

## **INTEGRATED PEST MANAGEMENT (IPM) IN COTTON BASED ON ENVIROFEAST® AND LUCERNE TECHNOLOGIES : WHERE ARE WE**

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### **INTRODUCTION**

The major focus of the Australian cotton industry for pest management is to reduce the dependence on synthetic insecticides. However, despite widespread use of economic thresholds and the so called "soft option" IPM in the current production systems, only limited progress has been made to achieving this goal.

Little emphasis has been placed on beneficial insects and since 1992, we have been funded by the Cotton Research and Development Corporation (CRDC) to develop an IPM strategy which places much more emphasis on natural enemies of the cotton pests particularly *Helicoverpa* spp. in order to reduce the cotton industry's dependence on synthetic insecticides. The project has developed Envirofeast® (food) spray product and lucerne refugia technologies to conserve and enhance the activities of natural enemies in cotton systems. The Envirofeast® product when applied to cotton crops attracts and conserve the natural enemies. The lucerne crop when interplanted in cotton as strips serves as a refuge for the natural enemies (Mensah and Harris, 1995, 1996; Mensah, 1998, 1997) and sink for another cotton pest, the green mirid (Mensah and Khan, 1997). The total IPM package is being evaluated by Rhone-Poulenc Rural (Australia) Pty Ltd prior to commercialisation.

We report here stages 6 and 7 of the program where we compared pest, natural enemy populations and also the yield of normal and transgenic cotton crops managed with Envirofeast IPM to those managed with conventional synthetic insecticides under the Insecticide Resistance Management strategy for 1996/97 and 1997/98 seasons.

### **STAGE 6 TRIALS (1996-97)**

This stage of the IPM integrated Envirofeast® spray, lucerne refugia with biological and synthetic insecticides. The trial was conducted in irrigated normal and transgenic cotton fields at the Australian Cotton Research Institute in Narrabri, Bellevue near Warren and Norwood near Moree. The cotton crops were interplanted with lucerne to conserve beneficial insects and manage green mirids (Mensah, 1998, 1997; Mensah and Khan, 1997). The size of the trials ranged from 2ha (ACRI); 132 ha (Bellevue) and 170 ha (Norwood). All the trials were replicated and

compared with cotton crops (normal and transgenic) of similar size but pests managed with synthetic insecticides under the Insecticide Resistance Strategy.

The treatments at each site are summarised in Table 1. All treated plots under Envirofeast IPM strategy were initially sprayed with Envirofeast® and when the predator to prey (*Helicoverpa* spp.) ratio fell below 0.5 (recommended action threshold for Envirofeast® IPM), some of the plots were treated with either Gemstar® virus or Tracer® (spinosad, a new selective insecticide produced by Dow Elanco). When the natural enemy population in the lucerne strips and cotton has been severely impacted as a result of insecticide drift from conventional insecticide managed farms on site or from neighbours, the treatments were replaced by conventional insecticide sprays when the threshold was exceeded. In this wise the number of synthetic insecticides used on the IPM plots were recorded and compared with those used on plots managed with conventional insecticides.

At the end of the season, the number of synthetic insecticide saved or replaced by biological insecticide through the use of the IPM was determined. Yields harvested from the IPM treatments and the conventional insecticide managed crops were compared to determine any loss in yield.

**TABLE 1: TREATMENTS COMPARED AT NORWOOD, BELLEVUE AND ACRI, 1996-97.**

Treatments	Features
1. Sicala V2 + Lucerne strips + Envirofeast® + Envirofeast/Gemstar virus + insecticides	Normal leaf cotton with lucerne strips and managed with predator food attractant, biological and synthetic insecticides
2. Sicala V2 + Lucerne strips + Envirofeast® + Tracer + synthetic insecticides	Normal leaf cotton with lucerne strips and managed with predator food attractant, selective and synthetic insecticides.
3. Sicala V2 + Conventional insecticides	Normal leaf cotton managed with conventional insecticides (Insecticide Resistance Management Strategy)
4. Sicala V2 (Ingard) + Conventional insecticides	Normal leaf cotton (Ingard) managed with conventional insecticides (TIMS Committee Ingard Management Strategy).

## RESULTS AND DISCUSSION

The total number of spray products (biological and synthetic insecticides) applied through the season on IPM and conventional insecticide managed cotton crops were similar but synthetic insecticides were substantially replaced by biological sprays within the IPM strategy. In the trials at Norwood, 50% of the synthetic insecticide sprays were replaced by biological sprays, 80% were replaced at Bellevue and 88% at ACRI. There were no yield loss at Norwood and ACRI but at Bellevue the IPM program consisting of Envirofeast and Gemstar virus and Envirofeast and Tracer had a yield loss of 0.57 bales and 0.20 bales per acre respectively compared to the conventional cotton (Table 2). This means that one or two more insecticide sprays at the expense of biological sprays could have been enough to avert the yield loss. The result of the trial on Ingard cotton showed that the Ingard cotton saved 2 sprays at Norwood and 5 sprays each at Bellevue and ACRI respectively (Table 2). However, at Bellevue site, the trial lost 0.3 bales per hectare on the Ingard compared with the conventional cotton (Table 2). In general, the level of insecticide sprays in these trials reflected the level of *Helicoverpa* spp. infestations on these plots.

