New approach to mirid control on mature cocoa

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ABSTRACT

The experiment was conducted to determine the minimum number of insecticide applications, shade adjustment, and canopy manipulation for management of mirids on mature cocoa. Two cocoa farmers' farms and a third farm belonging to the Cocoa Research Institute of Ghana (CRIG) were selected, each farm measuring 5.0 ha except the CRIG farm which measured 2.0 ha. In each farm, five 0.4 -ha plots were demarcated. The two farmers' farms were infested with mirids while the third farm received regular mirid treatment. Parameters which were assessed over a 5-year period included monthly mirid population count, frequency and duration of each insecticide application, yield, black pod disease incidence, and canopy improvement. The shade trees were adjusted to between 15 and 20 ha^{-1}. The 5-year observation showed that in mirid-degraded mature cocoa farm, chemical control was essential during the first 2 years to reduce the mirid population. After the 2nd year, 86 per cent of the mirids were found on the pods. The population of the mirids decreased considerably after harvesting in December to the extent that chemical control was not needed. Also, when the canopies were completely formed in the treatments with initial severe mirid damage, the mirid numbers and damage reduced significantly. The results also showed that although there was some yield advantage in the use of insecticide to control cocoa mirids, once the canopy had been restored, this was not significantly economical. The results have been used to formulate another mirid control strategy for mature cocoa.

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RÉSUMÉ

OWUSU-MANU, E.: *Nouvelle approche au contrôle de mirid sur le cacao mûr.* L'expérience se déroulait pour déterminer le nombre minimum d'application d'insecticide, ajustement d'ombrage et la manipulation de voûte pour le contrôle de mirids sur le cacao mûr. Deux champs des cultivateurs et un troisième champs apartenant à l'Institut de Recherche en Cacao du Ghana (IRCG) étaient sélectionnés, chaque champs mesure 5.0 ha sauf le champs de IRCG qui mesure 2.0 ha. Sur chaque champs cinq lots de 0.4 ha étaient dé limité. Les deux champs de cultivateurs étaient infestés de mirids alors que le troisième champs recevait un traitement regulier de mirid. Les caractéristiques qui étaient évaluées sur une période de 5 ans comprenaient compte mensuel de population de mirid, fréquence et durée de chaque application d'insecticide, rendement, taux de maladie de cosse noire et l'amélioration de voûte. Les arbres d'ombrage étaient ajustés d'entre 15 et 20 ha^{-1} L'observation de 5 ans montrait que dans le champs de cacao mûr dégradé par le mirid, le contrôle chimique était essentiel pendant les 1ers, 2 années pour réduire la population de mirid. Après la 2e année, 86 pour cent de mirids étaient découverts sur les cosses. La population des mirids diminuait considérablement aprè la récolte en Decembre jusqu'au point que le contrôle chimique n'était pas nécessaire. En plus, lorsque les voûtes étaient complètement formées dans les traitements avec les dégâts sévèrès initiaux de mirid, les nombres de mirids et les dégâts réduisaient considérablement. Les résultats montraient que, malgré qu'il y avait quelques avantages en rendement dans utilisation d'insecticide pour enrayer les mirids de cacao, une fois que la voûte a été rétablie, ceci n'était pas considérablement économique. Les résultats ont été utilisés à formuler une autre stratégie de contrôle de mirid sur le cacao mûr.

Introduction

The damage caused by cocoa mirids (Hemiptera : Miridae), particularly *Distantiella theobroma* (Dist.) and *Sahlbergella singularis* Hagl., is one of the major factors limiting cocoa production and the establishment of new plantings in Ghana. Owusu-Manu (1984) estimated that, on a national scale, about 25 per cent of acreage under cocoa was badly affected by mirids, causing an average of 30 per cent crop loss annually. Due to the unique position of cocoa in Ghana's economy, control measures have been sought since these insects were recognised as pests in 1910 (Dundgeon, 1910). The emphasis has been on chemical spraying although other control methods have been studied. The possibility of using alternative control methods such as semiochemicals, natural enemies, cultural methods and resistant varieties has been highlighted by Padi (1997). Presently, there is a general call to either minimise or completely eliminate the use of these chemicals. Consumers and manufacturers are also demanding pesticide-free (organic) cocoa. These, together with the already known disadvantages associated with misuse or over-dependence on insecticides, have resulted in public outcry against the use of insecticides in general. Therefore the present emphasis on chemical control of cocoa mirids needs to be reviewed so as to reduce, or if possible, eliminate the use of insecticides to satisfy the requirements of manufacturers and consumers.

