

FINAL REPORT TO THE IR-4 PROGRAM FOR ASSEMBLING OF FOOD USE DATA
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Project title: Insecticide seed treatment for cucurbit crops

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Background: Cucumber beetles are key pests of cucurbits particularly in the seedling stage when they defoliate plants and transmit bacterial wilt disease. Systemic insecticides from the neonicotinoid group have been registered for in-furrow soil treatment of cucurbits for several years in the products Admire (imidacloprid) and Platinum (thiamethoxam). Admire applied in-furrow has been highly effective for control of cucumber beetles as well as seedcorn maggot and squash bug. Platinum is effective for flea beetle control, but unpublished work by the manufacturer of Platinum suggests that control of cucumber beetles has been inconsistent, thus this pest has not been included as a target pest on the label. Although imidacloprid is also available as a seed treatment called Gaucho, which is registered for use on sweet corn and snap beans, its manufacturer has not yet been supportive of its registration as a seed treatment on cucurbits. Thiamethoxam is available as the seed treatment Cruiser, which is registered for use on sweet corn and snap beans, and its manufacturer is interested in pursuing registration on cucurbits if efficacy can be documented. This project focused on efficacy of thiamethoxam seed treatment.

Objectives:

1. To evaluate efficacy of commercial seed treatment with systemic insecticide for control of cucumber beetles on pickling cucumbers and fresh-market pumpkins and zucchini.
2. To test the crop safety of insecticide seed treatment by evaluating effects of on germination of cucurbit seed.

Methods:

Field trials with pickling cucumbers, pumpkins, and zucchini were conducted to evaluate efficacy of thiamethoxam (Cruiser) seed treatment. Untreated seed, which was not treated with fungicide, of 'Eureka' pickling cucumbers, 'Spineless Beauty' zucchini, and 'Hybrid Pam' pumpkins was obtained from Harris Seeds. Seminis 'Vlaspik' pickling cucumber seed treated with Thiram fungicide was also used, with over-treatment by Cruiser. Seed was sent to Syngenta's commercial facility in Minnesota for treatment at three rates of Cruiser: a low rate of 0.05 mg a.i. per seed, a medium rate of 0.25 mg a.i. per seed, and a high rate of 0.4 mg a.i. per seed. Seeds were also treated by Syngenta with Apron XL and Maxim. Trials were set up in a randomized complete block design with four replicates per treatment. Plots were one row wide and 20 to 45 ft long. All trials were planted early to maximize the probability of beetle infestation. Data were taken on plant emergence, beetle damage to seedlings, and beetle density during the seedling stage. Damage and density were evaluated on ten randomly selected plants per plot at least twice during the seedling stage. Yield of fruit was taken only in the pumpkin trial in Clark County.

The pickling cucumber trial was conducted at OARDC/NCARS in Fremont, Sandusky County, with 'Eureka' and 'Vlaspik' varieties, in plots 20 ft long, rows 4ft apart, and 75 seeds per plot. The comparison treatment was Furadan 4F as a post-seeding drench at a rate of 2.4 fl oz per 1000 ft of row. Furadan was intended for use with seed that was not treated with Cruiser, but due to a seed labeling problem, seed treated with the high rate of Cruiser was used in the Furadan plots. The trial was seeded on 31 May 2005.

A trial on seedling pumpkins and seedling zucchini was conducted at Waterman Lab at Columbus in Franklin County, with plots 25 ft long and 25 seeds per plot. Admire 2F in-furrow was used as the comparison treatment at a rate of 2.9 fl oz per 1000 ft of row, which is 16 fl oz per acre for rows 8 ft apart. The trials were seeded on 23 May 2005.

A yield trial on pumpkins was conducted at OARDC/WARS in South Charleston, Clark County, in plots 45 ft long with 34 seeds per plot. Comparison in-furrow treatments were Admire 2F used at a rate of 3.3 fl oz per 1000 ft of row, which is the minimum labeled rate of 16 fl oz per acre for rows 9 ft apart, and Platinum 2SC used at a rate of 1.7 fl oz per 1000 ft of row, which is the maximum labeled rate of 8 fl oz per acre for rows 9 ft apart. The trial was seeded on 1 June 2005, after the initial planting on 24 May was destroyed by mice.

