VG020

Pest Management in North Queensland Vegetables

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QHI, QDPI

Know-how for Horticulture™

VG020

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Pest Management in North Queensland Vegetables

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Project Number VG020

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Contents

Industry Summary

The project aimed to improve pest management systems for three vegetable crops in the Dry Tropics (Lower Burdekin-Bowen) region of north Queensland. Little work had been done on pest management in capsicums, eggplant, and sweet corn in this region for many years.

The main results of the study were:

- Insecticides were screened for their effectiveness against green peach aphid on capsicums. Methamidophos, acephate, pirimicarb and the new insecticide imidacloprid were effective. Demeton-S-methyl and dimethoate had little effect, and endosulfan and parathion methyl were ineffective. Strategic spraying against aphids based on treatment thresholds appears promising. Studies to define the thresholds and to investigate the role of parasitoids and predators are needed.

- Eggfruit caterpillar is the major pest of eggplant. Insecticides effective in protecting eggfruit caterpillar damage to eggplant were identified. Several would be useful and more effective alternatives than endosulfan, the sole registered chemical.

- The female-produced eggfruit caterpillar pheromone was extracted and its components identified. The pheromone was used to trap male moths in several field trials. While more studies on the pheromone are needed, it should be a useful field monitoring tool for eggfruit caterpillar.

- Methomyl, monocrotophos, endosulfan, esfenvalerate and thiodicarb were shown to be effective insecticides in protecting sweet corn cobs from damage by heliothis. Trials on spray application frequency indicated that 7 day intervals were as effective as 2 day intervals at some times of year. Shorter intervals were needed sometimes. The results indicated that strategic spraying based on monitoring heliothis pressure could be used in sweet corn.

The project has established effective insecticides for the range of pests in the range of crops, and has initiated work that should result in a more integrated approach to pest management in these three crops. Work aimed at developing sustainable IPM-based pest management systems in vegetable crops in the Dry Tropics is underway after a long period of neglect.

Technical Summary

Replicated trials were conducted to test the efficacy of insecticides against *Myzus persicae* on capsicums, *Sceliodes cordalis* on eggplant, and *Helicoverpa armigera* on sweet corn in the Dry Tropics region of north Queensland from 1988 to 1991. Studies on the pheromone from *S. cordalis*, and on varietal resistance in sweet corn also were carried out.

Three trials in 1989 investigated the efficacy of insecticides in controlling against *M. persicae* on capsicums. Methamidophos (290, 580, 1102 gai/ha), acephate (750 gai/ha), imidacloprid (50,100 gai/ha), and pirimicarb (250, 500 gai/ha) were very effective. Methomyl (337.5 gai/ha) gave some but inadequate control. Fluvalinate (96 gai/ha), demeton-S-methyl (250 gai/ha), and dimethoate (300 gai/ha) were ineffective, and endosulfan (750 gai/ha) and parathion methyl (350 gai/ha) gave no control at all. A trial in 1990 showed that weekly and fortnightly applications of insecticides were equally effective in controlling *M. persicae*, while applications based on nominal treatment thresholds of 1, 5 or 10 aphids per leaf also were effective. These experiments defined the effectiveness of insecticides against *M. persicae* in the region and showed that further studies on strategic spraying and IPM development were warranted.

Weekly applications of esfenvalerate (20 gai/ha) and fluvalinate (96 gai/ha) gave better control of *S. cordalis* than the recommended endosulfan (750 gai/ha). Methomyl (450 gai/ha), thiodicarb (525 gai/ha), methidiathion (560 gai/ha), and mevinphos (388.5 gai/ha) were as effective as endosulfan although the latter two were marginal. Sulprofos (720 gai/ha), methamidophos (1102 gai/ha), diazinon (1120 gai/ha) and fenthion (412.5 gai/ha) were ineffective. Increasing the application frequency to twice a week increased the effectiveness of methomyl significantly, and reduced the level of damage in the thiodicarb and methidathion treatments, but it did not increase the effectiveness of endosulfan. Pheromone was extracted from virgin female *S. cordalis*, and two components, an acetate and an alcohol, were identified. Field trials showed that 1:1 and 3:1 ratios of the two components at loads of 1mg were as effective as each other and as a virgin female in attracting male *S. cordalis* to a trap. Pheromone loads of each ratio of 1mg were significantly more attractive than loads of 100µg. The pheromone shows great potential for use as a monitoring tool.

An insecticide trial against *H. armigera* in sweet corn in 1990 showed that methomyl (337.5 gai/ha), monocrotophos (500 gai/ha), endosulfan (735 gai/ha), esfenvalerate (20 gai/ha), and thiodicarb (525 gai/ha) were effective in preventing cob damage. Fluvalinate (96 gai/ha) and mevinphos (388.5 gai/ha) were less effective. In a series of trials throughout 1990 methomyl and esfenvalerate applied during silking at intervals of 2, 3, 4, or 7 days were equally effective in preventing cob damage in crops harvested in mid May and mid July, but the 7 day interval was less effective than the others in a crop harvested in mid November. This indicates the potential for strategic rather than calendar spraying in the crop. Despite difficulties in synchronising silking, varietal differences in susceptibility to heliothis were indicated.

The studies have established effective insecticides for the range of pests in the range of crops, and have initiated work that should result in a more integrated approach to pest management in these three crops.

1.0 Introduction

Horticultural production in the Dry Tropics region of north Queensland, the region including the Lower Burdekin and Bowen districts, is important in supplying Australian requirements of many vegetables during the winter months. The vegetables produced include capsicums, eggplant and sweet corn. The approximate values of these crops in the region are given in Table 1.

Table 1
Estimated areas, production and value of capsicum, eggplant and sweet corn in the Burdekin-Bowen region in 1987. (Source: DPI extension officers).

	Area (ha)	Production (t)	Value ($m)
capsicum	580	8600	7.7
eggplant	140	3500	3.2
sweet corn	325	2890	3.5

These crops are grown during the autumn, winter and spring months (March to November) in the Dry Tropics rather than as summer crops as in southern areas. This seasonal difference means that pest management systems developed in other areas may not be suitable for the north Queensland area as the insects' biology, ecology and seasonal occurrence patterns may differ. Little work on these crops has been done in northern areas for many, many years. Insect pest management systems suitable for winter cropping areas have not been developed.

Green peach aphid, *Myzus persicae* (Sulzer), is an important pest of capsicums. It can cause direct damage through its feeding by reducing plant growth and vigour, and through the production of honeydew with its attendant sooty mould. The aphid also transmits potato virus Y to susceptible varieties. As well as being a pest of capsicums, green peach aphid is the main vector of watermelon mosaic virus disease of cucurbits in the Dry Tropics. Resistance in green peach aphid strains over a wide geographical range in Australia to various insecticides (particularly demeton-S-methyl and dimethoate) has long been known (Hamilton and Attia 1978; Attia and Hamilton 1978; Attia *et al.* 1979; Franzmann *et al.* 1980). However strains from the Bowen-Lower Burdekin area were not included in those reported tests, and no recent work has been done on the effectiveness of insecticides against green peach aphid in the area. Accordingly a range of insecticides were tested against green peach aphid in this project to provide information on effective insecticides. We also initiated research to look at treatment intervals and treatment thresholds as the first step in developing IPM strategies for aphids on capsicums.

