Minimizing Corn Rootworm Losses
Safe, responsible, effective rootworm management

We’ve been dealing with corn rootworm for nearly as long as we’ve been growing corn, but the tools, strategies and economics related to managing this pest have changed in recent years.

Historically, crop rotation has been one of the most effective rootworm management tools. With the increase in continuous corn in Iowa over the past 10 years and the rapid adoption of trait technology in plant breeding, we’ve quickly switched to hybrids with in-plant protection against corn rootworm that comes from a gene from the bacteria Bacillus thuringiensis (Bt), which, put simply, is toxic to certain insect species.

There is no doubt that Bt traits have had a tremendous impact on reducing yield losses from corn rootworm. However, using hybrids with Bt rootworm traits requires that anywhere from 5-20% of the field area be planted to hybrids without rootworm traits as a refuge.

In this era of record high commodity prices and rising production costs, growers are looking for every bushel they can get, and leaving the refuge areas unprotected may cut into overall yields.

Another consideration is that in order for Bt traits to work, rootworm larvae must consume some of the root tissue. In areas where rootworm pressure is high, or in dry years like 2012 when limited moisture may slow root regrowth, this feeding can ultimately reduce yield.

Additionally, there have been reports of rootworm resistance to some of the Bt-traited corn. We are not aware of any new genetic sources of insect protection that are close to being introduced, so it’s extremely important that we manage the traits we already have. We know that weeds and insects develop resistance to pesticides faster when managed improperly, so we could expect that corn rootworms are also capable of developing resistance to Bt traits if proper management strategies are not implemented.

Studies have shown that in certain scenarios, using soil insecticides with Bt rootworm hybrids can add to a grower’s bottom line. Soil insecticide use can be a part of a responsible stewardship program for managing insect resistance to Bt.

Many growers remember the label precautions for handling some soil insecticides in the past and may be reluctant to go back. The SmartBox® system permits easy and safe handling of insecticides by eliminating contact with the product itself.

This publication was put together by On-Farm Network staff to highlight basic information about managing corn rootworm and to present results of some of our studies using insecticides with Bt traits. Our intent is to help you maintain or increase corn profitability while making use of all the tools available to improve the stewardship of the Bt traits and soil insecticides to increase grower profitability.
Understanding the corn rootworm life cycle

All three corn rootworm species (western, northern and southern) found throughout Iowa have similar four-stage life cycles, which include egg, larva, pupa and adult (beetle). However, southern corn rootworm, also known as spotted cucumber beetle, differs from the other two in the time of egg laying.

**Northern and western corn rootworm**

Northern and western corn rootworm adult females lay eggs in the soil in the fall and then die. Larvae hatch in late May or early June. Corn root tips emit CO₂ into the soil, which attracts the larvae to the roots. Larvae begin feeding at once and go through three instars (developmental stages), each lasting a week to 10 days, for a total feeding time of up to 30 days.

After completion of the third instar, in which larvae can reach up to about half an inch in length, they quit feeding and pupate into adults in the soil. Adult beetles begin to emerge in July. They instinctively dig their way to the soil surface and crawl upward. If they’re in a cornfield, this means crawling up a corn plant, where they begin feeding on leaves, pollen and silks.

Mating takes place soon after the adults emerge. Beetles continue to feed for about two weeks. Then they return to the soil surface, find a crack and crawl in to deposit their eggs. Once this is completed, they remain in the soil and die.

**Southern corn rootworm**

Southern corn rootworm adults survive through the winter, emerging in March to feed, and then lay eggs from late April until early June. Eggs generally hatch in 7-10 days.

Larvae and pupae follow the same developmental stages as northern and western rootworms, although the timing of these stages can vary, particularly because of the prolonged egg-laying period.

The next generation of adult beetles appears from September to November, and may feed in alfalfa, clover, other field crops, weeds or grasses. This pest can damage vegetable crops, fruit, flowers, leaves and stems. They overwinter in non-frozen parts of plants before they emerge to begin feeding again in the spring.

Traditional corn-soybean crop rotations help manage rootworm by taking advantage of the insect’s normal life cycle. However, nature has a way of adapting.

**Northern corn rootworm extended diapause**

Diapause is the period between when eggs are laid and when they hatch. Normally, this lasts only from fall until the following spring.

