Update on the Area-Wide Budworm/Bollworm Management Program with Virus in the United States

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ABSTRACT

An area-wide management program with Helicoverpa zea nucleopolyhedrovirus (HzSNPV) has been conducted in the Mississippi Delta to control the first generation of cotton bollworm and tobacco budworm in wild geranium. Results are reported for the 1997 area-wide management program using a lower HzSNPV application rate. The HzSNPV formulation used in this study consisted of Gemstar™ LC (Thermo Trilogy, Inc.) diluted in water with an equal volume of cotton seed oil with an emulsifier. Aerial applications of the HzSNPV formulation were applied at a volume of 2.33 liters per ha and with an application rate of 2.5 X 10^{11} occlusion bodies (OB's) per ha. Adult emergence, moth numbers and virus stability and activity were monitored to assess the effectiveness of the program. Adult emergence was reduced significantly (82.7%) in naturally-infested enclosure cages treated with the virus. Pheromone trap data suggested that total moth emergence was reduced 47% compared with moth emergence in untreated areas. Wild geranium treated with the virus retained >50% of the original activity 3 days after virus application. Virus mortality was >80% from samples collected randomly immediately after application. A grower-funded program for managing Heliothis/Helicoverpa has been proposed for the Mississippi Delta that would encompass approximately 324,000 ha at an estimated total cost of US$ 1,905,120.

Introduction

The cotton bollworm, *Helicoverpa zea* (Boddie), and the tobacco budworm, *Heliothis virescens* (F.) are multivoltine pest species on cotton and other cultivated crops. In the Mississippi Delta, these pests are active prior to the availability of host crops and the first larval generation of these species develops on wild host plants (Stadelbacher, 1981). The principal wild host plant is a wild geranium, *Geranium dissectum* L. (Stadelbacher, 1979) with *H. zea* larvae usually found one week earlier than *H. virescens* larvae among wild host plants in the Delta of Mississippi (Stadelbacher, 1981).

Knipling and Stadelbacher (1983) proposed an area-wide approach to *Heliothis* management that would implement preventative suppression tactics to manage tobacco budworm and cotton bollworm populations during the first generation, as opposed to managing the pests during later generations with chemical insecticides. Several potential control tactics were discussed, including application of the nucleopolyhedrovirus, *Helicoverpa zea* SNPV (HzSNPV). Since 1990, an area-wide management program with HzSNPV has been conducted in the Delta to control the first generation of cotton bollworm and tobacco budworm in geranium before the later generations move to cotton (Hardee and Bell, 1996). The cost of the program at roughly $29.00 per hectare of cotton may still be prohibitive to most growers. Application and spray oil adjuvants are relatively fixed costs. However, it may be possible to use lower virus application rates and still obtain adequate suppression of the pest population. This paper reports the results from the 1997 area-wide management program with HzSNPV at a lower virus application rate.

Material and Methods

Treatment Site and Virus Application

A circular treatment area was established near Bourbon, MS (N33$_0$ 19.386' W90$_0$ 47.908') with an 8 km radius that encompassed approximately 40,500 ha. The HzSNPV formulation used in this study consisted of Gemstar™ LC (Thermo Trilogy, Inc.) diluted in water with an equal volume of cottonseed oil (PBSY) containing an emulsifier (7%) (Quality Unlimited Products). The HzSNPV formulation was applied aerially at an application volume of 2.33 liters per ha. Aerial application of the virus was carried out from May 4 to May 6 at a rate of 2.47 X 10^{11} occlusion bodies (OB's) per ha.

Laboratory bioassays were conducted to verify virus activity as described by (Bell and Romine, 1986) with the following modifications. Six concentrations of virus were incorporated into the diet by dispersing each pathogen concentration in 30 ml of distilled water and blending with 270 ml of diet. Colony-reared *H. virescens* were used in all the assays that were conducted at 30$_0$ C.

Enclosure Cage Sampling

Sixteen plots (26.8 m^2) with *G. dissectum* were selected at two locations in the treatment area. Plot edges were mowed and the plots were randomized in a complete block design with four replicates of four treatments. Treatments within each replicate consisted

of an untreated naturally infested control, a naturally-infested virus treatment, an artificially-infested control, and an artificially-infested virus treatment. The plots selected for artificial infestation were treated on 23 April with methyl-parathion (0.25 lb ai/acre) to reduce parasites and predators. Neonate *H. zea* and *H. virescens* were released daily (100/species) into the artificially infested plots during the four days preceding aerial application. Control plots were covered with plastic during the aerial application. Enclosure cages (26.8 m_2 x 1.8 m high) were set up the following day on each treatment. Each treatment cage was monitored daily for adult emergence from 30 May until 3 July. Earlier studies have shown that each enclosure cage isolated a representative sample of tobacco budworm and cotton bollworm larvae. The number and species of moths emerging in each cage were recorded for data analysis.

