Ohio Vegetable & Small Fruit Research & Development Program
2007 Report on Research

Project Title: **New Corn Earworm Management for Fresh Market Sweet Corn**
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Objectives(s) of research proposal:
1. Evaluate efficacy of conventional and experimental insecticides for corn earworm control.
2. Compare corn earworm larval infestations of a Bt sweet corn hybrid (Attribute BC 0805) with it's non-Bt isoline hybrid (Providence) under several insecticide spray treatments.

Introduction
Since 2000, there have been many documented reports throughout the Midwest of corn earworm resistance to the pyrethroid class of insecticides, which are widely used and cost effective (Capture, Warrior, Baythroid, etc.). While this is usually not a problem for early planted sweet corn, mid to late plantings (planted mid May through late June) can require 3-6 insecticide applications to keep the ears clean. Even with numerous insecticide applications, due to growing resistance to pyrethroid chemistry, control is often not acceptable. The potential loss of efficacy of these products requires proactive investigation into replacement insecticides and other alternatives to control earworm, such as the use of transgenic Bt sweet corn.

We evaluated combinations of pyrethroid, carbamate, and new insecticide chemistries with conventional and Bt sweet corn hybrids in research trials conducted at the OARDC Western Agricultural Research Station in South Charleston (Table 1). The new non-pyrethroid chemistries included in this trial are "Coragen" from DuPont, "Radiant" from Dow, "Alverde" from BASF, and "Belt" from Bayer.

Methods
The plots were 4 rows wide, centered on 30 in, 40 ft long, and replicated 4 times in a randomized complete block design. The planting date was June 16th, a late planting date intended to maximize corn earworm pressure. The plots were treated using a boom sprayer outfitted with ConeJet-18 drop nozzles directed at the ear zone using at 50-55 PSI at 45 GPA.

Insecticide sprays for all treatments were applied on a three day schedule beginning August 17th, ending September 1st. The exceptions to the application schedule were treatment 1 which received no sprays, treatment 2 which received only two sprays (8/29, 9/1) at the wilted and brown silk stages, and treatment 3 which received only the first 5 sprays due to label rate restrictions. Treatment plots were evaluated on September 5th and 6th by harvesting 25 ears from the middle two rows. Ears were examined and rated for presence of insect larvae and overall kernel damage. Data were subjected to analysis of variance (ANOVA) and mean comparisons by least significant difference (LSD) tests in the SAS 9.1 microcomputer statistics program.

Table 1. Corn earworm insecticide trial treatments.

Treatment	Hybrid	Sprays 1 & 2	Sprays 3-6
1 [A]	Attribute (Bt)	None	None
2 [B]	Attribute (Bt)	Capture (6.4 oz/A)	None
3 [A]	Providence	Capture (2.56 oz/A)[C]	Capture (2.56 oz/A) [C]
4 [A]	Providence	Capture (6.4 oz/A)	Warrior (3.84 oz/A)
5	Providence	Capture (6.4 oz/A) + Lannate LV (24 oz/A)	Larvin 3.2 (30 oz/A)
6 [A]	Providence	Warrior (3.84 oz/A)	Warrior (3.84 oz/A)
7	Providence	Coragen (5.1 oz/A)	Coragen (5.1 oz/A)
8	Providence	Coragen (6.7 oz/A)	Coragen (6.7 oz/A)
9	Providence	Radiant (6 oz/A)	Radiant (6 oz/A)
10	Providence	Alverde (16 oz/A)	Alverde (16 oz/A)
11	Providence	Belt (3 oz/A)	Belt (3 oz/A)
12 [A]	Providence	**Untreated check**	**Untreated check**
13 [A]	Providence	Hero (Capture + Mustang Max) @ 6 oz/A	Hero (Capture + Mustang Max) @ 6 oz/A
14	Providence	Capture (6.4 oz/A)	Larvin 3.2 (30 oz/A)

[A] Midwest Corn earworm resistance trial treatment.
[B] Two sprays applied only at wilted and brown silk stage, 8/29 & 9/1.
[C] Label limit 5 sprays per season.

