

## Value of Multiple Modes of Action for Corn Rootworm Control

- SmartStax® Corn technology provides corn products with multiple modes of action (MOA) protection for belowground corn rootworm (CRW) and aboveground corn earworm (CEW) insect protection.
- A soil-applied insecticide (SAI) is recommended to be used with single MOA insect protection products.
- In moderate to high corn rootworm pressure situations, SmartStax® Corn technology provided an average advantage of 20+ bu/acre over non-rootworm B.t.-protected corn products without an SAI and 8 bu/acre over single MOA products without an SAI.

### Importance of Corn Product Selection

Selecting corn products each year is one of the most important decisions made toward maximizing yield potential. Products should be selected based on the environment in which the product will be grown. The environment not only includes weather but pressure from disease and insects. Stress from the weather, with the exception of irrigation, cannot be controlled; however, products can be selected for tolerance to heat and drought. Likewise, products can be selected with varying degrees of tolerance or resistance to certain diseases. Selecting products with *Bacillus thuringiensis* (B.t.) insect traits can allow growers to help protect their corn yield potential while significantly reducing their reliance on soil-applied insecticides (SAI) and foliar-applied insecticides (FAI), particularly with multiple modes of action (MOA) B.t. protection.

### Insecticide Safety Considerations

Insecticide applications can be an effective means of controlling insects. However, they can have specific safety requirements. For example, requirements may include personal protective equipment for applicators and re-entry restrictions for the applied area.

An insecticide application may negatively affect beneficial insects and other non-target organisms. Corn products protected with B.t. traits may reduce reliance on insecticides, thereby minimizing the negative aspects of their use.

### B.t. Protection

With lower commodity prices, consideration may be given to selecting corn products without B.t. protection to save on seed costs. However, selecting non-B.t. protected products expose growers to the risk of lost yield potential due to insect activity (Figure 1) and insecticide safety concerns.<sup>1</sup> The cost of a SAI can also be about \$16/acre.

Corn products with B.t. protection can be divided into those with belowground protection, those with aboveground protection, or both. Within those protections, above- and belowground protection can be accomplished with either single or multiple MOA protection. SmartStax® Corn technology provides corn products with multiple MOA protection for belowground corn rootworm (CRW) and aboveground corn earworm (CEW) insect protection. SmartStax® RIB Complete® Corn Blend Products are refuge-in-the-bag products, making refuge compliance automatic in the Corn-Growing Area. In the Cotton-Growing Area, an additional structured refuge is required.

Soil insecticides are recommended for use with single MOA belowground B.t. products to add an additional MOA for CRW protection. Safety issues discussed earlier come with the use of a SAI. Table 1 lists CRW single MOA products for which the use of a SAI is recommended.

Table 1. Largest Volume Trait B.t. Products for Corn Rootworm/Earworm Protection

Products with the Following Technology	Abbreviation	Modes of Action for Control of Corn Rootworm/Earworm
SmartStax®		Two/Two
Genuity® VT Triple PRO		One/Two
Optimum® AcreMax® Xtra	AMX	One/X*
Optimum® AcreMax®1	AM1	One/X
Agrisure® 3000GT	3000GT	One/X
Herculex® XTRA	HR or HXX	One/X
Optimum® Intrasect® Xtra	YXR	One/X
Optimum® TRIsect®	CHR	One/X
Optimum® AcreMax® TRIsect®	AMT	One/X

