THE EFFECT OF SPINOSAD (TRACER) ON ARTHROPOD PEST AND BENEFICIAL POPULATIONS IN AUSTRALIAN COTTON

D. A. H. Murray and R. J. Lloyd
Department of Primary Industries
Toowoomba, Australia

Abstract

Arthropod pest and beneficial populations were compared in unreplicated 3 hectare plots of unsprayed, spinosad-treated and conventional insecticide-managed cotton in a season-long trial programme on the Darling Downs, Queensland, Australia. Pest activity was assessed twice-weekly by visual methods and beneficial populations estimated by weekly suction samples of 5 x 20 metre lengths of row in each treatment. Most insecticide applications were made using a ground rig sprayer. *Helicoverpa* spp. were well managed in the spinosad-treated plot, but spinosad had no effect on green mirids (*Creontiades dilutus* (Stål)) and cotton aphids (*Aphis gossypii* Glover). The data clearly showed the non-disruptive nature of spinosad (Tracer) on three key predator groups - beetles, true bugs and spiders. There were no differences in predator populations between the unsprayed and spinosad-treated plots for the duration of the season. Cotton aphid populations were controlled by beneficials under the spinosad program. Predator populations in the conventional treatment were substantially reduced. There was an indication that relative to the unsprayed, hymenoptera densities were reduced in both the spinosad-treated and conventionally-treated plots. The non-disruptive effect of spinosad on predator populations suggests this product has an important place in integrated pest management programs.

Introduction

In Australia, production of cotton relies heavily on the use of insecticide sprays for the control of the major caterpillar pests, cotton bollworm, *Helicoverpa armigera* (Hübner), and native budworm, *H. punctigera* (Wallengren). Most of the 10 to 12 sprays applied to cotton are to control *Helicoverpa* spp. (Fitt 1994). Some of these sprays contain additional insecticides for the control of other pests e.g. green mirids, aphids or mites. Associated with this high insecticide use are problems with the development of insecticide resistance, and concerns for the environment and hazards to human health. Most of the insecticides in use on cotton have a broad spectrum of insect activity, resulting in secondary pest outbreaks and pest resurgences. While there is a desire within the cotton industry to develop integrated pest management (IPM) programs, efforts are hampered by the disruptive effect of most of the products that are currently available. Apart from *Bacillus thuringiensis* sprays, a DowElanco developmental product (spinosad (Tracer)) is the first to reportedly offer effective and selective management of *Helicoverpa* spp. This report presents results comparing the efficacy of spinosad with unsprayed and conventional insecticide management and the relative effects of these programs on arthropod pest and beneficial fauna in the cotton crop.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1087-1091 (1997)
National Cotton Council, Memphis TN

Materials and Methods

Trial Details

A trial was conducted near Warra (26°53'E, 150°54'S) on the Darling Downs, Queensland, Australia. Raingrown cotton (variety CS189+) was sown on 29 September 1995 in double skip row configuration (two rows planted, two rows missed). There were five unreplicated insect pest management treatments - unsprayed (no insect pest control), biological (no synthetic chemical treatments, utilising releases of egg parasitoids in conjunction with nuclear polyhedrosis virus (NPV) sprays), spinosad (sole use of the DowElanco developmental product), reduced (limited use of selective insecticides, especially early season) and conventional (standard commercial treatment). Data from the biological and reduced treatments are not included in this paper.

Since the main objective of the study was to investigate the effect of spinosad on beneficial insects, it was decided at the commencement that non-heliothis pests e.g. green mirids, cotton aphids or mites, on the spinosad treatment were not to receive specific control actions. Recommended treatments for these pests were likely to be very disruptive to beneficial insects and cloud the assessment of spinosad treatments. All applications of spinosad were applied at 96 g a.i. per ha (Table 1).

Apart from an aerial spray to the conventional on 6 January 1996, all spray applications were made using a wind-assisted ground rig. The ground-rig spray boom operated at 5 bar and a ground speed of 20 km per hr, and treated 12 rows in a single run. Wet conditions occasionally prevented ground rig applications and aerial applications were not an option for the smaller treatment plots because of the potential risk of spray drift.

