Incorporating Nuclear Polyhedrosis Virus Into an IPM Program for Corn Earworm in Sweet Corn

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Summary

An aerially applied insecticide trial comparing the biopesticide Gemstar in rotation with spinosad to traditionally used pyrethroids for corn earworm control in sweet corn was conducted in western Colorado during 2004. Corn earworm damaged 5.3% of the ears in lambda-cyhalothrin (Warrior) treated plots, 8.8% in plots treated with a rotation of Gemstar and spinosad (Spintor), and in 16.5% in untreated plots averaged over ten sweet corn varieties. There were differences in insecticide performance among varieties, but. differences in control between the Gemstar/spinosad combination and pyrethroids were not significantly different in any variety. Banks grass mite populations were greatest in the Gemstar/spinosad treated plots, while aphid populations were greatest in the untreated plots.

Background

Sweet corn is an important crop in western Colorado. The success of this crop is based on consistent quality, of which a major concern is insect-damage free ears. The crop is typically treated for corn earworm, *Helicoverpa zea*, with pyrethroid and carbamate insecticides on a two or three day schedule beginning with silk emergence. The frequency of insecticide application is dependent upon pheromone trap captures, and is based on a model which has been developed by the local industry over time. Any sweet corn field is treated ten to fifteen times, depending on variety and corn earworm pressure. Corn earworm control had been excellent until 2002, when control failures and near failures became common. Resistance to pyrethroid and carbamate insecticide is the most probable cause of the control failures.

Corn earworm resistance to pyrethroids is an issue which is increasingly experienced in North America and other regions where it is present. The Australians experienced total loss of their 50,000 ton crop in 1996 as *Helicoverpa* developed resistance to pyrethroid and carbamate insecticides. A transition to a Nuclear Polyhedrosis Virus (NPV) based spray program using Gemstar and spinosad has reduced *Helicoverpa* damage by 85% (http://www.nre.vic.gov.au/agvic/ihd/projects/sc.htm). This program has been more successful when materials are applied by ground, using drop nozzles and higher spray volume to guarantee good coverage of the ears. It is typically used in combination with releases of egg parasitoids. Sweet corn for export requires sorting with X-ray technology to separate infested from uninfested sweet corn ears.

Methods

An aerially applied insecticide trial comparing the traditional pyrethroid treatments (Warrior, Syngenta Crop Protection) to a rotation of NPV (Gemstar, CertisUSA) and spinosad (Spintor, Dow AgroSciences) was conducted in Delta County CO during the summer of 2004. The experiment was placed in a sweet corn variety trial belonging to a production and marketing company. Treatments were aerially applied perpendicular to the furrow irrigated 30" rows. There were 13 varieties in the trial, but only 10 were included in the experimental analysis. The varieties on either end of the trial (‘Double Play’ and ‘Miracle’) were not included because spray coverage was not complete. Another variety (‘Head Start’) was much earlier maturity than other varieties ad the initial spray was not started in a timely fashion. Experiment details are outlined in Table 1.

Insecticides were applied on a three day schedule beginning with the appearance of the first silk within the field. A cone type *Heliothis* pheromone trap was placed on the NW corner of the field, and checked daily. The application schedule remained at three days until13 or more moths were captured on

Table 1. Plot location, design, application equipment, and treatments.

Location	Mountain Fresh Farm, 54, 1500 Rd, Delta CO 81416, GPS
Plot Design	Randomized complete block, split plot; Variety (10) main plot, insecticide treatment (3) sub plot; three replications
Plot size	Insecticide spray swath 74 ft, all sampling from center 25 ft of swath; Width of variety strip varied from 20 to 80 ft, depending on variety
Application equipment	Air Tractor AT302A; applications made at 5 gallons per acre
Insecticide treatments	1) Rotation of Gemstar LC, 4 oz/A, and Spintor 2SC, 3 oz/A; The first three applications were a combination of the 2 materials, with the rotation beginning with the fourth application 2) Pyrethroid standard, Warrior with Zeon Technology, 3.86 oz/A 3) Untreated control

Table 2. Insecticide application dates, materials, and environmental conditions.