Eggfruit caterpillar, *Sceliodes cordalis* (Doubleday), is a major pest of eggplant and a minor pest of tomatoes and capsicum in Queensland and it also damages eggplant in New South Wales (Hely *et al.* 1982). It attacks pepino and poroporo in New Zealand (Galbreath and Clearwater 1983). Despite its importance the last published information on eggfruit caterpillar in Queensland is that of Davis (1964) who described the insect and its habits. Eggs are laid on the calyx and the newly hatched larvae burrow into the fruit where further development occurs. The larvae emerge from the fruit to pupate. Endosulfan is the only insecticide registered for use against eggfruit caterpillar. Apart from the report by Martin and Workman (1985) who found that methomyl applied weekly prevented any damage to greenhouse pepinos while deltamethrin and permethrin applied fortnightly did not prevent all damage, there is no information on the efficacy of insecticides against eggfruit caterpillar. Trials were done in this project to evaluate a range of insecticides against the insect.

Pheromones are a useful tool for monitoring insect populations and possibly for determining when treatments are required. Clearwater *et al.* (1986) identified the components of the female produced sexual pheromone of eggfruit caterpillar in New Zealand, and Galbreath and Clearwater (1983) used traps baited with the pheromone to trap eggfruit caterpillar males over two years in New Zealand. We intended to use the pheromone to monitor the seasonal incidence of eggfruit caterpillar in north Queensland but first needed to confirm its composition and effectiveness.

Corn earworm or heliothis, *Helicoverpa armigera* (Hubner), is the major pest of sweet corn. Usually eggs are laid on the silks and the larvae feed on the cob. Damaged cobs are unmarketable or their value is greatly reduced. Frequent applications of insecticides usually are needed to protect the cobs from damage. In south-east Queensland applications of insecticides at two day intervals during silking were found necessary to prevent damage (J. Hargreaves pers. comm.). Hamilton and Muirhead (1981) screened a range of insecticides against heliothis in sweet corn in New South Wales. Again, no recent studies on effective insecticides or the required frequency of application had been done in the northern growing areas, and this information was needed. New varieties of sweet corn were being grown and there were anecdotal reports that some of these varieties were more susceptible to heliothis than the older varieties. Studies to try to test this suggestion also were undertaken.

The range of studies carried out on the three crops and their insect pests are described in this report.

2.0 Materials and Methods

2.1 Aphid management in capsicums

2.1.1 Insecticide trials

Three trials were done. Trials CA1 and CA2 were done at Bowen Research Station and Trial CA3 at Ayr Research Station in August 1989. All three trials were done on capsicum plants grown on black plastic mulch and irrigated by trickle irrigation. The plants were sprayed weekly with copper and mancozeb for disease control.

Each trial consisted of eight treatments replicated three times in a randomised block design. Blocking was done on the basis of pre-treatment counts to overcome variations in aphid density and distribution over the trial area. Plot size was one row by 5m. (i.e. about 25 plants).

The insecticides used were:

acephate	750g kg^{-1}	soluble powder
demeton-S-methyl	250g L^{-1}	emulsifiable concentrate
dimethoate	300g L^{-1}	emulsifiable concentrate
endosulfan	350g L^{-1}	emulsifiable concentrate
fluvalinate	240g L^{-1}	suspension concentrate
imidacloprid	200g L^{-1}	soluble concentrate
methamidophos	580g L^{-1}	emulsifiable concentrate
methomyl	225g L^{-1}	soluble concentrate
parathion methyl	500g L^{-1}	emulsifiable concentrate
pirimicarb	500g L^{-1}	wettable powder

In all trials insecticides were applied in 500L ha^{-1} of water using a motorised knapsack sprayer with a boom fitted with four Albuz brown hollow cone nozzles operated at 655kPa.

Green peach aphid populations were allowed to develop on the plants until aphid numbers were high enough to count easily and to treat.

Aphids were counted at 1d pre-treatment and at 3d and 7d post-treatment in all trials, and at 14d post-treatment in Trial CA1. The results from Trial CA1 showed that the effectiveness of the insecticides was obvious by 7d post-treatment and aphid numbers increased by 14d, so sampling was confined to 3d and 7d in subsequent trials. Four randomly selected plants per plot were tagged and these plants were used at each count. Aphid numbers were counted on each of five randomly selected leaves on each plant i.e. aphids were counted on 20 leaves per plot. Individual aphids on a leaf were counted up to 100, and if the numbers on the leaf exceeded 100 the additional aphids were estimated in groups of 10.

Data were analysed by analysis of variance, using the QDPI RANB program, after ln (x+1) transformation.

2.1.2 Treatment timing trial

This trial (CA4) was done at Bowen Research Station in from June to September 1990 to test the effectiveness of weekly or fortnightly applications of various insecticides in controlling green peach aphid on capsicums. As well, three treatment threshold levels were chosen arbitrarily and sprays of methamidophos (290g ai/ha) were applied if the thresholds were reached. The thresholds were 1, 5 or 10 aphids per leaf.

The trial was done on capsicum plants grown on black plastic mulch and irrigated by trickle irrigation. The plants were sprayed weekly with copper and mancozeb for disease control. The trial consisted of 12 treatments replicated four times in a randomised block design. Insecticides were applied in 500L ha^{-1} of water using a motorised knapsack sprayer with a boom fitted with four Albuz brown hollow cone nozzles operated at 655kPa.

Aphid numbers in the threshold treatment plots were counted each week. Four randomly selected plants per plot were tagged and these plants were used at each count. Aphid numbers were counted on each of five randomly selected leaves on each plant i.e. aphids were counted on 20 leaves per plot. A spray was applied if the count exceeded the threshold.

Aphid numbers in all treatments were assessed on three occasions. Counts were done as for the threshold counts. The numbers of parasitised aphids (as aphid mummies) and the numbers of predators present were assessed on one occasion. Fruit were harvested from all plots and yield (weight and number) recorded. Data were analysed by analysis of variance, using the QDPI RANB program, with appropriate transformations as necessary.

2.2 Eggfruit caterpillar

2.2.1 Insecticide trials

Two trials were conducted at Ayr Research Station to test the efficacy of a range of insecticides in controlling eggfruit caterpillar in eggplant. Trial EC1 was done in 1989 and Trial EC2 in 1990. Similar methods were used in each trial.