Different species of natural enemies (mostly predators) were sampled from the trials at each site (Table 3). The highest number of predators per plot were recorded on the IPM plots treated with Envirofeast/Gemstar virus mixture, followed by Envirofeast® plus Tracer, and then Ingard plus conventional insecticides. The conventional insecticide treated normal cotton plot had the lowest number of beneficial insects which were predominantly spiders. The beneficial insects were abundant early in the season but numbers declined drastically during stage 2 and were completely exterminated in stage 3. The decline in beneficial insect numbers coincided with the periods when synthetic pyrethroids were used by farm neighbours to control *Helicoverpa* spp. and was probably due to spray drift. The beneficial insect population collapsed completely in February when the trial farms also used pyrethroids to control their cotton pests. The decline and subsequent collapse of the beneficial insect population resulted in high densities of *Helicoverpa* spp. larvae and when threshold was exceeded trials were converted to conventional insecticide sprays.

Green mirid numbers were highest in treatments without lucerne strips but lowest in those interplanted with lucerne strips. Within the lucerne/cotton interplants, green mirids were highest in the lucerne strips than the cotton and remained low until the end of the study indicating there was no movement of green mirids into adjacent cotton.

**TABLE 2: SUMMARY OF YIELDS (BALES/ACRE) AND SPRAYS USED IN TRIALS AT NORWOOD (N\*), BELLEVUE (B\*) AND ACRI (A\*), 1996-97.**

Treatments	No. of		No. of		No. of		Synthetic insecticide sprays	Yields (bales/acre)
	Envirofeast sprays	Envirofeast +virus sprays	Envirofeast sprays	Tracer sprays	insecticide sprays			
1. Sicala V2 + Lucerne strips + Envirofeast® + Envirofeast/ Gemstar virus+ insecticides	N*=3	3	0	0	4	3.0		
	B*=4	4	0	0	2	2.40		
	A*=4	4	0	0	1	3.01		
2. Sicala V2 + Lucerne strips + Envirofeast® + Tracer + synthetic insecticides	N*=3	0	3	3	4	3.20		
	B*=4	0	0	3	2	2.80		
	A*=4	0	4	4	0	2.95		
3. Sicala V2 + Conventional insecticides	N*=0	0	0	0	8	3.0		
	B*=0	0	0	0	10	3.0		
	A*=0	0	0	0	9	2.73		
4. Sicala V2 (Ingard) + insecticides	N*=0	0	0	0	6	2.90		
	B*=0	0	0	0	5	2.70		
	A*=0	0	0	0	5	3.07		

**TABLE 3: MAJOR PREDATORS IDENTIFIED FROM STUDY PLOTS IN THE IPM TRIALS, 1996-98.**

Order	Family	Species	Group
Coleoptera	Coccinellidae	<i>Coccinella transversalis</i> (Fabricius)	Predatory
		<i>Adalia bipunctata</i> (Linnaeus)	beetles
Melyridae		<i>Dicranolais bellulus</i> (Guerin-Meneville)	
Hemiptera	Nabidae	<i>Nabis capsiformis</i> (Germar)	Predatory
		<i>Geocoris lubra</i> (Kirkaldy)	bugs
Pentatomidae		<i>Cermatulus nasalis</i> (Westwood)	
Reduviidae		<i>Ochella schellenbergii</i> (Guerin-Meneville)	
		<i>Coranus tribeatus</i> (Horvath)	
Neuroptera	Chrysopidae	<i>Chrysopa</i> spp.	Predatory
Hemeroptera		<i>Micromus tasmaniae</i> (Walker)	lacewings
Araneida	Lycosidae	<i>Lycosa</i> spp.	Spiders
		Oxyopidae	<i>Oxyopes</i> spp.
		Salticidae	<i>Salticidae</i> spp.
		Araneidae	<i>Araneus</i> spp.

### STAGE 7 TRIALS (1997-98 SEASON)

Following the results of the stage 6 trials, an Envirofeast IPM strategy consisting of Envirofeast® sprays, lucerne refuge crops, Gemstar® and synthetic insecticides was selected and evaluated on large scale commercial Ingard and normal cotton crops. This was compared with Ingard and normal cotton crops with no Envirofeast spray, but managed with Gemstar® and insecticides when the predator to prey threshold was exceeded (control) and also cotton crops managed with synthetic insecticides under the current Insecticide Resistance Management Strategy. The trials were established at Yarral in Narrabri, Norwood near Moree, Bellevue near Warren and ACRI. The cotton crops at each trial site were interplanted with lucerne. The size of the trial at Yarral was 50 ha; Norwood was 170 ha; Bellevue, 132 ha and ACRI, 2 ha. The treatments evaluated at these sites are summarised in table 4. The trial protocol was the same as for stage 6.

