



Know-how for Horticulture™

**Developing strategies
to control sweet
potato weevil**

Bruno Pinese
Queensland Department of
Primary Industries

Project Number: VG98002

VG98002

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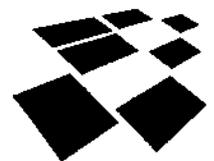
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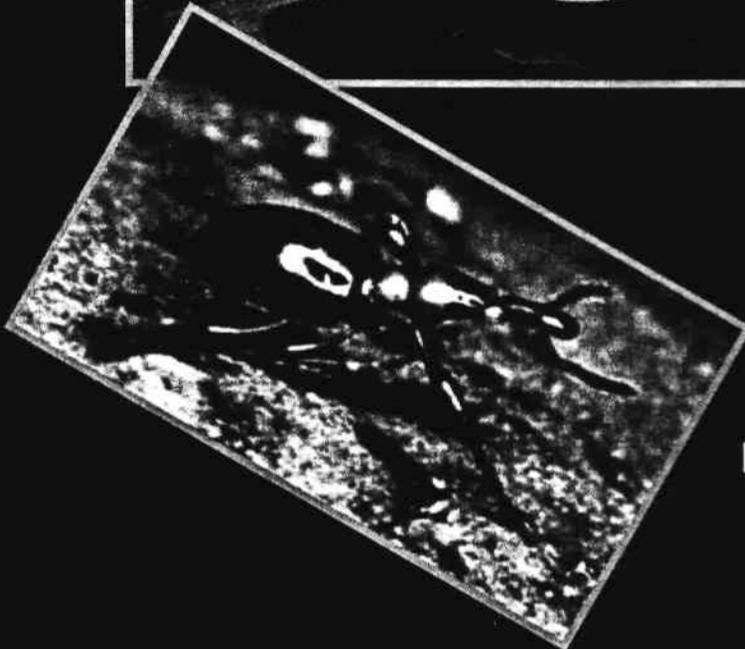
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**Final Report
VG98002**

(30 June 2001)



Bruno Pinese

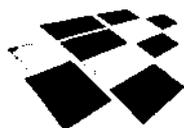
**Queensland
Department of Primary
Industries**

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The sustainable control of the sweetpotato weevil requires an integrated approach. In Australia, the industry has relied almost exclusively on insecticide treatments. Chemical control has only been partly effective and cultural controls, used in other countries, have been mostly ignored. In this work, more effective insecticides have been identified and the significance of good hygiene, alternative hosts and the possible use of varieties which show tolerance or resistance to weevil attack have been highlighted.

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Horticulture Australia



**Queensland
Fruit & Vegetable
Growers**

Research staff involved with the project were attached to the Queensland Horticulture Institute of QDPI based at Mareeba, Bundaberg and ARI, Brisbane.



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Department of Primary Industries

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1. PROJECT TEAM

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2. MEDIA SUMMARY

The project "Developing control strategies for sweetpotato weevil" set out to improve the control of this serious insect pest of sweetpotato. A constant threat to the production of this crop worldwide, the sweetpotato weevil, *Cylas formicarius*, is also the most important pest for Australian growers. Funding from grower levies and Federally, through Horticulture Australia Limited has allowed research to be carried out in a range of areas. These included: evaluation of new pesticides, crop resistance, importance of other hosts, monitoring to define what factors result in increased activity by adult weevils and cultural control methods.

This work has identified better pesticides than those currently in use and has demonstrated areas where improved cultural practices can be adopted to reduce the impact of the insect. A synthetic male-attracting pheromone was used extensively to study seasonal variation in weevil numbers within crops as well as in non-cropping areas. This showed the need for good farming practices, in particular the need for the prompt destruction of crop residues after harvest to prevent carryover of weevils into new crops.

Further studies are needed into the use of pheromone trapping as a means of non-chemical control and into ways to prevent insect carryover using post harvest management of residues. Both of these approaches will further reduce the need for pesticide treatments.

3. INDUSTRY SUMMARY

The sweetpotato weevil was identified by grower survey as the most important constraint to the viable production of sweetpotato. Aspects relating to improving the management of this pest were studied in a number of laboratory and field experiments in north and south Queensland. Poor chemical control with the current approved insecticide was implicated as the main reason for poor control resulting in significant crop losses. Therefore a major part of this work was devoted to finding suitable alternative pesticides. The project also involved studies into resistance factors within new lines and currently grown varieties, monitoring in crop and in non-crop situations to determine seasonal population changes, cultural control and the importance of alternative wild hosts as sources of weevils.

Carbaryl, the currently approved pesticide, provided inferior kill in laboratory tests and this was confirmed in field trials where it also performed poorly. Bifenthrin (Talstar), fipronil (Regent) and chlorpyrifos (Lorsban, etc.) were all shown to be effective. An application for NRA approval for both bifenthrin and chlorpyrifos to be used in rotation to reduce the risk of resistance has been submitted. Residue work is now being obtained by another agency as a prerequisite to registration. Using the variety Centennial, effective insecticides increased yields by 20% when compared to the untreated control. This was due to reduced damage to plant crowns. These results demonstrated the importance of good pesticide coverage in the area of the crown. Prothiophos (Tokuthion) provided extended residual adult weevil kill when used as a soil treatment and post harvest soil treatment with Tokuthion should be considered as a treatment to reduce weevil carryover between crops.

Evaluation of an integrated approach to weevil management using late hilling up to prevent weevil access to surface roots, monthly insecticide treatments and early harvest failed to demonstrate significant benefits of hilling up with minor benefits from early harvest. Only insecticide treatments were effective. Nonetheless an integrated approach, which includes the use of weevil free planting tips, late hilling up, early harvest and strategic insecticide use is recommended in preference to an insecticide only approach.

Significant variation in susceptibility to weevil attack was evident among the 16 lines evaluated, but the results were not consistent, with apparently resistant lines shown to be susceptible in a subsequent trial. Flesh colour was the most reliable indicator and, in general, orange-fleshed lines were more likely to be more heavily attacked, with the white-fleshed lines showing good levels of resistance. Dry matter content did not appear to have any relationship to weevil susceptibility.

Monitoring of adult weevils with pheromone-baited traps indicated that fluctuations in weevil numbers were associated with harvest activity in commercial farms or, on host availability, in sites some distance from sweetpotato growing areas. Seasonal factors did not appear to be important in north Queensland with population increases being associated with harvesting and with build up of weevils in roots left in the field after harvest. In southern Queensland populations appeared to be influenced by season, increasing in spring and peaking in summer with much lower activity in autumn and winter. Neglected plantings produced the most increase in weevil numbers and this result indicates the importance of prompt destruction of crop residues as a strategy to reduce weevil migration into subsequent crops.

Future work should aim at investigating the use of Tokuthion for residual control of post harvest populations and evaluating the use of high density pheromone trapping grids to reduce the number of males thereby reducing the mating potential of the females. Repeated insecticide use for weevil management has to be closely monitored for resistance as well as potential for causing flare up of mites and possibly silverleaf whitefly. Plant breeders should not overlook evidence of resistance/susceptibility when evaluating new lines for desirable commercial and agronomic characteristics.

4. TECHNICAL SUMMARY

The Apionid weevil *Cylas formicarius* (Fabricius) var. *elegantulus* (Summers) is a severe and widespread tropical and subtropical pest of sweetpotato. *C. formicarius* was described from a specimen collected near Madras, India in 1798 and the name *elegantulus* was applied to the colour form that is widely distributed in India, the Pacific islands, Australia and the Americas, but morphological differences between this colour form and *C. formicarius* have not been detected.

Chemical control using prophylactic foliar field treatments of carbaryl and other pesticides is widely practiced in Australia. However, control levels have been poor with unacceptable levels of root damage, particularly on late season crops. In a series of laboratory bioassay and field tests, the pyrethroid, bifenthrin, the phenyl-pyrazole, fipronil and the organophosphate, chlorpyrifos were shown to provide the best protection of roots and plant crowns. These treatments increased root yields by up to 20% in response to reduced weevil damage to the plant crown when compared to untreated control and this was significantly better ($P < 0.05$) than the result obtained with similar monthly spray regimes using carbaryl. In these trials, carbaryl treatments did not improve control when compared to the untreated controls ($P > 0.05$).

Evaluation of 16 sweetpotato lines demonstrated significant differences in susceptibility to weevil attack but this was not constant from year to year with results showing a reversal of trends in some lines. Flesh colour provided the best indicator to weevil susceptibility with white-fleshed lines showing the highest level of weevil resistance/tolerance and orange-fleshed lines being the most susceptible. No correlation could be drawn between dry matter percentage and damage across the lines evaluated. Weevil damage to the crown area was usually the first indication of attack and a good indicator of future root damage and reduced yield response. Monitoring damage in this area would provide an early indication of weevil attack and assist with chemical application timing rather than rely on calendar spray treatments.

The synthetic pheromone (Z)-3-dodecenyl (E)-2-butenate was used to monitor seasonal population changes in commercial crops and in non-cropping environments. A comparison of trap catches from northern and southern Queensland, showed that seasonal factors were less important in north Queensland due to the milder winters. In north Queensland the most important factor influencing weevil populations was crop stage. In particular, weevils increased suddenly in the period immediately post harvest, apparently in response to removal of tops. Thereafter, populations remained high for a period of eight or more weeks, the period during which residual roots were a viable food source. In areas away from commercial sweetpotato crops in north Queensland, weevil populations peaked in spring in response to seasonal development and availability of roots and stems of alternative wild *Ipomaea* host species.

Sweetpotato weevil fed on 11 alternative species including three commercial hosts and eight wild hosts collected in north Queensland. Breeding was only noted on *Ipomaea saintronaensis*, *I. Nil* and *I. angulata*. These wild hosts are common species in natural vegetation and thus their removal to suppress build up of weevil in non-crop situations is considered impractical.

Further work is required to determine the impact of post harvest control of residual weevil populations using pesticides such as prothiophos. The use of high density pheromone trapping grids to achieve mating disruption may also provide further means of minimising damage and reducing the need for pesticides. The impact of pesticides use should be monitored particularly with regard to mites and silverleaf whitefly a pest which has recently become established and is a potential severe pest of sweetpotato.

5. RECOMMENDATIONS

1. Queensland Fruit and Vegetable Growers (QFVG) should liaise with CPA Research P/L to expedite the registration of bifenthrin and chlorpyrifos. Based on results obtained from the bioassay study and field trials, permit applications have been sent to the NRA. Crop residue data, to be obtained by CPA research P/L, is still required to finalise the application.
2. Growers should carry out prompt destruction of post harvest crop residues to reduce weevil build up and eventual carryover into new crops. It is recommended that, if reject roots cannot be removed from the field and quickly disposed by feeding to livestock or by other means, that multiple discing be used to break up roots to speed up their breakdown to prevent weevil breeding. If possible as an added precaution, new crops should not be planted near old crops for a period of at least six months to allow sufficient time for residue breakdown and reduction in the weevil population.
3. New lines of sweetpotato being evaluated for desirable agronomic characteristics should also be evaluated for resistance to the sweetpotato weevil, as there is good evidence of resistance/tolerance to damage particularly in the white-fleshed lines.
4. Future studies should investigate the effectiveness of post harvest soil insecticide treatments to reduce weevil carryover into new crops and the use of high density pheromone trapping to reduce mating through the use of the confusion technique. Prothiophos was shown to provide long term kill of weevils when applied to bare soil and the impact of this post harvest "clean up" needs to be evaluated under commercial conditions.

6. PROJECT INTRODUCTION

The sweetpotato weevil, *Cylas formicarius* a native to the Indian subcontinent and eastward to Malaysia is one of about 24 species of *Cylas* that originated from Africa. *C. formicarius* is now distributed widely throughout tropical and subtropical regions. In Australia it is confined to northern and eastern parts where it has become an important and recurring pest of cultivated sweetpotato, *Ipomoea batatas*. Other related non-commercial species including morning glory, *I. purpurea*, potato vine *I. aquatica* and the beach morning glory *I. pes-caprae* have been documented as hosts (Sutherland, 1986) and these species plus others have been shown to be hosts in north Queensland.

The life cycle occurs entirely on the host plant and a full cycle can be completed in as little as 33 days under warm to hot conditions but this period is greatly extended during cold weather. Eggs are laid singly in pits produced by the female in the vines near the crown above the soil or in exposed roots. As the top portion of roots increase in size they become exposed due to soil erosion or soil cracking, and therefore become a preferred egg laying site. Under warm spring and summer conditions the small larvae hatch in about 8 days and tunnel within the host tissue. They develop through three stages prior to pupation (Sherman and Tamashiro, 1954). The larval period is variable depending on temperature ranging from 10 - 25 days. Pupation occurs within the larval burrows and lasts for about 8 days. Adults are relatively long lived and females start laying eggs about a week after emergence and can continue to lay eggs for a period of three or more months.