Some variants of northern corn rootworm have adapted to corn-soybean rotation by developing an extended diapause, in which eggs laid in a cornfield remain dormant for two or more years, and hatch when the field is rotated back to corn. This has been documented in Iowa, Minnesota, Nebraska, South Dakota and North Dakota.

**Western corn rootworm soybean variant**

In Illinois, Indiana, Michigan and Ohio, variants of western corn rootworm have adapted to a traditional corn-soybean rotation. After mating, some females in this area now migrate to soybean fields to lay eggs. Since the result may be rootworm damage in first year corn, growers in affected areas may need to use tools other than rotation to prevent losses.
Refuge is mandatory

Because Bt proteins are considered a type of pesticide, transgenic crops containing them must be approved by the US Environmental Protection Agency before they can be marketed. One of the conditions EPA has made for their approval is that growers plant a portion of their acreage to a non-Bt crop to avoid development of resistance to Bt by insect pests. The refuge should prevent development of resistant insects, giving the technology a longer life span.

Refuge requirements for Bt hybrids fall into two categories. The first is “refuge in the bag” (sometimes called RIB) where the refuge seed is mixed in the bag with the seed containing the Bt trait. In some hybrids, only the corn rootworm refuge is mixed in and a separate corn borer refuge must be planted. The second is a structured refuge, in which a hybrid without a Bt trait is planted in separate strips (four-row minimum width) or in blocks.

Refuge requirements differ according to the Bt trait in the hybrid being planted. If there is a single Bt trait in the hybrid, there are different refuge requirements for corn borer, corn rootworm and stacked traits. Stacked traits can have a common or a separate refuge. General refuge requirements are listed below. The table on the next page shows requirements for specific Bt traits and hybrids.

Sources of genetic rootworm resistance

Because Bt proteins have been genetically modified by inserting a gene from Bacillus thuringiensis (Bt). Many strains of Bt have been isolated, but they are divided into two groups, based on the insect categories they control.

One gene group controls above-ground pests like European corn borer, stalk borer and other Lepidoptera insects. The other group controls the below-ground corn rootworm larvae. Hybrids with rootworm Bt traits are listed on page 5.

There are currently three Bt proteins available for corn rootworm control: Cry34/35Ab1 (from Dow AgroSciences and Pioneer Hybrids under the Herculex brand); Cry3Bb1 (from Monsanto under the YieldGard brand); and, mCry3A (from Syngenta under the Agrisure brand).

These three proteins have also been used in combination with each other. Dow AgroSciences and Monsanto joined Cry34/35Ab1 and Cry3Bb1 in SmartStax or GenuineSmartStax. Syngenta and Pioneer sell a combination of mCry3A and Cry34/35Ab1 as Agrisure 3122 E-Z Refuge (Syngenta) and Optimum Intrasect Xtreme (Pioneer). These below-ground traits are usually combined with above-ground insect protection traits and herbicide resistance.

**General Refuge Requirements**

**Single Traits**

- Depending on the trait package, as much as 20% of the total acres need to be planted as corn rootworm or corn borer refuge in northern corn growing areas.
- Refuge for corn rootworm must be planted in the same field or an adjacent field.
- For corn borer, the refuge can be planted in the same field or in a separate field within ½ mile but must be on the same farm and managed by the same grower.
- Refuge can be planted as a block or split planter, as long as the blocks or strips are at least four rows wide.
- For corn borer, only a non-Bt insecticide may be used in the refuge if targeted insects reach an economic threshold. For corn rootworm, the refuge may be treated with soil or seed applied insecticides, but foliar insecticides are restricted.

**Stacked Bt Traits – Common Refuge**

- With a common refuge the requirements for both the corn rootworm and corn borer refuge are met. The refuge must be planted with a hybrid that does not have a Bt trait (conventional corn or only herbicide resistant traits).
- Depending on the trait, the refuge requirements range from 5-20% in northern corn growing areas.
- Common refuge must be planted in the same field or an adjacent field.
- Refuge can be planted as a block or split planter, as long as the blocks or strips are at least four rows wide.

