FIELD PERSISTENCE OF SEVERAL INSECTICIDES ON COTTON FOLIAGE AS DETERMINED BY BEET ARMYWORM (*SPODOPTERA EXIGUA*) BIOASSAY

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Abstract

A laboratory bioassay of beet armyworm foliar feeding damage was used to evaluate the persistence of Dimilin® Insect Growth Regulator (diflubenzuron) and Tracer® Naturalyte Insect Control (spinosad) when applied at respective rates of 0.062 and 0.067 lb ai/acre to foliage of field-grown cotton. In the first of two evaluations, Dimilin was found to be persistent through 31 days exposure in the field. No activity from Tracer was detected at the first leaf harvest which corresponded to 7 days exposure in the field. In the second evaluation Dimilin again demonstrated persistence while Tracer showed no residual effectiveness at the first leaf harvest, following 6 days exposure in the field. In this trial, bioassays of foliage treated with Dimilin or Tracer immediately before field sampling demonstrated good efficacy by both products.

Introduction

The foliar persistence of an insecticide which needs to be consumed for activity against feeding larvae is desirable as long as the insecticide expresses little activity on the beneficial insect populations (Weiland et al., 1996). The insect growth regulator, Dimilin® (diflubenzuron), has been shown to be persistent on cotton tissue (Bull and Ivie, 1978; McDonald and Weiland, 1995; Weiland et al., 1996) and to have little activity on beneficial cotton insects (e.g. Ruberson et al., 1993). After consumption, Dimilin renders susceptible larvae unable to complete the next molt (Mulder and Gijswijt, 1973). The larvae are usually unable to shed the old cuticle and often lethally rupture the underlying new cuticle.

Beet armyworms (BAW) have previously been shown susceptible to Dimilin after ingestion (Granett et al., 1983). McDonald and Weiland (1995) used a beet armyworm bioassay to demonstrate superior rainfastness of Dimilin compared to Larvin® (Rhone-Poulenc). Weiland et al. (1996) demonstrated a field persistence of greater than 4 weeks for Dimilin using the bioassay.

Spinosad received a cotton tolerance from U.S.E.P.A. in February, 1997 (Anonymous, 1997). It is a naturally occurring mixture of two macrocyclic lactones, known as spinosyns, produced by the soil actinomycete *Saccharopolyspora spinosa* (Salgado et al., 1997). In cotton spinosad has been introduced under the trade name of Tracer® Naturalyte Insect Control by DowElanco, Indianapolis, IN. It has been shown to exhibit both contact and oral activity against a wide range of Lepidoptera and other orders, such as Diptera, Thysanoptera, Siphonoptera and Hymenoptera (e.g. Thompson et al., 1995a,b), while also having little effect on beneficial insects (Thompson et al., 1995b).

In the current evaluations the BAW bioassay method was used to compare the field persistence of Dimilin and Tracer on foliage of field cotton.

Materials and Methods

A petri dish bioassay (McDonald and Weiland, 1995) was used in each of two field evaluations assessing insecticide persistence on cotton foliage. Either unsprayed or treated leaves were singly evaluated in the bioassay. Beet armyworms, received as eggs from the USDA-ARS Southern Field Crop Insect Management Laboratory, Stoneville, MS, were reared to the second/third instar stage on artificial tobacco budworm diet (BIOSERVE, Frenchtown, NJ). Five larvae were transferred onto a single cotton leaf resting on a moist filter paper in a 3.54-inch diameter petri dish for a single replicate, with a total of 8 replicates per treatment. Dishes were then placed in an incubator (80°F). This timing was designated as 0 days of bioassay (DOB). The percent leaf damage (consumption) was determined almost daily for 5 days and reported through 4 DOB for the days of assessment.

For the first evaluation a uniform stand of Stoneville 825 cotton was grown under field conditions at Sanford, FL. When the plants had reached the 5 to 6 true leaf stage, 0.062 lb ai Dimilin 2L/acre and 0.067 lb ai Tracer 4SC/acre were applied separately (June 23, 1997) to a portion of the stand at a volume of 20 gpa using a hand hydra gun. On June 30 (7-day field exposure) 4th and 5th true leaves from untreated plants and those treated with either Dimilin or Tracer were shipped overnight in sealed plastic bags (ambient temperature) to Bethany, CT for bioassay. On July 10 (17-day field exposure), July 17 (24-day field exposure) and July 24 (31-day field exposure), only untreated leaves and those with Dimilin were shipped to Bethany, CT for bioassay.

