

Pioneer® brand hybrids with the Herculex® RW and Herculex XTRA Traits

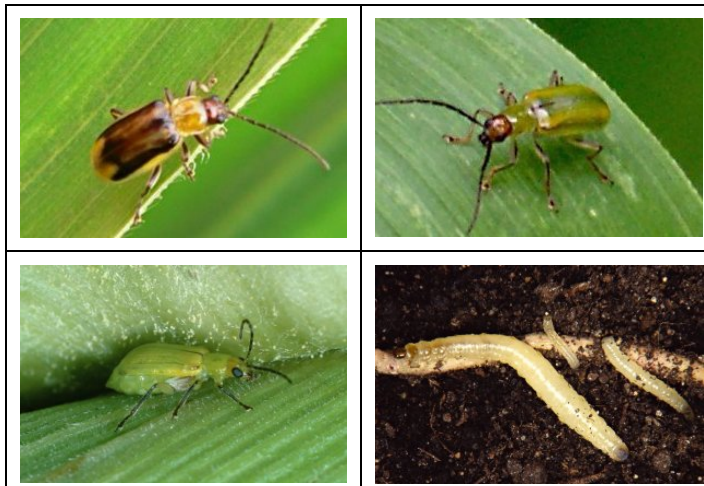
by Murt McLeod, Tom Doerge and Steve Butzen

Summary

- Pioneer customers will have access to new corn rootworm (CRW) management options for 2006 planting – Pioneer® brand hybrids with the Herculex® RW and Herculex XTRA *Insect Protection* traits.
- The Herculex RW (HXRW) trait protects against western, northern and Mexican CRW larval feeding, providing an alternative to soil or seed-applied insecticides.
- Herculex XTRA is a stack of Herculex I and Herculex RW technologies. The Herculex XTRA (HXX) trait provides the broadest spectrum of in-plant insect control available today.
- In Pioneer testing across the Corn Belt in 2004 and 2005, hybrids with HXRW and HXX significantly decreased CRW larval feeding and root lodging, and increased grain yield compared to untreated check plots.
- Grain yield in HXRW plots was 27 bu/acre higher than the untreated check in 2004. In 2005, HXRW and HXX plots were higher yielding than the untreated check by 22 and 23 bu/acre, respectively.
- In 4 locations with season-long drought stress in 2005, grain yield in HXRW and HXX plots was 16 to 19 bu/acre higher than Aztec-treated plots and 22 to 25 bu/acre higher than the untreated check plots.
- Late summer re-evaluation of Pioneer locations with high CRW pressure in 2005 showed excellent *season-long* protection for HXRW and HXX traits.
- Hybrids with HXRW and HXX reduced the number of CRW adults emerging from protected plants by an average of 92% compared to untreated plants.
- This *Crop Insights* will discuss the HXRW and HXX *Insect Protection* traits, and Pioneer Agronomy Sciences and university studies conducted to evaluate this technology.

Introduction

Corn rootworm (CRW) larvae are one of the most destructive insect pests of corn in North America. In fact, yield losses of 10% to more than 30% are common with moderate to high CRW populations in untreated fields. CRW feeding causes a reduction in root mass, which can



Top: Western (L) and Mexican (R) CRW beetles (magnified)¹.
Bottom: Northern CRW beetle (L) and larva (R) (magnified)².

affect standability and reduce water and nutrient transport in the plant, ultimately impacting grain development.

With the recent registration of the Herculex RW (HXRW) and Herculex XTRA (HXX) *Insect Protection* traits, growers now have new, highly effective options to help control CRW. HXRW is a transgenic Bt trait, providing protection against western, northern, and Mexican CRW and increasing production efficiency and return on each acre. Herculex XTRA is a stack of the Herculex I and Herculex RW traits. Pioneer hybrids with the HXX trait protect against a broad array of destructive plant and ear-feeding insects in addition to corn rootworm, including European and southwestern corn borer, black cutworm, western bean cutworm, fall armyworm, lesser and southern cornstalk borer, sugarcane borer, and suppression of corn earworm. This spectrum of insect protection provided by hybrids with Herculex XTRA is unmatched by any other in-plant technology available today.