**Stacked Bt Traits – Separate Refuges**

- Separate refuges are designed to work independently for each insect pest. One refuge must be planted for corn borer and another refuge planted for corn rootworm.
### Current October 29, 2012

**Bt protein(s)** | **Insects controlled (bold) or suppressed (italics)** | **Herbicide tolerance** | **Refuge %, location**
--- | --- | --- | ---
### Agrisure products
Agrisure CB LL | Cry1Ab | ECB CEW FAW SB | LL | 20% within ½ mile
Agrisure GT CB LL | Cry1Ab | ECB CEW FAW SB | GT LL | 20% within ½ mile
Agrisure RW | mCry3A | --- | CRW | 20% in field/adjacent
Agrisure GT RW | mCry3A | --- | CRW | 20% in field/adjacent
Agrisure CB LL/RW | Cry1Ab mCry3A | ECB CEW FAW SB | CRW | 20% in field/adjacent
Agrisure 3000GT | Cry1Ab mCry3A | ECB CEW FAW SB | GT LL | 20% in field/adjacent
Agrisure Artesian 4011 | Cry1Ab mCry3A | ECB CEW, FAW, SB | CRW | 20% in field/adjacent
Agrisure Vipertica 3110 | Cry1Ab Vip3A | BCW CEW ECB FAW WBC SB | --- | GT LL | 20% within ½ mile
Agrisure Vipertica 3111 | Cry1Ab mCry3A Vip3A | BCW CEW ECB FAW WBC SB | CRW | 20% in field/adjacent
Agrisure 3122 E-Z Refuge | Cry1Ab Cry1F mCry3A Cry34/35Ab1 | BCW ECB FAW WBC CEW SB | CRW | 5% in the bag
Agrisure Vipertica 3220 E-Z Refuge | Cry1Ab Cry1F Vip3A | BCW CEW ECB FAW WBC SB | --- | GT | 5% in the bag
### Herculex products
Herculex 1 (HX1) | Cry1F | BCW ECB FAW WBC CEW SB | --- | RR2 (some) | 20% in field/adjacent
Herculex RW (HXRW) | Cry34/35Ab1 | --- | CRW RR2 | LL RR2 (some) | 20% in field/adjacent
Herculex XTRA (HXX) | Cry1F Cry34/35Ab1 | BCW ECB FAW WBC CEW SB | CRW | LL RR2 (some) | 20% in field/adjacent
### Optimum products
Optimum (AM-R) AcreMax | Cry1F Cry1Ab | BCW ECB FAW WBC CEW SB | --- | RR2 | 5% in the bag
Optimum (AMRW-R) AcreMax Rootworm | Cry34/35Ab1 | --- | CRW RR2 | 10% in the bag
Optimum (AMT) AcreMax1 | Cry1F Cry34/35Ab1 | BCW ECB FAW WBC CEW SB | CRW | LL RR2 | 10% in the bag
Optimum (AMX-R) AcreMax Xtra | Cry1F Cry1Ab Cry34/35Ab1 | BCW ECB FAW WBC CEW SB | CRW | RR2 | 10% in the bag
Optimum (AMXT-R) AcreMax Xtreme | Cry1F Cry1Ab mCry3A Cry34/35Ab1 | BCW ECB FAW WBC CEW SB | CRW | RR2 | 5% in the bag
Optimum Intrasect | Cry1F Cry1Ab | BCW ECB FAW WBC CEW SB | --- | LL RR2 | 5% within ½ mile
Optimum Intrasect Xtra | Cry1F Cry1Ab Cry34/35Ab1 | BCW ECB FAW WBC CEW SB | CRW | LL RR2 | 20% in field/adjacent
Optimum Intrasect Xtreme | Cry1F Cry1Ab mCry3A Cry34/35Ab1 | BCW ECB FAW WBC CEW SB | CRW | LL RR2 | 5% in field/adjacent
Optimum TRIssect | Cry1F mCry3A | BCW ECB FAW WBC CEW SB | CRW | LL RR2 | 20% in field/adjacent
### YieldGard products
YGCB | Cry1Ab | ECB CEW FAW SB | --- | RR2 (some) | 20% within ½ mile
YGRW | Cry33B1 | --- | CRW RR2 (some) | 20% in field/adjacent
YieldGard Plus | Cry1Ab Cry3Bb1 | ECB CEW FAW SB | CRW RR2 (some) | 20% in field/adjacent
YieldGard VT Triple | Cry3Bb1 | --- | CRW RR2 | 20% in field/adjacent
### Genuity / SmartStax products
Genuity VT Double PRO | Cry1A,105 Cry2Ab2 | CEW ECB FAW | --- | RR2 | 5% within ½ mile
Genuity VT Double PRO RIB Complete | Cry1A,105 Cry2Ab2 | CEW ECB FAW | --- | RR2 | 5% in the bag
Genuity VT Triple PRO RIB Complete | Cry1A,105 Cry2Ab2 Cry3Bb1 | CEW ECB FAW | CRW | RR2 | 10% in the bag
SmartStax (Dow) or Genuity SmartStax (Monsanto) | Cry1A,105 Cry2Ab2 Cry1F Cry3Bb1 Cry34/35Ab1 | BCW CEW ECB FAW WBC SB | CRW | LL RR2 | 5% in field/adjacent
Genuity SmartStax RIB Complete | Same as Genuity SmartStax | BCW CEW ECB FAW WBC SB | CRW | LL RR2 | 5% in the bag
REFUGE ADVANCED Powered by SmartStax | Same as SmartStax | BCW CEW ECB FAW WBC SB | CRW | LL RR2 | 5% in the bag

