Reprinted from MARCH 2021

The Manager

Published by Progressive Dairy

PRO DAIRY Education & Applied Research

Biological control of corn rootworm with native N.Y. entomopathogenic nematodes

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In 2021, the level of corn rootworm (CRW) resistance to the current Bt-RW corn varieties will increase another significant level with associated yield losses. Throughout the corn-growing regions of the U.S. and Canada, increased CRW root damage, yield losses, and increased levels of CRW resistance have been reported to all commercial corn varieties containing all of the different BT toxins effective on CRW. This increased CRW root damage, yield losses, and increased levels of CRW resistance have also been reported in N.Y. and the northeastern U.S.

Corn growers need to seriously consider implementing CRW strategies to reduce the selection of increased resistance in CRW, to protect this technology and protect their yields, because new GMO-RW technologies are a few years from widespread availability.

Biological control is the use of naturally occurring insect diseases, parasites and predators to reduce pest insect populations.

Classical biological control is the use of these organisms which are so adapted to the environment where they are released that they continue to reduce the insect pest population for multiple years from a single introduction/application.

Thirty years of research in New York has yielded a new biological strategy for corn rootworm in New York and throughout the Corn Belt. The discovery of using native New York entomopathogenic nematodes (EPNs) that have not lost their genetic ability to persist across adverse conditions, along with mixing EPN species to cover the agricultural soil profile, controls soil insects including CRW, across multiple growing seasons with a single application. This new strategy has opened a new door in biological control of a broad range of agricultural soil insect pests.

The concept of using native EPNs in EPN species mixes to tackle soil insect pest problems was developed during research to find an effective management strategy for alfalfa snout beetle, an insect that destroys alfalfa in a single year with its root feeding larvae. Alfalfa snout beetle is currently restricted in North America to nine northern New York counties and a small portion of southeast Ontario, Canada. Currently, the concept of applying a single application of native persistent EPNs for multi-year control of alfalfa snout beetle has been applied to more than 28,000 alfalfa snout beetle-infested acres. As a result, alfalfa stand life has returned to four to six years rather than one to two years. Within this research, it was observed that these native EPNs are also effective on CRW, when the alfalfa field was rotated to corn.

CRW BIOLOGICAL CONTROL RESEARCH

In 2014, research was initiated at the Cornell Musgrave Farm to test the concept of using the same technology developed to combat alfalfa snout beetle against CRW in continuous corn. A first-year cornfield was planted in 2014 and inoculated with native New York persistent EPNs. Starting in 2015 and continuing through 2020, six rows of the following Bt-RW traited corn varieties were planted both in the nematode-treated areas and the areas where EPNs were not present. Those Bt-RW varieties were 1) non-Bt-RW, 2) Yieldgard (Cry3Bb1), 3) Herculex (Cry34/35) and 4) Smartstak (Cry3Bb1 + Cry 34/35). The research was designed to compare the impact of persistent EPNs against CRW within a Bt-RW trait package. For example, non-Bt-RW was planted in both the EPN-present plot areas and the non-EPN-present area and could be directly compared. Similar comparisons could

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be made with the other three Bt-RW trait packages.

During the first week of August each year, roots from each treatment were dug, washed, and scored for CRW larval feeding damage. Root damage scoring used the zero to three Iowa scale, where economic losses start occurring between a rating of 0.5 (1/2 root node damaged) to 1.0 (one full node damaged) depending on the level of soil moisture and conditions for root regrowth.

DISCUSSION OF THE RESULTS

In the research areas where non-Bt-RW corn was planted for the past seven years, results indicate a significant reduction of CRW feeding damage in the areas where New York native, persistent EPNs were inoculated in 2014. In 2016, very heavy CRW larval pressure resulted in almost two root nodes destroyed (1.85) in areas where EPNs were absent, a level significantly above where economic losses occur (0.5 to 1.0). By comparison, the areas where EPNs were inoculated in 2014 and present, the CRW root feeding damage was 0.2 root nodes damaged, well below the economic loss level (89 percent reduction in damage). The following two years (2017 and 2018) were very wet during the CRW larval hatching period and the larvae drowned from field capacity soils. CRW populations were reduced area-wide and started building again in 2019. In 2019, the CRW larval population started building with the root feeding damage 0.5 nodes where EPNs were absent, an economic threshold level during the drought of 2019. In areas with EPNs, the damage was reduced to sub economic levels (0.25 nodes damaged) and a damage reduction of 50 percent. Similar results were recorded in 2020 with the non-EPN plots suffering 0.6 nodes damage and the presence of EPNs reduced the damage to 0.1 node (86 percent).

