Using Precision Agriculture to Reduce In-Furrow Insecticides in Cucurbits

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Abstract

In 2004 and 2005, researchers at OSU designed and built a precision insecticide delivery system capable of injecting variable length insecticide bands in-furrow over the top of direct seeded cucurbits (pumpkin, zucchini, and cucumber). Two critical factors supporting this project include wide in-row seed spacing (up to 36 inches) and an effective systemic insecticide (imidacloprid) to control early season pests, particularly Striped cucumber beetles (StrCB), *Acalymma vittatum* (Fabricius). Studies conducted in both years indicate bander accuracy is between 93-96% on all cucurbit seeds, and from 90-97% at speeds up to 4.0 miles per hour. Cucurbit seeds were planted under four treatments in 2004; water only, 16 and 24 oz. / A rate of imidacloprid via precision in-furrow injector, and a 24 oz. / A continuous in-furrow application of imidacloprid. In 2005, there were five treatments, water only, 16 and 24 oz. / A rate of imidacloprid via the precision bander, and 16 and 24 oz. / A rate of continuous in-furrow application of imidacloprid. Efficacy of treatments in both years were determined with bioassays of excised cotyledon through 5th leaf stages of cucurbits using StrCB. In 2004 and 2005, scoring moribund beetles as dead in the analysis, there were significant differences in beetle mortality between the check and all other treatments in 71% of the trials (17/24). Significant differences between the check and some of the remaining treatments occurred in 25% of the trials (6/24), and in one trial no significant differences were found. Projected economic savings using the precision bander system at the rates employed in this study range from 58.3 to 84.5% of the targeted rate per acre. Rate savings are dependent on band length, row and seed spacing.

Objectives

1. To determine the accuracy of the insecticide band in relation to seed size (cucumber, zucchini, and pumpkin)at speeds of 1.4 to 4.0 miles per hour.

2. To determine the efficacy of the precision banded insecticide system in a series of leaf tissue bioassays using striped cucumber beetles.

Design of the Precision In-furrow Insecticide Bander

The precision bander (Figure 1) functions in the following way. Seed is metered from the hopper box into the seed tube. As seed falls past an optical sensor, it sends an electrical impulse to the cab mounted row controller. The controller activates a solenoid valve allowing insecticide to flow for a pre-determined time frame. When the time period expires, the valve shuts off and waits for the next seed to drop, i.e. the next signal to repeat the process.

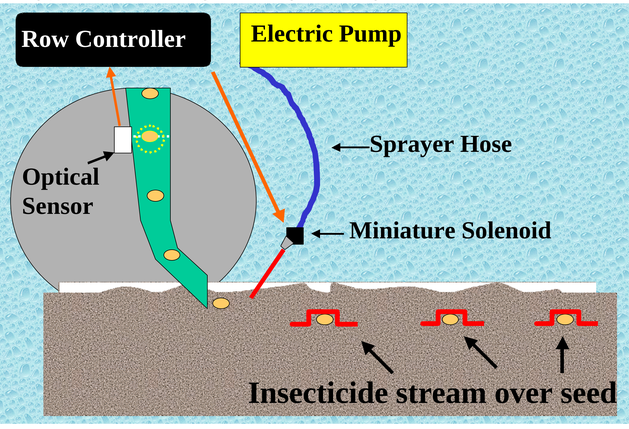

Figure 1: Illustration of precision bander function and operation.

Evaluation of Precision bander

To determine the synchronicity between the injected bands of insecticide and the seed, trials where seed was "planted" on the soil surface and "banded" using water only determined how accurately the band overlaid the seed (Table 1). The "band" is a single stream of liquid directed at the bottom of the seed furrow, or in this case, directed at a ¼" furrow on the soil surface. Seed dropped within the water band was considered "in the band"; seed dropped within 2 inches of the band (front or back) it was considered a bounce, meaning the seed initially landed in the band, then bounced out. Seed falling beyond 2 inches from the band were considered missed by the bander. There were four replicates of 100 seed / band events recorded per treatment.

Table 1. 2004 and 2005 % seed and water band synchronization means.

	Pumpkin		Zucchini		Cucumber		All Cucurbits	
Planting speed	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
1.4 mph	97.0	NA	96.0	NA	91.8	NA	94.9	NA
2.0 mph	94.0	97.3	97.3	96.0	93.8	95.0	95.0	96.1
2.8 mph	93.8	94.0	89.5	97.5	92.5	93.8	91.9	95.1
4.0 mph	NA	90.0	NA	95.0	NA	92.5	NA	92.5
Avg.	94.9	93.7	94.3	96.2	92.7	93.7	93.9	94.5

Table 2. 2004 Striped cucumber beetle % mortality by treatment after 72 hours of bioassay at various seedling stages.

