Final report to
Bayer CropScience, Syngenta Crop Protection Inc., and
The IR-4 Program for Assembling of Food Use Data
18 December 2008

Project title: Cucumber beetle control by insecticide seed treatment in Ohio

Principal investigator: Celeste Welty (Ohio State University)

Cooperators: Alan Taylor (Cornell University), Matt Hofelich (OSU), Glenn Mills (OSU)

Background: The striped cucumber beetle is the key pest of cucurbit crops particularly in the seedling stage when it defoliates plants and transmits bacterial wilt disease. Systemic insecticides from the neonicotinoid group have been registered for in-furrow soil treatment of cucurbits for several years but none were registered for commercial seed treatment on cucurbits until late 2008. Commercial seed treatment provides control as good as from soil-applied insecticides but at a lower rate of active ingredient per acre. These products showed good efficacy in trials in Ohio in 2005, 2006, and 2007, in which they were combined with thiram as a standard fungicide seed treatment. Trials in 2008 continued these evaluations, and included products with the seed-applied fungicides that will be used with seed-applied insecticides once they are registered.

Objective: To evaluate efficacy of commercial seed treatment with systemic insecticides for control of cucumber beetles on pickling cucumbers and fresh-market pumpkins, in comparison to standard treatments.

Methods:

Seed of 'Vlaspik' pickling cucumbers (Seminis Inc., Oxnard, CA) and 'Gladiator' pumpkins (Harris Moran Seed Company, Modesto, CA) were treated with experimental insecticides and thiram fungicide (141 mg a.i. per 100 g seed) in Alan Taylor's seed laboratory at Cornell University in Geneva NY. All treatments were applied in a Rotary Pan treater with binder of Disco A with water (1:1) with conditioning powder MJJ10-E. Seed treatment insecticides for both pickling cucumbers and pumpkins were thiamethoxam (Cruiser 5SC; Syngenta Crop Protection, Inc., Greensboro, NC) at 0.75 mg a.i. per seed, and clothianidin plus imidacloprid (Sepresto; Bayer CropScience, Research Triangle Park, NC) at 1.0 mg a.i. (1.33 mg product) per seed.

Seed of 'Vlaspik' pickling cucumbers was used in three additional treatments with clothianidin plus imidacloprid that were treated at a Bayer facility in Research Triangle Park, NC. One treatment was the same rate of clothianidin plus imidacloprid (1.0 mg a.i./seed; 1.33 mg product/seed) but with fungicides Thiram plus Vortex plus Allegiance. Other treatments were with the same fungicides but with insecticide at a lower rate (0.75 mg a.i./seed; 1.0 mg product/seed) and a higher rate (1.33 mg a.i./seed; 1.78 mg product/seed).

Seed of 'Vlaspik' pickling cucumbers was used in two additional treatments with thiamethoxam that were treated at a Syngenta facility in Stanton, MN. One treatment was the same rate of thiamethoxam (0.75 mg a.i./seed) but with fungicides Apron plus Maxim. The other was with the same rate of thiamethoxam and fungicides but with an additional insecticide/nematicide, abamectin (Avicta) at 0.1 mg a.i./seed.

Field trials were set up in a randomized complete block design with four replicates per treatment. Stand counts were taken at least once. Beetle density and plant damage were evaluated at the cotyledon stage, second true-leaf stage, and fourth true-leaf stage, with a sample size of ten plants per plot at the second true-leaf stage and five plants at the other stages. All fruit per plot were harvested by hand and weighed.

The pickling cucumber trial was conducted at the Ohio Agricultural Research and Development Center's North Central Agricultural Research Station at Fremont, Sandusky County. Plots were single rows 25 ft long with rows 2.5 ft apart. Seeds were spaced 3.6 inches apart, equivalent to 58,000 seeds per acre. There was one guard row between adjacent treatment plots. Seeds were planted on 6 June

2008 by a precision cone seeder. Comparison treatments were imidacloprid (Admire Pro 4.6F) applied in-furrow at the minimum labeled rate of 7 fl oz per acre (12 ml per 1000 ft of row for rows 2.5 ft apart), and thiamethoxam (Platinum 2SC) applied in-furrow at the maximum labeled rate of 8 fl oz per acre (14 ml per 1000 ft of row for rows 2.5 ft apart). Plants were not blocked (thinned) after emergence, as standard for pickling cucumbers intended for machine-pick harvest. Vines were trained once per week after the vine-tip stage so that harvest of single rows was possible. One row in each plot was harvested by hand in one harvest that mimicked a machine-pick harvest on 21 July 2008, when the field reached the target of approximately 40% of fruit in Grade #3. Yield per plot in standard Ohio grade categories was measured. Grade #1 is fruit up to 1 1/16 inch in diameter, grade #2 is fruit up to 1 ½ inches in diameter, grade #3 is fruit up to 2 inches in diameter, and the oversize grade is fruit over 2 inches in diameter.

The pumpkin trial was conducted at the Ohio State University's Waterman Agricultural and Natural Resources Laboratory at Columbus in Franklin County. Plots were single rows, 30 ft long, with rows 7.5 ft apart, and no guard rows. Plots were hand seeded with 30 seeds per plot on 29 May. Seed-applied insecticides were compared with imidacloprid (Admire Pro 4.6F) applied in-furrow at the minimum labeled rate of 7 fl oz per acre (36 ml per 1000 ft of row, for rows 7.5 ft apart), and thiamethoxam (Platinum 2SC) applied in-furrow at the maximum labeled rate of 8 fl oz per acre (41 ml per 1000 ft of row, for rows 7.5 ft apart); both in-furrow treatments were applied at a rate of 430 ml of solution per plot. Two additional treatments used foliar sprays: carbaryl (Sevin XLR) at a standard rate of 32 fl oz/A, and carbaryl (Sevin XLR) at a low rate of 3.2 fl oz/A mixed with a cucurbitacin-based adjuvant (CideTrak CRW, Trécé Inc., Adair, OK) at 3.1 oz/A. Foliar treatments were applied by a backpack sprayer with a TX-10 nozzle, operated at 40 psi, at a rate of 116 ml of spray mix per 30 ft plot. Spray dates were 6, 9, 13, and 18 June. The stand was thinned to 10 plants per plot on 2 July. The number of fruit and weight of fruit per plot were measured at harvest on 16 September.