The HXRW and HXX *Insect Protection* traits:

- Provide a high level of protection from root feeding by CRW larvae by expressing Bt proteins in the corn root.
- Provide an alternative to traditional methods of CRW control such as granular or liquid insecticides applied at planting or high-rate insecticide seed treatments.

- Provide reliable performance even with extreme weather conditions, and improved safety vs. soil insecticides.

Pioneer hybrids with the HXRW or HXX technologies offer herbicide program flexibility including the LibertyLink® system and stacks available with the Roundup Ready® Corn 2 trait. All Pioneer hybrids with these technologies also come with Pioneer’s premium seed treatment: Maxim® XL + Dynasty® fungicide and Poncho® 250 seed-applied insecticide, to protect against secondary insects and seedling diseases that can significantly impact early stand establishment and seedling health.

To determine the efficacy of this new corn rootworm management technology, Pioneer Agronomy Sciences researchers have evaluated hybrids with HXRW and HXX at test sites across the Corn Belt.

Research Methods

Hybrids with Herculex RW in several diverse genetic backgrounds were evaluated in small-plot testing at eight locations in 2004 and 11 locations in 2005. In 2005, hybrids with HXX were also evaluated. The 17.4-foot plots were two rows wide in 2004 and four rows wide in 2005. Treatments included hybrids with HXRW or HXX compared to hybrids with a similar genetic background treated with Poncho 1250 or Aztec® 2.1G soil-applied insecticide, and an untreated check. Treatments were replicated four times per location.

In mid to late July, five plants were randomly selected from each plot; plants were dug and roots were evaluated for corn rootworm larval injury using the 0.0-3.0 node injury scale developed at Iowa State University (Oleson, et al.). Plots were also evaluated for percent late-season root lodging and harvested for grain yield. Harvest data were not obtained from the Janesville, WI and Rochelle, IL locations due to unfavorable environmental conditions in 2004.

Test Locations and Corn Rootworm Levels

Testing locations and the average node injury score for untreated check plots at each location are listed in Table 1. Corn rootworm feeding pressure was generally high across testing locations in 2004, as indicated by an average node injury score of the untreated check of 1.9. In 2005, CRW feeding pressure was moderate to high (average node injury score of the untreated check = 1.4). The previous crop was corn at all test sites except Gilman, IL, (located in the CRW variant zone), which had soybeans for the previous crop.

Research Results

Root Injury Ratings

Root node injury scores for the various CRW treatments are presented in Figure 1. Pioneer hybrids with the Herculex

RW and Herculex XTRA traits provided excellent protection from corn rootworm larval feeding that was significantly better than that of other management options evaluated under moderate to high CRW feeding pressure.

Table 1. Testing locations and CRW node injury score in untreated check plots for 2004 and 2005 evaluations.

Location	Untreated Check Node Injury Score	
	2004	2005
Marion, IA	2.8	1.9
Johnston, IA	2.6	2.1
Emington, IL	2.3	0.8
Rochelle, IL	2.0	2.4
Janesville, WI	1.8	2.8
York, NE	1.3	0.7
Fulda, MN	0.6	1.1
Willmar, MN	1.6	-
Milan, MN	-	0.7
Princeton, IL	-	1.4
Gilman, IL*	-	0.6
Genoa, NE	-	1.3
Average	1.9	1.4

* Previous crop – soybeans.