Insect Activity

Helicoverpa spp. activity was estimated at regular intervals (usually two times per week) by counting all stages (white eggs, brown eggs, very small (less than 3 mm), small (3 - 7 mm), medium (7 - 20 mm) and large (greater than 20 mm) larvae on four groups of five plants per treatment. Counts were transformed to numbers per metre using the entomoLOGIC program (McKewan *et al.* 1996). Other pests and beneficials encountered during the visual samples were recorded.

Beneficial insects were sampled at least weekly, and more frequently when spinosad applications were made, using a suction sampler (McCulloch Super Air Stream IV Blower Vacuum). Insects were sampled from five randomly selected 20 m lengths of row per treatment. Samples were placed directly into 70% alcohol and returned to the laboratory for sorting using a stereomicroscope.

Assessments of egg parasite activity were made by collecting brown eggs from foliage using a leaf disc punch. Leaf discs with eggs attached were placed into 96-well microtitre trays, covered with plastic wrap and held at 25°C and 60% RH. Eggs were recorded as hatched, parasitised or unhatched. Collections were made at irregular intervals and were dependent on the presence of suitable egg densities in the field.

Activity of the larval parasitoid *Microplitis demolitor* (Wilkinson) was assessed using virgin female-baited sticky traps placed in the crop canopy. Traps were placed in the field at irregular intervals as availability of virgin female wasps dictated. There were normally twelve traps per treatment placed in a 4 x 3 grid arrangement with 40 m between traps in a row and 28 m between traps across rows.

Plant measurements

The number of squares and bolls were counted each week in 4 x 1 m lengths of row per treatment. Fruit retention was estimated from 20 plants (4 groups of 5 non-tipped plants) per treatment and was estimated only during an 11 week period (16 November 1995 to 29 January 1996) of fruit production. Retention was estimated from the number of first positions retaining fruit of the total first fruit positions. Yield from each treatment was estimated by hand harvest from 4 x 2 row plots each 5 m long. Samples were taken to determine turnout percentages and quality parameters. Sub-plots were also machine harvested from each treatment.

Results and Discussion

Insect activity

Pest species

The spray programs for the spinosad and conventional treatments are shown in Table 1. Eight spinosad applications were made in a season-long treatment program. In comparison a total of 13 sprays were applied to the conventional treatment. Data on *Helicoverpa* spp. egg and larval activity are presented graphically in Figure 1.

Severe difficulties were encountered with *Helicoverpa* spp. management under the conventional insecticide program, especially during January and mid to late February. Spinosad provided satisfactory control of *Helicoverpa* spp. for most of the season, but some larval damage occurred during late February on this treatment.

Adult green mirids, *Creontiades dilutus* (Stål), invaded the entire trial site during late October (Figure 2). Populations of adults and nymphs caused severe square losses during the early fruit production phase. Spinosad had negligible effect on the green mirid population. At no stage were there apparent differences in total green mirid densities between the unsprayed and spinosad treatments. Green mirids were recorded on the spinosad treatment throughout the entire season. In contrast, conventional insecticides applied for green mirid control on 27 November 1995 and 2 December 1995 reduced their densities to low levels.

Cotton aphid, *Aphis gossypii* Glover, reached high infestation levels on all treatments. Population densities peaked at the same time on the unsprayed and spinosad treatment. Aphids were controlled by natural enemies on both of these treatments, but the infestation levels were greater than those normally tolerated by conventional practice. Aphids were controlled on the conventional treatment by applications of profenofos (Curacron) (29 December 1995) and dimethoate (De-Fend) (13 February 1996).

Nymphs of spur-throated locust, *Nomadacris guttulosa* (Walker) were abundant on the unsprayed and spinosad treatments. Spinosad had no observable effect on these pests. Conventional insecticide treatments effectively reduced numbers of spur-throated locust.

Occasional specimens of green vegetable bug, *Nezara viridula* (L.), cotton harlequin bug, *Tectocorus diopthalmus* (Thunberg) and pale cotton stainer, *Dysdercus sidae* Montrouzier, were recorded on the unsprayed and spinosad treatment. At no stage were these occasional pests at densities requiring treatment. Spinosad had no observable effect on these hemiptera.