Striped cucumber beetles were tested in laboratory bioassays with plants from late-planted field plots in Columbus. The bioassay arena was a lidded 8-oz plastic deli dish. Each dish held three excised cotyledon-stage plants or one excised true leaf. The stems or petiole of each excised plant or leaf was held in a cube of moist floral foam. Beetles were collected immediately before testing from a pumpkin field that was not treated with insecticides. Pickling cucumbers were planted on 24 June, and tested at the cotyledon stage on 6 July, the first true-leaf stage on 10 July, the second true-leaf stage on 17 July, and the fourth true-leaf stage on 26 July. There were five beetles per replicate, and four replicates of each pickle bioassay except for the fourth true-leaf tests, which had three replicates. Mortality and damage to pickle leaves were evaluated 24, 72, and 120 hours after beetles were released in the dishes. Pickling cucumbers were planted again on 26 July and 7 August, including one additional treatment: thiamethoxam 0.75 mg a.i. per seed and thiram fungicide (141 mg a.i. per 100 g seed) with a pre-conditioning treatment done in the Taylor lab at Cornell. The pre-conditioning treatment consisted of soaking seeds in pyridine overnight to alter seed coat permeability, and then air drying prior to thiamethoxam application. Pickle plants from the 7 August planting were tested in the cotyledon stage on 19 August with three beetles per dish and three replicates, and mortality and damage were evaluated after 72 and 120 hours. Pumpkins were planted on 8 August, and tested with five beetles per dish in three replicates for the first true-leaf stage on 21 August and again on 25 August, and for the second true-leaf stage on 26 August. Mortality and damage were evaluated after 72 and 120 hours.

In field trials and bioassays, beetle feeding damage was rated on a scale of 0 to 3; a rating of 0 was used for no damage; a rating of 1 was used for light damage: a few small gouges, affecting <10% of leaf area; a rating of 2 was used for moderate damage: many small or several large gouges, on 10 to 50% of area; a rating of 3 was used for heavy damage: many large gouges, on >50% of area. Some evaluations of bioassays also included an estimate of defoliation, expressed as the percentage of leaf area damaged or the amount of leaf area damaged. For all trials, data were subjected to analysis of variance using the SAS microcomputer statistics program (version 9.1), with mean separations by LSD. The angular transformation was used on percentage data before analysis.

Results, pickling cucumber.

Stand counts at the cotyledon stage on 13 June, 7 days after seeding, ranged from 40 to 70 plants per plot and showed some significant differences (P=0.02) (Table 1). The trend was for higher stand counts in the Thiram/Vortex/Allegiance and Apron/Maxim treatments, and lower counts in the Thiram treatments. No phytotoxicity was observed.

On pickling cucumber, damage and beetle density were negligible at the cotyledon stage (Table 1); of 280 plants examined, only one plant was damaged by beetles. Damage and beetle density were light at the second true-leaf stage (Table 2), and light to moderate at the fourth true-leaf stage (Table 2). Significant treatment effects were seen only at the fourth true-leaf stage, when the rating of beetle feeding damage ranged from 0.2 to 0.7 on a scale from 0 to 3. Compared to the no-insecticide checks, beetle damage was significantly less (P=0.006) in four treatments: 1) the low rate (0.75 mg a.i./seed) of clothianidin/imidacloprid + Thiram/Vortex/Allegiance, 2) Cruiser + Thiram, 3) in-furrow Admire + Thiram/Vortex/Allegiance, and 4) Cruiser + Apron/Maxim. Among the three rates of clothianidin plus imidacloprid, the lowest rate (0.75 mg a.i./seed) resulted in significantly lower damage than the other two rates. Among the Cruiser treatments, damage in the Cruiser-alone treatments was not significantly different than in the Cruiser plus Avicta treatment. It is unknown why damage in the Platinum in-furrow treatment was similar to the untreated checks. At the fourth leaf stage, the number of live beetles per plant differed among treatments (P = 0.03), but the number of dead beetles did not (P = 0.16). There was not a clear trend of beetle density relative to the amount of damage. Yield of pickling cucumbers in grades 1 to 3 combined ranged from 15.2 to 24.8 pounds per plot (Table 3). Yield did not differ among treatments, in individual grades on in combined grades (P>0.05).

The subset of five treatments for which cucumber seeds were treated in the Taylor lab at Cornell was analyzed separately for comparison with the same treatments evaluated on cucumbers in Delaware and Virginia. The trends are the same as presented above for stand counts and damage to cotyledons (Appendix 1, Table 1A), second true-leaf plants (Appendix 1, Table 1B), and fourth true-leaf plants (Appendix 1, Table 1C). Among these five treatments, Cruiser had the least damage from beetles, but it was not significantly different than Admire in-furrow or Sepresto.