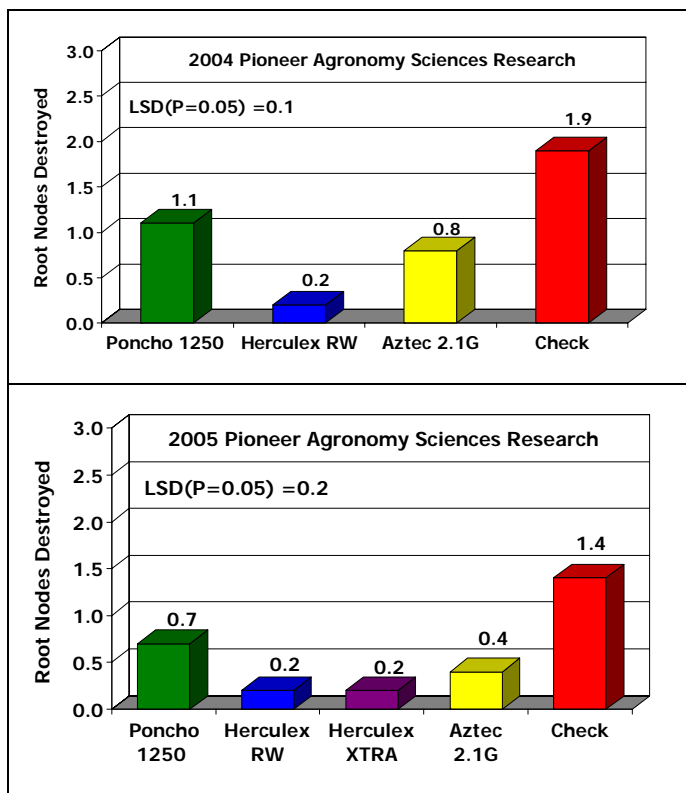


Figure 1. Root node injury score for CRW management options averaged across eight locations in 2004 and 11 locations in 2005, and two hybrid backgrounds per location.



Roots of hybrid with HXRW trait (L) and genetically similar, untreated hybrid without the trait (R).

Root Lodging

Percent root lodging prior to harvest is presented in Figure 2.

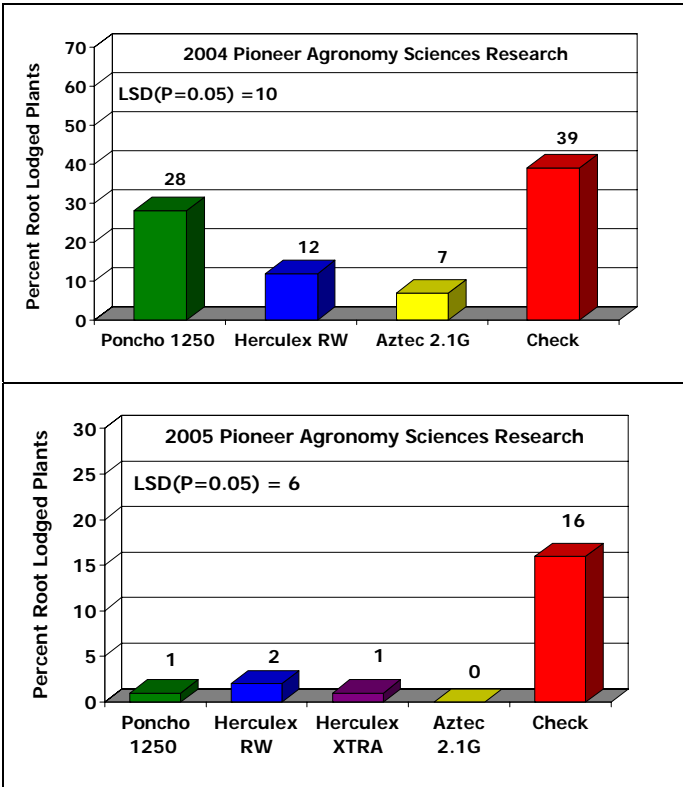


Figure 2. Percent root lodging for CRW management

options averaged across eight locations in 2004 and 11 locations in 2005, and two hybrid backgrounds per location.

Percent root lodging in Herculex® RW and Herculex XTRA plots was similar to that of plots treated with Aztec® 2.1G granular soil-applied insecticide and significantly lower than that of the untreated check plots both years and Poncho® 1250 plots in 2004.