	Cucumber			Pumpkin			Zucchini		
Stage	Treatments	% Mortality		Treatments	% Mortality		Treatments	% Mortality	
cotyledon	Check	16.7	A	Check	1.7	A	Check	5.0	A
	PB, 16oz/A	86.7	B	PB, 16oz/A	41.7	B	PB, 24oz/A	70.0	B
	PB, 24oz/A	90.0	B	CF, 24oz/A	41.7	B	CF, 24oz/A	70.0	B
	CF, 24oz/A	100.0	B	PB, 24oz/A	68.3	C	PB, 16oz/A	73.3	B
	p < 0.0001			p < 0.0001			p < 0.0001		
1st leaf	Check	23.3	A	Check	0.0	A	Check	0.0	A
	PB, 16oz/A	66.7	B	PB, 16oz/A	25.0	B	PB, 16oz/A	55.0	B
	PB, 24oz/A	78.3	B	CF, 24oz/A	48.8	C	CF, 24oz/A	77.9	C
	CF, 24oz/A	90.0	B	PB, 24oz/A	79.6	D	PB, 24oz/A	86.7	C
	p < 0.0001			p < 0.0001			p < 0.0001		
2nd leaf	Check	6.7	A	Check	3.3	A	Check	5.0	A
	PB, 16oz/A	58.3	B	PB, 16oz/A	6.7	A B	PB, 16oz/A	53.3	B
	PB, 24oz/A	66.7	B	PB, 24oz/A	21.7	B C	PB, 24oz/A	58.3	B
	CF, 24oz/A	90.0	C	CF, 24oz/A	25.0	C	CF, 24oz/A	81.7	C
	p < 0.0001			p < 0.003			p < 0.0001		
5th leaf	Check	NA		Check	NA		Check	3.3	A
	PB, 16oz/A	NA		PB, 16oz/A	NA		CF, 24oz/A	28.3	A B
	PB, 24oz/A	NA		PB, 24oz/A	NA		PB, 24oz/A	30.0	B
	CF, 24oz/A	NA		CF, 24oz/A	NA		PB, 16oz/A	31.7	B
							p < 0.017		

PB – Precision Banded, CF – Continuous Flow

Table 3. 2005 Striped cucumber beetle % mortality by treatment after 72 hours of bioassay at various seedling stages.

	Zucchini			Pumpkin			Cucumber		
Stage	Treatments	% Mortality		Treatments	% Mortality		Treatments	% Mortality	
cotyledon	Check	0.153	A	Check	0.033	A	Check	0.108	A
	CF, 16oz/A	0.875	B	CF, 24oz/A	0.933	B	PB, 16oz/A	0.883	B
	PB, 16oz/A	0.933	B C	PB, 16oz/A	0.933	B	PB, 24oz/A	0.942	B C
	PB, 24oz/A	0.967	C	CF, 16oz/A	0.967	B	CF, 16oz/A	0.942	B C
	CF, 24oz/A	1.000	C	PB, 24oz/A	0.967	B	CF, 24oz/A	0.975	C
	p < 0.0001			p < 0.0001			p < 0.0001		
1st leaf	Check	0.050	A	Check	0.044	A	Check	0.009	A
	CF, 16oz/A	0.714	B	PB, 16oz/A	0.530	B	PB, 16oz/A	0.487	B
	PB, 16oz/A	0.717	B	CF, 16oz/A	0.609	B C	CF, 16oz/A	0.500	B
	CF, 24oz/A	0.808	B	PB, 24oz/A	0.754	C D	PB, 24oz/A	0.667	C
	PB, 24oz/A	0.825	B	CF, 24oz/A	0.814	D	CF, 24oz/A	0.767	C
	p < 0.0001			p < 0.0001			p < 0.0001		
2nd leaf	Check	0.000	A	Check	0.008	A	Check	0.008	A
	CF, 16oz/A	0.208	B	PB, 16oz/A	0.186	B	CF, 16oz/A	0.050	A B
	PB, 16oz/A	0.305	B C	CF, 16oz/A	0.261	B	PB, 16oz/A	0.075	A B
	CF, 24oz/A	0.345	B C	PB, 24oz/A	0.458	C	CF, 24oz/A	0.138	B C
	PB, 24oz/A	0.425	C	CF, 24oz/A	0.549	C	PB, 24oz/A	0.183	C
	p < 0.0001			p < 0.0001			p < 0.0001		
3rd leaf	Check	0.000	A	Check	0.000	A	Check	0.011	A
	CF, 16oz/A	0.095	A B	CF, 16oz/A	0.076	A	PB, 16oz/A	0.133	A B
	PB, 16oz/A	0.117	B	PB, 16oz/A	0.085	A	CF, 16oz/A	0.168	B
	CF, 24oz/A	0.138	B	PB, 24oz/A	0.208	B	CF, 24oz/A	0.316	C
	PB, 24oz/A	0.176	B	CF, 24oz/A	0.277	B	PB, 24oz/A	0.370	C
	p < 0.0002			p < 0.0001			p < 0.0001		
4th leaf	Check	0.118	A	NA			PB, 24oz/A	0.008	A
	PB, 16oz/A	0.258	B	NA			PB, 16oz/A	0.051	A
	CF, 16oz/A	0.317	B C	NA			CF, 16oz/A	0.051	A
	PB, 24oz/A	0.358	B C	NA			Check	0.068	A
	CF, 24oz/A	0.412	C	NA			CF, 24oz/A	0.076	A
	p < 0.0001						p = 0.154		

