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SEED TREATMENTS FOR WIREWORM CONTROL IN FIELD CORN

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ABSTRACT

Wireworms are the soil-dwelling larvae of click beetles. Wireworms feed on the seed and roots of various crops and are a particular pest of field corn in the Sacramento-San Joaquin River Delta region. Wireworms are generally managed by seed treatments or treatments at planting, and the objective of our study was to evaluate the efficacy of eight seed treatments versus an untreated control at a site where wireworms are a perennial problem. We evaluated growth and yield parameters. Several treatments outperformed the untreated control in growth; however, there were no treatment differences in yield. Results from this study illustrate that there are different chemistries available for combatting wireworms in field corn, and growers have several options for controlling these pests.

INTRODUCTION

Wireworms (*Limonius* spp.) are the larvae of the click beetle. Wireworms are yellow to brown in color, cylindrical, and have tough skin. They live in the soil and may live three or more years depending on species, conditions, and food supply (UC IPM Guidelines, 2014). Wireworms feed on a variety of plants, including corn, and cause damage by feeding on the seed or roots of an emerging seedling. They can be particularly damaging to a corn crop that follows a crop with dense roots, like pasture, small grains, or alfalfa. Wireworm management in corn is generally by seed treatment or treatment at the time of planting. Cultural practices – like crop rotation, flooding, or cultivation – are generally ineffective because wireworms have a wide host range and adaptability to different environments (Andrews et al., 2008). Delaying planting to allow soils to dry and warm may improve corn emergence because wireworms retreat deeper in the soil under these conditions (McLeod and Studebaker, 2003), but this is a management practice that may not always be possible.

Many wireworm control studies focus on evaluating insecticide efficacy. Studies show that certain chemistries, like the neonicotinoids thiamethoxam and imidacloprid, are as effective at controlling wireworms as organophosphates (Kuhar and Alvarez, 2008), the latter being linked to environmental and wildlife persistence (Elliott et al., 2011). Additionally, researchers have found that seed treatments are as effective at controlling wireworms as granular treatments at the time of planting (Wilde et al., 2004). Seed treatments are easier to apply than granular treatments, and the range of chemistries available allows for chemical rotations as part of an integrated pest management program.

DELTA TRIAL

The seed treatment trial for wireworm control was located on Tyler Island in the Sacramento-San Joaquin River Delta region. The soil at the trial location is a Rindge muck, which characterizes approximately 57,000 acres in the Delta. The soil has approximately 45 percent organic matter in the top 15 inches of soil. The Rindge muck is considered very poorly drained, and thus, it was a good soil for this trial because the soil stays cool and damp into late spring and early summer.

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The site was chosen based on its history. The grower said that the site was notorious for wireworm damage, and additionally, the field had been fallowed since July 2013, when the previous wheat crop was harvested. The field was fall plowed after the wheat but was otherwise left undisturbed through the winter and early spring. Resident vegetation had grown over the winter, so plant roots were available for wireworm feeding in the early spring.

Three weeks before planting, we baited the field with carrots to confirm wireworm presence. We buried carrots over a large swath of the field. The GPS coordinates of the carrots were recorded, and we collected them one week later. Wireworms were counted on each carrot to determine where the pressure was highest. We then buried a second batch of carrots in a smaller portion of the field where the pressure was highest and confirmed the high pressure one week later when we dug up the second batch and counted the wireworms. We located the plot where the wireworm pressure was highest.

The trial was planted on May 19, 2014. The soil was moist and 65 degrees F at the time of planting. Four replicate blocks of eight seed treatments plus control (Table 1) were applied to Pioneer variety 1319HR. Three of the treatments are commercially available for the management of wireworm (Poncho®, Poncho® Votivo®, and Cruiser®). The other five treatments were different rates and combinations of a new product called Lumivia™.

Table 1. Seed treatment, company, and product information in the 2014 UCCE field corn trial.

Product	Company	Active Ingredient	Chemistry Class	Rate[a]
Lumivia™	DuPont	Chlorantraniliprole	Anthranilic Diamide	250 µg a.i./seed
Lumivia™	DuPont	Chlorantraniliprole	Anthranilic Diamide	500 µg a.i./seed
Lumivia™	DuPont	Chlorantraniliprole	Anthranilic Diamide	750 µg a.i./seed
PPST 250[b] + Lumivia™	DuPont	PPST 250[b] + Chlorantraniliprole	Neonicotinoid + Anthranilic Diamide	250 µg a.i./seed + 250 µg a.i./seed
PPST 250[b] + Lumivia™	DuPont	PPST 250[b] + Chlorantraniliprole	Neonicotinoid + Anthranilic Diamide	250 µg a.i./seed + 500 µg a.i./seed
Poncho®	Bayer CropScience	Clothianidin	Neonicotinoid	500 µg a.i./seed
Poncho® Votivo®	Bayer CropScience	Clothianidin + Bacillus firmus I-1582	Neonicotinoid + biological	1250 µg a.i./seed
Cruiser®	Syngenta	Thiamethoxam	Neonicotinoid	250 micrograms a.i./seed
Untreated control	N/A	N/A	N/A	N/A

[a] µg – micrograms
[b] Thiamethoxam plus fungicides. A Pioneer seed treatment offering.

