SCOUTING FOR EARLY INSTAR FALL ARMYWORMS IN COTTON AND THEIR CONTROL WITH DIMILIN® (DIFLUBENZURON)

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Abstract

Correct identification of early instar larvae of fall armyworm (*Spodoptera frugiperda*) and cotton bollworm (*Helicoverpa zea*) is needed since these species have different thresholds for treatment, and potential controlling insecticides have varying activity on them. Visual observations with a hand lens (20X magnification) of first instar larvae did not reveal any gross differences between species except the fall armyworm reacted very defensibly to probing. The cotton bollworm was docile. Second instar cotton bollworms had longer and coarser bristles and more prominent hairs than the fall armyworms; black bumps (tubercles) at the base of any spines on the bollworm were more raised. Although the insect growth regulator, Dimilin® (diflubenzuron), exhibits little activity on the cotton bollworm due to the nature of its feeding habits, it was shown to control fall armyworm infestations. Fall armyworm activity was demonstrated in the field using a single application (1998), multiple low dosage applications (1998), and in combination with a pyrethroid (1996, 1998).

Introduction

Cotton bollworm and the fall armyworm are two Lepidopteran pests that currently available Bt cotton germplasm fails to completely control (Adamczyk et al., 1997, 1998; Layton et al., 1998; Mahaffey et al., 1994, 1995; Stone and Sims, 1993; Smith, 1997; Turnipseed and Sullivan, 1997; Weiland et al., 1997). Regardless of the type of cotton used, both cotton bollworm and fall armyworm need to be treated at threshold levels.

Although cotton bollworms lay single eggs mainly on cotton terminals, and fall armyworms lay egg masses on the underside of lower canopy leaves (Ali et al., 1989), newly hatched neonates are virtually indistinguishable. Fall armyworms are cannibalistic and thus disperse quickly upon hatching (Smith and Freeman, 1994). Bollworm escapes on Bt cotton appear to be related to the location of egg deposition: on dried bloom tags (Smith, 1997). Early instar fall armyworms feed on one surface of boll bracts, leaving a windowpane etching effect (Smith and Freeman, 1994). This observation may aid in cotton scouting identification of the fall armyworm in contrast to the bollworm.

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Dimilin has been shown to have activity on the cotton bollworm (e.g. Graves et al., 1992). It is assumed this control is ovicidal by having an egg laid on residue of Dimilin. Dimilin is not translocated throughout the plant (Mansager et al., 1979) nor does it have translaminar movement, but binds strongly to plant tissue. The bollworm lays eggs on cotton terminals and flower blooms. Early instars enter bolls soon after hatching. These are areas where little Dimilin would be available for ingestion. So exposure to Dimilin is insufficient to achieve commercial control.

Dimilin has been shown to be active on fall armyworm under both laboratory (Mink and Luttrell, 1989; Redfern et al., 1976; Weiland et al. 1997) and field (Weiland, 1999) conditions. Since fall armyworms feed extensively on the external portion of the cotton fruits, spray coverage of reproductive structures (fruit, bracts, etc.) and foliage with Dimilin is effective (e.g. Weiland, 1999).

This study was initiated to investigate potential differences in early instar fall armyworms and cotton bollworms to aid in scouting identification. Additional results from field trials are shown to further demonstrate control of fall armyworms with Dimilin under field conditions.

Materials and Methods

Observations on Fall Armyworm and Cotton Bollworm Larvae

Stoneville 453 cotton plants were cultured in a greenhouse located in Bethany, CT. Leaves from these plants were excised and placed on moist filter paper in petri dishes. Fall armyworm and cotton bollworms were received as egg masses from USDA/ARS facilities in Gainesville, Florida and Stoneville, Mississippi, respectively. They were then placed on these leaves and allowed to hatch. When the larvae started to feed on the leaf tissue, they were transferred to less populated dishes to discourage cannibalism. Observations with a 20 power hand lens were made and pictures were taken to record any differences between early instars of the fall armyworms and cotton bollworms. Placing larvae on either a leaf or a clean disk of filter paper resting on ice within a section of a petri dish facilitated in their immobilization for photography.