Studies have shown that mirid populations start to build up in July and reach a peak between October and November (Collingwood & Marchart, 1971; Owusu-Manu & Somuah, 1989). These pests are attracted by light, and shade is the best insurance against their damage, while some cocoa varieties are known to overgrow the damage caused by mirids (Marchart & Collingwood, 1972). On the other hand, shade retards growth and decreases yield (Ahenkorah, Akrofi & Adri, 1974). Studies had also shown that good farm management without the use of insecticides resulted in 42 per cent yield increase after 18 months (Owusu-Manu & Somuah, 1984). It is, therefore, apparent that integrated management strategy will offer the best means of controlling these mirids on mature cocoa. Consequently, an integrated pest management study was initiated in 1992 at the Cocoa Research Institute of Ghana (CRIG).

The objectives of the study, which was carried out over a 5-year period, were as follows:

(i) To manage cocoa mirid damage under field conditions using the minimum amount of insecticide, shade adjustment, and canopy manipulation.
(ii) To monitor yield pattern.
(iii) To assess disease incidence as affected by shade adjustment and canopy formation.
(iv) To assess the economic benefit of such management practice.

Materials and methods

Two cocoa farmers' farms (designated Farm 1 and Farm 2), each measuring 5.0 ha which contained mixed populations of mature hybrid and Amelonado cocoa types, were selected at Tafo. A third farm measuring 2.0 ha and containing hybrid cocoa planted in 1972 was also selected at the CRIG, Tafo (Plots L9 and L10), and designated Farm 3. In each farm, five 0.4-ha plots were demarcated.

Farm 1 had patchy canopy with overhead shade trees and considerable number of cocoa trees showing mirid damage. Farm 2 was heavily infested by mirids. There were six mirid pockets within the farm, with few trees outside the pockets showing fresh mirid damage. Farm 3 had an already formed canopy without mirid damage. Previous records indicated that this farm had received the normal mirid control treatment since its establishment.

Mirids were inspected monthly on 10 randomly selected trees per plot using the "Pyrethrum knockdown" method described by Collingwood (1971). If a minimum average of six mirids were found on the 10 trees, the whole farm was sprayed with lindane (Gammalin 20) at 280 g.a.i/ha in 56 l of water. Farm 3 had no chemical treatment, but monthly mirid population was monitored.

Parameters which were assessed included the following:

(i) Monthly mirid population (from the monthly surveys).
(ii) Frequency and duration of insecticide application.
(iii) Yearly yield records (October).

(iv) Disease (black pod) incidence at each harvest.
(v) Half yearly canopy regeneration or improvement.

The overhead shade in the three farms was adjusted by reducing the number of shade trees to between 15 and 20 trees ha^{-1} in August 1995; that is, at the beginning of the 4th year. Regular weeding (three times per year) and other farm operations were carried out as required. Minor insect pests and predatory arthropod populations were assessed monthly.

The experimental design was a randomised complete block design with five replicates per treatment. The log N + 1 transformation was used to normalize the data. The experiment started in September 1992 and ended in July 1997.

Results and discussion

Mirid numbers

Table 1 summarizes the results of the mirid counts over the 5-year period. Farm 3, which initially had closed canopy, had no mirids during the first 8 months of the 1st year, i.e. September 1992 to April 1993. By the end of the 1st year, i.e. May to July 1993, however, mirids had started infesting the farm. Farm 1 which had few mirid-damaged trees initially required one treatment in September 1992. Less than six mirids per 10 trees were found in February, March and July 1993, and no mirids were observed during the rest of the season. Farm 2, which was initially severely damaged by mirids, received the recommended four insecticide applications between September and December. On this farm, mirids were found throughout the year (Table 1), which followed the normal pattern where the population started to build up in July, and reached a peak in either October or November, and then declined to low numbers between February and June (Owusu-Manu & Somuah, 1989).