**Insect targets**
- BCW: black cutworm
- CEW: corn earworm
- CRW: corn rootworm
- ECB: European corn borer
- E-Z Refuge: Liberty Link
- FAW: fall armyworm
- GT: glyphosate tolerant
- LL: Liberty Link
- RR2: Roundup Ready 2 (glyphosate tolerant)
- SB: stalk borer
- WBC: western bean cutworm

**Herbicide traits**
- GB: glufosinate tolerant
- LL: Liberty Link
- RR2: Roundup Ready 2

Table compiled by Chris DiFonzo, Michigan State University, East Lansing, MI, and Eileen Cullen, University of Wisconsin, Madison, WI. Used with permission. The most up-to-date version of this bulletin is posted at: http://labs.russell.wisc.edu/cullenlab/extension/extension-publications/
Rootworm Insecticides

When Bt proteins for rootworm control were first introduced, it was hoped they could replace soil applied insecticides. However, there has been documented evidence of rootworm resistance to some traits and performance of the traits has been challenged in several instances, particularly during last summer’s drought. While rootworm trait hybrids are still performing well across a wide geography, many growers have gone back to using soil applied insecticides, both for non-trailed corn and to supplement the control provided by the Bt traits.

Insecticides for soil application can be in either dry granular or liquid form.

Granular insecticides traditionally were applied with conventional planter insecticide application systems. Some of the granular insecticides are still available in bags. However, closed application systems like Lock ‘n Load® and SmartBox® (AMVAC Chemical Corporation) were developed to reduce user exposure and improve application precision. The SmartBox system is more accurate than conventional pulley and chain metering technology, and also makes variable rate application possible.

New systems make application safer

The biggest reason for using them, though, is operator safety. The closed systems have eliminated opening, pouring, and disposing of bags. The insecticide containers are returnable and refillable. With SmartBox, application history can be recorded and downloaded from the system controller.

Liquids are an alternative to granular insecticides, and several different systems have been developed to apply liquid insecticides in-furrow. John Deere developed the Central Insecticide System™ specifically for applying Force® CS. Force® CS is placed into an insecticide cabinet and the product is directly injected, mixed with the water, and delivered to the individual planter units, which apply it in a T-band over the furrow. There is very little chemical exposure with this system. Other liquid insecticide application systems include the Capture Liquid Ready® (FMC) unit and the Endeavor® system (Ohio Valley Ag).

Seed treatments alone may not be the best option for corn rootworm control, especially in areas with high corn rootworm pressure. However, they do provide an option to provide some protection on refuge acres or a second mode of action on treated corn. For example, Pioneer uses Poncho® 1250/VOTiVO® (Bayer CropScience) on refuge seed in their “refuge-in-a-bag” hybrids.
<table>
<thead>
<tr>
<th>System</th>
<th>Company</th>
<th>Insecticide Class</th>
<th>Rate of the Poncho portion of this product.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AMVAC</td>
<td>organophosphate + synthetic pyrethroid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AMVAC</td>
<td>organophosphate + synthetic pyrethroid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AMVAC</td>
<td>organophosphate</td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>AMVAC</td>
<td>organophosphate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Syngenta</td>
<td>synthetic pyrethroid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AMVAC</td>
<td>synthetic pyrethroid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AMVAC</td>
<td>organophosphate + synthetic pyrethroid</td>
<td></td>
</tr>
<tr>
<td>Load</td>
<td>AMVAC</td>
<td>organophosphate + synthetic pyrethroid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FMC</td>
<td>synthetic pyrethroid</td>
<td>0.39-0.49 6.8-8.5</td>
</tr>
<tr>
<td></td>
<td>Syngenta</td>
<td>synthetic pyrethroid</td>
<td>0.46-0.57 8-10</td>
</tr>
<tr>
<td></td>
<td>Syngenta</td>
<td>neonicotinoid</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>Bayer CropScience</td>
<td>neonicotinoid</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>Bayer CropScience</td>
<td>neonicotinoid/biological</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Note: ALS inhibitor herbicides should not be used if Counter 20G has been used at planting. Reason is the insecticide interferes with the plant's ability to metabolize the herbicide, which can result in herbicide damage to the plant.
Quantifying root feeding