Field Trials Using Dimilin® to Control Fall Armyworms in Cotton

Trials discussed in this paper were large plot experiments conducted by contract and grower cooperators. 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.

Results

Observations on Fall Armyworm and Cotton Bollworm Larvae

First instars of either species were approximately 1/8 inch long (~3 mm). It was very difficult to distinguish them. The head capsule of the fall armyworm may be darker than that of the cotton bollworm. The most distinguishing trait was that fall armyworms reacted more defensibly than the bollworms to probing.

Second instars were approximately 1/4 inch long (~6.5 mm). Spines (bristles or prominent hairs) were longer and coarser on the cotton bollworm. Additionally, the black tubercles, or bumps at the base of the spines, were more raised on the cotton bollworm. These traits give the fall armyworm a smoother look. Both the bollworm and the armyworm had 4 circular spots (sclerotized plates) arranged in a small square on the dorsal surface of the eighth abdominal segment.

Third instars were approximately 1/2 inch long (~1.3 cm). An inverted "Y" becomes prominent on the head capsule of the fall armyworm at this time. The base of the "Y' continues down the top of the fall armyworm, along with other parallel, light colored, stripes.

Third to fifth instar fall armyworms may have a black dot on each side of the first abdominal segment behind the three pairs of true legs. Cotton bollworms have most of the body segments covered with short, whiskerlike spines, in addition to the longer bristles or setae. This adds to the observed smoother look of later instar fall armyworms.

Field Trials Using Dimilin® to Control Fall Armyworms in Cotton

Cochran, GA, 1998. A large paired block (≥ 23 acres) experiment was established on conventional cotton. The standard grower program consisted of 3 applications of pyrethroid tank-mixed with organophosphate from 31 July to 22 August for control of a Heliothine complex. Dimilin at 2 fl. oz. (0.031 lbs. a.i.)/acre was included as a tank-mix with the grower's standard and applied to an adjacent block.

Ten days after the first application and 6 days after the second application, there were 6 and 9 small fall armyworms per 100 plants, respectively, in the standard program (Figure 1). There were no larvae detected in the block with Dimilin in either of these scouting reports. Nine days after the second application the standard program had 9 small and 3 large larvae per 100 plants, whereas the block with Dimilin averaged only 4 small larvae. The standard program also exhibited soybean loopers (1 per row foot); none were found in the area treated with Dimilin. Except for 3 small larvae identified per 100 plants 2 days after the third application, no larvae were reported in subsequent scouting reports in the block with Dimilin. At least 3 larvae per 100 plants were found at each of these sampling times in the standard program. Dimilin gave a definite control advantage for fall armyworm in this trial; however the damage was apparently minor since lint yields were similar (568 and 575 lbs. lint/acre for the grower's standard and that receiving Dimilin, respectively).

Calhoun County, GA, 1998. Another large block (50 acres) experiment was established on Bt cotton. The grower standard program consisted of an organophosphate plant bug spray and pyrethroid sprays for cotton bollworm and fall armyworm. One trial with Dimilin consisted of five applications of Dimilin 2L at 4 fl. oz. (0.062 lbs. a.i.)/acre from 9 June to 31 July. Another trial had 2 applications at 6 fl. oz. (0.094 lbs. a.i.)/acre made on 3 July and 21 July.

Fall armyworm activity is shown in Figure 2. There were no great differences among treatments throughout the scouting period for fall armyworms, except on 3 August when both programs with Dimilin had greatly reduced infestations. Fall armyworm populations tended to be lower in these programs, in contrast to the standard program throughout the scouting period, once an application of Dimilin was made. The scouting reports noted significant boll damage on 23 July (13 bolls out of 100) and 27 July (8 bolls out of 100) in the standard program, that was not reported in the treatment areas having applications of Dimilin (data not shown). This subsequent boll damage in the grower standard block resulted in depressed cotton lint yields of 827 lbs./acre in contrast to 956 and 961 lbs./acre for the blocks with 2 and 5 applications of Dimilin, respectively.

