



Northern NY Agricultural Development Program 2016-2018 Project Report

Impact of Biocontrol Nematodes on Corn Rootworm During Corn Rotation

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Cooperating Producers:

- Dave & Lisa Magos, Morning Star Farm, Adams, NY, Jefferson County

Background:

The application of biocontrol nematodes to combat alfalfa snout beetle has been shown by research initiated through the Northern New York Agricultural Development Program (NNYADP) to be effective in reducing the impact of alfalfa snout beetle on alfalfa stands. Related research in NNY has shown that not only do the populations of biocontrol nematodes persist in the field when the field is rotated to corn, but in many cases the populations actually increase during corn years 2-4. Since corn years 2-4 are the years when corn rootworm (CRW) larvae are feeding on corn roots, it is suspected that the biocontrol nematodes are reproducing in the corn rootworm larvae. NNY farmers have raised the question about the effectiveness of these resident biocontrol nematodes in controlling corn rootworm and whether or not the impact of these biocontrol nematodes is significant enough to eliminate the need for BT-rootworm corn or soil insecticide on conventional varieties. In a related study conducted at the Musgrave Research Farm (Aurora, NY) from 2014-present, biocontrol nematodes limited root feeding damage and the results were equal or a better level of root protection with the best BT-CRW corn variety.

2018 was the third year of a multi-year study in NNY focused on the effectiveness of resident biocontrol nematodes for controlling corn rootworm (Fig 1). The research planned for year 2 involved adding a second study site: either a field where biocontrol nematodes populations were established or fields with a history of corn rootworm damage and previously untreated with nematodes. To accurately measure the impact of these biocontrol nematodes on corn rootworm larvae, a comparison site(s) need to be evaluated in this multi-year study. The locations of the ASB-biocontrol nematode demonstration plots that have both nematode-treated areas and untreated areas would be perfect, unfortunately, the producers of these fields were not able to provide their assistance for the 2018 growing season.

In 2018, personnel from the Shields Lab at Cornell returned to the field plots established on the Dave Magos' Morning Star Farm in Jefferson County during 2016. At the Magos site, the eight field plots were flagged, prior to planting of each 0.5 acre plot. Half of these plots were previously inoculated with ASB biocontrol nematodes and the rest of the plots were left untreated.

Since the farm is no-till, movement of biocontrol nematodes with soil tillage is of lesser concern. Subsequent nematode sampling verified nematode persistence in the treated plots and the lack of contamination in the untreated field plots. Shortly thereafter, Magos determined that the field needed to be rotated back to alfalfa for 2018 due to dairy needs eliminating our efforts on the site for 2018. Furthermore, additional sites: Doubledale Farm (Dan Rossiter, Jefferson County) and Carsada Farm (Dave Moore, Franklin County) had insisted they needed to till across the plots which resulted in contamination of the untreated control plots. Therefore, the proposed scope of the study was negated. For 2018, results from the related study at the Musgrave Research Farm (Aurora, NY) and support for ADP manure application trials with entomopathogenic nematodes (EPN) in NNY will be discussed.

Methods & Results:

The Morning Star Farm site was established in a 132-acre field (N 43.8612, W -76.1252) owned and operated by Dave & Lisa Magos, Adams, NY in 2016. Using the multi-species approach, two native NY strains of bio-control entomopathogenic nematodes (*Steinernema carpocapsae* and *Steinernema feltiae*) were reared for the corn rootworm site, then applied to the first-year corn crop at plant emergence on May 17, 2016. Plot design included eight, 0.5 acre blocks. Four blocks were treated with nematodes and the other four blocks remained untreated (Fig.2). EPN infective juveniles (IJ) were applied at a rate of 75 million per species per treated block. Each treated block received a two-species combination, the total number of IJs per treated block were 150 million. A total of 600 million nematodes were reared for the Magos site.