The main damage done to corn by rootworms is by the larvae eating the roots and the adult beetles clipping the silks, which can significantly affect pollination. Controlling the larvae in the soil will help protect against both of these yield-robbing effects.

Most growers do not spend time scouting their fields by digging roots looking for feeding. Unless there is lodging or other signs of stress, many growers don’t suspect a problem.

Today’s corn hybrids are very resilient. Plants can re-grow roots during and after rootworm feeding has subsided, and rooting ability has definitely improved with many hybrids. Ultimately, there can be enough damage from moderate to severe feeding that water and nutrient uptake are affected. This, especially in combination with other factors like drought, can reduce yield and therefore profitability.

To quantify root damage, Iowa State University recommends using the 0-3 node injury scale. This system is based on a percent, or decimal, of the number of roots in the first three nodes showing rootworm damage. For example, if all of the roots (100%, or 1.0) were pruned at the first node, 50% (0.50) at the second node, and 15% (0.15) at the third node, the rating would be 1.00+0.50+0.15 = 1.65. This root rating scale is explained more fully in this Iowa State University guide: http://www.ent.iastate.edu/pest/rootworm/nodeinjury/nodeinjury.html

Root rating scale

Table 1. Effects of insecticide seed treatments on grain weight, plant root size, and corn rootworm injury rating.

<table>
<thead>
<tr>
<th>2012 trial ID</th>
<th>Treatment</th>
<th>Grain weight of 10 plants* grams</th>
<th>Lodging %</th>
<th>Root rating**</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST2012IA013B</td>
<td>Aztec (1.5 oz)</td>
<td>1247</td>
<td>13.9</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Aztec (3 oz)</td>
<td>1362</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>1526</td>
<td>82.2</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>SmartChoice 5G</td>
<td>1724</td>
<td>75.4</td>
<td>0.1</td>
</tr>
<tr>
<td>ST2012IA029A</td>
<td>Untreated</td>
<td>1484</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Aztec</td>
<td>1567</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>ST2012IA185A</td>
<td>Untreated</td>
<td>1398</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Aztec</td>
<td>1598</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>ST2012IA185B</td>
<td>Untreated</td>
<td>1354</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Aztec</td>
<td>1663</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Ten corn plants were sampled at 6 locations for each treatment in each trial.
** Based on Iowa State’s 0-3 root rating scale.

The On-Farm Network uses aerial imagery to monitor crops for signs of stress in all of its replicated strip trials and other research sites. We collected imagery in August from all of the trials where soil insecticides were being studied. It was surprising to see the number of sites where treatment strips were visible in the aerial imagery. Most of these fields were corn following corn and planted to hybrids with genetic rootworm resistance traits, so being able to see the test strips was somewhat of a surprise.

In response to what we saw in the imagery, we collected samples from three locations in each treatment in five trials. Roots, ears, stalks and lodging data were collected for all sites.

Grain weights, percent lodging and corn root ratings are in the table below, which has results from five sites where alternating strips compared a full rate of insecticide to no applied insecticide. Despite the relatively low root ratings, there were still differences in the grain weight from those plants. (A full yield analysis from these trials is shown on page 10.)

Ear comparison

On the right is a comparison of 10 ears taken from two adjacent strips with an insecticide (top row) and untreated (bottom row). Notice the difference in ear fill between the treatments. See the full trial report at: http://www.isafarmnet.com/Replicated_Strip_Trials/Reports/ST2012IA185B_Final_Report.pdf
Measuring yield differences

No matter what other difference we may see in a trial, final yield is the most important measurement. The On-Farm Network uses a standardized method to report results from successfully completed trials. There is a summary of all 2012 corn insecticide trials on page 10.

