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Insecticide Trial on Red Bell Peppers in Ohio, 2000

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Background:

European corn borer is the key pest of bell peppers in Ohio. To meet the pepper processors' maximum tolerance of 3% of fruit infested or damaged, this pest typically is controlled by insecticide treatments from late July until at least early September. The most common insecticide used in Ohio for control of this pest has been acephate (Orthene) used four to ten times per year at 7-day intervals, either alone or alternated with other products. Starting in the year 2000, acephate use was restricted to two applications per year. This trial was done to evaluate alternatives to an Orthene-alone control program, to supplement previous Ohio trials that included SpinTor alone and Confirm alone. Avaunt was included because it is approaching registration and data have been lacking on whether or not it is effective at controlling corn borer on peppers.

Methods:

'King Arthur' red bell peppers were transplanted from size 288 plug trays into single-row beds under black plastic mulch on 17 June 2000 at the Ohio Agricultural Research and Development Center (OARDC) Vegetable Crops Branch at Fremont, Sandusky County, in northwestern Ohio. Planting was later than normal due to frequent heavy rains. Plants were 12 inches apart and beds were on 5-ft centers. Each plot was 30 ft long by 15 ft (three rows) wide. There was an untreated guard row between adjacent plots and on field edges. There were 20-ft bare alleys between blocks.

Six treatments each with four replicates were set up in a randomized complete block design. Acephate (Orthene) alone and indoxacarb (Avaunt) alone in eight applications were compared with Orthene in the first two applications followed by six applications of spinosad (SpinTor), cyfluthrin (Baythroid), or Avaunt. The untreated control treatment was not treated with any insecticides. Orthene 97 SP (Valent Corp.) was used at 0.97 lb AI/A (= 1.0 lb product/A). Avaunt 30WDG (DuPont Co.) was used at 0.065 lb AI/A (3.5 oz product/A). SpinTor 2SC (Dow AgroSciences) was used at 0.0625 lb AI/A (4 fl oz product/A). Baythroid 2EC (Bayer Corp.) was used at 0.044 lb AI/A (2.8 fl oz product/A). All treatments included the adjuvant R-11 (Wilbur Ellis Co.) at 0.25% of volume.

Insecticide treatments that targeted second generation larvae of the European corn borer (ECB) were initiated once first generation ECB moths began emerging, as detected by a blacklight trap that was emptied five days per week. Treatments were continued until activity by ECB moths subsided. Insecticide treatments were applied 8 times at weekly intervals on 4, 11, 18, 25 August, and 1, 8, 14, 22 September. The fourth, fifth, and sixth applications were applied with a tractor-mounted CO_2-pressurized research boom sprayer that delivered 38 gallons per acre using 60 psi pressure, with D4-25 hollow cone nozzles spaced 15 inches apart, and speed of 3 mi/hr. Due to soil conditions too wet for the tractor, the first, second, third, seventh, and eighth applications were applied with a backback CO_2-pressurized sprayer with a three-nozzle boom that delivered 33 gallons per acre using 59 psi pressure, with D4-25 hollow cone nozzles spaced 19 inches apart. For disease control in all plots, copper (Champ, 2 pt/acre) and Manex (1.5 qt/A) were used on 15 and 31 August and 9 September.

Damage by European corn borer larvae and other insects was evaluated at harvests on 13 and 29 September and 17 October. All fully ripe red pepper fruit that were firm enough to pick (i.e., not rotten) were cut from a flagged 20-ft section in the center row per plot; fruit were counted, weighed, and cut open to evaluate insect infestation. Data were subjected to analysis of variance (ANOVA) followed by mean compasisons using LSD tests in the SAS JMP microcomputer program. Percentage data were transformed by arcsine square root before analysis. Data were analyzed for three individual harvests, and were pooled for analysis of cumulative harvests.

Results:

Blacklight trap sampling of adult European corn borer (Table 1) showed that two generations developed with peak catch of the overwintering generation on 2 June and with peak catch of the first summer generation on 15 August 2000. Both generations were about normal in timing and number of moths caught per week. All three harvests showed damage by second generation larvae of ECB. In all harvests, ECB was the only caterpillar species found.

In untreated plots, insect damage was extremely high throughout the harvest season as demonstrated by low yields and low percentage of fruit that were clean of insect damage. Clean fruit made up only 13% of the first harvest, 0% of the second and third harvests, and 12% of pooled harvests (Table 2).

