CONTROL OF ESTABLISHMENT PESTS IN VINEYARDS

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PROJECT TERMINATION REPORT

(PROJECT DAS 7V)

TO THE GRAPE AND WINE RESEARCH COUNCIL

DEPARTMENT OF AGRICULTURE, SOUTH AUSTRALIA

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DAS-7V

GRAPE AND WINE RESEARCH COUNCIL
FINAL REPORT FOR TERMINATED PROJECT DAS 7V

PROJECT:	CONTROL OF ESTABLISHMENT PESTS IN VINEYARDS
ORGANISATION:	South Australian Department of Agriculture
PROJECT SUPERVISOR:	Dr P T Bailey, Senior Entomologist
DATE OF PROJECT COMMENCEMENT:	1 July, 1989
DATE OF PROJECT COMPLETION:	30 June, 1991

PROJECT OBJECTIVES:

To develop an insecticidal strategy for the control of curculio beetle, garden weevil, and cutworms in young grapevine plants. In particular:

(i) To protect young, non bearing grapevines against curculio beetle (*Otiorhynchus cribricollis*), garden weevil (*Phlyctinus callosus*) and cutworms (*Agrotis spp.*) by the use of chemicals.

(ii) To investigate sufficient of the biology of these pests to allow proper timing of control.

(iii) To develop trapping methods to allow warning of damage to young vines.

CONCLUSIONS

1. Non-bearing grapevines can be adequately protected against curculio beetle, garden weevil and cutworms by application of 0.01% active constituent alphamethrin. Applied at the first sign of insect damage, one application gave adequate protection during these trials but, in years when pests are active for a longer period, a second spray may be necessary. Alphamethrin should be registered for use on non-bearing vines in South Australia by spring 1991 (Appendix I) (Objective (i)).

2. The period during which young vines are susceptible to damage by pink cutworm and curculio beetle starts at first leafburst and continues to early January, by which time both those pests have passed on to another stage and vigorous growth of the vine compensates for leaf feeding. Alphamethrin has residual activity on vine leaves for up to 14 days, by which time leaves have matured, and are apparently unpalatable, at least to curculio beetle.

   Vines are susceptible to garden weevil for a similar period but in addition, since adult weevils over-summer in vineyards, feeding may continue during summer. Under these circumstances continued trunk applications of alphamethrin to prevent adults moving up the vine during summer may be necessary (Appendix II) (Objective (ii)).

3. The presence of pink cutworm in a new vineyard cannot be predicted but is more likely to occur on sandy soil. The presence of curculio weevil in a new vineyard can be expected if host plants (including older vines) are grown nearby and is more likely to occur on heavier soils. The presence of garden weevil is the result of chance introduction, and its occurrence in previous years is indicative of the likelihood of damage.

   Monitoring is best done by careful vineyard inspection during the susceptible period for signs of leaf damage and scraping around the base of vines for evidence of pink cutworm or curculio. As a rule of thumb, spray should be applied before 20% of vines show leaf damage, or insect numbers exceed one pink cutworm per five vines, or before numbers of curculio beetle exceed 3-4 per vine.

   Detection at the first emergence of garden weevil is aided by tying corrugated cardboard wraps around the base of mature rootstocks (20-40 wraps in a known "hot spot") and inspecting at least weekly. (Appendix II) (Objective iii).

4. The use of alphamethrin on non-bearing vines is unlikely to result in residues in the fruit or in subsequent disruption of the arthropod fauna of the vineyard. If, contrary to label instruction, insecticide is sprayed on to fruit and foliage of bearing vines, residues and secondary pests may result.

5. Further work on non-insecticidal control of pink cutworm and curculio beetle may include studies on the behaviour of these insects to physical barriers such as sticky bands or investigating the anti-feedant properties of mature vine leaves.

6. Further work on non-insecticidal control of garden weevil in vineyards should include a study on relationship of weevil numbers to ground cover.

BACKGROUND

A complex of weevil species damage vines in south eastern Australia and until recently they have been controlled by organochlorine insecticides. The withdrawal of these insecticides from use in Australian agriculture has been accompanied by an increase in damage caused by weevils, and also an increase in the variety of weevils attacking vines. In South Australia, curculio weevil has for some years been common in vineyards, but in the past two years there are increasing reports of damage caused by garden weevil. No chemicals are presently registered for use on vines to control these weevils, and there are no other obvious methods for their control. Cutworms, although a different group of insects to weevils, cause similar damage during a similar period of the year.

The economic importance of weevils and cutworms is that they damage young vines in newly-established vineyards and they can also damage grafts made to established scions in older vineyards. The chewing by these insects of buds on grafts often results in the complete failure of the graft or the later development of a weaker bud. In some areas (eg at Padthaway in the 1988 season) weevils significantly limited the grafting of new varieties onto old stocks. The apparent increase in weevil numbers in vineyards coinciding with increased planting of new vines and grafting over to new varieties suggests that the problem will become more acute in the future.

In the long term, cultural or biological control methods may be developed to control some of these pests. Work along these lines using insect parasitic nematodes is presently being undertaken by the Victorian Department of Agriculture and Rural Affairs at the Plant Research Institute, Burnley. Results are not expected for another 3-5 years. This report concerns interim control measures.

Agrotis munda (pink cutworm) a native moth, is recorded damaging lucerne crops in spring and legume pastures and cereal crops in summer; in addition, it damages seedlings of a number of horticultural crops. *A. munda* overwinters as a pupa in the soil, the adult moth emerges in late August and September and lays eggs on bare sandy areas. By this time new vineyards are often clean cultivated, and the young vines planted. The eggs of the moth hatch in September-October and the young larvae seek suitable food, which in a cultivated vineyard is the shoots of young vines. Like curculio beetle, *A. munda* is active at night, when it climbs the young cutting and eats its leaves. The scalloped feeding areas at the edge of vine leaves may be distinguished from the serrated feeding margin left by curculio beetle.

Otiorhynchis cribricollis (Curculio beetle, also known as apple weevil) adults are recorded as foliage feeders on strawberries, some vegetables, lucerne, pastures, many fruit trees, including apples, citrus, olives and on grapevines. Damage to mature grapevines by curculio beetle does not cause economic damage but feeding on newly-planted cuttings may retard their growth or even kill some young vines.