Pierce County, GA, 1998. A large block (10 acres) trial was established on Bt cotton to assess control of a newly hatching fall armyworm population with a single 8 fl. oz. (0.125 lbs. a.i.)/acre application (4 August) of Dimilin 2L. Evaluations were made 7 and 14 days after treatment (DAT) with fall armyworm larvae being categorized as small (<1/4 inch), medium (1/4 to 1/2 inch) and large (>1/2 inch). At 7 DAT, population counts showed similar numbers of small and medium sized larvae between blocks with and without Dimilin, although numbers were lower in the block with Dimilin (Figure 3). However, there was an 80% infestation (80 larvae/100 plants) of large larvae in the grower's standard in contrast to 7% in the block with Dimilin. The follow-up count at 14 DAT showed no large fall armyworms in the block with Dimilin; there was a 13% infestation in the untreated control. No small or medium larvae in either block at this time indicated a cycling of that fall armyworm generation. Another infestation did not occur. Yields were not determined because of excessive boll rot and inclement weather.

Headland, AL, 1998. A replicated (4) small block (0.028 acres) trial was established on conventional cotton. Fall armyworm control was assessed with a single application (7 August) of a mixture of Dimilin 2L (8 fl. oz./acre) and deltamethrin (Decis® 1.5 EC @ 0.25 lbs. a.i./acre; AgrEvo USA Co.) on an existing population (61% infestation). Counts were made at 7 DAT (Figure 4). At that time the untreated control exhibited a 50% infestation. Deltamethrin alone reduced the population by 50% and deltamethrin with Dimilin reduced it 72%. No estimation of yield was made.

Sampson, AL, 1996. Another large block (25 acres) trial was made on Bt cotton to assess fall armyworm control with a single application (29 July) of a mixture of Dimilin 2L (8 fl. oz./acre) and lambda cyhalothrin (Karate® @ 0.03 lbs. a.i./acre; Zeneca Ag Products). There was initially a 38% fall armyworm infestation. At 5 DAT, the infestation was reduced to an 18 and 24% plant infestation for Dimilin + lambda cyhalothrin and cyhalothrin alone, respectively (Figure 5). It was respectively reduced to 8 and 16% at 12 DAT and 0 and 4% at 19 DAT. No additional armyworm generations occurred for further evaluation. Block lint yields were not taken.

Fairhope, AL, 1996.
A small (18 rows by an unidentified row length) replicated (3) block experiment was established to assess fall armyworm control on Bt cotton with two applications (10 and 19 July) of Dimilin 2L at 4 fl. oz./acre. An application of lambda cyhalothrin at 0.03 lbs. a.i./acre was also made on 17 July to the entire field. Six days after the initial application of Dimilin the infested plant population dropped from 37 to 26% (Figure 6). Six days after the lambda cyhalothrin application (4 days after the second application with Dimilin), the small and large larvae population was 5 and 14%, respectively in the areas with Dimilin, and 14 and 47% in the area with lambda cyhalothrin alone. It was noted that the blocks with Dimilin plus lambda cyhalothrin had 4.8 more bolls per 3 feet than the areas with lambda cyhalothrin alone.

Discussion

Dimilin applied in multiple low doses has previously been shown to control field infestations of fall armyworms (Weiland, 1999). Multiple applications aid in depositing residues inside the canopy and covering new and expanding tissues that have developed since a previous spray. Initiation of applications at first signs of egg deposition by fall armyworms will maximize control. This is demonstrated in Figures 1 and 2. A single, higher dosage application was also shown to control a newly hatching fall armyworm population (Figure 3). Tank mixing or supplementing a pyrethroid program with Dimilin can significantly enhance control of fall armyworms (Figures 4, 5, and 6).

References

Adamczyk, J.J Jr., J.W. Holloway, B.R. Leonard, and J.B. Graves. 1997. Defining the period of boll susceptibility to fall armyworm injury in cotton. pp. 941-943. *In* 1997 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Adamczyk, J.J. Jr., V.J. Mascarenhas, G.E. Church, B.R. Leonard, and J.B. Graves. 1998. Cotton boll susceptibility to fall armyworm and beet armyworm injury. pp. 1170-1172. *In* 1998 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Ali, A., R.G. Luttrell, H.N. Pitre, and F.M. Davis. 1989. Distribution of fall armyworm (Lepidoptera: Noctuidae) egg masses on cotton. Environ. Entomol. 18:881-885.