For the second evaluation at Sanford, FL, more untreated cotton was treated on July 31 with the same rates of Dimilin and Tracer as described in the first evaluation. Fifth to 6th

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true leaves were used in the bioassay. On August 6 untreated leaves and leaves previously treated with Dimilin and Tracer (6 days after treatment, DAT) where shipped to Bethany, CT. Additionally, separate untreated leaves were sprayed with these treatments (0 DAT), and once dry (~1 hour), included in the August 6 shipment for bioassay. These treatments were included to give an indication of maximum product activity to BAW. On August 13, leaves treated on July 31 (13 DAT) plus ones treated just prior to shipment (0 DAT) were again shipped for bioassay.

Weather data were determined on site except for the period from June 19 to June 23, 1997. The Central Florida Research and Education Center, Sanford, FL, which was approximately 1 mile from the field site, provided these entries. Rainfall and maximum/minimum air temperatures for the months of June, July and August (1-13) of 1997 are shown in Table 1.

Data were analyzed using Duncan's Multiple Range test (Duncan, 1955) with a significance level of $\underline{P} = 0.05$.

Results and Discussion

The field persistence of Dimilin was superior to that of Tracer in the first evaluation (Table 2). At 7 days of field exposure, treatment of Dimilin reduced BAW feeding damage in the bioassay from 2 DOB through 4 DOB. In contrast no reduction in feeding damage resulting from residual effects of Tracer was noted. Rainfall was measured at 1.1 inches during this period (Table 1). Since there was no residual efficacy of Tracer after 7 days of exposure in the field, no additional samples of foliage treated with Tracer were taken or bioassayed. At 17, 24 and 31 days of field exposure, residual effects of Dimilin were evident despite exposure to accumulative amounts of rainfall of 5.1, 5.7 and 7.6 inches for these respective days.

The second evaluation included treatments identical to those in the first plus Dimilin and Tracer each sprayed to leaves just prior to sampling and shipment for bioassay (0 DAT). Following 6 days of field exposure Dimilin demonstrated good residual activity while Tracer showed no residual activity (Table 3). Rainfall of 3.5 inches had occurred prior to the 6 DAT sampling (Table 1). Following 13 days of field persistence, Dimilin demonstrated residual activity. Rainfall of 8.5 inches had occurred between the treatment date and sampling. Rainfall and susceptibility to photolysis on plant surfaces (Thompson et al., 1995a) probably contributed to the loss of activity of Tracer. Both products demonstrated strong effectiveness when treatments were sampled on the day of treatment. In the 0 DAT treatments Dimilin feeding damage was reduced by 2 DOB following an initial lag period before the next molt. In contrast an immediate cessation of BAW feeding was noted on tissue treated with Tracer just prior to shipment for bioassay in both field exposure evaluations. This corresponds with the mode of action of Tracer which causes as initial flaccid, irreversible paralysis to treated larvae (Thompson et al., 1995b), and more specifically as a nicotinic agonist in the acetylcholine nervous response system (Salgado et al., 1997).

There was no phytotoxicity from applications of either treatment. In the first trial feeding damage in the untreated controls was low after the 17-day field exposure. Signs of leaf senescence, such as development of chlorotic and necrotic spots, were seen in the latest sampled tissue (both treated and untreated) of both evaluations. Thus this tissue was not preferred by all BAW for consumption, after having hatched on and adapted to artificial media. Similar results have previously been noted by Weiland et al. (1996).

The persistence of Dimilin on foliage and the immediate feeding cessation caused by Tracer would suggest the possibility of benefits of tank mixes of these products.

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Table 1. Air temperatures and rainfall amounts for the months of June, July and August (1-13) in 1997 at Sanford, Florida as recorded on site, with the exception of June 19-23, which was provided by the Central Florida Research and Education Center, Sanford, Florida.