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Each plot consisted of four 30-inch beds on a row length of 50 feet. Seed was planted approximately two inches deep and six inches apart down the row, for an approximate planting density of 35,000 seeds per acre. The field was pre-irrigated before planting, and subsurface irrigation by "spud ditch" was employed three times during the season. Nitrogen was applied preplant (100 units/acre as aqua ammonia), and 30 gallons/acre of 8-24-6 was applied as a starter fertilizer. One glyphosate application served to control weeds, and no miticide was applied.

Growth parameters of interest were emergence, stand count, vigor, damaged plants, dead plants, and height (Tables 2 and 3). These parameters were measured from one week after planting to six weeks after planting, with the exception of height, which was measured from four weeks after planting to six weeks after planting. Emergence and stand counts were the number of plants in a 10-foot length from the second row of each plot. Vigor was a visual rating on a scale of 1-10, where Cruiser® was the standard and always rated 5. Damaged and dead plants were counts out of 25 plants from the second row of each plot. Height was measured from the soil level to the tip of the last fully emerged leaf.

On June 5th, five seedlings from each of the first and fourth rows were lifted, and dead and live wireworms were counted on the seeds, roots, and surrounding soil (Table 2). The seedlings were given a visual rating on a scale of 0-3, where 0 indicated no damage, 1 indicated some root feeding but overall good plant health, 2 indicated moderate feeding and declining plant health, and 3 indicated dead plants.

The field was harvested on October 23rd. Two 20-foot lengths from the middle two rows were hand harvested for each plot, and the number of plants in the harvested area were counted. The kernels were threshed from the cobs using a Kincaid® 18-inch bundle thresher, and the moisture was read using a Dickey-John® GAC 2100b moisture meter. Yield for the harvested area was scaled up to pounds per acre and adjusted to 15 percent moisture (Table 4).

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Table 2. Emergence and wireworm counts of the 2014 UCCE field corn seed treatment study.

Date: **Treatment**	**May 28th** **Emergence (#/10 feet)**	**June 5th** **Live Wireworms (#/10 plants)**	**Dead Wireworms (#/10 plants)**	**Damage Rating (0-3 scale, 10 plants)**
Lumivia™ 250	16.8	10.23	0.325	1.16
Lumivia™ 500	16	10.4	0	1.27
Lumivia™ 750	18	8.15	0	1.12
PPST 250 + Lumivia™ 250	17.8	10.26	0.8	1.23
PPST 250 + Lumivia™ 500	18.5	9.43	0	0.82
Poncho®	19	12.34	0.55	0.75
Poncho® Votivo®	18.8	11.67	0.775	0.99
Cruiser®	18	8.97	0.575	0.84
Untreated control	16	8.75	0.325	1.34
Treatment P value	**0.07**	**0.54**	**0.21**	**0.05**
Standard Error	**0.83**	**1.62**	**0.27**	**0.14**

Table 3. Growth parameters of the 2014 UCCE field corn seed treatment study.

Date: **Treatment**	**Stand Count (# plants/10 feet)**		**All Dates (Weekly from June 5th to July 2nd)** **Vigor (Cruiser® is standard, 5)**		**Damaged Plants (#/25 plants)**		**Dead Plants (#/25 plants)**		**Height (inches)**	
Lumivia™ 250	16.75	bc	3.7	ef	6.31	bc	1.18	ab	32.3	de
Lumivia™ 500	16.75	abc	3.9	def	4.83	cd	0.73	bc	30.1	e
Lumivia™ 750	17.7	ab	4.5	cde	3.33	cd	0.33	c	34.3	cd
PPST 250 + Lumivia™ 250	18.2	ab	4.7	bcd	4.39	cd	0.49	c	37.4	bc
PPST 250 + Lumivia™ 500	18.65	a	5.7	ab	2.51	d	0.42	c	40.2	ab
Poncho® Votivo®	18.2	ab	5.7	ab	4.38	cd	0.18	c	40	ab
Poncho®	15.2	c	6.2	a	9.94	a	0.1	c	41.9	a
Cruiser®	16.65	bc	5	abc	8.56	ab	0.64	bc	38.2	b
Untreated control	15.65	c	3.1	f	5.51	bc	3.33	a	32.5	de
Treatment P value	**<0.0001**		**<0.0001**		**<0.0001**		**<0.0001**		**<0.0001**	
Standard Error	**0.5**		**0.42**		**1.69**		**0.32**		**1.65**	

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Table 4. Harvest results of the 2014 UCCE field corn seed treatment study.