Crops of eggplant , var. Market Supreme, were grown on plastic mulch using trickle irrigation and standard agronomic techniques. Each trial was a randomised block design with three replicates. Plots were two rows by 5m, and there were untreated guard rows between plots. Trial EC1 had eight treatments and Trial EC2 had 12. Insecticide treatments were applied in 1000L/ha of water using a motorised knapsack sprayer operated at 665kPa and fitted with a boom and four Albuz hollow cone nozzles. Both sides of each row were sprayed to simulate the use of a boom with droppers to get good coverage of the whole plant. Spraying started soon after flowering when small fruit were present. In Trial EC1 sprays were applied weekly and a total of nine sprays were applied. In Trial EC2 some treatments were sprayed weekly and others twice a week (ie applications separated by 3 and 4 days) with 10 and 19 applications respectively. The insecticides used in the two trials were:

diazinon	200g/L	emulsifiable concentrate
endosulfan	350g/L	emulsifiable concentrate
esfenvalerate	50g/L	emulsifiable concentrate
fenthion	550g/L	emulsifiable concentrate
fluvalinate	240g/L	emulsifiable concentrate
methamidophos	580g/L	emulsifiable concentrate
methidathion	400g/L	emulsifiable concentrate
methomyl	225g/L	soluble concentrate
mevinphos	1100g/L	soluble concentrate
sulprofos	720g/L	emulsifiable concentrate
thiodicarb	375g/L	suspension concentrate

In each trial fruit were harvested on three occasions each separated by a fortnight from the central 4m of each plot row (ie 8m per plot). Large fruit only were picked in the first two harvests and all remaining fruit were picked in the final harvest. Each harvested eggplant fruit was cut lengthways into quarters and examined for eggfruit caterpillar damage. Numbers of fruit and percent damage were recorded, and data from the three harvests were bulked for analysis.

Analyses of variance wee done on the number of fruit per plot, and on the percent damaged fruit using the DPI RANB program. Transformations were used as required.

2.2.2 Pheromone studies

Eggfruit caterpillar larvae from a natural infestation in eggplant at Ayr were reared to the pupal stage. The pupae were sent to Dr C Whittle, CSIRO, in Canberra for pheromone determination and analysis.

Three field trials were done in 1990 and 1991 in large trial plantings of eggplant at Ayr Research Station to compare the attractiveness to male eggfruit caterpillar of: 1:1 and 3:1 ratios of the two pheromone components (Trial EC3); two loadings (1mg and 100μg) of the two ratios (Trial EC4); and the two ratios and virgin females (Trial EC5).

Triangular (delta style) traps of 160mm by 95mm base dimensions and 80mm vertical height with a sticky base were used in all trials. Traps were suspended just above crop height from wooden posts. The pheromones were impregnated into rubber septa suspended centrally from the inside apex of the trap.

In Trial EC3 five traps of each pheromone component ratio and a single unbaited trap were randomly allocated to 11 positions within the eggplant crop. Traps were separated by 10-16m. Traps remained in the field from mid March to mid May 1990, and were re-randomised on five occasions. Traps were examined frequently, and moths were counted and removed.

In Trial EC4 five traps of each pheromone ratio and loading and a single unbaited trap were randomly allocated to 21 positions (separated by 10-16m) in the crop in October 1990. Traps were in the field for four weeks and were re-randomised on three occasions. Traps were examined frequently, and moths were counted and removed.

In Trial EC5 five traps of each pheromone ratio and five traps containing a single virgin female held in a mesh cage, and a single unbaited trap were randomly allocated to 16 positions (separated by 10-12m except for 6 positions that were separated by only 6m) in the crop. The traps were exposed for 8d in September 1991, and they were re-randomised twice. Captured moths were counted and removed on three occasions.

Analysis of variance was done on the data from each trial following square root (x + 0.5) transformation using the QDPI RANB program. The unbaited traps were ignored.

2.3 Sweet corn studies

2.3.1 Insecticide trials

Two sets of insecticide trials against heliothis, *Helicoverpa armigera*, were conducted. The efficacy of seven insecticides was tested in Trial SC1, while a range of spraying frequencies was tested in Trial SC2.

Trial SC1 was conducted at Ayr Research Station in early 1990 in a block of the variety Snosweet grown under standard agronomic conditions with a row spacing of 0.75m. The crop was planted in late January, sprayed during silking in early to mid March and harvested in late March. The trial had eight treatments by three replicates in a randomised block design. Plot size was four rows by 10m, with a guard area along the rows of 1m between plots. The insecticides (see Table SC1) were applied using an Echo motorised sprayer fitted with a single lance and an Albuz hollow cone nozzle operated at 654kPa. The insecticides were applied at cob height to the centre two rows of the plots from early silking until the silks had browned off. Seven applications were made, on 2, 5, 7, 9, 12, 14, 16 March. At harvest all cobs from the sprayed portions of the plots were harvested and assessed for heliothis damage. Analysis of variance was carried out on the percentage damaged cob data using the DPI RANB program following arcsin transformation.

Trial SC2 was conducted at Ayr Research Station throughout 1990. Three plots of sweet corn, variety Snosweet, were grown at different times of the year to simulate different times or stages within the growing season in the district. The first crop was grown in April-May and harvested in mid May, the second was grown in June-July and harvested in late July, and the third was grown in October-November and harvested in mid November. In each planting two insecticides, methomyl and esfenvalerate, were applied at two, three, four and seven day frequencies from early silking until the silks had browned off. The insecticides were applied using an Echo motorised sprayer fitted with a single lance and an Albuz hollow cone nozzle operated at 654kPa. In each planting there were three replicates in a randomised block design and plot size was four rows by 10m and the centre two rows were sprayed. At harvest all cobs from the sprayed portions of the plots were harvested and assessed for heliothis damage. The percentage damaged cob data were analysed using the DPI BALF and RANB programs following arcsin transformation.

2.3.2 Variety trials

Trial SC3 was carried out at Bowen Research Station in 1989 to test the relative susceptibility of eight varieties of sweet corn to attack by heliothis. The varieties (see Table 13) were planted on three dates over four days in an attempt to synchronise silking dates in a randomised block design with three replicates, and plots of four rows by 10m. Standard agronomic practices were used to grow the corn, but no insecticides were applied. Dates of tasselling and silking were recorded, and cobs were assessed for heliothis damage at harvest.

Trial SC4, a virtual repeat of Trial SC3, was carried out at Bowen Research Station in 1990. Eight varieties of corn were used, seven of which were common to Trial SC3. The planting dates were staggered to attempt to synchronise the silking times of the varieties. The trial was a randomised block design with three replicates, and plots of four rows by 10m. Standard agronomic practices were used to grow the corn, but no insecticides were applied. Dates of tasselling and silking were recorded, and cobs were assessed for heliothis damage at harvest.

Data on percentage damaged cobs were analysed, following arcsin transformation, using the DPI RANB program.

3.0 Results

3.1 Aphid management in capsicums

3.1.1 Insecticide trials

The results of Trials CA1 are shown in Table 2, and the results of Trials CA2 and CA3 are shown in Table 3.

Table 2
The effect of insecticides on *M. persicae* in Trial CA1 at Bowen.