On the right is an example of one specific trial report, which can viewed at http://www.isafarmnet.com/Replicated_Strip_Trials/Reports/ST2012IA029A_Final_Report.pdf. Aerial imagery and grain yield analysis are standard features of all our reports. These are enlarged below to illustrate their utility.

Aerial image of trial area

Color differences between strips can only be due to the difference resulting from insecticide use.

The bar graph below shows yield for each strip in the trial, in order from west to east. The average yield increase from using an insecticide here was 24.9 bu/a.

Strip-by-strip yield results

These red and blue bars show the approximate location of the strips in the graph on the right.
2012 On-Farm Network® insecticide trial results

In furrow corn insecticides had some of the biggest yield responses in the 2012 On-Farm Network strip trials. Ten successfully completed trials compared a full rate of insecticide to strips without insecticide. Most of these trials were in fields in continuous corn, and all but two were planted to hybrids with at least one corn rootworm Bt trait.

The summary of these trials is in the table below. Use the trial ID to view the individual reports at http://www.isafarmnet.com/2012_Trial_Results_By_Project.pdf.

It is interesting to note that yield responses were not any lower with the use of single or stacked traits than with conventional corn. This may be due to refuge present in the Bt corn, heavy rootworm pressures or simply additional control. But given the current high price for corn, there was a profitable yield increase in most of these trials with differing traits and insecticides.

Dry conditions
At least some of the differences documented in most of the 2012 corn rootworm management trials were likely influenced by the dry conditions. Of the two sites that were not profitable, one site was irrigated and the other site had enough rain to yield over 180 bu/a.

An additional trial we're reporting on page 11 showed considerable root feeding, but the average yield difference for the trial was only 3.4 bu/a. when comparing full to half use rate of insecticide. Even with the drought and what appeared to be significant root damage, this field received some timely rain and averaged more than 200 bu/a.

Look beyond one year
Grain yield is measured each year, which makes it tempting to look at only one year of results. Insect resistance to the Bt traits is building over time. Managing resistance is important. Rotating the genetic traits and insecticide use will help keep these tools viable, so please use these tools for control responsibly to benefit everyone.

### Table 2. Corn insecticide seed treatment evaluations in 10 on-farm trials in Iowa.

<table>
<thead>
<tr>
<th>2012 trial ID</th>
<th>County</th>
<th>Previous crop</th>
<th>Rainfall (inches)</th>
<th>Hybrid</th>
<th>CRW Traits</th>
<th>Insecticide</th>
<th>Yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spring</td>
<td>Summer</td>
<td></td>
<td>Insecticide</td>
<td>Insecticide</td>
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<tr>
<td>ST2012A050B</td>
<td>Iowa</td>
<td>Corn (2 yrs)</td>
<td>8.57</td>
<td>5.90</td>
<td>Great Lakes 6354</td>
<td>Conventional</td>
<td>Aztec 4.67G</td>
</tr>
<tr>
<td>ST2012A193A</td>
<td>Worth</td>
<td>Soybean</td>
<td>8.97</td>
<td>6.46</td>
<td>Titan Pro 1018</td>
<td>Conventional</td>
<td>SmartChoice 5G</td>
</tr>
<tr>
<td>ST2012A026A</td>
<td>Iowa</td>
<td>Corn (3 yrs)</td>
<td>7.13</td>
<td>5.03</td>
<td>Pioneer P1360HR</td>
<td>Single</td>
<td>Aztec 4.67G</td>
</tr>
<tr>
<td>ST2012A103A</td>
<td>Jones</td>
<td>Corn (2 yrs)</td>
<td>6.48</td>
<td>5.73</td>
<td>Pioneer 33W98AM1</td>
<td>Single</td>
<td>Force</td>
</tr>
<tr>
<td>ST2012A105A</td>
<td>Jones</td>
<td>Corn (2 yrs)</td>
<td>6.48</td>
<td>5.73</td>
<td>Channel 208-77VT3</td>
<td>Single</td>
<td>Force</td>
</tr>
<tr>
<td>ST2012A186A</td>
<td>Story</td>
<td>Corn (&gt;5 yrs)</td>
<td>8.96</td>
<td>6.49</td>
<td>Pioneer P1162AMRW</td>
<td>Single</td>
<td>Aztec 4.67G</td>
</tr>
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<td>Story</td>
<td>Corn (&gt;5 yrs)</td>
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<td>Story</td>
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<td>6.49</td>
<td>Channel 210-57</td>
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<td>Aztec 4.67G</td>
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<tr>
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<td>Corn (&gt;5 yrs)</td>
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<td>6.49</td>
<td>Channel 210-57</td>
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<td><strong>Average</strong></td>
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Adult rootworm beetles feeding on corn leaves and silks can cause significant yield loss through reduced photosynthesis and poor pollination.