Adult weevils feed on host leaves, leaf petioles and stems. The damage it causes on aerial parts is considered to have minor economic importance compared to the damage inflicted by the larvae feeding on crowns and more importantly the marketable roots. Even minor damage to the roots makes them unfit for human consumption due to release of bitter and unpleasant terpene flavours, caused by weevil feeding and hence, culling of even slightly infested roots at harvest or during packing is very important and results in reduced packing throughput. In Australia, direct average crop losses from discarded roots has been estimated at between 5 and 15 % of production but total losses have been reported in some crops where the level of damage makes harvest uneconomic. Reduced root yield due to crown and stem damage could not be demonstrated by Takelar (1982) but our results, using the susceptible cultivar Centennial, have shown that even moderate levels of damage to the crown resulted in a reduction in total root weight.

In contrast to resource poor countries, where cultural methods are recommended and used extensively, in Australia control has relied primarily on multiple prophylactic insecticide treatments during root formation. Nonetheless, only the carbamate insecticide carbaryl is approved for use against sweetpotato weevil in Queensland and the level of control achieved is reported by growers to be marginal, particularly in crops grown in spring and summer when pest pressures are higher. Pest suppression through good crop hygiene is not widely practiced nor is there any active research being carried out to select resistant or tolerant lines.

Aims of this Project

This project set out to:

1. Find more effective pesticide(s) than that currently approved.
2. Identify alternative hosts.
3. Identify tolerance to weevil in a number of new lines.
4. Determine the seasonal fluctuations in weevil populations.
5. Provide growers with information on overall management of the pest.

7. DETAILED REPORT

7.1 Insecticide Bioassays

Introduction

Insecticide based work has been undertaken worldwide against sweetpotato weevils including among others, Rajamma (1990), Muruwanda *et al* (1985), Southerland (1986), Mason *et al* and Teli and Salunkhe (1994) but no work has included the new phenyl pyrazole insecticide fipronil (Regent- Rhone-Poulenc) or the synthetic pyrethroid bifenthrin (Talstar - FMC). Both of which have shown good efficacy against other soil insects (B. Pinese, unpublished results and R. Bull, personal communication).

Carbaryl, the current approved pesticide for control of the sweetpotato weevil, does not appear to provide adequate levels of protection and its efficacy is considered inadequate with growers requesting a more effective alternative. Nine insecticides with known or reported efficacy against other weevil pests were evaluated in a series of bioassay tests to determine their efficacy against the sweetpotato weevil. Bioassays using treated filter paper and sweetpotato tips and soil residual tests were conducted under controlled conditions to rapidly and efficiently screen these insecticides prior to field evaluation of the more promising candidates.

Materials and Methods

Bioassay 1

Six insecticides each at four dilutions were compared to the standard recommended field (foliar) application rate for carbaryl.

Insecticide trade name and (common name) and individual test dilutions; millilitre active ingredient (ml ai) per litre used in the tests were as follows:

Talstar (bifenthrin)	0.12, 0.06, 0.03, 0.015 ml ai/L
Lorsban (chlorpyrifos)	0.312, 0.156, 0.078, 0.039 ml ai/L
Regent (fipronil)	0.5, 0.375, 0.188, 0.094 ml ai/L
Tokuthion (prothiophos)	0.125, 0.063, 0.032, 0.016 ml ai/L
Lebaycid (fenthion)	0.5, 0.25, 0.125, 0.062 ml ai/L
Confidor (imidachloprid)	0.06, 0.03, 0.015, 0.0075 ml ai/L
Carbaryl (carbaryl)	1ml ai/L

Commercial formulations of pesticides were diluted to the required concentration in water and 0.5ml of solution was applied to the middle of a 9cm diameter filter paper (Whatman No 2) in a petri dish. When dry, ten unsexed adult weevils were placed upon the filter paper with a small cube of sweetpotato root as a food source. For each test insecticide, each concentration was replicated three times. Between 48 and 168 hours after weevils were introduced to the filter paper, mortality was assessed every 24 hours. Water only treatment was used as control.

Bioassay 2

Tip cuttings of the sweetpotato variety Centennial, which is highly susceptible to weevil attack, were dipped in concentrations of insecticide used for foliar application of commercial formulations. The following insecticides were evaluated: bifenthrin (0.3ml/L ai), chlorpyrifos (1ml/L ai), fipronil (0.188ml/L ai), prothiophos (1ml/L ai), fenthion (0.5/L ai) and carbaryl (1ml/L ai). Cuttings were dipped sequentially every seven days and maintained at room temperature in separate tubes half filled with water to maintain cuttings in a viable condition. Testing commenced 14 days after the initial dipping when treated cuttings with deposits aged for zero, seven and 14 days were available for testing. Ten adult unsexed weevils were used for each replicate (as in bioassay 1) and mortality was assessed every 24 hours starting 24 hours after the introduction of weevils and continued up to 120 hours after weevils were placed on the tips. Each treatment was replicated three times.

Bioassay 3

Five insecticides with known efficacy against soil insects were evaluated using commercial insecticide formulations diluted in water. The following rates (per m²) of active ingredients (g ai) were used; bifenthrin (0.006), fipronil (0.0075), chlorpyrifos (0.25), prothiophos (0.1) and terbufos (0.15). Each was applied evenly to a 1m² plot of previously disced and levelled sandy loam using an airless battery powered spraygun. Terbufos (Counter[®] 15 G) was mixed with fine sieved sand and 100 grams of sand/Counter[®] mixture was evenly distributed over the 1m² plot. After application each insecticide was either left undisturbed or lightly incorporated with a rake into the top 2cm of soil. Each treatment was replicated 3 times in a completely randomised layout. Soil samples consisted of an area of 10cm × 10cm and from 0.5 to 2cm deep were first collected after 24 hours and thereafter every seven days up to 35 days post treatment. Each soil sample was thoroughly mixed and a sub-sample placed in a petri dish, the dry soil was moistened with about 5ml of water and ten adult weevils from laboratory culture were placed on each soil sub-sample. Weevil mortality was assessed daily over a six day period.

Results and Discussion

Results from all three bioassays are presented in Figures 1-3.

When tested on filter paper under controlled conditions, chlorpyrifos, prothiophos and fenthion, were the most effective treatments, achieving 100% mortality within 24 hours and 72 hours at the higher and lower test concentrations respectively (Figure 1). Of the new chemistry insecticides, bifenthrin and fipronil were also very effective, but 100% mortality was recorded after 72 hours indicating a slower kill rate. Carbaryl at 1ml ai/L, the currently registered insecticide (included in all graphs for comparison) and imidachloprid were the least effective. This result confirms grower opinion that carbaryl does not provide economically acceptable levels of control when used as a cover spray in the field.

Fenthion was not as effective when used on tip cuttings where it provided good knockdown kill but provided very limited residual efficacy (Figure 2). This result was confirmed when it also performed poorly in the Southedge field trial, failing to prevent damage to roots and plant crowns (Table 1) and was only significantly better ($P < 0.05$) than control in a commercial field trial where weevil pressure was very low (Table 2). Carbaryl also failed to provide adequate weevil control in the Southedge field trial (Table 1) where root damage, crown infestation and the number of weevils in crowns were not significantly different ($P > 0.05$) from the untreated control. In the commercial trial (Table 2), carbaryl and fenthion treatments reduced the level of crown infestation compared to control but this was an atypical situation due to very low pest pressure.

Figure 1. Results of bioassay testing of selected insecticides against *C. formicarius*.

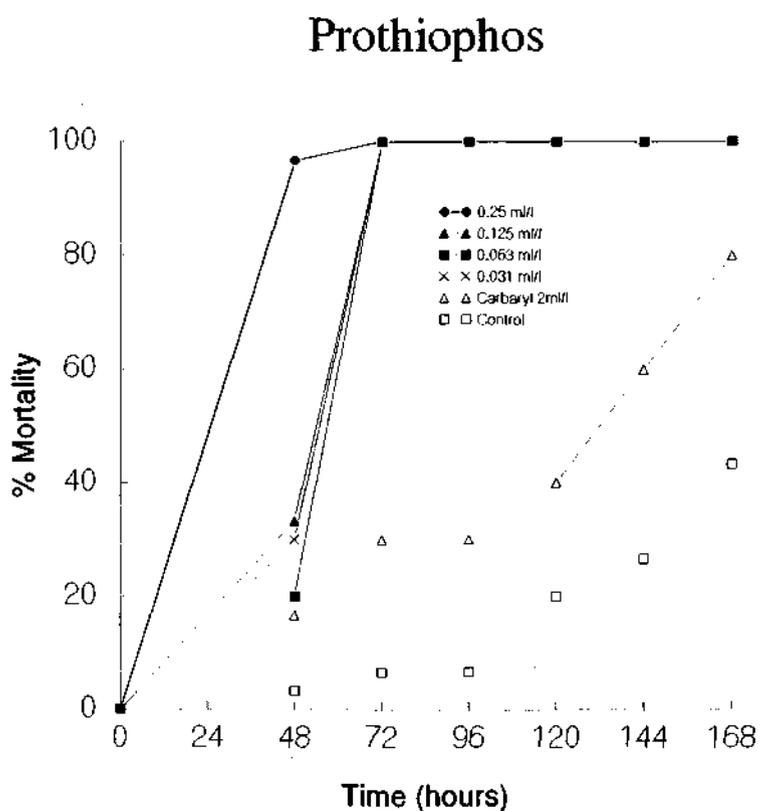
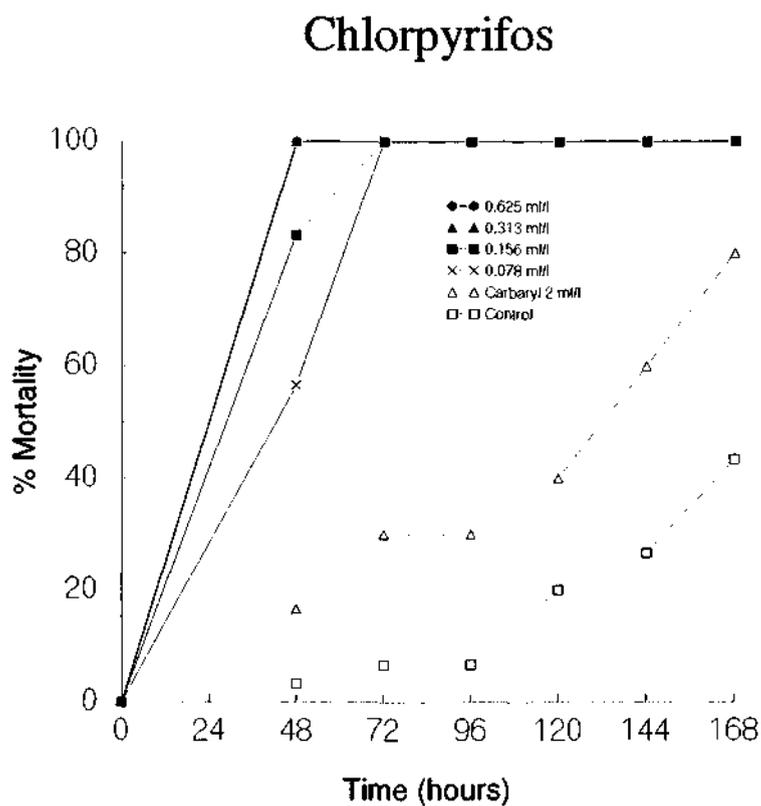
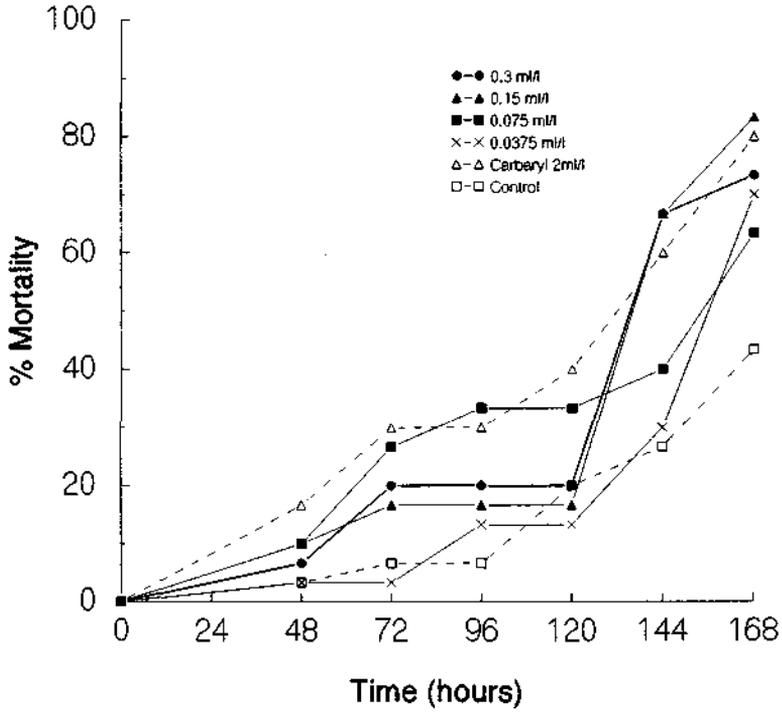


Figure 1 cont.