Beneficials - Predators

In the period up to 27 November 1995 when the first insecticide spray was applied to the conventional treatment, predator densities were similar on all three treatments (Figure 3). Total predator densities on the unsprayed and spinosad treatments remained relatively the same throughout the season. While predator densities were generally low (<1 per metre), there were no apparent differences in species abundance or diversity between the unsprayed and spinosad treatments.

There are extensive and detailed data to indicate that spinosad sprays had minimal effect on predator species. During mid-season, predatory bugs such as the damsel bug, *Nabis kinbergii* Reuter, remained in the spinosad treatment at densities similar to those on the unsprayed, and continued to breed in the crop as indicated by the presence of immature stages (nymphs) in the suction samples.

During late January and early February high aphid populations developed on the unsprayed and spinosad treatments. High densities of predators, mostly coccinellid adults and larvae (predominantly three banded ladybird, *Harmonia octomaculata* (F.)) but also some syrphid (hover fly) larvae, developed in response to the aphid infestation and provided effective control. These beneficial populations increased under the spinosad spray regime in parallel with the unsprayed and were obviously unaffected by spinosad applications at that time (Figure 3).

Predator populations on the conventional treatment declined after the second insecticide treatment on 2 December 1995 which contained dimethoate (De-Fend), and never recovered for the remainder of the season under a barrage of highly disruptive insecticides (Figure 3 and Table 1).

Beneficials - Parasitoids

A high proportion of the microhymenoptera (small parasitic wasps) recorded on the unsprayed during late January and early February were aphid parasitoids (predominantly *Aphidius colemani* Viereck). Densities of microhymenoptera were higher on the unsprayed than on both the spinosad and conventional treatments (Figure 4).

Egg parasitoid activity on the unsprayed and spinosad treated plots was similar on most sampling dates (Table 2). *Trichogrammatoidea bactrae* was the most common egg parasitoid, comprising 83.4% of parasitised eggs from the unsprayed and 82.4% of those from the spinosad treatment. Samples on 5 February 1996 indicated lower egg parasitism on the spinosad treatment compared with the unsprayed, but it is unlikely that this difference was due to spinosad residues as the previous spray was applied on 25 January 1996. Other samples on 12 and 15 February 1996 followed a spinosad spray on 11 February 1996. Egg parasitism levels in these samples were similar to those of the unsprayed. In contrast, there was no egg parasitism in the sample from the conventional treatment on 2 January 1996 following a profenofos (Curacron) spray on 29 December 1995. Egg parasitism on the conventional treatment also declined between 12 and 15 February 1996 when a cyfluthrin (Tempo)/amitraz (Mitac)/dimethoate (De-Fend) spray was applied on 13 February 1996.

Trap catch data for the larval parasitoid *M. demolitor* are inadequate to determine the effect of spinosad on this parasitoid (Table 3). For the early sample dates trap catches were very low in all treatments, but increased later in the season. During the period 7-11 February 1996, trap catches were similar in all treatments. The previous spinosad spray was applied on 25 January 1996. Trap catches in both the spinosad and conventional treatments during 6-10 March 1996 were lower than the unsprayed. In this case the previous spinosad spray was applied on 19 February 1996.

Plant measurements

Early square production on both the unsprayed and spinosad treatments was lower than that on the conventional (Figure 5). These differences were primarily the result of green mirid activity. Specific insecticides were applied to control green mirids on the conventional treatment, although these treatments were probably delayed more than is normal under commercial practice. Thus fruit retention on all treatments dramatically declined during November; well below the accepted industry standard of 60% (Figure 6).

Most square losses after early January were attributed to *Helicoverpa* and low retention levels persisted (Figure 6). Good control of *Helicoverpa* spp. with spinosad during this period saw the square production on the spinosad treatment regain lost ground on the conventional treatment. Conventional treatments did not satisfactorily control *Helicoverpa* spp. during mid January, and resulted in a decline in square production (Figure 4). Final boll counts were similar for both the spinosad and conventional treatments and maturity as determined by open boll counts was only delayed slightly on the spinosad treatment compared to the conventional treatment. Boll opening on the unsprayed was delayed compared to the conventional treatment.