**TABLE 4: TREATMENTS COMPARED AT YARRAL, NORWOOD, BELLEVUE AND ACRI, 1997-98.**

<b>Treatments</b>	<b>Features</b>
1. Sicala V2 + Lucerne strips + Envirofeast® + Envirofeast/Gemstar virus + insecticides	Normal leaf cotton with lucerne strips and managed with predator food attractant, Gemstar virus and synthetic insecticides
2. Sicala V2 (Ingard) + Lucerne strips + Envirofeast® + Envirofeast/virus + synthetic insecticides	Normal leaf (Ingard) cotton with lucerne strips and managed with predator food attractant, Gemstar virus and insecticides.
3. Sicala V2 + Lucerne strips + Gemstar virus + insecticides (No Envirofeast)(Control)	Normal leaf cotton managed with Gemstar virus and synthetic insecticides.
4. Sicala V2 (Ingard) + Lucerne strips + Gemstar virus + insecticides (No Envirofeast)(Control)	Normal leaf (Ingard) cotton managed with Gemstar virus and synthetic insecticides.
5. Sicala V2 + insecticides (Conventional cotton)	Normal leaf cotton managed with conventional insecticides under the Insecticide Resistance Management Strategy.
6. Sicala V2 (Ingard) + insecticides (Conventional Ingard)	Normal leaf (Ingard) cotton managed with conventional insecticides under the TIMS Committee Ingard Management Plan.

## RESULTS AND DISCUSSION

A large amount of data on pests, beneficial insects and yield have been collected throughout the season. Most of the data on pests and beneficial insects have not been analysed with the exception of the Yarral trials and the cotton yield data for all the sites. We have summarised the data on yield and the number of insecticide sprays in each treatment which is a reflection of the levels of pest management in the Envirofeast IPM and conventional cotton treatments (Table 5). The results showed that the number of synthetic insecticides used on normal cotton crops managed with Envirofeast IPM was reduced by 57, 42.8, 37.5 and 75 per cent at Bellevue, Yarral, Norwood and ACRI respectively without any yield loss (Table 5). Similarly, Ingard cotton managed with Envirofeast IPM received lower synthetic insecticide sprays than those managed with conventional insecticides with no yield loss (Table 5). There was a reduction of 60 to 67 per cent of insecticide sprays when the Ingard crop was managed with Envirofeast IPM (Table 5).

When the normal cotton crops were managed with IPM tools other than Envirofeast® the cotton crops suffered a yield loss of 0.50 bales per acre at Bellevue, 1.4 bales at Yarral, 1.22 bales at Norwood and 0.80 bales at ACRI (Table 5). In Ingard cotton trials, there was a yield loss of 0.50 bales per acre at Bellevue, 0.40 bales at Yarral, 0.30 bales at ACRI but Norwood there was a yield gain of 0.52 bales (Table 5). The reason for the gain of 0.52 bales of no Envirofeast treated Ingard over Envirofeast treated Ingard at Norwood was that we delayed the first application of Envirofeast® on the Ingard which was not the normal strategy used in the other sites because we thought the efficacy of the Ingard was enough to prevent damage. It was only when the first signs of damage was realised that we decided to put the Envirofeast sprays on. Apart from the reduction in synthetic insecticide sprays on cotton crops managed with Envirofeast IPM, the biological insecticides in the IPM reduced the use of endosulfan by 50% at Yarral and 67% at ACRI. At Norwood no endosulfan was used on the Envirofeast IPM plots at all indicating a 100% reduction. The replacement of endosulfan sprays especially early season is very important to the cotton industry considering the industry's focus on limited use of endosulfan in line with NRA position on the chemical.

In terms of green mirids at the Yarral trial site, the Envirofeast IPM managed cotton crops and no Envirofeast® treated plots which were interplanted with lucerne had fewer mirids than the conventional insecticide managed crops (Figure 1). The conventional cotton crops were sprayed against green mirids on 2 January but there was no green mirid sprays on either the Envirofeast IPM managed or no Envirofeast treated crops. The lucerne strips served as sinks for the green

mirids preventing them from moving into the cotton.

Beneficial insect numbers per metre viz; predatory beetles, bugs and lacewings were highest in the Envirofeast IPM treated plots than the no Envirofeast and conventional crops (Figs 2 and 3). In contrast, number of spiders per metre were highest in the Envirofeast IPM on normal cotton and no Envirofeast treated plots than the Envirofeast IPM on Ingard and conventional cotton crops (Fig 3.).

*Helicoverpa* spp. numbers are summarized for Ingard and normal cotton in Figs 4 and 5. The most interesting results to note are the dates of appearance of medium and large larvae on the Envirofeast IPM managed Ingard cotton and conventional insecticide managed Ingard cotton (Fig. 4 and 5). The results showed that medium and large *Helicoverpa* larvae were recorded on the conventional Ingard crop on 2 January 1998 and on the Envirofeast IPM Ingard crop on 13 January. Also, application of the first insecticide spray against *Helicoverpa* spp. occurred in the conventional insecticide managed Ingard on the 12 January 1998 whereas on Envirofeast IPM managed Ingard, the first insecticide spray was applied on the 28 January 1998. Until this date, Envirofeast was the only product applied to the Envirofeast IPM Ingard indicating that beneficial insects together with the efficacy of the Ingard crop were managing the *Helicoverpa* spp. population.