Treatment	Mean number of aphids per leaf							
	Pre-treatment		3d post-treat.		7d post-treat.		14d post-treat.	
(g ai/ha)	trans#	equiv.	trans#	equiv.	trans#	equiv.	trans#	equiv.
unsprayed check (-)	2.46 a*	10.65	4.01 a	54.38	4.83 a	123.67	5.37 a	213.62
methamidophos (290)	2.60 a	12.50	0.62 cd	0.87	1.15 c	2.16	3.48 c	31.53
methamidophos (580)	2.20 a	8.00	0.40 de	0.50	0.76 cd	1.13	2.80 cd	15.49
methamidophos (1102)	2.16 a	7.64	0.20 e	0.22	0.23 d	0.26	1.72 e	4.60
pirimicarb (500)	2.44 a	10.43	0.94 c	1.56	2.06 b	6.87	4.45 b	84.92
parathion methyl (350)	2.08 a	6.98	3.69 b	39.13	4.69 a	107.53	5.49 a	241.78
imidacloprid (50)	2.05 a	6.77	0.44 de	0.55	0.85 c	1.35	2.62 d	12.68
imidacloprid (100)	2.35 a	9.49	0.47 de	0.59	0.74 cd	1.10	2.72 d	14.17

ln(x+1) transformation applied before analysis of variance.
* In each column values followed by the same letter are not significantly different at the 5% level.

Table 3
The effect of insecticides on *M. persicae* in Trial CA2 at Bowen and Trial CA3 at Ayr.

Treatment (g ai/ha)	Mean number of aphids per leaf					
	Pre-treatment		3d post-treat.		7d post-treat.	
	trans#	equiv.	trans#	equiv.	trans#	equiv.
Trial CA2 Bowen						
unsprayed check (-)	4.52 a*	90.60	5.14 a	169.60	5.28 a	195.99
methamidophos (1102)	4.49 a	87.68	0.22 f	0.24	0.36 e	0.43
methomyl (337.5)	4.51 a	89.64	2.58 c	12.16	3.76 b	41.84
endosulfan (735)	4.54 a	92.26	5.00 a	146.91	5.17 a	174.39
fluvalinate (96)	4.58 a	96.84	3.96 b	51.48	3.80 b	43.77
acephate (750)	4.59 a	97.34	0.55 ef	0.74	0.69 e	0.99
pirimicarb (250)	4.60 a	98.77	1.39 d	3.02	2.34 c	9.37
pirimicarb (500)	4.51 a	90.11	0.71 e	1.04	1.55 d	3.73
Trial CA3 Ayr						
unsprayed check (-)	2.45 a*	10.57	3.32 a	26.71	3.59 a	35.04
methamidophos (290)	2.43 a	10.34	0.58 c	0.78	0.16 c	0.17
methamidophos (1102)	2.31 a	9.04	0.05 c	0.05	0.00 c	0.00
demeton-S methyl (250)	2.19 a	7.93	2.24 b	8.39	2.32 b	9.23
dimethoate (300)	1.92 a	5.82	2.46 b	10.75	2.29 b	8.86
fluvalinate (96)	2.25 a	8.47	2.17 b	7.79	2.08 b	7.02
acephate (750)	2.48 a	10.94	0.62 c	0.86	0.07 c	0.07
pirimicarb (500)	2.22 a	8.19	0.39 c	0.48	0.13 c	0.14

ln(x+1) transformation applied before analysis of variance.
* In each column, for each trial, values followed by the same letter are not significantly different at the 5% level.

3.1.2 Treatment timing trial

Aphid numbers initially were very low. No aphids were recorded on the first count on 11 June. Aphid numbers on the second count on 10 August and on the third count on

6 September are given in Table 4. Coccinellid beetles were the predominant predators observed during the trial, but as their numbers were very low no attempt has been made to analyse differences in numbers between treatments. Aphid parasitoids were more common and the results of counts of aphid mummies per leaf made on 6 September are given in Table 5.

Yields of capsicums, as both weight and number, are given in Table 6.

Table 4
The number of aphids and the number of sprays applied in the timing and threshold trial.

Treatment (g ai/ha)	10 August			6 September			Total no. sprays
	Mean no. aphids per leaf		Prev. spray days	Mean no. aphids per leaf		Prev. spray days	
	trans.#	equiv.		trans.#	equiv.		
unsprayed check (-)	2.690 a*	13.74	-	0.044 d	0.04	-	0
demeton-S-methyl (250) weekly	1.785 b	4.96	8	0.272 ab	0.31	7	11
acephate (750) fortnightly	0.059 d	0.06	8	0.000 d	0.00	7	6
methamidophos (290) weekly	0.099 d	0.10	8	0.011 d	0.01	7	11
methamidophos (290) fortnightly	0.057 d	0.06	8	0.021 d	0.02	7	6
pirimicarb (250) weekly	0.238 d	0.27	8	0.000 d	0.00	7	11
pirimicarb (250) fortnightly	0.317 d	0.37	8	0.000 d	0.00	7	6
methomyl (337.5) weekly	1.477 bc	3.38	8	0.350 a	0.42	7	11
methomyl (337.5) fortnightly	1.403 bc	3.07	8	0.197 bc	0.22	7	6
scout 1 aphid per leaf	1.048 c	1.85	15	0.076 cd	0.08	27	2
scout 5 aphid per leaf	0.081 d	0.08	8	0.048 d	0.05	35	1
scout 10 aphid per leaf	0.156 d	0.17		0.011 d	0.01	35	1

ln(x+1) transformation applied before analysis of variance.
* In each column values followed by the same letter are not significantly different at the 5% level.

Table 5
The mean number of aphid mummies per leaf in the timing and threshold trial.

Treatment (g ai/ha)	Mean no. mummies per leaf trans.#	equiv.	Days since previous spray
unsprayed check (-)	1.269 a*	2.56	-
demeton-S-methyl (250) weekly	0.618 b	0.86	7
acephate (750) fortnightly	0.000 c	0.00	7
methamidophos (290) weekly	0.011 c	0.01	7
methamidophos (290) fortnightly	0.011 c	0.01	7
pirimicarb (250) weekly	0.034 c	0.03	7
pirimicarb (250) fortnightly	0.000 c	0.00	7
methomyl (337.5) weekly	0.337 bc	0.40	7
methomyl (337.5) fortnightly	0.540 b	0.72	7
scout 1 aphid per leaf	0.032 c	0.03	27
scout 5 aphid per leaf	0.048 c	0.05	35
scout 10 aphid per leaf	0.083 c	0.09	35

ln(x+1) transformation applied before analysis of variance.
* Values followed by the same letter are not significantly different at the 5% level.

Table 6
Mean weight and number of capsicums per plot in the timing and threshold trial.

Treatment (g ai/ha)	Mean fruit yield	
	Number of fruit	Weight (kg)
unsprayed check (-)	100.75 cd*	14.90 cde
demeton-S-methyl (250) weekly	71.00 e	10.95 e
acephate (750) fortnightly	143.50 a	20.71 ab
methamidophos (290) weekly	138.95 ab	21.40 a
methamidophos (290) fortnightly	113.25 bc	17.17 abcd
pirimicarb (250) weekly	83.25 de	13.12 de
pirimicarb (250) fortnightly	94.00 cde	15.22 cde
methomyl (337.5) weekly	130.75 ab	20.65 ab
methomyl (337.5) fortnightly	96.00 cde	15.77 cd
scout 1 aphid per leaf	116.50 abc	18.31 abc
scout 5 aphid per leaf	88.25 cde	14.15 cde
scout 10 aphid per leaf	108.50 bcd	16.20 bcd

* In each column values followed by the same letter are not significantly different at the 5% level.