Pre-harvest plant mapping clearly indicated poor retention of first and second position fruit on the lower fruiting branches (nodes 7-12) of all treatments. These losses were due to green mirids as previously discussed. Vegetative branches and fruit three or more nodes from the mainstem made a major contribution to yield in all treatments.

Estimates of lint yield confirmed the similarity of spinosad and conventional treatments (Table 6). These results were in agreement with the end-of-season boll counts. The unsprayed yield was 55.8% of the average yield of the spinosad and conventional treatments. The unsprayed yield was higher than expected given the moderate to high *Helicoverpa* spp. activity during the season. Quality parameters were similar across all treatments.

Conclusion

Control of *Helicoverpa* spp. using spinosad was equivalent to or better than conventional practice. As the main purpose of the trial was to investigate the effects of spinosad on beneficial populations in the cotton crop, and since treatments for other pests were not applied, yield comparisons between treatments are not valid. Other pests, in particular green mirids, adversely impacted on fruit production on the spinosad treatment when compared to that of the conventional treatment.

Even though predator densities were low (mostly <1 per metre) during the trial, suction sampling indicated the non-disruptive effect of spinosad on the key predator groups - true bugs, beetles and spiders. Densities of ants and lacewings were too low to allow meaningful comment on the effect of spinosad on these groups. Under the conventional insecticide regime, most surviving predators were spiders.

The most dramatic evidence of the non-disruptive effect of spinosad on predator groups occurred during late January and early February when predator numbers (mostly coccinellids) increased in response to aphid infestation. Sprays of spinosad on 25 January 1996 and 11 February 1996 had no adverse effect on predator densities relative to the unsprayed.

The suction sample data on adult hymenoptera indicated that spinosad adversely affected this group. However, data on *Helicoverpa* spp. egg parasitism suggested no adverse effect as a result of spinosad sprays. Further investigations are warranted to clarify the effect of spinosad on hymenoptera. Studies are continuing to investigate the effect of spinosad on *M. demolitor*-parasitised larvae and adult *M. demolitor* (R. Annetts pers. comm.).

Some caution should be exercised in making a broad statement about the selectivity of spinosad to all beneficial insects. While disruption to parasitic groups (hymenoptera) was apparent, this effect was less than that which resulted from conventional practice.

The data generated in this study indicate the important role that spinosad could play in developing IPM programs in Australian cotton production. Spinosad is one of the rare products that is efficacious against *H. armigera* **and** conserves beneficial fauna in the cotton crop.

Acknowledgments

We are grateful for the support and cooperation of Jeff and Marilyn Bidstrup, 'Prospect' Warra. Murray Boshammer provided professional agronomic support. Barry Ingram, Rob Annetts, Brad Scholz, Kerry Rynne, Jamie Hopkinson, Ken Dusza, and Nathan Murray provided capable technical support. Financial support for this study was provided by DowElanco Australia Limited. We acknowledge these contributions.

References

Fitt, G.P. 1994. Cotton pest management: Part 3. An Australian perspective. Annual Review of Entomology 39:543-562.

McKewan, L., Plummer, C., Nash, G. and Deutscher, S. 1996. entomoLOGIC 96: Further improvement to a successful product The Eighth Australian Cotton Conference, August 1996. pp.185-188.

Table 1. Spray history for the Warra trial for 1995/96.

Date	Conventional	Spinosad
27 Nov	endosulfan (Tiovel) + Bt (Dipel)	
28 Nov		Tracer
2 Dec	endosulfan (Tiovel) + Bt (Dipel) + dimethoate (De-Fend)	
8 Dec		Tracer
9 Dec	cyfluthrin (Tempo) + Bt (Dipel)	
18 Dec	cyfluthrin (Tempo) + methomyl (Lannate)	
20 Dec		Tracer
22 Dec	cyfluthrin (Tempo) + thiodicarb (Larvin)	
29 Dec	profenofos (Curacron)	
2 Jan		Tracer
6 Jan	endosulfan (Tiovel) + thiodicarb (Larvin)	
Wet weather from 8 Jan prevented ground rig application until 16 January		
17 Jan		Tracer
19 Jan	cyfluthrin (Tempo) + Bt (Dipel)	
22 Jan	thiodicarb (Larvin)	
25 Jan		Tracer
1 Feb	cyfluthrin (Tempo) + amitraz (Mitac)	
9 Feb	thiodicarb (Larvin)	
11 Feb		Tracer
13 Feb	cyfluthrin (Tempo) + amitraz (Mitac) + dimethoate (De-Fend)	
17 Feb	bifenthrin (Talstar)	
19 Feb		Tracer