Strickland *et al.* (1998) attempted to exploit the benefit of our Envirofeast IPM technology to develop IPM on cotton in the Ord. They could not achieve the full benefit of using Envirofeast® because of small plot size and close proximity of treatments and also agronomic problems associated to their trials resulting in the delay of Envirofeast® application and the product not applied at the right time. It was a problem of too few people looking after too many.

Envirofeast IPM in my view will work for farmers or researchers who does not panic spray, spend time to check their farms correctly and applying the sprays at the right time they need to. Envirofeast should not be used as one of the insecticides and expect *Helicoverpa* spp. larvae to disappear overnight. Envirofeast® product cannot kill an ant. It is a product designed to conserve beneficial insects and the decision to intervene with insecticides within the IPM program is explained in the Envirofeast IPM guidelines and this is based on the predator to *Helicoverpa* spp.(*Heliothis*) ratio which is calculated from your regular insect sampling or bug checking.

**TABLE 5: SUMMARY OF YIELDS (BALES/ACRE) AND SPRAYS USED IN TRIALS AT BELLEVUE (B\*), YARRAL (Y\*), NORWOOD (N\*) AND ACRIC (A\*), 1997-98.**

Treatments	No. of Envirofeast sprays	No. of Envirofeast +virus sprays	No of selective insecticides	Synthetic insecticide sprays	Yields (bales/acre)
1. Sicala V2 + Lucerne strips + Envirofeast® + Envirofeast/ Gemstar virus+ insecticides	B*= 3	3	2	1	3.50
	Y*= 3	2	2	2	4.60
	N*= 2	3	0	5	4.51
	A*= 3	1	1	1	3.80
2. Sicala V2 (Ingard) + Lucerne + Envirofeast®+ Envirofeast/ virus + synthetic insecticides	B*= 5	1	2	0	3.70
	Y*= 6	0	1	1	4.40
	N*= 3	1	0	5	3.29
	A*= 3	1	1	1	3.60
3. Sicala V2 + Lucerne strips + Gemstar Virus + insecticides (No Envirofeast)(Control)	B*= 0	3	2	1	3.00
	Y*= 0	2	2	2	3.20
	N*= 0	1	4	4	2.66
	A*= 0	1	1	1	3.00
4. Sicala V2 (Ingard) + Lucerne strips + Virus + insecticides (No Envirofeast)(Control)	B*= 0	1	2	0	3.20
	Y*= 0	0	1	1	4.00
	N*= 0	0	4	4	3.81
	A*= 0	1	1	1	3.30
5. Sicala V2 + insecticides (Conventional cotton)	B*= 0	0	2	5	3.40
	Y*= 0	0	4	3	3.70
	N*= 0	0	4	4	3.77
	A*= 0	0	3	5	3.50
6. Sicala V2 (Ingard) + insecticides (Conventional Ingard)	B*= No conventional trials at this site				
	Y*= 0	0	2	3	3.60
	N*= 0	0	1	6	3.79
	A*= No conventional trials at this site				