Virus Sampling

Eight plots of *G. dissectum* were selected at two locations in the treatment area, and the plot edges were mowed to assist in identifying plot boundaries. Untreated control plots were covered with plastic during the virus application. The control plots were entered first on each sampling date to reduce contamination. Virus mortality was confirmed by microscopic examination of all cadavers that did not display the characteristic signs of infection.

Viral Persistence

Plant terminals of *G. dissectum* were removed randomly from both the control and virus treated plots at 0, 1, 3, 5, and 7 days post-application. Thirty-two *H. virescens* larvae (6 day old) were individually fed a single plant terminal for 48 hrs from each plot on a given sampling date. Those failing to consume the entire plant terminal were excluded from the assay. Each remaining larva was transferred to a 30 ml cup containing artificial diet and reared for 14 days at 30_0 C. Virus inactivation was measured by recording viral mortality at 7, 10, and 14 days after the initial feeding period.

Viral Prevalence

Neonate *H. zea* and *H. virescens* (1000/species) were released into each control and virus treated plot on each day for the four days preceding aerial application. Vegetation was removed from half of each plot on 16 May (10 days post-application) and 22 May (16 days post-application). Larvae were removed from the vegetation and individually transferred to 30 ml diet cups. The larvae were returned to the laboratory for identification (Oliver and Chapin, 1981) and reared at 30_0 C. Larvae were examined at 7, 10, and 14 days after placement in diet cups and the total virus-caused mortality was tabulated at 14 days.

Pheromone Trap Sampling

Pheromone trap counts were used to evaluate the number of adult tobacco budworms and cotton bollworms in the treated area compared to the untreated surrounding area during the period of time moths were emerging from early season hosts. A sampling transect ran east to west through the study site centre and extended 4.8 km beyond the study site boundaries. Sampling sites were located every 1.6 km along the transect with two (one each for cotton bollworm and tobacco budworm) standard cone traps (Hartstack *et al.*, 1979) established at each site. Trap contents were sorted for identification and counted three times each week over the 12-week period following virus application.

Statistical Analysis

A log transformation was used on the adult emergence data to approximate a normal distribution. Enclosure cage data were analyzed by analysis of variance and means were compared by least significant difference (SAS Institute, 1989). Means and standard errors reported in Table 1 were calculated from the untransformed data. Original activity remaining (OAR) in the viral persistence study was calculated by dividing percent mortality of sample at a given time period by the percent mortality at 0 h and multiplying by 100.

Results and Discussion

The 1997 studies with a dose 2.47 X 10_{11} occlusion bodies (OB's) per ha. (ca. 50 larval equivalent (LE)/ha) appeared to be effective at reducing *H. zea* and *H. virescens* adult emergence. Overall, *H. zea* adult emergence among all of the treatments in the study area was low, so these data were combined with the *H. virescens* adult emergence data for analysis. Adult emergence within the enclosure cages began on 9 June and ended on 25 June. In the naturally-infested cages, a significant reduction ($P < 0.05$) in adult emergence (82.7%) was observed for the virus treatments compared with the control (Table 1). A significant reduction ($P < 0.05$) of 77% in adult emergence was also detected for the artificially-infested cages treated with virus compared to the control (Table 1).

Virus inactivation on geranium did not occur rapidly. Most of the viral activity was lost between day 3 and 5 post-application. Viral mortality among larvae fed geranium terminals 5 days after application had decreased to 11% of the original virus activity (Fig. 1). This was substantially lower than the 75% virus mortality reported at 6 days post-application for tobacco budworms at the higher HzSNPV application rate (Bell and Hardee, 1994). The lower virus activity on geranium terminals observed 5 days after application in this study can be explained by the lower virus application rate.

Prevalence in the virus-treated plots for the two collection dates showed >69% virus mortality. Virus

mortality observed in the control plots was attributed to contamination (Table 2).