PB – Precision Banded, CF – Continuous Flow

Bioassay studies with striped cucumber beetle

To establish efficacy of the precision bander compared to continuous in-furrow, seedling clippings were taken from seeds treated by both systems and bioassayed using StrCB. Forty bioassays were conducted per treatment (4 reps x 10 samples). For each bioassay, one beetle was sealed in a clear 5 oz. plastic container with a clipped cucumber, zucchini, or pumpkin seedling stage (cotyledon, 1st, 2nd, 3rd, 4th, or 5th leaf). Mortality observations were taken at 24, 48, and 72 hours (Table 2,3) where beetles were classified as alive, dead, or moribund. Although moribund beetles were not absolutely dead, they were categorized as functionally dead for the purposes of this study and analysis because they could only twitch, not move, feed, or mate.

In 2004, beetle mortality was significantly higher in all Admire treatments compared to the water only check in 8/10 bioassay trials. Mortality at the "high" rate banded and continuous flow treatment levels was consistently higher than that of the "low" rate banded treatment. In 9 out of 10 bioassay trials, a portion of the beetles that appeared dead in one inspection revived at a later inspection.

In 2005, beetle mortality was significantly higher in all Admire treatments compared to the water only check in 9/14 bioassay trials. Mortality in the "high" rated banded and continuous flow treatment levels was consistently and frequently statistically higher than the "low" rate precision banded and continuous flow treatments. Similar to 2004, a portion of the beetles that appeared dead in one inspection revived at a later inspection.

In general over both years, beetle mortality increased as the initial rate of Admire increased, and mortality decreased as seedlings matured and developed, possibly as a function of increasing leaf area diluting imidacloprid tissue concentration.

Table 4. Economics of precision banding vs. continuous flow. Assumes same row spacing, Admire @ $4.30 / oz., and injected band is 5" long.

Application Technique	Target Rate / A (oz)	Seed Spacing (in)	Projected Savings	Projected Cost / A
Precision banded	16	12	58.3%	$ 28.67
Precision banded	16	32.5	84.5%	$ 10.66
Continuous flow	16	DNA	0.0%	$ 68.80
Precision banded	24	12	58.3%	$ 43.00
Precision banded	24	32.5	84.5%	$ 16.00
Continuous flow	24	DNA	0.0%	$ 103.20

Summary

In 2004, 80% of the trials indicated mortality achieved by the precision bander at the 24 oz./A rate were statistically no different from the conventionally accepted standard in our trial. In 2005, 100% of the trials indicated no statistical difference in the mortality achieved by the precision bander and the continuous application at the same rate. These two years of data indicate the precision bander system is as effective for early season StrCB control as conventional, continuously applied in-furrow insecticides.

As a result of this research project, immediate economic savings for cucurbit production could range between $58 and $87 per acre (Table 4). Environmental benefits include a reduction of imidacloprid on a per acre basis of 58.3 to 84.5% based on band length, row and seed spacing without apparent loss of efficacy. The precision bander is currently only a prototype but has generated significant interest in the grower community and industry.

In closing, there is overwhelming evidence that the precision bander can have immediate and substantial economic and environmental impact on a wide range cucurbit production in Ohio and throughout the Midwest.

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