IMPACT OF SELECTED INSECTICIDES ON BOLL WEEVIL AND NATURAL ENEMIES

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Abstract

In response to producer concerns about the impact of various insecticides on the natural enemy complex in cotton, the Texas Boll Weevil Eradication Foundation changed the insecticides used in the Southern Rolling Plains Zone in 1996. Vydate® was the insecticide being used for control of overwintered boll weevils prior to July 4th. After that date, endosulfan (Phaser® or Thiodan®) was used to control mid season infestations from July 5th until August 10th. After August 20th, malathion ULV was used to control late season infestations and Malathion ULV was used in the diapause control program.

Boll weevils, *Anthonomus grandis* Boheman, lady beetle adults, *Hippodamia convergens* Guerin-Meneville., *Cotesia marginiventris* (Cresson) and insidious flower bug adults, *Orius insidiosus* (Say) were exposed to the different insecticides in two different tests. In the first test, the insects were exposed to two different bioassays. The first bioassay consisted of exposing the insects to three treated leaves inside a petri dish. The second bioassay consisted of exposing the insects to treated plants that were in muslin cages in the field. A second test was initiated because a rain occurred four days after treatment in the first trial. The second trial consisted of exposing the insects to three treated leaves inside a petri dish. All the insecticides had reduced effectiveness after the rain. Insects exposed to malathion ULV had the lowest percent survival in both tests. Vydate® was comparable to the malathion ULV. Insects exposed to endosulfan had the highest percent survival. The insidious flower bug was the most susceptible insect to the insecticides followed by *C. marginiventris*. Although endosulfan had minimal impact on the natural enemies in these trials, its value as a boll weevil control material in an eradication program may be questionable.

Introduction

Although the boll weevil eradication program has been highly successful in reducing boll weevil numbers in the Southern Rolling Plains, the potential for secondary pest outbreaks continues to concern producers. Many studies have implicated insecticide use as a cause of secondary pest outbreaks (van den Bosch et al. 1956, Stern et al. 1960, Ridgway et al. 1967, Dinkins et al. 1971, Stoltz & Stern 1978). Most producers are well aware of the negative impacts of insecticides to the natural enemies present in cotton and make insecticide choices that “minimize” the impact.

Some trials have been conducted to determine the impact of insecticides on natural enemies in controlled settings (Lingren & Wolfenbarger 1976, Bull et al. 1989, Powell & Scott 1990). These trials were established to compare the effectiveness of different insecticides on the boll weevil in a controlled study and to measure the impact of the insecticides on natural enemies.

Materials and Methods

The trials were conducted in commercial cotton fields near Winters, TX in Runnels County. The tests consisted of three insecticide treatments and an untreated cotton field. Malathion ULV (12.0 fl oz/ac, 0.92 lbs ai/ac), Vydate® CLV (8.5 fl oz/ac, 0.25 lbs ai/ac) and Phaser® (22 fl oz/ac, 0.51 lbs ai/ac) were applied by airplane on June 13, 1996. A second test using the same insecticides, rates and volumes was established on other fields on June 28, 1996 due to a heavy rainfall on June 17, 1996. Malathion ULV was applied at a total volume of 12.0 fl oz/ac and the other insecticides were applied with a total volume of 1 gal/ac. In the first test, leaves were collected from the field at 1, 24, 48, 72, 96, 120 and 144 hours post treatment in each of the three insecticide treated fields and the untreated control. The leaves were brought back to the lab and three leaves were placed in a petri dish. Different insects (field collected boll weevils, laboratory reared boll weevils, *C. marginiventris*, lady beetles and insidious flower bugs) were placed inside the petri dish. Each dish would contain three treated leaves and five insects of the same species, except the *C. marginiventris* in which only three per dish were used. Each treatment was replicated five times. Percent survival was evaluated twenty four hours after insects were exposed to treated leaves. An insect was considered dead if it was placed on its back and was unable to stand up in one minute.

The first test also consisted of caging five plants in each treatment at 1, 24, 48, 72 and 120 hours post treatment. Cages were constructed of cotton muslin so that the insects could not escape. Five of each insect (boll weevils, lady beetles and insidious flower bugs) were released in each cage and the cage was secured to avoid insect escape. After 24 hours, caged plants were cut at ground level and brought back to the lab to determine insect survival. *C. marginiventris* was not used in this trial due to limited numbers. Cages were not established 96 hours after treatment due to a 1.5 inch rain that made handling the cages difficult.