Phlyctinus callosus (garden weevil) of South African origin, has a wide host range, including many ornamentals, stonefruit and vines; although it has been recorded in Adelaide (since the 1930's), the Adelaide Hills and Mt. Gambier, it is yet only in vineyards at Padthaway. Larvae feed on the roots of weedy ground cover during winter and pupate in early spring. Adults begin to emerge later in spring and, being flightless, must walk in search of food and shelter. They may be found sheltering under the bark of mature vines, or in the litter at the base of newly-planted cuttings. Damage is caused to the opening leaves of newly-planted vine cuttings and buds grafted onto established rootstocks; damage to either may retard or even kill new growth. Adult weevils may shelter near the base of cuttings or under the bark of established rootstocks. The weevils must walk up the cutting or rootstock in order to chew the young leaves.

METHODS AND RESULTS

Cutworms:

Site Selection

The occurrence of pink cutworm in newly-established vineyards cannot be accurately predicted, so for these trials it was necessary to survey as many new plantings as possible in early spring to detect the presence of pink cutworm. Trial sites were chosen which contained a block of at least 200 vines in which early signs of leaf chewing were evenly distributed throughout the block.

Trial Design and measurement

A 'plot' consisted of 10 consecutive vines in a row, and the two treatments (sprayed or control) were allocated at random to each plot; 10 plots were treated with insecticide and 10 were unsprayed.

The number of cutworm larvae at the base of each vine was counted by carefully scraping away the top 5 cm of soil surrounding the base of the cutting in an area described by a ca 15 cm radius from the base; preliminary observations showed few outside this area. The larvae were replaced after counting and covered with soil.

Chemical and application

The chemical used was alphamethrin (Dominex®), which was chosen because of its reported efficacy against many. It is also reported effective against other establishment pests, including garden weevil (Mr S. Learmonth, Western Australia Department of Agriculture, personal communication) and curculio beetle. A further reason for choosing this chemical was the interest by the manufacturer in registering the product if the trial results were favourable.

The dilution used was 1 ml of emulsifiable concentrate product (100 g/l) per litre of water (= 0.01% active constituent). This concentration was used because it was found effective as a butt spray on apples against garden weevil (*Phlyctinus callosus*), (S. Learmonth, W.A. Department of Agriculture, personal communication). In preliminary trials, a 60-70 ml volume of solution was found sufficient to wet all the opened leaves on the young vines and the ground surrounding the vine 15 cm from its base. In these trials, a knapsack sprayer with a fan nozzle was used to apply the chemical to each treated vine.

Monitoring for occurrence

Reports of early damage by pink cutworm were sought from advisers and growers in early summer. The following new vineyards were inspected as trial sites:

Locality	Date	Estimate of vines with damage signs	Comments
Eden Valley	4 December 1989	25%	trial established
Rowland Flat, Barossa Valley	12 December 1990	50%	trial established

At the Eden Valley site, the vineyard was established on relatively sandy soil and the cuttings were planted in the nursery 'pot' of washed river sand, ca 10 cm in diameter, which provided a favourable refuge for larvae of pink cutworm.

At the Rowland Flat site, the natural soil was heavy; however, transported sandy loam had been layered onto ca 1 ha of vineyard and it was on this area where cutworm damage was evident; in other parts of the vineyard where the surface soil was heavy, there were few signs of heat damage.

Field trials

A treatment of alphamethrin was applied to plots at an Eden Valley site on 4 December, 1989, and the leaf feeding was assessed 14 days later. There was no evidence of pink cutworm damage to new growth in either the treated or control plots at this time, and further inspections during December failed to reveal further evidence of cutworm damage. It was concluded that although there were early indications of cutworm populations in this vineyard, the numbers were not sufficient to demonstrate treatment differences.

In the following season, a well established population of pink cutworm larvae was found in a vineyard at Rowland Flat which by 12 December 1990, had caused damage to young vines; the vines were treated with alphamethrin at this time and three days later the number of pink cutworm larvae were counted (Table 1).

Table 1: Mean no. *Agrotis munda* larvae per vine in treated and untreated plots (10 vines per plot) three days after treatment.

Block no.	1	2	3	4	5	6	7	8	9	10	Overall* mean
treated	0	0	0	0	0	0.2	0	0.2	0	0.1	0.05
untreated	0.2	0.3	0.3	0	0.3	0.2	0.3	0.3	0.7	0.4	0.30
* Difference at 1% level of significance (F-test on log transformed values).											

The larvae at the time of sampling were of large size, and were probably the final instar before pupation. Any live larvae were replaced in the soil in approximately the same position where each was found. A second count was made on 4 January, 1990, when a total of five larvae were found at the bases of 100 untreated vines but none were found near treated vines.

Curculio beetle:

Site selection, trial design, chemical and application.

Similar to pink cutworm, the occurrence of curculio beetle cannot be accurately predicted, and it was necessary to undertake extensive surveys for suitable trial sites. The trial design and chemical type and application was similar to that used for pink cutworm. Measurements of vine height were made from soil level to the tip of the longest shoot.

Bioassay of residual action

The residual action of alphamethrin on the feeding activity of *O.cribricollis* was measured by spraying the leaves of potted vines (cv. Cabernet Franc) as described for field trials, picking some sprayed leaves at various intervals after treatment and allowing adult *O.cribricollis* to feed on the treated issue. An area of ca 1.5 x 1.5 cm was excised from the leaf, and placed into a 1.5cm deep well in a multiwell clear plastic tray, designed for ELISA testing. Twelve replicates of treated leaf tissue and an equal number of untreated replicates were run on each sample date in the laboratory under natural lighting at ca 22°C. Individual adults of *O.cribricollis*, field collected, and fed vine leaves in holding cages prior to testing, were placed singly into the wells and allowed to feed on the tissue for 24 hours. The leaf fragments were then stuck to a sheet of paper, photocopied and the area eaten was measured with a planimeter.

Monitoring for occurrence

Reports of early damage by *O.cribricollis* were actively sought in spring and early summer from advisers and growers. The following new vineyards were inspected as trial sites:

Locality	Date	Estimate of vines with damage signs	Comments
Auburn, Clare Valley	29 November, 1989	20%	Trial established
Bethany, Barossa Valley	19 December, 1989	50%	Grower already treated
Flaxmen's Glen , Eden Valley	5 January, 1990	70%	Grower already treated
McLaren Vale	23 December, 1990	85%	Grower already treated
Tanunda, Barossa Valley	7 January 1991	25%	Trial established

Surveys of these vineyards indicated the first signs of damage occurred in late November and the potential damage period ended in early January - a period of about eight weeks. During sampling at these sites, teneral (newly emerged) adults were found until mid-December, and on this basis it is concluded that the generation of weevils which attack young vines results from a spring emergence. The adults are flightless, so the source of invasion may be nearby mature vines.

The vineyards where damage by *O.cribricollis* was extensive and severe were usually on heavy soil; no damage to vines planted in sandy soil was recorded. This requirement seems to separate *O.cribricollis* from pink cutworm.

