Institute of Ag Professionals

Proceedings of the
2008 Crop Pest Management Shortcourse &
Minnesota Crop Production Retailers Association Trade Show

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Is IPM Relevant in the Corn and Soybean Commercial Landscape?

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Integrated pest management is the intelligent selection and use of pest control actions (tactics) that will ensure favorable economic, ecological, and sociological consequences.
IPM … another definition

“IPM is a system that controls pests and contributes to long-term sustainability by combining the judicious use of biological, cultural, physical, and chemical tools in a way that minimizes the risks of pesticides to human health and the environment.”

Sorensen (1994) – National Coalition on IPM
Pest Management Tools

- Tillage
- Crop rotation
- Planting date
- Harvest date
- Resistant varieties
- Use of pheromones
- Biological control
- Sampling and use of thresholds
- Pesticides (insecticides, herbicides, fungicides)
Are the IPM “pillars” relevant in the modern corn and soybean agroecosystem?

- Fewer producers
- Increasing farm size
- Absentee landowners
- Pest management decisions increasingly made by suppliers of inputs
- Corn increasingly viewed as a biofuel
- Surging interest in continuous corn
- Current commodity prices ($4 to $4.50 corn, $9.00 soybeans)
- Trait-driven market place
- Paradigm shift from IPM to IRM
- Federal support for use of transgenic crops
“We are in the midst of an agricultural revolution regarding the management of pests in the corn and soybean agroecosystem of the United States. This revolution in pest control is perhaps even more significant than the post-World War II over-use of chlorinated hydrocarbons to control agricultural, veterinary, ornamental, and urban pests worldwide.”
Rapid growth in adoption of genetically engineered crops continues in the U.S.

http://www.ers.usda.gov/data/biotechcrops/

Data for each crop category include varieties with both HT and Bt (stacked) traits. Source: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-08 are available in tables 1-3.
USDA – Economic Research Service Estimates of Stacked Gene Varieties – MN and USA

% of all Corn Planted

Years


http://www.ers.usda.gov/data/biotechcrops/ExtentofAdoptionTable1.htm
USDA – Economic Research Service Estimates of Genetically Engineered Corn Plantings – MN and USA

http://www.ers.usda.gov/data/biotec/hcrops/ExtentofAdoptionTable1.htm
The United States leads the world in herbicide resistant biotypes.

Distribution of Herbicide Resistant Biotypes

Resistant Weeds by # Biotypes:
- 41+ (1)
- 31-40 (3)
- 21-30 (2)
- 16-20 (3)
- 11-15 (5)
- 6-10 (8)
- 2-5 (11)
- 1 (20)
- 0 (164)

Source: Dr. Ian Heap
www.weedscience.com
Greenhouse Results

14 DAT

waterhemp management challenges – courtesy of Aaron Hager

<table>
<thead>
<tr>
<th>Untreated controls</th>
<th>0.75 lb ae glyphosate</th>
<th>3 lb ae glyphosate</th>
</tr>
</thead>
</table>
Horseweed/marestail
*(Conyza canadensis)*

Resistant to glyphosate

Located in central and southern IL

First reported ~ 2005
63 out of 168 = 38% of the time had a yield increase of 6 bu/A or greater.
Mean = 3 bu/A increase over the untreated
Data from IL, IN, IA, KS, KY, MD, MN, MO, NE, ND, OH, ON, WI

Courtesy: Carl Bradley
Crop prices slide
(Chicago Board of Trade settlement prices for Dec. 2009 and Nov. 2009 contracts.)

$ per bushel

Source: University of Illinois

U.S. corn

FarmWeek, November 24, 2008
The Pest Management Concept:

Led by entomologists, researchers in the 1950s who began to identify problems associated with the over reliance on insecticides.

Insecticide resistance

Insecticide residues on fruits & vegetables

Biomagnification of insecticides in the food chain

V.M. Stern and his associates formally developed the economic-injury level concept.

Integrated control – “Applied pest control which combines and integrates biological and chemical control.”
Are these IPM “pillars” relevant within a transgenic culture?