Date	Insecticide	Rate	Time	Temp ˚F	Wind
July 13	Warrior ZT	3.84 oz.	7:33	73	SE 2
	Gemstar/Spintor	4 oz./3 oz.	7:53	73	SW 2
July 16	Warrior ZT	3.84 oz.	7:30	68	SW 1
	Gemstar/Spintor	4 oz./3 oz.	7:51	68	NE 1
July 19	Warrior ZT	3.84 oz.	8:14	67	SE 1
	Gemstar/Spintor	4 oz./3 oz.	8:31	70	NE 1
July 22	Warrior ZT	3.84 oz.	9:06	71	NE 2
	Spintor	3 oz.	9:33	72	NE 2
July 25	Warrior ZT Dyne-Amic	3.84 oz./3 oz.	8:52	65	NE 0
	Gemstar	4 oz.	9:21	65	NE 0
July 28	Warrior ZT Dyne-Amic	3.84 oz./3 oz.	7:53	55	SW 1
	Spintor Dyne-Amic	3 oz./3 oz.	8:55	58	SW 2
July 31	Warrior ZT Dyne-Amic	3.84 oz./3 oz.	8:37	70	SE 1
	Gemstar Dyne-Amic	4 oz./3 oz.	8:22	68	SE 1
Aug. 2	Warrior ZT	3.84 oz.	9:04	70	NE 1
	Spintor Dyne-Amic	3 oz./3 oz.	9:10	71	SW 1
Aug. 4	Warrior ZT	3.84 oz.	10:21	72	N 1
	Gemstar	4 oz.	10:39	72	N 1
Aug. 6	Warrior ZT	3.84 oz.	12:36	78	NE 2

consecutive days. When this happened, the spray schedule went to a two day interval. The insecticide application schedule is presented in Table 2 and is displayed in Figure 1.

The plots were evaluated five times. There were four varieties that were sampled on each sample date. These varieties were chosen because their first silk date was nearest to optimum timing for ideal corn earworm control. Each of the ten varieties that were evaluated were sampled when the ears were determined to be harvest-mature. Twenty-five ears of each variety were chosen randomly from the center of each plot when samples were taken. They were removed from the field, husked and CEW damage and larvae counted. Corn earworm larvae were separated by instar class: I-II, III-IV, V-VI based on size.

Six varieties (Table 5) were sampled for non-target insects (beneficial insects and other pest species). Non-target insects were evaluated from five random ear leaves in the center of each plot. Leaves were collected in paper bags, removed from the field and cooled immediately. Insects were extracted in Berlese funnels for 24 h before counting. Arthropods that appeared consistently in samples were counted, while those that appeared only on an irregular basis were not counted.

Results

A synopsis of experimental results is displayed in Figure 1. This includes CEW flights, infestation data from each sample date, and size distribution of CEW larvae recovered from the samples. CEW flights increased in the second half of the spray period, and a two day spray schedule was triggered by consecutive captures of more than 13 moths on Aug 1.The increase in corn earworm flights in late July was experienced over the entire sweet corn production region, not only at this field.

Corn earworm infestation data by variety, insecticide treatment and variety x insecticide is displayed in Table 3. Earworm damage varied among varieties from 3.3% to 26.7% in untreated plots. Warrior treated plots had numerically less CEW damage than Gemstar/Spintor treated plots on all sample dates, but differences were not significant (P=0.05) when averaged over all varieties. The number of CEW larvae recovered from ears followed the same trend. Both treatments had fewer CEW damaged ears than the untreated control. Earworm control with Gemstar/Spintor, as compared with the untreated control, increased over time. This is as expected, since nuclear polyhedrosis virus is a slow acting material, and infected caterpillars have time to enter the ears before dying. No instar 5/6 larvae were found in any Gemstar/Spintor treated plots, while they were present in Warrior-treated and untreated plots on the final sample date.

Non-target insect count data are displayed in Table 4. Banks grass mite infestation was significantly greater in the Gemstar/Spintor treated plots than either the Warrior treated or untreated plots. Aphid abundance (mostly corn leaf aphid, *Rhopalosiphum maidis*) was greatest in the untreated and Gemstar/Spintor treated plots. Warrior is effective at reducing mite and aphid numbers in the absence of significant beneficial insect populations. Western flower thrips counts varied with variety, but not insecticide treatment. There were too few beneficial insects found in any samples to count.