Biocontrol Nematode Assessment:

Soil cores were collected from only the treated plots to verify a successful inoculation 60 days post-nematode application during year 1 of the study. Each sample was removed from the soil and split into upper 2" and 3-6" portions that would be used to bioassay for nematode presence. Soil cores were returned to the laboratory and bio-assayed using a

standard technique with wax moth larvae as an indicator for the presence of biocontrol nematodes in the sample. In year 2, prior to corn rootworm larval hatch, soil cores were collected from the treated and untreated plots 380 days post-nematode application; standard sampling protocols were adhered to.

The level of nematodes in each sample was documented to show expected overwintering populations in the treated plots and the lack of nematodes in the untreated plots. Samples within each treated block were removed and split; 40-samples within non-BT and 40-samples within CRW–BT variety rows respectively, 450 days post-nematode application using standard sampling protocols. The final soil assay evaluation was conducted 730 days post-nematode application within the treated plots using standard sampling protocols. Resulting population levels were documented to show population levels throughout study at the Magos site (Table 1).

Musgrave Research Farm, Aurora, NY

The Musgrave Research Farm site in Popular Ridge (42.72353, -76.66213) has been in continuous corn, rootworm–BT corn and corn-soybean rotation since 2014 (Fig. 3). The plot design includes four nematode-treated areas (~0.6 acres) including non-BT-CRW-treated corn, commercially available GMO-BT-CRW corn varieties; and every other year-soybeans in two of the nematode treated areas (conventional corn-even years, e.g. 2014 and 2016). All four areas were treated with bio-control nematodes on June 20, 2014.

Evaluations for effectiveness of biocontrol nematodes in controlling CRW larvae and verification of multi-year persistence of EPNs have been conducted since 2014. The field site was planted with both types of corn on May 11, 2018.

Biocontrol Nematode Assessment:

Spring 2018: 320 soil core samples were collected from the continuous corn EPN-treated combination blocks 1432 days post-application to verify multi-year persistence of EPNs. The four *Steinernema* sp. combination blocks assayed resulted in:

- <1% of the samples positive for *S. carpocapsae* and
- 23% positive for *S. feltiae*.

Bioassays were also conducted in the four *S. feltiae* and *H. bacteriophora* combination blocks. The assay resulted in:

- 26% of the samples positive for *S. feltiae*, and
- <1% positive for *H. bacteriophora*.

Soil assay results indicate a continued presence of bio-control nematodes in all plots; percent positive reflect the expected lower populations of CRW larvae in the spring.

Fall 2018: 320 soil core samples were collected from the continuous corn EPN-treated combination blocks 1550 days post-application to verify multi-year persistence of EPNs. The four *Steinernema* sp. combination blocks assayed resulted in:

- 0% of the samples positive for *S. carpocapsae*, and
- 3% positive for *S. feltiae*.

Bioassays were also conducted in the four *S. feltiae* and *H. bacteriophora* combination blocks. The assay resulted in:

34% of the samples positive for *S. feltiae*, and
<2% positive for *H. bacteriophora*.

Soil assay results indicate a continued presence of bio-control nematodes in all plots; percent positive reflect the expected higher populations of CRW larvae in the fall.

Impact on Corn Rootworm:

To measure the impact of biocontrol nematodes on corn rootworm larval populations, each plot area (treated and untreated) was evaluated in two different ways: collection of emerging CRW adult beetles and root damage assessment.

Root Damage Assessment:

Evaluation for feeding damage by CRW larvae on corn planted at the Musgrave Research Farm site was conducted beginning August 10, 2019. and concluding August 15, 2018. Researchers visited the site where corn roots were labeled (Untreated & Treated Blocks), then dug samples from each replicated block for each nematode treatment.

Each variety within a replicated EPN block had 20 corn roots removed: 10 inside each screen tent and 10 outside screen tent (80 per block). Similarly, for each variety within a non-EPN replicated block (untreated), 10 corn roots were removed within the screen tent and an additional 10 were removed from outside the screen tent (80 per corn variety). The number of corn roots was pre-determined before arriving based on previous analysis parameters. Corn roots were washed and rated (Iowa 0-3 scale) at the Musgrave Research Farm using a double blind format (Fig 4-6). Rating information was recorded for each variety replicated throughout test plot (Table 2).