Photos courtesy of Rhonda Birchmier
A rootworm management case study

This page is focused on a single trial, which was a comparison in third-year corn between a half rate and a full rate of Aztec®, applied at planting on a corn rootworm Bt hybrid. The standard report can be seen at http://www.isafarmnet.com/Replicated_Strip_Trials/Reports/ST2012IA013B_Final_Report.pdf.

Growers often associate corn lodging with root damage. While it is true that rootworm damage can result in plant lodging, there can be significant damage and yield loss from rootworm feeding, even if there’s not significant lodging in the field.

To quantify the differences between the strips in this field trial, we selected two areas of the field to make root comparisons between the two rates of insecticides.

The aerial image (below, right) shows the location of Areas A and B where we collected root samples from three replications at each location. When we analyzed this imagery we were able to see differences between the treatments that suggested varying degrees of lodging.

More than 25% of the plants in the half-rate strips in Area A were lodged. In the half-rate strips in Area B, less than 3% of the plants were lodged.

The graph (upper right) shows root scoring on the samples collected, as described on page 8. Despite significantly less lodging in Area B, the scores indicate that rootworm damage occurred here. This trial did not include untreated check strips for comparison of root damage to insecticide-treated strips as did other trials in 2012.

On the right are some of the roots collected from the trial from the first sampling location in area A. The six roots on the left were taken from the half rate treatment, while those on the right came from the full rate treatment.

The aerial image on the right, taken near Area A collected by an aerial drone with a high resolution camera, shows the differences between the treatments because of the lodging. The red lines show the difference between the treatment strips, which are 12 rows wide. The degree of lodging is very noticeable in the half rate strips.
Develop a rootworm management plan

As we've shown in our 2012 soil applied insecticide trials, damages and yield losses can be significant (check the table on p. 10 again), even when you've planted a hybrid with rootworm resistance traits. When pressures are high, as they often are in continuous corn, the damage done by the feeding necessary for the Bt gene in the hybrid to actually do its job may still lead to enough root damage to impact yields.

Here are some thoughts to keep in mind as you plan for your 2013 corn crop:

1. Rotating corn with other crops like soybeans is the best control because it breaks the insect's life cycle on the field.
2. Corn rootworm traits can provide valuable below-ground protection, but do not always provide complete control.
3. Even with rootworm trait technology, there is still the unprotected refuge area where soil-applied insecticides should be considered.
4. As part of a stewardship program, you should rotate different trait families, trait pyramids containing multiple below-ground proteins, and different soil insecticides.
5. Packaging and delivery systems have been developed that make insecticides safer and easier to handle and also improve application rate accuracy.
6. Because of the life cycle of the rootworm and the possibility of damage to roots by larvae as well as potential impact on yield by destruction of leaf tissue and silk feeding, scouting at important times during the growing season is recommended.

More information on rootworm management

ISA On-Farm Network 2012 strip trial results
http://www.isafarmnet.com/2012_Trial_Results_By_Project.pdf

Handy Bt Trait Table (Chris DeFonzo, Michigan State University, and Eileen Cullen, University of Wisconsin)
http://labs.russell.wisc.edu/cullenlab/files/2012/10/Handy_Bt_Trait_Table.pdf

Iowa State University Root Rating Guide
http://www.ent.iastate.edu/pest/rootworm/nodeinjury/nodeinjury.html

Iowa State University Corn Rootworm Management Information
http://www.ent.iastate.edu/dept/faculty/hodgson/files/ul/CRW%20management%202012%20final.pdf
http://www.ent.iastate.edu/dept/faculty/gassmann/rootworm

AMVAC Smartbox system
http://www.smartboxsystem.com/

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