## CONCLUSIONS

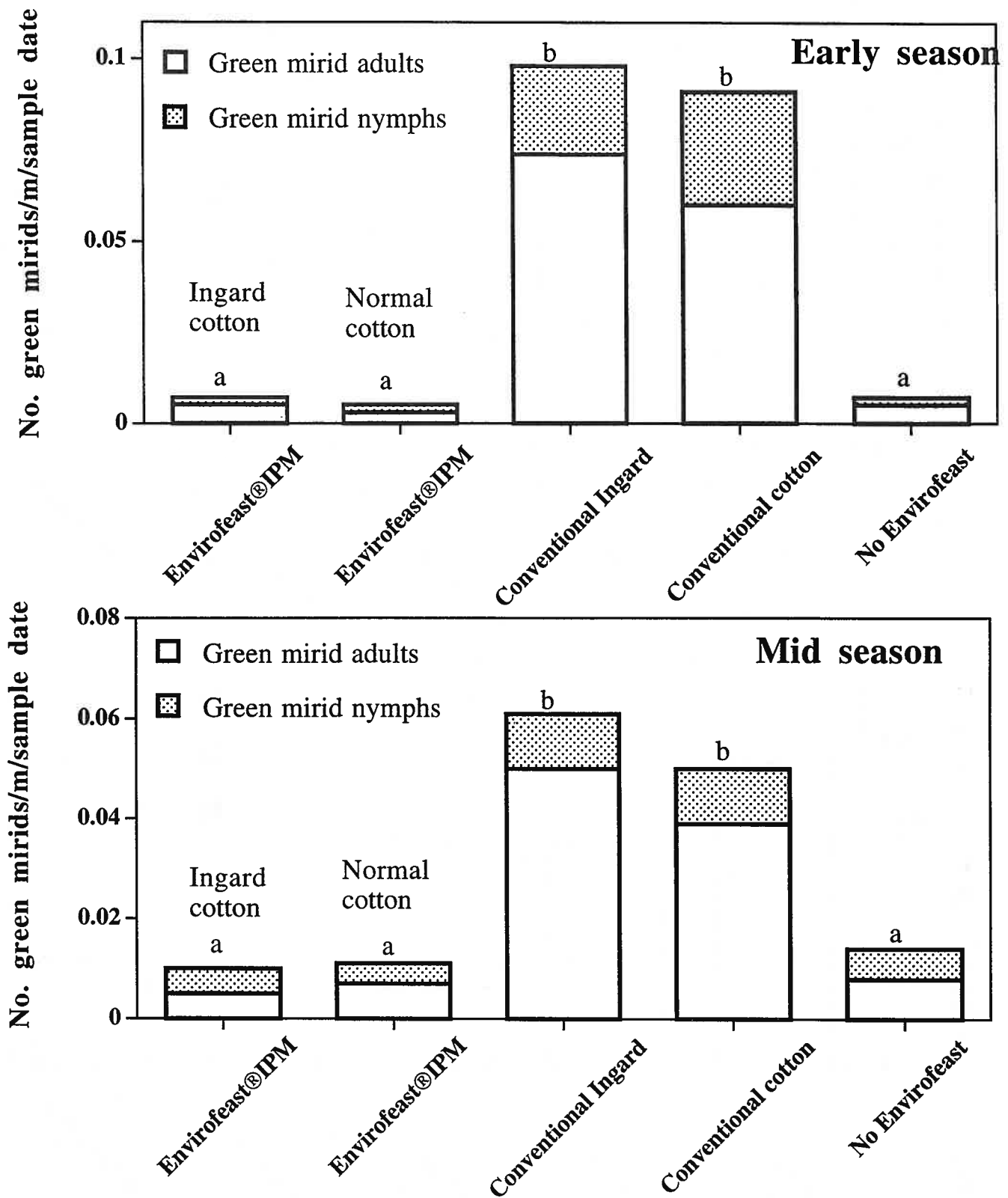
- Envirofeast IPM program can effectively manage cotton pests to achieve cotton yields similar to or sometimes higher than conventional insecticides.
- Envirofeast® when applied to cotton can attract and sustain beneficial insects enabling them to be utilised in IPM programmes.
- Performance of Envirofeast is enhanced by the presence of lucerne strips which serve as a refuge for beneficial insects and sinks to manage green mirids on cotton.
- Cotton crops managed with IPM tools without Envirofeast® had a yield loss of between 0.5 to 1.4 bales per acre.
- Envirofeast IPM on conventional cotton can help manage resistance through the reduction in total insecticide use and replacement of synthetic insecticides, particularly endosulfan.
- Envirofeast IPM on Ingard cotton enhances the efficacy and durability of the Ingard crops by increasing the activity of the beneficial insects and exposing *Helicoverpa* spp. neonates to a second mortality factor instead of a single killing mechanism i.e. the Ingard crop.
- Envirofeast IPM should be used in areas free from disruptive insecticides such as pyrethroids and this can be best achieved if neighbours co-operate to form a regional or area wide group and use the strategy. Thus area-wide or regional based Envirofeast IPM program can be more successful than an individual adjacent to neighbours managing their cotton with synthetic insecticides.
- Envirofeast IPM will work for users who do not panic spray, spend time to check their crops thoroughly and apply the sprays at the correct time.
- Any decision to intervene with insecticides within the Envirofeast IPM program should be based on the predator to *Helicoverpa* spp.(*Heliothis*) ratio which is calculated from regular sampling (bug checking). Guidelines for use of Envirofeast IPM are available to growers from the Technology Resource Centre at ACRI and Rhone-Poulenc representatives.
- For the future sustainability of the cotton industry there should be a reduction in the use of chemical pesticides and Envirofeast IPM is an option to assist in this process.

### ACKNOWLEDGEMENTS

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**Fig. 1. Management of green mirids under Envirofeast®IPM and conventional insecticide regimes at Yarral near Narrabri, 1997-98 (Means of treatments followed by the same letter are not significantly different).**