There was a significant effect of insecticide treatment on yield expressed as weight of fruit harvested ($P < 0.0001$) or number of fruit harvested ($P < 0.0001$), for the second, third, and cumulative harvests (Table 2). Yield was significantly higher in insecticide treated plots than in the untreated plots. In the second harvest, which was the largest of the three harvests, there was no yield difference among Orthene alone and Orthene followed by Avaunt, SpinTor, or Baythroid, but these four treatments had significantly higher yield than Avaunt alone. These trends were identical for the cumulative harvests. Similar trends were found in the small third harvest except that significantly higher weight was harvested in plots treated with Orthene followed by Avaunt than with Orthene followed by Baythroid, while Orthene alone and Orthene followed by SpinTor were intermediate (Table 2).

The percentage of fruit that were clean of insect damage differed significantly among treatments in all harvests ($P < 0.0001$); there was a significantly lower percentage of good fruit in the untreated check than in all insecticide treatments, and the Avaunt alone treatment had a significantly lower percentage of clean fruit than the other four insecticide treatments (Table 2). Among the other four treatments, the rankings varied among harvests; the overall effect is best seen in the cumulative harvest, when Orthene alone and Orthene followed by Baythroid or Avaunt had significantly higher percentage of good fruit than Orthene followed by SpinTor.

The best summary of results for all variables can be seen by estimating the yield of good fruit, which combines the total yield and percentage of fruit clean of insect damage (Table 2). For the cumulative harvest data, analysis of this variable showed that Orthene alone and Orthene followed by Baythroid, Avaunt, or SpinTor were no different than each other but all four had significantly higher yield of good fruit than Avaunt alone. Avaunt alone had significantly higher yield of good fruit than the untreated check.

Discussion:

Under the conditions of heavy pressure from European corn borer seen in this trial, none of the treatments met the processors' required standard of at least 97% clean fruit in all three harvests. When data from the three harvests were pooled, the cumulative data showed that >95% clean fruit resulted from three treatments: Orthene alone, Orthene followed by Baythroid, and Orthene followed by Avaunt. Avaunt alone in 8 applications on a 7-day schedule was clearly less acceptable (61% clean fruit) than the other insecticide treatments. The intermediate performance of Orthene followed by SpinTor (89% clean fruit) could perhaps be attributed to the 7-day spray schedule. SpinTor is known to have short persistence, and it should be applied on a 5-day schedule during periods of heavy pest pressure. It is not known whether Avaunt might be more effective at shorter intervals. An additional treatment that would be useful to evaluate is Orthene in the first two applications followed by no additional treatments.

This data supplements previous Ohio trials that have evaluated SpinTor alone and Confirm alone. SpinTor alone applied on a 7-day schedule gave excellent control in 1998 when ECB pressure was low (97% clean) and in 1997 when ECB pressure was moderate (96% clean), but gave only fair control (70% clean) in 1999 when ECB pressure was high; it is likely that intensifying the SpinTor schedule to a 5-day interval would provide excellent control when ECB pressure is high. Confirm alone was tested only in 1998 when ECB pressure was low, when it provided excellent control (99% clean).

With the new Orthene restriction in effect, Ohio pepper growers also need information on which insecticides are best for managing ECB in a year with a third generation of ECB, which is devastating to peppers. In 6 of the past 11 years, there were only two generations of ECB larvae in Ohio, but in 5 of the past 11 years, there were three generations of ECB larvae in Ohio. In a year with three generations, the two applications of Orthene could be made at the time of peak egg hatch of second generation, as done in the 2000 trial, leaving alternative insecticides to be used for third generation. A second option would be to use just one application of Orthene at peak egg hatch of second generation and leave the second application of Orthene for peak egg hatch of third generation. The difficulty with this option is trying to predict in late July or early August whether or not a third generation is likely to develop. A third option might be to evaluate lower rates of Orthene. The new Orthene limit is 2 lb AI per acre per season, with control of ECB by 0.75 to 1.0 lb AI/acre per application. In Ohio trials, the 1.0 lb AI/acre rate has always been tested. Treatments that could be evaluated are three applications at 0.67 lb AI/acre, or two applications at 0.75 lb AI/acre plus one application at 0.5 lb AI/acre.

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Table 1. Weekly capture of European corn borer moths in a blacklight trap and a pheromone trap at Fremont, Ohio, in 2000.