Grain Yield

Grain yield for several corn rootworm management options is presented in Figure 3. Grain yield in Herculex RW plots was 27 bu/acre higher than the untreated check in 2004 testing. In 2005, Herculex RW and Herculex XTRA plots were higher yielding than the untreated check by 22 and 23 bu/acre, respectively. Yield of Herculex RW and Herculex XTRA plots were not significantly different from the Aztec and Poncho 1250 treatments both years.

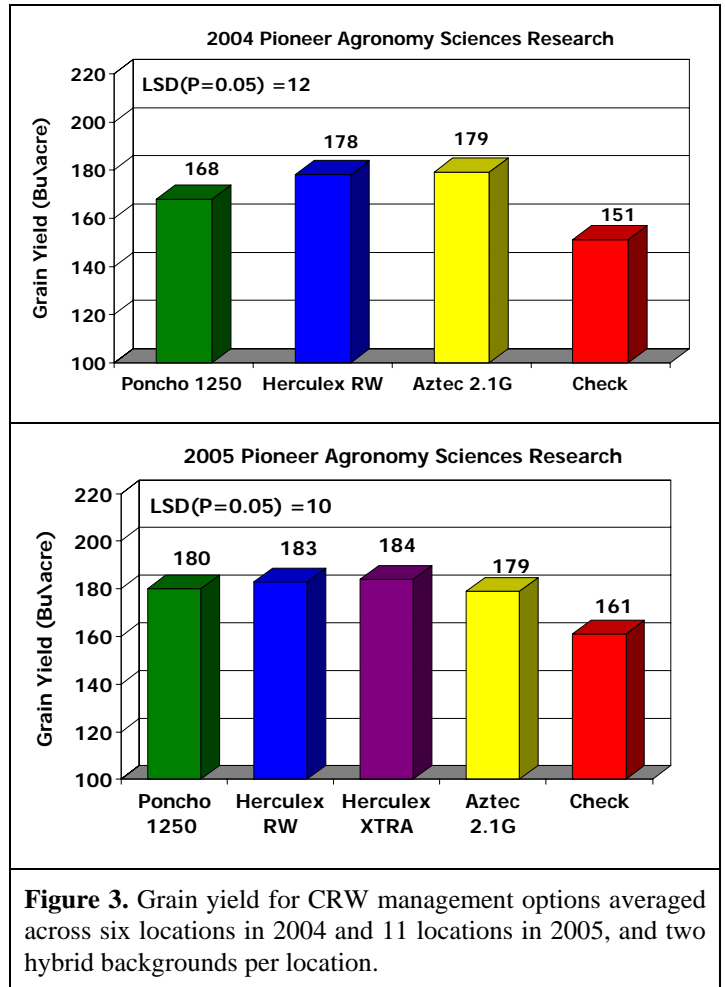


Figure 3. Grain yield for CRW management options averaged across six locations in 2004 and 11 locations in 2005, and two hybrid backgrounds per location.

Northern Corn Rootworm Efficacy

Three testing locations in 2005 had significant northern corn rootworm populations – Marion, IA, Fulda, MN and Milan, MN (untreated check node injury scores = 1.9, 1.1 and 0.7, respectively.)



Northern corn rootworm larva on corn root.

Data from these three locations were combined and analyzed to verify that the Herculex® RW and Herculex XTRA *Insect Protection* traits were effective in reducing feeding from northern CRW (Figure 4). The node injury scores of 0.1 for these technologies validate that they have very good efficacy against northern CRW larvae.