Bioassays of pickling cucumbers at the cotyledon stage showed that damage by beetles was significantly less in all seed and in-furrow treatments than in the untreated check after 24 hours (P=0.04), 72 hours (P=0.01), and 120 hours (P=0.01) (Table 4). Beetle mortality after 24 hours was significantly higher in the Sepresto treatment than in all other treatments, but there were no significant differences in mortality after 72 and 120 hours (Table 4). Bioassays with the first true-leaf after 24 hours showed significantly less damage than the check only in the in-furrow Admire treatment; after 120 hours, damage was significantly less than the check in all treatments, and damage in the Sepresto treatment was significantly lower than in the Cruiser treatment (Table 5). Trends in defoliation of the first true-leaf were similar to trends in damage rating at 120 hours (Table 5). There were no mortality effects with the first true-leaf bioassays (Table 5). Bioassays with the second true-leaf after 24 hours showed significantly less damage than the check in all treatments except the in-furrow Admire treatment, and there were no significant effects on damage at 72 or 120 hours; trends in defoliation were similar, and there were no differences in mortality (Table 6). Bioassays with the fourth true-leaf showed no significant differences among treatments in damage rating, area defoliated, or mortality (Table 7). In general, Platinum in-furrow was much more effective in plots in Columbus as measured by bioassays (Tables 4-7) than it was in the field trial at Fremont (Tables 1-3).

In late plantings of cucumbers, emergence was poor due to high temperatures, inadequate irrigation, and herbicide issues, which resulted in an inadequate number of plants for a full set of bioassays. Stand counts in unreplicated plots seeded on 26 July showed no emergence from the preconditioned seeds (Table 8). Stand counts in replicated plots seeded on 7 August showed some emergence from the preconditioned seeds (Table 9). These plants were used in bioassays only with cotyledon stage plants. Although control mortality was unacceptable (>20%) in these bioassays, there was a trend of superior damage prevention by Cruiser with the preconditioning treatment. The damage rating was significantly lower in the Cruiser preconditioning treatment than in the standard Cruiser treatment after both 72 and 120 hours (Table 10). The leaf area defoliated after 72 hours did not differ between the two Cruiser treatments but both were significantly lower than the untreated check (Table 10). Beetle mortality did not differ significantly among treatments (Table 10).

Results, pumpkin.

Stand counts In the pumpkin field trial did not differ significantly among treatments at the cotyledon or first leaf stage, but at the second leaf stage there were significantly fewer plants in the check and Admire plots than in Sepresto, Cruiser, and Sevin treatments (Table 11). Damage to pumpkins by cucumber beetles showed a significant treatment effect at the first leaf stage; there was significantly less

damage in all insecticide treatments than in the untreated check (Table 12). At the second leaf stage, beetle damage was lowest in plots treated with Sevin as a foliar spray alone or with CideTrak, Admire in-furrow, and Sepresto, which all had significantly less damage than in plots treated with Platinum in-furrow or Cruiser (Table 12). Treatments did not differ significantly at the cotyledon or fourth leaf stages (Table 12). Beetle density showed a significant treatment effect only for dead beetles at the first leaf stage; significantly more dead beetles were found in Admire and Sepresto treatments than in the untreated check or Sevin treatments (Table 13). Yield of pumpkins showed no significant treatment effect, for either weight or number of fruit (Table 14).

The subset of five treatments used in multi-State trials was analyzed separately for comparison with the same treatments evaluated on pumpkins in New York and Maryland. The trends are the same as presented above for stand counts (Appendix 2, Table 2A), damage ratings (Appendix 2, Table 2B), and beetle density (Appendix 2, Table 2C). Differences were greatest at the second leaf stage, when damage was significantly less in Admire in-furrow and Sepresto seed treatments than in Platinum in-furrow or Cruiser seed treatments but all were significantly less than the check.

Bioassays with pumpkin leaves showed a significant effect of treatment at the first leaf stage; damage was significantly less in the Platinum treatment than in all other treatments after 120 hours (Table 15). The area defoliated in the Sepresto treatment was significantly higher than in Cruiser, Admire, or Platinum treatments after 120 hours (Table 15). There was no treatment effect on mortality. In a second round of bioassays with the first leaf, all insecticide treatments resulted in significantly less area defoliated than the untreated check after 72 hours, and again there was no effect on mortality (Table 16). At the second leaf stage, there were no differences among treatments in damage rating, area defoliated, or mortality (Table 17).

Discussion & Conclusions: Both Cruiser and Sepresto seed treatments were as effective as Admire in-furrow at preventing damage by striped cucumber beetle, athough the results varied between cucumber and pumpkin, and between field evaluations and bioassay evaluations. In the pumpkin trial, beetles were present starting at plant emergence, and insecticides were effective through the second true-leaf stage, but control was no longer apparent at the fourth true-leaf stage. In the pickling cucumber trial, beetles did not colonize the field until after the cotyledon stage, and insecticides were effective through the fourth true-leaf stage. In both crops, yield was not affected by insecticide treatment. Laboratory bioassays with leaves excised from field-grown plants were valuable for assessing the duration that insecticides protected plants from damage, and in comparing different crop growth stages at equal pest pressure. Bioassays with cucumbers showed that seed and in-furrow treatments resulted in significant reduction of damage at the cotyledon to second true-leaf stages, but by the fourth leaf stage there was no reduction in damage.

Table 1. Stand count, damage rating, and density of striped cucumber beetle in 25-ft single-row plots of 'Vlaspik' cucumbers at the **cotyledon stage** on 13 June 2008 (7 days after seeding), Fremont, Ohio.