TABLE 1

Corn rootworm damage in the presence and absence of EPNs in non Bt-RW traited corn. CRW damage was rated using the Iowa 0-3 scale.

Year	No EPNs	EPNs	EPNs Damage Reduction
2016	1.85		
2017 & 2018	No significant CRW pressure		
2019	0.5	0.25	50%
Droughty soil (within emergence cages)	2.1	1.6	24%
2020	0.6	0.1	86%
Drier soil (within emergence cages)	0.7	0.1	86%

TABLE 2

Corn rootworm damage in the presence and absence of EPNs in failing Bt-RW traited corn. CRW damage rated using the Iowa 0-3 scale.

Year	No EPNs	EPNs	EPNs Damage Reduction
2016	0.2	0.2	89%
2017	No significant CRW pressure		
2018	0.7	0.1	86%
2019	1.1	0.2	82%
Droughty soil (within emergence cages)	1.9	0.7	63%
2020	0.8	0.2	75%
Drier soil (within emergence cages)	1.4	0.3	79%

Starting in 2019, field emergence cages were placed in the field to collect emerging CRW beetles. Within those field cages, the soil became very dry and indicated the impact of droughty soils on EPN activity against CRW. CRW feeding is not hampered by dry soils because they are feeding on a water source, the plant roots. However, since EPNs move about in the soil on the film of water on each soil particle, dry soils reduce their ability to search and find insect hosts. Those results are indicated in 2019 (under droughty soils) where the soils became extremely dry and the activity of EPNs was greatly reduced (24 percent). In 2020, the soil in the field cages had a higher water content and the control by EPNs returned to a higher level of control with an 86 percent damage reduction.

During the past seven years of the study, the resident CRW population has developed resistance to one of the Bt-RW traits as reported in **Table 2**. In 2016, the CRW root damage in both areas (without EPNs and with EPNs) was very low (0.2 nodes damaged) and sub-economic. Wet spring soils in 2017 reduced the CRW larval population and no root damage was present. However, in 2018 the results started to

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become interesting. In areas without EPNs, the CRW root damage on the Bt-RW traited variety was 0.7 nodes, an economic level in a Bt-RW trait package previously not being damaged by CRW. The presence of EPNs reduced the damage 86 percent to a sub-economic level (0.1 node damaged). In 2019, damage to the Bt-RW traited corn increased to 1.1 nodes damaged, an economic level and the presence of EPNs reduced the damage 82 percent to sub-economic level (0.2 nodes damaged). Similar results occurred in 2020, with CRW feeding damage equal to 0.8 root node damaged without EPNs present and a sub-economic level in the presence of EPNs (0.2 nodes damaged, 75 percent damage reduction).

As with the non-Bt-RW traited corn, field emergence cages were placed in the field in 2019, to collect emerging CRW beetles. Within those field cages, the soil became very dry and indicated the impact of droughty soils on EPN activity against CRW. In 2019, the CRW root damage level was 1.9 nodes damaged without EPNs and 0.7 nodes damaged, a 63 percent reduction in root damage with EPNs present. In 2020 within the cages, CRW damage was 1.4 nodes damaged without EPNS and the damage level was reduced to a sub-economic 0.3 nodes damaged when EPNs were present (79 percent damage reduction).

RESULTS SUMMARY

Research results over seven growing seasons from the Cornell Musgrave Farm strongly indicate the inoculation of fields with New York native EPNs will provide sufficient CRW control in rotated corn to allow you to grow non-Bt-RW corn without additional protection **(Table 1)**. In New York corn rotated with alfalfa, the usual rotation

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Native New York EPNs expand to the national corn production scene

Positive New York research results on controlling CRW has created an interest in New York native EPNs across the Corn Belt, resulting in a number of cooperative research and demonstration projects across several states. Their efficacy is being evaluated at Pennsylvania State University and the University of Vermont. In 2017, research plots were established in the high plains of northwest Texas under center pivot irrigation. In 2019, cooperative research was initiated in Roswell, New Mexico, under irrigation. At both these locations, the Bt-RW traited corn was suffering extreme CRW feeding damage. In 2020, additional sites were established in northeast Iowa and western Nebraska. Both areas have reported Bt-RW failures. In all sites, New York native EPNs have established and persisted at populations sufficient to suppress CRW larvae. Multi-year research will document the suppression of CRW damage in the presence of EPNs and the interim data looks excellent and promising.