Field Trials

Auburn, Clare Valley. This trial was laid out on 29 November , 1989 on the basis of early leaf damage to the vines. The trial was assessed on 18 December, 1989, but no new damage to control vines was apparent and the number of *O.cribricollis* found at the base was less than one per vine in untreated vines, which was no different to treated vines. It was concluded that there were not sufficient *O.cribricollis* at this site for treatment differences to be detected.

Tanunda, Barossa Valley. This trial was laid out on 7 December, 1990, and the number of *O.cribricollis* at the base of vines was counted 10 days later (Table 2).

Table 2: Mean no. *O.cribricollis* per vine in treated and untreated plots (10 vines per plot) 10 days after treatment.

Block No.	1	2	3	4	5	6	7	8	9	10	Overall* mean
treated	1.6	0	0.4	0	1.8	0.5	0.4	2.9	0.7	1.5	0.93
untreated	9.4	8.9	3.3	10.8	12.7	4.2	0.9	0.9	11.6	14.8	8.22
* Different at 1% level of significance (F-test)											

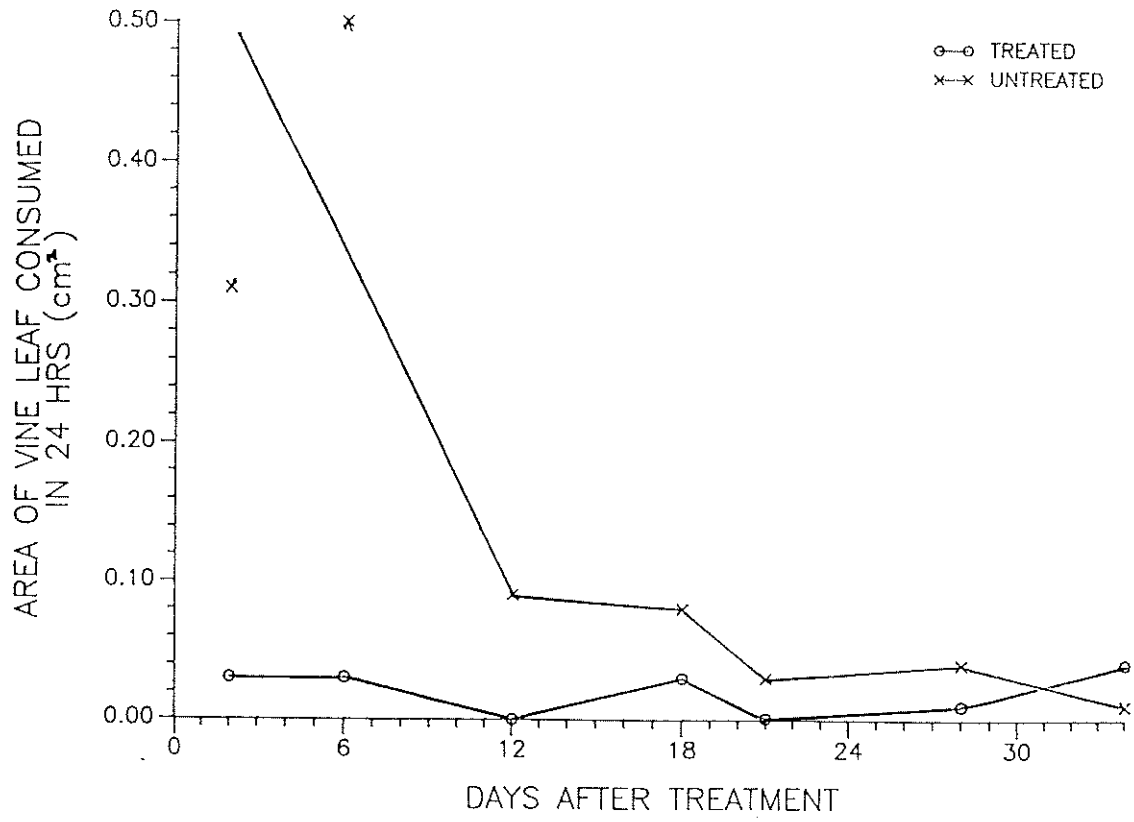
Another count was made 28 days later on 4 January, 1991, but by this time the numbers of *O.cribricollis* was less that 0.1 per vine in the control plots; the adults may have died after a succession of days above 40°C in early January.

On 4 January, 1991 the heights of vines in each treatment was measured ; the mean height of vines in the treated plots was 24cm and that of the untreated vines was 21cm. This mean difference of 3cm growth of new shoots was significant at the 1% probability level (F-test).

Residual protection of alphamethrin on leaves

The residual action of alphamethrin on vine leaf foliage was bioassayed by allowing *O.cribricollis* to eat treated tissue; the results are shown in Figure 1. Feeding by *O.cribricollis* on treated tissue was reduced compared with untreated tissue for 12-18 days after application. There was no increase in feeding on treated tissue up to 34 days after application but consumption of the untreated leaves declined, so that after 18 days it was similar to the treated leaves.

Figure 1. Residual activity of alphamethrin on vine leaves exposed to weathering. Feeding inhibition by the insecticide was probably due to its anti-feedant action. The decline in feeding on untreated leaves after 6-12 days may be due to natural anti-feedants in mature leaves.



The reduced consumption may have been associated with the aging of the leaf; perhaps older leaves contain an anti-feedant compound. If this explanation is correct, then vine leaves are susceptible to *O.cribricollis* damage during a period of only several weeks, because earlier, the young hairy leaves appear to be avoided in the first few weeks of growth.

Garden Weevil:

Trial Site

The trial was conducted at the vineyard of Thomas Hardy and Sons, Keppoch Estate, Padthaway, S.A. on 20 rows of shiraz vines in a 7 ha block. The vines were mature (planted 1970); however, since the aim of the trial was to test the contact action of alphamethrin on vine wood, the bearing status of the vine was not important. The site was chosen because garden weevil adults were observed on vines in the previous summer. Larvae were sampled from soil in the rows between vines in spring; the density of larvae on 17 October, 1989 was $24m^{-2} \pm$ S.E. 16.6.

Trial Design

Each vine was a plot, 5 treatments were randomly allocated to five plots in each of 20 replicates. Treatments were 0, 0.005%, 0.01%, 0.05% and 0.1% active ingredient (a.i.) solutions of alphamethrin. 1 ml of wetter (Agral 60) was added to each 5 litres of solution.

Application and Timing

Insecticide was applied using knapsack sprayer; a volume of 200 ml was found to adequately wet the trunk of the vine from ground level to 50 cm height, plus the ground surrounding the base in an area described by a 10 cm radius.

