Cornell Cooperative Extension
Eastern NY Commercial Horticulture Program

Evaluating the use of Entomopathogenic Nematodes for Controlling Wireworms and Colorado Potato Beetle in Potatoes

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Summary

In the fall of 2016, an outbreak of the wireworm pest was documented at the Hudson Valley Farm Hub in field 10 during sweet potato harvest. It was estimated that over 50% of the crop sustained significant damage. Cornell Cooperative Extension (CCE) researchers and vegetable specialists worked with Farm Hub staff to find a pest management solution that was in line with organic agricultural practices that are adhered to on site. The wireworm problem was not unique to the Farm Hub. Damage to root crops had been identified as an increasing problem for growers in the northeast, particularly on organic farms and farms using long term cover crop rotations. Estimating losses from wireworm damage is difficult as information has not been published since 1994. High crop losses are not uncommon in NYS; stand losses can vary from zero to 80 percent, however typically only 5-10% will be affected.

After exploring possible cultural, chemical, and biocontrol strategies, it was determined from prior lab studies that entomopathogenic nematodes (EPNs) could be an effective biocontrol management tool, but needed further research. Over the past 25 years, the Shields' Lab at Cornell University has developed a biological control strategy using native New York biocontrol nematodes (EPNs) that are adapted to conditions in NY agricultural fields. Native NYS biocontrol nematodes are safe; they do not harm animals or plants. Biocontrol nematodes that are available commercially (e.g. NemaSeek and NemAttack), are short-lived, do not persist, and require repeated applications leading to higher operational costs and unreliable efficacy. Native NY biocontrol nematodes however can be applied to the soil a single time and provide multiple years of pest control. A single application of a mix of EPN species has shown to successfully reduce larval populations and restore fields to full production. One of the most successful projects has included control of alfalfa snout beetle, where more than 25,000 acres have been treated in northern NY. Other successes have included the black vine weevil on a variety of berry crops, corn rootworm in field corn, and plum curculio in NY organic apple production.

With support from the Farm Hub, the Eastern NY Commercial Horticulture Program conducted a multi-year study at a Hudson Valley farm to determine if NY native EPNs can suppress wireworm populations and reduce damage to vegetable root crops. The initial objectives of this project were to: 1) determine which complex of EPNs are best adapted to establish in the sandy/loam soils at the Farm Hub, and 2) evaluate which combination of nematodes is most effective at suppressing wireworm damage in sweet potatoes. Research work began in May of

2017 at the Farm Hub, where we established control plots and EPN inoculated plots in Field 10, where wireworms were found in large numbers in 2016. Subsequent soil assays confirmed establishment of EPNs and persistence 1,076 days post inoculation. Wireworm damage evaluations of sweet potato from the 2017 trial at the Farm Hub showed an average 36% reduction of wireworms in EPN inoculated plots compared to untreated plots. In 2018, damage to sweet potatoes from wireworm was very low in both EPN treated and non-treated plots. This indicated a crash in wireworm populations throughout all the plots as the majority of the wireworms completed their 3-year subterranean cycle.

Colorado potato beetles (CPB) are serious insect pests of potato in NY. Conventional potato growers typically apply a neonicotinoid insecticide at planting to manage the pest. Yet, resistance in CPB populations to multiple neonicotinoid insecticides are becoming more common throughout NY and no alternative insecticides are currently available for potato seed piece treatment. Organic potato growers only have one highly effective foliar-applied insecticide option (Entrust SC) to manage CPB, but the threat of resistance is increasing. Identifying non-chemical tactics for CPB and wireworm control in potato is abundantly clear. Because we already had plots established and inoculated with EPNs at the Farm Hub, we proposed to utilize the plots in 2019 to study the impact of EPNs on CPB as well as wireworms. By planting regular potatoes into the plots, rather than sweet potatoes, we were able to continue to monitor the impact of EPNs on wireworms by harvesting and evaluating potato tubers at the end of the season. Results from the CPB studies at the farm hub were inconclusive, however, a similar trial run in tandem by the Shield's lab in Freeville showed positive results. Research on EPN bio-control for CPB and wireworm will continue through 2022 at Cornell University as well as two conventional and organic cooperating farms in western NY.