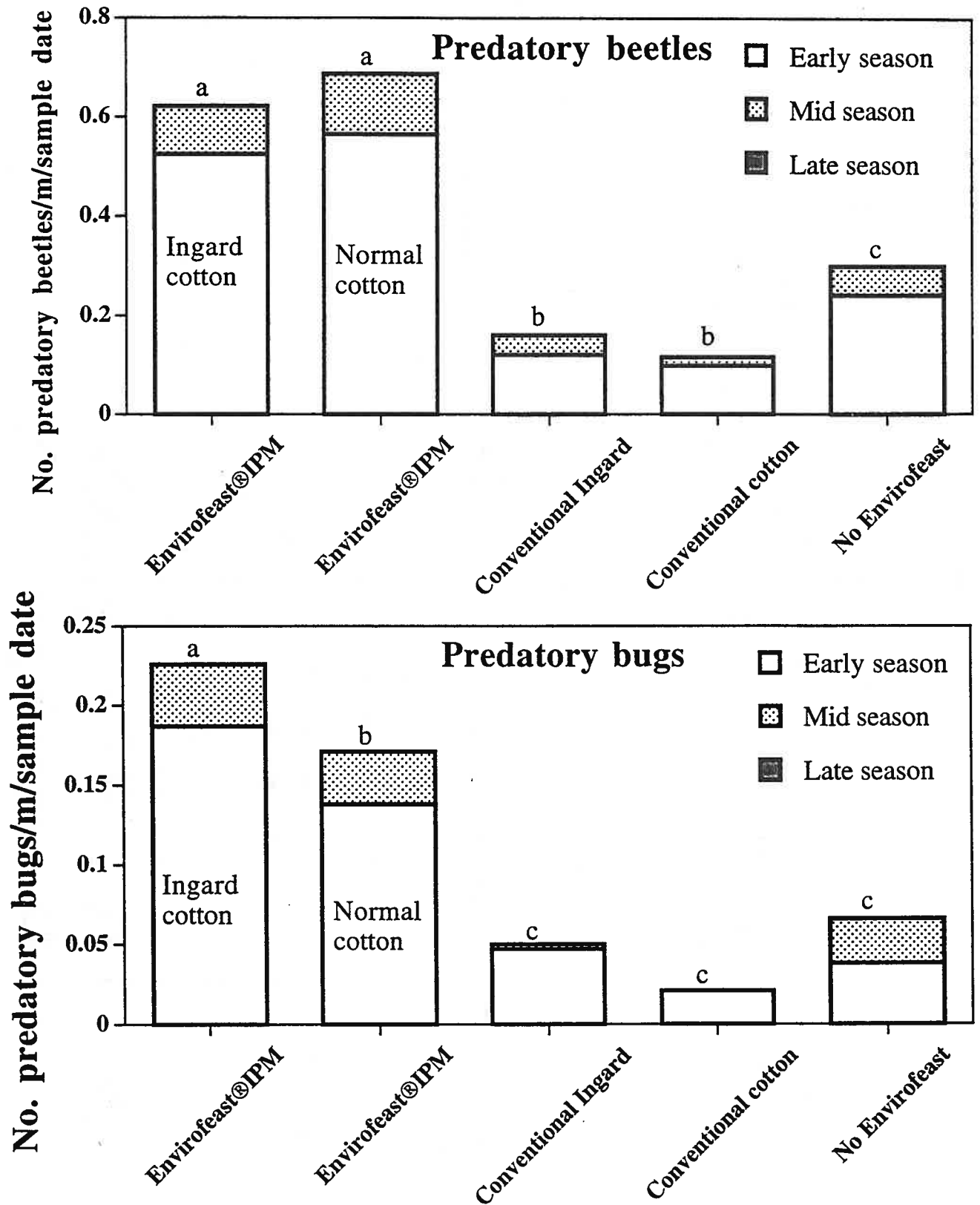


Fig. 2. Populations of predatory beetles and bugs on normal and Ingard cotton under Envirofeast®IPM and conventional insecticide regimes at Yarral near Narrabri, 1997-98.