The insecticide was applied when the first adult weevil was detected in spring. Adults were detected by tyeing a band of corrugated cardboard about 60 cm up the trunk of a vine; weevils sheltering in the band were detected by regular (at least weekly) inspection. Bands were placed on the 100 vines in the trial, and also on vines bordering those in the trial.

Assessment

The success of a treatment in preventing weevils ascending the vine was measured by (a) counting the numbers of weevils in corrugated bands and (b) counting the proportion of leaves with weevil damaged leaves on the first shoot on either arm of the vine. The first shoot was chosen because this is where weevil feeding is usually first noticed.

Field Trial

The first adult weevil was trapped in trunk bands in the buffer rows surrounding the trial on 1 November, 1989 and the treatments were applied on the same day (day 0). However, no weevils were caught on the trial vines until 21 days after treatment (Figure 2); the .005% residues were active for 35 days for compared with controls, while 0.01% and 0.05% were active for 48 days and the 0.1% treatment was active in excess of 65 days.

The leaf damage assessment reflected the treatment differences shown by adult trapping, but indicated an increase in leaf damage between 20-35 days in all but the 0.1% treatment (Figure 3).

Figure 2. Incidence of garden weevil adults in trunk bands placed above a barrier of alphamethrin on vine trunks (mean of 20 vines per treatment).

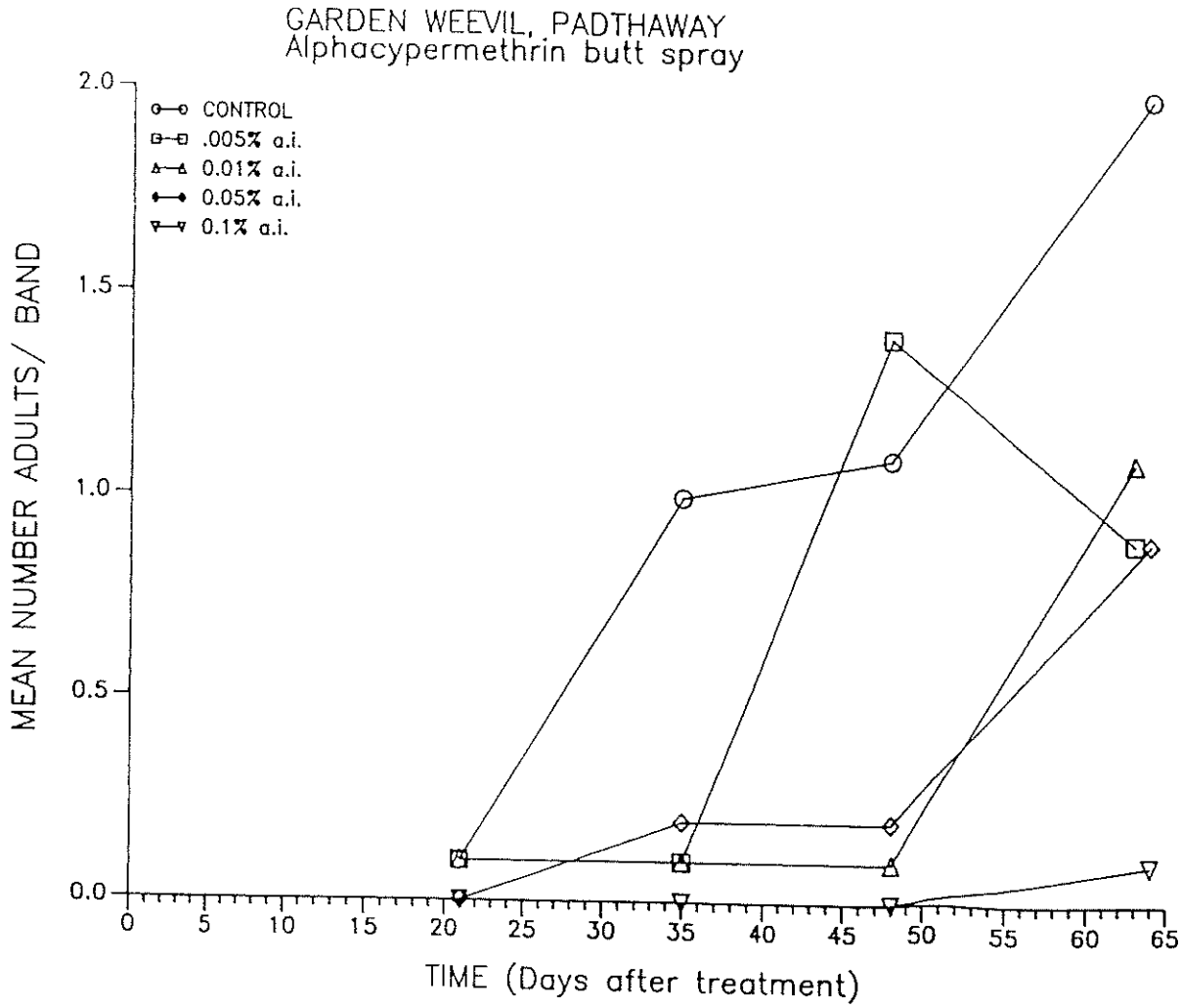
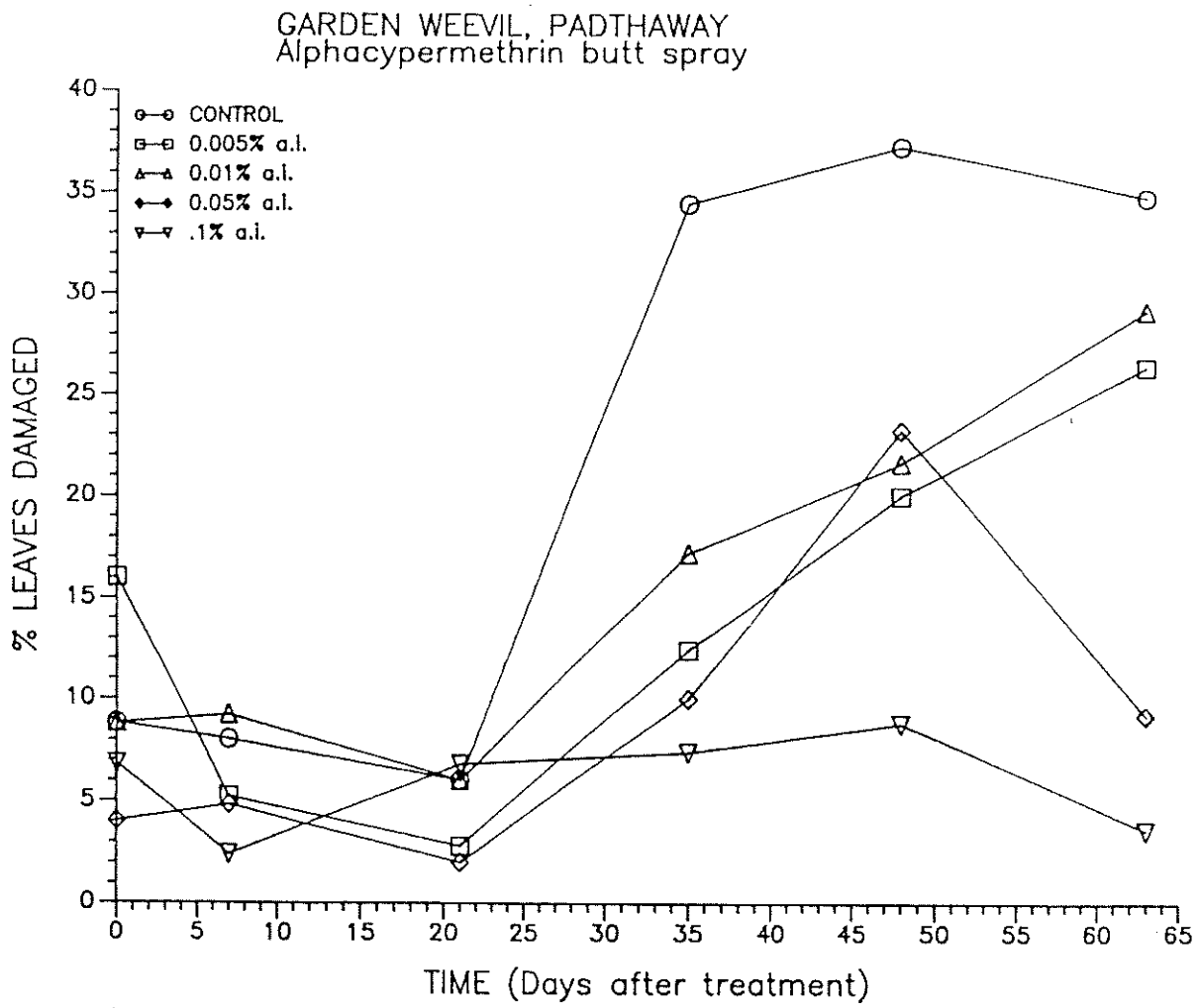