3.2 Eggfruit caterpillar

3.2.1 Insecticide trials

Tables 7 and 8 show the number of fruit picked and the percentage of fruit damaged by eggfruit caterpillar in Trial EC1 and Trial EC2 respectively.

Table 7
Number of fruit harvested and the percentage of fruit damaged by eggfruit caterpillar in Trial EC1.

Treatment (g ai/ha)	Mean number fruit	Mean percent damaged fruit trans.#	equiv.
unsprayed check (-)	227.7 a*	0.4945 a	22.52
esfenvalerate (20)	212.0 a	0.0645 c	0.42
fluvalinate (96)	242.3 a	0.1433 c	2.04
methidathion (560)	230.3 a	0.3346 b	10.78
endosulfan (665)	218.7 a	0.3476 b	11.60
mevinphos (388.5)	238.7 a	0.4471 ab	18.70
sulprofos (720)	226.0 a	0.5005 a	23.03
methamidophos (1102)	233.0 a	0.5147 a	24.23

Arcsin transformation applied before analysis.
* In each column, numbers followed by the same letter are not significantly different at the 5% level.

Table 8
Number of fruit harvested and the percentage of fruit damaged by eggfruit caterpillar in Trial EC2.

Treatment Insecticide (g ai/ha)	Freq. per week	Mean number fruit	Mean percent damaged fruit trans.#	equiv.
unsprayed check (-)	-	203.7 bcd*	0.6014 bc	32.01
methomyl (450)	2	259.7 ef	0.2304 f	5.21
esfenvalerate (20)	1	250.0 ef	0.2416 f	5.73
thiodicarb (525)	2	280.0 f	0.2793 ef	7.60
methidathion (560)	2	193.0 abc	0.3757 de	13.46
thiodicarb (525)	1	236.7 cdef	0.3976 de	14.99
methomyl (450)	1	240.3 def	0.4265 d	17.11
endosulfan (665)	2	265.7 f	0.4524 d	19.11
endosulfan (665)	1	272.7 f	0.4584 d	19.58
methidathion (560)	1	216.3 bcde	0.4999 cd	22.98
diazinon (1120)	1	184.7 ab	0.6554 ab	37.14
fenthion (412.5)	1	157.3 a	0.7619 a	47.65

Arcsin transformation applied before analysis.
* In each column, numbers followed by the same letter are not significantly different at the 5% level.

3.2.2 Pheromone studies

The CSIRO collaborators in Canberra extracted the pheromone from virgin females and identified the components as (E)-11-hexadecen-1-yl acetate and (E)-11-hexadecen-1-ol, in an approximately 3:1 ratio.

In the field trials no moths were caught in the unbaited traps which indicates that it was the pheromones and not the traps themselves that were attractive. The results for the three field trials are shown in Table 9.

Table 9
Numbers of eggfruit caterpillar male moths caught in the three field trials.

Pheromone treatment	Mean catch per trap	
	trans.#	equiv.
Trial EC3		
3:1 1mg	2.74 a*	7.03
1:1, 1mg	2.26 a	4.63
Trial EC4		
3:1, 1mg	3.47 a	11.54
3:1, 100μg	1.55 b	1.89
1:1, 1mg	3.27 a	10.21
1:1, 100μg	1.34 b	1.29
Trial EC5		
3:1, 1mg	1.60 a	2.05
1:1, 1mg	1.08 a	0.54
virgin female	1.23 a	1.02

Square root (x + 0.5) transformation applied before analysis.
* In each trial, numbers followed by the same letter are not significantly different at the 5% level.

There were no significant differences ($P>0.05$) in numbers of male eggfruit caterpillar moths caught in traps baited with either ratio of the pheromone components in Trial EC3, or in numbers caught in traps baited with either of the two ratios or with a virgin female in Trial EC5. In Trial EC4 traps baited with either ratio at 1mg load caught significantly ($P<0.05$) more moths than those baited with 100μg load, but there were no differences ($P>0.05$) between traps baited with either pheromone ratio at the same loading.

3.3 Sweet corn studies

3.3.1 Insecticide trials

The insecticide treatments used and the results of Trial SC1 are shown in Table 10.

Table 10
The effect of insecticides on heliothis damage to cobs of sweet corn in Trial SC1

Treatment (g ai/ha)	Percent damaged cobs transformed#	equivalent
unsprayed check (-)	0.6299 a*	34.70
methomyl (337.5)	0.0793 d	0.63
monocrotophos (500)	0.1984 cd	3.89
endosulfan (735)	0.1716 d	2.91
esfenvalerate (20)	0.1318 d	1.73
fluvalinate (96)	0.3147 bc	9.58
thiodicarb (525)	0.0942 d	0.88
mevinphos (388.5)	0.3646 b	12.71

arcsin transformation applied before analysis.
* treatments followed by the same letter are not significantly different at the 5% level.

There was a lower percentage of damaged cobs in all the insecticide treatments compared with the unsprayed check, and there were some significant differences ($P<0.05$) between the efficacy of the insecticides.

The results of the three plantings in Trial SC2 are shown in Table 11, together with the analysis of variance results. Factorial analyses of the data in each planting showed no differences in plantings harvested on 15 May and 20 July, but there were differences due to spray interval in the crop harvested on 14 November. These results are shown in Table 12. The 7 day spray interval resulted in a significantly lower percentage of undamaged cobs than the other three shorter intervals.

Table 12
Factorial analyses of percent undamaged cobs for two insecticides and four spray intervals on three harvest dates. Values are back-transformed means following arcsin transformation before analysis.

Factors	Percent undamaged cobs on harvest dates 15 May	20 July	14 November
Insecticides			
methomyl	99.67 a*	99.24 a	33.54 a
esfenvalerate	99.01 a	98.54 a	29.14 a
Spray interval			
2 days	99.64 a*	99.36 a	36.68 a
3 days	99.49 a	99.26 a	38.45 a
4 days	99.38 a	99.45 a	37.13 a
7 days	98.94 a	96.93 a	15.25 b

* In each column for each factor means followed by the same letter are not significantly different at the 5% level.

Table 11
The effect of insecticides and spray frequencies on heliothis damage to sweet corn on three harvest dates in 1990.

Treatment	Percentage of undamaged cobs					
	15 May		20 July		14 November	
	trans.#	equiv.	trans.#	equiv.	trans.#	equiv.
unsprayed check	0.9519 a*	66.35	0.9618 a	67.28	0.2177 a	4.67
methomyl 2d	1.5708 b	100.00	1.5358 b	99.88	0.6395 d	35.62
methomyl 3d	1.4739 b	99.06	1.5330 b	99.86	0.7006 d	41.56
methomyl 4d	1.5041 b	99.56	1.4655 b	98.90	0.7167 d	43.15
methomyl 7d	1.5050 b	99.57	1.4008 b	97.14	0.4137 bc	16.16
esfenvalerate 2d	1.4507 b	98.56	1.4454 b	98.44	0.6616 d	37.74
esfenvalerate 3d	1.5244 b	99.79	1.4366 b	98.21	0.6370 d	35.37
esfenvalerate 4d	1.4804 b	99.19	1.5280 b	99.82	0.5938 cd	31.29
esfenvalerate 7d	1.4300 b	98.03	1.3885 b	96.71	0.3886 b	14.36

arcsin transformation applied before analysis.
* In each column treatments followed by the same letter are not significantly different at the 5% level.