Table 2. Percentage parasitism of *Helicoverpa* spp. eggs. Number in brackets is the number of eggs collected.

Date	Unsprayed	Spinosad	Conventional[1]
2 Jan	48.4 (71)	63.6 (32)	0 (14)
5 Feb	64.6 (48)	22.2 (36)	29.4 (36)
8 Feb	63.4 (48)	51.9 (54)	36.8 (96)
12 Feb	43.8 (51)	34.4 (65)	48.8 (48)
15 Feb	34.7 (50)	34.0 (50)	16.7 (17)

[1] See Table 1 for spray dates prior to egg collection dates.

Table 3. Comparative catches (number/trap/day) of male *M. demolitor*.

Trapping Period	Unsprayed	Spinosad[1]	Conventional[1]
28 November 1995	0	0	0.08
10 December 1995	0.08	0	0.08
27 December 1995	0	0.08	0.17
7-11 February 1996	0.48	0.52	0.63
6-10 March 1996	1.46	0	0.04

[1] See Table 1 for spray date prior to trapping period.

Table 4. Yield assessments (bales/ha) for treatments at Warra, 1995/96.

Treatment	Unsprayed	Spinosad	Conventional
Hand Harvest	2.42	4.26	4.42
Machine Harvest	3.24	4.10	4.10

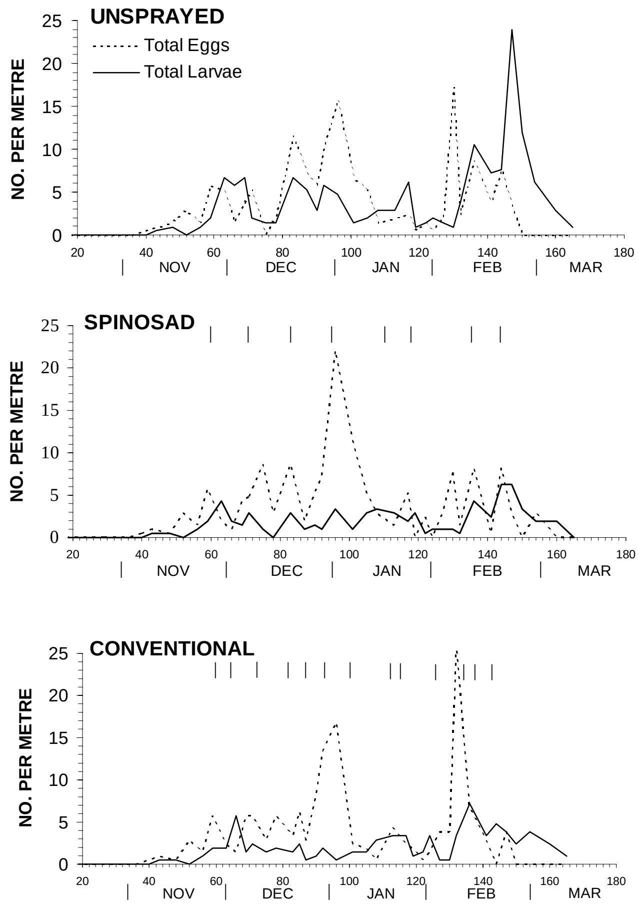

Figure 1. *Helicoverpa* spp. egg and larval activity on unsprayed, spinosad and conventional treatments at Warra, 1995/96. Vertical bars indicate spray dates.