Graves, J.B., D.W. Long, and B.R. Leonard. 1992. Efficacy of Dimilin against bollworm and tobacco budworm. Insect. & Acar. Tests:17:223.

Layton, B., S.D. Stewart, and M.R. Williams. 1998. Performance of Bt cotton in Mississippi, 1997. pp. 970-973. *In* 1998 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Mahaffey, J.S., J.S. Bacheler, J.R. Bradley, Jr. and J.W. Van Duyn. 1994. Performance of Monsanto's transgenic B.t. cotton against high populations of Lepidopterous pests in North Carolina. pp. 1061-1063. *In* 1994 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Mahaffey, J.S., J.R. Bradley, Jr. and J.W. Van Duyn. 1995. B.t. cotton: field performance in North Carolina under conditions of unusually high bollworm populations. pp. 795-798. *In* 1995 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Mansager, E.R., G.G. Still, and D.S. Frear. 1979. Fate of [^{14}C] diflubenzuron on cotton and in soil. Pest. Biochem. Physiol. 12:172-182.

Mink, J.S. and R.G. Luttrell. 1989. Mortality of fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) eggs, larvae and adults exposed to several insecticides on cotton. J. Entomol. Sci. 24:563-571.

Redfern, R.E., A.B. DeMilo, and J.E. Oliver. 1976. Analogues of TH-6038 and TH-6040. Growth regulating effects on the fall armyworm. Beocheu Kagaku 42:89-91.

Smith, R.H. 1997. An extension entomologist's 1996 observations of Bollgard (Bt) technology. 1997. pp. 856-858.

In 1997 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Smith, R.H. and B.L. Freeman. 1994. Fall armyworms: consistent cotton pests. Circular ANR-892, Alabama Cooperative Extension Serv., Auburn University, Alabama

Stone, T.B. and S.R. Sims. 1993. Geographic susceptibility of *Heliothis virescens* and *Heliocoverpa zea* (Lepidoptera: Noctuidae) to Bacillus thuringiensis. J. Econ. Entomol. 86:989-994.

Turnipseed, S.G. and M.J. Sullivan. 1997. Reduced effectiveness of B.t. cotton following disruption of beneficials with early season insecticides. p. 876. *In* 1997 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Weiland, R.T. 1999. Earlier cotton harvest and increased yield with Dimilin® (diflubenzuron). pp. 1072-1075. *In* 1999 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

Weiland, R.T., P.T. McDonald and M.K. Kish. 1997. Efficacy of Dimilin® (diflubenzuron) and transgenic Bt cotton on several Lepidopteran species. 1997. pp. 1095-1099. *In* 1997 Proceedings Beltwide Cotton Prod. Res. Conf., National Cotton Council, Memphis, Tennessee.

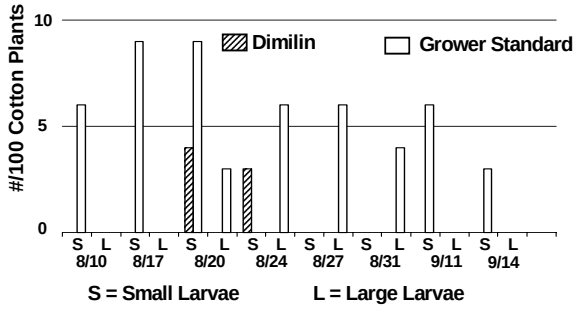

Figure 1. Effect of three 2 oz./A applications (7/11, 8/11, 8/22) of Dimilin 2L on fall armyworms in Cochran, GA during 1998. Small larvae were < 1/4 inch in length.