Collection of Emerging CRW Adults:

To determine if the combination of treated corn and EPNs impact the number of emerging CRW adults, the emerging adults must be collected and compared across variety and nematode treatment. The CRW adults were captured using field cages. The processes to set up cages in the corn plot located at Musgrave Research Farm began in early July, 2018. Single 10X10 screen cages were placed over each variety x treatment x replication prior to the anticipated adult CRW emergence around mid-July (Fig. 7).

An additional study on non-nematode treated corn using the same varieties was conducted in parallel plot to the main research plot. Those corn rows also had cages added to collect any surviving adult CRWs. Observations for CRW adult emergence began on July 13, 2018. Cages were checked for adults twice a week for six weeks, concluding on August 15, 2018. The number and sex of emerging adults were collected during the observation period; results were recorded (Table 3).

Adjunct Study: Application of EPNs in Liquid Manure

To further strengthen the case for adoption of biocontrol nematodes, the Shields Lab in coordination with a local CCE Field Crops Specialist Mike Hunter has conducted new

applied research focusing on the application of biocontrol nematodes in liquid manure to determine if using manure is an effective alternative to application through conventional pesticide sprayers.

The advantage of a liquid manure application is the manure provides an effective UV barrier to protect the nematodes while they enter the soil. The nematodes applied in the field are very susceptible to U/V light. Additionally, the use of manure to apply EPNs saves the farmer a “trip over the field” and the related investment in cost, time, labor, and soil contact. Furthermore, the potential to eliminate the requirement to apply nematodes in the evening to avoid UV exposure could result in an increase of applications by growers. Simplifying the application process will likely increase the adoption of the biocontrol program for both ASB and CRW management in NNY to support alfalfa forage production for the dairy industry.

Manure applications: in year 1, the application of biocontrol nematodes through liquid manure field applications was conducted on farms in Jefferson and Lewis counties.

Conclusions/Outcomes/Impacts:

With the past successes of farmers who have adopted the biocontrol nematode program to control ASB on their farms in NNY, the opportunity to provide protection against corn rootworm seemed a logical next research step as resident biocontrol nematodes populations in many cases have increased during corn years 2-4. Ideally, this study needs to be conducted in multiple fields across the NNY region in fields where biocontrol nematodes have been established in alfalfa during proceeding years, while also conducting research in untreated areas with corn rootworm. To date, only one site located in NNY has met the criteria for the study as the producers of the established demonstration plots have yet to rotate into corn. In 2018, the single qualifying site no longer met the criteria.

The agricultural industry across the United States has taken great interest in the ASB and CW management research results built in Northern New York. For example, a project in Western Texas, where CRW adult populations are very high, continues to show a significant reduction in CRW adult emergence and root damage while maintaining a resident population of biocontrol nematodes. The project manager has secured additional localized funding to expand the project based on the results.

Due to the issues noted for identifying qualified research sites in a timeframe suited to both research requirements and forage production needs, and currently low CRW populations in the NNY region, concludes this research.

The continuous study at the Musgrave Research Farm (Aurora, NY), shows the potential for the application of biocontrol nematodes to manage CRW. The biocontrol nematodes there limited root feeding damage and the results were nearly identical to the level of root protection with the best BT-CRW corn variety beginning in year 3.

Increased CRW larval populations at the site, however, did not result in the intended impact; damage and emergence. In year three at the Musgrave Research Farm, soil assays performed in the designated plots treated with biocontrol nematodes indicated a resident population that would be used to measure any impact on corn rootworm larvae.

Furthermore, an evaluation on the effectiveness of resident population in controlling CRW larvae below an economically-damaging level was conducted. Surviving corn rootworm adults were collected during a six-week period and roots were dug for feeding damage assessment. Despite the year-three population levels of CRW adults being higher at the site and impacting the number of emerging adults to collect and identify, feeding damage from CRW larvae assessment was inconclusive.

