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Attempted suppression of *Inopus rubriceps* (Macquart) (Diptera: Stratiomyidae) by application of insecticides to plant crops of sugarcane

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Summary

Management of sugarcane soldier fly *Inopus rubriceps* in sugarcane ratoons was attempted by applying insecticides soon after planting, to reduce the breeding population within fields. Aldicarb and carbofuran reduced numbers of larvae several months after treatment in small plot trials. In one series of large trials repeated across farms, neither insecticide was effective but treatment was later than desirable. In a second series of large trials, aldicarb applied at the 3–5 leaf stage reduced larval numbers in plant crops and there tended to be fewer larvae in treated plots in the first ratoon. Reductions were only 50-60% and were not sufficient to justify commercial use of this treatment.

Introduction

Root-feeding larvae of the sugarcane soldier fly *Inopus rubriceps* (Macquart) are a pest of sugarcane in Australia. Larval feeding results in poor ratooning of infested plants after harvest. The soldier fly life cycle occupies at least one year, with pupation in autumn (Samson and McLennan 1995). Damage symptoms are more frequent in older ratoons (Samson *et al.* 1991), as it usually requires one or more generations for soldier fly populations to increase to damaging levels after planting.

No insecticides are available for soldier fly control. Aldicarb and carbufuran were the most effective of 21 insecticides in laboratory bioassays (Samson 1992), but were not consistently effective when applied into infested sugarcane ratoons (Samson and Harris 1994). It is difficult to obtain a good distribution of insecticides in ratoons without damaging the sugarcane roots, and this may have been part of the reason for the poor results.

An alternative strategy is to apply insecticides in the plant crop, to reduce numbers of larvae present in the field at planting or that resulted from females laying eggs soon after planting. This treatment may delay the build up of larvae in subsequent ratoon crops by reducing the initial breeding population. Newly planted cane has a root zone that is small and localized, and so may be more effectively treated with insecticide than ratoon crops when the same plants have been growing for a year or more.

In these trials we evaluated the carbamates aldicarb and carbofuran and the organophosphates ethoprophos, which was registered in sugarcane for control of scarabs when the research was conducted, and isofenphos, one of the most effective organophosphates against soldier fly in New Zealand pastures (Robertson 1979). We measured the short-term effect of insecticide application in small-plot trials and the longer-term effect in both the plant and first ratoon crops in large trials repeated across farms.

Materials and methods

Short-term effect of insecticides applied soon after planting

Two trials were carried out near Bundaberg, southern Queensland.

In Trial 1, a young plant cane field was identified with poor establishment and soldier fly larvae feeding on the roots near the planting pieces of stalk (setts). Three treatments were applied, aldicarb (Temik 15G®) at 2.5 kg ha^{-1} a.i., carbofuran (Furadan 10G®) at 3 kg ha^{-1} a.i. and ethoprophos (Mocap 100G®) at 4 kg ha^{-1} a.i., these being the registered rates in sugarcane for control of other soil pests, plus untreated Controls, in a randomized complete block design with five replications. Plots measured 4 rows by 8 m long. Granules were applied by hand-held applicator over the top of the rows in July 1990, and were loosely incorporated by raking and then irrigated the same day. Soldier fly larvae were counted in October, by taking a soil core (6.5 cm diameter × 20 cm depth) adjacent to each of four plants in the middle two rows of each plot. Larvae were extracted by wet-sieving through a 1 mm screen (Robertson 1984).

In Trial 2, insecticides were applied in August 1991 to a young cane crop (planted late March) infested with soldier fly. Treatments were aldicarb, carbufuran granular (10G), carbofuran liquid (360EC) and isofenphos (Oftanol 500EC®), each applied at two or three rates (see Table 2), plus untreated Controls, in a randomized complete block design with six replications. Plots measured 4 rows by 6 m long. Granules were applied by hand-held applicator while liquids were applied from a gas-pressurized sprayer in 2 L water per plot, each in a band about 15 cm wide over the rows. Insecticides were then incorporated by raking and irrigation. Soldier fly

larvae were sampled in November, by digging one plant from each of the middle two rows of each plot and wet-sieving larvae from roots and surrounding soil.