Imidachloprid



Fenthion

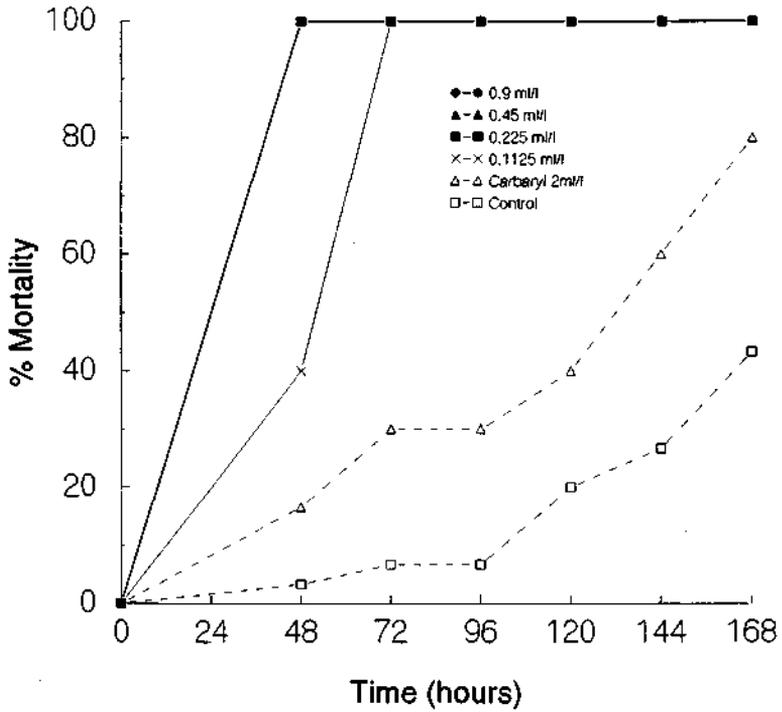
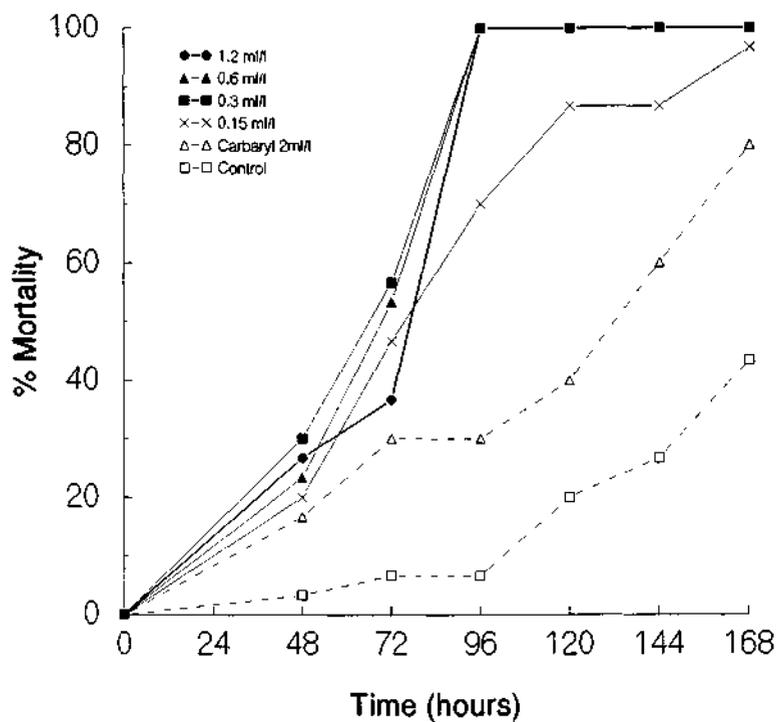
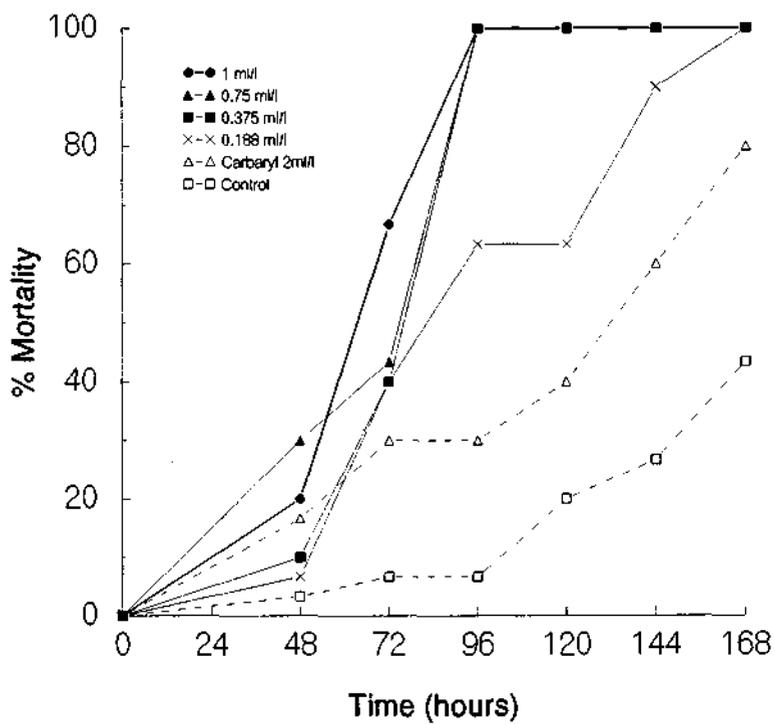


Figure 1 cont.

Bifenthrin

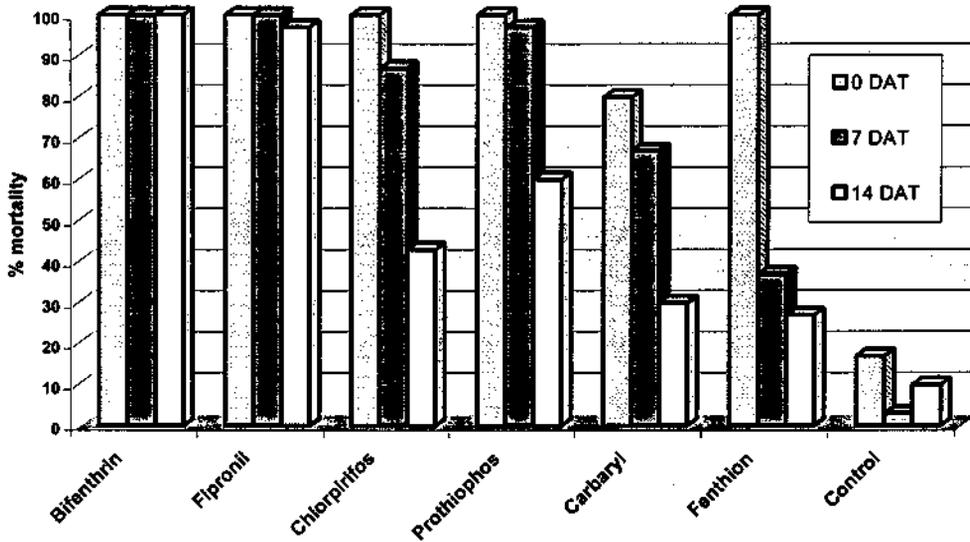


Fipronil



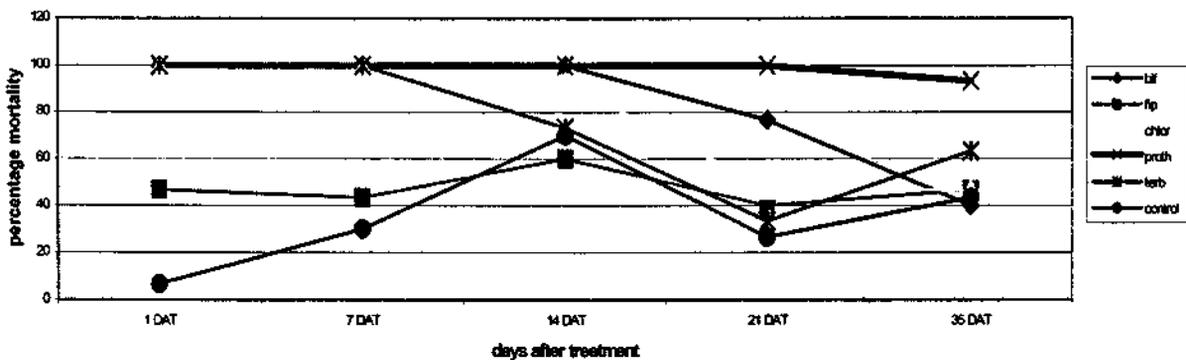
Results from the insecticide ageing test (Figure 2) show that when pesticides were applied to sweetpotato tip cuttings, all the deposits provided equally effective ($P>0.05$) initial knockdown at zero days after application. Bifenthrin, fipronil, prothiophos and carbaryl were equally effective ($P>0.05$) and significantly better than fenthion ($P<0.05$) after 7 days. When deposits were aged for 14 days, bifenthrin and fipronil were equally effective and significantly better than all the other treatments.

Figure 2. Residual efficacy against *C. formicarius* of insecticide deposits aged for 0, 7 or 14 days on sweetpotato tips.



Prothiophos was the most effective insecticide when tested as soil applied treatment, providing good residual control (about 90% kill) up to 35 days after treatment (DAT) (Figure 3). Further testing past this period could not continue due to high natural weevil mortality caused by infection from the fungal pathogen, *Bauveria bassiana*. This pathogen also resulted in high control mortalities particularly at 14 DAT. Nonetheless this result demonstrates that prothiophos could be used effectively as a post harvest soil treatment to prevent weevil build up which occurs in residual roots and volunteer plants after harvest. The high weevil build up post harvest was recorded in pheromone trapping conducted as part of the seasonal monitoring program (Ref Fig 8a).

Figure 3. Residual efficacy of soil applied insecticide against *C. formicarius*.



The residual efficacy of foliar applied insecticide treatments is an important consideration for the management of sweetpotato weevil if the number of applications is to be minimised. The treatment frequency used in subsequent field trials has shown that monthly applications of an insecticide such as bifenthrin with good residual efficacy would be adequate and that a monthly schedule of sprays starting one month post planting should provide adequate levels of weevil protection.

7.2 Field Control Trials

Introduction

Following the identification of effective insecticides in the bioassay tests presented above, these insecticides were further evaluated under commercial conditions in the field. A total of four trials were conducted at Mareeba and Southedge in north Queensland, and at Bundaberg in Southern Queensland. The once commercial variety Centennial, which is known to be highly susceptible to sweetpotato weevil, was tested under experimental field conditions at the QDPI research station at Southedge. The commercial variety Beauregard was used in commercial grower trials at Mareeba and Bundaberg. A final trial investigated a combined IPM approach to weevil control by incorporating chemical and cultural practices.

Materials and Methods

Trial 1 - Southedge Research Station, north Queensland

Five insecticides were evaluated for the control of sweetpotato weevil in a randomised block design with six replications. Datum plots were established using tip cuttings of the commercial variety Centennial on 9 September 1999, using standard commercial row and plant spacing. The trial crop was irrigated as required using overhead sprinklers and no pesticides, except for the test insecticides were used. Each plot consisted of two rows with eight datum plants in each. Plots were separated from each other by a single guard row across rows and four plants plus a three metre bare soil buffer along the rows. This prevented contamination from treatment overspray and provided equal plant competition for all datum plants thus avoiding edge effects for the datum plants. As a further precaution against drift contamination of the plots all treatments were applied before 9 am to avoid windy conditions.

Diluted insecticides were applied as foliar sprays to 'run-off' using a hand held lance with double hydraulic red Albuz[®] nozzles. Treatments were applied approximately every four weeks starting 28 days after planting. Spray volumes ranged from the equivalent of 300L/ha for the first spray, increasing up to 2000L/ha for the final two sprays. The initial two sprays were concentrated in the crown area with subsequent treatments being applied generally over the crowns and runners. A total of four applications were carried out with the harvest at 19.5 weeks after planting, seventeen days after the last spray treatment.