Treatment	Stand count[1]	Damage rating (scale 0 to 3)	Number of beetles per plant	
			Alive	Dead
clothianidin + imidacloprid 0.75 mg AI (1.0 mg product), + Thiram + Vortex + Allegiance	70 A	0	0	0
in-furrow Admire Pro 4.6F (7 fl oz/A), + Apron + Maxim	70 A	0	0	0
check-3 (Apron + Maxim)	69 A	0	0	0
check-2 (Thiram + Vortex + Allegiance)	67 A	0.02	0	0
clothianidin + imidacloprid 1.0 mg AI (1.33 mg product), + Thiram + Vortex + Allegiance	66 A	0	0	0
Cruiser 0.75 mg AI + Avicta 0.1 mg AI, + Apron + Maxim	62 AB	0	0	0
clothianidin + imidacloprid 1.33 mg AI (1.78 mg product), + Thiram + Vortex + Allegiance	62 AB	0	0	0
Cruiser 0.75 mg AI, + Thiram	60 AB	0	0	0
check-1 (Thiram)	60 AB	0	0	0
Cruiser 0.75 mg AI, + Apron + Maxim	58 AB	0	0	0
Sepresto 1.0 mg AI (clothianidin + imidacloprid 1.33 mg product), + Thiram	58 AB	0	0	0
in-furrow Admire Pro 4.6F (7 fl oz/A), + Thiram + Vortex + Allegiance	57 AB	0	0	0
in-furrow Platinum 2SC (8 fl oz/A), + Thiram	49 BC	0	0	0
in-furrow Admire Pro 4.6F (7 fl oz/A), + Thiram	40 C	0	0	0
Treatment effect from ANOVA	*P=0.02*	*P=0.47*	*P=1.0*	*P=1.0*

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

Table 2. Damage rating and density of striped cucumber beetle on 'Vlaspik' cucumbers at the **second true leaf stage** on 23 June 2008 (17 days after seeding), and at the **fourth true leaf stage** on 1 July 2008 (25 days after seeding), Fremont, Ohio.

Treatment	2nd true-leaf stage			4th true-leaf stage		
	Damage rating (scale 0 to 3)	Number of beetles per plant		Damage rating (scale 0 to 3)[1]	Number of beetles per plant	
		Alive	Dead		Alive[1]	Dead
clothianidin + imidacloprid 0.75 mg AI (1.0 mg product), + Thiram + Vortex + Allegiance	0.02	0.00	0.05	0.2 E	0.10 BCD	0 B
Cruiser 0.75 mg AI, + Thiram	0.01	0.08	0.02	0.3 E	0.15 BCD	0.05
in-furrow Admire Pro 4.6F (7 fl oz/A), + Thiram + Vortex + Allegiance	0.03	0.05	0.02	0.3 DE	0.25 ABCD	0.05
Cruiser 0.75 mg AI + Avicta 0.1 mg AI, + Apron + Maxim	0.01	0.05	0.02	0.3 CDE	0.05 CD	0.10
in-furrow Admire Pro 4.6F (7 fl oz/A), + Thiram	0.02	0.02	0.10	0.4 BCDE	0.15 BCD	0.20
Cruiser 0.75 mg AI, + Apron + Maxim	0.05	0.00	0.05	0.4 ABCDE	0.20 ABCD	0
Sepresto 1.0 mg AI (clothianidin + imidacloprid 1.33 mg product), + Thiram	0.09	0.02	0.05	0.4 ABCDE	0.35 AB	0
in-furrow Admire Pro 4.6F (7 fl oz/A), + Apron + Maxim	0.08	0.05	0.12	0.5 ABCDE	0.25 ABCD	0.10
clothianidin + imidacloprid 1.0 mg AI (1.33 mg product), + Thiram + Vortex + Allegiance	0.02	0.05	0.00	0.5 ABCD	0.10 BCD	0
clothianidin + imidacloprid 1.33 mg AI (1.78 mg product), + Thiram + Vortex + Allegiance	0.02	0.10	0.05	0.6 ABC	0.45 A	0.10
check-3 (Apron + Maxim)	0.03	0.00	0.00	0.6 AB	0.00 D	0
check-1 (Thiram)	0.08	0.10	0.00	0.6 AB	0.15 BCD	0
check-2 (Thiram + Vortex + Allegiance)	0.14	0.00	0.02	0.6 AB	0.00 D	0
in-furrow Platinum 2SC (8 fl oz/A), + Thiram	0.14	0.25	0.02	0.7 A	0.30 ABC	0
Treatment effect from ANOVA	*P=0.21*	*P=0.76*	*P=0.70*	*P=0.006*	*P=0.03*	*P=0.16*

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

Table 3. Yield per plot of 'Vlaspik' cucumbers in standard grade categories at harvest on 21 July 2008, Fremont, OH.

Treatment	Pounds of fruit per 25-foot plot					
	Grade #1	Grade #2	Grade #3	Grade oversize	Sum grades #1-3	Sum all grades
in-furrow Admire Pro 4.6F (7 fl oz/A), + Apron + Maxim	0.50	2.74	21.56	4.70	24.8	29.5
clothianidin + imidacloprid 0.75 mg AI (1.0 mg product), + Thiram + Vortex + Allegiance	0.44	2.18	19.79	6.01	22.4	28.4
clothianidin + imidacloprid 1.0 mg AI (1.33 mg product), + Thiram + Vortex + Allegiance	0.69	2.05	19.39	5.02	22.1	27.2
Cruiser 0.75 mg AI, + Apron + Maxim	0.50	1.66	19.08	5.62	21.2	26.9
Cruiser 0.75 mg AI, + Thiram	0.56	2.21	18.05	5.56	20.8	26.4
check-3 (Apron + Maxim)	0.62	2.24	17.48	4.86	20.3	25.2
Sepresto 1.0 mg AI (clothianidin + imidacloprid 1.33 mg product), + Thiram	0.54	1.68	17.95	3.90	20.2	24.1
in-furrow Admire Pro 4.6F (7 fl oz/A), + Thiram + Vortex + Allegiance	0.48	2.01	17.70	6.51	20.2	26.7
check-2 (Thiram + Vortex + Allegiance)	0.72	1.64	17.54	6.02	19.9	25.9
clothianidin + imidacloprid 1.33 mg AI (1.78 mg product), + Thiram + Vortex + Allegiance	0.52	2.46	16.75	5.11	19.7	24.8
Cruiser 0.75 mg AI + Avicta 0.1 mg AI, + Apron + Maxim	0.69	1.64	19.96	8.62	19.3	27.9
check-1 (Thiram)	0.50	1.81	16.09	2.95	18.4	21.4
in-furrow Platinum 2SC (8 fl oz/A), + Thiram	0.38	1.31	13.62	7.29	15.3	22.6
in-furrow Admire Pro 4.6F (7 fl oz/A), + Thiram	0.38	1.59	13.20	5.71	15.2	20.9
Treatment effect from ANOVA	*P=0.63*	*P=0.13*	*P=0.15*	*P=0.23*	*P=0.11*	*P=0.19*