Germination tests of seed treated with three rates of Cruiser on pickling cucumber, pumpkin, and zucchini included standard paper tests as well as soil-plug greenhouse tests. There were four replicates with 50 seeds per replicate for each of the two types of tests.

Laboratory bioassays of cucumber beetles on pickle plants after Cruiser seed treatment were done using the cotyledon-stage plug plants from greenhouse germination tests. This allowed comparison of two species of beetles: striped cucumber beetle and spotted cucumber beetle. Beetles were collected in mid-August from a field in Columbus that was not treated with insecticides. There were five replicates per treatment, with one seedling and five beetles per cage per replicate. Each cage was made of two one-quarter

plastic deli containers sealed together by parafilm, with ventilation panels in the top and sides. Mortality and damage were evaluated 48 hours after beetles were released in the cages.

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. For all trials, data was subjected to analysis of variance using the SAS microcomputer statistics program, with mean separations by LSD.

Results:

The stand counts in all trials showed no negative effect of Cruiser seed treatment on plant emergence. In the pickle trial (Tables 1 and 2), there was a difference between the two varieties, with significantly lower stand counts in the Eureka treatments than in the Vlaspiik treatments. In the pickle trial, the lowest stand count was in the Furadan treatment which was due to severe crusting in those plots which resulted from the drench treatment followed by hot dry weather.

The population of striped cucumber beetle in early summer was heavy in the pickle trial in Sandusky County and in the pumpkin and zucchini trials in Franklin County, but light in the pumpkin trial in Clark County. The population of spotted cucumber beetle was very light in early summer at all sites, but heavy in late summer.

In the pickle trial, beetle damage and the density of live and dead beetles did not differ significantly among treatments when evaluated during the cotyledon stage (Table 1), but treatment differences were found by the first-leaf stage (Table 2). On Eureka pickles, damage was significantly lower in the medium and high rate Cruiser treatments than the untreated check and low rate Cruiser treatment (Table 2). On Vlaspiik pickles, damage was significantly lower in the low rate Cruiser treatment than in the no Cruiser treatment (Table 2). The number of live beetles per plant was significantly higher in the no insecticide treatment on Vlaspiik than in the medium and high rate Cruiser treatments on Eureka (Table 2). By the 7-leaf stage in late June, beetles were too mobile to readily count, but no differences were detected (Table 3). By mid-July, symptoms of bacterial wilt were found in all plots with no treatment differences found (Table 3).

In the zucchini trial, no treatment differences were found at the cotyledon stage (Table 4). By the 2-leaf stage, there was significantly less beetle damage in all Cruiser and Admire treatments than in the no insecticide treatment (Table 5). The high rate of Cruiser was not significantly different than the standard Admire treatment both in damage and in the density of live beetles (Table 5). Damage and live beetles in the low and medium rates of Cruiser were significantly higher than the Admire treatment.

In the pumpkin seedling trial in Franklin County, again there were no treatment differences at the cotyledon stage (Table 6) but by the 2-leaf stage there was significantly less damage and fewer live beetles in all insecticide treatments than in the no-insecticide check (Table 7). By the 4-leaf stage, when damage was evaluated separately on each leaf category (Table 8), there were no significant differences in damage, but there were significantly higher numbers of live beetles per plant on the medium and high rates of Cruiser, which has no apparent explanation.

In the pumpkin yield trial in Clark County, there were treatment differences only in the third seedling evaluation, which was at the first - to second-leaf stage (Table 9); the high rate of Cruiser and the Platinum treatment had significantly less damage than the no-insecticide check. At harvest, there were no treatment differences in number or weight of fruit (Table 10).

Seed germination was not negatively affected by any of the three rates of Cruiser in standard paper tests (Table 11). There was a significant treatment effect in the soil test with Eureka pickle seed, for which there was significantly higher germination after the medium rate of Cruiser than in the no-fungicide treatment and the low rate of Cruiser (Table 11).