The rotation of Gemstar and Spintor is effective in reducing CEW populations in sweet corn, but control levels are no different, and probably slightly worse than the traditional pyrethroid spray programs. Differences in control between sweet corn varieties are not easily explained, and more research will be necessary to determine if these hold up in other years or locations. The performance of either insecticide program is currently unacceptable to sweet corn buyers, and changes to the control program are needed. The performance of the biopesticide program closely matches the experience from Australia in the mid 1990's. The Australians increased the performance of the Gemstar/spinosad rotation by altering application methods to the use of high-boy type sprayers with drop nozzles at relatively high spray volume. This would be difficult under western Colorado conditions because of heavy soils and high summer temperatures which require weekly irrigation during the time between silking and harvest. This tight irrigation schedule prohibits ground traffic in the fields for several days after water is applied. Gemstar may play a role in CEW control programs in sweet corn, but further research involving tank mixes and application methods is needed to define what that role is.

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Table 3. Corn earworm and sap beetle larvae infestation data. A 2-way analysis of variance was conducted for the randomized complete block, split plot design. Means displayed are for Variety (main plot; top), subplot (insecticide, middle), and variety x insecticide interaction (bottom). Means within a column grouping followed by the same letter are not significantly different (LSD, P=0.05).

Variety	Insecticide	% CEW	Damage	CEW larvae/100ears		% SB larvae	
Accord		11.1	ABCD	5.8	A	0.9	B
EX8487249		6.7	BCD	2.7	ABC	1.3	B
Buccaneer		11.7	ABC	0.4	C	4.0	A
Charmed		3.9	D	3.1	ABC	0.0	B
Eureka		13.3	AB	4.9	A	0.0	B
Chief Ouray		17.2	A	4.9	A	0.0	B
Breeders Choice		12.8	AB	4.0	AB	4.9	A
EX8414247		4.4	CD	0.9	BC	0.0	B
PX9330109		10.6	ABCD	3.1	ABC	0.4	B
Ogunquit		10.6	ABCD	5.8	A	0.0	B
	Gemstar/Spintor	8.8	B	3.1	B	1.3	
	Warrior	5.3	B	1.5	B	0.7	
	Untreated	16.5	A	6.1	A	1.5	
Accord	Gemstar/Spintor	8.3	DEFG	6.7	BCD	1.3	
Accord	Warrior	3.3	FG	0.0	F	0.0	
Accord	Untreated	21.7	ABC	10.7	AB	1.3	
EX8487249	Gemstar/Spintor	6.7	EFG	1.3	EF	1.3	
EX8487249	Warrior	0	G	0.0	F	1.3	
EX8487249	Untreated	13.3	BCDEF	6.7	BCD	1.3	
Buccaneer	Gemstar/Spintor	13.3	BCDEF	0.0	F	5.3	
Buccaneer	Warrior	3.3	FG	0.0	F	2.7	
Buccaneer	Untreated	18.3	ABCDE	1.3	EF	4.0	
Charmed	Gemstar/Spintor	5	FG	4.0	CDEF	0.0	
Charmed	Warrior	3.3	FG	2.7	DEF	0.0	
Charmed	Untreated	3.3	FG	2.7	DEF	0.0	
Eureka	Gemstar/Spintor	20	ABCD	8.0	BC	0.0	
Eureka	Warrior	10	CDEFG	1.3	EF	0.0	
Eureka	Untreated	10	CDEFG	5.3	CDE	0.0	
Chief Ouray	Gemstar/Spintor	11.7	CDEFG	5.3	CDE	0.0	
Chief Ouray	Warrior	18.3	ABCDE	4.0	CDEF	0.0	
Chief Ouray	Untreated	21.7	ABC	5.3	CDE	0.0	
Breeders Choice	Gemstar/Spintor	8.3	DEFG	4.0	CDEF	5.3	
Breeders Choice	Warrior	3.3	FG	0.0	F	2.7	
Breeders Choice	Untreated	26.7	A	8.0	BC	6.7	
EX8414247	Gemstar/Spintor	1.7	FG	0.0	F	0.0	
EX8414247	Warrior	0	G	0.0	F	0.0	
EX8414247	Untreated	11.7	CDEFG	2.7	DEF	0.0	
PX9330109	Gemstar/Spintor	11.7	CDEFG	1.3	EF	0.0	
PX9330109	Warrior	6.7	EFG	4.0	CDEF	0.0	
PX9330109	Untreated	13.3	BCDEF	4.0	CDEF	1.3	
Ogunquit	Gemstar/Spintor	1.7	FG	0.0	F	0.0	
Ogunquit	Warrior	5	FG	2.7	DEF	0.0	
Ogunquit	Untreated	25	AB	14.7	A	0.0	

