

## Managing Corn Rootworm in NY to delay Bt resistance (& save seed costs)

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Across the US and within NY, corn rootworm (CRW) is developing resistance to the Bt-RW traits in our GE corn varieties, causing increased root damage and decreasing yields. Yield losses from CRW root feeding can surpass 10% without any above ground symptoms, making this type of losses difficult to detect. In addition, corn grown for silage is more sensitive to yield losses from CRW feeding than corn grown for grain. As CRW resistance increases to Bt-RW, the damage becomes more apparent and easier to detect, but losses have been occurring in the field in prior years, going undetected. Increased damage has been reported in NY for all of the Bt-RW traits regardless of company.

**Important points about CRW biology:** There are two important points about CRW biology which need to be remembered when managing this pest and reducing its potential for developing resistance to any of our management tools. 1) In NY, all eggs are laid in existing corn fields during August, and 2) if the newly hatch CRW larvae in the spring do not find a corn root, they die. Since CRW eggs are laid in existing corn fields in August of prior year, crop rotation is our best resistance management tool. Since the majority of the corn grown in NY is in rotation with alfalfa for our dairy farms, NY trails the rest of the nation in the development of CRW resistance to Bt-RW.

**For our dairy farmers,** that grow corn in rotation with alfalfa, corn is typically grown in a field for 3-5 years. The longer corn is grown continuously in a field, the higher risk the field has for economically damaging CRW root feeding and yield losses. After rotating out of a non-corn crop, first year corn does not need any CRW management (or expensive Bt-RW trait costs). A non-Bt-RW corn variety should be planted with a seed corn maggot/wireworm effective seed treatment. This choice in year 1 saves \$15-\$20 per acre in seed costs. In year 2, the risk of CRW loss increases to 25-30% in NY. To offset this risk, a farmer has several options. Many farmers will assume the risk and plant a non-Bt-RW corn variety without any additional protection such as a soil insecticide. A second option in year 2 is to use either a 50% rate of soil insecticide (if insecticide boxes are available), high rate of neonic seed treatment or an insecticide added to the liquid popup fertilizer. The CRW pressure in year 2 is not high enough to recommend the use of Bt-RW in most cases and the option of an insecticide is often a less expensive route to reduce production costs. The deployment of different modes of toxicity in year 2 from Bt-RW significantly reduces the selection for Bt-RW resistance by CRW. In continuous corn years 3-5, the risk of economic loss from CRW is high enough to merit the use of Bt-RW corn varieties. A second option in years 3-5 of continuous corn is the use of a full rate of soil insecticide, if insecticide boxes are available. Adding insecticide to the popup fertilizer during years 3-5 is not recommended due to unreliable efficacy with the higher CRW populations and increased risk for economic damage.

**Strategy 2 for our dairy farmers: Incorporating biocontrol nematodes into their rotation and crop production.**

By using the biocontrol nematode technology developed to combat alfalfa snout beetle in NNY, our dairy farmers can reduce their corn seed costs by eliminating the purchase of the Bt-RW traits in their corn varieties. A single inoculation of each field with native persistent NY biocontrol nematodes provides protection from corn rootworm larval feeding by attacking these insects before they damage the corn roots. NY research data indicates a single soil inoculation (\$50-\$60/acre) establishes these NY adapted biocontrol nematodes in the soil profile for many years, where they attack a wide range of pest soil insects across a wide variety of crops. During the corn years, these biocontrol nematodes attack rootworm larvae and during the alfalfa years, attack wireworms, white grubs, clover root curculio feeding on the alfalfa and grass in the field.

If the biocontrol nematodes are inoculated into the field during the alfalfa portion of the crop rotation, the farmer can use corn varieties without Bt-RW for the entire corn rotation. Biocontrol nematodes take until the second growing season after application to become fully established in the soil profile and when applied to the alfalfa crop, become fully established before corn is planted. If the field is inoculated with biocontrol nematodes during the first year of the corn rotation, the corn variety planted in year 1 can be without the Bt-RW trait because rootworm is never a problem in 1<sup>st</sup> year corn in NY. By the second year, the biocontrol nematodes are fully established and corn varieties can be planted without Bt-RW for the remaining years of the corn portion of the rotation.

However, if the corn field is inoculated with biocontrol nematodes during the 2<sup>nd</sup>-4<sup>th</sup> year when rootworm damage risk is higher, the corn variety planted during the year of inoculation needs to have the Bt-RW trait to provide some additional protection while the biocontrol nematodes become fully established in the field. If the cost of establishing biocontrol nematodes in a field is a one-time cost of \$50-60/acre and the Bt-RW trait adds \$20/acre/year to the seed costs, the breakeven point for the nematode application is year 3 when the Bt-RW trait is not purchased or used. In the years beyond 3-years after application, the seed cost savings will continue to be the cost of the Bt-RW which is an unnecessary expense.

**For our cash grain farmers**, an annual rotation of corn and a non-host crop like soybeans completely eliminates the need for any CRW management tools. During the corn years, non Bt-RW corn varieties can be safely planted without risk of losses from CRW. The elimination of the Bt-RW trait in the corn planted reduces the seed cost \$15-\$20 per acre and the use of a Bt-RW trait is completely unnecessary. However, a seed treatment for seed corn maggot to protect plant emergence is recommended due to our typically wet cold soils. The enhanced adoption of cover crops to protect our soil from erosion and any history of animal manure application significantly increases the risk of plant stand losses from seed corn maggot.

**Long-term continuous corn fields:** The culture of corn continuously in the same field for multiple years using only Bt-RW to control CRW places tremendous selection pressure for the insect to develop resistance to the Bt-RW toxins. This widespread practice across the corn belt has resulted in the documented CRW resistance to all Bt-RW traits and the insect is causing economic losses for farmers adopting these continuous corn practices. Closer to home, Bt-RW failures have been reported in Central NY corn fields, multiple corn growing areas of Ontario, Canada and to the south in Pennsylvania. With no new technology against CRW available for the next few years, these growers have a real challenge on their hands to minimize losses from

this adaptable insect, if these farmers continue with long-term continuous corn production without breaking the CRW cycle with crop rotation. Farmers with fields producing corn continuously for multiple years need to seriously consider working a crop rotation into their farming practices. There are well documented agronomic yield advantages/responses from crop rotation over continuous corn, even without considering the reduction in CRW root feeding damage.

However, if farmers insist on growing continuous corn in field without interruption, there are several issues to consider. The continued use of Bt-RW accelerates CRW resistance and the single field failure becomes the source of highly resistant beetles moving into neighboring fields, causing significant yield losses even in neighboring fields where farmers are utilizing crop rotation to minimize CRW-Bt-RW resistance development and yield losses. The farmer growing continuous corn and producing highly resistant beetles becomes “a neighborhood social problem” for his neighbors. Some farmers add a soil insecticide over the top of the Bt-RW trait, think this is a solution to the resistance issue. While the corn stands better with less damage at the plant base, selection for CRW Bt-RW resistance continues to accelerate within the root system in areas outside of the soil insecticide treated zone.

The addition of biocontrol nematodes to the continuous corn culture is a way of introducing an independent mortality factor to help the Bt-RW trait control rootworm larval populations. However in these high CRW pressure systems, biocontrol nematodes should not be used alone. CRW has developed resistance to every other management strategy used to manage its damage, biocontrol nematodes used alone will also select for CRW resistance. If farmers are interested in incorporating biocontrol nematodes into their continuous corn production, farmers should continue to use varieties with the Bt-RW trait to continue to kill the susceptible CRW larvae or match the use of biocontrol nematodes with a full rate of soil insecticide.