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The second test consisted only of the leaf bioassay in a petri dish. The second test was conducted like the first except that collection of treated leaves ended when survival in the treated field for each insect was 50% or greater. All data for percent survival were corrected for control mortality using Abbott's formula and a Fischer's LSD at the 95% level of probability was used to separate treatment means.

Results

The results of the first test were affected by the rain that occurred on June 17, 1996. The second test, which was unaffected by rainfall, indicates that the residual of Vydate and malathion ULV extend beyond the 96 hours seen in the first test. *C. marginiventris* were very susceptible to the insecticides (Table 1). All the insecticides reduced survival significantly after 1 hour. Endosulfan did not have any effects after twenty four hours. Both Vydate® and Malathion ULV significantly reduced survival for 96 hours (4 days).

Insidious flower bugs were exposed to treated leaves at one and 72 hours in the first test due to insufficient numbers of insidious flower bugs available for other time intervals. All three insecticides had a negative impact at one hour post treatment and 72 hours post treatment (Table 2). In the second trial, insidious flower bugs survival was significantly reduced for nine days by both Vydate and malathion ULV (Table 9).

Lady beetles appeared to be more tolerant of the various insecticides (Table 3). Endosulfan seems to have no affect on lady beetles while Vydate® and Malathion ULV significantly reduced numbers for four days.

Two sets of boll weevils were compared in the first petri dish trial. The laboratory weevils were received from a laboratory colony at the USDA GAST rearing facility in Mississippi. Because of some concern about the inherent vigor of these weevils and their lack of exposure to insecticides while reared in the colony, field collected weevils were also evaluated. The field collected weevils were collected from pheromone traps outside the Southern Rolling Plains Zone and brought back to the laboratory. Both sets of weevils showed the same general results in the test (Tables 4 and 5). All three insecticides were effective one hour after treatment. Endosulfan showed reduced effectiveness 24 hours after treatment and was not significantly different from the untreated control 72 hours later (3 days). Vydate® was equally effective as Malathion ULV for the first 72 hours but survivorship was significantly different (increased) from the malathion after 96 hours (4 days) in the first test. The second test indicates that the residual of Vydate® without a rain may extend to five days (Table 11). The Malathion ULV was significantly different from the untreated control for four days.

The field cage trials supported the results seen in the petri dish trials. Insidious flower bugs were not available at the one hour treatment. The endosulfan did not have a large impact although percent survival was significantly reduced at 24 hours (Table 6). No reduction in survivorship was seen after 120 hours (5 days).

As in the petri dish studies, the lady beetles seemed to be tolerant of the endosulfan. The Vydate® and Malathion ULV reduced numbers up to 72 hours and no significant differences were seen after 120 hours (Table 7).

The caged boll weevil study supported the petri dish data (Table 8). Endosulfan was significantly different from the untreated control for 72 hours (3 days), but percent survival was high averaging 60% survival for the three day period. Responses to Vydate® and malathion ULV were very similar but the level of control was reduced at 120 hours (5 days).

The second trial was established because of the rain that occurred on June 17,1996. The results from this trial (Tables 9-12) support the data from the first trial and show the long residual of Malathion ULV. One unexpected result was the residual impact of Vydate® on the insidious flower bug (Table 9).

Discussion

The two tests tend to support other studies that look at the impact of various insecticides on boll weevils and natural enemies. Malathion ULV has a long residual and is extremely effective at controlling the boll weevil. This makes it one of the ideal insecticides in a boll weevil eradication program. Unfortunately, the long residual makes it a poor choice with an integrated pest management (IPM) philosophy that concentrates on conserving natural enemies.

C. marginiventris is a parasite that is commonly found in cotton fields. This wasp will parasitize many lepidopteran larvae including bollworm/budworm and beet armyworms. The petri dish trial confirms that the insect is susceptible to the insecticides used. Endosulfan gives a quick initial knock down but the long term effects seem small.

Orius spp. (insidious flower bugs) are important predators in the Southern Rolling Plains. This insect also seems to be susceptible to the insecticides. Endosulfan gave a large initial knock down in the petri dish trial and the residual appears to be at least 48 hours. The cage study with endosulfan did not appear to be as devastating and may be related to the ability of the insect to move to untreated parts of the plant.

Lady beetles seem to be relatively tolerant of most of the insecticides. Endosulfan had no impact in either trial. Although Vydate® reduced numbers initially, the effects were minimal after 4 days and survivorship after 4 days was significantly better than the Malathion ULV.

