PERFORMANCE OF DIMILIN® 2L (DIFLUBENZURON) IN THE CONTROL OF BEET ARMYWORM (SPODOPTERA EXIGUA) IN COTTON

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Abstract

Beet armyworms (Spodoptera exigua) (BAW) have recently become a significant economic pest on cotton (Gossypium hirsutum L.) throughout the entire Cotton Belt. Although DIMILIN (diflubenzuron) is currently recommended for early control of BAW using a preemptive program of multiple applications at low rates, this study assessed using DIMILIN in grower's insect management programs to control higher infestations of BAW. DIMILIN was found to be effective in controlling BAW, as long as infestations were not at levels where no insecticide would perform. As an insect growth regulator, DIMILIN may not be as rapid as other insecticides in affecting BAW, but its persistence on the cotton foliage and favorable effects on beneficial insects make it a valuable tool in managing BAW, and other foliar feeding Lepidopterous pests.

Introduction

The insect growth regulator, DIMILIN, has been shown to be an effective alternative to harder chemical insecticides for managing infestations of foliar feeding insects in cotton. When ingested, it interferes with chitin formation/deposition in susceptible larvae (Mulder and Gijswijt, 1973). These larvae are usually unable to discard the old cuticle and the molting process results in rupture of the underlying new cuticle with fatal consequences. Even if they succeed in molting, the larvae usually die soon thereafter (Grosscurt, 1993). Sublethal ingestion by larvae can result in weakened pupae and malformed adults (Van Laecke et al., 1989).

Activity of DIMILIN on BAW has been reported on larvae feeding on treated artificial media (Coudriet and Seay, 1979; Granett et al., 1983), on treated castor bean leaves (Van Laecke and Degheele, 1991) and on treated cotton (Smith, 1989; McDonald and Weiland, 1995). A preemptive program, applying low rates of DIMILIN in multiple applications until at least 0.125 lb ai/acre has been applied, as promoted by extension entomologists (Lambert, 1993; Smith, 1993; Layton, 1994; Huffman et al., 1995) and county extension agents (e.g. Beard and Brown, 1995), has been successful in preventing major BAW infestations. This preemptive program is based on two properties of DIMILIN; persistence on the foliage (Bull and Ivie, 1978) and its minimal effect on beneficial cotton insects (e.g. Ruberson et al., 1993). However, as DIMILIN is not translocated (Mansager et al., 1979), it is necessary to keep new foliage covered with sequential treatments. In areas with a history of regular BAW infestation, several low rate (0.031 lb ai/acre) applications of DIMILIN have been found to be beneficial for BAW control (Smith and Freeman, 1994). Examples of BAW control and cotton leaf protection with DIMILIN using the preemptive approach are published by Lambert (1992) and Burris et al. (1994).

In 1995 field trials were conducted in several States throughout the Cotton Belt to demonstrate how DIMILIN might be incorporated into grower's cotton insect management programs for mid to late season control of BAW.

Materials and Methods

Trials discussed in this paper range from small plot to large plot experiments conducted by university and contract cooperators, as well as Uniroyal Chemical personnel in 1995. Cotton was grown using typical commercial practices throughout the Cotton Belt. Insect populations and/or damage ratings were determined by standard procedures. Specifics concerning methods of application are identified in the **Results** section by site.

Results

Early County, Georgia: The following treatments, applied by air (5 gal/acre) on dryland cotton were compared for BAW control:

a) DIMILIN 2L @ 0.062 lb ai/acre applied July 11, 18 and 28.
b) DIMILIN 2L @ 0.125 lb ai/acre applied July 11, and @ 0.062 lb ai/acre applied July 28.
c) Grower Standard was chlorpyrifos (Lorsban 4E) @ 1.0 lb ai/acre applied July 11 and 28.

Larval counts are shown in Table 1. Beet armyworm pressure was heavy with continuous hatchouts over a 4-week period. The worm population was well established at the time of the first treatments with DIMILIN and it is evident that larvae may have been already too mature to be affected. Counts made after the July 28 applications however showed that DIMILIN was controlling the younger larvae of the next generation. Lorsban showed no effect at that time. There was no difference in levels of control by either regime with DIMILIN. Overall, Lorsban had less impact on the BAW population.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1050-1054 (1996)
National Cotton Council, Memphis TN

Cochran, Georgia: Treatments of DIMILIN 2L @ 0.125 lb ai/acre and thiodicarb (Larvin 3.2F) at 0.4 lb ai/acre were applied in tank mixes with tralomethrin (Scout X-tra) @ 0.019 lb ai/acre and NuFilm at 4 oz/acre on July 28.