Results from the current corn rootworm study sites at the Musgrave Research Farm will be shared with the agribusiness community of NNY during winter cycles beginning in 2019. It is important to remember that without the support of prior research in NNY on alfalfa snout beetle, the study to evaluate eliminating the need for BT-rootworm corn or soil insecticides on conventional varieties would not be possible.

Outreach:

The following dates and discussions were conducted this quarter to disseminate research information:

- January 10, 2018: WNY Corn Congress, Batavia, NY
- January 11, 2018: WNY Corn Congress, Waterloo, NY
- February 12, 2018: Lowville Farmers Co-Op, Lowville, NY)
- March 26, 2018: Cornell Entomology Department Seminar: *Biological Control with Entomopathogenic Nematodes: Is a more sustainable classical approach feasible or are we stuck in a bio-pesticide paradigm?*
- November 14, 2018: Presentation at the 2018 ESA, ESC, and ESBC Joint Annual Meeting, "Biological control of corn soil insects: Single inoculation of native persistent entomopathogenic nematodes for multi-year suppression."

Additionally, five press releases during 2018 provided continued delivery of research efforts and information to the agricultural industry in NNY on the value and benefits of using bio-control nematodes to limit corn root feeding damage (Fig. 8).

Information on research efforts can be found online via the links below:

NNY Agricultural Development Program Website:

- <http://www.nnyagdev.org/index.php>

ASB: Alfalfa Snout Beetle Website

- <http://www.alfalfasnoutbeetle.org/>

Next Steps:

For 2019 the Shields Lab will continue its efforts at the Musgrave Research Farm. Prior to corn rootworm larval hatch (mid-late May), all plot areas will be sampled for biocontrol nematodes to document the expected overwintering populations in the treated plots and the lack of nematodes in the untreated plots. Plot areas will be re-sampled prior to harvest to document the level of biocontrol nematodes entering the winter. The impact

of biocontrol nematodes on the corn rootworm larval populations in each plot area will be measured in three different ways: 1) Within each plot, two 10'x10' screen houses will be erected in each corn variety (BT, Non-BT) to capture the number of CRW beetles emerging from each 10'x10' area. Beetles will be collected 2x per week, counted, sexed and recorded. Beetle emergence is expected to begin around July 15 and continue until late August; 2) After larval feeding is finished (early August), a specified number of plants will be dug, washed, and the root feeding damage rated using the Iowa 0-3 scale; 3) Before harvest, sections of each plot area will be rated for lodging as a result of CRW feeding damage.

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For More Information:

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- Dave & Lisa Magos, Morning Star Farm, 13143 County Route 75, Adams, NY 13605, 315-771-0431

APPENDIX

Table 1. Persistence of Nematode Positive Samples from 2016 EPN Establishment at Morning Star Farm: Percentage of soil samples positive for EPNs; NNYADP project, 2016.

Persistence of Nematode Positive Samples from 2016 EPN Establishment					
Date	GMO/NGMO	Plot	# Soil Samples	% Sc Positive	%Sf Positive
7/16/2016 60D	-	1	50	4	26
	-	3	50	2	28
	-	5	50	2	16
	-	7	50	0	26
6/6/2017 380D	-	1	25	0	16
	-	3	25	0	28
	-	5	25	0	24
	-	7	25	0	20
8/17/2017 449D	GMO	1	40	0	28
	GMO	3	40	0	23
	GMO	4	40	0	23
	GMO	7	40	0	20
	NGMO	1	40	0	30
	NGMO	3	40	0	20
	NGMO	5	40	0	20
	NGMO	7	40	0	18
5/25/2018 730D		1	25	0	32
		3	25	0	28
		5	25	0	24
		7	25	0	40

Table 2. 2018 Corn Rootworm Damage Root Rating Results, Musgrave Research Farm.