Endosulfan performed poorly in these trials against the boll weevil. Initial knock down was adequate but the residual effects were minimal. This would make endosulfan a poor choice for overwintered or diapause control in an eradication program. Endosulfan may have a fit during the midseason when bollworm/budworm is more of a threat but numbers of boll weevils would have to be relatively low for the endosulfan to keep numbers below economically damaging levels. Vydate® performed well for 72 hours but the residual was not as great as the Malathion ULV. Vydate® may be an alternative for Malathion ULV for overwintered boll weevil control but the trap inspection would have to be intensified to determine if a second application was necessary. If the treatment intervals were extended past four days, overwintered boll weevils may have a chance to establish in the field between treatments.

Conclusion

This study was conducted to determine the effectiveness of the different insecticides against boll weevils and the effect of the insecticides on natural enemies. This study shows that the insecticides used not only have different residual effectivness against boll weevils but also against natural enemies. If insecticide changes are implemented in an eradication program then the residual effectiveness of the insecticide chosen must be taken into consideration when determining the spray intervals.

The impact of insecticides in a cotton agroecosystem is difficult to measure. The use of insecticides has two impacts on natural enemies. Insecticides not only reduce natural enemy numbers directly but also reduce their food source. The reduction in their food resources may prevent successful colonization of the field. The natural enemies in the cotton system probably function early in the pest population increase. If adequate natural enemy numbers are present the pest build up can be delayed. If the delay is long enough, the cotton may have a chance to mature a crop before damaging levels of pests occur. Unfortunately, determining what constitutes an adequate number of natural enemies is difficult. Any reduction in the natural enemy complex probably puts the field at risk to an economically damaging attack.

This study shows that all the insecticides cause an initial reduction to the natural enemies. The exception is endosulfan having no impact on lady beetles. This initial reduction may be enough to favor a pest outbreak under the right conditions. The fact that Vydate® and endosulfan have a reduced residual may help in the recolonization of the field but only if food resources are adequate to support the natural enemies. The lack of significant boll weevil control past one day shown by the endosulfan makes it a questionable material in an eradication program, especially in the initial start up of the program. Once initial weevil numbers are reduced, endosulfan may have a place during the blooming period of the cotton. Vydate® shows good control up to five days but its effectiveness is questionable after that period. Trap count survey intervals may need to be reduced if Vydate® is to be used during the early season. This trial does not show if Vydate® is less likely to cause secondary pest problems. The long residual of the malathion ULV makes it the insecticide to use during the diapause portion of the eradication effort.

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Table 1. Percent survival of *Cotesia marginiventris* exposed to treated cotton leaves in a petri dish at various times post treatment. Runnels Co., TX. 1996.

	Rate	Time Post Treatment			
Treatment	lbs ai/ac	1 Hr	1 DAT	2 DAT	3 DAT
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	55 b	100 a	100 a	77 a
Vydate	0.25	33 b	53 b	78 b	22 b
Malathion ULV	0.92	0 c	0 c	0 c	0 b

Table 1. Continued

	Rate	Time Post Treatment	
Treatment	lbs ai/ac	4 DAT	5 DAT
		Percent Survival[1]	
Untreated		100 a	100 a
Endosulfan	0.51	100 a	100 a
Vydate	0.25	56 b	100 a
Malathion ULV	0.92	0 c	100 a

1. All percent survival has been corrected using Abbott's formula. Data were transformed using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fischer's LSD, p=0.05)

Table 2. Percent survival of *Orius insidiosus* (insidious flower bug) exposed to treated cotton leaves in a petri dish at various times post treatment. Runnels Co., TX. 1996.

	Rate	Time Post Treatment	
Treatment	lbs ai/ac	1 Hr	3 DAT
		Percent Survival[1]	
Untreated		100 a	100 a
Endosulfan	0.51	24 b	88 b
Vydate	0.25	0 c	0 c
Malathion ULV	0.92	0 c	0 c

1. All percent survival has been corrected using Abbott's formula. Data were transformed using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fischer's LSD, p=0.05).

Table 3. Percent survival of lady beetles exposed to treated cotton leaves in a petri dish at various times post treatment. Runnels Co., TX. 1996.