The following insecticides and rates were evaluated: bifenthrin (Talstar, 60ml/100L), fipronil (Regent, 37.5ml/100L), chlorpyrifos (Lorsban, 200ml/100L), fenthion (Lebaycid, 100ml/100L) and carbaryl (Carbaryl 200ml/100L). Weevil infestation relied on natural populations and on artificial releases. Approximately 5000 weevils from laboratory culture were released on 26 October 1999, with a further 2500 and 1200 released on 16 and 23 November respectively. Weevils were spread evenly throughout the trial site at each release.

Roots and plant crowns were assessed visually for weevil damage at harvest using a 0-4 scale based on estimated percentage of surface root damage where, 0 = no damage; 1 = 1-25%; 2 = 26-50%; 3 = 51-75% and 4 = 76-100%. This allowed statistical comparison of the treatments. Crowns were inspected for external signs of weevil damage and kept in closed paper bags for 8 weeks to allow emergence of weevils. Weights of damaged and undamaged roots of four size classes (based on weight) were used to determine yield impacts. Data was analysed using standard analysis of variance (ANOVA).

Trial 2 - Commercial crop - Grower trial, Mareeba

This trial evaluated the same treatments as Trial 1 in a commercial planting of the variety Beauregard planted on 1 July 1999. The first spray was applied 4 weeks after planting with three subsequent applications at monthly intervals. No other sprays were applied except for a single treatment of acephate four weeks after planting to suppress aphids. Roots and crowns were harvested twenty weeks after planting and all assessments were conducted as per Trial 1.

Trial 3 - Commercial crop - Grower trial, Bundaberg

This trial evaluated the same treatments as Trials 1 and 2 but included two soil incorporated applications of fipronil at planting (250ml/ha Regent) and at hilling-up (75ml/ha Regent) using the variety Beauregard. The trial was planted on 10 November 1999 in a small portion of a commercial sweetpotato field. The grower treated the remainder of the area with phorate before planting to control other pests. Four monthly foliar applications were used starting on 16 December using between 500 and 1000L/ha per application. Harvest date was 27 March 2000. One pheromone trap was used to record adult male weevil presence from 20 January to 23 March 2000.

Trial 4 - IPM control evaluation

Treatment combinations, including late hilling-up versus no hilling-up, early or late harvest and chemical or no chemical (bifenthrin), were investigated in a randomised block design with four replications using the variety Centennial. Plots consisted of two datum rows with 10 datum plants each. A single row guard was used across rows and four plants plus a two metre plant free buffer was used as guard along the rows. Normal commercial row and plant spacings and hilling up procedures were used.

Tip cuttings were planted on 30 August 2000. Extreme heat in the week immediately post planting caused significant plant losses and, although these were replaced on 12 September, these failed to catch up with the initial planting and yield and roots had to be discarded from the data as they failed to crop satisfactorily.

Approximately 480 adult weevils were released weekly to augment the natural weevil population on each of five occasions starting on 12 October. Three insecticide treatments were applied approximately monthly starting on 5 October. The early harvest was conducted on 2 January 2001 with the late harvest four weeks later on 29 January. Weevil damage was assessed as per the earlier field trials.

Results and Discussion

Results of all field trials are presented in Table 1 and Figure 4 (Trial 1 - Southedge), and Tables 2 and 3 plus Figure 5 (Trial 2 - Mareeba). Results from the Bundaberg trial (Trial 3) are not included due to the very low level of infestation that prevented the collection of meaningful data. Yield results for Trial 1 are summarised in Figure 4 and Table 3. Poor plant establishment due to extreme heat prevented meaningful data being obtained from trial 4.

Table 1. Summary of trial data: evaluation of insecticide treatments to control the sweetpotato weevil, *C. formicarius*, at Southedge, north Queensland.

Treatment	Yield kg/plot (16 plants)	Proportion of roots undamaged	Mean damage rating* on roots	Mean no of infested crowns/16	Mean total no of weevils in crowns
Bifenthrin	49.27 c	98.55 e	0.02 a	0.50 a	0.17 a
Fipronil	44.27 bc	90.06 d	0.13 ab	8.17 b	3.33 ab
Chlorpyrifos	43.14 ab	82.91 c	0.23 b	9.33 b	4.83 ab
Fenthion	40.48 ab	69.72 b	0.42 c	12.67 c	20.33 c
Carbaryl	39.20 ab	67.24 b	0.46 c	12.83 c	16.17 bc
Control	38.12 a	60.16 a	0.58 c	14.17 c	17.5 bc
LSD	5.20	NA	0.17	2.88	14.30

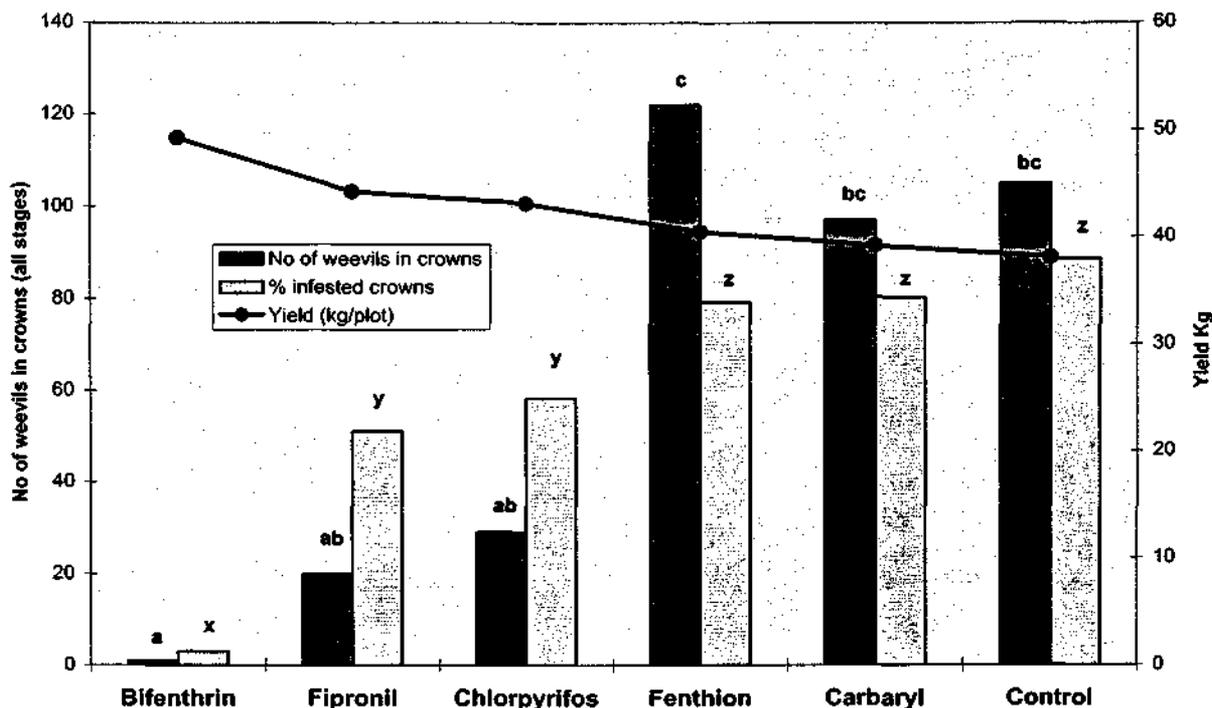
Treatments followed by the same letter are not significant at 5% level.

LSD at 5% level.

NA - Not Applicable

* Rating scheme for damage to roots based on % surface area of root infested -- where 0= 0; 1= 1 to 25%; 2= 26 to 50%; 3= 51 to 75% and 4= 76 to 100%

Figure 4. Number of weevils in the crowns of sweetpotato (var. Centennial), percentage of infested crowns and root yield following application of monthly insecticide treatments at Southedge, north Queensland.



Note: Bars with the same letter (a-c: no of weevils and x-z: percent infested crowns) are not statistically different at the 5% level

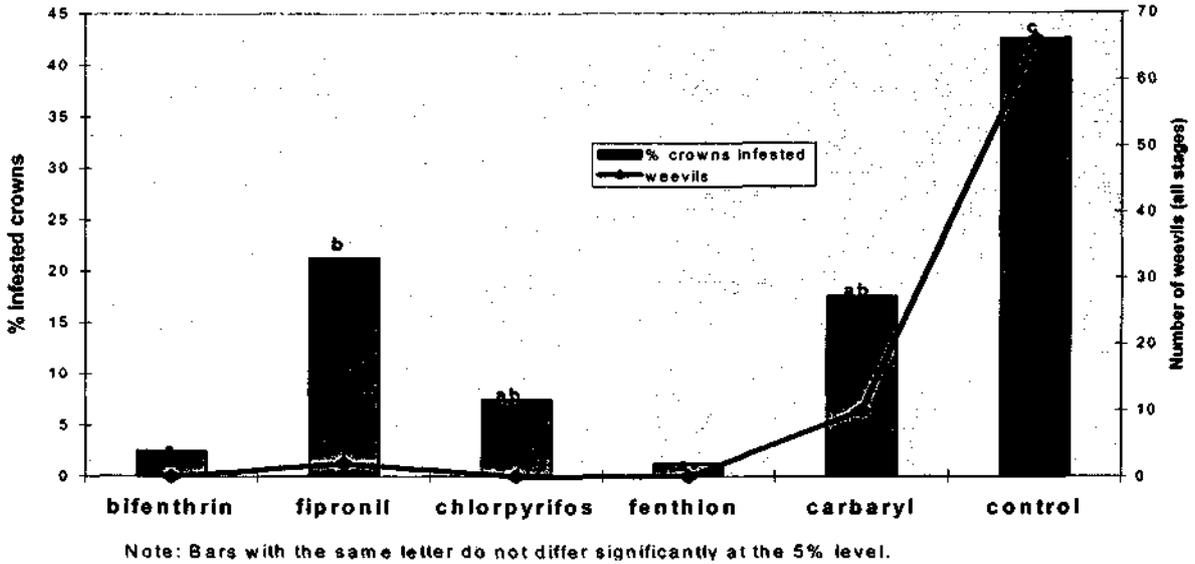
Table 2. Damage assessment on roots and crowns of sweetpotato (var. Beauregard) at harvest following insecticide treatments at Mareeba, north Queensland.

Treatment	Yield kg/plot (16 plants)	Proportion of roots undamaged	Mean damage rating on roots	Mean no. of infested crowns/16	Mean no of weevils in crowns/plot
Bifenthrin	22.45	100	0.0	0.4 a	0.00 a
Fipronil	22.09	100	0.0	3.4 b	0.40 a
Chlorpyrifos	18.19	98.71	0.01	1.2 ab	0.00 a
Fenthion	18.44	100	0.0	0.2 a	0.00 a
Carbaryl	18.66	91.67	0.08	2.8 ab	2.00 a
Control	16.39	92.66	0.07	6.8 c	13.20 b
LSD	NS	NA	NS	2.7	6.06

NS - No Significant differences at 5% level

NA - Not Applicable

Figure 5. Percent crown infestation and number of *Cylas formicarius* in sweetpotato crowns (var. Beaugard) at harvest following application of insecticide treatments, Mareeba trial, north Queensland



Assessments of root damage, particularly in the Southedge Trial, showed that monthly sprays from four weeks after planting with bifenthrin and fipronil provided good protection against the sweetpotato weevil.

Infestation levels occurring in the crown provided a good indication of treatment efficacy (Figure 5). Bifenthrin was the most effective treatment with a mean of only 0.4 infected crowns being detected from a plot size of 16. Similarly, the population of live weevils (total of larval, pupal and adult stages) was significantly lower in the bifenthrin treatments (Figure 5).

Table 3. Impact of sweetpotato weevil on the number of roots of three different size classes and total number of roots produced in the variety Centennial after chemical treatment.

Treatment	Total no. of roots	No. of roots >1kg	No of roots 600-1000g	No of roots 250-600g
Bifenthrin	77.8	10.3 a	23.2	44.3
Fipronil	78.3	6.5 b	19.2	49.8
Chlorpyrifos	72.8	6.3 b	21.0	45.5
Fenthion	71.5	4.5 b	17.3	49.7
Carbaryl	71.8	5.8 b	18.0	48.0
Control	67.0	5.0 b	19.7	43.8
LSD	NS	3.4	NS	NS

Treatments with the same letter are not statistically different at 5%.
NS - No Significant differences at 5% level

In trial 1, yields were inversely proportional to the level of infestation and significantly higher in bifenthrin plots compared with those in untreated control plots but yields from other treatments were not significantly higher than the controls (Table 1). The main reason for negative yield response with increasing weevil attack appears to be due to interference with water and nutrient transfer within the crowns. These results agree with earlier work on chemical control (Subramanian *et al*, 1977; Pillai *et*

al, 1981; Sutherland, 1986) where positive yield responses were demonstrated following good control of weevil with insecticide treatments at 3-4 week intervals during the growing season. In contrast, Takelar (1982), working with the cultivar AIS35-2, was unable to demonstrate yield responses in relation to different levels of weevil attack either to the roots or crowns. In our trials, even modest levels of crown infestation resulted in severe deformation and 'woodiness' of the crown of the cultivar, Centennial. Such damage would have severely reduced the capacity of the plant to develop storage roots resulting in lower yields. This was evident in the significant reduction ($P < .05$) in the number of the larger roots (>1kg) from plots with higher weevil infestation even though the number of roots produced overall was not effected (Table 3).