The numbers of BAW larvae were lower than in most of the other tests and both DIMILIN and Larvin gave good control (Table 2). Soybean loopers (Pseudoplusia includens) were also controlled, although numbers in the last count were higher which indicated another generation hatching out.

Belle Mina, Alabama: Treatments of DIMILIN 2L, tebufenozide (Confirm 2F), nuclear polyhedrosis virus (Spod-X LC), chlorfenapyr (Pirate 3SC) and Larvin 3.2F were applied to a heavy population of BAW July 20 and July 31. Spod-X LC was also applied on July 25 and August 3. Treatments were made by ground in 9.5 gallons of water per acre; they were side-by-side and each block was approximately 17 acres. Rates and results are shown in Table 3.

None of the treatments gave acceptable control of BAW at this location. This BAW population was well established and the sheer numbers overwhelmed all treatments evaluated. This infestation should have been controlled by earlier treatment.

Franklin County, Alabama: DIMILIN 2L @ 0.125 lb ai/acre was tank mixed with the grower's standard treatment of profenofos (Curacron 8E) @ 0.67 lb ai/acre + methomyl (Lannate 2.4 LV) @ 0.2 lb ai/acre and compared with the grower's standard tobacco budworm (Heliothis virescens) treatment. Applications were made on August 10 using 10 gallons of water by ground equipment. A second application of DIMILIN 2L @ 0.125 lb ai/acre was made on August 16. Results on BAW and soybean loopers are shown in Table 4.

DIMILIN effectively reduced the BAW population. The Curacron/Lannate treatment was not adequate against BAW. Treating with DIMILIN was also much more effective on soybean loopers.

Cruger, Mississippi: DIMILIN 2L @ 0.125 lb ai/acre and Confirm 2F @ 0.125 lb ai/acre (plus 1 pint/acre Latron CS-7) were applied to a heavy BAW population on August 8. Twenty-acre treatments were applied at a water volume of 5 gallons/acre by aerial equipment.

By 7 days after treatment (DAT), DIMILIN had reduced the BAW infestation to 0.1 larvae per row-foot compared to 1.0 larvae per row-foot for Confirm (Table 5). Activity of both treatments was also assessed on a mixed population of soybean and cabbage (Trichoplusia ni) loopers. DIMILIN was more effective on the looper levels than Confirm at both 7 and 34 DAT (Table 5).

Greenwood, Mississippi (Site 1): Applications of DIMILIN 2L (0.125 lb ai/acre) and Pirate 3SC (0.35 lb ai/acre) were made to above treatment threshold levels of BAW on August 9. Forty-acre blocks were treated by ground equipment at volumes of 3 gallons/acre.

DIMILIN was equal to Pirate in controlling BAW at 15 DAT, but not at 9 DAT (Table 6). By 34 DAT control was better in the treatment with DIMILIN than with Pirate.

Greenwood, Mississippi (Site 2): Both DIMILIN 2L (0.125 lb ai/acre) and Confirm 2F (0.125 lb ai/acre plus 8 oz Latron CS-7/acre) were applied on August 10 to a heavy infestation of BAW. The 5-acre blocks were treated by ground equipment at a volume of 15 gallons/acre.

DIMILIN had lowered the BAW population to 0.3 larvae/row-foot by 12 DAT, whereas there were 5.0 larvae per row-foot in the Confirm block (Table 7). By 20 DAT there were no larvae in the treatment with DIMILIN compared to 11.3/row-foot in the Confirm block.