The mirid population was very low on Farm 1 throughout the 2nd year, except in January 1994 when the number rose above six mirids per 10 trees which required spraying. Farm 2, which previously had mirids throughout the year and had received four applications, had less than six mirids per 10 trees per month, except in August when an average of six mirids per 10 trees was recorded. However, mirids were found almost throughout the year (Table 1). Mirids were found in low numbers throughout the year on Farm 3, except in August and September 1993 when high numbers of 14 and 13 mirids per 10 trees, respectively, were observed. Mirids were significantly more on this farm than on Farms 1 and 2, but no visible damage was seen in the canopy. The sudden increase in mirid population on Farm 3 during this period may be due to better agronomic management practices at the beginning of the experimental period. This may have given rise to more chupon and fan growth at the beginning of the rainy season which are preferred by mirids (Owusu-Manu, Somuah & Padi, 1979).

Farm 1 had few mirids in August, September and October of the 3rd year, 1994. Farm 2 which was initially heavily damaged had no mirids throughout the year. On Farm 3, mirids were found between August and October 1995, and in June and July 1996.

Mirids were found almost throughout the 4th year on Farm 1, but the numbers were so low (less than six per 10 trees) that there was no need for chemical control. On Farm 2, there were high mirid numbers in August 1995 and January 1996 which needed application of insecticide. On this farm, three applications per season controlled the mirids. On Farm 3, mirid numbers were above the average of 6/10 trees in August which required insecticide application. There were no mirids between November 1995 and June 1996. The increase in mirid population, especially on Farms 1 and 2 during the 4th year, may be attributed to the removal of overhead shade in August 1995 which allowed more light to enter the farms, as light attracts mirids (Collingwood & Marchart, 1971; Owusu-Manu & Somuah, 1989).

In the last (5th) year of the experiment, mirid numbers were very low in all the three farms

TABLE 1

Mean Number of Mirid Population in the Three Cocoa Farms, September 1992 to July 1997

Month	Mean numbers of mirids per 10 trees														
	1st year (1992/93)			2nd year (1993/94)			3rd year (1994/95)			4th year (1995/96)			5th year (1996/97)		
	Farm 1	Farm 2	Farm 3	Farm 1	Farm 2	Farm 3	Farm 1	Farm 2	Farm 3	Farm 1	Farm 2	Farm 3	Farm 1	Farm 2	Farm 3
August	-	-	-	0.0	6.0	14.0	1.0	0.0	1.2	1.0	19.0	7.4	0.0	3.0	2.0
September	6.8	46.0	0.0	0.0	5.2	12.9	2.8	0.0	4.6	2.0	3.0	2.3	3.0	2.0	0.0
October	0.0	29.2	0.0	0.0	4.2	2.6	1.8	0.0	0.7	4.0	5.0	1.0	1.0	0.0	3.0
November	0.0	15.0	0.0	0.0	0.6	1.6	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0
December	0.0	14.2	0.0	0.0	2.8	2.6	0.0	0.0	0.0	4.0	0.0	0.0	14.0	5.0	3.0
January	-	-	-	6.4	4.0	1.8	0.0	0.0	1.0	4.0	8.0	0.0	1.0	3.0	0.0
February	3.6	15.2	0.0	2.4	0.2	3.0	0.0	0.0	0.2	0.0	0.0	0.0	3.0	1.0	0.0
March	0.4	0.2	0.0	3.4	1.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
April	0.0	2.6	0.0	1.0	0.0	2.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
May	0.0	3.0	15.0	0.0	0.0	0.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
June	0.0	0.6	0.0	1.1	2.2	0.2	0.0	0.0	1.1	2.0	0.0	0.0	0.0	0.0	1.0
July	1.0	1.0	8.0	1.0	4.0	0.7	0.0	0.0	7.4	2.0	1.0	1.0	0.0	0.0	0.0

throughout the year, except on Farm 1 where high numbers were found in December when the control measure was applied.