Results

The corn earworm population was exceptionally high during the trial. Corn earworm (CEW) was the most abundant species found at harvest, but European corn borer (ECB) and fall armyworm (FAW) were also found. In tables 2 and 3, kernel injury from all pests (Fall armyworm, Corn earworm, and European corn borer, etc.) were quantified in both the tip and the overall ear. There were significant differences in kernel protection between the untreated check and all insecticide treatments. Attribute (Bt) plus Capture, Attribute (Bt), and Hero were among the best treatments at reducing tip injury. These treatments plus Coragen at the high rate kept overall ear kernel injury to a minimum. The treatments with Capture and Larvin or Lannate performed in the bottom tier of all treatments. In general, treatments listed in green had statistically lower tip and overall ear kernel damage compared to treatments listed in red text.

In tables 4 and 5, the number of Corn earworm found on the ear and the total number of insect pests (Fall armyworm, European corn borer) found on the ear was analyzed by treatment. There were significant differences in insect infestation between the untreated check and all insecticide treatments. Attribute (Bt) plus Capture, Hero, Coragen at the high rate, Radiant, and Capture at the low rate, were among the best treatments at reducing insect pests in the ear. Although statistically similar to six other treatments, Hero was among the best in reducing all insect pests in the ear. The treatments with Capture and Larvin or Lannate performed in the bottom tier of all treatments. In general, treatments listed in green had statistically fewer Corn earworm and fewer overall insect larvae infesting the ears compared to treatments listed in red text.

Table 2. Mean number of kernels damaged in the ear tip.

Treatment	Tip
Attribute (Bt) + Capture high	**1.9 F**
Attribute (Bt)	**2.0 F**
Hero	**2.2 F**
Coragen high	2.6 EF
Capture low	3.8 DEF
Capture high, then Warrior	3.9 DEF
Warrior	4.1 DEF
Radiant	4.8 DEF
Belt	5.7 CDE
Capture high, then Larvin	6.4 CD
Coragen low	6.9 CD
Capture high + Lannate, then Larvin	8.5 C
Alverde	16.6 B
Untreated	23.0 A
P (trtmt effect)	<0.0001

Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.

Table 3. Mean number of kernels damaged in the overall ear.

Treatment	Overall
Attribute (Bt) + Capture high	**1.9 E**
Attribute (Bt)	**2.1 E**
Hero	**2.6 E**
Coragen high	**2.6 E**
Capture high, then Warrior	4.2 DE
Capture low	4.2 DE
Radiant	5.0 DE
Belt	6.1 CD
Warrior	6.2 CD
Capture high, then Larvin	6.7 CD
Coragen low	6.9 CD
Capture high + Lannate, then Larvin	8.5 C
Alverde	16.7 B
Untreated	25.8 A
P (trtmt effect)	*<0.0001*

Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.

Among pyrethroid treatments, Hero alone performed best and Warrior alone performed worst, while Capture alone and Capture/Warrior were intermediate. Most larvae were found in kernels in the tip of the ear, but many were also found in silks (Table 6). Most of the corn earworm larvae found at harvest were in the middle size range for all ear sub-locations combined (Table 6)

and for location in kernels at the tip or middle of ears (Table 7), but the average size was smaller for corn earworm larvae found in husks and silks (Table 8).

Table 4. The mean number of Corn earworm larvae in each ear.

Treatment	CEW
Attribute (Bt) + Capture high	**0.4 F**
Hero	**0.4 F**
Coragen high	**0.4 F**
Radiant	**0.4 F**
Capture low	**0.5 F**
Coragen low	0.6 DEF
Attribute (Bt)	0.6 EF
Capture high, then Warrior	0.6 EF
Warrior	0.6 EF
Belt	0.9 DE
Capture high, then Larvin	1.0 D
Capture high + Lannate, then Larvin	1.4 C
Alverde	2.0 B
Untreated	2.7 A
P (trtmt effect)	<0.0001

Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.

Table 5. The mean number insect larvae (Corn earworm, Fall armyworm, and European corn borer) per ear.

Treatment	All Pests
Hero	**0.4 G**
Coragen high	0.5 FG
Radiant	0.5 FG
Warrior	0.6 EFG
Capture low	0.6 FG
Capture high, then Warrior	0.7 EFG
Coragen low	0.8 EFG
Belt	1.0 EF
Capture high, then Larvin	1.1 DE
Capture high + Lannate, then Larvin	1.5 CD
Attribute (Bt) + Capture high	1.8 BC
Alverde	2.2 B
Attribute (Bt)	2.3 B
Untreated	3.6 A
P (trtmt effect)	*<0.0001*

Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.