St. Joseph, Louisiana: Three formulations of DIMILIN (2L, 2F and 80WG, each @ 0.125 lb ai/acre) and several other insecticides (Confirm 70WP @ 0.07, 0.09 and 0.13 lb ai/acre; Confirm 2F @ 0.07 lb ai/acre; Pirate 3SC @ 0.15 lb ai/acre; Larvin 3.2F @ 0.60 lb ai/acre) were evaluated for controlling cotton leaf feeding in a replicated small plot trial (Table 8). Applications of each treatment were made on August 2, 8, 12 and 25 by ground equipment. All treatments resulted in significantly less leaf feeding compared to the untreated control at 4 days after the last treatment. The three formulations of DIMILIN gave similar reductions in defoliation. All treatments resulted in similar reductions in defoliation except the Confirm treatments @ 0.07 lb ai/acre.

Macon Ridge, Louisiana: DIMILIN 2L (0.125 and 0.25 lb ai/acre) and 80WG (0.125 lb ai/acre) were compared with other insecticides (Confirm 70W @ 0.07 and 0.125 lb ai/acre; Confirm 2F @ 0.125 lb ai/acre; Pirate 3SC @ 0.175 lb ai/acre; Larvin 3.2F @ 0.6 lb ai/acre) for activity against BAW in a replicated small plot trial at Macon Ridge, Louisiana (Table 9). Applications were made on August 29. Larval populations were determined at 2 and 7 days after application. All treatments gave similar control of beet armyworms. Decreasing larval counts in the untreated plots indicated a declining BAW population.

Uvalde, Texas: Treatments of DIMILIN 2L @ 0.125 lb ai/acre applied on June 29 and @ 0.062 lb ai/acre on June 29 and July 3 were compared to Confirm 2F @ 0.125 lb ai/acre applied on June 29. They were made aerially in 5 gallons/acre to 20-acre blocks. All treatments were similarly effective in reducing a heavy BAW infestation through 17 DAT (Table 10).

Discussion

Beet armyworm has been described as a 'new' pest on cotton, and there are indications that it is able to survive the winter farther north in the Cotton Belt than once believed (Ruberson et al., 1994). Trap counts of adults in Alabama, Florida and Louisiana show significant numbers of moths throughout the winter months (unpublished results, R.K. Sprenkel, Univ. of FL). The multi-state trapping program coordinated by the Univ. of FL (Sprenkel and Austin, 1994), along with other trapping results (e.g. Hendricks et al., 1995), provide an excellent early warning system to predict the onset of emerging generations of BAW. Once moth trapping has identified a peak moth flight, and knowing it takes 3-5 weeks (depending on temperature) from one BAW generation to the next during the cotton season (Fye and McAda, 1972), one can anticipate treating for the oncoming larval generation.

Use of pheromone trapping information, careful scouting, and applications of DIMILIN under a preemptive control is an effective and economical way of preventing BAW devastation in cotton. Results presented in this paper show that DIMILIN can be effective, along with other currently available insecticides, in controlling BAW present under higher infestation pressure. However, it is essential that DIMILIN is on the leaf surface and applications are timely. Applying DIMILIN at or near peak pheromone moth trappings will place it in the canopy for consumption by the developing larvae. Since the majority of BAW eggs are laid on the underside of the cotton leaf and the early hatchouts mainly feed on the lower leaf surface, the earliest instars may not be exposed to DIMILIN until they eat through the upper cuticle. This is where the majority of DIMILIN is deposited using conventional ground and aerial equipment. Larvae must consume and molt before effects of DIMILIN can be observed, and unless an application coincides with molting (e.g. Table 9), these effects may be delayed for several days. Thus, one should extend field evaluations through at least 5 days after an application of DIMILIN, and longer if assessing persistence.

Persistence of DIMILIN, in contrast to that of other insecticides being used for control of Lepidopterous pests, is illustrated in Tables 1, 2, 4, 5, 6, and 7. Persistence on cotton foliage has also been shown by Bull and Ivie (1978) and Weiland et al. (1996) for at least 28 days. This characteristic makes DIMILIN a suitable tank-mix component with insecticides which exhibit less persistence on cotton leaves, especially when BAW populations are high and overlapping in mid to late season. In addition, DIMILIN may predispose insects to be more susceptible to a tank-mix insecticide; it has been shown to be synergistic with several cotton insecticides (e.g. Van Laecke and Degheele, 1991; Haynes, 1995).

Results in Table 3 illustrate that under certain conditions BAW populations can build to a point where no chemical treatments can give adequate control. The solution is to apply treatments before populations become too vigorous to control. An early season preemptive program of multiple applications of DIMILIN has been effective in preventing major BAW infestations (e.g. Lambert, 1992; Burris et al., 1994).