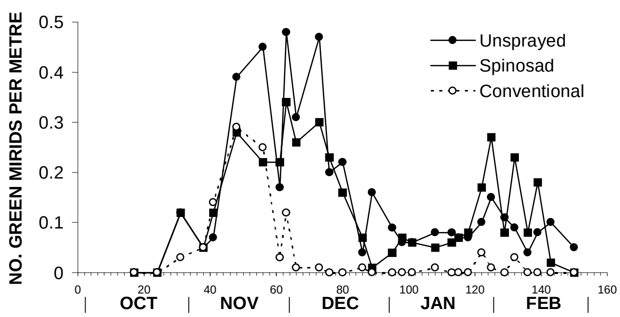

Figure 2. Relative densities of green mirids on unsprayed, spinosad and conventional treatments at Warra, 1995/96.

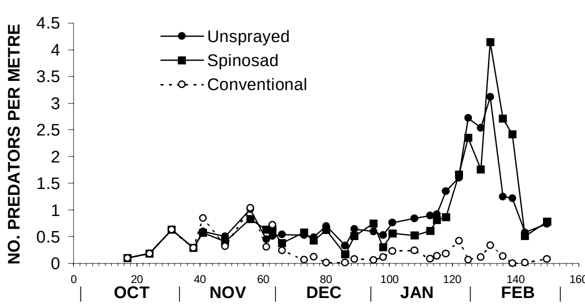

Figure 3. Relative densities of total predators on unsprayed, spinosad and conventional treatments at Warra, 1995/96.

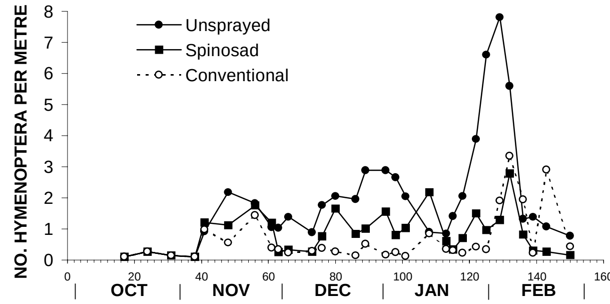

Figure 4. Relative densities of hymenoptera (wasps) on unsprayed, spinosad and conventional treatments at Warra, 1995/96.

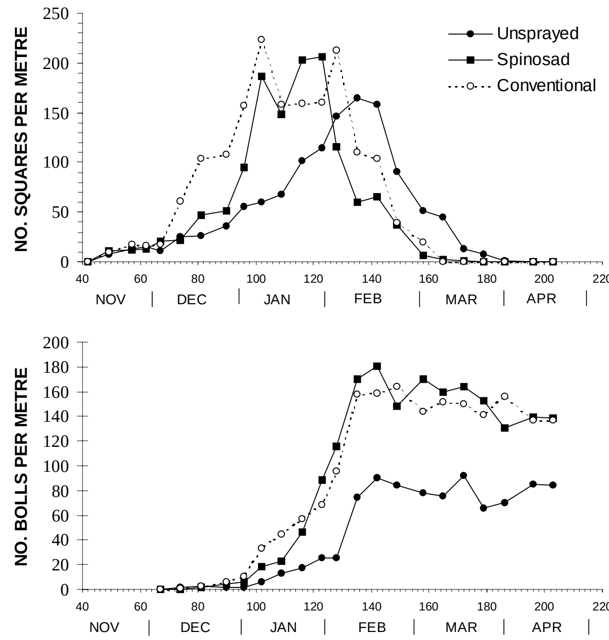

Figure 5. Square and boll counts for treatments at Warra, 1995/96.

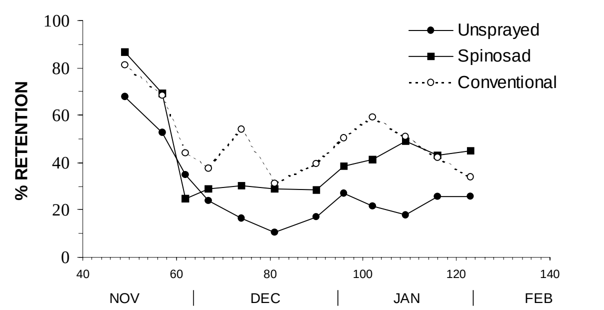

Figure 6. First position fruit retention for treatments at Warra, 1995/96.