The 5-year observation showed that in the mirid- degraded mature cocoa farm, four chemical treatments in the 1st year were essential to reduce mirid population drastically. However, a recent study has shown that two treatments per season, September and October, were as effective as the four treatments (Owusu-Manu, 2001). Thus, the four treatments could be reduced to two. Studies have shown that "spot" spraying (spraying only the mirid-infested trees) or "pocket" spraying (spraying only the "capsid pocket") was more effective in controlling cocoa mirids than "blanket" spraying (spraying the entire farm contiguously) (Owusu-Manu & Somuah, 1989). It may be suggested that two treatments per season in the form of "spot" or "pocket" spraying may be used to control cocoa mirids after the 1st or 2nd year when the canopy had started forming. These would further reduce the number (quantity) of insecticide applications per season.

Mirid damage

Where mirid damage was severe as observed on Farm 2, there was a high degree of chupon damage of 93 per cent as against 7 per cent on both the fans and the pods (Table 2). Contrarily, on Farm 3 where the damage was very little, about 86 per cent of the mirid population was confined to the pods, with only 14 per cent found on the chupons and fans (Table 3). These observations indicated that during the rehabilitation phase, mirid damage was confined to the chupons while at the post-rehabilitation phase, the mirids were found mainly on pods. Mirid control during the rehabilitation phase should be aimed at the whole farm, that is, "blanket" treatment. However, at the post-rehabilitation phase, control measures may be confined to the pods only.

Canopy regeneration

Initially, Farms 1 and 2 had mirid pockets (broken canopies) which were more pronounced on Farm 2 with six pockets as against few on Farm 1. By the end of the 3rd year, almost all the trees (99 %) on the two farms had completely developed closed canopies while those on Farm 3 remained as they were at the beginning of the study (Table 4). The

TABLE 2

Mean Infested Trees with Damage on Chupons, Pods and Fans

Month	Mean mirid infested tree on		Mean percent infestation	
	Chupons	Pods/Fans	Chupons	Pods/Fans
August	131	5	96.3	3.7
September	280	29	90.6	9.4
October	187	36	83.5	16.5
November	197	11	94.7	5.3
December	347	12	96.7	3.3
January	432	32	93.1	6.9
February	165	16	91.2	8.8
March	18	2	90.0	10.0
April	205	14	93.6	6.4
May	119	3	97.5	2.5
June	141	4	97.2	2.8
July	92	5	94.9	5.1

TABLE 3

Mean Number of Mirids on Pods, Fans and Chupons

Month	Mean mirids/plot on		Mean percent mirids on	
	Chupons/Fans	Pods	Chupons/Fans	Pods
August	0.1	2.9	3.3	96.7
September	0.1	11.5	0.9	99.1
October	1.5	8.9	14.4	85.6
November	0.9	10.2	8.1	91.9
January	1.8	6.2	22.5	77.5
February	2.1	11.0	16.0	84.0
March	1.5	5.0	23.1	76.9
April	2.0	3.0	40.0	60.0
May	0.1	2.1	4.5	95.5
June	0.3	2.8	9.7	90.3
July	1.9	18.4	9.4	90.6

changes in the canopies in the three farms were not significant after the 3rd year. The canopies had virtually closed up and were maintained up to the end of the 5th year. The canopy improved by a factor of three on Farm 1 while that on Farm 2 was by about six. Canopy improvement over the 5-year period was best on Farm 2.

Although a continuous canopy was formed on Farm 2 during the 2nd year (1993/94 season), a reasonable number of mirids was still observed throughout the year (Table 1). This might have been due to the availability of tender cocoa shoots (chupons) associated with canopy regeneration, which were preferred by mirids as food source (Owusu-Manu *et al.*, 1979). By the end of the 2nd year, and during the 3rd year, when the fans and chupons had hardened, few or no mirids were found on this farm. This confirms the assertion that the abundance of mirids during the 2nd year was partly due to the abundance of chupons.

On Farm 3, the canopy remained intact throughout the experimental period. Nevertheless, as Table 1 indicates, mirids were found during the 2nd, 3rd and 5th years, i.e. the 1993/94, 1994/95 and 1996/97 mirid seasons, which should have affected the canopy. However, since more mirids (86 %) were found on the pods, the canopy was unaffected.

In this study, the overhead shade trees were reduced to between 15 and 20 ha^{-1} to allow enough sunlight to penetrate into the canopy. Overhead shade had various effects. Ahenkorah *et al.* (1974) found out that heavy overhead shade on cocoa retarded growth and decreased yield considerably. The removal of the overhead shade, with or without fertilizer, resulted in yield increases. Williams (1953) also observed that overhead shade reduced flushing, that is, fan growth, and increased chupon growth which was preferred by mirids at the expense of fan growth. While the total damage due to mirid was higher on unshaded cocoa due to the effect of direct light, severe damage was significantly greater on shaded cocoa.