Aurora-2018	Sc & Sf EPN Combo		Sc & Sf EPN Combo	
	<i>Outside Tents</i>		<i>Inside Tents</i>	
	Mean	SE	Mean	SE
Conventional Corn	.19	.02	.58	.15
Cry 34/35	.10	.02	.19	.02
SmartStack	.11	0	.11	.01
Cry 3Bb1	.15	.04	.17	.06
	Sf & Hb EPN Combo		Sf & Hb EPN Combo	
	<i>Outside Tents</i>		<i>Inside Tents</i>	
	Mean	SE	Mean	SE
Conventional Corn	.68	.2	.23	.07
Cry 34/35	.25	.17	.14	.04
SmartStack	.10	0	.10	.02
Cry 3Bb1	.33	.11	.20	.10
	Untreated variety		Untreated variety	
	<i>Outside Tents</i>		<i>Inside Tents</i>	
	Mean	SE	Mean	SE
Conventional Corn	.23	.05	.14	.02
Cry 34/35	.74	.13	.52	.09
SmartStack	.12	.01	.09	.01
Cry 3Bb1	.12	.03	.12	.01

Table 3. 2018 Corn Rootworm Adult Collection Summary, Musgrave Research Farm.

2018-Aurora	Totals				Totals	
Males-NonEPN	Conv	861		Males-Sc/Sf	Conv	1961
	3bb1	1008			3bb1	974
	34-35	2140			34-35	1435
	SS	688			SS	539
Females-NonEPNs	Conv	1579		Females-Sc/Sf	Conv	2257
	3bb1	1794			3bb1	1510
	34-35	2742			34-35	1682
	SS	1106			SS	932
				Males-Sf/Nb	Conv	2369
					3bb1	1408
					34-35	858
					SS	361
				Females-Sf/Hb	Conv	2257
					3bb1	2706
					34-35	1090
					SS	455

**Figure 1. 2018 NNY ADP CRW/Alfalfa Snout Beetle-Related Media Hits
Press Releases and Issue Dates:**

. June 26: Got Corn Rootworm? Try this Alfalfa Pets Solution from Northern NY
. June 5: Dairies: Don't Ignore the Cost of Snout Beetle
. April 14: Research project to halt alfalfa snout beetle spawns thriving business
. Feb. 27: 2018 Biocontrol Nematodes Discount Available
. Feb. 15: Unexpected benefits of a pest bio-control project (Joe Lawrence column)
Key: Am Ag: American Agriculturist; ASB: Alfalfa Snout Beetle;
CRW: Corn Rootworm

DATE	PUBLICATION	TOPIC
Aug 2018	Empire Farm and Dairy	CRW: try ASB solution
07-12-18	Farm and Dairy Ohio	CRW: try ASB solution
07-03-18	New York Ag Connection	CRW: try ASB solution
07-03-18	ATTRA	CRW: try ASB solution
July 2018	CCE Lewis News	ASB: try ASB solution
July 2018	Empire Farm and Dairy	ASB: try ASB solution
06-30-18	Country Folks	ASB: try ASB solution
06-29-18	CCE Essex News	ASB: try ASB solution
06-27-18	Morning Ag Clips	CRW: try ASB solution
06-26-18	CCE Jefferson News	CRW: try ASB solution
06-26-18	Cornell Field Crops News	CRW: try ASB solution
06-25-18	NYFVI FB	ASB: Am Ag feature
06-25-18	Cornell CALS Twitter	ASB: Am Ag feature
06-20-18	American Agriculturist	CRW: try ASB solution
06-20-18	Boonville Herald	ASB: dairy cost-benefit
06-18-18	CCE St Lawrence News	ASB: dairy cost-benefit
06-16-18	Lancaster Farming Online & Print	ASB: dairy cost-benefit
06-15-18	CCE St Lawrence	ASB: dairy cost-benefit
06-11-18	Focus on Farming	ASB: dairy cost-benefit
06-??-18	Bullvine	ASB: dairy cost-benefit
06-09-18	Country Folks Facebook	ASB: dairy cost-benefit
06-08-18	Cowsmopolitan	ASB: dairy cost-benefit
06-07-18	New York Ag Connection	ASB: dairy cost-benefit
06-07-18	Dairy Business	ASB: dairy cost-benefit
06-06-18	Morning Ag Clips	ASB: dairy cost-benefit
06-06-18	Dairy Agenda Today	ASB: dairy cost-benefit
06-05-18	Cornell Field Crops Blog	ASB: dairy cost-benefit
05-05-18	Twitter: Cornell Bugman	ASB sighting in NNY
05-01-18	Dairy Herd Management	ASB update by Eric Young
04-23-18	Country Folks	Nematode enterprise
04-14-18	Lowville Journal	Nematode enterprise
04-14-18	Malone Telegram	Nematode enterprise
04-14-18	Carthage Republican Tribune	Nematode enterprise
04-14-18	Massena Potsdam Courier	Nematode enterprise
04-14-18	Batavia Daily News	Nematode enterprise

