**Performance Problems with *Bt*-Rootworm Corn:**

Trait Resistance in Minnesota and Corn Rootworm Management

Bruce Potter, IPM Specialist and Ken Ostlie, Extension Entomologist – Department of Entomology

*Bt* corn with traits conferring resistance to corn rootworms offer growers a simple, seed-based solution to managing corn rootworms. These traits are more effective than soil insecticides or seed treatments in protecting corn roots.

Corn rootworms have developed resistance to many control tactics over the last 50 years including crop rotation, soil insecticides and foliar insecticides. Because of the potential for corn rootworms to develop resistance to *Bt*-RW traits, the EPA registration for each trait outlines an insect resistance management (IRM) program that growers agree to implement when they sign the technology agreement. The heart of resistance management involves planting a refuge (non-*Bt*-RW hybrid) that will produce susceptible beetles to mate with beetles emerging from the *Bt*-RW hybrids and dilute accumulating resistance genes.

**PERFORMANCE PROBLEMS IN MINNESOTA**

Performance problems with *Bt* traits surfaced in 2009 when MN growers first reported lodging and unexpectedly high levels of root injury in VT Triple hybrids (see root photo). Investigations commonly revealed severely pruned roots (> 1.0 NIR) while tissue tests confirmed presence of *Bt* protein.

Field histories were similar: corn after corn with repeated use of the same trait. Bioassays of beetles from the fields confirmed elevated survival (>3X) in MN and IA. While debate swirls about whether these levels can be called resistance, the point is lost on the farmers that need an immediate rootworm management solution for their problem fields.

The geographical pattern and magnitude of problem fields remained scattered across southern MN from 2009–2011, but the scope and intensity of performance complaints increased markedly in 2012 (see map). Performance problems have been primarily limited to corn after corn fields with a history of 3 or more years of repetitive Cry3Bb1 (*VT*Triple or *VT* Triple Pro) hybrids in the field. However, in 2012, performance problems began surfacing with other single (*AgriSure 3000GT*, *Herculex Xtra*) and even pyramided traits (*SmartStax*). While requiring confirmation and bioassay of beetles, these reports are disturbing in their potential implications for rootworm management.
PERFORMANCE PROBLEMS: WHAT TO DO

If you note unexpected levels of corn rootworm injury or lodging, or suspect performance problems with any Bt-RW hybrid, please follow these steps:

1. Consult your planting notes to confirm hybrids and trait placement.

2. Scout where problems are occurring in the field. Look at lodging. Dig a few roots to verify corn rootworm damage. Note the corn rootworm species and relative abundance in the field.

3. Contact your seed dealer to report unexpected corn rootworm injury. Arrange to have an independent ag professional familiar with corn rootworm present for company field visit(s).

4. Each company has its own internal reporting process ... but expect these elements:
   - Ground truth of planting information by tissue testing with gene check kits.
   - Digging roots, both Bt-RW and refuge hybrids, to verify excessive root feeding and explore other potential causes of lodging.
   - Field history information including cropping history and management practices.
   - If verified, the company may collect beetles, if present, to confirm resistance and may request management steps for the following corn crop.

5. If you experience Bt-RW performance issues, please let us know about it so we can learn about the geography and extent of Bt-RW performance problems in Minnesota. To report a problem field and get the latest information on this topic, go to: [www.extension.umn.edu/cornrootworm/](http://www.extension.umn.edu/cornrootworm/).

Once you’ve completed these steps, now comes the hard part...determining how to manage this mess!

MANAGING A Bt-RW TRAIT FAILURE FIELD

The days are passing when you can plant a Bt-RW trait repeatedly and ignore the field until harvest. Evaluate each field for trait performance and signs that management problems are looming. These signs may include stunted or drought–stressed plants, abundant beetles in the field, and excessive corn root injury. If you suspect a developing performance problem with a trait, switch corn rootworm management tactics:

**Take the field out of continuous corn for one year**

- Most effective management option since it eliminates western corn rootworms in the field.
- Western corn rootworms in Minnesota do not exhibit extended diapause trait, unlike northern corn rootworms, nor significant egg laying in soybean. As a result, crop rotation is the simplest way to reduce rootworm populations and can provide local extinction of rootworms from the field.
- Benefits will extend more than one year. The duration of this reduced threat will depend on re-colonization of subsequent corn crops by adult beetles (local migration up to 2 miles). Resistance characteristics of the new population will reflect the local population.
- Grassy weeds and volunteer corn must be aggressively controlled. A special effort to control volunteer corn may be needed including a separate application of ACCase herbicides. Volunteer corn roots that survive until mid/late June can allow larvae to survive and continue production of resistant beetles in the field. Volunteer corn plants that survive to silk will attract female beetles back into the field to lay eggs.

**Fig. 4:** Bt-RW issues create corn rootworm management dilemma!

**Fig. 5:** Crop rotation can eliminate western corn rootworm populations but manage volunteer corn!
careful consideration. A one-year break from corn may be more profitable than you suspect. Fields that have not seen soybean for several years should produce good soybean yields. Volunteer corn and weed control options are increased. Finally, a corn yield increase of 10% or so can be expected after the break.