3.3.2 Variety trials

Planting dates and dates of tasselling and silking for the varieties in Trial SC3 and the percentage of damaged cobs are shown in Table 13. Planting dates and percent damaged cobs for the varieties tested in Trial SC4 are shown in Table 14.

Table 13
Planting, tasselling and silking dates and percent heliothis damaged cobs for sweet corn varieties grown in 1989. (Damage values are back-transformed means following arcsin transformation before analysis.)

Variety	Dates			% damaged cobs
	Planting	Tasselling	Silking	
Snosweet	16/8	3/10	6/10	66.53 a*
Honeysweet Improved	18/8	26/9	3-6/10	61.77 ab
Florida Staysweet	16/8	6/10	10-13/10	52.58 bc
Sugarsweet Improved	16/8	3/10	6/10	62.21 ab
NS 80 16T	16/8	3-6/10	10-13/10	58.71 ab
Mapee	14/8	6-10/10	17/10	37.67 d
Kulara	14/8	6-10/10	17/10	42.06 cd
Terrific	18/8	3/10	6/10	56.22 ab

* Numbers followed by the same letter are not significantly different at the 5% level.

Table 14
Planting dates and percent heliothis damaged cobs for sweet corn varieties grown in 1990. (Damage values are back-transformed means following arcsin transformation before analysis.)

Variety	Planting date	% damaged cobs
Snosweet	30/8	50.63 bcd*
Honeysweet Improved	30/8	64.39 ab
Florida Staysweet	23/8	71.33 a
NS 80 16T	23/8	42.13 cd
New Kairi line	16/8	41.35 cd
Mapee	16/8	40.04 cd
Kulara	16/8	33.52 d
Terrific	30/8	53.77 abc

* Numbers followed by the same letter are not significantly different at the 5% level.

4.0 Discussion

4.1 Aphid management in capsicums

4.1.1 Insecticide trials

The effect of insecticides on green peach aphid populations at Bowen and Ayr was similar (1987 trials at Bowen (Kay and Brown unpub. data) and Tables 2 and 3 here) and there is a continuum of cropping between the two towns so that comments on the effectiveness of insecticides are relevant to the whole area.

Methamidophos gave excellent control at all three rates tested in Trial CA1, and at 290g ai/ha and 1102g ai/ha in Trial CA3. In Trial CA1 use of the 1102g ai/ha rate resulted in significantly fewer ($P<0.05$) aphids than use of the 290g ai/ha rate at 3, 7 and 14d post-treatment, but there was no significant difference ($P>0.05$) at 3 and 7d post-treatment in Trial CA3. Methamidophos is registered on capsicums at 1102g ai/ha for *Helicoverpa* spp., and at 290g ai/ha for green peach aphid so growers could use the low rate when aphids alone are present, and the high rate when both pests require control.

Pirimicarb (500g ai/ha) gave good control in all three trials. In Trial CA2 both rates gave good control, although the 500g ai/ha rate was significantly better ($P<0.05$) than the 250g ai/ha rate at both 3 and 7d post-treatment. Pirimicarb has Board Approval for use on cucurbits and rockmelons at 250-500g ai/ha. The lower rate should be effective in most instances.

Acephate gave excellent control, equivalent to methamidophos at 1102g ai/ha in Trials CA2 and CA3.

The new Bayer chemical, imidacloprid, was very effective in Trial CA1 at both rates used. The effectiveness of the two rates did not differ significantly ($P>0.05$) at 3, 7 or 14d post-treatment. Imidacloprid gave control equivalent to the higher rates of methamidophos.

Parathion methyl had significantly fewer ($P<0.05$) aphids than the unsprayed check at 3d post-treatment, but the same numbers ($P>0.05$) at 7 and 14d. It was not effective. Attia and Hamilton (1978) reported resistance to parathion methyl in some strains of green peach aphid in Australia.

Methomyl gave some control in Trial CA2, although it was inferior to methamidophos, acephate and pirimicarb. Fellowes and Ferguson (1974) reported that methomyl gave inadequate control of green peach aphid in trials in New Zealand and our conclusions are similar. Methomyl is registered against *Helicoverpa* spp. on capsicums and effectiveness against green peach aphid would have been useful. Under conditions of low aphid pressure it may be sufficiently effective to replace a specific aphicide treatment.

Endosulfan was completely ineffective in Trial CA2, confirming earlier results (Kay and Brown unpub. data).

Demeton-S-methyl and dimethoate were significantly better ($P<0.05$) than the unsprayed check in Trial CA3 at Ayr, but the level of control was inadequate. They are not considered effective.

Fluvalinate is registered against green peach aphid on tomatoes. It performed poorly in Trial CA2, and in Trial CA3 it performed poorly again, being equivalent to dimethoate and demeton-S methyl. On this evidence it cannot be considered an effective insecticide against green peach aphid.

These three trials and the 1987 trials (Kay and Brown unpub. data) have determined which insecticides are effective against green peach aphid in the Dry Tropics district. Methamidophos, pirimicarb, acephate, imidacloprid, and monocrotophos are effective. Methomyl has some, but not adequate, efficacy. Fluvalinate, dimethoate and demeton-S-methyl are very poor, and endosulfan, sulprofos, parathion methyl and methidathion are completely ineffective. Attia *et al.* (1979) and Franzmann *et al.* (1980) reported low levels of resistance to both methamidophos and pirimicarb in a strain of green peach aphid from Gatton although field control was adequate. The serious possibility exists that these insecticides could be lost through the development of resistance.

4.1.2 Treatment timing trial

Aphid numbers were low at the start of the trial but had increased to reasonable numbers by the first count on 10 August. All the insecticide treatments and the scouted treatments significantly ($P<0.05$) reduced the numbers of aphids compared to the unsprayed check on this date, which was eight days after a spray for all treatments except the scout (1 aphid) treatment. The less effective aphicides (demeton-S-methyl, methomyl) had more aphids than the better chemicals, but there were no differences between weekly and fortnightly applications. This count was taken soon after all scouted treatments had been sprayed so it did not give a clear impression of aphid build up in these treatments. However the very nature of these treatments indicated that few aphids had been present (ie levels had been below the thresholds), so insecticide applications had not been needed.

Aphid numbers had fallen to almost none by the second count on 6 September. It was interesting to note, however, that plots sprayed with the less effective aphicides methomyl and demeton-S-methyl had significantly ($P<0.05$) more aphids than other plots including the unsprayed check.

It had been hoped that clearly different levels of parasitoid and predator activity would have been noted between the various treatments. There were significantly ($P<0.05$) more mummies in the untreated check than in any of the other treatments, but numbers of predators were very low throughout the trial area. Neither parasitoids nor predators built up in the scout treatments despite the long period since the previous spray. These were small plots with the attendant complications of interactions between plots on mobile insects such as wasps and many of the predatory insects. The effects of the different treatment regimes on beneficial insects may be better investigated in plots of much greater size.