Positive results from the trials, coupled with outreach to growers through workshops, articles and podcasts, has spurred interest from ENY farmers to apply EPNs on their own fields. To date we have assisted fourteen growers in the Hudson Valley region with EPN applications on their farms. These successes have provided organic farms who have adopted the use of EPNs the first option for managing wireworms and a brand new option for conventional growers who are attempting to reduce their reliance on insecticides.

The seminal work on wireworm management conducted at the Farm Hub provided the justification and leverage to successfully apply for additional funding from NYS Farm Viability Institute to expand the study on nine farms in Eastern New York. In 2021, research using EPN biocontrol research continues on Colorado potato beetle at Cornell University research facilities. New studies on the impacts of EPNs on cabbage, corn seed and onion maggot, are underway in the Hudson Valley and Cornell University.

EPN Plot Establishment

Methods: Three entomopathogenic nematode (EPN) treatments were applied at the HV Farm Hub on 5/23/2017. Treatment one was an EPN species mix of *Steinernema carpocapsae* 'NY01' (*Sc*) + *Steinernema feltiae* 'NY04' (*Sf*) at a rate of 250 million *Sc* infective juveniles (IJs) per ha and 170 million Sf IJs per ha. Treatment two was a mix of *Sf* + *Heterorhabditis bacteriophora* 'Oswego' (*Hb*) at a rate of 170 million *Sf* IJs per ha and 250 million IJs per ha. In both treatments, the total 420 million IJs per ha were applied. (NY research data indicates a mix of biocontrol nematode species gives better control of soil insects than a single species alone. Each of the three species of EPNs occupies a different depth in the soil and has a different mode of action. For example, *Sc* prefers the top 2-3" of the soil profile and becomes the dominate species in this region. If *Sc* is the only nematode used, insect larvae below the 2" level escape attack from *Sc*.) Treatment three was an untreated check. EPNs were applied to the soil surface using a modified ATV small plot sprayer with all the screens and filters removed and calibrated to apply 945 L per ha through fertilizer stream nozzles (TeeJet™0010, Springfield, IL) mounted 30 cm apart. Application timing was late in the day to allow UV sensitive IJs to enter the soil with limited UV exposure. After Treatment 1 was applied, the sprayer was thoroughly washed before being used to apply Treatment 2.

EPN Persistence

Methods: Post inoculation, plots treated with combinations of EPNs were sampled to test for EPN persistence seven times over the course of this study. Control plots were sampled as well to rule out cross contamination from the EPN treated plots. Samples were transported and assayed at the Cornell University Shields Lab to track and verify multi-year EPN population and persistence of biocontrol nematodes. Research and demonstration plots located in the Hudson Valley were sampled following standard procedures developed by Professor Elson Shields.

On 5-25-17 prior to inoculation with the NY Native EPNs, 150 soil cores were taken from the research field and assayed to determine which, if any, naturally occurring EPNs were present in the soil. On June 22, 2017, 30 days after application of the EPNs, one hundred total soil samples were collected from each of the twelve plots to assess the level of nematode establishment in the soil at 2'' and 8'' deep. All soil samples were laboratory bio-assayed using *G. mellonella* larvae as indicator hosts (5 larvae per 7 cm core, 10 larvae per 13 cm core). Samples were incubated at room temperature (23^{o}C), on shelves in the laboratory for 7 d. Dead *G. mellonella* were examined for nematode infection by observing the condition and color of the cadaver (Poinar 1984). Cadaver coloration between Sc, Sf and Hb is uniquely different and cannot be confused.

Results: Of the 150 samples taken before EPN application, 2 or 1.3% were positive for *Sc*. No other EPN was detected at that sampling. The data in the following table summarizes the persistence data collected post EPN application beginning on 5-27-2017, 30 days' post application. None of the control plots showed evidence of cross contamination over the course of the study.

