier Glue.

Have repeat equal numbers of areas of untreated and treated to give you more confidence your new method works.

Have the same number of untreated areas as you have for treatment areas to even up the comparison.

3. Measure the effects of the new control strategy

Insect numbers

Count the number of adult weevils in untreated areas and also in the areas where the new method has been applied.

Suggestions for counting weevil numbers are:

- cardboard trunk monitoring bands available from ACTIV Industries in Busselton

- count weevil numbers in the same amount of time while searching the same position on the vine in each untreated and treated area, for example, count the number of weevils you can see in say 30 seconds around the vine crown and/or post.

These counts can be made as often as time allows. Weekly is best as activity increases from September. After mid December when numbers decline, fortnightly to 4 weekly would be sufficient.

Record the date and vine stage at all times of monitoring -refer to the accompanying figure.

Vine damage
Score or measure weevil damage to the vine.

A scoring system/index has been proposed for garden weevil damage to vine leaves, stems, buds, berries and bunches (see Table 3.1 in this report). This system could also be adapted to score damage to bunches only.

Record the date and vine stage at all times of assessment - refer to the accompanying figure.

At vintage, hand harvest untreated and treated areas. Grapes can be weighed and juice attributes measured – such as pH, TTA and others.

For large treatment areas, a GPS mounted on a grape harvester could be incorporated in making yield comparisons.

4. Tell others about what you've found

This involves producing a written report on what you have done and/or telling others about what you have done.

This will allow you to get feedback from fellow vignerons on what you've done and helps in the overall progress of sustainable management of garden weevil.

Staff in Agricultural Research Western Australia (see Point 6 below) will help collate what you have done and advise you on the best means of telling others.

Examples of how to tell others are to put your report or a modified version of it on email lists in WA Wine Industry Associations, the Department of Agriculture and Food (DAFWA) garden weevil web site, an industry magazine or publication such as the DAFWA Wine Industry Newsletter, national magazines such as Australian Grapegrower & Winemaker and Australian Viticulture. Your experiences also can be told to fellow vignerons at seminars on pest issues as they arise – state or national.

5. Review what you have done before you move forward

In the process of undertaking your own experiment, and writing and speaking about what you have done, you will know whether your idea:

didn't work at all
can be implemented on a wider scale by yourself and others or
needs more refinement and
move on to the next logical stage in the development process.

6. Contacts in case you need some help with this

Department of Agriculture and Food
Stewart Learmonth and Diana Fisher 9777 0000

Curtin University of Technology, Margaret River Education Campus
A/Prof Mark Gibberd and Dr Mia Williams 9780 5830

MODIFIED E-L SYSTEM FOR IDENTIFYING MAJOR AND INTERMEDIATE GRAPEVINE GROWTH STAGES

Permission to use this figure has been provided courtesy of Dry, P. R. and Coombe, B. G. (2004) Viticulture Vol. 1. - Resources. 2nd Edition. Publ. Winetitles P/L. p153.

Early season - entire blocks

Early season damage by garden weevil adults to buds and watershoots across entire blocks of vines may be assessed by scoring damage to 100 vines per block.

Early season damage to grapevines may be severe if **buds** are attacked, but there may be some compensation. Primary buds may be replaced within the same bud or by other buds nearby. The importance of early bud loss to the eventual yield of grapes is not well understood. Usually a high proportion of damage to buds by garden weevil suggests the need for early cordon spraying. Check weekly for presence of damage and record proportion of buds/100vines attacked if and when such damage occurs.

Damage to **watershoots** will not affect yield however it provides a record of the timing of weevil emergence and is a good indication of the extent of a garden weevil infestation across a block. This helps in planning action against the pest. It is also a good indictor of weevil abundance should the treatment being examined affect the number or timing of garden weevil emergence and movement up a vine trunk. Usually a moderate to high proportion of garden weevil **damage to water shoots** suggests the need for preventative butt drenching. Check weekly for presence of leaf feeding and record proportion of vines/100 vines attacked if and when such damage occurs.

<u>After early season</u> - entire blocks
Early to mid season damage to vines includes damage to all parts of a vine – leaves, stems, growing tips, flowers, berries and fruit stalks. It also includes damage at the crown, post and canes assessed. Observations of say 100 vines across a block would indicate the need for the application of a foliar insecticide if a high proportion of vines were affected by garden weevil.

Appendix 6: Budget reconciliation

Please use End of Project Financial Statement, downloadable from the GWRDC website at www.gwrdc.com.au

Acknowledgements

We would like to particularly thank the many people associated with the vineyards where field studies were conducted, including the Swan Valley, Margaret River, Manjimup/Pemberton, Frankland and Porongorups.

We would like to express our sincere appreciation for the financial support for this research project provided by the Grape and Wine Research Development Corporation and the Australian Government, Curtin University of Technology and the Department of Agriculture and Food, Western Australia.