The trial clearly showed that regular calendar spraying was not necessary. Even reducing spray frequency from weekly to fortnightly almost halved the number of sprays applied with no adverse effect on efficacy of control. The scout treatments received few spray applications and had few aphids and no noticeable yield or quality loss. Higher numbers of aphids may well alter this of course, as would the issue of virus transmission, but scouting to a reasonable threshold should still be preferable to calendar spraying. The trial is a starting point for work on developing spray thresholds for aphids on capsicums.

4.2 Eggfruit caterpillar

4.2.1 Insecticide trials

In Trial EC1 the synthetic pyrethroids esfenvalerate and fluvalinate were very effective in preventing eggfruit caterpillar damage to eggplant fruit. The use of synthetic pyrethroids in some crops is sometimes linked to a build-up of mite populations but no such problems were noted during this trial. Endosulfan, the recommended insecticide for eggfruit caterpillar, was significantly ($P<0.05$) better than the unsprayed check, but there was still a large amount of damaged fruit. Methidathion gave similar results. Endosulfan and methidathion may give better control if the spray interval was shorter, and this was tested in Trial EC2. The percentage of eggfruit caterpillar damaged fruit in the mevinphos, sulprofos and methamidophos treatments was not significantly different ($P>0.05$) from that in the unsprayed check. This lack of effectiveness is rather surprising as sulprofos and methamidophos are effective against other lepidopterous pests (eg *Helicoverpa* spp. in tomatoes).

The pressure from eggfruit caterpillar was higher in Trial EC2 than in Trial EC1 judging from the percentage of infested fruit in treatments common to both trials ie check 32.01% in Trial EC2 and 22.52% in Trial EC1, esfenvalerate 5.73% and 0.42%, methidathion (1) 22.98% and 10.78%, and endosulfan (1) 19.58% and 11.6%. The efficacy of these treatments relative to each other was similar in both trials so valid comparisons between treatments indifferent trials can be made.

Esfenvalerate, methomyl (2 – two times a week) and thiodicarb (2) were the most effective treatments in preventing eggfruit caterpillar damage. Percent damaged fruit was significantly ($P<0.05$) lower in the esfenvalerate treatment than in any other insecticide treatment applied once a week. Levels of damage in once-weekly applications of thiodicarb, methomyl, endosulfan and methidathion did not differ significantly ($P>0.05$) from each other. Esfenvalerate was one of the best insecticides in Trial EC1. Thiodicarb (1) did not differ significantly ($P>0.05$) from thiodicarb (2), but methomyl (1) gave significantly less ($P<0.05$) control than methomyl (1). Martin and Workman (1985) reported that weekly applications of methomyl (at 0.25g/L which is equivalent to 250g/ha in 1000L/ha) prevented any eggfruit caterpillar damage to pepinos in a greenhouse in New Zealand. Methomyl and thiodicarb are useful candidates for eggfruit caterpillar control in eggplant.

Endosulfan, the registered chemical for eggfruit caterpillar in eggplant, provided control but there still was a large amount of damaged fruit. There were no differences

(P>0.05) in efficacy between the two application frequencies for endosulfan. The situation with methidathion was similar. Methidathion (1) did not differ significantly (P>0.05) from the unsprayed check (although with a transformed LSD of 0.1282 it was very close to being significantly different). Methidathion (2) gave reasonable control although it was not significantly different (P>0.05) from weekly applications.

Diazinon and fenthion were ineffective. They had as much or greater percentage damaged fruit than the unsprayed check.

The effect of frequency of application has been mentioned already in the discussions on insecticide effectiveness, but as it was an important aim of Trial EC2 it bears further mention. In summary, methomyl (2) was much more effective than methomyl (1), a result not unexpected for an insecticide with a known short residual life. For thiodicarb and methamidophos the percentages of damaged fruit were lower for twice weekly applications than for weekly applications but the differences were not significant at the 5% level. Increasing the frequency of application of endosulfan did not increase its effectiveness.

Increasing the frequency of application increases the cost of control, and this increased cost must be balanced against any improved control. More frequent applications may be required when pressure from eggfruit caterpillar is high, and this emphasises the importance of having a good monitoring system for the pest and of knowing its seasonal incidence patterns. The pheromone work in this project is a start in developing techniques for doing this.

Differences between treatments in the number of fruit harvested were recorded. These differences are difficult to interpret as a lot of factors can affect yield, so care should be taken in relating treatments, numbers of fruit, and eggfruit caterpillar control. However, broadly numbers of fruit corresponded with percentage damaged fruit, with diazinon and fenthion having the highest damage level and lowest number of fruit. Loss of damaged fruit through breakdown from secondary rots before harvest may be a reason for the lower yields in these treatments. Methidathion (2) with reasonably good control had a low yield, but the reasons for this are not known.

The two trials screened a total of 11 insecticides for eggfruit caterpillar control in eggplant. Endosulfan, the registered chemical, gave some protection, but the level of protection was not exceptionally high. Methidathion, fenthion, diazinon and mevinphos are registered for other pests on eggplant. Of these only methidathion gave any control over eggfruit caterpillar at a level equivalent to endosulfan. The other three were ineffective. The other insecticides are not registered on eggplant. Sulprofos and methamidophos were ineffective. The synthetic pyrethroids esfenvaleate and fluvalinate gave good control, as did the carbamates methomyl and thiodicarb, particularly at the higher application frequency. Methomyl is registered against lepidopterous pests in a variety of crops including the solanaceous crops capsicum and tomato, and thiodicarb is registered on tomato. (Eggplant is a member of family Solanaceae.)

It would be of great advantage to eggplant growers to have more than just endosulfan registered to control eggfruit caterpillar. These trials have identified esfenvalerate, fluvalinate, methomyl, thiodicarb, and methidathion (to a lesser extent) as being useful alternatives.

4.2.2 Pheromone studies

These trials indicate that 1:1 and 3:1 ratios of the components attracted males equally. However Clearwater *et al.* (1986) reported that the 1:1 (Ac:OH) ratio was significantly more attractive than a 3:1 or 1:3 ratio. They found no statistical differences in attractiveness between virgin females and 3:1 and 1:3 ratios, while Galbreath and Clearwater (1983) reported no significant difference in catch in traps baited with virgin females or with a 1:1 ratio. Our results differ from those of Clearwater *et al.* (1986) in that we found no difference between the attractiveness of 1:1 and 3:1 ratios. Otherwise our results are similar. Clearwater *et al.* (1986) concluded that male eggfruit caterpillar do not discriminate greatly between different ratios of the two pheromone components. The results reported here appear to confirm this. However the pheromone loading was important, with the higher loading catching more males. Clearwater *et al.* (1986) reported a similar finding.

Overall, relatively few eggfruit caterpillar were caught. This does not necessarily mean that the lures were not particularly effective. The block of eggplant used in the trials was not large so it may have contained only a small population of the insect, and it was isolated from other eggplant crops. As the seasonal incidence patterns of eggfruit caterpillar are not known the population level may have been low at the times the trials were done.