Mean total trap captures per week for the two sampling sites along the transect near the centre of the virus treatment area (treated) and at the two sampling sites along the transect that were furthest from the centre of the treatment area (control) are presented in Figure 2. *H. zea* was the predominant species with 71 % present in the control and treated areas. Tobacco budworm moth captures in the centre of the virus treatment area averaged 21 moths/trap/week versus 49 moths/trap/week in the untreated area during peak trap capture, representing a 57% reduction in tobacco budworm moth captures. Trap counts for cotton bollworms in the centre of the virus treatment area averaged 62 moths/trap/week, whereas moth captures in the surrounding untreated area averaged 108 moths/trap/week for a 43% reduction in trap captures.

Results from the pheromone trap capture data suggest that the virus application was less effective in reducing *H. zea* moth emergence than *H. virescens* moth emergence (Figure 2). These results were consistent with earlier area-wide pheromone trap capture results (Hardee and Bell, 1996). Timing of application or movement into the treatment area was considered to be the primary factors responsible for the lack of reduction in cotton bollworm moth emergence in the treatment area. The pheromone trap sites reported for the treatment area were only 3.2 km from its border. Movement of 8 km and upwards to 19 km has been reported for *H. virescens* and *H. zea*, depending on environmental conditions (Hayes, 1991). This degree of movement could have a significant impact on any attempt to evaluate the success of the 1997 area-wide program using pheromone trap capture data.

Projected Cost Analysis

A grower-funded program for managing *Heliothis/Helicoverpa* has been proposed for the Mississippi Delta, encompassing approximately 324,000 ha. A conservative estimate on the amount of cotton planted in this area would be approximately 91,000 to 101,000 ha, although this amount may vary by 20% for a given year. The total grower contribution per cotton acre can be calculated by determining the total cost of the program and dividing by the total acreage of cotton planted in the treated area.

The estimated cost for aerial application of the virus would range from $1.24 to $1.73 per ha and the cost for the oil adjuvant would be approximately $1.06 per ha. Thus, the estimated total cost for the aerial application and oil adjuvant would not exceed $2.79 per ha. Virus costs would be $3.09 per ha at the lower application rate. The estimated total cost for the program would be $5.88 per ha or $1,905,120 for the entire area. The area-wide virus program at the current virus application rate has an estimated cost of $28.70 per hectare of cotton ($11.61 per cotton acre). The lower virus application rate apparently provided adequate suppression of the pest population. Therefore, it may be possible to reduce grower costs to approximately $19.00 per ha of cotton ($7.69 per cotton acre), a 34% reduction in total cost for future area-wide management programs.

Disclaimer

Mention of a proprietary product does not constitute an endorsement by the USDA.

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Table 1. Cotton bollworm and budworm emergence from geranium in area-wide virus Program in 1997.

Infestation	Treatment	No. Moths/Cage (Mean ± SEM[1])
Natural	Control	33.5 ± 8.6
Natural	Virus	5.8 ± 1.8
Artificial	Control	88.5 ± 22.4
Artificial	Virus	20.3 ± 6.3

[1] n = 4 cages / treatment

Table 2. Virus prevalence in cotton bollworm and tobacco budworm populations in wild geranium[1].

Treatment	Collection Date	% Virus Mortality (Tot. No.)	Adult Emergence (Total No.)	
			H. virescens	*H. zea*
Control	May 16	7.7 (26)	2	8
Virus	May 16	73 (37)	1	4
Control	May 22	5.3 (38)	3	12
Virus	May 22	69 (51)	2	6

[1] Larvae collected at 10 and 16 days post application. The total larvae were collected from 4 plots for each treatment.

Figure 1. Viral persistence in geranium (1997 field test).

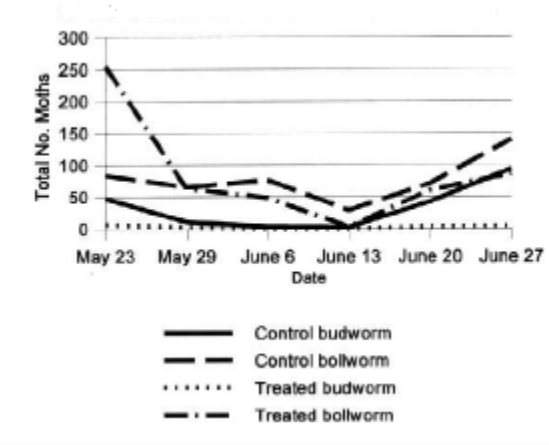

Figure 2. Moth pheromone trap captures in 1997.