Date (end of week)	Number of moths in blacklight trap			Number of male moths in pheromone trap
	Male	Female	Total	
5/9	0	7	7	-
5/16	7	30	37	-
5/23	13	19	32	30 (peak)
5/30	68	66	134 (peak)	9
6/6	51	57	108	10
6/13	56	76	132	2
6/20	13	19	32	1
6/27	2	4	6	0
7/4	1	0	1	4
7/11	0	0	0	4
7/18	5	6	11	4
7/25	4	5	9	6
8/1	60	148	208	22
8/8	56	149	205	18
8/15	66	184	250 (peak)	99
8/22	35	68	103	154
8/29	51	115	166	248 (peak)
9/5	46	78	124	152
9/12	19	17	36	69
9/19	0	4	4	26
9/26	1	1	2	0
10/3	0	2	2	5
10/10	1	3	4	1
10/17	0	0	0	1

Table 2. Yield of red bell pepper fruit per 20-foot length of row, and percentage of fruit clean of insect damage in three harvests at Fremont, Ohio, 2000; mean[1] of four blocked replicates.

HARVEST	TREATMENT: product and number of sprays	YIELD (KG)	YIELD (COUNT)	% GOOD[2]	ESTIMATED KG GOOD[3]
First (9/13/00)	Orthene 97SP 1 lb/A (8 sprays)	4.625	16.0	98.7 A	4.555 AB
	Orthene (2); Avaunt 30WDG 3.5 oz/A (6)	4.925	17.2	97.6 A	4.787 A
	Orthene (2); Spintor 2SC 4 oz/A (6)	6.512	23.2	85.5 B	5.424 A
	Orthene (2); Baythroid 2EC 2.8 oz/A (6)	4.900	17.8	95.6 AB	4.612 A
	Avaunt 30WDG 3.5 oz/A (8 sprays)	5.131	21.5	57.2 C	2.921 B
	untreated check	5.562	25.0	13.0 D	0.664 C
	P value (ANOVA treatment effect)	*0.40*	*0.18*	*<0.0001*	*0.0002*
Second (9/29/00)	Orthene 97SP 1 lb/A (8 sprays)	13.494 A	48.0 A	99.5 AB	13.418 A
	Orthene (2); Avaunt 30WDG 3.5 oz/A (6)	12.638 A	46.8 A	95.9 B	12.166 A
	Orthene (2); Spintor 2SC 4 oz/A (6)	13.000 A	49.5 A	91.5 C	11.872 A
	Orthene (2); Baythroid 2EC 2.8 oz/A (6)	12.806 A	48.2 A	100.0 A	12.806 A
	Avaunt 30WDG 3.5 oz/A (8 sprays)	7.706 B	30.8 B	66.2 D	5.145 B
	untreated check	0.194 C	2.0 C	0.0 E	0.000 C
	P value (ANOVA treatment effect)	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
Third (10/17/00)	Orthene 97SP 1 lb/A (8 sprays)	3.488 AB	14.2 A	96.2 AB	3.358 A
	Orthene (2); Avaunt 30WDG 3.5 oz/A (6)	3.738 A	15.2 A	92.4 AB	3.477 A
	Orthene (2); Spintor 2SC 4 oz/A (6)	3.488 AB	14.0 A	88.5 B	3.098 A
	Orthene (2); Baythroid 2EC 2.8 oz/A (6)	2.650 B	11.0 A	100.0 A	2.650 A
	Avaunt 30WDG 3.5 oz/A (8 sprays)	1.294 C	5.8 B	70.2 C	0.929 B
	untreated check	0.000 D	0.0 C	0.0 D	0.000 B
	P value (ANOVA treatment effect)	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
Cumulative	Orthene 97SP 1 lb/A (8 sprays)	21.606 A	78.2 A	98.8 A	21.321 A
	Orthene (2); Avaunt 30WDG 3.5 oz/A (6)	21.300 A	79.2 A	95.5 A	20.438 A
	Orthene (2); Spintor 2SC 4 oz/A (6)	23.000 A	86.8 A	88.9 B	20.425 A
	Orthene (2); Baythroid 2EC 2.8 oz/A (6)	20.356 A	77.0 A	98.6 A	20.084 A
	Avaunt 30WDG 3.5 oz/A (8 sprays)	14.131 B	58.0 B	60.8 C	8.999 B
	untreated check	5.756 C	27.0 C	12.0 D	0.644 C
	P value (ANOVA treatment effect)	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*

[1] within each column and for each harvest date, means followed by the same letter are not significantly different by LSD tests ($P > 0.05$).
[2] means shown are actual percentages but analysis results shown were based on arcsine square-root transformed data.
[3] estimated yield (kg) of fruit clean of insect damage = (total yield, in kg) x (% clean).