Treatment	Total Plants (# plants/harvested area)	Moisture (%)	Plot Yield at 15% Moisture (lbs/acre)
Lumivia™ 250	61 ab	13.2	8348
Lumivia™ 500	59 ab	13.4	8934
Lumivia™ 750	66 ab	12.9	9849
PPST 250 + Lumivia™ 250	66 ab	12.8	9070
PPST 250 + Lumivia™ 500	74 a	12.7	10376
Poncho® Votivo® 1250	69 a	12.8	9494
Poncho® 500	72 a	12.3	10005
Cruiser® 250	69 a	12.9	9652
Untreated Control	50 b	13.1	8373
Treatment P value	**0.0016**	**0.4704**	**0.3413**
Standard Error	**3.55**	**0.38**	**737**

INTERPRETATION OF RESULTS

When interpreting the results, keep the following in mind. The mean is equal to the sum of values divided by the number of values. When evaluations occurred on only one date, the mean value is calculated for the four replicate blocks. For stand count, vigor, damaged plants, dead plants, and height, however, evaluations were made weekly over multiple weeks. The mean values for these parameters were calculated for all of the dates that data were collected. The statistical method used to compare the means, called Tukey's range test, compares all means against each other. Treatments were considered statistically different if their P value was less than 0.05, or 5 percent. What this means is that when differences between treatments exist, we are 95% certain that the treatments are actually different; the results are not due to random chance. Differences between treatments are indicated by different letters following the mean. For example, a treatment that has only the letter "a" after the mean value is different from a treatment that is followed by only the letter "b", but it is ***not*** different from a treatment whose mean value is followed by both letters ("ab").

Treatment differences became evident about two weeks after planting. While there were no differences among the treatments for the parameters presented in Table 2, there were differences among treatments for the parameters presented in Table 3. The Lumivia™ 500 and 750 treatments, the PPST 250 + Lumivia™ combination treatments, and the Poncho® Votivo® treatment had high stand counts, and all of these treatments except Lumivia™ 500 performed better than the untreated control. Plant vigor rated highest for the PPST 250 + Lumivia™ 500 combination treatment, the two Poncho® treatments, and the Cruiser® treatment, all of which were statistically similar and better than the untreated control. The PPST 250 + Lumivia™ 500 treatment had the lowest number of damaged plants and was statically different from the

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untreated control. The number of dead plants was similarly low for all treatments except the Lumivia™ 250 treatment, which performed similarly to the untreated control. Average height over the three weeks was highest and statistically similar for PPST 250 + Lumivia™ 500, Poncho® Votivo®, and Poncho®, and better than the untreated control.

Among the parameters measured at harvest, only the number of plants per harvested area differed, with PPST 250 + Lumivia™ 500, Poncho® Votivo®, Poncho®, and Cruiser® having higher plant counts than the untreated control. There were no statistical differences among treatments for moisture or yield. Numerically, the PPST 250 + Lumivia™ 500 and Poncho® treatments yielded over five tons to the acre, compared to the control which yielded approximately 4.2 tons per acre, but based on this research, we cannot attribute the numerical differences to treatment differences.

SUMMARY

Wireworms are the soil-dwelling larvae of click beetles, and they are a pest of field corn in the organic soils of the Delta. In 2014, we studied eight seed treatments against the untreated control to evaluate their efficacy against wireworms. Three of the treatments are commercially available for the management of wireworm (Poncho®, Poncho® Votivo®, and Cruiser®). The other five treatments were different rates and combinations of a new product called Lumivia™. Growth parameters such as stand count, vigor, height, and the number of damaged or dead plants differed among the treatments, with the PPST 250 + Lumivia™ 500 combination treatment outperforming the untreated control in all five parameters. Poncho® Votivo® and PPST 250 + Lumivia™ 250 outperformed the untreated control in four of the five parameters. At harvest, the number of plants per harvested area differed among treatments – with PPST 250 + Lumivia™ 500, Poncho®, Poncho® Votivo®, and Cruiser® outcompeting the untreated control – but this did not result in statistical yield differences. While PPST 250 + Lumivia™ 500 and Poncho® yielded over 5 tons per acre, due to variability, we cannot attribute this to treatment differences.

The trial results illustrate that growers have several options for managing wireworms. The two Poncho® products are commercially available from Bayer CropScience, and Cruiser® is commercially available through Syngenta. DuPont/Pioneer is now offering the PPST 250 + Lumivia™ 250 combination treatment. When trying to make a decision on products, growers should consider their wireworm pest pressure and other soil-dwelling pests that could limit their production. Growers should consider what seed treatments they have been using and whether those are still controlling pests. If not, rotating to a different chemistry might be a way to bring pests back under control. Integrated pest management practices recommend rotating chemistries for insect resistance management.

We will be repeating the trial in 2015 to evaluate treatments under different conditions. Special thanks go to grower cooperator, Dennis Lewallen, and Stephen Colbert of DuPont.

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