The bioassay test was most valuable in showing that this method is suitable for evaluating effects of systemic insecticide seed treatments on beetles, although mortality in the check treatments was too high (>20%) to make firm conclusions about the efficacy of the treatments. The high check mortality was likely due to the beetles being held in captivity for more than one day before the tests were run, and due to some overwatering of plants that resulted in drowning of some beetles. The bioassays with striped cucumber beetle on Eureka pickles, which included all three rates of Cruiser, showed that the medium and high rates of Cruiser caused significantly higher mortality to beetles and lower damage to cotyledons than the no insecticide check treatment, but for spotted cucumber beetle only the high rate of Cruiser caused significantly higher beetle mortality and lower damage to cotyledons than the check (Table 12). The bioassays with Vlaspiik pickles, which included only the low rate of Cruiser, showed that the low rate of Cruiser caused significantly higher beetle mortality and lower damage to cotyledons than the untreated check, for both species of beetles (Table 12).

Conclusions: Seed treatment with thiamethoxam (Cruiser) provided protection to seedlings that was as good as the standard in-furrow Admire treatment for zucchini and pumpkins, but at a lower rate of a.i. per acre. The highest rate of Cruiser tested, 0.4 mg a.i. per seed, provided more consistent control than the 0.25 and 0.05 mg a.i. treatments. Germination tests showed that there was no negative effect of the treatments at the rates that provided effective beetle control. We had expected that a neonicotinoid insecticide applied as a seed treatment would provide control for a longer period of time than in-furrow soil treatment, but observations suggest that effective control might not extend beyond the 2-leaf stage at the rates tested. It would be useful to test rates higher than 0.4 mg thiamethoxam per seed to see if control could extend to a longer period. Commercial seed treatment with systemic insecticide provides a convenient way for growers to protect seedling crops in comparison with in-furrow applications of liquid insecticide because seed treatment is done before seed is purchased. Commercial seed treatment should be more effective, more consistent, and less risky than on-farm seed treatment. Commercial seed treatment is likely to be the preferred method of cucumber beetle control if registration is obtained.

Table 1. Pickling cucumber ('Eureka' and 'Vlaspik') at Sandusky County on 9 June 2005: stand count and cucumber beetle damage at cotyledon stage, mean of 4 blocked replicates.

Treatment	Stand count (number of plants per plot)	Damage rating (0 to 3)	Number of beetles per plant	
			Live (on plant)	Dead (under plant)
Eureka, No insecticide	48.8 B	0.25	0.25	0.00
Eureka, Cruiser low (0.05 mg a.i./seed)	48.5 B	0.08	0.00	0.30
Eureka, Cruiser medium (0.25 mg a.i./seed)	44.5 B	0.05	0.00	0.12
Eureka, Cruiser high (0.4 mg a.i./seed)	45.0 B	0.00	0.00	0.00
Eureka, Cruiser high + Furadan drench	24.2 C	0.02	0.02	0.00
Vlaspik, No insecticide	61.8 A	0.38	0.32	0.05
Vlaspik Cruiser low ¹ (0.05 mg a.i./seed)	66.2 A	0.35	0.22	0.50
<i>ANOVA treatment effect (LSD)</i>	<i>P = 0.0001</i>	<i>P = 0.09</i>	<i>P = 0.19</i>	<i>P = 0.19</i>

¹ On Vlaspik, Cruiser was overtreated on seed already treated with fungicide.

Table 2. Pickling cucumber at Sandusky County, on 14 June 2005: stand count and cucumber beetle damage at one-leaf stage, mean of 4 blocked replicates.