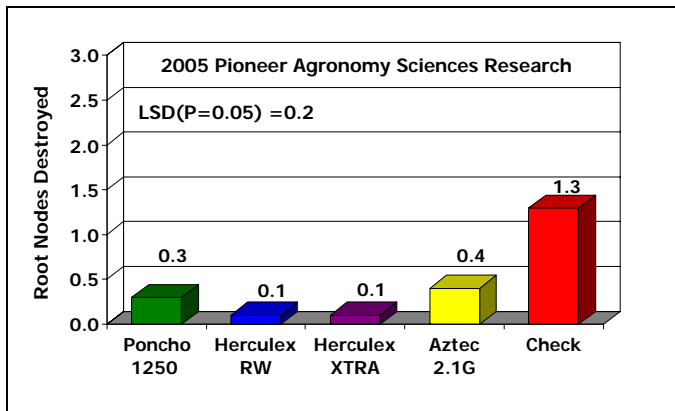


Figure 4. Node injury score for CRW management options averaged across three locations with northern CRW infestations and two hybrid backgrounds per location, 2005.

Performance in Drought-Stressed Locations

Drought-stress conditions can significantly interact with the corn rootworm feeding injury to impact grain yield. For example, moderate root feeding damage with abundant rainfall throughout the season rarely results in significant grain yield loss, whereas that same level of feeding damage coupled with a drought-stressed environment would usually result in significant grain yield reduction.

Four of the eleven testing locations in 2005 experienced significant drought stress throughout the season. These locations included Johnston, IA; Princeton, IL; Rochelle, IL; and Emington, IL. Data from these four drought-stressed locations were combined for analysis to evaluate the impact

of drought stress on performance of Herculex RW and Herculex XTRA *Insect Protection* traits. Corn rootworm damage ratings averaged across the four locations are presented in Figure 5. Root ratings in these drought stressed locations were very similar to root ratings for all 2005 plots shown in Figure 1.

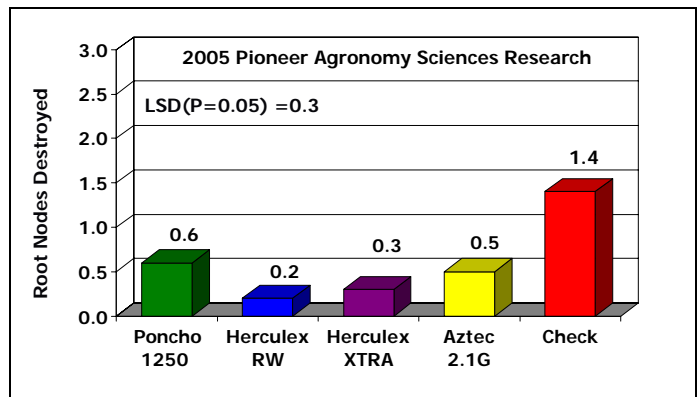


Figure 5. Node injury scores for several CRW management options averaged across four drought-stressed testing locations and two hybrid backgrounds per location, 2005.

Although root ratings were virtually the same in drought stressed locations as in the larger data set, yield protection by Herculex RW and Herculex XTRA technologies was greater under drought stress (Figure 6).

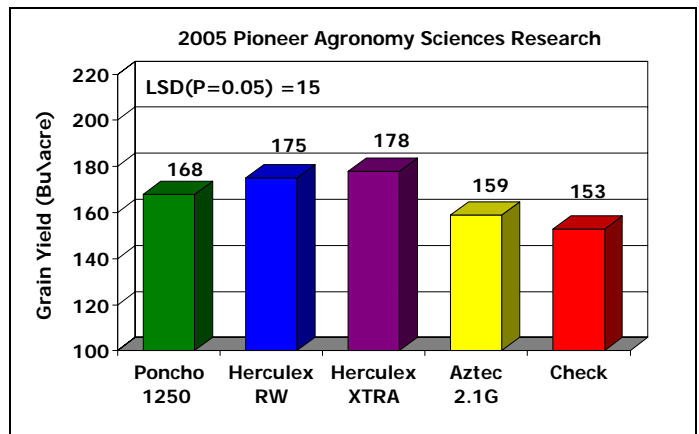


Figure 6. Grain yield for several CRW management options averaged across four drought-stressed testing locations and two hybrid backgrounds per location, 2005.