Table 4. Damage rating and mortality of striped cucumber beetle in laboratory bioassays with **cotyledons** excised from field plots of 'Vlaspik' cucumbers on 6 July 2008 (12 days after seeding), Columbus OH.

Treatment (all with Thiram fungicide on seed)	Damage rating (scale 0 to 3)			% Mortality[2]		
	24 hrs[1]	72 hrs[1]	120 hrs[1]	24 hrs[1]	72 hrs	120 hrs
Sepresto 1.0 mg AI	0.6 B	0.8 B	0.7 B	45 A	50	75
in-furrow Admire (7 fl oz/A)	0.7 B	0.8 B	0.8 B	20 B	30	75
in-furrow Platinum (8 fl oz/A)	1.0 B	1.0 B	0.9 B	5 B	55	80
Cruiser 0.75 mg AI	1.0 B	1.0 B	1.2 B	5 B	45	65
Check	1.8 A	2.0 A	2.2 A	5 B	15	25
Treatment effect from ANOVA	*P=0.002*	*P=0.01*	*P=0.01*	*P=0.003*	*P=0.33*	*P=0.11*

[1] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.
[2] Means shown are actual percentages, but ANOVA based on transformed values.

Table 5. Damage rating, defoliation, and mortality of striped cucumber beetle in laboratory bioassays with the **first true-leaf** excised from field plots of 'Vlaspik' cucumbers on 10 July 2008 (16 days after seeding), Columbus OH.

Treatment	Damage rating (scale 0-3)			% Defoliation[2]			% Mortality[2]		
(all with Thiram)	24 hr[1]	72 hr	120 hr[1]	24 hr	72 hr[1]	120 hr[1]	24 hr	72 hr	120 hr
Sepresto 1.0 mg AI	1.5 AB	1.8	1.9 C	7	13 B	16 C	5	25	40
in-furrow Admire (7 fl oz/A)	1.2 B	2.0	2.0 C	5	10 B	16 BC	0	0	25
in-furrow Platinum (8 fl oz/A)	1.8 AB	1.9	2.2 BC	14	16 B	31 BC	0	5	30
Cruiser 0.75 mg AI	2.0 A	2.1	2.5 B	11	22 B	35 B	10	5	10
Check	2.0 A	2.5	3.0 A	12	65 A	76 A	0	0	10
Treatment effect, ANOVA	*P= 0.04*	*P= 0.10*	*P= 0.002*	*P= 0.10*	*P< 0.0001*	*P= 0.0003*	*P= 0.60*	*P= 0.28*	*P= 0.60*

[1] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.
[2] Means shown are actual percentages, but ANOVA based on transformed values.

Table 6. Damage ratings, defoliation, and mortality of striped cucumber beetle in laboratory bioassays with the **second true-leaf** excised from field plots of 'Vlaspik' cucumbers on 17 July 2008 (23 days after seeding), Columbus OH.

Treatment (all with Thiram)	Damage rating (scale 0-3)			% Defoliation[2]			% Mortality[2]		
	24 hr[1]	72 hr	120 hr	24 hr[1]	72 hr	120 hr	24 hr	72 hr	120 hr
Sepresto 1.0 mg AI	1.0 C	1.4	1.9	3 B	7	19	0	15	25
in-furrow Admire (7 fl oz/A)	1.6 AB	2.0	2.4	6 AB	18	32	0	5	15
in-furrow Platinum (8 fl oz/A)	1.4 BC	1.5	1.6	4 B	10	14	0	15	30
Cruiser 0.75 mg AI	1.2 BC	1.4	1.9	4 B	10	18	0	5	20
Check	2.0 A	2.0	2.4	10 A	21	38	5	5	10
Treatment effect, ANOVA	*P= 0.016*	*P= 0.15*	*P= 0.29*	*P= 0.046*	*P= 0.07*	*P= 0.21*	*P= 0.44*	*P= 0.76*	*P= 0.66*

[1] Within each column, means followed by the same letter are not significantly different ($P>0.05$), by LSD.
[2] Means shown are actual percentages, but ANOVA based on transformed values.

Table 7. Damage rating, area defoliated, and mortality of striped cucumber beetle in laboratory bioassays with the **fourth true-leaf** excised from field plots of 'Vlaspik' cucumbers on 26 July 2008 (32 days after seeding), Columbus OH.

Treatment (all with Thiram)	Damage rating (scale 0-3)			Area defoliated (mm^2)			% Mortality[1]		
	24 hr	72 hr	120 hr	24 hr	72 hr	120 hr	24 hr	72 hr	120 hr
Sepresto 1.0 mg AI	1.0	1.7	1.7	48	76	80	0	53	80
in-furrow Admire (7 fl oz/A)	0.8	1.5	1.5	39	59	76	0	40	60
in-furrow Platinum (8 fl oz/A)	1.0	1.7	2.0	46	115	185	0	30	50
Cruiser 0.75 mg AI	0.8	1.7	2.0	27	93	158	7	20	53
Check	1.3	1.7	1.7	65	182	202	7	20	40
Treatment effect, ANOVA	*P= 0.27*	*P= 0.99*	*P= 0.75*	*P= 0.51*	*P= 0.25*	*P= 0.22*	*P= 0.44*	*P= 0.25*	*P= 0.09*

[1] Means shown are actual percentages, but ANOVA based on transformed values.