Treatment	Stand count (number of plants per plot)	Damage rating (0 to 3)	Number of live beetles per plant
Eureka, No insecticide	51.5 B	1.62 AB	0.22 ABC
Eureka, Cruiser low (0.05 mg a.i./seed)	52.5 B	1.45 B	0.22 ABC
Eureka, Cruiser medium (0.25 mg a.i./seed)	48.8 B	0.75 C	0.08 BC
Eureka, Cruiser high (0.4 mg a.i./seed)	48.2 B	0.78 C	0.08 BC
Eureka, Cruiser high + Furadan drench	27.5 C	0.58 C	0.00 C
Vlaspik, No insecticide	64.2 A	1.98 A	0.48 A
Vlaspik, Cruiser low (0.05 mg a.i./seed)	69.8 A	1.48 B	0.30 AB
<i>ANOVA treatment effect (LSD)</i>	<i>P = 0.0001</i>	<i>P = 0.0001</i>	<i>P = 0.03</i>

Table 3. Pickling cucumber at Sandusky County, 2005: cucumber beetle and bacterial wilt evaluations on 29 June and 18 July, mean of 4 blocked replicates.

Treatment	Number of live beetles per plant on 6/29/05 (7-leaf stage)	Number of plants per plot with symptoms of bacterial wilt on 7/18/05
Eureka, No insecticide	2.2	3.8 B
Eureka, Cruiser low (0.05 mg a.i./seed)	1.6	5.5 B
Eureka, Cruiser medium (0.25 mg a.i./seed)	1.8	5.5 B
Eureka, Cruiser high (0.4 mg a.i./seed)	2.8	5.2 B
Eureka, Cruiser high + Furadan drench	2.2	3.0 B
Vlaspik, No insecticide	0.4	8.8 A
Vlaspik, Cruiser low (0.05 mg a.i./seed)	1.8	9.0 A
<i>ANOVA treatment effect (LSD)</i>	<i>P = 0.10</i>	<i>P = 0.003</i>

Table 4. Zucchini ('Spineless Beauty') at Franklin County on 3 June 2005: stand count and cucumber beetle damage at cotyledon stage, mean of 4 blocked replicates.

Treatment	Stand count (number of plants per plot)	Damage rating (0 to 3)	Number of Beetles Per Plant	
			Live (on plant)	Dead (under plant)
No insecticide	15.2	0.10	0	0
Cruiser low (0.05 mg a.i./seed)	12.0	0.15	0	0
Cruiser medium (0.25 mg a.i./seed)	13.5	0.02	0	0
Cruiser high (0.4 mg a.i./seed)	12.2	0.05	0	0
Admire in furrow	13.2	0.05	0	0
<i>ANOVA treatment effect (LSD)</i>	<i>P = 0.41</i>	<i>P = 0.16</i>		

Table 5. Zucchini ('Spineless Beauty') at Franklin County on 8 June 2005: stand count and cucumber beetle damage at 2-leaf stage, mean of 4 blocked replicates.

Treatment	Stand count (number of plants/plot)	Damage rating (0 to 3)	Number of beetles per plant	
			Live (on plant)	Dead (under plant)
No insecticide	14.5	2.28 A	3.42 A	0.05
Cruiser low (0.05 mg a.i./seed)	12.0	1.61 B	2.54 A	1.18
Cruiser medium (0.25 mg a.i./seed)	13.2	1.23 B	1.39 B	3.04
Cruiser high (0.4 mg a.i./seed)	12.0	1.09 BC	0.58 BC	2.53
Admire in furrow	13.2	0.48 C	0.08 C	1.50
<i>ANOVA treatment effect (LSD)</i>	<i>P = 0.62</i>	<i>P = 0.0006</i>	<i>P = 0.0001</i>	<i>P = 0.31</i>

Table 6. Pumpkin ('Hybrid Pam') at Franklin County on 3 June 2005: stand count and cucumber beetle damage at cotyledon stage, mean of 4 blocked replicates.

Treatment	Stand count (number of plants per plot)	Damage rating (0 to 3)	Number of beetles per plant	
			Live (on plant)	Dead (under plant)
No insecticide	12.0	0	0	0
Cruiser low (0.05 mg a.i./seed)	12.5	0.025	0	0
Cruiser medium (0.25 mg a.i./seed)	10.8	0.028	0	0
Cruiser high (0.4 mg a.i./seed)	9.5	0	0	0
Admire 2F in furrow	12.0	0.025	0	0
<i>ANOVA treatment effect (LSD)</i>	<i>P = 0.35</i>	<i>P = 0.78</i>		

Table 7. Pumpkin ('Hybrid Pam') at Franklin County on 8 June 2005: stand count and cucumber beetle damage at 2-leaf stage; mean of 4 blocked replicates.