**Switch to a different Bt-RW protein (or pyramid)**

- **Bt–RW** performance problems typically occur in corn–on–corn fields planted to the same trait for several years, usually 3 or more. A seemingly simple management strategy to minimize yield loss and reduce rootworm problems would be switch to a different protein after 3 to 4 years. Many fields have not experienced any problems yet; predicting when traits will fail in a field is a challenge.

Fig. 6: Crop rotation can eliminate western corn rootworm populations... but manage volunteer corn!

- The majority of problem fields since 2009 have been with the Cry 3Bb1 protein, the first introduced and the most frequently grown trait (VT Triple or Triple Pro hybrids). In this situation, plant a Cry 34/35 Ab1(Herculex Xtra) hybrid or Cry3Bb1 + Cry34/35 (SmartStax) hybrid, or their blends. Note: mCry3A (Agrisure 3000GT) hybrids have not fared well under heavy pressure in some of these Cry3Bb1 performance problem fields.

- Resistance by corn rootworms is expected with all traits so be alert to changing performance. This year an increasing number of performance problems have emerged with other traits, including Agrisure 3000GT, Herculex Xtra (OAM1) and SmartStax RIB hybrids, which hint at the potential for new resistance issues. The role of drought in performance problems is unknown.

- Problems have also surfaced with alternative traits in a few Cry3Bb1 (VT Triple, VT Triple Pro) problem fields. A number of 2012 fields with severe root injury to mCry3A (Agrisure 3000GT), Cry34/35 alone (Herculex Xtra) or the stack of Cry34/35 + Cry3Bb1 (SmartStax Hybrids) call into question the wisdom of this approach. The potential for unacceptable root injury in alternative traits may be elevated with the extremely high larval populations possible in Bt–RW failure fields. A rootworm insecticide overlaid over these alternative traits may be advisable as added insurance under extremely high rootworm pressure.

- Switching traits may be a diminishing option for all growers as companies move forward with more Bt–RW trait pyramids. The goal is to make resistance development harder for corn rootworms and prolong the commercial life of traits. The irony is that all companies are pyramiding with the Cry34/35 trait, so the selection pressure for resistance to this trait will increase dramatically.

**Apply soil insecticides to maintain stand-ability**

- Soil insecticides protect a portion of the corn root system to improve standability; essentially they are lodging insurance. While many growers and ag professionals think insecticides achieve high kill: in reality, most products deliver 70% kill at best.

- Insecticides do not change Bt selection pressure in the field. Insecticides only protect a small area of the root system. Larvae outside that zone are only dealing with the naked hybrid (refuge corn or Bt–RW traits).

- When a trait is working, few larvae enter the insecticide zone so, in this situation, insecticides contribute little to yield protection. The challenge is determining when a trait is failing and insecticide use will “pay out.”

- Planting a hybrid without a Bt–RW trait and using an insecticide does not increase selection pressure against Bt. This strategy can work in problem fields where beetle populations have been reduced by an effective rotation or adult beetle control.

- Be advised, fields with Bt–RW performance problems typically have incredibly high beetle populations and probably egg densities. In these cases, insecticides may not be able to provide adequate protection for yield since their performance degrades with heavy pressure.
• We no longer have any effective, labeled post-emerge insecticides for rootworm larval control.

• Soil insecticides may not be an option for all growers. Many growers lack application equipment and there are challenges, including equipment availability, in retro-fitting planters. Soil insecticide shortages may occur as demand increases, exacerbated by non-profitable, insurance-justified applications to fields where traits are performing well.

• All insecticides are not equal. Choose an insecticide with a documented, good-performance history. Seed-applied insecticides and many liquid insecticides do not perform well under heavy rootworm pressure. Expect poorer performance of all soil insecticides under drought conditions, but especially with liquid insecticides.

Spray beetles to prevent egg laying

Fig. 7: Corn rootworm beetles are easily killed so a single spray early in pollination can relieve silk pruning concerns.

• Spraying beetles to prevent silk clipping is relatively simple; to ensure pollination control beetles if silk pruning keeps less than 0.5” of silks exposed during pollination.

• Beetle control can help reduce egg-laying in performance problem fields, but it is difficult to accomplish effectively. Corn rootworm beetles are not hard to kill. Successful adult management, however, requires frequent and careful scouting to minimize both the number of sprays and egg-laying. Adult beetles may be active in the field for 6 to 8 weeks and with spray residuals lasting only 5 to 7 days at best, spray timing is critical. Two, or often three, insecticide applications may be required to control egg laying. After one or two sprays, late emerging beetles may still lay enough eggs to cause problems in next year’s corn.

Fig. 8: Successful adult control requires frequent scouting to time the 2-3 sprays required to reduce egg laying significantly.

• Adult control, if well done, will lower egg populations and may allow corn to be planted the following year. It does not change frequency Bt-resistance in the population and the problem can worsen if the same trait is used.

• Routine adult western corn rootworm beetle control has led to foliar insecticide resistance in Nebraska.

• Many of the pyrethroid sprays that can be used against corn rootworms will flail two-spotted spider mite populations. Be careful under drought conditions!

This publication is based on research funded by the farm families of Minnesota through their corn checkoff and the Minnesota Legislative Rapid Agricultural Response Fund. Thank you!

For more information on Corn Rootworms and Bt-RW corn, see the following website: www.extension.umn.edu/corn_rootworm/