Table 8. Stand count in unreplicated plots of 'Vlaspik' cucumbers planted 26 July 2008, Columbus OH.

Treatment	Number of plants per plot		
	3 August	4 August	6 August
Cruiser with preconditioning	0	0	0
Sepresto	21	23	32
Platinum in-furrow	25	30	32
Cruiser	1	1	1
Admire in-furrow	6	9	11
untreated	2	4	7

Table 9. Stand count in replicated plots of 'Vlaspik' cucumbers planted 7 August 2008, Columbus, OH.

Treatment	15 August			18 August		
	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3
Cruiser with preconditioning	6	0	0	7	0	2
Sepresto	10	16	0	11	21	2
Platinum in-furrow	15	4	7	17	8	11
Cruiser	20	9	21	24	12	23
Admire in-furrow	9	11	1	9	11	5
Untreated	1	15	2	6	16	5

Table 10. Damage rating, area defoliated, and mortality of striped cucumber beetle in laboratory bioassays using excised **cotyledon** stage leaves from field plots of 'Vlaspik' cucumbers planted 7 August 2008, Columbus, OH.

Treatment	Damage rating (scale 0 to 3)		Area defoliated (mm^2)		% Mortality[2]	
	72 hrs[1]	120 hrs[1]	72 hrs[1]	120 hrs	72 hrs	120 hrs
Cruiser with preconditioning	0.1 D	0.1 D	0.1 C	0.6	89	89
Sepresto	0.3 C	0.3 CD	2.0 C	2.2	56	78
Platinum in-furrow	0.3 C	0.4 BCD	3.0 BC	4.4	56	78
Cruiser	0.5 BC	0.5 BC	2.9 BC	2.9	56	100
Admire in-furrow	0.6 AB	0.7 AB	8.9 AB	11.4	33	53
untreated	0.8 A	0.9 A	10.6 A	18.5	22	78
Treatment effect from ANOVA	*P=0.0002*	*P=0.0035*	*P=0.0275*	*P=0.08*	*P=0.45*	*P=0.45*

[1] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.
[2] Means shown are actual percentages, but ANOVA based on transformed values.

Table 11. Stand count in 30-ft single-row plots of 'Gladiator' pumpkins after field planted with 30 seeds per plot on 29 May 2008, Columbus, Ohio.

Treatment (all with Thiram fungicide seed treatment)	Number of plants per plot		
	6 June, 8 days after seeding	9 June, 11 days after seeding	16 June, 18 days after seeding[1]
Sevin XLR, 32 fl oz/A, foliar spray (4 times)	16.0	23.8	25.8 A
Admire Pro 4.6F, 7 fl oz/A, in-furrow	13.5	22.3	22.5 B
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	17.2	24.8	27.0 A
Sevin XLR, 3.2 fl oz/A, + CideTrak CRW, 3.1 oz/A, foliar spray (4 times)	17.2	22.5	25.2 AB
Platinum 2SC, 8 fl oz/A, in-furrow	19.8	24.0	24.5 AB
Cruiser 0.75 mg AI/seed, seed treatment	17.8	24.2	26.8 A
Untreated	15.8	20.5	22.5 B
Treatment effect from ANOVA	*P=0.62*	*P=0.60*	*P=0.037*

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

Table 12. Rating of damage by striped cucumber beetle on 'Gladiator' pumpkins, Columbus, Ohio, 2008.

Treatment (all with Thiram fungicide seed treatment)	Damage rating (scale 0 to 3)			
	Cotyledon stage, 8 days after seeding	First true-leaf stage, 11 days after seeding[1]	Second true-leaf stage, 18 days after seeding[1]	Fourth true-leaf stage, 29 days after seeding[2]
Sevin XLR, 32 fl oz/A, foliar spray (4 times)	0.2	0.3 B	0.3 D	0.5
Admire Pro 4.6F, 7 fl oz/A, in-furrow	0.3	0.6 B	0.5 CD	0.4
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	0.2	0.7 B	0.7 C	0.4
Sevin XLR, 3.2 fl oz/A, + CideTrak CRW, 3.1 oz/A, foliar spray (4 times)	0.3	0.8 B	0.7 C	0.4
Platinum 2SC, 8 fl oz/A, in-furrow	0.2	0.9 B	1.0 B	0.4
Cruiser 0.75 mg AI/seed, seed treatment	0.0	0.7 B	1.0 B	0.4
Untreated	0.6	1.8 A	1.7 A	0.4
Treatment effect from ANOVA	*P=0.73*	*P=0.0035*	*P<0.0001*	*P=0.85*

[1] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.
[2] Note, ratings are lower at 4th true leaf stage than at previous stage because cotyledons had withered and could no longer be included in the ratings.

Table 13. Density of striped cucumber beetle on 'Gladiator' pumpkins, Columbus, Ohio, 2008.