Grain yield in Herculex RW and Herculex XTRA plots under drought stress was 16 to 19 bu/acre higher than Aztec-treated plots and 22 to 25 bu/acre higher than untreated check plots. Both of these yield differences were statistically significant at the 0.05 level of probability.

University Results

Performance trials with hybrids that contain HXRW were conducted by 10 universities across the U.S. Corn Belt in 2005. States included IA, IL, IN, KS, MI, MN, NE, OH, SD and TX. Each state compared a hybrid with Herculex RW, the non-transgenic isoline treated with Force[®] insecticide (Aztec[®] insecticide was used at the Emington, IL location), and the untreated isoline. Root damage ratings are shown in Figure 7. Under all levels of CRW pressure, hybrids with the Herculex RW trait showed almost no damage, while hybrids treated with Force insecticide had up to 0.6 nodes of roots destroyed.

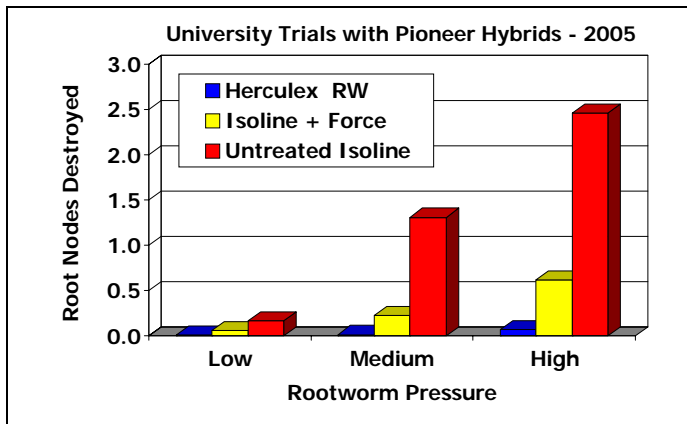


Figure 7. Average root injury ratings across 10 university Herculex RW trials in the U.S. Corn Belt in 2005. Rootworm pressure: Low – 5 locations, Medium – 2 locations, High – 4 locations.

Percent consistency ratings are shown in Figure 8. Hybrids with Herculex RW technology were 100% consistent, followed by Force insecticide-treated hybrids at 69% and untreated hybrids at 40%.

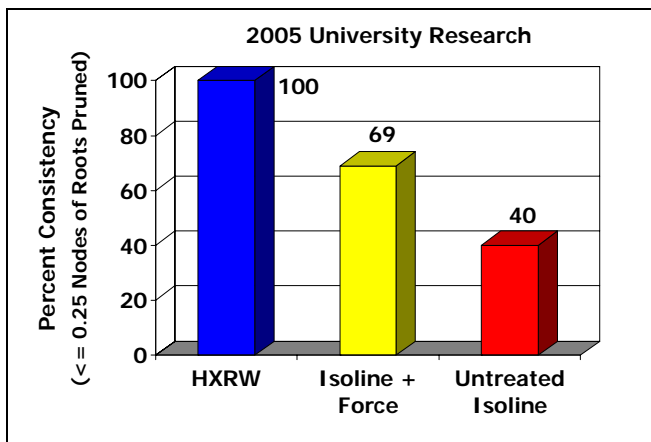


Figure 8. Average percent consistency* in root injury ratings across 10 university HXRW trials in the U.S. Corn Belt in 2005.

* % of plants with no more than 0.25 nodes of roots pruned to within 1.5 inches of the stalk.

Season-Long Protection

Pioneer Agronomy Sciences researchers returned to four 2005 high-pressure locations (Johnston, IA; Rochelle, IL; Princeton, IL; and Emington, IL) in late August to re-evaluate root-feeding damage. Five plants were randomly selected from each Herculex RW, Aztec and untreated check plot. Plants were dug and roots were evaluated for CRW larval injury using the 0.0-3.0 node injury scale. This additional sampling was conducted to determine if hybrids with Herculex RW were providing season-long protection from CRW larval feeding.