Figure 3. Incidence of leaf feeding on vines treated with a barrier spray of alphamethrin (mean of 20 vines per treatment).



Weevils and Ground Cover

While sampling for larvae of garden weevil, an association between larval density and ground cover was noted:-

Number of garden weevil larvae per M^2, Padthaway, 19 September, 1989		
Bare ground (herbicide strip beneath vines) (n=5)	weed cover (n=7)	mainly grass cover (n=3)
0	242 ± 34.9	28

The weeds were mainly plants such as capeweed with large top roots.

On the basis of these results, a replicated trial of different ground covers was set up on Hardy's vineyard, Padthaway, by Mr. Graeme Kay in the winter of 1990. The treatments included bare ground, barley cover crop, mainly grass sod and weedy ground cover.

Unfortunately virtually no weevils were detected in any treatments - 1990 was a light year for weevils in this vineyard.

Biology of weevils in Padthaway vineyards

The population at Padthaway progressed through only one generation in the period studied (winter, 1989 to late summer 1990). This contrasts with populations of garden weevil in strawberries in the Adelaide Hills which overwinter as larvae but develop several overlapping generations during summer, presumably as a response to a constant supply of food and water. In vineyards the ground cover dies off over summer, so there is no food for a summer generation of larvae. The vulnerability of the oversummering adults to environmental stress and the patchiness of larval food supply in winter may explain the irregular seasonal occurrence and patchiness of distribution of garden weevils in vineyards.

DISCUSSION

Pink cutworm damage to leaves of young vines was observed in early December; at this time the larvae were almost fully grown. Monitoring for young larvae and early signs of their damage during November may have allowed earlier treatment. The decrease in numbers of larvae by early January probably represented the end of the larval generation. During the 1990-91 season, larvae were present at the bases of vines during December and were probably present during part of November also; a period of 6-8 weeks.

The field trial indicated that a single application of alphamethrin (0.01% a.c.) applied when larvae were in their later stages of development, provided protection to vines for the remaining period of susceptibility.

The first occurrence of *O.cribricollis* recorded in early November during this study indicates that new vine plantings should be closely examined for signs of early leaf damage starting at this time and the presence of adults confirmed by scraping the soil around the base of vine cuttings or inspection of the plant at night. The presence of newly-emerged adults until mid-December indicates a period of emergence which extends at least 3-4 weeks. The absence of adults in early January may be associated with heat-induced mortality, or natural mortality at the end of the generation. During the 1990-91 season, adults were present at the base of vines for about 6 weeks and this represents the period of susceptibility by vines to attack.

The field trial indicated that a single application of alphamethrin (0.01% a.c.) applied when 25% of plants showed some signs of leaf damage, provided protection to the vines for the remaining period of susceptibility. It is possible that an earlier spray may have prevented part of this 25% damage but a second spray may have been needed midway through the period.

A damage threshold of *O.cribricollis* has not been established for young vines, but it has been shown in this trial that a density of about 8 per vine retards vine growth compared with a density of one per vine. However, there was no evidence of a difference between

treatments in the number of vines which did not produce shoots and establish, so the mean density of 8 per vine was not high enough to kill young vines.

The mode of action of alphamethrin was as an anti feedant, since in the bioassay, *O.cribricollis* survived exposure to treated tissue even though it did not eat the leaf tissue. In the field a spray applied during the day may not have any knockdown effect since most adults are protected by soil. If applied at night, the spray might directly contact the adults; this technique may give rapid results.

Garden weevil adults were inhibited from ascending mature vine trunks by application of alphamethrin but the pest pressure in this trial was relatively low and may not be indicative of results where higher numbers are present. Alphamethrin concentrations higher than 0.01% a.c. provided longer protection, but adopting the principle of using the minimal effective dose, this concentration is recommended; more than one treatment during the season may be necessary if emergence is prolonged or if adult numbers are high.

The mode of action of a barrier spray of alphamethrin was not observed, but was assumed to either repel the weevils from the base of the vine, or knock them down when they came in contact, to which case the adult weevils thus may have remained live on the vineyard floor.

The use of trunk bands to monitor first emergence was effective and practical in these trials, and can be used as a management tool. However, the occurrence of garden weevils in the vineyard was very patchy during the season, and did not bear a direct relationship with occurrence in the previous season. Because of this the use of trunk bands in "hot spots" of previous seasons should be supplemented with careful and extensive searches for weevils and damage symptoms.