Treatment (all with Thiram fungicide seed treatment)	Number of beetles per plant							
	Cotyledon stage, 8 days after seeding		First true-leaf stage, 11 days after seeding		Second true-leaf stage, 18 days after seeding		Fourth true-leaf stage, 29 days after seeding	
	Alive	Dead	Alive	Dead[1]	Alive	Dead	Alive	Dead
Sevin XLR, 32 fl oz/A, foliar spray (4 times)	0.2	0.0	0.0	0.0 B	0.02	0.02	0.4	0.0
Admire Pro 4.6F, 7 fl oz/A, in-furrow	0.0	2.0	0.2	2.8 A	0.1	0.1	0.1	0.2
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	0.0	0.4	0.1	2.4 A	0.1	0.0	0.2	0.1
Sevin XLR, 3.2 fl oz/A, + CideTrak CRW, 3.1 oz/A, foliar spray (4 times)	0.2	0.0	0.0	0.1 B	0.0	0.0	0.3	0.1
Platinum 2SC, 8 fl oz/A, in-furrow	0.1	0.1	0.2	1.0 AB	0.1	0.02	0.4	0.0
Cruiser 0.75 mg AI/seed, seed treatment	0.0	0.0	0.2	1.0 AB	0.1	0.0	0.1	0.0
Untreated	0.1	0.0	0.1	0.0 B	0.0	0.02	0.1	0.0
Treatment effect from ANOVA	*0.57*	*0.46*	*0.55*	*0.026*	*0.50*	*0.46*	*0.24*	*0.53*

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

Table 14. Yield per plot of 'Gladiator' pumpkins in harvest on 16 September 2008, Columbus, Ohio.

Treatment	Kg of fruit per plot	Number of fruit per plot
Sevin XLR, 32 fl oz/A, foliar spray (4 times)	44.8	9.0
Admire Pro 4.6F, 7 fl oz/A, in-furrow	34.1	8.0
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	43.4	9.0
Sevin XLR, 3.2 fl oz/A, + CideTrak CRW, 3.1 oz/A, foliar spray (4 times)	38.9	7.8
Platinum 2SC, 8 fl oz/A, in-furrow	35.7	8.0
Cruiser 0.75 mg AI/seed, seed treatment	39.9	8.8
untreated	26.2	6.5
Treatment effect from ANOVA	*P=0.60*	*P=0.84*

Table 15. Damage rating, area defoliated, and mortality of striped cucumber beetle after 72 and 120 hours of exposure in laboratory bioassays using **first true-leaf stage** leaves excised on 21 August 2008 from field plots of 'Gladiator' pumpkins planted 8 August 2008, Columbus OH.

Treatment	Damage rating (scale 0 to 3)		Area defoliated (mm^2)		% Mortality[2]	
	72 hr[1]	120 hr[1]	72 hr[1]	120 hr[1]	72 hr	120 hr
Platinum 2SC, 8 fl oz/A, in-furrow	0.5 B	0.5 B	7 B	7 B	7	37
Admire Pro 4.6F, 7 fl oz/A, in-furrow	1.3 AB	1.7 A	33 B	71 B	0	33
Cruiser 0.75 mg AI/seed, seed treatment	1.3 AB	2.0 A	42 B	77 B	7	7
untreated	2.0 A	2.0 A	98 AB	128 AB	7	7
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	2.3 A	2.3 A	195 A	233 A	0	28
Treatment effect from ANOVA)	*P=0.03*	*P=0.01*	*P=0.02*	*P=0.02*	*P=0.74*	*P=0.16*

[1] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.
[2] Means shown are actual percentages, but ANOVA based on transformed values.

Table 16. Damage rating, area defoliated, and mortality of striped cucumber beetle after 72 and 120 hours of exposure in laboratory bioassays using later-emerging **first true-leaf stage** leaves excised on 25 August 2008 from field plots of 'Gladiator' pumpkins planted 8 August 2008, Columbus OH.

Treatment	Damage rating (scale 0 to 3)		Area defoliated (mm^2)		% Mortality[2]	
	72 hr	120 hr	72 hr[1]	120 hr	72 hr	120 hr
Admire Pro 4.6F, 7 fl oz/A, in-furrow	1.7	1.7	59 B	128	13	33
Platinum 2SC, 8 fl oz/A, in-furrow	2.2	2.3	100 B	228	20	33
Cruiser 0.75 mg AI/seed, seed treatment	2.0	2.0	102 B	325	7	18
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	2.2	2.5	135 B	325	7	7
untreated	2.7	2.7	350 A	492	0	7
Treatment effect from ANOVA	*P=0.10*	*P=0.18*	*P=0.002*	*P=0.14*	*P=0.22*	*P=0.11*

[1] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.
[2] Means shown are actual percentages, but ANOVA based on transformed values.

Table 17. Damage rating, area defoliated, and mortality of striped cucumber beetle after 72 and 120 hours of exposure in laboratory bioassays using **second true-leaf stage** leaves excised on 26 August 2008 from field plots of 'Gladiator' pumpkins planted 8 August 2008, Columbus OH.

Treatment	Damage rating (scale 0 to 3)		Area defoliated (mm^2)		% Mortality[1]	
	72 hr	120 hr	72 hr	120 hr	72 hr	120 hr
Cruiser 0.75 mg AI/seed, seed treatment	1.5	1.7	73	112	7	20
Admire Pro 4.6F, 7 fl oz/A, in-furrow	1.7	1.7	132	242	7	20
untreated	1.7	2.0	137	312	7	20
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	2.0	2.3	230	367	7	7
Platinum 2SC, 8 fl oz/A, in-furrow	2.0	2.2	250	417	7	13
Treatment effect from ANOVA	*P=0.82*	*P=0.66*	*P=0.39*	*P=0.58*	*P=1.00*	*P=0.49*

[1] Means shown are actual percentages, but ANOVA based on transformed values.

APPENDIX 1: Results of pickling cucumber trials with subset of treatments used in multi-State trials.

Table 1A. Stand count, damage rating, and density of striped cucumber beetle in 25 ft single-row plots of 'Vlaspik' cucumbers at the **cotyledon stage** on 13 June 2008 (7 days after seeding), Fremont, Ohio, including only the five treatments used in multi-State trials.