Data from these four locations were combined and analyzed to determine if node injury scores for the various treatments were significantly higher in late August compared to node injury scores from the same plots in mid July. Results from these August evaluations are presented in Figure 9.

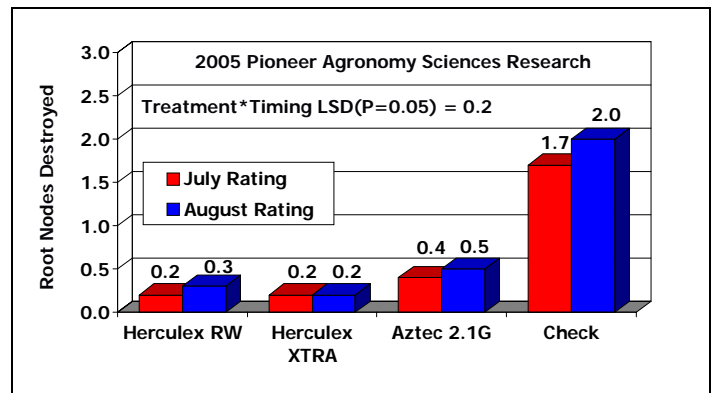


Figure 9. Node injury scores for a mid-July rating and a late-August rating averaged across four locations and two genetic backgrounds per location, 2005.

Averaged across four locations, node injury scores in the untreated check plots were higher in August compared to the node injury scores from the same untreated check plots in July. This indicates that damage increased from July to August. However, in the Herculex RW plots, the node injury scores were not significantly higher than they were in July. HXRW technology provided *season-long protection* from corn rootworm larval feeding in these plots.

Beetle Emergence from HXRW Plants

Studies were conducted by Pioneer and university researchers in 14 environments over 3 years to evaluate the level of CRW beetle emergence from Herculex RW vs. check plots. Environments were selected to target mixed populations of northern, western, and the western soybean variant corn

rootworms. Beetle emergence was measured from natural infestations. Results are shown in Figure 10.

Results showed that averaged across the 14 environments, HXRW reduced the number of emerging CRW adults by 92% compared to the check hybrid. Beetle emergence from HXRW plants started later but ended sooner relative to the check hybrid. Variations in the measurements were attributed to rootworm egg density, species composition, and weather conditions.

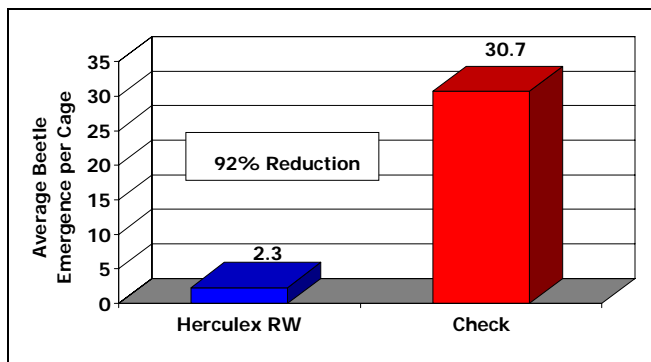


Figure 10. Northern and western corn rootworm beetle emergence*.

*Data Source: 2003-05 Pioneer and university research, averaged across 14 locs. in IL, IA, NE, & WI. 12 single-plant cages per treatment per location. Not corrected for density dependent mortality.

References

Oleson, J.D., Y. Park, T.M. Nowatzki, and J.J. Tollefson. 2005. Node-injury scale to evaluate root injury by corn rootworms (Coleoptera: Chrysomelidae) *J. Econ Entomol.* 98(1): 1-8).

¹ Image of western corn rootworm beetle courtesy of Paula Davis. Image of Mexican corn rootworm beetle courtesy of Eduardo Navarro.

² Image of northern corn rootworm beetle courtesy of Donald Specker. Image of corn rootworm larvae courtesy of Jim Kalisch, University of Nebraska.



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