Data: Hudson Valley Farm Hub Soil Assay Results to Track EPN Persistence

Hudson Valley Farm Hub	Sc & Sf Combo				Sf & Hb Combo			
	Sc & Sf Treated Blocks				Sf & Hb Treated Blocks			
	Sc		Sf		Sf		Hb	
	Mean ± SE		Mean ± SE		Mean ± SE		Mean ± SE	
30 Days Post Application	2 ± 1		29 ± 2		30 ± 1		1 ± 4	
150 Days Post Application	1 ± 4		23 ± 2		28 ± 2		1 ± 4	
390 Days Post Application	2 ± 2		34 ± 4		28 ± 2		3 ± 3	
487 Days Post Application	0 ± 0		28 ± 4		33 ± 4		2 ± 1	
694 Days Post Application	0 ± 0		35 ± 5		30 ± 2		2 ± 1	
	Sc & Sf Treated Blocks				Sf & Hb Treated Blocks			
	Sc		Sf		Sf		Hb	
	Inside versus Outside Tents				Inside versus Outside Tents			
	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
860 Days Post Application	1 ± 3	6 ± 3	30 ± 8	25 ± 0	40 ± 4	30 ± 2	0 ± 0	1 ± 1
1,076 Days Post Application (5-5-20)	0 ± 0	1 ± 1	25 ± 7	30 ± 4	30 ± 4	26 ± 8	0 ± 0	4 ± 2

- Values represent % positive samples for EPN species listed in the respective column.

EPN levels: The levels of *Sf* in both of the nematode species combinations were not significantly different from each other. The level of *Sf* (24-35%) is very similar to the long-term persistence levels in the 20-30% range under NY agricultural conditions reported by Shields in previous studies across 75 fields ranging from clay loam to sandy loam. The levels of *Sc* (NY01) (0-6%), were lower in this study than reported by Shields in alfalfa fields (8-13%), but it is reported that *Sc* prefers the top 5-7 cm of the soil profile and this zone can become very dry in sandy loam soils which was the case in the research field at the Farm Hub. This may explain the lower level of *Sc* in this study. In addition, the ambush nature of *Sc* along with limited dispersal behavior often results in *Sc* hotspots separated by areas without *Sc*, resulting in a lower reported level of *Sc* than actually is present in the field. *Sf* ranges deeper in the soil and is less effected by the dry upper soil layers, coupled with a hybrid searching behavior using both ambush and cruising strategies. When these two species are mixed, data suggests that Sf fills in the gaps between the *Sc* areas of concentration (hotspots) resulting in a more complete coverage of the soil environment.

The levels of *Hb* in this study range from 1-3% of the soil samples across the duration of the study. With the relatively low density of hosts in this study, these low levels are not unexpected. *Hb* is a cruising nematode resulting in two issues; 1) this behavior matched with the bioassay technique of removing a soil sample for laboratory bioassay significantly underestimates the presence of *Hb* in the soil profile searching for hosts, 2) *Hb* numbers rise after the host has increased to economic numbers and 3) *Hb* prefers to attack larger larvae, often after damage has occurred to the crop. Shields reports that *Hb* numbers can rise to 100% of the soil samples in the presence of large numbers of hosts, but a more typical range under moderate host densities are 2-10%. The very presence of *Hb* 1076 d after inoculation indicated that *Hb* is established in the soil and available to respond to host invasion. Soil assay results collected at the Hudson Valley Farm Hub provide a positive picture of consistency throughout the treated blocks 1,076 days post application. This longevity compares similarly to the long-term studies conducted by the Shields' Lab in other NYS cropping systems for EPN persistence.