\*X = Suppression

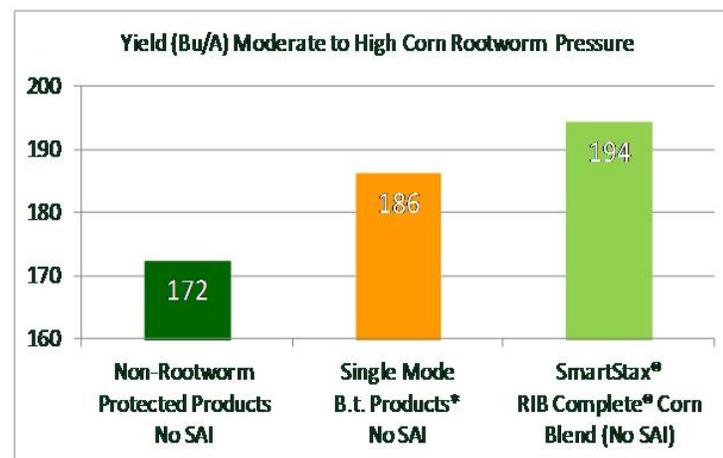


Figure 1. Expected Yield Over the Long-Term  
SAI = Soil-Applied Insecticide; TD Sites in IL, IA, KS, CO, NE, WI, MI, IN, MN, SD (2012-2013) 100-112 RM; N = 31 protocol site years under moderate and high CRW pressure. \*Moderate Pressure = locations where untreated check had an average Nodal Injury Score (NIS) of > 0.5-1.0; High Pressure = locations where untreated check had an average NIS of > 1.0



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## Research

In efforts to define the value and CRW efficacy provided by products with SmartStax® Corn technology compared to single MOA products, Monsanto Technology Development Representatives conducted CRW control studies in 2012 and 2013 in ten states. All products were adapted for the testing area, had their respective seed treatments, and contained required CRW refuge seed within the seed bag.

## Results and Discussion

In moderate to high CRW pressure situations, products with SmartStax® Corn technology provided an average advantage of over 20 bu/acre compared to non-rootworm B.t. protected corn products without a SAI and 8 bu/acre over single MOA products without a SAI (Figure 1).

## Importance of Controlling Corn Rootworm Larvae

Historical estimates suggest western corn rootworm (WCRW) and northern corn rootworm (NCRW) are responsible for nearly 1 billion dollars annually in crop losses and control costs.<sup>2</sup> Larval feeding can decrease yield potential and increase the risk of root lodging. Although the average yield advantage is over 20 bu/acre, data show there can be an even greater impact of up to 80 bu/acre yield loss due to CRW.<sup>3</sup> Predicting the extent of CRW damage is very difficult, but the potential for damaging populations is more probable under certain circumstances.

## Practices That Can Increase CRW Pressure

In all areas of the Corn Belt, production practices that favor growth in CRW populations include long-term corn rotations, late-planted fields, and/or planting of late-maturing products. For example, full season products used by many silage growers are often prime targets for escalating CRW beetle populations because they pollinate when other desirable adult CRW food sources have deteriorated.

## Management Options

- Crop rotation has been and continues to be a recommended method to effectively control CRW larvae. However, crop rotation is no longer as effective in specific areas of the Corn Belt due to extended diapause populations of NCRW and the soybean variant of WCRW.

- Seeds with multiple MOA, such as products with SmartStax® Corn technology have proven to be a consistent CRW control tool.

- If rotation or SmartStax® RIB Complete® Corn Blend products are not acceptable options, consider using soil-applied insecticides in combination with corn products that do not provide B.t. protection from CRW.

- Due to resistance concerns, planting single-mode-of-action technologies such as Genuity® VT Triple PRO® products or Genuity® VT Triple PRO® RIB Complete® Corn Blend products is not recommended when less than satisfactory control of CRW has been observed.

### Additional Considerations:

Regardless of high or low CRW pressure, products with SmartStax® Corn technology can provide growers a better opportunity to maintain and increase profitability through their consistent CRW protection. Along with the \$16/acre cost for a SAI, consideration should be given to:

- Soil-applied insecticides are relatively insoluble and protection is limited to a relatively small portion of the root zone.

- The consistency of performance of SAIs can be highly dependent on environmental conditions.