Table 6. Location in ear and size of corn earworm larvae in sweet corn ears at harvest on 9/5/07, Clark County, Ohio.

Treatment	Location of corn earworm larvae found at harvest[a]				Size of corn earworm larvae found at harvest[a]		
	husk	silks	tip kernels	side kernels	small	medium	large
Attribute + Capture	0 B	0.08 DE	0.27 G	0.01 B	0.25 BCDE	0.11 D	0 E
Attribute	0 B	0.10 CDE	0.44 DEFG	0.01 B	0.40 BC	0.14 D	0.01 DE
Hero	0.01 B	0.08 DE	0.27 G	0.01 B	0.02 E	0.34 CD	0.01 DE
Coragen high	0 B	0.14 CDE	0.30 FG	0 B	0.12 CDE	0.27 CD	0.05 CDE
Capture/Warrior	0 B	0.04 E	0.56 DEF	0.02 B	0.07 DE	0.46 BC	0.09 CDE
Capture	0 B	0.08 DE	0.40 EFG	0.01 B	0.07 DE	0.30 CD	0.12 CD
Radiant	0.01 B	0.07 DE	0.35 FG	0.01 B	0.15 CDE	0.22 CD	0.07 CDE
Belt	0 B	0.25 CD	0.64 CDE	0.01 B	0.30 BCDE	0.47 BC	0.13 C
Warrior	0.01 B	0.10 CDE	0.50 DEFG	0 B	0.15 CDE	0.38 CD	0.08 CDE
Capture/Larvin	0 B	0.30 BC	0.69 CD	0.02 B	0.13 CDE	0.73 B	0.15 C
Coragen low	0 B	0.08 DE	0.55 DEFG	0 B	0.10 CDE	0.38 CD	0.15 C
Capture+Lannate/ Larvin	0 B	0.51 A	0.91 C	0 B	0.55 AB	0.71 B	0.16 C
Alverde	0.03 B	0.48 AB	1.48 B	0.01 B	0.33 BCD	1.16 A	0.51 B
untreated	0.18 A	0.58 A	1.77 A	0.16 A	0.71 A	1.34 A	0.64 A
P (trtmt effect)	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*0.0013*	*<0.0001*	*<0.0001*

[a] Within each column, means followed by the same letter are not significantly different ($P>0.05$), by LSD.

Table 7. Number of corn earworm larvae in each of three size classes, in tip kernels and mid-ear kernels of sweet corn ears at harvest on 9/5/07, Clark County, Ohio.

Treatment	Number of corn earworm larvae, in each of 3 size classes, found in kernels in tip third of ears[a]			Number of corn earworm larvae, in each of 3 size classes, found in kernels in center third of ears[a]		
	small	medium	large	small	medium	large
Attribute + Capture	0.16 BCD	0.11 E	0 D	0.01 B	0 B	0 B
Attribute	0.32 A	0.12 E	0 D	0 B	0 B	0.01 B
Hero	0 E	0.26 CDE	0.01 CD	0 B	0.01 B	0 B
Coragen high	0.04 DE	0.21 CDE	0.05 BCD	0 B	0 B	0 B
Capture/Warrior	0.05 DE	0.42 BC	0.09 BCD	0.01 B	0.01 B	0 B
Capture	0.04 DE	0.25 CDE	0.11 BCD	0 B	0.01 B	0 B
Radiant	0.13 CDE	0.17 DE	0.05 BCD	0 B	0.01 B	0 B
Belt	0.13 CDE	0.40 BCD	0.11 BCD	0 B	0 B	0.01 B
Warrior	0.07 DE	0.35 BCDE	0.08 BCD	0 B	0 B	0 B
Capture/Larvin	0.04 DE	0.53 B	0.12 BC	0 B	0 B	0.02 AB
Coragen low	0.05 DE	0.36 BCDE	0.14 B	0 B	0 B	0 B
Capture+Lannate/ Larvin	0.25 ABC	0.54 B	0.12 BC	0 B	0 B	0 B
Alverde	0.16 BCD	0.85 A	0.47 A	0 B	0.01 B	0 B
untreated	0.29 AB	0.93 A	0.55 A	0.03 A	0.09 A	0.04 A
P (trtmt effect)	*0.0004*	*<0.0001*	*<0.0001*	*0.0011*	*<0.0001*	*0.0325*

[a] Within each column, means followed by the same letter are not significantly different ($P>0.05$), by LSD.