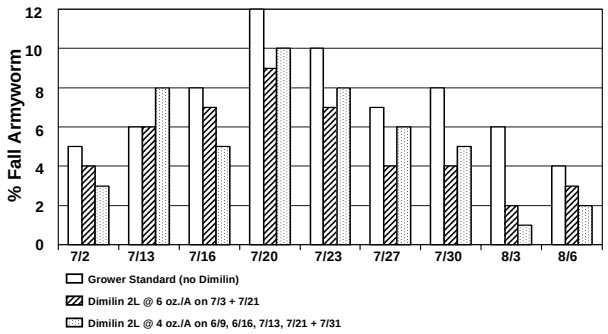

Figure 2. Effect of two spray programs using Dimilin 2L on fall armyworm populations in Calhoun County, GA during 1998.

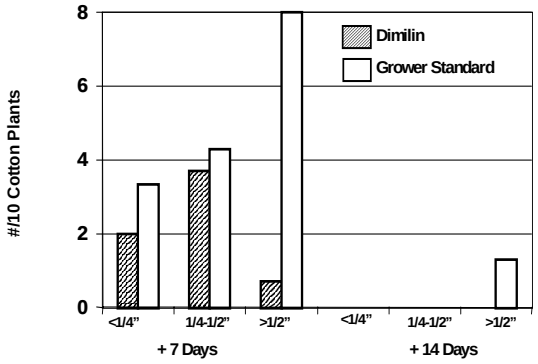

Figure 3. Effect of an 8 oz./A application (8/4) of Dimilin 2L on a newly hatching fall armyworm infestation in Pierce County, GA during 1998. Unpublished data, Dr. P. M. Roberts, University of Georgia, and J. E. Smith, Pierce County Agent.

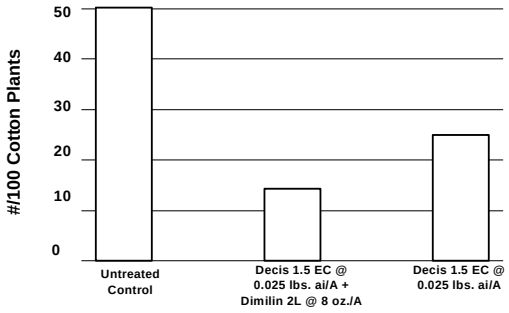

Figure 4. Effect of an 8 oz./A application (8/7) of Dimilin 2L with Decis on a fall armyworm population in Headland, AL during 1998. Counts were made 7 days post application. Adapted from unpublished data, Dr. R. H. Smith, Auburn University.

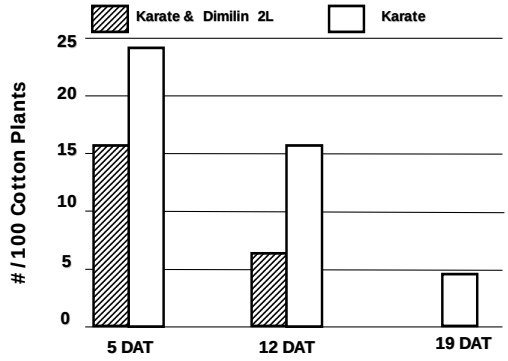

Figure 5. Effect of an 8 oz./A application (7/29) of Dimilin 2L with 0.03 lbs. a.i./A of Karate on a fall armyworm population in Sampson, AL during 1996.

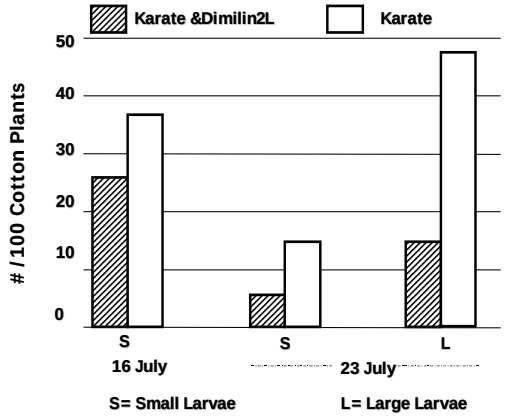

Figure 6. Effect of two 4 oz./A applications (7/10, 7/19) of Dimilin 2L with Karate @ 0.03 lbs. a.i./A (7/17) in Fairhope, AL, during 1996. Unpublished data, Dr. R.H. Smith, Auburn University.