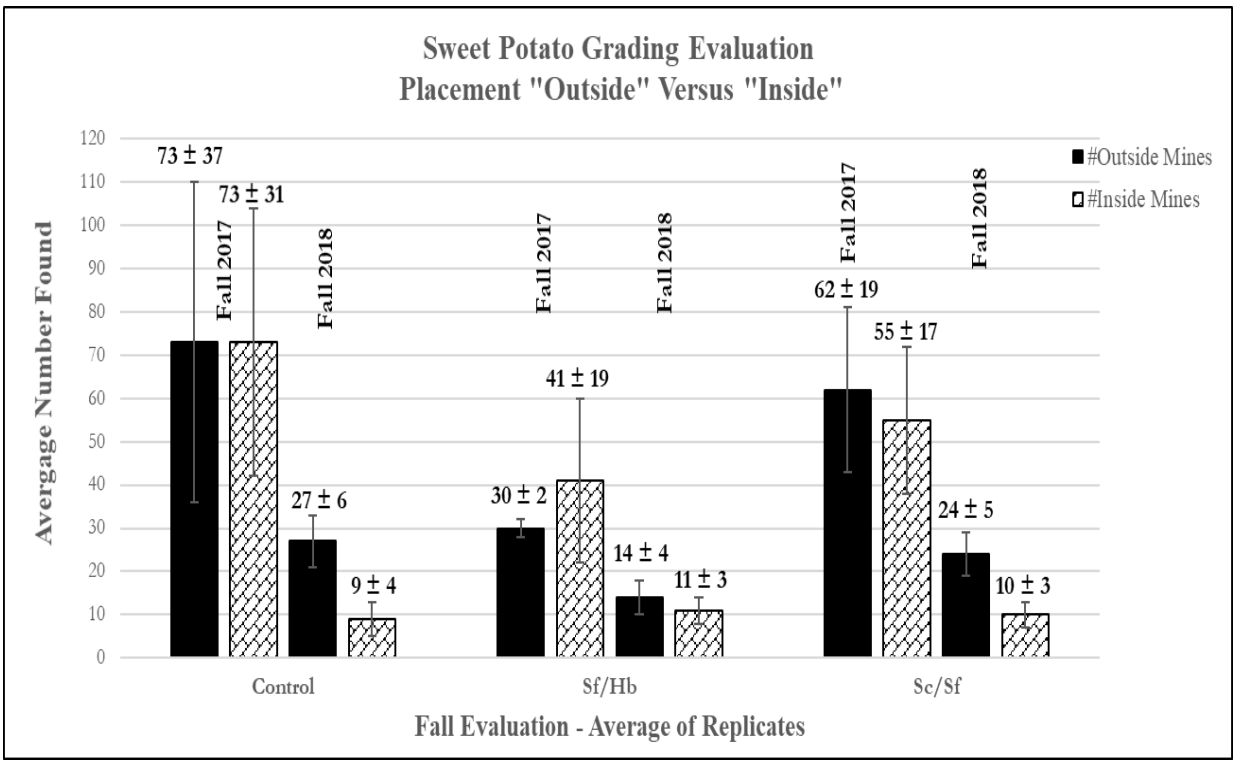
Wireworm Suppression

Justification: Wireworms are another significant insect pest of potato. Wireworm larvae persist in the soil for one or more years feeding on roots of plants. Wireworms develop from eggs laid in previous grassy crops before rotation into potatoes. Wireworms damage potato by boring into the tuber and contaminating the injury with bacteria, which then causes the tuber to rot. Wireworm problems can be minimized by not planting potato into fields that had been in sod, small grains, corn or grass-based cover crops, but this is not always possible and requires an insecticide at planting. However, the only effective products for conventional potato growers include the highly toxic organophosphate, ethoprop (Mocap), and neonicotinoids. Organic growers have no insecticides options for wireworm control.
There is a substantial need for effective non-chemical options for managing CPB and wireworms in both conventional and organic farming systems. Biocontrol nematodes are safe and do not harm animals or plants. While biocontrol nematodes are commercially available (e.g., NemaSeek and NemAttack), they are short-lived and require repeated applications resulting in high cost, and unreliable efficacy.

Methods: Sweet potato slips were planted into EPN inoculated and control trial plots in early June 2017 and 2018. Plots consisted of 4 ridges (10' x 100'planted area within the 50'x200' plots), the buffer areas outside of the sweet potato planted ridges are planted into grass sod. Fertilizer was applied at a rate of 91 Kg N, 23 Kg P205, 23 Kg K20/hectare. Weed control in planted ridges included two mechanical cultivations in June and hand pulling weeds the remainder of the season. Buffer zones around the plots were over-seeded with rye cover crop and mowed twice during the growing season. There was no application of pesticide and no supplemental irrigation to the plots or buffer zones in the field. Harvesting of sweet potatoes

was conducted in September of each year. In late-September in 2017 and 2018, two hundred potatoes were dug from within the individual plot areas, 50 from the two outer ridges and 50 from each of the two inner ridges. Sweet potatoes were sampled from treated and untreated EPN plots for damage assessments. Each treatment and grouping of sweet potatoes was evaluated for: incidence of wireworm feeding, number of wireworm mines, weight of potatoes, grub damage and number of inches of grub channels observed on the surface of the sweet potatoes. Results were recorded.