The treatment effect was more significant in the larger roots (>1kg) due to these being close to, or partly above, the soil surface and therefore more prone to weevil attack. In the Southedge trial, the yield of non-damaged (marketable) large roots was increased by over 100% when compared with the untreated control (Table 3). Smaller roots are usually deeper in the soil and thus escape attack from the weevil and, as a consequence, these showed no significant treatment effect. The overall yield increase of all three size categories (>1kg, 600-1000 g and 250-600g) increased by almost 20% when bifenthrin was used compared with the untreated control. The other treatments produced more modest overall increases in marketable roots ranging from 15% for fipronil, 10% for chlorpyrifos and 7% each for fenthion and carbaryl (Table 1 and Figure 4).

Bifenthrin outperformed the other insecticides and was significantly better ($P < .05$) than carbaryl, the only currently approved insecticide for use against sweetpotato weevil. Data on residues needs to be obtained to meet the requirements for permit or registration to be issued.

7.3 Alternative Hosts

Introduction

Fourteen plant species belonging to nine families have been reported as alternative host for the sweetpotato weevil (Das, 1992). These non-commercial hosts can be important as sources of weevils and therefore their prevalence in non-commercial areas needs to be considered before formulating cultural control practices that may involve removal of alternative hosts. The host status of seven *Ipomaea* spp. that occur on the Atherton Tableland, north Queensland, plus four other root producing plants was investigated by feeding studies in the glasshouse at Mareeba.

Materials and Methods

Plant materials of wild Convolvulaceae, including roots of *Ipomaea polpha*, *I. aquatica*, *I. pes-caprae*, *I. saintronamensis*, *I. cairica*, *I. nil*, *I. angulata* and *Meremia quinata* were collected from sites on the Atherton Tableland and coastal areas (*I. pes-caprae*) of north Queensland. The tubers of commercial plants including yam beans, (*Pachyrhizus* spp.) cassava, (*Mannihot esculenta*) and taro, (*Colacasia manihot*) were also collected and grown in the QHI glasshouse in Mareeba.

Twelve pairs of adult weevils were introduced to each of the test food sources in a screened insect-proof cage and allowed to feed and oviposit for 20 days in the glasshouse environment. Plants were subsequently sampled for presence of feeding, stem/root damage and weevil breeding and development.

Results and Discussion

Results of the host studies are presented in Table 4.

Table 4. Observations of host preference of *Cylas formicarius* on selected wild and cultivated plants in north Queensland.

Test Species	Surface Feeding	Tunnelling	Egg Laying	Larval Development
<i>Ipomaea polpha</i>	+	+	?	-
<i>I. aquatica</i>	+	+	?	?
<i>I. pes-caprae</i>	+	+	?	-
<i>I. saintronaensis</i>	+	+	+	+
<i>I. cairica</i>	+	+	?	-
<i>I. nil</i>	+	+	+	+
<i>I. angulata</i>	+	+	?	+
<i>I. batatas</i>	+	+	+	+
<i>Meremia quinata</i>	+	+	-	-
<i>Colacasia esculenta</i>	*	-	-	-
<i>Mannihot esculenta</i>	*	-	-	-
<i>Pachyrhizus spp.</i>	+	+	-	-

Notes

* = Trace only

This investigation confirmed that *C. formicarius* has a wide host range including relatively common wild hosts botanically related to the commercial sweetpotato, *I. batatas*. Although larval development could not be always confirmed in these glasshouse tests, due in part to total plant destruction by adult feeding, breeding on a range of plants from the family Convolvulaceae appears to be common in the wild. Hence, particularly when host material is plentiful close to cropping areas, these hosts act as a source of migrant weevils that can rapidly infest commercial crops. The importance of wild hosts was confirmed by the trapping of *C. formicarius* in natural bushland more than 10km from any known sweetpotato plants at a number of trap sites in north Queensland. A stand of *I. angulata* was the suspected source of weevils in the vicinity of one pheromone baited trap site.

The presence of significant numbers of alternative wild hosts mitigate against a practical and effective strategy of host removal to reduce migration of wild populations of weevils into commercial plantings. At this stage the effect of such a strategy has not been tested and it is unknown how significant migration from external sources is in comparison to populations that develop within cultivated crops especially after harvest.

After harvest residual roots left in the field and volunteer sweetpotato plants which develop from these can become heavily infested. Regular trapping within commercial crops has shown that weevil populations increase dramatically after harvest (see Figure 8a-c), indicating that this may be the most significant contributor of weevil infestation into existing crops. Destruction or preferably removal of crop residues during or immediately after harvest should be considered as a practical management option. Repeated cultivation could also be employed but would be costly and undesirable due to over cultivation. Post harvest residual insecticide soil treatment to prevent weevil breeding could also be used to prevent weevil breeding particularly if prothiophos to exploit its long residual efficacy (refer to Figure 3).

7.4 Evaluation of Weevil Resistance in Sweetpotato Cultivars

Introduction

Significant research studies to identify sweetpotato lines with resistance to sweetpotato weevil have been conducted primarily in the US, (Waddill and Canover, 1978; Rolston *et al*, 1979; Mullen *et al*, 1981; Mullen *et al*, 1982; Son *et al*, 1991) but the resistance levels have been relatively low (Jones *et al*, 1980; Mullins *et al*, 1985). These research efforts have failed to provide sweetpotato lines with stable resistance over time and location (Takelar, 1982) and the basis for weevil resistance remains elusive.

Nonetheless considerable scope exists to exploit resistance factors within accession lines that show reduced damage from the sweetpotato weevil. Differences in surface volatile compounds were shown by Son *et al* (1990) to be important in moderately resistant lines (Resisto, Regal and Jewel) and susceptible lines (Centennial, SC1149-19 and W115). Other parameters including dry matter content, silica, N, K, protein and sugar content have also been investigated (Anon, 1990; Singh *et al*, 1993) with results showing various levels of correlation with infestation. Son *et al* (1991) developed a method to rapidly screen test lines for resistance.

Non-preference appears to be the most likely mechanism for resistance but, antibiosis, tolerance and, in some deeper-rooted lines, escape, are likely to all ply a part in contributing to resistance or tolerance against the weevil. Barlow and Rolston (1981) identified non-preference as the explanation for most of the resistance they noted but also included escape as a significant mechanism. Cockerham and Don (1947) also proposed escape as an important factor in cultivars with deep growing roots attached to long necks since these escaped infestation more than short necked and shallow rooted cultivars. Lower crown infestation was also reported to influence yield (Mullen *et al*, 1981) and high sugar and low latex favoured weevil development. (Pillai and Kamalan, 1977.)

Materials and Methods

Sixteen sweetpotato lines, including four named varieties and twelve accession lines from Mr Lester Loader's evaluation trials of new introductions, were tested for susceptibility to the sweetpotato weevil. All lines were established with tip cuttings and grown according to accepted commercial practice using a randomised block design with four replications with forty plants within each plot. Roots were harvested weekly over four weeks starting on 8 August, sixteen weeks after planting. Roots smaller than 150g were discarded as these were considered not commercial. Weevil damage was assessed based on superficial spotting and roots were assigned as either damaged or undamaged. Other characteristics used as indicators of weevil attack were: weevil infestation in the crown (plant section from immediately above the roots to the fork where runner development starts), dry matter percentage and flesh colour. Where applicable, data was analysed using conventional analysis of variance (ANOVA).

Results and Discussion

Results are summarised in Table 5. Based on the proportion of infested roots; Q95-14, Kestle, L93-93Q9, Q95-3, Northern Star and L93-93Q12 had the lowest damage ranging from 9-24% of roots infested. The lines L93-IQ17, L93-9Q7, Hernandez, L86-33Q7, L93-Q24 had medium levels of damage with the proportion of infested roots ranging from 25-33%. The lines L93-7Q3, Centennial, L86-33Q9 and 93-93Q14 had the most damage with the proportion of damaged roots ranging between 43 and 48%.

Table 5. Summary data on 16 accession lines of sweetpotato for susceptibility to the sweetpotato weevil in north Queensland

Accession Line	Proportion of weevil infested roots	No of weevils in 16 crowns	Dry Matter %	Flesh Colour
L93-93 Q14	48.06	8	17.54	Orange
L86-33Q9	46.45	9	18.63	Orange
Centennial	43.05	21	23.16	Orange
L93-7Q3	42.65	5	12.37	Orange
L93-93Q24	32.99	8	18.28	Orange
L86-33Q7	31.88	4	19.79	Orange
Hernandez	29.50	2	20.38	Orange
L93-9Q7	26.63	3	19.21	Orange
L93-1Q17	24.79	18	16.05	Orange
L93-93Q12	24.19	1	20.86	Orange
Northern Star	22.26	5	24.87	White
Q95-3	22.01	1	24.82	White
Accession 87	21.21	4	25.73	White
L93-93Q9	20.51	13	16.07	Orange
Kestle	11.27	0	27.57	White
Q95-14	8.91	0	25.82	White
LSD (5%)	14.38	NA	2.33	NA

This field trial relied solely on natural infestations and, therefore was subjected to the usual limitations of excessive crop variation, crop loss and variable pest activity. Nonetheless, the results show significant differences between the various lines in general terms. These results agree with those of others (Waddell and Conover, 1978; Rolston *et al*, 1979; Mullen *et al*, 1982), who stated that resistance in sweetpotato is essentially a continuous gradient and suggested that due to this, resistance in sweetpotato is most likely to be polygenic.

Crown infestation varied significantly between lines and, with the exception of L93-93Q9, was directly correlated to root damage. Flesh colour was the most reliable indicator of potential for weevil attack with the orange fleshed lines having a mean of 33.7% infested roots compared to 17.1% for white fleshed lines. This trend was also evident in crown infestation where a mean of 8.4 and 2.0 weevils were recovered from 16 crowns of orange and white-fleshed lines respectively. Dry matter percentage had no apparent correlation with weevil damage.

Considerable natural variation in susceptibility to sweetpotato weevil occurs between different varieties/cultivars and lines and this should be considered in breeding programs or in the choice of cultivars to grow commercially. Because the mechanism of resistance/tolerance is currently poorly understood, selection of desirable lines should be based primarily on good agronomic characteristics but the level of weevil infestation should also be taken into account when making selections. The orange fleshed varieties were on average much more susceptible. Planting white fleshed cultivars should be considered in preference to orange fleshed ones if reduced damage from sweetpotato weevil is a major consideration.

8. SEASONAL POPULATION STUDIES

Introduction

Growers have reported more problems in spring and summer grown crops than in those growing during cooler winter months. While it has long been known that weevil numbers build up within successive commercial crops and fly to adjacent crops, the significance of weevil populations which develop outside the cropping environment, particularly on wild hosts, has not been considered as important. Knowledge of the factors which may determine seasonal population trends and build up in crop and non-crop situations would assist formulation of improved management options for growers.

This study was undertaken primarily to determine what factors influence sweetpotato weevil population fluctuations within cropping and non-cropping environments and to test a number of commercial trap designs and a simple trap produced from plastic bottles (Photos 1-4).

Materials and Methods

Monitoring

Regular weekly monitoring of sweetpotato weevil was carried out within commercial crops at Mareeba, north Queensland, (3 sites) and Bundaberg, south Queensland, (4 sites). Sixteen sites at least 10km from known sweetpotato crops and volunteer plants were also studied. These were located on the Atherton Tablelands (13 sites) and in coastal areas (3 sites) in north Queensland. This study commenced in mid 1999 and ended in late 2001, a period that included at least two sweetpotato cropping cycles.

Rubber septa lures each baited with one milligram of the male pheromone (Z)-3-dodecenyl (E)-2-butenate were used in conjunction with simple funnel traps (Appendix 4, photos 1-4). Traps were serviced weekly at the time when weevils were removed and counted. Pheromone charged rubber septa were replaced every four weeks to maintain catching efficiency. The pheromone ester was synthesised by Dr Moore from ingredients obtained through Aldrich Chemical Company Inc. and using techniques outlined by Heath et al (1986). Prior to use, the pure ester was diluted with toluene (1 part ester:10 parts toluene). Ten microlitres (1mg) was deposited on the inner wall of a 15-20mm length of natural rubber tube with a 9mm outer diameter. A manually operated Burkard micro drop applicator was used to charge the rubber tubing. Charged lures were allowed to air dry for approximately 30 minutes and stored in airtight containers under refrigeration until required.