Effect of insecticides applied soon after planting on subsequent soldier fly populations

In Trial 3, eight plant cane fields were selected near Bundaberg that had experienced soldier fly damage in the previous crop cycle. Treatments were applied to large plots, at least 21–25 rows wide and 40–50 m long, with two replications at each site. Granules of aldicarb or carbofuran were applied during June-July 1991; calculated application rates of the two products in each field were 2.0–3.2 kg ha^{-1} a.i. (mean 2.5) and 2.2–4.0 kg ha^{-1} a.i. (mean 3.1), respectively, comparing well with target rates of 2.5 and 3.0 kg ha^{-1} a.i. Granules were applied on top of the cane rows, raked, and then irrigated within three days. Soldier fly larvae were subsequently counted in samples from nine cane stools from each plot, from a central area measuring 5 rows × 20 m. Samples were either four soil cores (6.5 cm diameter × 20 cm depth) or two spade samples (each 1.4 L) from the root zone around each stool. Fields were sampled twice, in the plant crop during January-March 1992 and again in the first ratoon crop during October-December 1992.

In Trial 4, seven plant cane fields were selected and treated similarly to Trial 3. However, only one insecticide, aldicarb, was used, and it was applied at an earlier stage of cane growth than in Trial 3, at the 3–5 leaf stage and usually at the first working of the field. Plots were 17–27 rows wide and 45–50 m long with two or three replications at each site. Aldicarb granules were applied within two months of planting, during April-May 1994 to cane planted in March–April in four fields near Bundaberg, and during July–October 1994 to cane planted in June-August in three fields near Mackay, central Queensland. Calculated application rates in each field were 1.5-3.0 kg ha^{-1} a.i. (mean 2.3). Fields were irrigated within two days of treatment. Soil samples for counting soldier fly larvae were taken from around nine cane stools in a central area measuring 3–5 rows × 10 m in each plot, with 4 L of soil collected by spade from beside each stool. Fields were sampled twice, in the plant crop during March–April 1995 and again in the first ratoon crop during March–April 1996.

Statistical analysis

Counts of soldier fly larvae were transformed as log(x+1) before analysis of variance. A significance level of 0.05 was chosen for assessing differences between treatment means.

Results

Short-term effect of insecticides applied soon after planting

In Trial 1, fewer live larvae were found beneath cane stools that had been treated with aldicarb or carbofuran than beneath untreated stools (Table 1). There was no apparent effect from the ethoprophos treatment.

In Trial 2, the overall analysis of variance indicated no significant difference in numbers of living larvae between individual treatments (Table 2, P = 0.084). However, the average number of live larvae over all treated plots was significantly lower than in the untreated Controls (P = 0.006).

Long-term effect of plant cane treatment

In Trial 3, larvae were found in the plant crop at six of the eight sites (Table 3). The number of larvae was not reduced by application of either aldicarb or carbofuran (Table 3, P = 0.28). Larval numbers were higher in most of the fields in the first ratoon. Analysis of variance indicated fewer larvae in plots treated with aldicarb and carbofuran than in untreated plots (P = 0.012), although this was not apparent from examination of the untransformed data (Table 3). Back-transformation of transformed means gave larval numbers per nine samples of 12.5, 6.3 and 6.9 in Control, aldicarb and carbofuran treatments, respectively, in the first ratoon. There was no significant interaction between site and treatment in either the plant or first ratoon crops (P = 0.46 and 0.14, respectively).

In Trial 4, larvae were found in the plant crop at six of the seven sites (Table 4). Numbers of larvae were significantly lower in the aldicarb treatment than in untreated plots (P = 0.012). The reduction in larval numbers was not great, 57% on untransformed data (Table 4) and 32% on transformed data, but these figures are poorly estimated because of the low density of larvae overall. In the first ratoon, the probability of a difference between treatments, P = 0.052, just failed to reach the predetermined level of significance (0.05). The apparent reduction in larval numbers in the treated plots in the first ratoon was 49% on the untransformed data (Table 4) and 43% on transformed data. There was no significant interaction between site and treatment in either the plant or first ratoon crops (P = 0.46 and 0.36, respectively).

Table 1. Number of live soldier fly larvae three months after insecticide treatment of young plant cane (Trial 1).

Live larvae/4-core sample (mean ± se)			
Untreated	Aldicarb	Carbofuran	Ethoprophos
5.8 ± 2.2 a	0.8 ± 0.4 b	2.0 ± 0.4 b	7.0 ± 1.4 a

Means in rows followed by the same letter were not significantly different by least significant difference test (P = 0.05).

Table 2. Number of live soldier fly larvae three months after insecticide treatment of young plant cane (Trial 2).