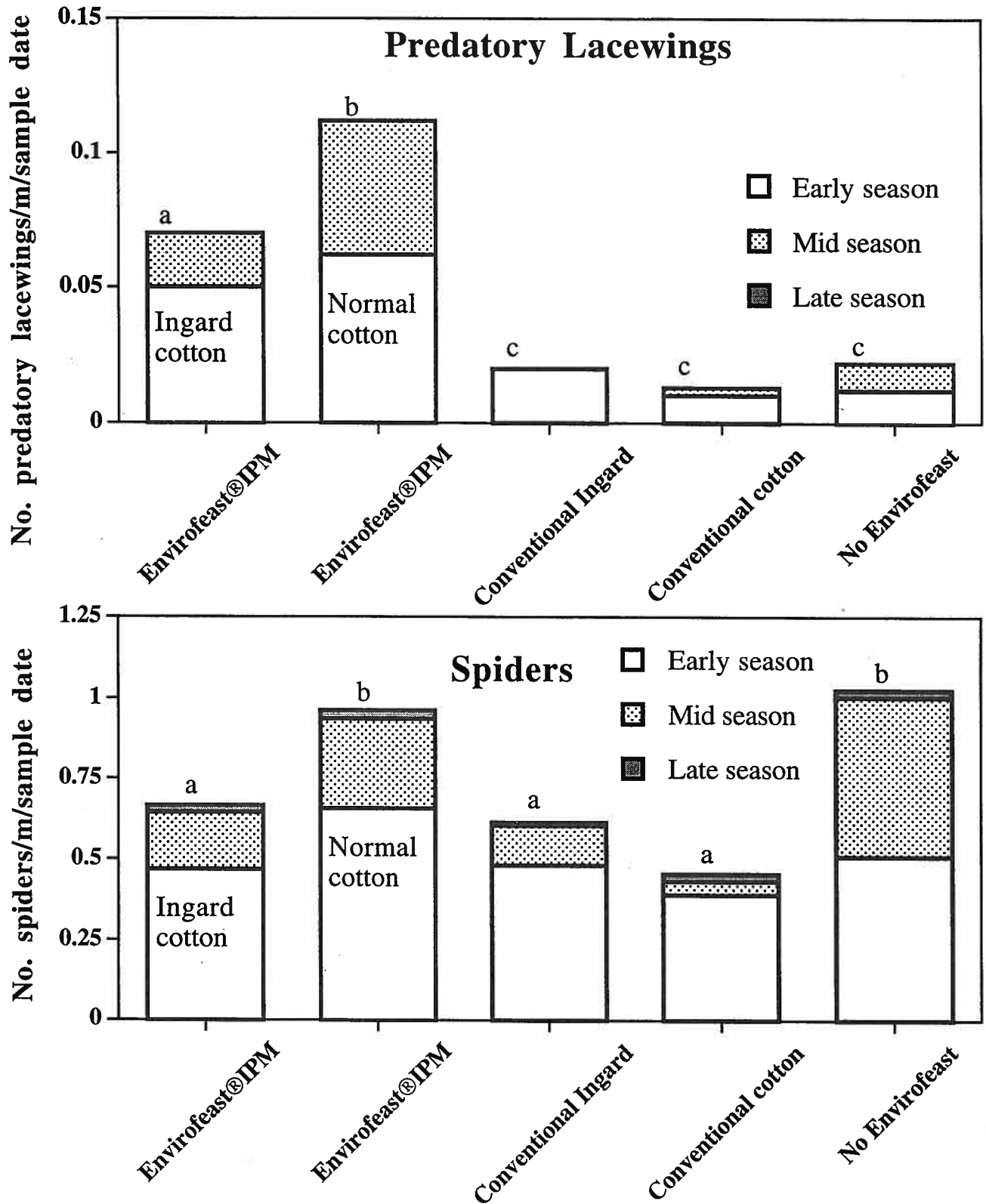


Fig. 3. Populations of predatory lacewings and spiders on normal and Ingard cotton under Envirofeast®IPM and conventional insecticide regimes at Yarral near Narrabri, 1997-98 (Means of treatments followed by the same letter are not significantly different).