Treatment	Stand count (number of plants per plot)	Damage rating (0 to 3)	Number of beetles per plant	
			Live (on plant)	Dead (under plant)
No insecticide	12.2	1.59 A	4.3 A	0.00
Cruiser low (0.05 mg a.i./seed)	12.2	0.50 B	0.2 B	0.02
Cruiser medium (0.25 mg a.i./seed)	11.8	0.46 B	0.4 B	0.10
Cruiser high (0.4 mg a.i./seed)	10.5	0.53 B	0.3 B	0.72
Admire in furrow	12.8	0.84 B	1.0 B	0.05
<i>ANOVA treatment effect (LSD)</i>	<i>P = 0.77</i>	<i>P = 0.03</i>	<i>P = 0.011</i>	<i>P = 0.35</i>

Table 8. Pumpkin ('Hybrid Pam') at Franklin County on 14 June 2005: cucumber beetle damage at 4-leaf stage; mean of 4 blocked replicates.

Treatment	Damage rating (0 to 3)					Number of live beetles per plant
	Cotyledon	1 st leaf	2 nd leaf	3 rd leaf	4 th leaf	
No insecticide	3.0	2.1	1.6	1.4	0.6	1.0 B
Cruiser low (0.05 mg a.i./seed)	3.0	1.9	1.6	1.4	0.8	1.6 B
Cruiser medium (0.25 mg a.i./seed)	3.0	1.6	1.5	0.8	0.4	4.3 A
Cruiser high (0.4 mg a.i./seed)	3.0	1.8	1.3	1.0	0.5	4.0 A
Admire in furrow	2.8	1.6	1.6	1.4	1.1	1.0 B
<i>ANOVA trtmt effect (LSD)</i>	<i>P=0.44</i>	<i>P=0.45</i>	<i>P=0.72</i>	<i>P=0.13</i>	<i>P=0.08</i>	<i>P = 0.0017</i>

Table 9. Pumpkin ('Hybrid Pam') damage by cucumber beetles at Clark County, June 2005; mean of 4 blocked replicates.

Treatment	Stand count (number of plants per plot) on 6/27	Damage rating (0 to 3) on 5 dates				
		6/14 (cotyledon/ 1 st leaf)	6/16 (cotyledon/ 1 st leaf)	6/20 (1 st /2 nd leaf)	6/23 (1 st /2 nd leaf)	6/27 (2 nd /3 rd leaf)
Check, Fungicide only	27.8	0.100	0.200	0.65 A	0.525	0.950
Admire in-furrow, 16 fl oz/A (3.3 fl oz/1000' for 9'rows)	26.8	0.050	0.125	0.275 AB	0.300	0.375
Platinum in-furrow, 8 fl oz/A (1.7 fl oz/1000' for 9' rows)	18.8	0.050	0.050	0.125 B	0.125	0.425
Cruiser low (0.05 mg a.i./seed)	29.2	0.025	0.150	0.300 AB	0.400	0.825
Cruiser high (0.40 mg a.i./seed)	28.8	0.000	0.075	0.125 B	0.300	0.325
<i>ANOVA trtmt effect</i>	<i>P = 0.12</i>	<i>P = 0.57</i>	<i>P = 0.38</i>	<i>P = 0.009</i>	<i>P = 0.09</i>	<i>P = 0.30</i>

Table 10. Pumpkin ('Hybrid Pam') yield at harvest on 25 August 2005, Clark County; mean of 4 blocked replicates.

Treatment	Number of orange fruit per plot	Weight (kg) orange fruit per plot
Check, Fungicide only	24.50	44.23
Admire in-furrow, 16 fl oz/A (3.3 fl oz/1000' for 9'rows)	22.75	42.51
Platinum in-furrow, 8 fl oz/A (1.7 fl oz/1000' for 9' rows)	24.25	46.19
Cruiser low (0.05 mg a.i./seed)	25.25	43.94
Cruiser high (0.40 mg a.i./seed)	23.00	40.99
<i>ANOVA treatment effect</i>	<i>P = 0.76</i>	<i>P = 0.85</i>

Table 11. Germination of cucurbit seeds after treatment with Cruiser, August 2005; mean of 4 replicates.

