

Bell pepper insecticide trial, Ohio, 2013

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INTRODUCTION: The objective of this trial was to evaluate insecticides for control of European corn borer (*Ostrinia nubilalis* (Hübner), Lepidoptera: Crambidae), which is the key pest of peppers. Red bell peppers were chosen because they are a popular crop that takes longer to grow than green bell peppers and thus is more challenging to produce. Bell pepper production in Ohio in 2007 was valued at \$23 million and was ranked fourth in the nation. Ohio had 1,547 acres of bell and 1,046 acres of non-bell peppers in 2007. The standard control program for European corn borer is insecticide sprays at 7-day intervals during the time of second-generation activity; two sprays of acephate are used at peak egg hatch, followed by a pyrethroid.

METHODS

The experimental design was randomized complete block with 12 treatments and 4 blocked replicates. Four of the treatments were confidential and not included in the analysis or results below. Each plot was one single row bed, 25 feet long. Each treatment bed was flanked by an untreated guard bed. Blocks were separated by 20-foot alleys. Plant spacing was 12 inches within rows and 5 feet between rows. Plants of cv 'Aristotle' were seeded in 200-cell plug trays in a greenhouse on 1 April and transplanted on 29 May near Fremont, Ohio at the North Central Agricultural Research Station (NCARS) of the Ohio Agricultural Research and Development Center (OARDC).

The European corn borer (ECB) population was monitored by a blacklight trap that was checked five days per week and a pheromone trap that was checked once per week. Insecticide treatments were applied five times at 10-day intervals starting after traps indicated emergence of new adults that began the second generation of ECB. Spray dates were 8/8, 8/19, 8/30, 9/9, and 9/19. Sprays were applied by a CO₂ boom sprayer that delivered 45.9 gallons per acre with TwinJet nozzle tips. Six treatments used a single product: Coragen 1.67SC (chlorantraniliprole) at 5 fl oz/A, Radiant 1SC (spinetoram) at 6 fl oz/A, Avaunt 30DG (indoxacarb) at 3.5 oz/A, Orthene 97SP (acephate) at 1 lb/A, IKI-3106 (cyclaniliprole) at a low rate of 11 fl oz/A and a high rate of 16.4 fl oz/A. One treatment used a 3-product program with the first spray of Gladiator 0.25EC (zeta-cypermethrin + avermectin) at 19 fl oz/A, the second spray of Hero 1.24EC (zeta-cypermethrin + bifenthrin) at 6.4 fl oz/A, the third spray of Mustang Max 0.8EC (zeta-cypermethrin) at 4 fl oz/A, and the fourth and fifth sprays of Hero again at 6.4 fl oz/A.

Fully mature red fruit from the center 20 plants per plot were harvested four times, on 8/29, 9/11, 9/18, and 9/30. Fruit too rotten to pick were not harvested. The total number of fruit harvested per plot was counted and weighed. All fruit were sorted into two categories: marketable, if free of external damage, or cull, if showing obvious insect injury, sunscald, blossom end rot, bacterial soft rot, mechanical injury, or cracks. All fruit in both categories were cut open to determine presence of damage by caterpillars. Cutting all fruit was important because damage by European corn borer is often without external symptoms. In all harvests, fruit that were externally marketable but internally damaged were counted then subtracted from the marketable category. In the first two harvests, these culls due to internal damage were not weighed separately but in the last two harvests, these culls were weighed separately. Percentage data were transformed by arcsine square root before analysis. Data were tested by analysis of variance using the general linear models procedure in the SAS 9.3 microcomputer statistics program, and Fisher-protected least significant difference (LSD) values were used for mean comparisons.

RESULTS

The European corn borer population was about 3 weeks later than normal for most of the summer. Peak activity of the summer generation of adults was from 7 to 9 August as detected in a blacklight trap. Population trends in a pheromone trap were similar but lagging behind the trends seen in the blacklight trap (Table 1).

In the tables of results, treatments are listed in order of marketable yield. In the first harvest, damage from European corn borer was found in only five of eight treatments, in 0 to 5% of fruit. There was no significant difference among treatments in any variable analyzed ($P > 0.05$; Table 2).

In the second harvest, borer damage was found in all eight treatments, in 9 to 34% of fruit (Table 3). There was a significant difference among treatments in the number of fruit infested or damaged by borers ($P = 0.0100$) and in the percentage of fruit infested ($P = 0.0071$) although there was no significant difference in marketable yield ($P > 0.05$). There were significantly fewer borer-damaged fruit in plots treated with Coragen, IKI-3106 low rate, and IKI-3106 high rate than in the untreated control.

In the third harvest, borer damage was found in 9 to 41% of fruit. There was no significant difference among treatments in any variable analyzed ($P > 0.05$; Table 4).

In the fourth harvest, borer damage was found in 1 to 24% of fruit. There was a significant difference among treatments in marketable yield weight ($P = 0.0197$) and in the percentage of fruit infested as number ($P = 0.0043$) or weight ($P = 0.0100$; Table 5). There was significantly higher marketable yield in plots treated with Coragen, Orthene, or IKI-3106 high rate than in the untreated control.