FURTHER WORK SUGGESTED BY THE PRESENT EXPERIMENTS

Mode of action of alphamethrin

In these experiments, alphamethrin has been shown to have anti-feedant activity against curculio beetle. This chemical is known also to have contact and stomach toxicity and may also act as a repellent. Clarification of its mode of action against these pests under field conditions may allow more effective timing and placement of the chemical.

Cultural Control

The observations that high numbers of garden weevil larvae are associated with weedy ground cover during winter, in contrast with the low numbers of larvae associated with grassy ground cover or bare ground, suggest that this species can be controlled by planting non-host cover crops, or by herbicide or cultivation practices.

Grapevine resistance to leaf feeding insects

Results of the leaf-disc feeding experiment suggested that substances develop in maturing vine leaves which are anti-feedants to curculio beetle. This observation could be developed into a basis for selecting plants resistant to insect attack.

HEALTH AND ENVIRONMENTAL IMPACT OF ALPHAMETHRIN IN VINEYARDS

Alphamethrin is effective against all the major pests of young vines, has long persistance on vine tissue but, as with some other pyrethroids, is rapidly metabolised by mammals and appears to degrade in soil.

The use of alphamethrin on non-bearing vines is unlikely to result in residues in fruit, since the first fruit will not be produced from sprayed vines for over two years.

In newly planted vineyards, there is unlikely to be a developed arthropod ecosystem, so the use of a broad-spectrum insecticide is unlikely to kill predators or cause secondary pests such as twospotted mites and vine scale. However, great care should be taken not to use any such chemical as a foliar spray in established vineyards.

ACKNOWLEDGMENTS

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PUBLICATIONS

Bailey, P. 1990 Controlling garden weevil in vineyards. Australian Grapegrower and Winemaker, No. 316, P.105.

Bailey, P. 1991. Insect pests in newly-planted vineyards. Australian Grapegrower and Winemaker, No. 328, PP. 34-36.

APPENDIX I

Draft label which includes use on non-bearing grapevines

WARNING

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING

Agchem

Dominex® 100

INSECTICIDE

Active constituent: 100g/L [1RS,3SR,SR] - A-CYANO-3-PHENOXYBENZYL 3-(2,2-DICHLOROVINYL)-2,2-DIMETHYLCYCLOPROPANECARBOXYLATE
Solvent: 771.3 g/L LIQUID HYDROCARBON

COMPLETE DIRECTIONS FOR USE

This leaflet is part of labels S&7-0891 attached to 5 and 20 litre containers.
®Dominex is the Registered Trademark of FMC Corporation, Philadelphia, U.S.A.

PROTECTION OF LIVESTOCK:

Dangerous to bees. Do not spray on any plants in flower while bees are foraging.

PROTECTION OF WILDLIFE, FISH, CRUSTACEA AND THE ENVIRONMENT:

Dangerous to fish. Do not contaminate dams, rivers, drains or streams with the chemical or the used container.

STORAGE AND DISPOSAL:

Do not store below 4° C. Store in the closed, original container in a dry well-ventilated area, as cool as possible out of direct sunlight. Store in a locked room or safe place away from children, animals, food, foodstuffs, seeds or fertilizers. Do not repack or use container for other purposes. Triple rinse empty containers adding the rinsate to the spray tank or dispose with the empty containers. Puncture top bottom and sides of empty containers, then crush and bury in an approved land-fill or bury under at least 50 cm of soil in a non-crop, non-pasture area away from water sources or homes.

SAFETY DIRECTIONS:

Product is poisonous if swallowed. Will irritate the eyes and skin. Sensitive workers should use protective clothing. Facial skin contact may cause temporary facial numbness. Avoid contact with eyes and skin. Do not inhale vapour or spray mist. When preparing spray wear cotton overalls buttoned to the neck and wrist and washable hat, elbow-length PVC gloves, face shield or goggles. After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water. After each day's use, wash gloves, face shield or goggles and contaminated clothing.

FIRST AID:

If poisoning occurs, contact a doctor or Poisons Information Centre. If swallowed, and if more than 15 minutes from a hospital induce vomiting, preferably using Ipecac Syrup APF.

CONDITIONS OF SALE: Incitec Ltd. accepts responsibility for the consistent quality of this product; however, since application of this product is beyond the control of Incitec Ltd. and since all conditions of application cannot be foreseen, Incitec Ltd. accepts no responsibility whatsoever for any injury, damage, loss or other results following the use of this product whether used in accordance with directions or not; subject to any overriding statutory provision and provided that such liability under those provisions shall be limited to the replacement of the goods as supplied or the rendering again of the services that are provided. The buyer accepts and uses this material subject to these conditions.

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Incitec Ltd.

Manufacturers and Distributors of Agricultural Chemicals
Port Wakefield Road, Parafield Gardens, South Australia 5107

DIRECTIONS FOR USE:

RESTRAINT:
DO NOT apply if rainfall is expected within 6 hours of application.