04-14-18	Livingston County News	Nematode enterprise
04-14-18	Oswego Hometown News	Nematode enterprise
04-14-18	Ogdensburg Journal	Nematode enterprise
04-14-18	Watertown Daily Times	Nematode enterprise
April 2018	Empire Farm and Dairy	ASB nematodes: order now
03-15-18	Small Farms News	ASB nematodes: order now
03-06-18	CCE Jefferson News	ASB nematodes: order now
03-05-18	Focus on Farming	ASB nematodes: order now
03-05-18	Country Folks	ASB nematodes: order now
03-04-18	Plattsburgh Press Republican	ASB nematodes: order now
03-03-18	Lancaster Farming	ASB nematodes: order now
03-02-18	CCE St L News	ASB nematodes: order now
03-01-18	Morning Ag Clips	ASB nematodes: order now
02-28-18	New York Ag Connection	ASB nematodes: order now
02-28-18	Cornell Field Crops News	ASB nematodes: order now
02-15-18	ASB nematodes	ASB biocontrol benefits, J Lawrence
02-15-18	Livingston County News	ASB biocontrol benefits, J Lawrence
02-15-18	CCE Jefferson News	ASB biocontrol benefits, J Lawrence
02-14-18	Batavia Daily News	ASB biocontrol benefits, J Lawrence
02-14-18	Oswego Hometown News	ASB biocontrol benefits, J Lawrence
02-14-18	Malone Telegram	ASB biocontrol benefits, J Lawrence
02-14-18	Ogdensburg Journal	ASB biocontrol benefits, J Lawrence
02-14-18	Massena Potsdam Courier	ASB biocontrol benefits, J Lawrence
02-14-18	Carthage Republican	ASB biocontrol benefits, J Lawrence
02-14-18	Lowville Journal	ASB biocontrol benefits, J Lawrence
02-14-18	Watertown Daily Times	ASB biocontrol benefits, J Lawrence

Photos:



Figure 2. Adult Corn Rootworm. Photo: Purdue Extension Entomology.



Figure 3. Magos Farm Corn Rootworm Research Site, Adams, NY. Photo: Shields Lab/Google Earth.



Figure 4. Musgrave Research Farm, Corn Rootworm Site, Popular Ridge, NY. .Photo: Shields Lab/Google Earth.



Figure 5, left. Dug corn roots soaking pre-rating for corn rootworm damage at Musgrave Research Farm, August 15, 2018. Photo: Antonio Testa

Figure 6, right. Students from Cornell University washing corn roots for CRW damage assessment at Musgrave Research Farm, August 15, 2018.



Figure 7, left. Corn root damage from CRW at Musgrave Research Farm, 2018. Photo: Antonio Testa

Figure 8, right. Screen houses over EPN treated and untreated corn at the Musgrave Research Farm, 2018. Photo: Antonio Testa