The overall treatment effect is best seen by marketable yield in cumulative harvests, both as number of fruit and as weight of fruit. Marketable yield was significantly higher than in the untreated control in plots treated with Coragen, Orthene, IKI-3106 at the low rate, Gladiator/Hero/Mustang, or IKI-3106 at the high rate (Table 6). Marketable yield in plots treated with Avaunt or Radiant was not significantly different than the untreated control.

DISCUSSION AND CONCLUSIONS

Pepper growers have benefitted from the trend of declining populations of the European corn borer during the past decade in Ohio and throughout the Midwest, most likely due to the widespread use of transgenic B.t. field corn, but the population in 2013 was higher than it has been for several years and caused severe damage to peppers.

Although damage in most insecticide-treated pepper plots was less than in untreated plots, damage was heavier than expected in treated plots, most likely because plots were sprayed at 10-day intervals rather than the standard 7-day schedule used by most growers when pest pressure is high. The 10-day schedule was determined by the company that had confidential treatments.

Among the insecticide products tested, Coragen performed well, as did the experimental IKI-3106 (cyclaniliprole), the Gladiator/Hero/Mustang program, and Orthene. There was no significant rate effect with IKI-3106 at 11 fl oz/A versus 16.4 fl oz/A. It must be noted that the Orthene label allows only two sprays, not five sprays as done in this trial. Avaunt and Radiant did not perform as well as the other products when applied on a 10-day schedule. If a similar trial is done next year, some insecticides should be applied on a 7-day schedule.

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Table 1. Population trends of European corn borer (ECB) as detected in traps, Fremont, Ohio, 2013.

Date	Number of ECB moths in previous 7 days				Generation (estimate)
	Pheromone trap (males only)	Blacklight trap			
		Males	Females	Total	
5/7	-	0	0	0	1
5/14	-	0	0	0	1
5/21	-	0	1	1	1
5/28	-	1	1	2	1
6/4	-	0	3	3	1
6/11	-	8	2	10	1
6/18	2	3	11	14	1
6/25	7	4	3	7	1
7/2	2	0	2	1	1
7/9	22	1	1	2	1
7/16	9	3	6	9	1
7/23	0	2	1	3	1
7/30	3	2	1	3	2
8/6	0	5	6	11	2
8/13	7	37	69	106	2
8/20	10	9	27	36	2
8/27	12	19	40	59	2
9/3	45	5	4	9	2
9/10	7	0	2	2	2
9/17	1	0	0	0	2
9/24	2	0	0	0	2
10/1	0	0	0	0	-

Table 2. Yield of red bell peppers in first harvest, 8/29/2013, at Fremont, Ohio; means per 20 plants.

Treatment	Total yield		Marketable yield		Yield infested or damaged by borers		% ^a of total yield infested or damaged by borers ^a	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
Coragen	10.5	3.638	9.0	3.400	0.2	.	2.8	.
untreated	8.2	2.975	7.5	2.825	0.0	.	0	.
IKI-3106 low	7.5	2.738	7.0	2.650	0.0	.	0	.
Radiant	9.0	3.100	7.0	2.475	0.2	.	5.0	.
Gladiator/ Hero/ Mustang	7.5	2.562	6.8	2.438	0.0	.	0	.
Avaunt	8.5	2.765	6.2	2.365	0.2	.	2.5	.
IKI-3106 high	7.8	2.388	6.5	2.200	0.2	.	4.2	.
Orthene	6.5	2.325	5.5	2.100	0.2	.	2.5	.
<i>P</i> value for treatment effect in ANOVA	0.6619	0.7075	0.8350	0.7991	0.7610	-	0.7284	-

^a Means shown are actual percentage values; ANOVA based on transformed values.

Table 3. Yield of red bell peppers in second harvest, 9/11/2013, at Fremont, Ohio; means per 20 plants.

Treatment	Total yield		Marketable yield		Yield infested or damaged by borers		% ^b of total yield infested or damaged by borers ^a	
	Number	Weight (kg)	Number	Weight (kg)	Number ^a	Weight (kg)	Number ^a	Weight (kg)
Orthene	23.2	8.150	16.8	6.063	5.0 AB	.	25.3 AB	.
Coragen	19.0	6.975	15.5	5.888	1.5 C	.	12.5 CD	.
Gladiator/ Hero/ Mustang	22.2	8.113	15.5	5.838	4.2 ABC	.	25.4 ABC	.
IKI-3106 high	19.2	6.988	15.2	5.738	2.0 BC	.	11.0 BCD	.
IKI-3106 low	17.5	6.438	14.2	5.250	1.5 C	.	8.8 D	.
Avaunt	22.2	7.675	12.5	4.575	6.75 A	.	32.7 A	.
Radiant	20.0	6.588	12.2	4.375	5.5 A	.	29.2 A	.
untreated	19.8	6.950	11.0	4.113	6.75 A	.	33.6 A	.
<i>P</i> value for treatment effect in ANOVA	0.7962	0.8198	0.6321	0.6145	0.0100	-	0.0071	-

^a Within each column, means followed by same letter are not significantly different ($P > 0.05$); mean separations by LSD.