Crop	Pest	State	Rate	Withholding Period	Critical Comments
Beans (Mung & Navy)	Native budworm *(Helicoverpa punctigera)* * Corn earworm *(Helicoverpa armigera)*	Qld. & N.T. only.	300 or 400mL/ha	7 days	Apply when flower or pod feeding numbers reach 1-2 per metre of row. Use the higher rate when the canopy is dense. To help contain pyrethroid resistance in *Helicoverpa armigera* in summer crops, do not apply to Corn earworm larvae > 5mm in Northern N.S.W. and Qld.
Cabbages Cauliflowers Brussels Sprouts Broccoli Kale Kohl Rabi Chinese Cabbage Turnips	Cabbage white butterfly *(Pieris rapae)* Cabbage moth *(Plutella xylostella)* * Helicoverpa spp.	Qld., N.S.W., Vic., Tas., W.A. & N.T. only.	Low Volume 400mL/ha High Volume 50mL/100L	1 day	Apply when pest populations indicate. When reinfestation is continuous, treatment every 7-10 days may be required. Add Ag-spred wetting agent at 15-20ml per 100 litres of spray mixture. LOW VOLUME: When applying by ground equipment use a fine spray with droplet size of 100 to 200 microns. Apply in 100 to 600 L water per hectare. For aerial application, apply in 20 to 60 L water/ha with a droplet size of 100 to 150 microns. HIGH VOLUME: Use a medium spray with a droplet size of 200 to 400 microns. Apply 600 L spray mixture per hectare just after transplanting and increase gradually to 1000 L/ha toward maturity.
	Cluster caterpillar *(Spodoptera litura)*	N.S.W., Vic. & W.A. only.			
Cereals (Winter)	Cutworms *(Agrotis spp.)*	Qld., N.S.W., W.A.& N.T. only.	75 mL/ha	7 days	Check emerging and establishing crops in the late afternoon and evening for caterpillars crawling on the soil surface and feeding on the seedlings. Spray in late afternoon or evening. In N.S.W. do not apply before May or after August.
	Pasture webworm *(Hednota spp.)*	W.A. only.			Pre-planting: Dominex may be applied with knockdown herbicides prior to planting. Apply from the last week in May when the larvae have emerged. Pasture should be closely grazed to ensure good spray penetration. Use high water volumes e.g. 100L/ha. Do not apply on dense pasture. Post crop emergence: Inspect crop regularly from emergence and spray at first sign of pest activity.
	Common armyworm *(Mythimna convecta)* Southern armyworm *(Persectania ewingii)*	Vic., W.A., & Tas. only.	160mL/ha		Apply before "head lopping" occurs when larval numbers exceed two or more per square metre. Spray in the cool of the day (late afternoon) when larvae are most active. Spray to achieve good crop penetration. This rate is effective against small (6mm) and large (20mm) grubs. This rate is effective if added to 840mL diesel/ha and applied through Micronair equipment at a rate of 1 litre of mixture/ha.
	Common armyworm *(Mythimna convecta)* Southern armyworm *(Persectania ewingii)*	N.S.W. only.			Spray in the cool of the day (late afternoon) when larvae are most active.
Cotton	Native budworm *(Helicoverpa punctigera)* * Cotton bollworm *(Helicoverpa armigera)*	Qld., N.S.W. & N.T. only.	300mL/ha	14 days	Apply as indicated by field checks. Application should be timed to coincide with egg hatching, before larvae are in protected feeding sites. Apply when egg laying is light i.e., 5-20 brown eggs/m or 2-5 newly hatched larvae per 100 terminals.
			400mL/ha		Apply as indicated by field checks. Application should be timed to coincide with egg hatching, before larvae are in protected feeding sites. Apply when egg laying is heavy and larvae are <5mm in length.
			500mL/ha		Apply as indicated by field checks. Application should be timed to coincide with egg hatching, before larvae are in protected feeding sites. Apply when egg laying is continuous, larvae are <5mm in length and longer residual control is required.
	Rough bollworm *(Earias huegeli)*		300 or 400mL/ha		Apply when an average of 2 or more larvae are present per 100 bolls. It is essential to detect and treat infestations in the early stages before larvae are established or concealed in bolls deep in the canopy. Use the higher rate if larvae greater than 10mm are present.
Eucalypt Plantations	Adults and larvae of Tasmanian eucalyptus leaf beetle. *(Chrysophtharta bimaculata)*	Tas. only	250 mL/ha	-	Apply by fixed wing aircraft or by helicopter using hydraulic nozzles or micronair equipment, to the crowns of eucalypt trees in a minimum of 20 litres of water/ha. Apply before insect damage causes severe defoliation. Treatment will control small and large larvae as well as adult beetles.
Grapevines (non bearing)	Pink cutworm *(Agrotis munda)* Apple weevil (Curculio beetle) *(Otiorhynchus cribricollis)*	S.A. only.	100 mL /100L		Monitor young vines during Spring and early Summer and apply at the first signs of leaf damage. Spray the leaves, canes and the soil around each vine to a diameter of 30cm. 70-80mL of dilute spray should be sufficient for each vine. If pest infestations persist, a second application may be required

APPENDIX II

Draft of a Fact Sheet to form part of a viticulture series being prepared by P. Nichol as, Loxton Research Centre

INSECT PESTS OF NEWLY-PLANTED VINEYARDS

Peter Bailey, Entomologist

Vigorous spring growth of newly-planted cuttings is important for early establishment of a new vineyard. Similarly, survival of newly-grafted buds on established rootstocks is dependent on uninterrupted early growth. In South Australia, four insect species have been recorded as damaging young vines in their critical growth period during spring and early summer; these are pink cutworm (*Agrotis munda*), curculio beetle or apple weevil (*Otiorhynchus cribricollis*), garden weevil (*Phlyctinus callosus*) and African black beetle, (*Heteronychus arator*).

Of these insects, pink cutworm and curculio beetle can be expected to occur in vineyards in the Clare Valley, Barossa Valley, Southern Vales, Padthaway and Coonawarra. Garden weevil has yet only been recorded in Padthaway vineyards, although it occurs on other hosts in the Adelaide Hills. African black beetle has been recorded from a few vineyards in the Southern Vales.

The key to control of these pests is careful monitoring during spring and early summer. To aid monitoring, each pest is described below, together with damage and life cycle.

Pink cutworm

Pink cutworm occurs in vineyards with sandy soil but may also be found where cuttings have been planted into a 'pot' of sand in heavy soil. Pink cutworm larvae are poor burrowers and need to be able to cover themselves at the base of the cutting during the day. At night, the larva climbs the cutting and eats leaves. Pink cutworm feeds from the edge of the leaf and produces a fairly smooth scalloped feeding area in contrast to curculio beetle, which produces a feeding area with jagged edges (Figure 1). During the day, pink cutworm larvae may be found in the top 1-2 cm of soil, usually within a 25 cm radius of the base of the cutting; the larva is grey-pink, soft and fleshy and appears inert when handled. One larva per vine may cause significant damage, and 3-4 larvae per vine are often encountered in the field.

Pink cutworms are widespread in pastures surrounding vineyards; in early spring, adult moths from these pastures lay their eggs in bare sandy areas, so the newly-cultivated vineyard with vines as the only available host, vulnerable to attack.

Curculio beetle

Curculio beetles prefer vineyards planted on heavier soils than those on sandy soil. The adults may be found during the day in the top 1-2 cm of soil at the base of the cutting and may be seen at night feeding on young leaves. Densities of about 5 per vine may result in significant damage to the young cutting and in the field, numbers may reach 20-30 per cutting.

The adult weevil is flightless, so the source of the invasion is usually adults walking from nearby mature vines, but other crops such as apples, stonefruit and strawberries may be sources of adults. Feeding of curculio beetle does not generally cause economic damage in grapevines other than those newly-planted.

Garden weevil

Larvae of garden weevil feed during winter on the roots of weeds growing between rows of vines. Adult weevils emerge from the ground at about the time of bud burst, and during the day they may be seen sheltering among the litter at the base of the vine, or under the bark of the vine. The weevils ascend the vine at night and feed on open buds. Later in the season, weevils feed on leaves of all stages, giving a shot hole appearance to the leaf (Figure 3).