Data:



In the 2017 harvest, the EPN combination of Sf x Hb had significantly less wireworm feeding damage than the untreated check irrespective of whether the plants were located in the outside rows or the inside rows (F = 2.39, df=23, P = 0.01). The EPN combination of Sc x Sf were numerically different from the untreated checks but the fewer wireworm feeding wounds were not statistically different from either the untreated check (F = 0.95, df=7, P = 0.05). When comparing the outside rows between the two EPN combinations, the Sf x Hb combination had significantly fewer feeding wounds than the Sc x Sf combination (F = 2.15, df=11, P = 0.05). However, when comparing the inner rows between the two EPN combinations, the numerical difference was not statistically different (F = 1.05, df=11, P = 0.05).

At the second year harvest, the level of wireworm feeding wounds across all treatments were reduced from year 1. Comparing the outside rows across treatment, only the EPN combination of Sf x Hb has significantly less damage than either the untreated control plots or the Sc x Sf combination. (F = 2.05, df=11, P = 0.05). At the third year harvest, no wireworm damage was recorded in any of the treatments.

Analysis: In 2017**,** EPN treated plots overall had an average of 36% less wireworm damage than the untreated control plots. The decrease in wireworm damage ranged between 15%-60% over the 4 repetitions of EPN treated plots. In 2018, damage to sweet potatoes from wireworm was low in both EPN treated and non-treated plots. This indicated a crash in wireworm populations throughout all the plots. We believe that the majority of the wireworms completed their 3-year subterranean cycle as immatures and became adults. Adult wireworms (click beetles) were not attracted to our plots for egg laying in 2017 and 2018 because of weed control. Continued biocontrol nematode persistence in the potato production plots for 4 years from a single inoculation independent of economic pest pressure at the Hudson Valley Farm Hub has been recorded. Over the four-year period, observations of wireworm damage decreased; in the final year of observation, no damage was recorded in the biocontrol nematode treated plots. Demonstration sites within the Hudson Valley have had similar reported observations, with the initial year harvest observations recording varied levels of damage to seeing reductions in damage the following season at all locations.

Colorado Potato Beetle Suppression

Justification: Potato continues to be the most valuable vegetable crop in the US with a farm-gate value of $4 billion per year. One million acres of potatoes are produced annually in the US, with a majority grown for processing. In NY, there are 13,400 acres of potatoes with an annual value of $47 million. Colorado potato beetle (CPB) is one of the most devastating insect pests of potato in the world. If not controlled, CPB can completely defoliate potato plants resulting in very low tuber yields. Insecticides continue to be the primary means for managing CPB, but populations have developed resistance to dozens of classes of insecticides. Potato growers in NY continue to experience difficulty managing CPB because resistance has developed to neonicotinoid insecticides, a critical insecticide for nearly all conventional growers. Organic growers have only one highly effective product to manage CPB, spinosad (Entrust SC), and continued reliance on this single product will eventually lead to resistance. Rotating potato fields at least 0.5 mile away from all previous potato planting will reduce CPB infestations, but rotations of this distance are rarely feasible.

Because the plots were established and inoculated with EPNs, we utilized the plots in 2019 to study the impact of EPNs on Colorado Potato Beetle (CPB) as well as wireworms.

Methods: On June 4, 2019, a dozen screen house tents; one per block, were set up to cover emerging potato plants. Tents covered three rows of potatoes approximately 10' long; a two row-ten-foot border of plants remained outside each tent. Beginning on June 7, 2019, each tent was checked twice per week to monitor for emerging CPB adults that had over-wintered previous to the current project. No adult CPB were found at the Hudson Valley Farm Hub site during the two weeks of evaluation.