Crop stage and commencement date of harvest was recorded during trap servicing operations.

Trap design

A standard green plastic funnel trap, commercially available from AgriSense, a vertical pipe trap, used for monitoring potato moth in tomatoes, and a Delta-style trap with a Tac trap sticky base were compared for efficacy in catching weevils in two trials. In each trial, five traps of each design were randomly allocated to 10 positions in a sweetpotato crop. They were cleared after 24 hours, re-randomised, and cleared again 24 hours later.

Pheromone lure evaluation

Two types of lures were evaluated using funnel traps. Commercially available AgriSense lures loaded with 0.1mg of pheromone and lures produced "in house" and referred to as project lures loaded with 1mg of pheromone were tested. Six traps charged with each lure were randomly allocated amongst 12 positions in a sweetpotato crop. The traps were cleared after 24 hours and re-randomised over a five day period using a completely randomised design.

Age of lures

The effect of lure age on catch efficacy was determined for the two types of lures used in the pheromone evaluation. Both types were aged for either 2, 4, 8, 12, or 16 weeks by placing them in Delta-style traps outdoors at Bundaberg Research Station. After the required aging, the lures were stored in a freezer until needed for testing. Placing them in funnel traps within sweetpotato crops tested the catching efficiency of the aged lures. The traps were cleared after 24 hours and re-randomised within the blocks over a five day period using a completely randomised design.

Results and Discussion

Monitoring

Trapping results from pheromone baited traps placed at least 10km from known sweetpotato plants and crops are shown in figures 7(a) and 7 (b). Results from traps placed within commercial crops are shown in Figures 8a-c for the Mareeba district and Figures 8d-g for the Bundaberg district.

Differences are evident between commercial farms at Mareeba and Bundaberg. Specifically, trap catches in the Mareeba area did not appear to be influenced by seasonal factors but were more affected by field practices, in particular harvesting (Figure 8a-c). On the other hand, trends in Bundaberg appeared to be influenced by seasonal factors with the numbers increasing in spring (October-November), peaking during summer (December-February) and falling during autumn, with the lowest numbers recorded in winter. The importance of harvest and the immediate post harvest period on weevil catch shown in Mareeba could not be demonstrated in Bundaberg as traps were relocated to new plantings when the harvest started. On two of the farms, (farms M and T) where plantings were neglected, large weevil build up occurred during March-May and November-February respectively and these results were similar to those obtained on farms at Mareeba after harvest or relating to the Emerald Ck farm where the crop was not harvested.

Seasonal trends were evident despite weekly catches being affected by weather conditions such as high wind and rain, crop development and movement of traps between plantings on the same farm. Lower autumn and winter temperatures in the Bundaberg district compared to Mareeba would explain the decline in weevil numbers in Bundaberg during the winter months.

Trapping results on the three Mareeba area farms showed consistent trends, with high catches apparently triggered by harvesting or mature crop left unharvested. In general, trap numbers were low before the harvest and as the harvest began, numbers increased rapidly and remained high for a period of about 6 to 8 weeks post harvest when numbers again subsided to low levels. These results indicate that removal of tops and digging of roots either attracts weevils from nearby areas, or triggers flight from the harvested area. The residual roots, which are invariably left on the surface of the soil, attract females to lay eggs and the ensuing generation maintains the high catches until the residual roots rot and become unsuitable as breeding sites. A similar situation occurred in a neglected planting (Emerald Creek) where high catches were the result of within-crop breeding.

Farm management activities, in particular harvesting, appeared to influence weevil activity on commercial farms. Warmer conditions and possibly the availability of feeding and breeding sites on alternative host roots/tubers appeared to be the factors influencing weevil activity on non-commercial sites. At these sites, adult trap catches increased in spring during September and October. Alternative host tubers were also collected at this time and found to be infested with sweetpotato weevil. The short peak in adult weevil activity from September to January/February was similar between coastal and Tableland areas and appears to be associated with the suitability of host roots for larval development. Weevil populations developing in wild non-commercial hosts particularly in spring would pose a threat to commercial crops but the large number of hosts in a large area of natural bushland does not allow any practical management options to be implemented.

Trap design

Catches were very variable, with field position having a large effect on trap catch. The large natural variability in catch made it difficult to demonstrate statistical differences between trap designs. However, despite the variation, it was clear that the funnel traps were the most effective with the Delta traps less effective and the pipe traps ineffective. Funnel traps were chosen for use in future trapping at Bundaberg. Smaller, locally designed and assembled funnel type traps were used for monitoring work in Mareeba (Appendix 4, photos 1-4).

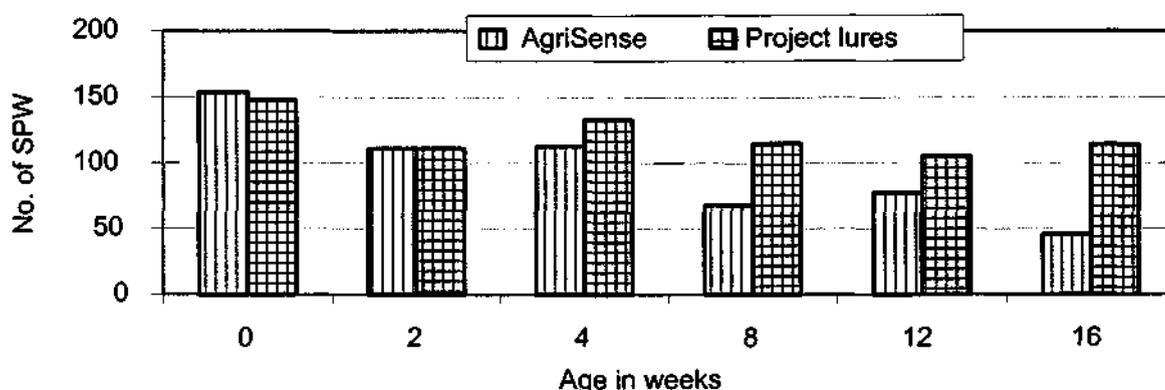
Pheromone lure evaluation

The project lures generally caught more weevils than the AgriSense lures during the first five days but the effect of one trap in a "hotspot" position masked any significant differences. Traps baited with project lures caught significantly more ($P < 0.05$) weevils than traps baited with AgriSense lures on four of the five days of the trial. This result was most likely due to the higher pheromone loading on the project lures rather than any qualitative difference between the pheromone ester used, although qualitative comparisons of commercial and project-provided pheromone ester was not carried out. The smaller pheromone loading in the AgriSense lures is designed to attract males from short distances and thus provide smaller catches that are easier to process.

Age of lures

The results are shown in Figure 6. There were no significant differences in the numbers of weevils caught by project lures of different ages. This result shows that the lures do not need replacement for at least 16 weeks. In practical terms, this is approximately equal to one crop cycle. The new (0 week) AgriSense lures, were as efficient as those aged for two and four weeks ($P < 0.05$) but the new lures caught significantly more weevils than those aged for 8, 12, and 16 weeks. Lures aged for 16 weeks caught significantly fewer weevils than the others did. Because of the reduced catching efficiency after four weeks, AgriSense lures would need to be replaced every 4 weeks to allow comparable monitoring of numbers over time.

Figure 6. Catches of male *C. formicarius* by AgriSense and project lure baited funnel traps aged from 0 to 16 weeks



While it was not evaluated, the lower trapping efficiency and shorter attraction period obtained from the AgriSense lures is most likely related to the lower quantity of pheromone used in these lures compared to the project lures. The higher pheromone concentration did not repel the male weevils as initial catches from both lures produced equivalent catches ($P > 0.05$).

Figure 7a. Mean number of *Cylas formicarius* males collected in pheromone baited traps at least 10km from known sweetpotato growing areas - Atherton Tableland sites, north Queensland.

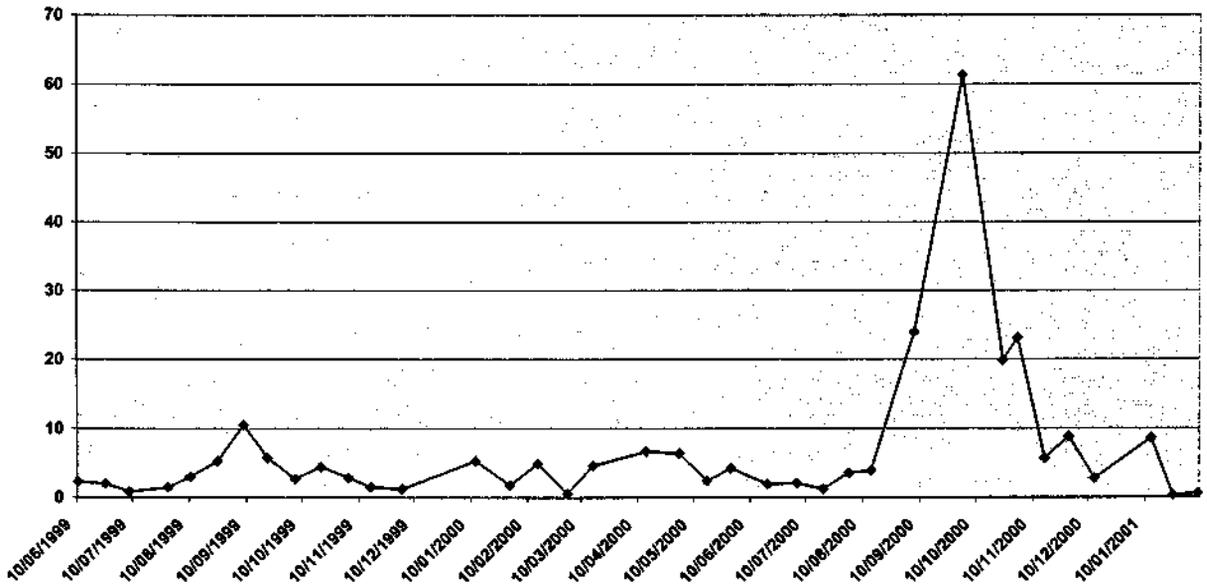


Figure 7b. Mean number of *Cylas formicarius* males collected in pheromone baited traps at least 10km from known sweetpotato growing areas - Coastal sites, north Queensland.

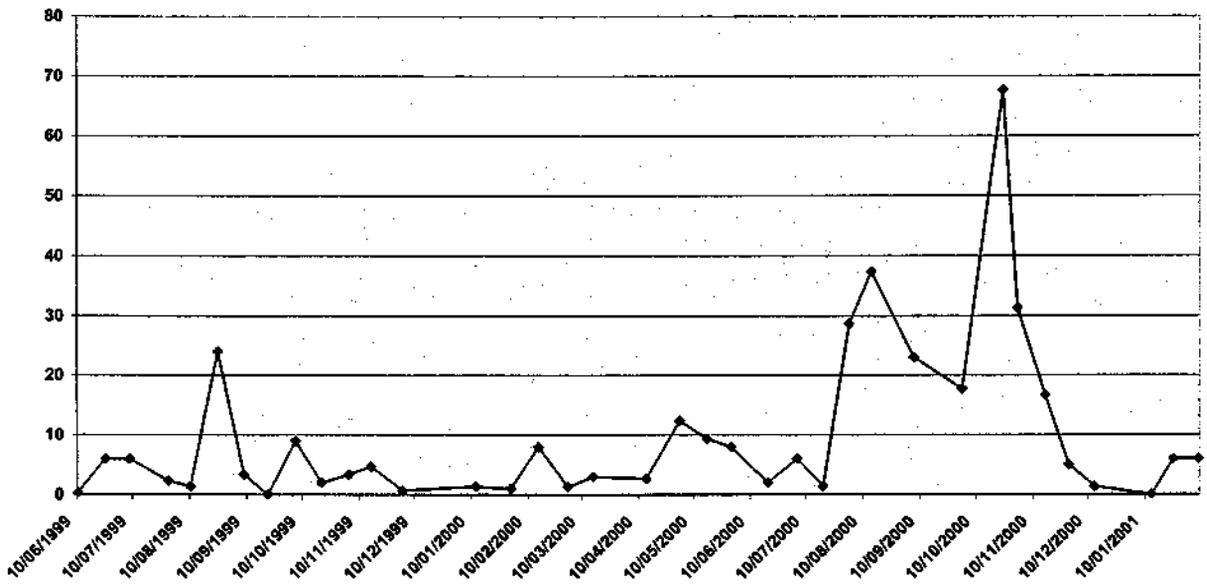


Figure 8a. Average trap catches per week at Bibohhra.