TABLE 4

Canopy Improvement in the Three Cocoa Farms in September 1992, 1994 and 1997

Treatment	*Percent trees with good canopy*			*Percent canopy improve*			*Improvement factor*
	1992	*1994*	*1997*	*1993/92*	*1997/94*	*1997/92*	
Farm 1	31.7	99.0	98.8	212.3	-0.2	211.7	3.1
Farm 2	17.3	99.0	97.8	472.2	-1.2	465.3	5.7
Farm 3	98.3	98.0	98.5	-0.3	0.5	0.2	0.0

Williams (1953) further found that where the cocoa canopy was incomplete, mirid damage was more prevalent. Thus, provided the canopy was complete, even in areas where the shade was sparse , or absent, 90 per cent of the trees were free from mirid damage. Marchart & Collingwood (1972), therefore, concluded that continuous canopy was the best insurance against mirid damage.

This study indicated that when the canopies were completely formed in the two treatments (Farms 1 and 2), mirid numbers and damage reduced significantly. These findings are consistent with those of Williams (1953) and Marchart & Collingwood (1972) that mirid damage was sparse in contiguous canopied farm.

Pod count

There were pod increases in all the three farms during the 5-year period compared with the pre-treatment figures of 1992. The October pod counts on Farm 1, which initially had few damaged trees, showed a fluctuating yield pattern over the 5-year period. Thus, there were increases during the first 2 years, followed by a drop and another increase (Table 5).

The October pod counts on Farm 2 also showed gradual increases during the first 4 years and a slight drop in the last year. It must be recalled that Farm 2 initially had severe mirid damage and received four insecticide treatments during the 1st year, two treatments during the 2nd year, and no treatment during the last 3 years (Table 5).

Farm 3 which received no chemical treatment also had varied yields over the 5-year period, although the levels of fluctuation over the years were lower compared with that of Farm 1 (Table 5). The high increase in yield after the 1st year may have been due to improved agronomic management during the experiment. Agronomic practices alone have been shown to result in 42 per cent pod increase after the 1st year (Owusu-Manu & Somuah, 1984).

The yield figures suggest that there is some advantage in the use of insecticide against cocoa mirids. Farm 2 which received the highest number of insecticide treatments had the highest pod increase of 630 pods per 100 trees. For percent pod increase, Farm 3 had the highest (26 %), although this was not significant (Table 5).

Black pod disease incidence

Black pod disease was monitored after the shade had been adjusted and continuous canopies had been formed (Table 6). On the average, Farm 1 had 3 per cent diseased pods, which was not significantly different from Farm 2 which had 4 per cent. However, Farm 3 had significantly the highest incidence of black pod disease (10 %). The 10 per cent black pod incidence was the national average in *Phytophthora palmivora*-infected areas (Dakwa, 1977).

The results seemingly indicate that good agronomic management of mature cocoa farms where continuous canopies have been formed (with 15 to 20 overhead shade trees ha^{-1}) would not cause any appreciable increase in the incidence of blackpod disease.

TABLE 5

Number of Pods on the Three Farms in October (1992-1997)

Treatment	*Mean number of pods per 100 trees*						*Mean 5-year increase*	
	1992	*1993*	*1994*	*1995*	*1996*	*1997*	*Pods*	*Percent*
Farm 1	370	506	1077	834	1021	1010	519.6	140.4
Farm 2	271	409	930	937	1143	1088	630.4	232.6
Farm 3	221	816	816	629	929	870	591.0	267.4

TABLE 6

Black Pod Incidence on the Three Cocoa Farms, October 1995 and July 1997

Treatment	*Total pods/100 trees*		*Blackpod pods*		*Percent black pod incidence*		
	1995/96	*1996/97 (July)*	*1995/96*	*1996/97*	*1995/96*	*1996/97*	*Mean*
Farm 1	1 021	472	11	26	1.1	5.5	3.3
Farm 2	1 143	370	53	12	4.6	3.2	3.9
Farm 3	929	638	59	86	6.4	13.5	10.0