Table 4. Non-target insect abundance in six varieties. Means within a column group followed by the same letter are not significantly different (LSD; P=0.05)

Variety	Insecticide	BGM		Aphid		WFT	
Accord		54.7		12.2		6.9	A
EX8487249		9.3		1.8		8.1	A
Buccaneer		8.1		0.0		1.8	B
Charmed		47.6		4.4		1.3	B
Breeders Choice		88.9		2.9		1.1	B
PX9330109		27.1		6.4		0.7	B
	Gemstar/Spintor	86.8	A	4.3	AB	3.6	
	Warrior	9.6	B	0.1	B	2.7	
	Untreated	21.4	B	9.5	A	3.7	
Accord	Gemstar/Spintor	97.7		4.0	B	5.7	ABCD
Accord	Warrior	24.3		0.3	B	5.0	BCD
Accord	Untreated	42.0		32.3	A	10.0	AB
EX8487249	Gemstar/Spintor	5.3		3.0	B	12.0	A
EX8487249	Warrior	14.0		0.0	B	7.3	ABC
EX8487249	Untreated	8.7		2.3	B	5.0	BCD
Buccaneer	Gemstar/Spintor	12.3		0.0	B	0.3	D
Buccaneer	Warrior	1.7		0.0	B	0.3	D
Buccaneer	Untreated	10.3		0.0	B	4.7	BCD
Charmed	Gemstar/Spintor	128.3		11.3	B	1.7	CD
Charmed	Warrior	2.3		0.0	B	0.7	D
Charmed	Untreated	12.0		2.0	B	1.7	CD
Breeders Choice	Gemstar/Spintor	219.0		7.3	B	1.0	CD
Breeders Choice	Warrior	10.7		0.0	B	1.7	CD
Breeders Choice	Untreated	37.0		1.3	B	0.7	D
PX9330109	Gemstar/Spintor	58.3		0.3	B	0.7	D
PX9330109	Warrior	4.3		0.0	B	1.0	CD
PX9330109	Untreated	18.7		19.0	AB	0.3	D

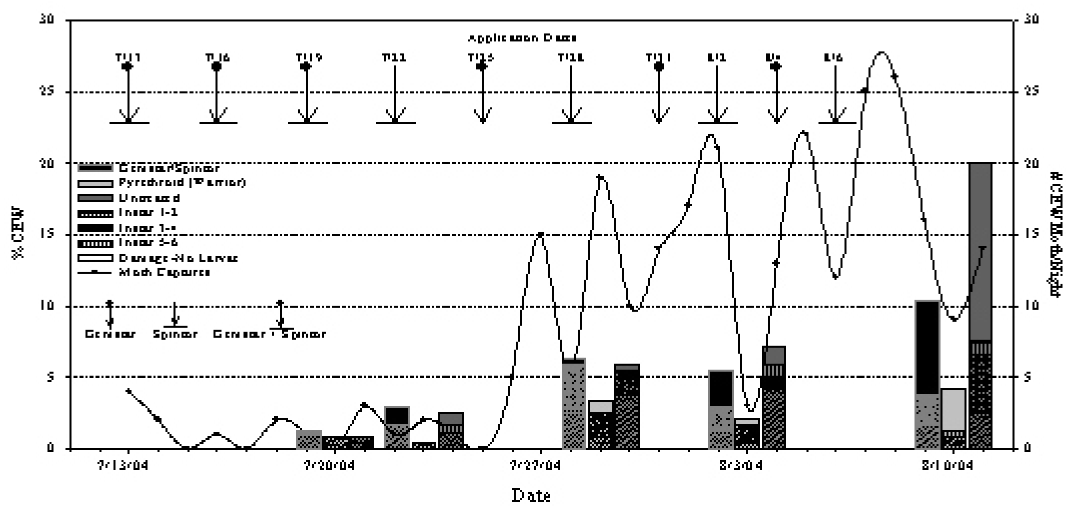

Figure 1. Corn earworm damage (bar graph), and instar distribution (shading within bars) within insecticide treatments (bar grouping) on six sample dates. Corn earworm moths captured per night (line graph) are displayed on right axis. Insecticide application schedule is marked with arrows.