Rate kg ha^{-1} a.i.	Live larvae/2 stools (mean ± se)				
	Untreated	Aldicarb	Carbofuran G	Carbofuran EC	Isofenphos
0	4.2 ± 1.7				
1		2.5 ± 1.3			
2		0.7 ± 0.5	1.3 ± 0.4	0.8 ± 0.7	2.5 ± 1.0
4		0.7 ± 0.3	1.0 ± 0.5	1.0 ± 0.5	0.5 ± 0.2

Table 3. Number of live soldier fly larvae in plant and first ratoon crops following insecticide treatment of cane about four months after planting (Trial 3).

Site	Larvae/9 samples (mean ± se)					
	Plant crop			First ratoon		
	Untreated	Aldicarb	Carbofuran	Untreated	Aldicarb	Carbofuran
1	2.0 ± 1.0	4.5 ± 2.5	4.0 ± 3.0	11.0 ± 4.0	17.5 ± 12.5	20.0 ±10.0
2	1.5 ± 1.5	0.0 ± 0.0	0.5 ± 0.5	7.5 ± 3.5	3.0 ± 3.0	5.5 ± 5.5
3	0.0 ± 0.0	0.0 ± 0.0	2.0 ± 0.0	–	–	–
4	2.0 ± 1.0	1.0 ± 0.0	0.5 ± 0.5	4.0 ± 1.0	1.0 ± 0.0	0.5 ± 0.5
5	13.5 ± 6.5	8.5 ± 4.5	13.0 ± 8.0	166.5 ± 50.5	100.0 ± 14.0	183.5 ± 73.5
6	4.0 ± 4.0	0.5 ± 0.5	3.0 ± 1.0	5.0 ± 4.0	0.5 ± 0.5	0.0 ± 0.0
1–6	3.8 ± 1.7	2.4 ± 1.1	3.8 ± 1.7	38.8 ± 22.6a	24.4 ±13.1b	41.9 ± 26.2b

For the first ratoon, sites 1-6 combined means followed by the same letter were not significantly different by least significant difference test (P = 0.05).

Table 4. Number of live soldier fly larvae in plant and first ratoon crops following insecticide treatment of cane within two months of planting (Trial 4).

Site	Larvae/9 samples (mean ± se)			
	Plant crop		First ratoon	
	Untreated	Aldicarb	Untreated	Aldicarb
1	9.5 ± 3.5	4.5 ± 3.5	169.5 ± 54.5	60.0 ± 15.0
2	0.3 ± 0.3	0.0 ± 0.0	2.7 ± 0.9	0.3 ± 0.3
3	2.7 ± 0.9	1.0 ± 0.6	13.3 ± 5.0	27.3 ± 10.4
4	3.3 ± 1.5	1.7 ± 1.2	30.0 ± 14.6	17.0 ± 8.0
5	1.0 ± 0.6	0.3 ± 0.3	8.7 ± 5.2	2.7 ± 1.5
6	0.3 ± 0.3	0.0 ± 0.0	–	–
7	0.0 ± 0.0	0.0 ± 0.0	20.3 ± 4.2	8.0 ± 3.6
1–7	2.1 ± 0.7a	0.9 ± 0.4b	33.2 ± 13.7	16.8 ± 5.2

For the plant crop, sites 1–7 combined means followed by the same letter were not significantly different by least significant difference test (P = 0.05).

Discussion

Small plot trials in infested fields indicated that insecticides applied to cane soon after planting can reduce numbers of soldier fly larvae around the plant roots. Aldicarb and carbofuran were more effective than ethoprophos, as was found when the same insecticides were applied to sugarcane ratoons (Samson and Harris 1994).

When fields were chosen based on their history of damage in the previous crop cycle, larvae were found in the plant crop at 12 of 15 sites. These could have been individuals that were present as large larvae at planting, having survived through the pre-plant fallow and then failing to emerge as flies in that first year, or they could have been the progeny of adults that were produced in the same or adjacent fields and that oviposited soon after planting. The high frequency of infestations suggests that high-risk fields can be identified and a control strategy of preventative treatment of plant crops could be implemented, provided treatment was successful.

In Trial 3, no control of larvae was seen in the plant crop using either aldicarb or carbofuran. Insecticides were applied during June-July; plants had begun stooling out and planting furrows had been partly filled-in by this time. Earlier treatment should be more effective, when the root zone is more localised. A study of larval movement showed that most larvae were concentrated near plants within six weeks of planting in troughs of 1 m width (Samson and Harris 1995). In Trial 4, aldicarb reduced the number of larvae in plant cane when applied at the 3-5 leaf stage within two months of planting. This reduction seemed to be maintained into the first ratoon. However, the level of control was insufficient to justify recommending this treatment to farmers.

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