	June			July			August		
	Temp (°F)		Rain	Temp (°F)		Rain	Temp (°F)		Rain
Day	High	Low	(“)	High	Low	(“)	High	Low	(“)
1	87	73	0.00	108	72	0.00	93	73	1.14
2	95	71	0.90	110	79	0.00	97	73	0.00
3	100	61	0.00	113	75	0.00	101	73	0.00
4	104	70	0.00	114	98	0.00	99	74	1.03
5	97	73	0.31	97	74	0.00	93	77	0.05
6	90	72	0.00	94	71	0.00	104	76	0.00
7	98	65	0.00	100	73	3.12	108	73	0.00
8	90	70	0.00	107	73	0.81	91	74	3.72
9	82	74	0.00	105	73	0.09	92	74	0.20
10	86	73	0.05	104	74	0.00	101	76	0.00
11	87	73	0.00	104	76	0.00	98	74	0.08
12	105	71	0.07	108	71	0.00	101	74	1.46
13	96	74	0.85	105	74	0.00	110	76	0.00
14	95	76	0.00	103	73	0.28			
15	91	73	0.00	106	73	0.00			
16	104	71	0.10	103	73	*0.25			
17	99	73	0.13	104	71	0.09			
18	99	75	0.31	99	74	0.00			
19	96	72	0.00	97	72	0.00			
20	89	70	0.00	96	72	0.00			
21	91	69	0.00	101	72	1.64			
22	91	69	0.00	102	73	0.00			
23	95	70	1.38	97	74	0.30			
24	90	72	0.01	98	78	0.00			
25	93	73	0.00	102	74	0.00			
26	104	93	0.15	100	75	0.92			
27	99	73	0.63	98	74	0.05			
28	101	72	0.00	100	73	0.06			
29	99	72	0.00	98	73	1.26			
30	106	73	0.27	97	73	0.20			
31				105	74	0.85			

*irrigation

Table 2. Beet armyworm damage to cotton leaves as affected by Dimilin 2L and Tracer 4SC through 4 days of bioassay (DOB) when exposed to field conditions up to 31 days prior to the initiation of the bioassay.

	Rate in	Cumulative Units of Damage*			
Treatment**	lb ai/acre	1DOB	2DOB	3DOB	4DOB
7-day field exposure					
UNTREATED		3	8 ab		37 a
DIMILIN 2L	0.062	2	3 b		4 b
TRACER 4SC	0.067	3	11 a		43 a
17-day field exposure					
UNTREATED		9 a***		25 a	46 a
DIMILIN 2L	0.062	4 b		4 b	5 b
24-day field exposure					
UNTREATED			4 a	13 a	24 a
DIMILIN 2L	0.062		2 b	6 b	10 b
31-day field exposure					
UNTREATED		1		7 a	15 a
DIMILIN 2L	0.062	1		3 b	6 b

* 100 Units = 100% damage to one leaf.

** It took one day to initiate the bioassay due to shipment of leaf tissue from Sanford, FL to Bethany, CT.

*** Means followed by the same letter within a column, for a given field exposure period, do not significantly differ (P = 0.05, Duncan’s MRT).

Table 3. Beet armyworm damage to cotton leaves as affected by Dimilin 2L and Tracer 4SC through 4 days of bioassay (DOB) when exposed to field conditions for 0, 6 and 13 days (DAT) prior to the initiation of the bioassay.

	Rate in	Cumulative Units of Damage*		
Treatment**	lb ai/acre	1DOB	3DOB	4DOB
6-day field exposure				
UNTREATED		2.6 b***	20.8 a	32.1 a
DIMILIN 2L 6 DAT	0.062	2.1 b	6.5 c	7.3 bc
TRACER 4SC 6 DAT	0.067	2.1 b	18.3 a	27.9 a
DIMILIN 2L 0 DAT	0.062	4.9 a	12.5 b	12.5 b
TRACER 4SC 0 DAT	0.067	0.0 c	1.0 c	1.0 c
13-day field exposure				
UNTREATED		1.6 ab	2.5 ab	2.7 ab
DIMILIN 2L 13 DAT	0.062	0.3 b	0.8 bc	0.8 b
TRACER 4SC 13 DAT	0.067	2.5 a	3.4 a	4.7 a
DIMILIN 2L 0 DAT	0.062	0.9 b	1.3 bc	1.7 b
TRACER 4SC 0 DAT	0.067	0.0 b	0.2 c	0.4 c

* 100 Units = 100% damage to one leaf.

** It took one day to initiate the bioassays due to shipment of leaf tissue from Sanford, FL to Bethany, CT.

*** Means followed by the same letter within a column, for a given field exposure period, do not significantly differ (P = 0.05, Duncan’s MRT).