Non-target organisms

The populations of cocoa minor pests and mirid predatory arthropods were monitored. The population of minor pests such as aphids, *Toxoptera aurantii* (Fonsc); psyllids, *Tyora tessmanni* (Aulm); thrips, *Selenothrips rubrocintus* (Giard), *Bathycoelia thalassina* (H-S.) and *Helopeltis* spp.; the leaf-eating caterpillars, mainly *Anomis leona* (Schus) and *Earias biplaga* (Wlk); and other pests at the rehabilitation stage were either found in very low numbers or were completely absent in all the farms throughout the study (Table 7). Predatory insects such as reduviids and mantids and salticid spiders were also found in low numbers, but predatory ants such as *Oecophylla* spp. and *Macromiscoides* spp. were found in large numbers (Table 8). These mirid predatory arthropods, especially the ants, might have helped to reduce the mirid population. Ants, mainly *Oecophylla* spp., have been shown to prey on *D. theobroma* but not on *S. singularis* (Leston, 1971), although these findings have not been supported by other workers (Marchat, 1971; Brew & Koranteng, 1985).

Cost of treatment

Two machine operators were able to treat 2.0 ha of mature cocoa in a day, using Solo 423 motorized knapsack mistblower with constrictor No. 2 setting. They were assisted by one attendant who carried extra fuel and insecticide solution.

The estimated mean number of pods per plot over the 5-year period was used to calculate the yield on the farms, although these were based on the pod count for one month (October) only. Using the five-year mean pod increases, the estimated gross profit for Farm 1 was ¢538,300.00, Farm 2 was ¢653,100.00, and Farm 3 was ¢537,684.00. Farm 1 had four insecticidal treatments in the first 2 years while Farm 2 had a total of six treatments.

The cost of treatment per ha, using either lindane (Gammalin 20) or Propoxur (Unden 20), was estimated to be ¢40,000.00 at a subsidized price of ¢20,000.00 l^{-1}. Thus, the estimated net profit Farm 1 was ¢378,300.00 and that for Farm 2 was ¢398,100.00. Farm 3 had no treatment cost.

TABLE 7

Mean Number of Cocoa Minor Pests on the Three Farms from September 1995 to July 1997

Treatment	Mean number of insects per plot								
	Helopeltis *spp.*	*Leafhoppers*	Anomis *sp.*	Earias *sp.*	*Other caterpillars*	*Beetles*	*Tettigonids*	*Pentatomids*	Bathycoelia
Farm 1	1.2	19.0	1.4	0.4	2.6	16.6	0.6	0.2	0.0
Farm 2	0.4	17.0	1.8	0.6	3.8	27.6	1.2	0.8	0.0
Farm 3	0.4	20.0	0.6	1.4	1.6	16.4	1.0	1.2	0.4

TABLE 8

Mean Number of Predatory Insects and Salticid Spiders from September 1995 to July 1997

Treatment	Mean number of arthropods per plot					
	Mantids	Macromiscoides *spp.*	Oecophylla *spp.*	Camponotus *spp.*	*Reduviids*	*Salticid spiders*
Farm 1	0.4	11.6	35.8	34.8	2.0	15.6
Farm 2	0.4	9.0	31.8	63.0	2.8	10.8
Farm 3	4.2	11.8	12.8	53.0	2.4	13.2

From the data, there seems to be no advantage in treating the farms with insecticide to control cocoa mirids once the canopy has been restored. However, the insecticide is essential to restore the canopy but it is not economical to treat the farm with insecticide afterwards. Good farm management is essential.

Conclusion

The 5-year observation showed that it was essential to use insecticides during the first 2 years when reclaiming mirid-devastated mature cocoa farm.

Where the damage is severe, two treatments, one in September and the other in October, are required in the 1st year of rehabilitation. Thereafter, "spot" or "capsid pocket" treatment may be applied when the damage is first noticed. The number of overhead shade trees may be reduced to between 15 and 20 ha^{-1}. However, once the canopy has been restored, it may be uneconomical to use insecticide on the farm, although few mirids may be found on pods. The recommended agronomic management practices are enough to keep the mirid population below the acceptable damage level. Other control agents suggested by Padi (1997) may be included in future studies.

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