Treatment (all with Thiram fungicide on seed)	Stand count	Damage rating (scale 0 to 3)	Number of striped cucumber beetles per plant	
			Alive	Dead
Cruiser 0.75 mg AI	59.5	0	0	0
in-furrow Admire Pro 4.6F (7 fl oz/A)	39.5	0	0	0
Sepresto 1.0 mg AI (clothianidin + imidacloprid 1.33 mg product)	58.2	0	0	0
Check (no insecticide)	60.0	0	0	0
in-furrow Platinum 2SC (8 fl oz/A)	49.2	0	0	0
Treatment effect from ANOVA	*P=0.20*	-	-	-

Table 1B. Damage rating and density of striped cucumber beetle in 'Vlaspik' cucumbers at the **second true leaf stage** on 23 June 2008 (17 days after seeding), Fremont, Ohio, including only the five treatments used in multi-State trials.

Treatment (all with Thiram fungicide on seed)	Damage rating (scale 0 to 3)	Number of striped cucumber beetles per plant	
		Alive	Dead
Cruiser 0.75 mg AI	0.01	0.08	0.02
in-furrow Admire Pro 4.6F (7 fl oz/A)	0.02	0.02	0.10
Sepresto 1.0 mg AI (clothianidin + imidacloprid 1.33 mg product)	0.09	0.02	0.05
Check (no insecticide)	0.08	0.10	0.00
in-furrow Platinum 2SC (8 fl oz/A)	0.14	0.25	0.02
Treatment effect from ANOVA	*P=0.48*	*P=0.65*	*P=0.32*

Table 1C. Damage rating and density of striped cucumber beetle in 'Vlaspik' cucumbers at the **fourth true leaf stage** on 1 July 2008 (25 days after seeding), Fremont, Ohio, including only the five treatments used in multi-State trials.

Treatment (all with Thiram fungicide on seed)	Damage rating (scale 0 to 3)[1]	Number of striped cucumber beetles per plant	
		Alive	Dead
Cruiser 0.75 mg AI	0.3 C	0.15	0.05
in-furrow Admire Pro 4.6F (7 fl oz/A)	0.4 BC	0.15	0.20
Sepresto 1.0 mg AI (clothianidin + imidacloprid 1.33 mg product)	0.5 ABC	0.35	0.00
Check (no insecticide)	0.6 AB	0.15	0.00
in-furrow Platinum 2SC (8 fl oz/A)	0.7 A	0.30	0.00
Treatment effect from ANOVA	*P=0.0498*	*P=0.27*	*P=0.25*

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

APPENDIX 2: Results of pumpkin trials with subset of treatments used in multi-State trials.

Table 2A. Stand count in 30-ft single-row plots of 'Gladiator' pumpkins after field planted with 30 seeds per plot on 29 May 2008, Columbus, Ohio, including only the five treatments used in multi-State trials.

Treatment (all with Thiram fungicide seed treatment)	Number of plants per plot		
	6 June, 8 days after seeding	9 June, 11 days after seeding	16 June, 18 days after seeding[1]
Admire Pro 4.6F, 7 fl oz/A, in-furrow	13.5	22.3	22.5 B
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	17.2	24.8	27.0 A
Platinum 2SC, 8 fl oz/A, in-furrow	19.8	24.0	24.5 AB
Cruiser 0.75 mg AI/seed, seed treatment	17.8	24.2	26.8 A
Untreated	15.8	20.5	22.5 B
Treatment effect from ANOVA	*P=0.53*	*P=0.46*	*P=0.046*

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

Table 2B. Rating of damage by striped cucumber beetle on 'Gladiator' pumpkins, 2008, Columbus, Ohio, including only the five treatments used in multi-State trials.

Treatment (all with Thiram fungicide seed treatment)	Damage rating (scale 0 to 3)			
	Cotyledon stage, 8 days after seeding	First true-leaf stage, 11 days after seeding[1]	Second true-leaf stage, 18 days after seeding[1]	Fourth true-leaf stage, 29 days after seeding[2]
Admire Pro 4.6F, 7 fl oz/A, in-furrow	0.3	0.6 B	0.5 D	0.4
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	0.2	0.7 B	0.7 CD	0.4
Platinum 2SC, 8 fl oz/A, in-furrow	0.2	0.9 B	1.0 BC	0.4
Cruiser 0.75 mg AI/seed, seed treatment	0.0	0.7 B	1.0 B	0.4
Untreated	0.6	1.8 A	1.7 A	0.4
Treatment effect from ANOVA	*P=0.46*	*P=0.0186*	*P<0.0001*	*P=0.90*

[1] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.
[2] Note, ratings are lower at 4th true leaf stage than previous stage because cotyledons not included.

Table 2C. Density of striped cucumber beetle on 'Gladiator' pumpkins, 2008, Columbus, Ohio, including only the five treatments used in multi-State trials.

Treatment (all with Thiram fungicide seed treatment)	Number of beetles per plant							
	Cotyledon stage, 8 days after seeding		First true-leaf stage, 11 days after seeding		Second true-leaf stage, 18 days after seeding		Fourth true-leaf stage, 29 days after seeding	
	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
Admire Pro 4.6F, 7 fl oz/A, in-furrow	0.0	2.0	0.2	2.8	0.1	0.1	0.1	0.2
Sepresto 1.0 mg AI/seed, seed treatment (clothianidin + imidacloprid 1.33 mg product)	0.0	0.4	0.1	2.4	0.1	0.0	0.2	0.1
Platinum 2SC, 8 fl oz/A, in-furrow	0.1	0.1	0.2	1.0	0.1	0.02	0.4	0.0
Cruiser 0.75 mg AI/seed, seed treatment	0.0	0.0	0.2	1.0	0.1	0.0	0.1	0.0
Untreated	0.1	0.0	0.1	0.0	0.0	0.02	0.1	0.0
Treatment effect from ANOVA	*0.61*	*0.46*	*0.74*	*0.08*	*0.73*	*0.44*	*0.40*	*0.44*

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