- Products with SmartStax® Corn technology offer CEW B.t. protection. Lost yield attributable to CEW feeding can be as high as 7%.<sup>4</sup>

- Products with SmartStax® Corn technology are treated with Acceleron® Seed Applied Solutions plus Poncho®/VOTIVO® with clothianidin at 500 mg/kg rate, which has shown an increased yield potential of 3.7 bu/acre over other basic seed treatments.<sup>5</sup>

- In the Corn-Growing Area where SmartStax® RIB Complete® Corn Blend Products are available, market research showed that farmers place a value of \$5/acre on refuge-in-the-bag products.<sup>6</sup>

## Genuity® Rootworm Manager App

iPad® device users can download an app that allows farmers to complete assessments on each field to determine the potential risk of corn rootworm damage. The tool follows proven pest management recommendations for scouting, crop rotation, utilizing multiple MOA when planting, and suggesting specific insecticides based on crop type. The app also allows growers to take notes, access scouting reports, set alerts, and share results by email. The app can be downloaded by accessing <http://www.Genuity.com/RootwormManager> and then selecting Get the App or by visiting the iTunes® Store from your iPad®.

## Sources

<sup>1</sup> Technology Development Sites in IL, IA, KS, CO, NE, WI, MI, IN, MN, SD (2012-2013). <sup>2</sup> Croff, C.D. and Mitchell, P.D. 2007. When does it pay to plant RW Bt corn in Wisconsin? Proceedings of the 2007 Wisconsin Fertilizer, Agrilime & Pest Management Conference, Vol. 46. <sup>3</sup> Technology Development Sites in IL, IA, KS, CO, NE, WI, MI, IN, MN, SD, OH, DE (2010-2013). <sup>4</sup> Boyd, M.L. and Bailey, W.C. 2001. Corn earworm in Missouri. MU Guide, G7110. University of Missouri-Columbia. <http://extension.missouri.edu>. <sup>5</sup> 2011 and 2012 Internal Monsanto Commercial Field Trials. <sup>6</sup> 2011 Market probe farmer quantitative study. Web source verified 9/7/2016. 141011095048

For additional agronomic information, please contact your local seed representative. Developed in partnership with Technology Development & Agronomy by Monsanto. Individual results may vary, and performance may vary from location to location and from year to year. Monsanto Company is a member of Excellence Through Stewardship®(ETS). Monsanto products are commercialized in accordance with ETS Product Launch Stewardship Guidance, and in compliance with Monsanto's Policy for Commercialization of Biotechnology-Derived Plant Products in Commodity Crops. Commercialized products have been approved for import into key export markets with functioning regulatory systems. Any crop or material produced from this product can only be exported to, or used, processed or sold in countries where all necessary regulatory approvals have been granted. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted. Growers should talk to their grain handler or product purchaser to confirm their buying position for this product. B.t. products may not yet be registered in all states. Check with your Monsanto representative for the registration status in your state. **IMPORTANT IRM INFORMATION:** Genuity® RIB Complete® corn blend products do not require the planting of a structured refuge except in the Cotton-Growing Area where corn earworm is a significant pest. See the IRM/Grower Guide for additional information. Always read and follow IRM requirements. Individual results may vary, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible. **ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS.** Roundup Ready® crops contain genes that confer tolerance to glyphosate, the active ingredient in Roundup® brand agricultural herbicides. Roundup® brand agricultural herbicides will kill crops that are not tolerant to glyphosate. Acceleron®, Asgrow®, Genuity®, RIB Complete®, Roundup Ready 2 Technology and Design®, Roundup Ready®, Roundup®, SmartStax®, and VT Triple PRO® are trademarks of Monsanto Technology LLC. Leaf Design® is a registered trademark of Monsanto Company. LibertyLink and the Water Droplet Design®, Poncho® and VOTIVO® are registered trademarks of Bayer. Herculex® is a registered trademark of Dow AgroSciences LLC. Respect the Refuge and Corn Design® and Respect the Refuge® are registered trademarks of National Corn Growers Association. All other trademarks are the property of the respective owners. ©2016 Monsanto Company. 141011095048 091016LGM



Before opening a bag of seed, be sure to read, understand and accept the stewardship requirements, including applicable refuge requirements for insect resistance management, for the biotechnology traits expressed in the seed as set forth in the Monsanto Technology/Stewardship Agreement that you sign. By opening and using a bag of seed, you are reaffirming your obligation to comply with the most recent stewardship requirements.