^b Means shown are actual percentage values; ANOVA based on transformed valued.

Table 4. Yield of red bell peppers in third harvest, 9/18/2013, at Fremont, Ohio; means per 20 plants.

Treatment	Total yield		Marketable yield		Yield infested or damaged by borers		% ^a of total yield infested or damaged by borers ^a	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
IKI-3106 low	15.8	5.163	11.5	4.000	3.2	0.800	18.6	14.3
Orthene	12.2	4.025	10.2	3.538	1.8	0.425	18.4	16.6
Coragen	9.2	3.113	8.5	2.963	0.8	0.150	9.4	6.7
Gladiator/ Hero/ Mustang	13.8	4.113	9.0	2.938	3.0	0.625	19.7	14.3
Avaunt	13.2	3.613	8.0	2.375	3.2	0.725	25.9	22.5
Radiant	13.2	3.463	6.0	2.013	4.0	0.788	31.3	24.0
IKI-3106 high	8.8	2.750	5.5	1.963	3.0	0.725	33.1	26.5
untreated	12.5	3.525	5.5	1.863	5.5	1.212	41.3	33.9
<i>P</i> value for treatment effect in ANOVA	0.3069	0.2266	0.2475	0.1721	0.1192	0.1190	0.0886	0.1092

^a Means shown are actual percentage values; ANOVA based on transformed valued.

Table 5. Yield of red bell peppers in fourth harvest, 9/30/2013, at Fremont, Ohio; means per 20 plants.

Treatment	Total yield		Marketable yield		Yield infested or damaged by borers		% ^b of total yield infested or damaged by borers ^a	
	Number	Weight (kg)	Number	Weight ^a (kg)	Number	Weight (kg)	Number ^a	Weight ^a (kg)
Coragen	25.0	7.888	20.8	6.775 A	0.2	0.050	1.0 C	0.7 B
Orthene	24.5	7.863	20.0	6.675 A	3.5	0.925	11.8 B	9.6 A
IKI-3106 high	20.5	6.600	17.5	5.775 AB	1.8	0.488	9.7 B	8.7 A
Gladiator/ Hero/ Mustang	23.2	6.350	19.0	5.438 ABC	2.2	0.512	10.5 B	8.7 A
IKI-3106 low	19.5	6.138	16.5	5.313 ABC	2.2	0.562	11.3 B	9.3 A
Radiant	16.8	4.913	12.2	3.838 BC	3.8	0.925	20.9 AB	18.6 A
Avaunt	19.0	5.300	12.0	3.613 BC	4.2	0.950	24.4 A	18.6 A
untreated	14.2	4.550	9.8	3.150 C	1.5	0.412	10.5 AB	9.0 A
<i>P</i> value for treatment effect in ANOVA	0.3029	0.1041	0.0711	0.0197	0.0874	0.1740	0.0043	0.0100

^a Within each column, means followed by same letter are not significantly different ($P>0.05$); mean separations by LSD.

^b Means shown are actual percentage values; ANOVA based on transformed valued.

Table 6. Cumulative yield of red bell peppers in four harvests from 8/29/2013 until 9/30/2013, at Fremont, Ohio; means per 20 plants.

Treatment	Total yield		Marketable yield		Yield infested or damaged by borers		% ^b of total yield infested or damaged by borers ^a	
	Number	Weight (kg)	Number ^a	Weight ^a (kg)	Number ^a	Weight (kg)	Number ^a	Weight (kg)
Coragen	63.8	21.613	53.8 A	19.025 A	2.8 C	.	4.7 C	.
Orthene	66.5	22.362	52.5 A	18.375 AB	10.5 AB	.	16.4 B	.
IKI-3106 low	60.2	20.475	49.2 AB	17.213 AB	7.0 BC	.	12.2 B	.
Gladiator/ Hero/ Mustang	66.8	21.138	50.2 A	16.650 AB	9.5 AB	.	14.2 B	.
IKI-3106 high	56.2	18.725	44.8 AB	15.675 BC	7.0 BC	.	12.4 B	.
Avaunt	63.0	19.353	38.8 BC	12.928 CD	14.5 A	.	23.4 A	.
Radiant	54.8	18.063	34.0 C	12.700 D	13.5 A	.	25.8 A	.
untreated	54.8	18.000	33.8 C	11.950 D	13.8 A	.	24.7 A	.
<i>P</i> value for treatment effect in ANOVA	0.4863	0.0887	0.0016	0.0002	0.0022	-	<0.0001	-

^a Within each column, means followed by same letter are not significantly different ($P>0.05$); mean separations by LSD.

^b Means shown are actual percentage values; ANOVA based on transformed valued.