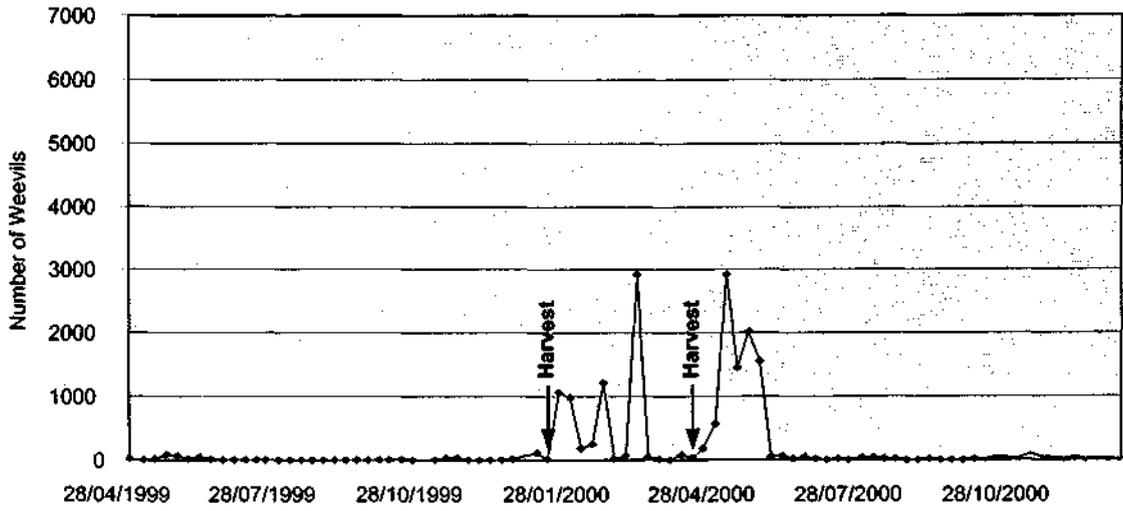


Figure 8b. Average trap catches per week at Paddy's Green.

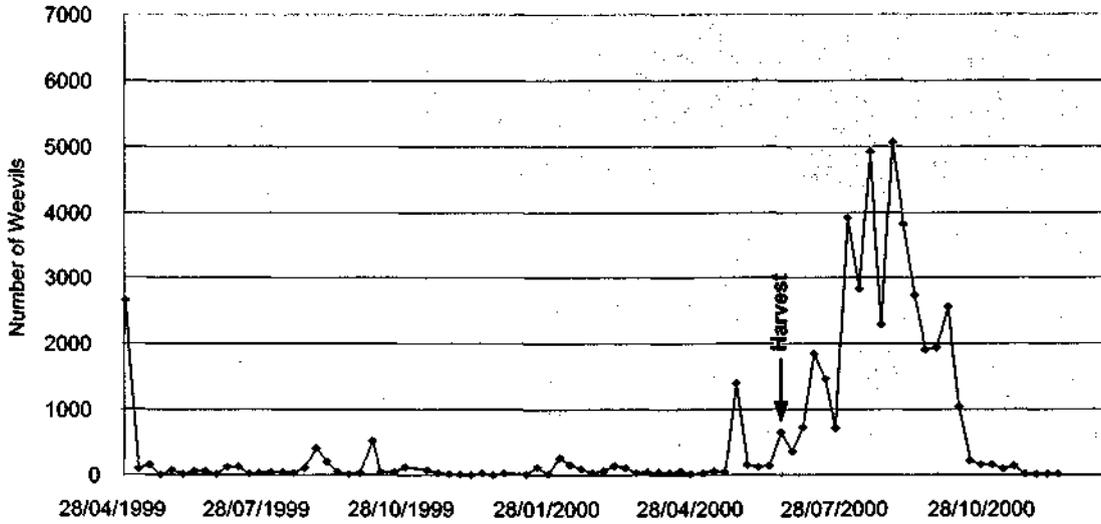


Figure 8c. Average number of weevils per week at Emerald Creek.

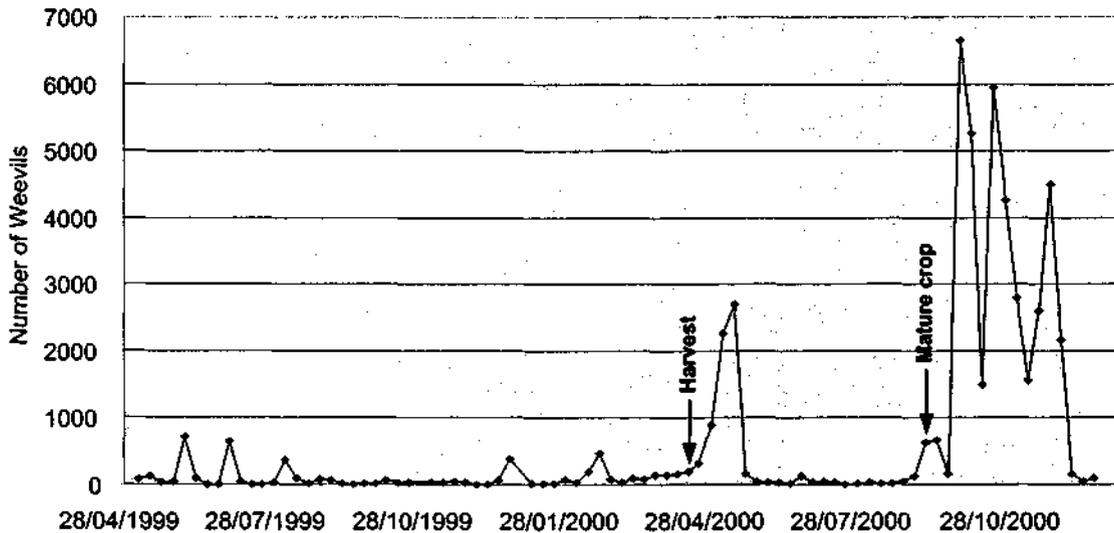


Figure 8d. Average trap catches per week at farm G, Bundaberg.

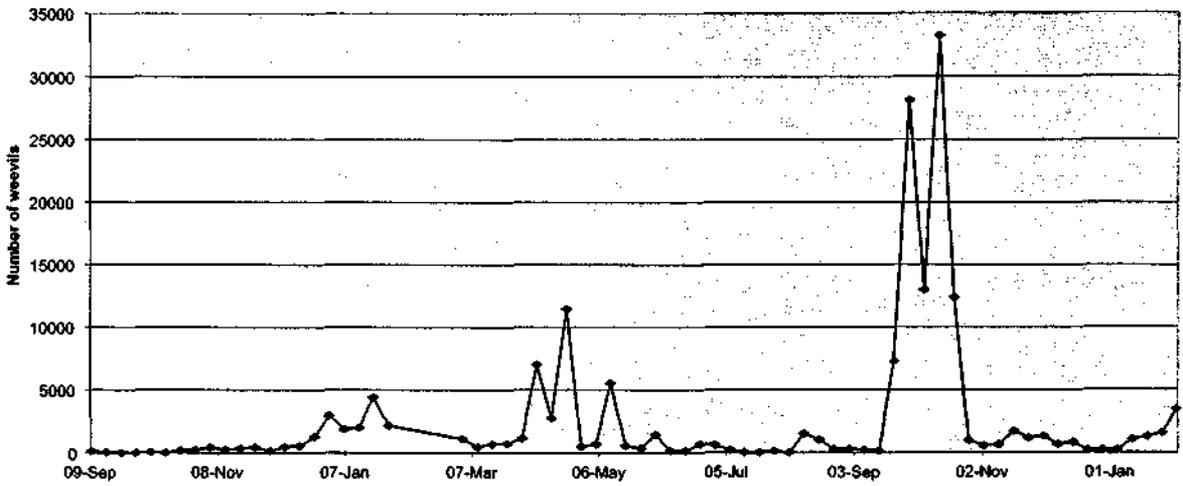


Figure 8e. Average trap catches per week at farm M, Bundaberg.

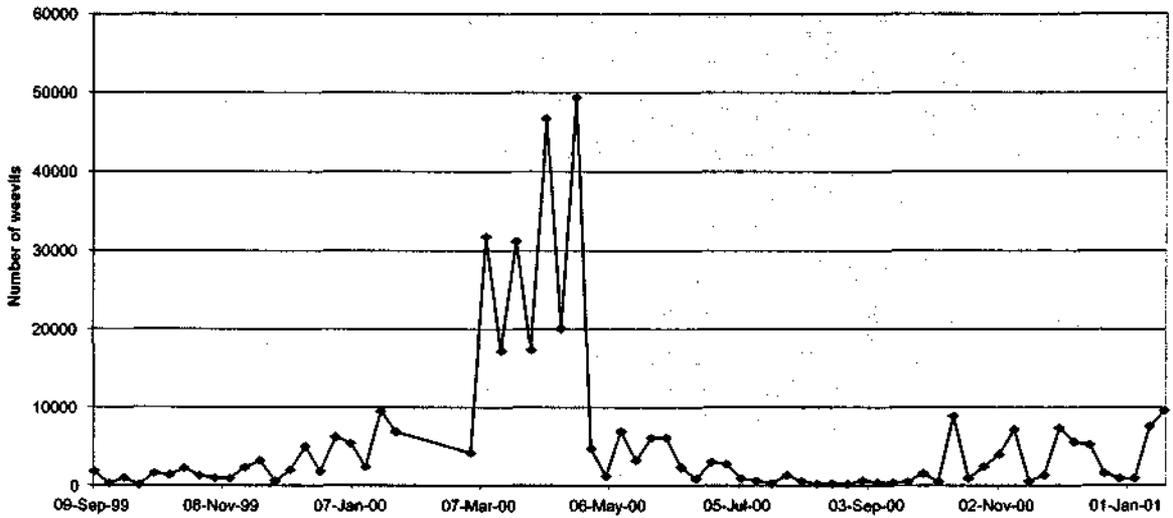


Figure 8f. Average trap catches per week at farm T, Bundaberg.

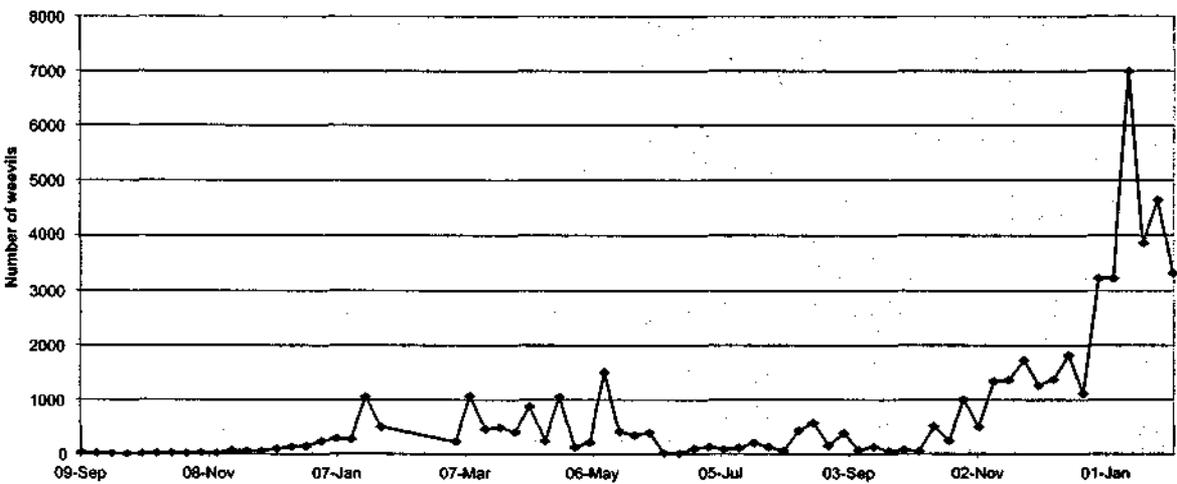
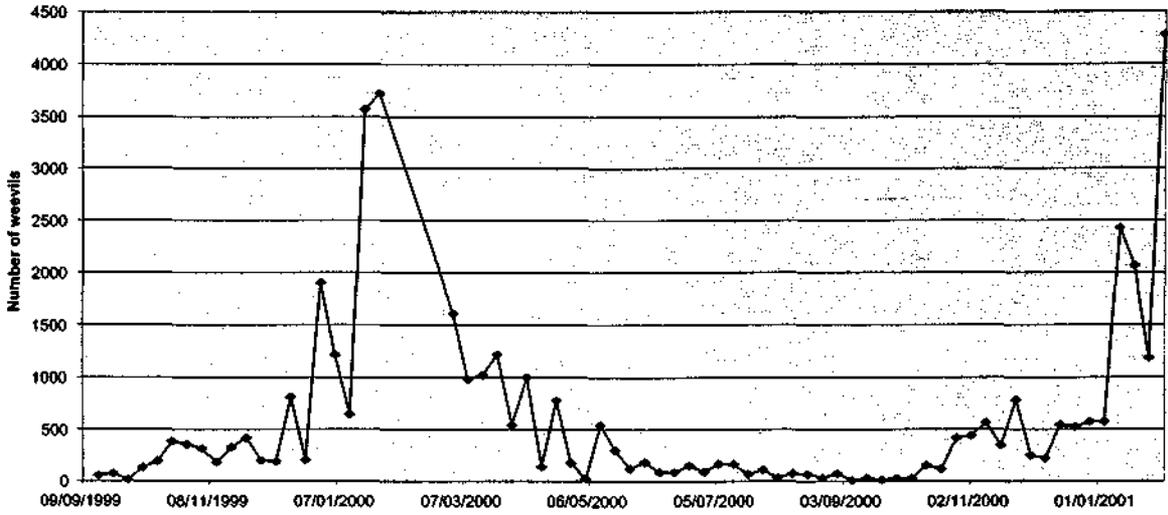


Figure 8g. Average trap catches per week at farm J, Bundaberg.