	Rate	Time Post Treatment			
Treatment	lbs ai/ac	1 Hr	1 DAT	2 DAT	3 DAT
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	100 a	100 a	100 a	100 a
Vydate	0.25	0 b	12 b	4 b	16 b
Malathion ULV	0.92	0 b	4 b	4 b	16 b

Table 3. Continued

	Rate	Time Post Treatment		
Treatment	lbs ai/ac	4 DAT	5 DAT	6 DAT
		Percent Survival[1]		
Untreated		100 a	100 a	100 a
Endosulfan	0.51	100 a	100 a	100 a
Vydate	0.25	52 b	98 a	100 a
Malathion ULV	0.92	4 c	98 a	100 a

1. All percent survival has been corrected using Abbott's formula. Data were transformed using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fisher's LSD, p=0.05)

Table 4. Percent survival of field collected boll weevils exposed to treated cotton leaves in a petri dish at various times post treatment. Runnels Co., TX. 1996.

	Rate	Time Post Treatment			
Treatment	lbs ai/ac	1 Hr	1 DAT	2 DAT	3 DAT
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	16 b	48 b	52 b	95 a
Vydate	0.25	4 bc	4 c	9 c	9 c
Malathion ULV	0.92	0 c	0 c	9 c	62 b

Table 4. Continued

	Rate	Time Post Treatment		
Treatment	lbs ai/ac	4 DAT	5 DAT	6 DAT
		Percent Survival[1]		
Untreated		100 a	100 a	100 a
Endosulfan	0.51	100 a	96 a	100 a
Vydate	0.25	100 a	100 a	100 a
Malathion ULV	0.92	28 b	100 a	100 a

1. All percent survival has been corrected using Abbott's formula. Data were transforme using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 5. Percent survival of laboratory reared boll weevils exposed to treated cotton leaves in a petri dish at various times post treatment. Runnels Co., TX. 1996.

	Rate	Time Post Treatment			
Treatment	lbs ai/ac	1 Hr	1 DAT	2 DAT	3 DAT
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	16 b	52 b	89 b	76 b
Vydate	0.25	4 b	4 c	0 c	0 c
Malathion ULV	0.92	0 b	0 c	0 c	0 c

Table 5. Continued

Treatment	Rate lbs ai/ac	4 DAT	5 DAT	6 DAT
		Time Post Treatmen		
		Percent Survival[1]		
Untreated		100 a	100 a	100 a
Endosulfan	0.51	96 a	100 a	100 a
Vydate	0.25	4 b	100 a	100 a
Malathion ULV	0.92	0 b	85 a	100 a

1. All percent survival has been corrected using Abbott's formula. Data were transforme using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 6. Percent survival of *Orius insidiosus* exposed to treated cotton leaves in a caged plant at various times post treatment. Runnels Co., TX. 1996.

Treatment	Rate lbs ai/ac	1 DAT	2 DAT	3 DAT	5 DAT
		Time Post Treatment			
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	75 b	98 a	98 a	100 a
Vydate	0.25	5 c	0 b	0 b	100 a
Malathion ULV	0.92	5 c	0 b	0 b	92 a

1. All percent survival has been corrected using Abbott's formula. Data were transforme using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 7. Percent survival of lady beetles exposed to treated cotton leaves in a caged plant at various times post treatment. Runnels Co., TX. 1996.

Treatment	Rate lbs ai/ac	1 Hr	1 DAT	2 DAT
		Time Post Treatment		
		Percent Survival[1]		
Untreated		100 a	100 a	100 a
Endosulfan	0.51	100 a	100 a	100 a
Vydate	0.25	20 b	40 b	6 b
Malathion ULV	0.92	12 c	4 c	6 b

Table 7. Continued

Treatment	Rate lbs ai/ac	3 DAT	5 DAT
		Time Post Treatment	
		Percent Survival[1]	
Untreated		100 a	100 a
Endosulfan	0.51	92 a	100 a
Vydate	0.25	12 b	100 a
Malathion ULV	0.92	8 b	100 a

1. All percent survival has been corrected using Abbott's formula. Data were transforme using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 8. Percent survival of laboratory reared boll weevils exposed to treated cotton leaves in a caged plant at various times post treatment. Runnels Co., TX. 1996.

Treatment	Rate lbs ai/ac	1 DAT	2 DAT	3 DAT	5 DAT
		Time Post Treatment			
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	58 b	63 b	60 b	100 a
Vydate	0.25	26 c	21 c	8 c	100 a
Malathion ULV	0.92	20 c	5 c	8 c	80 b

1. All percent survival has been corrected using Abbott's formula. Data were transforme using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fisher's LSD, p=0.05).

Table 9. Percent survival of *Orius insidiosus* (insidious flower bug) exposed to treated cotton leaves in a petri dish at various times post treatment. Second trial. Runnels Co., TX. 1996.