The results of this pheromone work are promising. Further research to determine optimum ratios and loadings are warranted as is work to use the pheromone to determine the seasonal occurrence of the insect. Its use as a monitoring tool would be most useful to develop IPM practices in eggplant production.

4.3 Sweet corn studies

4.3.1 Insecticide trials

The results of the insecticide trial showed that all the tested insecticides resulted in significantly fewer damaged cobs than the untreated check. The most effective insecticides included the carbamates methomyl and thiodicarb, an organophosphate, monocrotophos, a synthetic pyrethroid, esfenvalerate, and the organochlorine endosulfan. That such a wide range of insecticides is effective is beneficial for resistance management as growers could rotate chemical groups to minimise the risk of resistance selection.

The results of the three spray frequency trials are interesting. There were no differences ($P>0.05$) in the percentage of undamaged cobs sprayed at 2, 3, 4 or 7 day intervals with either insecticide on the first two harvest dates, in mid May an mid July, and control was excellent. However, at the mid November harvest control generally was poor (less than 40% undamaged cobs in the best treatment), and the 7d spray interval had significantly lower percent undamaged cobs than the other three spray intervals. Data on heliothis pressure were not collected during this trial, and in retrospect it would have been informative to do so. Kay (1989) studied the incidence of *Helicoverpa* spp. on tomatoes at Bowen from 1982 to 1984, and these records give some idea of what might have occurred. *H. armigera* usually was abundant from March to May, but low numbers had been recorded in late April and May. Numbers were low in June – July, and were low to very high in October – November, depending on the year. It seems likely that during the course of this trial in 1990 *H. armigera* numbers were low in April – May and in June – July (ie during silking in the first two trials), but very high in October – November in the third trial.

The results do show that a 4d spray interval is as effective as shorter intervals even under high pressure, and a 7d spray interval may be acceptable. Sprays should be applied based on the results of monitoring, rather than on a strict calendar basis.

4.3.2 Variety trials

The results of the variety trials should be treated with some caution, in particularly the results of Trial SC3. Despite efforts to obtain uniform silking by staggering the planting dates, silking occurred over a 10-14 day period so there is a possibility that the different varieties were subjected to different heliothis pressures. The staggered planting in Trial SC4 resulted in more even silking in that trial. The results do indicate that some varieties were damaged more than others. Further work on comparative varietal susceptibility and the mechanisms causing it is warranted.

5.0 Technology Transfer

A range of technology transfer activities were undertaken.

1. Results from the various insecticide trials were provided to the relevant agri-chemical companies for their use in obtaining registrations. Bayer used data on imidacloprid from Trial CA1 to obtain registration for the product (sold as Confidor) against aphids on capsicums, and the trial results are featured in their promotional literature.

2. Information from the trials was disseminated widely to QDPI extension officers and crop consultants in north Queensland and elsewhere in the state, and to growers through personal contact.

3. Results from the project have been published in a variety of extension and scientific publications. Publications include:

Brown, J.D. (1994). Notes on eggfruit caterpillar with reference to chemical control and pheromone studies. *Proceedings of the Fifth Workshop of Tropical Agricultural Entomology, Townsville, 1-5 July 1991.* pp 216-218.

Brown, J.D. (1991). Aphid control in capsicums. *NQ Horticultural News.*

Brown, J. and Kay, I. (1991). Control of eggfruit caterpillar in Queensland. *Queensland Fruit and Vegetable News,* 21 November: p. 14.

Brown, J. and Kay, I. (1991). Control of aphids on capsicums. *Queensland Fruit and Vegetable News,* 18 July: p. 12.

Kay, I.R. and Brown, J.D. (1992). Insecticidal control of eggfruit caterpillar *Sceliodes cordalis* (Doubleday) (Lepidoptera: Pyralidae) in eggplant. *Plant Protection Quarterly* 7: 178-179.

Kay, I.R. and Brown, J.D. (1995). Pest management in north Queensland Vegetables. *QFVG Research Report.* pp 20-21.

6.0 Recommendations

The project has successfully screened a range of insecticides against the three insect pests on the three crops. The project also initiated other studies that would lead to wider IPM strategies for the management of these insects and other pests in these crops. The principal recommendation is that these studies proceed and develop.

1. Studies of treatment thresholds for green peach aphid on capsicum should continue. Studies on the importance of beneficial insects on the regulation of aphid populations in the crop should be conducted.

2. The studies on eggfruit caterpillar pheromone should continue. They should be expanded to include studies of the seasonal history of the insect in production districts, and the use of the pheromone as a monitoring tool to determine treatment thresholds.

3. Further studies of the relative susceptibility of sweet corn varieties to heliothis damage should continue. This may lead to the development of resistant varieties of sweet corn.

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References

Attia, F.I. and Hamilton, J.T. (1978). Insecticide resistance in *Myzus persicae* in Australia. *Journal of Economic Entomology* **71:** 851-853.

Attia, F.I., Hamilton, J.T. and Franzmann, B.A. (1979). Carbamate resistance in a field strain of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). *General and Applied Entomology* **11:** 24-26.

Clearwater, J.J., Galbreath, R.A., Benn, M.H and Young, H. (1986). Female-produced sexual pheromone of *Sceliodes cordalis* (Lepidoptera: Pyralidae). *Journal of Chemical Ecology*. **12:** 1943-1964.

Davis, J.J. (1964). The eggfruit caterpillar. *Queensland Agricultural Journal*. **90: 76-78.**

Fellowes, R.W. and Ferguson, A.M. (1974). Field evidence for resistance to certain insecticides by green peach aphid in South Auckland. *New Zealand Journal of Experimental Agriculture* **2:** 83-88.

Franzmann, B.A, Hamilton, J.T. and Attia, F.I. (1980). A field and laboratory evaluation of insecticides on a multiresistant strain of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). *Protection Ecology* **2:** 41-46.

Galbreath, R.A. and Clearwater, J.R. (1983). Pheromone monitoring of *Sceliodes cordalis,* a pest of pepino. *Proceedings 36th New Zealand Weed and Pest Control Conference*. 128-130.

Hamilton, J.T. and Attia, F.I. (1978). *Myzus persicae* (Sulzer): strains resistant to demeton-S-methyl and dimethoate in Australia. *Journal of the Australian Entomological Society* **17:** 63-64.

Hamilton, J.T. and Muirhead, W.A. (1981). Chemical control of *Heliothis armiger* (Hubner) in sweet corn. *Australian Journal of Experimental Agriculture and Animal Husbandry* **21:** 231-235.

Hely, P.C., Pasfield, G. and Gellatley, J.G. (1982). *Insect pests of fruit and vegetables in NSW.* Inkata Press, Melbourne.

Kay, I.R. (1989). Seasonal incidence of *Heliothis* spp. (Lepidoptera: Noctuidae) on tomatoes in north Queensland. *Journal of the Australian Entomological Society* **28:** 193-194.

Martin, N.A. and Workman, P. (1985). Greenhouse pepinos: Control of poroporo fruit borer. *New Zealand Commercial Grower* **40:** 18.