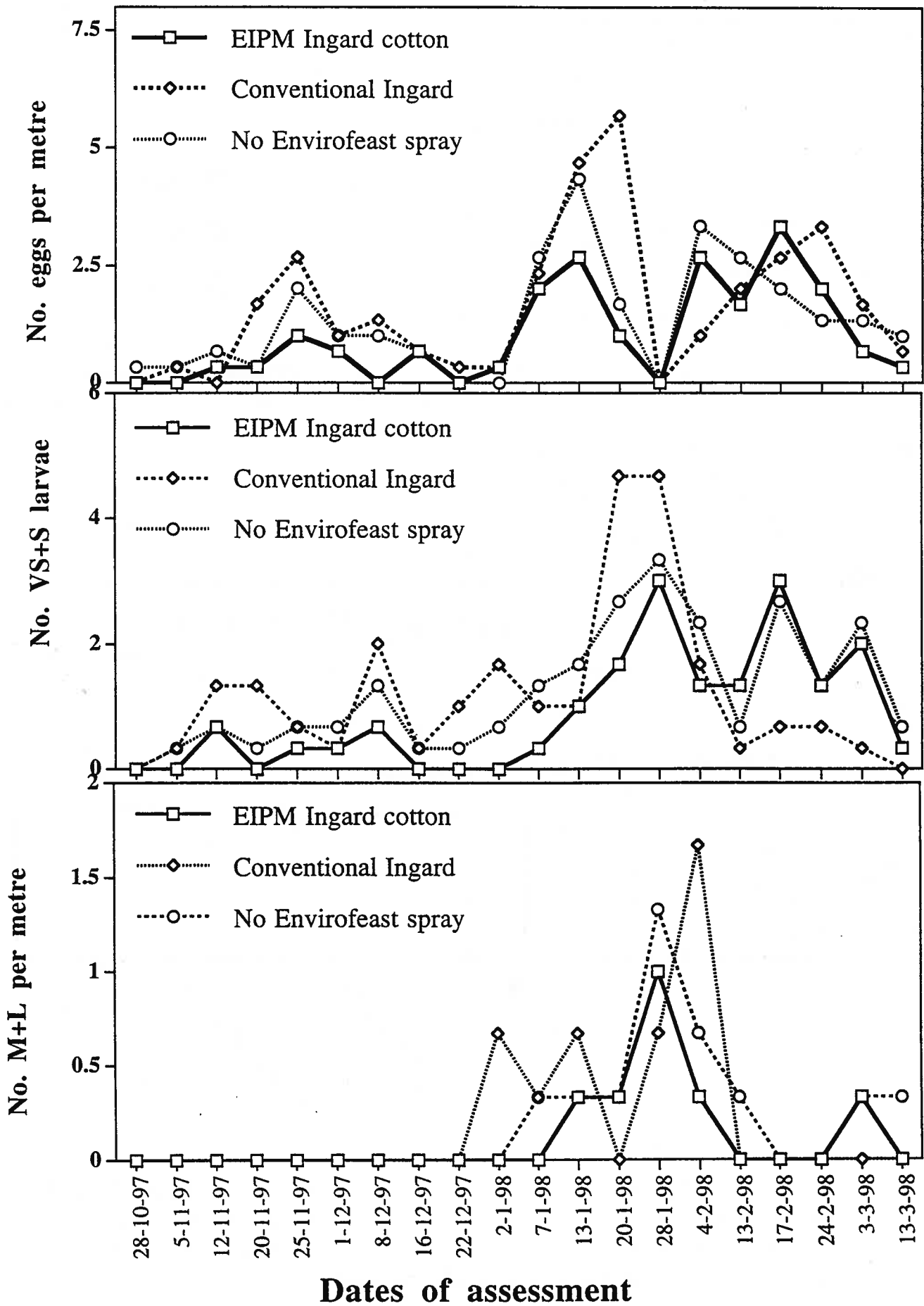


Fig. 4. Management of *Helicoverpa* spp. on Ingard cotton under Envirofeast®IPM and conventional insecticide regimes at Yarral near Narrabri, 1997-98.

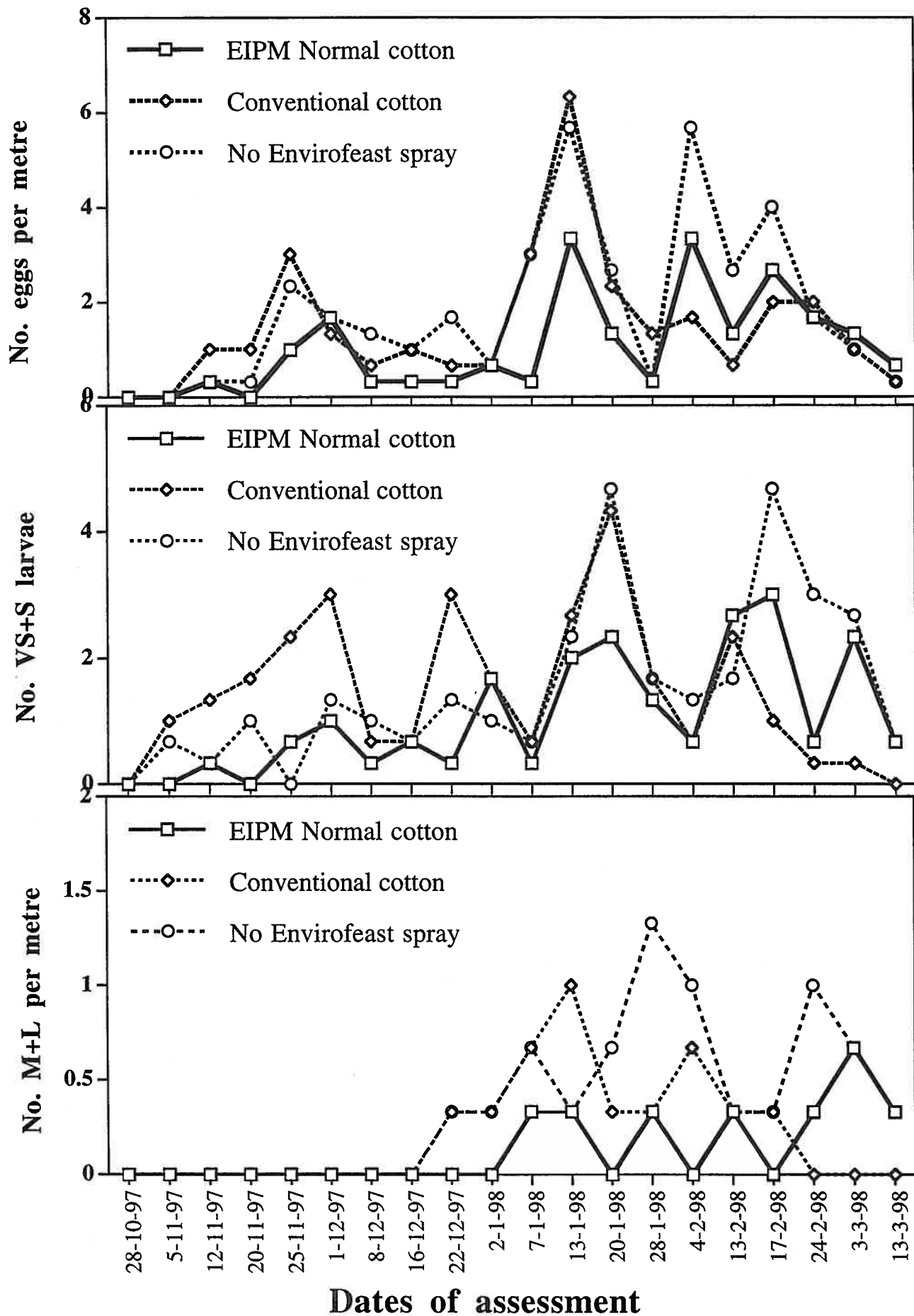


Fig. 5. Management of *Helicoverpa* spp. on normal cotton under Envirofeast®IPM and conventional insecticide regimes at Yarral near Narrabri, 1997-98.