Crop	Treatment	% germination in standard paper test		% germination in soil test
		4-day	7-day	
Pumpkin, 'Hybrid Pam'	No Cruiser	92.0	98.0	75.5
	Low Cruiser	92.0	97.0	74.5
	Med. Cruiser	92.0	97.5	68.0
	High Cruiser	91.0	96.5	64.0
	<i>ANOVA treatment effect</i>	<i>P = 0.94</i>	<i>P = 0.73</i>	<i>P = 0.10</i>
Zucchini, 'Spineless Beauty'	No Cruiser	95.5	97.0	93.0
	Low Cruiser	98.5	98.5	94.5
	Med. Cruiser	97.0	98.5	94.5
	High Cruiser	97.0	99.0	89.5
	<i>ANOVA treatment effect</i>	<i>P = 0.44</i>	<i>P = 0.70</i>	<i>P = 0.43</i>
Cucumber, 'Eureka'	Untreated	85.5	89.0	79.5 C
	No Cruiser	83.0	88.0	85.5 ABC
	Low Cruiser	82.5	86.5	82.5 BC
	Med. Cruiser	84.5	88.5	90.0 A
	High Cruiser	86.5	89.5	89.0 AB
	<i>ANOVA treatment effect</i>	<i>P = 0.79</i>	<i>P = 0.92</i>	<i>P = 0.02</i>
Cucumber, 'Vlaspik'	No Cruiser	95.5	96.5	97.0
	Low Cruiser	98.0	98.0	97.0
	<i>ANOVA treatment effect</i>	<i>P = 0.43</i>	<i>P = 0.74</i>	<i>P = 0.99</i>

Table 12. Mortality and damage by cucumber beetles in laboratory bioassays on pickle seedlings after Cruiser seed treatment, August 2005.

Beetle Species	Pickle Variety	Treatment	% Mortality of beetles	Damage rating (scale 0 to 3)	
				cotyledons	1 st true leaf
Striped cucumber beetle	Eureka	Untreated (no fungicide)	40 B	2.4 A	0.4
	Eureka	Fungicide only, no Cruiser	38 B	2.0 A	0.2
	Eureka	Cruiser low (0.05 mg a.i./seed)	56 AB	1.0 B	0.0
	Eureka	Cruiser medium (0.25 mg a.i./seed)	88 A	0.8 B	0.2
	Eureka	Cruiser high (0.4 mg a.i./seed)	92 A	0.8 B	0.0
	<i>Eureka</i>	<i>ANOVA treatment effect</i>	<i>P=0.008^b</i>	<i>P=0.0001</i>	<i>P=0.44</i>
	Vlaspik	Fungicide only, no Cruiser	32 B	2.4 A	1.0 A
	<i>Vlaspik</i>	<i>ANOVA treatment effect</i>	<i>P=0.02^b</i>	<i>P=0.005</i>	<i>P=0.03</i>
Spotted cucumber beetle	Eureka	Untreated (no fungicide)	24 C	2.8 A	1.4
	Eureka	Fungicide only, no Cruiser	16 BC	2.4 AB	1.8
	Eureka	Cruiser low (0.05 mg a.i./seed)	24 BC	2.0 ABC	0.2
	Eureka	Cruiser medium (0.25 mg a.i./seed)	52 AB	1.8 BC	0.6
	Eureka	Cruiser high (0.4 mg a.i./seed)	76 A	1.4 C	0.0
	<i>Eureka</i>	<i>ANOVA treatment effect</i>	<i>P=0.008^b</i>	<i>P=0.04</i>	<i>P=0.13</i>
	Vlaspik	Fungicide only, no Cruiser	8 B	3.0 A	2.2
	<i>Vlaspik</i>	<i>ANOVA treatment effect</i>	<i>P=0.046^b</i>	<i>P=0.004</i>	<i>P=0.09</i>

^a Cruiser over-treated on seed already treated with fungicide.

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