HOW ARE NATIVE EPNS APPLIED?

There are two methods developed to apply native EPNs to your field.

Pesticide sprayers

All sizes of pesticide sprayers, from 30 ft. to 120 ft. booms, have been successfully used to apply native EPNs to New York fields by adhering to the following requirements.

1. Remove all filters and screens from the sprayer lines and nozzles. These screens and filters block nematodes and prevent them from being applied.

2. Change the nozzles to a "stream type" nozzle so the stream of water/nematodes hits the ground in a solid stream. With nozzle spacing around 24," there will be a stream of concentrated nematodes and water every 2 ft. or so. Water splash hitting the ground fills in some of the gap between the application streams.

3. Apply nematodes in a minimum of 50 gpa. There needs to be enough water to thoroughly wet the area where nematodes are applied under all conditions to allow the nematodes to enter the soil.

4. Application needs to be either in the evening or on cloudy/rainy days. Nematodes are easily killed by UV (ultraviolet light) and need time to enter into the soil where they are protected.

5. Once the nematodes are dumped into the tank, they need to be applied on the field within an hour. During the hour in the tank, the tank needs to be agitated to keep the nematodes suspended in the water.

Liquid Dairy Manure

Native EPNs have been successfully applied in liquid dairy manure if the manure is spread on the field within 30 minutes of adding the nematodes to the tanker. Most growers add the nematodes during tanker filling to mix the nematodes through the manure and spread the manure on a field within 30 minutes. If the manure is not spread within 30 minutes, the nematodes start dying from lack of oxygen.

NEMATODE SOURCE AND COST

The cost of native New York EPNs run between $50 to $75 per acre, depending on the quantity purchased. Native New York EPNs can be purchased from Mary DeBeer, Moira, N.Y., (518) 812-8565 or md12957@aol.com. We have worked closely with Mary on the rearing practices to prevent her cultures of New York native EPNs from losing their persistent genetics. Mary has provided New York persistent biocontrol nematodes to farmers for six years.

In addition, interested farmers can contact the Shields' Lab at Cornell to purchase nematodes or to answer any questions (Cornell University – Shields' Lab es28@cornell.edu).

is four years alfalfa and four years corn. In this rotation, CRW is a potential economic problem for years two, three and four, with increasing risk each year of continuous corn. The usually sub-economic level of CRW larvae in year two corn will help to increase the resident EPN population for the typically higher numbers of CRW larvae in years three and four. Decreased CRW control was only observed under the conditions of extremely dry soil during June and July, which limit the EPNs' ability to locate and kill CRW larvae. Under these conditions, the impact of drought on yield has a greater impact than increased CRW root damage from reduced EPN efficacy. One additional benefit of soil inoculated with native New York EPNs is the suppression of wireworm and white grub in first-year corn. These insects build up during the alfalfa/grass portion of the rotation and at times damage first-year corn. Research has shown that these EPNs attack these insects as hosts during the alfalfa/grass crop and the populations of these insects are dramatically reduced when the field is rotated to corn.

Data in **Table 2** indicates that EPNs are not only compatible with Bt-RW traits in corn, but when those traits begin failing due to CRW resistance development, the presence of EPNs reduce the damage to below the economic threshold. This activity of EPNs under Bt-CRW traited corn provides a mortality factor independent of the Bt toxin, delays the development of CRW resistance by killing the toxin survivors, and extends the life of Bt-RW traits against CRW.

ACKNOWLEDGEMENTS

These research results, and their application to New York and U.S. agriculture, were made possible only with the long-term financial support of Northern N.Y. Agricultural Development Program, N.Y. Farm Viability Institute, Cornell University, and USDA funding from Hatch and multi-state programs.

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