Acknowledgments

The authors would like to thank all cooperators who contributed time and effort in tests with DIMILIN 2L during 1995.

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Table 1. Early County, Georgia: Effects of treatments ofDIMILIN and Lorsban on numbers of beet armyworm larvaein cotton during 1995.

	Days after initial application							
Treatment	**-1**	**+2**	**+6**	**+9**	**+13**	**+16**	**+20**	**+23**
	(ave larvae # per row-foot)							
DIMILIN 2L[1]	8	11	21	13	9	6	3	2
DIMILIN 2L[2]	7	8	18	16	11	9	5	4
Lorsban 4E[3]	9	4	11	18	10	21	11	8

[1]0.062 lb ai/A on July 11, 18, 28.
[2]0.125 lb ai/A on July 11; 0.062 lb on July 28.
[3]1.0 lb ai/A on both July 11 and 28.

Table 2. Cochran, Georgia: Effects of DIMILIN and Larvin onlarval populations of beet armyworm and loopers in cotton during 1995.

Treatment	Days after application +1	+3	+6	+10	+13
	BEET ARMYWORM LARVAE (avg # per row-foot)[1]				
DIMILIN 2L[2]	7.4	0.6	0.2	0.2	0.4
Larvin 3.2F[3]	4.7	0.5	0.4	0.2	0.2
	SOYBEAN LOOPER LARVAE (avg # per row-foot)[1]				
DIMILIN 2L[2]	ND	0.3	0.1	0.2	3.7
Larvin 3.2F[3]	ND	0.0	0.7	0.6	5.3

[1]Means averaged across 6 ground cloth samples, 6 row-ft per sample.
[2]0.125 lb ai/A + 0.019 lb ai/A Scout X-tra + 4 oz/A NuFilm 17 applied on July 28.
[3]0.4 lb ai/A + 0.019 lb ai/A Scout X-tra + 4 oz/A NuFilm 17 applied on July 28.

Table 3. Belle Mina, Alabama: Effects of several insecticides on numbers of beet armyworm larvae in cotton during 1995.

Treatment[1]	Rate	Days after 1st application +4	+7	+20
		ave larvae # per row-foot[2]		
DIMILIN 2L	0.125 lb ai/A	20.5	17.7	29.5
Spod-X LC	3.380 oz/A	24.9	16.0	28.5
Pirate 3SC	0.100 lb ai/A	12.7	10.2	22.4
Larvin 3.2F	0.450 lb ai/A	16.3	15.7	19.7
Larvin 3.2F	0.600 lb ai/A	20.4	13.8	16.9
Confirm 2F	0.125 lb ai/A	15.0	11.8	20.5
+ Latron	0.25%			

[1]Applications made on July 20 and 31; additional on July 25 and August 3 for Spod-X LC.
[2]Counts made on 15-row feet per sampling.

Table 4. Franklin County, Alabama: Effects of DIMILIN and Curacron on beet armyworm and soybean looper countsin cotton during 1995.

Treatment	Days after first application +5	+8	+11	+12
		BEET ARMYWORM LARVAE (ave # per row-foot)[1]		
DIMILIN 2L[2]	8.2	7.6	4.3	1.1
Curacron 4E[3]	15.8	8.0	5.7	9.3
		SOYBEAN LOOPER LARVAE (ave # per row-foot)[1]		
DIMILIN 2L[2]	2.8	1.8	1.5	0.3
Curacron 4E[3]	6.5	3.9	1.8	2.9

[1]Means averaged across 6 ground cloth samples, 3 row-ft per sample.
[2]DIMILIN 2L (0.125 lb ai/A) applied on August 10 and 16; Curacron 8E (0.67 lb ai/A) + Lannate 2.4 LV (0.2 lb ai/A) applied on August 10.
[3]Curacron 8E (0.67 lb ai/A) + Lannate 2.4 LV (0.2 lb ai/A) applied August 10.

Table 5. Cruger, Mississippi: Effects of DIMILIN andConfirm applied on August 8 on numbers of beet armyworm and looper larvae in cotton during 1995.