Garden weevil adults are flightless, and are distributed to new areas in soil, plants and n machinery. Garden weevils have a wide host range including ornamentals and strawberries. In vineyards where garden weevils are established, the seasonal occurrence of damaging outbreaks is sporadic, perhaps reflecting local weather conditions or variations in larval food supply.

African Black Beetle

Adults of African black beetle may eat around the base of vine cuttings at, or below, ground level in early summer. Larvae of this insect feed on grass roots, and it is possible that the adults on vines originate from the vines but since adult beetles are good fliers (they may sometimes be seen at lights during the night) they may fly in from outside a vineyard.

Monitoring

The period during which young vines are susceptible to attack from these insects extends from bud burst to December. For proper monitoring, inspect a representative sample of vines carefully at about five day intervals. Look for signs of leaf damage. Lightly scrape the soil at the base of the vine, and look for insects sheltering during the day. Inspection of the vines at night may reveal the insects feeding actively. A useful monitoring method for mature rootstocks grafted over is to wrap corrugated cardboard around the base of a number of representative vines, and inspect for insects sheltering in the band.

Biological and Cultural Control

Both pink cutworm and curculio beetle are attacked by natural enemies during some part of their life cycle, but these do not give reliable control during the period when young vines are susceptible to attack. Natural enemies of garden weevil or African black beetle have not been recorded in South Australia.

The effects of weed cover on the incidence of these insects has not yet been investigated, but it is possible that weed growth between rows of vines or cultivation practices may influence the incidence of some of these insects.

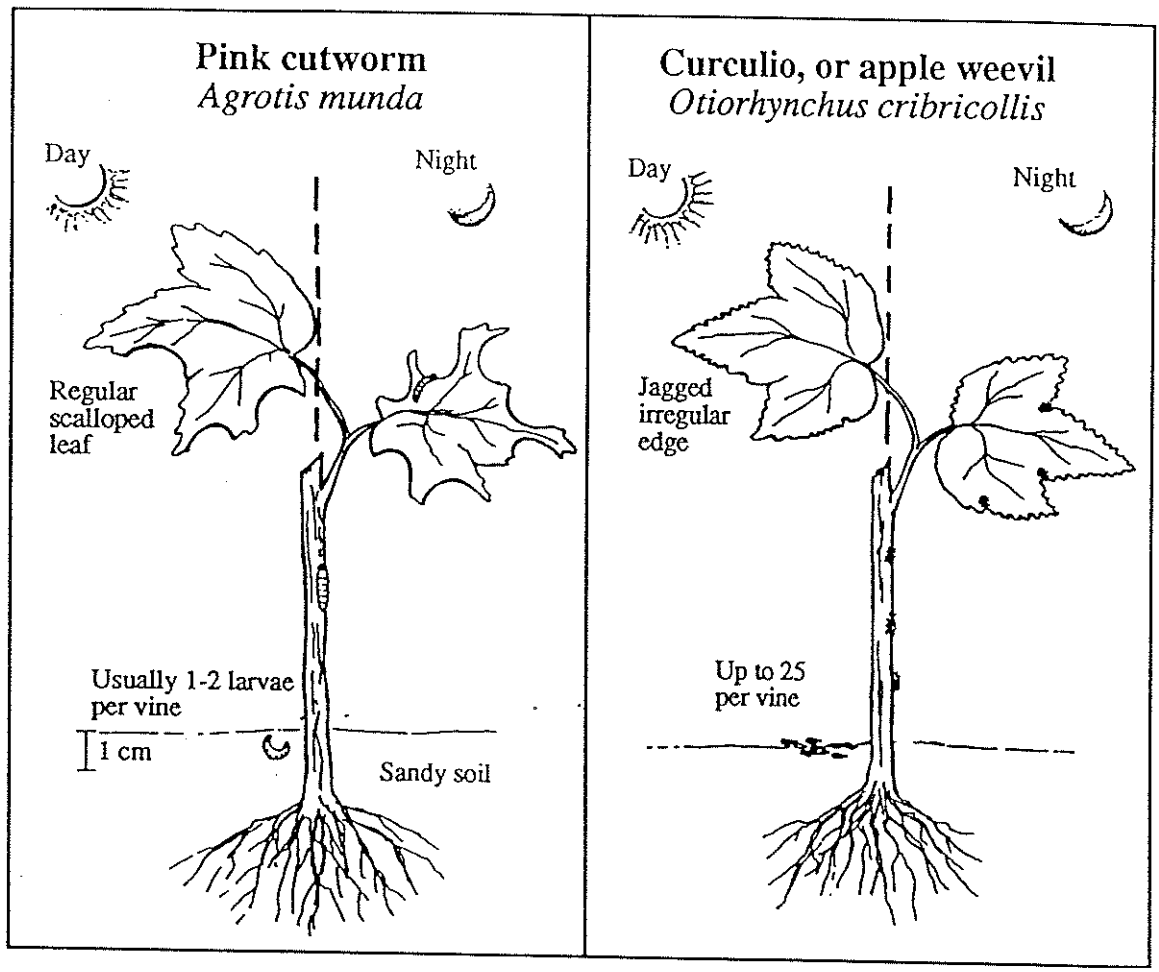
Thorough cleaning of machinery, particularly mechanical harvesters, is very important in preventing the spread of garden weevil to new areas.

Insecticidal control

Because of the short period that young vines are susceptible to economic damage and the long period to first fruit bearing (2 years), the judicious use of insecticides is not likely to upset the vineyard ecosystem or contaminate fruit. Pyrethroid insecticides have about two weeks residual life on vine leaves but appear to degrade in soil and do not accumulate in animal tissue: check in the "Guide to Insect Pest Control in Horticultural Crops" for the chemicals presently registered on non-bearing vines.

Control should be started before 10% of vines show damage symptoms. Continue monitoring after treatment because a second treatment may be required.

Since these insects are active at night, night-time spraying will directly kill the insects contacted by the spray, in addition to the stomach action of the residues on the leaves.


Pink cutworm
Agrotis munda
Day
Night
Regular scalloped leaf
Usually 1-2 larvae per vine
1 cm
Sandy soil
Curculio, or apple weevil
Otiorhynchus cribricollis
Day
Night
Jagged irregular edge
Up to 25 per vine

APPENDIX III

Grant Expenditure

The Grape and Wine Research Council provided funds for casual wages, travel and operating expenses for a two-year period as follows:

	$
1989/90	8,625
1990/91	8,925
Total	17,550
Minus funds unspent*	7,486
Net cost of Project	10,064

*Funds were not spent because

(i) experienced field staff were not available during some periods, so the principal investigator provided greater input than planned

(ii) a number of trials planned with garden weevil could not be conducted because of seasonal low numbers