To quantify the emergence of second generation CPB in treated and untreated screen houses at the Farm Hub, adult beetles previously collected by the Shield's lab, were removed from cold storage and used to rear new larvae for field release. These adult CPB were placed in small cages at Cornell University, and allowed to feed on potato plants that had been growing in the greenhouse for the purpose of collecting egg masses which once hatched produced new larvae. The goal was to collect enough mid-stage larvae to re-introduce into the tents at the Farm Hub to determine what if any impact biocontrol nematodes had on development; 100 larvae per tent – 1,200 total.

On June 21, 2019, one hundred larvae were placed within each screen house. A subsequent count for surviving larvae was done on June 28, 2019 to ensure each tent had 100 larvae. Those tents whose numbers were below 100 CPB larvae had additional larvae added to bring count back to 100.

Additional larvae were added to each plot area on July 3, 2019. Monitoring of 1st generation emergence within the screen house tents began on July 16, 2019. Screen tents were checked a minimum two times per week for CPB adults at the Hudson Valley Farm Hub throughout July.

Observations for 2nd generation CPB adults continued at the Hudson Valley Farm Hub site until August 13, 2019.

The evaluation for evidence of wireworm feeding on the potatoes within the research plots at Hudson Valley Farm Hub was conducted on August 15, 2019. On this date, 30 potatoes were dug from within the 12 tents located at the Hudson Valley Farm Hub site. Potatoes were dug within the treated and untreated EPN plots; potatoes were examined for wireworm damage. The evaluation showed that none of the potatoes presented wireworm damage.

To quantify EPN impact of over-wintering CPB, additional larvae generated from 2nd generation CPB adults were reared at Cornell University. The goal was to introduce an additional 100 larvae per tent to overwinter. Similar protocols for rearing and collecting of larvae conducted for first introduction were followed. The goal was to collect enough mid-stage larvae to re-introduce into the tents; 100 larvae per tent – 1,200 total.

On August 29, 2019, one hundred larvae were placed within each screen house.

Tent Trials – Quantification of EPN impact on over-wintering CPB populations continued into September. Monitoring of 2nd generation larvae, introduced in August within the screen house tents, began on September 9, 2019. Screen tents were checked once a week for CPB presence

at the Hudson Valley Farm Hub until September 24, 2019. The screen tents were removed from the field study area at the Hudson Valley Research Farm by September 30th. To mark the untreated and treated areas covered by screen tents, wooden posts were put into the corners of each plot for ease of identification for Year 2.

Data:

HV Farm Hub - 2019	**Treatment**										
	# Check			**# Sf & Hb**			**# Sc & Sf**				
Larvae Establishment 6/21/2019	400			400			400				
Larvae Check Date 6/28/2019	246			221			216				
Larvae Added 7/3/2019	154			179			184				
Total larvae at pupation Established	400			400			400				
	HV Farm Hub - 2019										
Adult Collections	Date of Collections in 2019										
	7/16	7/22	7/24	7/26	7/31	8/6	8/8	8/9	8/13		Total
Control	37	22	41	49	5	0	0	0	0		154
Sf + Hb	43	17	51	48	4	2	0	0	0		165
Sc + Sf	43	25	63	48	9	2	0	1	0		191
	HV Farm Hub - 2020										
Adult Collections	Date of Collections in 2020										
	6/1	6/5	6/9	6/15	6/23	6/29	7/6				Total
Control	0	0	0	4	10	3	0				17
Sf + Hb	2	0	2	3	9	1	2				19
Sc + Sf	2	0	2	0	1	0	0				5

2020 Quantification of Emerging CPB in Treated and Untreated Areas

Results and Analysis: Results were unclear from the Farm Hub site but a reduction of second generation CPB adults in EPN treated plots vs. untreated plots was found at the Freeville research site were the study was replicated by Prof. Elson Shields. A second set of larvae were

released into the tents the last week of August 2019 to overwinter as pupa. It was hypothesized that the overwintering generation of larva/pupa in the soil would be more susceptible to the EPNs because of the extended period of time they were exposed to the EPNs in the soil. The same protocol for assessing overwintering CPB susceptibility to EPNs was followed at the Freeville research site. The Freville site produced positive results, however the CPB data from the Farm Hub site was inconclusive.