Treatment	Rate lbs ai/ac	1 Hr	1 DAT	2 DAT	3 DAT
		Time Post Treatment			
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	0 b	22 b	81 b	42 b
Vydate	0.25	0 b	0 c	0 c	0 c
Malathion ULV	0.92	0.b	0 c	0 c	0 c

Table 9. Continued

Treatment	Rate lbs ai/ac	4 DAT	5 DAT	6 DAT	7 DAT
		Time Post Treatment			
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	79 b	91 b	89 b	69 b
Vydate	0.25	1.5 c	0 c		8.6 c
Malathion ULV	0.92	0 c	0 c		0 c

Table 9. Continued

Treatment	Rate lbs ai/ac	8 DAT	9 DAT	10 DAT	11 DAT
		Time Post Treatment			
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	100 a	96 ab	86 ab	100 a
Vydate	0.25	9.3 c	47 c	94 ab	87 b
Malathion ULV	0.92	66 b	81 b	79 b	98 a

1. All percent survival has been corrected using Abbott's formula. Data were transformed using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fischer's LSD, p=0.05).

Table 10. Percent survival of adult lady beetles exposed to treated cotton leaves in a petri dish at various times post treatment. Second trial. Runnels Co., TX. 1996.

Treatment	Rate lbs ai/ac	1 Hr	1 DAT	2 DAT	3 DAT	4 DAT
		Time Post Treatment				
Untreated		100 a	100 a	100 a	100 a	100 a
Endosulfan	0.51	100 a	100 a	76 b	100 a	96 a
Vydate	0.25	16 b	20 b	29 c	20 b	60 b
Malathion ULV	0.92	0.b	0 c	0 d	0 c	4 c

Table 10. Continued

Treatment	Rate lbs ai/ac	5 DAT	6 DAT	7 DAT	8 DAT
		Time Post Treatment			
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	100 a	100 a	100 a	100 a
Vydate	0.25	84 b	80 b	96 a	100 a
Malathion ULV	0.92	4 c	12 c	28 b	88 b

1. All percent survival has been corrected using Abbott's formula. Data were transformed using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fischer's LSD, p=0.05).

Table 11. Percent survival of adult boll weevils exposed to treated cotton leaves in a petri dish at various times post treatment. Second trial. Runnels Co., TX. 1996.

Treatment	Rate lbs ai/ac	Time Post Treatment 1 Hr	1 DAT	2 DAT	3 DAT	4 DAT
		Percent Survival[1]				
Untreated		100 a	100 a	100 a	100 a	100 a
Endosulfan	0.51	16 b	44 b	48 b	82 b	56 b
Vydate	0.25	4 b	4 c	4 c	4 c	16 c
Malathion ULV	0.92		0 c	4 c	0 c	0 d

Table 11. Continued

Treatment	Rate lbs ai/ac	Time Post Treatment 5 DAT	6 DAT	7 DAT	8 DAT
		Percent Survival[1]			
Untreated		100 a	100 a	100 a	100 a
Endosulfan	0.51	92 a	97 a	92 ab	100 a
Vydate	0.25	28 b	29 b	90 ab	100 a
Malathion ULV	0.92	21 b	16 b	77 b	100 a

1. All percent survival has been corrected using Abbott's formula. Data were transformed using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fischer's LSD, p=0.05).

Table 12. Percent survival of *Cotesia marginiventris* exposed to treated cotton leaves in a petri dish at various times post treatment. Second trial. Runnels Co., TX. 1996.

Treatment	Rate lbs ai/ac	Time Post Treatment 1 Hr	1 DAT	2 DAT	3 DAT	4 DAT
		Percent Survival[1]				
Untreated		100 a	100 a	100 a	100 a	100 a
Endosulfan	0.51	53 b	100 a	64 b	93 ab	100 a
Vydate	0.25	0 c	24 b	60 b	67 b	24 b
Malathion ULV	0.92	0 c	0 c	0 c	0 c	0 c

Table 12. Continued

Treatment	Rate lbs ai/ac	Time Post Treatment 5 DAT	6 DAT	7 DAT
		Percent Survival[1]		
Untreated		100 a	100 a	100 a
Endosulfan	0.51	96 ab	100 a	
Vydate	0.25	60 bc		
Malathion ULV	0.92	26 c	6 b	80 b

1. All percent survival has been corrected using Abbott's formula. Data were transformed using arcsine square root for analysis. Numbers followed by the same letter are not significantly different (Fischer's LSD, p=0.05).