Treatment	Rate (lb ai/A)	Days after application 0	+7	+34
		BEET ARMYWORM LARVAE (ave # per row-foot)[1]		
DIMILIN 2L	0.125	11.3	0.1	0.8
Confirm 2F (+ 1 pt Latron CS-7)	0.125	9.3	1.0	1.2
		LOOPER LARVAE (ave # per row-foot)[1]		
DIMILIN 2L	0.125	2.3	1.6	0.1
Confirm 2F (+ 1 pt Latron CS-7)	0.125	2.0	2.3	0.4

[1]Means averaged across 10 ground cloth samples, 3 row-ft per sample.

Table 6. Greenwood, Mississippi (Site 1): Effects of DIMILIN and Pirate applied on August 9 on numbers of beet armyworm larvae in cotton during 1995.

Treatment	Rate (lb ai/A)	Days after application +9	+15	+34
		(ave # per row-foot)[1]		
DIMILIN 2L	0.125	1.5	0.6	0.4
Pirate 3SC	0.350	0.2	0.6	1.2

[1]Means averaged across 10 ground cloth samples, 6 row- ft per sample.

Table 7. Greenwood, Mississippi (Site 2): Effects of DIMILIN and Confirm applied on August 10 on numbers of beet armyworm larvae in cotton during 1995.

Treatment	Rate (lb ai/A)	Days after application 0	+12	+20
		(ave # per row-foot)[1]		
DIMILIN 2L	0.125	10.0	0.3	0.0
Confirm 2F + 1 pt Latron	0.125	15.3	5.0	11.3

[1]Means averaged across 10 ground cloth samples, 3 row- ft per sample.

Table 8. St. Joseph, Louisiana: Effects of DIMILIN and other insecticides on defoliation caused by feeding of beet armyworm larvae on cotton during 1995.

Treatment[1]	Rate (lb ai/A)	% Defoliation[2]
Untreated		30.0 a[3]
Confirm 70WP	0.070	12.5 b
Confirm 70WP	0.090	7.5 bc
Confirm 70WP	0.130	5.5 bc
Confirm 2F	0.070	12.5 b
DIMILIN 2F	0.125	6.3 bc
DIMILIN 2L	0.125	7.5 bc
DIMILIN 80WG	0.125	6.3 bc
Pirate 3SC	0.150	3.0 c
Larvin 3.2F	0.600	10.0 bc

[1]Treatments applied on August 2, 8, 12, and 25.
[2]Ratings made on August 29.
[3]Means followed by the same letter are not significantly different (P = 0.05; DMRT).

Table 9. Macon Ridge, Louisiana: Effects of DIMILIN and other insecticides on larval populations of beet armyworm on cotton during 1995.

Treatment[1]	Rate (lb ai/A)	Days after treatment +2	+7
		(avg # per row-foot)[2]	
Untreated		5.7 a[3]	2.2 a
Confirm 70W	0.070	3.1 b	0.5 b
Confirm 70W	0.125	1.8 b	0.3 b
Confirm 2F	0.125	1.7 b	0.2 b
DIMILIN 2L	0.125	1.8 b	0.6 b
DIMILIN 2L	0.250	2.5 b	0.4 b
DIMILIN 80WG	0.125	2.5 b	0.6 b
Pirate 3SC	0.175	0.9 b	0.2 b
Larvin 3.2F	0.600	1.2 b	0.4 b

[1]Treatments applied on August 29; all included 0.25% Latron CS-7.
[2]Larval counts were made from 12 feet of row in each of the 4 replications.
[3]Means within a column followed by a common letter are not significantly different (P = 0.05; DMRT).

Table 10. Uvalde, Texas: Effects of DIMILIN and Confirm on larval populations of beet armyworm in cotton during 1995.

Treatment	Rate (lb ai/A)	Days after first application +1	+7	+12	+17
		(avg # per row-foot)[1]			
DIMILIN 2L[2]	0.125	8.0	2.3	1.4	1.8
DIMILIN 2L[3]	0.062	5.1	2.9	2.0	2.3
Confirm 2F[2]	0.125	8.6	1.1	0.6	0.4

[1]Averaged across 6 drop cloths, 6 feet of row per drop cloth.
[2]Applied on June 29.
[3]Applied on June 29 and July 3.