9. TECHNOLOGY TRANSFER

Result updates were presented at a number of field days held at Mareeba, Bundaberg and Redlands Research Stations on the following dates: Southedge - 24 June 1999; Mareeba - 7 July 2000; Redlands - 3 April 2000; and Bundaberg - 4 April 2000. A total of approximately 160 growers attended these meetings which were held to present research data from a number of areas associated with sweetpotato production.

Individual copies of a two page colour pamphlet outlining the best management options of the sweetpotato weevil were mailed to all registered growers via QFVG during August 2001. (Refer to Appendix 1.)

A poster outlining the technical issues and results from the project was prepared and presented at the Australian Entomological conference held in Darwin in 2001. (Refer to Appendix 2.)

Five hundred copies of a large colour poster (980mm × 650mm) which incorporates all relevant applied management information on the sweetpotato weevil was produced. Information on the pest's life cycle, monitoring and cultural plus chemical options was produced and a copy provided to all registered growers. Copies of the poster are available from the project leader on request. (Refer to Appendix 3.)

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11. APPENDIX

11.1 Sweetpotato weevil Extension Pamphlet

See pages 32 and 33.



SWEETPOTATO WEEVIL

Towards Better Management

The recently completed project on sweetpotato weevil identified two effective insecticides and highlighted the importance of good crop hygiene to reduce damage from this serious insect pest of sweetpotato.

Summary of Trial Findings

Chemical Control

Bifethrin (Talstar®) and chlorpyrifos (Lorsban®, etc) were shown to be very effective. An application for a minor use permit has been made by QFVG and approval is expected through the National Registration Authority.



Recommendation for effective chemical control

- Start spraying one month after planting and repeat monthly or as indicated by plant/pheromone counts (see over leaf).
- Ensure good spray cover to the crown.
- Use adequate volumes to ensure good coverage of the crowns and increase volume (slower speed/larger nozzles) as crop grows.
- Alternate chemicals to reduce resistance.



Hilling up was not effective

Cultural Control

A number of options were tested, including hilling up to cover crowns and developing roots, early harvesting, and natural tolerance in different lines.

Less damage was found on early harvested roots and some evidence was

shown towards white fleshed lines being more tolerant than orange fleshed lines. Hilling up was only possible before runner growth and therefore was not effective.

Cultural recommendations

- Use runners from a non-infested area to establish a new crop. If uncertain spray twice at two week intervals before harvesting runners for planting.
- Harvest crop as soon as possible.
- Destroy crop residues promptly by discing and/or rotary hoeing.
- Avoid continuous cropping if possible.



Residual roots act as a source of weevils

HORTICULTURE AUSTRALIA LIMITED



Queensland Fruit & Vegetable Growers



Queensland Government Department of Primary Industries



Monitoring

Pheromone traps

Inspection of pheromone trap catches give an indication of the presence of male weevils. This can then be used as a guide to treatment needs.

Plant counts

Monitor the presence of adult weevils, entry holes or crown swellings via weekly inspections of twenty (20) crowns per hectare. Consider treatment options if new damage (entry holes, crown swellings) or weevils are seen.

A simple, inexpensive trap.



**Damaged
Crown**



**Normal, undamaged
Crown**

Need for Future Work

Pheromone trapping in both north Queensland and Bundaberg has shown that very high populations of weevils develop on crop residues after harvest.

Suitable chemical clean up with residual soil insecticides would be an effective way to reduce weevil carry over to new crops. Future work would need to be undertaken to determine the suitable chemicals for after harvest "clean up".



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Further Information

For further information contact:

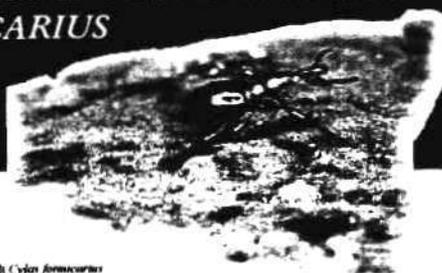
Bruno Pinese or Stef DeFaveri
Queensland Horticulture Institute
Department of Primary Industries
MAREEBA QLD 4880
Phone: (07) 4048 4600

11.2 Technical Information Poster

MANAGEMENT STRATEGIES FOR SWEET POTATO WEEVIL *CYLAS FORMICARIUS*

Stefano De Faveri and Bruno Pinese

Queensland Horticulture Institute, DPL 28 POLES STREET, MARCELA Q 4880



Adult *Cylas formicarius*

INTRODUCTION

The sweet potato weevil, *Cylas formicarius*, is the most important insect pest of sweet potato. The weevil feeds on and develops within the storage roots causing the release of terpenoid compounds which taint the flavour of the edible roots. The feeding within plant runners and the crown interferes with nutrient and water movement leading to yield loss.

Current controls are inadequate mainly due to poor chemical performance and lack of information on the pest biology.

AIMS OF PROJECT

- Evaluate a range of potentially effective pesticides.
- Determine the impact of infestation on yield.
- Screen new lines for tolerance.
- Investigate the presence of plant volatiles and their possible role in pest attraction.
- Determine seasonal population trends.

METHODS

• Pesticide trials

- a) Pesticides were screened using a range of bioassay tests.
- b) The more effective pesticides were field tested under commercial conditions using monthly treatments. Storage roots and plant crowns were assessed for damage at harvest. Root weights were recorded to assess yield impacts.

• Tolerance determination

- a) Sixteen lines were field evaluated. Storage root and crown damage and yield were used to compare lines for tolerance.
- b) Volatile compounds from storage roots were collected using Tenax charcoal tubes and analysed by GC/MS.

• Population trends

- a) Traps baited with the male sex pheromone, (Z)-3-dodecen-1-ol (E)-2-butenone are used to monitor population trends weekly.
- b) Four different trap designs have been evaluated.

RESULTS

• Pesticide trials

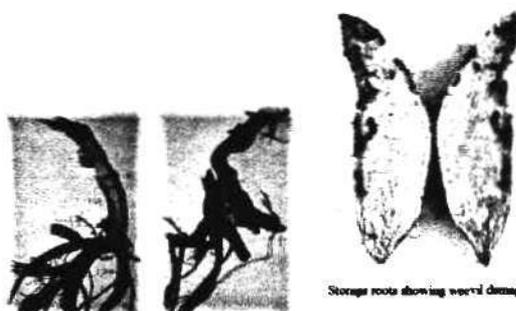
Bifenthrin and fipronil performed equally and significantly better than chlorpyrifos ($P < 0.05$). Fenitrothion and carbaryl were no better than the untreated control. Permits have been requested for bifenthrin and chlorpyrifos. A resistance management strategy based on monthly bifenthrin in rotation with chlorpyrifos will be tested in future work.

• Tolerance determination

Differences in tolerance to weevil infestation were evident with the white fleshed lines showing greater tolerance than the orange fleshed. Preliminary volatile analysis indicated that concentration of 2-methyl thiazole was higher in the more susceptible lines.

• Population trends

Early indications are that weevil populations as determined by pheromone trapping vary significantly from week to week. At this stage it cannot be determined if fluctuations are due to peaks in adult emergence or crop management effects, such as chemical treatments, harvesting or climatic effects.



Undamaged (left) and damaged (right) crowns

Storage roots showing weevil damage



Insecticide field trial

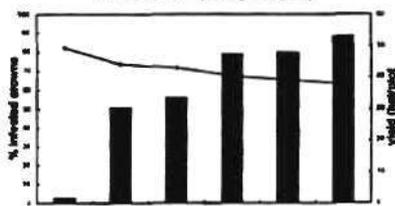
Sample of lines tested

Volatile sampling

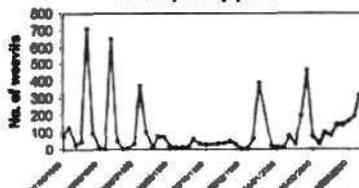


Pheromone trap

Impact of pesticide treatment on crown infestation (bar) and yield (line)



Average number of sweet potato weevils per trap per week



11.3 Grower Wall Poster on Managing Sweetpotato weevil

See page 36.

MANAGING SWEETPOTATO WEEVIL



Adult Sweetpotato Weevil *Cylas formicarius*



Monitoring

- Use pheromone traps in known hot-spots.
- Record weevil catches weekly and replace lure after 6 to 8 weeks.
- Inspect crown area for adults and look for swollen damaged areas.



STEP 1. Cut neck off bottle.



STEP 2. Invert cut portion to form a funnel.



STEP 3. Attach pheromone charged rubber above funnel with the wire.



STEP 4. Place completed trap just above crop height.

How to prepare a simple pheromone trap

Pre-plant

- Select tip cuttings from weevil free nursery area.
- Spray cutting source 1 week before harvesting tips.
- Dip tips in dilute insecticide to ensure freedom from viable eggs, larvae and adults.
- Allow to dry and plant out promptly.
- Use appropriate safety equipment.



Cultural Control

- Remove undersize/broken roots from field and destroy.
- Allow a break of 6 months between crops.
- Destroy volunteer regrowth by regular discing.
- Reduce root exposure by:
 - * maintaining constant soil moisture.
 - * hilling up around plants.
- Harvest as soon as possible.



Chemical Control

- Treat monthly beginning 1 month after planting or when a sudden increase in weevils is shown by pheromone trapping.
- Use high volume sprays to get good coverage in the crown area.
- Increase spray volumes as crop canopy grows.
- Rotate chemicals to reduce likelihood of resistance.



11.4 Photos on How to Make a Simple Pheromone Trap

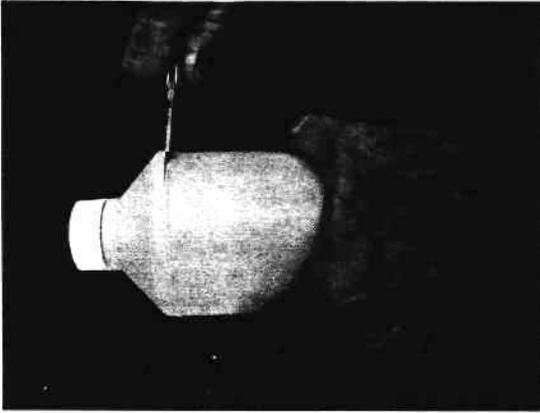


Photo 1. Cut the top from a plastic bottle, discarding the lid.



Photo 2. Invert the neck and place it inside the bottle to form a funnel and drill some very small holes in the base to allow water to escape.

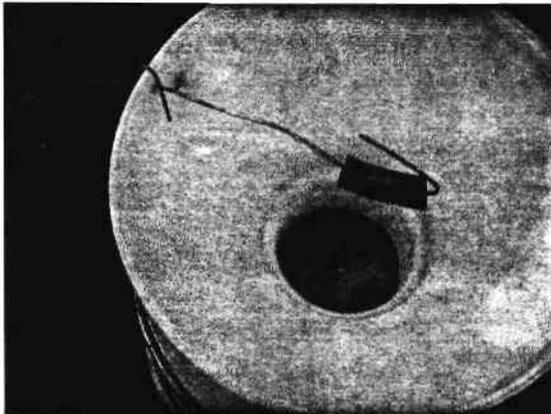


Photo 3. Attach pheromone charged rubber lure just above the funnel opening with fine wire.



Photo 4. Use a suitable stake to locate completed pheromone trap with the opening just above the sweetpotato crop.