Wireworm/EPN Outreach

DIY Entomopathogenic Nematode Biocontrol Twilight Meeting. Thursday, September 27, 2018. 4:00 PM- 6:00 PM. Hudson Valley Farm Hub, Hurley, NY. With Speakers: Elson Shields and Tony Testa of Cornell University; Teresa Rusinek and Charles Bornt of the Eastern New York Commercial Horticulture Program. 35 people in attendance.

In August 2019, Teresa Rusinek recorded a segment for the CCE Eastern NY Commercial Horticulture Program Podcast Newsletter. During the podcast, Teresa provided a summary and update on the continuing research of EPNs for wireworm control within the Hudson Valley and at the HV Farm Hub. The link to that podcast can be found here: **https://soundcloud.com/easternnewyorkvegnews/episode-5-entomopathogenic-nematodes** 124 listeners as of 5/10/21

Teresa Rusinek presented at the New England Vegetable & Fruit Conference, on December 10, 2019 in Manchester, NH. Title of the presentation was, “Managing Wireworms in Root Crops”. 125 people in attendance

Charles Bornt presented at the 39th Annual Long Island Agricultural Forum, on January 8, 2020. The forum was held at Suffolk County Community College in Riverhead, NY. Title of the presentation was, “Our Experience with Entomopathogenic Nematodes for Controlling Wireworms in Root Crops”. 38 people in attendance

Teresa Rusinek presented at the Catskill Regional Agriculture Conference, on January 9, 2020 in Syracuse, NY. Title of the presentation was, “Pests to watch out for in 2020”. 22 people in attendance

Teresa Rusinek presented at the 2020 Empire Producers Expo, on January 15, 2020 at SUNY Delphi. Title of the presentation was, “Managing Wireworm Damage in Sweet Potato Production”. 39 people in attendance

On Dec 24, 2020, Elson Shields discussed wireworm management using EPN biocontrol and was featured on the webinar “Getting the most out of beneficial nematodes in organic vegetable production” hosted by UMass Amherst Extension Program – 67 views as of 5/10/21

https://www.youtube.com/watch?v=Jx4TH1CUGCM&t=2s&ab_channel=UMassAmherstExtensionVegetableProgram

https://ag.umass.edu/vegetable/news-events/virtual-twilight-meetings

The following articles can be found online:

Wireworm Biocontrol Update. https://blogs.cornell.edu/biocontrolbytes/tag/wireworm/

Are Persistent Biocontrol Nematodes (Entomopathogenic) a fit for your organic farm? produce-pages-november-2020 (cceclinton.org)

Are Persistent Biocontrol Nematodes (Entomopathogenic) an economic benefit for your NY farm? What's cropping up? https://blogs.cornell.edu/whatscroppingup/2020/10/02/are-persistent-biocontrol-nematodes-entomopathogenic-an-economic-benefit-for-your-ny-farm/

Persistent Biocontrol Nematodes: What, Why, How, When and Where to Get Them
Persistent Biocontrol Nematodes: What, Why, How, When and Where to Get Them (nnyagdev.org)

Future Work with EPNs

Research on wireworms in the Hudson Valley has shown reduction in the soil populations of these soil insects along with reduced root injury in areas where NY Persistent Biocontrol Nematodes have been established. These results have caught the attention of researchers in other regions of the United States. In the High Plains of Texas, wireworms are prevalent in fields planted to wheat for winter grazing and hay. Success under NY conditions has triggered a trial (est. March 2021) north of Lubbock, TX where wireworms have become resistant to seed treatments in a cotton field. The focus of this trial is to try and replicate the results from NY within this crop production system. Researchers from Texas A&M University along with a local cotton producer, inoculated several 0.25 acre plots within a field using the Sf/Hb species combination.

In New York, Rusinek, Bornt and Shields are currently working on a New York Farm Viability Institute (NYFVI) funded project to study the efficacy of NY native EPNs in the management of Cabbage and Corn Seed Corn Maggot. This is a two-year study. Also, Cornell University researchers- C. Filgueiras (PI), B. Nault, E. Shields and D. Willet. have been funded by NYFVI to determine if EPNs can reduce thrips and onion maggot damage in allium crop production.