Table 8. Number of corn earworm larvae in each of three size classes, in husks and silks of sweet corn ears at harvest on 9/5/07, Clark County, Ohio.

Treatment	Number of corn earworm larvae, in each of 3 size classes, found in husks[a]			Number of corn earworm larvae, in each of 3 size classes, found in silks[a]		
	small	medium	large	small	medium	large
Attribute + Capture	0 B	0 B	0 B	0.08	0 C	0 C
Attribute	0 B	0 B	0 B	0.08	0.02 C	0 C
Hero	0 B	0.01 B	0 B	0.02	0.06 C	0 C
Coragen high	0 B	0 B	0 B	0.08	0.06 C	0 C
Capture/Warrior	0 B	0 B	0 B	0.01	0.03 C	0 C
Capture	0 B	0 B	0 B	0.03	0.04 C	0.01 C
Radiant	0 B	0.01 B	0 B	0.02	0.03 C	0.02 BC
Belt	0 B	0 B	0 B	0.17	0.07 C	0.01 C
Warrior	0.01 B	0 B	0 B	0.07	0.03 C	0 C
Capture/Larvin	0 B	0 B	0 B	0.09	0.20 AB	0.01 C
Coragen low	0 B	0 B	0 B	0.05	0.02 C	0.01 C
Capture+Lannate/ Larvin	0 B	0 B	0 B	0.30	0.17 B	0.04 AB
Alverde	0.01 B	0.02 B	0 B	0.16	0.28 A	0.04 AB
untreated	0.12 A	0.06 A	0 B	0.27	0.26 A	0.05 A
P (trtmt effect)	*0.0017*	*0.0172*	-	*0.06*	*<0.0001*	*0.0055*

[a] Within each column, means followed by the same letter are not significantly different ($P>0.05$), by LSD.

Summary

Looking at kernel injury, clearly the Attribute (Bt) hybrid with or with out the Capture sprays during late stage silking did an excellent job of reducing kernel feeding, as did the Hero insecticide. The Attribute (Bt) hybrid with or without Capture also did a good job of keeping Corn earworm out of the ear, but overall they were among the worst performers in keeping other insect larvae out of the ear. This may be in part due to a large portion of very small European corn borer larvae found alive in and around the silks on the day of evaluation, perhaps before they could feed on the Bt rich tissue which should have killed them.

While none of the treatments provided complete protection against kernel damage or larval infestation, of the new non-pyrethroid insecticides used in the trial, Coragen at the high rate and Radiant appear to be able to reduce injury to the ear and reduce insect larvae found in the ear comparable to the best treatments in the trial. Only Radiant is labeled for use in sweet corn at the time of this report. The traditional carbamate materials such as Larvin and Lannate, do not appear to be as effective as other materials in the trial.

Among pyrethroid treatments, Hero alone performed best and Warrior alone performed worst, while Capture alone and Capture/Warrior were intermediate. Most larvae were found in kernels in the tip of the ear, but many were also found in silks (Table 6). Most of the corn earworm larvae found at harvest were in the middle size range for all ear sub-locations combined (Table 6) and for location in kernels at the tip or middle of ears (Table 7), but the average size was smaller for corn earworm larvae found in husks and silks (Table 8).

In terms of Corn earworm pyrethroid resistance issues in Ohio, based on the results of this small plot trial, there is little evidence to suggest Hero, Warrior, and Capture are showing signs of field level resistance, i.e, these materials seem quite capable of controlling Corn earworm larvae and other insect pest larvae. We will of course continue to monitor and update the resistance status

of this insect as we cooperate with other Universities on Corn earworm resistance insecticide trials being conducted throughout the North Central region.

Based on the results of this trial, growers have several acceptable insecticide options to choose from to limit kernel and larval damage to sweet corn ears. If growers are looking to reduce their insecticide applications to fresh market sweet corn, then Bt sweet corn hybrids alone or in combination with insecticide sprays applied at brown or wilted silk appear to be alternative worth looking into, especially if planted early or mid season.