![Graph showing population fluctuations](image)

**Fig. 2.** Schematic graph of the fluctuations in population density of the cottony cushion scale, *Icerya purchasi*, on citrus from the time of its introduction into California in 1868. Following the successful introduction of two of its natural enemies in 1888 this scale was reduced to noneconomic status except for a local resurgence produced by DDT treatments.
McLean County soybean field

Not treated

120 feet check strip

Sprayed with Warrior at stage R2
1,000 to 2,000 aphids per plant
Twelve growing seasons have elapsed since the commercialization (1996) of Bt hybrids for European corn borers.
Program Announcement

Contact:
Shirley Pugh (202) 690-0437

FCIC BOARD EXTENDS BIOTECHNOLOGY PILOT COVERAGE AREAS AND QUALIFYING HYBRIDS

WASHINGTON, Aug 18, 2008 - USDA’s Federal Crop Insurance Corporation Board of Directors, at its Aug 14, 2008 meeting, approved additional seed technologies and states for a premium rate reduction for producers who plant certain qualifying corn hybrids. The Board’s approval is conditioned upon the submitters’ cooperation with Risk Management Agency (RMA) to develop a single unified biotechnology endorsement and work out associated details.

The biotechnology endorsement pilot program applies to approved corn seed hybrids containing specific biotech traits that enhance protection against above-ground lepidopteron pests (such as moths and their larvae) and below-ground corn rootworm damage, and confer tolerance to certain herbicides.

Under the resolutions approved by the FCIC Board, the following seed technologies and states will be eligible for coverage beginning with the 2009 crop year:
ECB Fall Survey (Larvae)-- Minnesota:

Time Series: 44 Years

Overwintering Borers (#/100 plants)

GEL: gen. equilibrium level
Minn. Dept. of Agriculture

GEL= 81.6

GEL= 21.3

*non-Bt fields only
ECB Fall Survey (Larvae) -- Illinois:

Time series: 62 Years

Overwintering Borers (#/100 plants)

GEL = 123.4

GEL = 48.1

U of IL: K. Steffey & M. Gray

* Bt and non-Bt fields
Approval expected for biotech corn that kills No. 1 pest

Pesky issue remains: Cropland ‘refuge’

By Elizabeth Weise
USA TODAY

The Environmental Protection Agency is expected to grant commercial approval this week for a new variety of transgenic corn that is deadly to the Western corn rootworm, a pest that is the No. 1 scourge of U.S. corn.

The rootworm costs farmers as much as $200 million in insecticides a year.

Ironically, it was the widespread use of pesticides that made this pest a major agricultural threat. David Andow, a professor of insect ecology at the University of Minneso-
to lay its eggs in soybean fields because they’ll be corn the next year, or to lay eggs that sit out a year until corn is again planted, says rootworm specialist Bruce Hibbard of the U.S. Department of Agriculture.

Monsanto has patented the corn under the trademarked name YieldGuard Rootworm. Scientists took a corn plant and added a gene from a common soil bacteria called Bacillus thuringiensis. The bacteria produce a protein that kills 50% to 80% of the rootworm larvae that eat the roots of the transgenic corn.

Though approval is almost certain, the question keeping both pro- and anti-biotech groups up at night is where the agency will come down on the issue of refuges. Those are the areas of cropland

Outsmarting the bug: Farmers also must plant non-bioengineered corn so rootworms don’t become too quickly resistant to a deadly protein.

USA Today, February 25, 2003
Transgenic Bt Corn Rootworm Products

- Agrisure RW – mCry3A
- Agrisure ECB/RW – Cry1Ab + mCry3A
- Herculex RW – Cry34Ab1/Cry35Ab1
- Herculex XTRA – Cry1F + Cry34Ab1/Cry35Ab1
- YieldGard RW – Cry3Bb1
- YieldGard Plus – Cry1Ab + Cry3Bb1
- YieldGard VT RW – Cry3Bb1
- YieldGard VT Triple – Cry1Ab + Cry3Bb1
- YieldGard VT Triple Pro – Cry3Bb1 + Cry1A.105 + Cry2Ab2 (anticipated for 2009)
INDIANAPOLIS and ST. LOUIS (Sept. 14, 2007) – Monsanto (NYSE: MON) and Dow AgroSciences LLC, a subsidiary of The Dow Chemical Company (NYSE: DOW), have reached a cross-licensing agreement aimed at launching SmartStax™, the industry’s first-ever eight-gene stacked combination in corn. The agreement is expected to create a new competitive standard for stacked-trait offerings and present an expanded growth opportunity for both companies’ seed brands and traits businesses by the end of the decade.
SmartStax™ (targeted commercialization in 2010)

- Event MON88017 – Cry3Bb1
- Event MON89034 – Cry1A.105 + Cry2Ab2
- Event DAS-59122-7 – Cry34/35Ab1
- Event TC 1507 – Cry1F
- Glyphosate tolerance
- Glufosinate tolerance
Are Bt hybrids for corn rootworm control “bullet proof?”
DeKalb, 63-74 RR2/YGPL, planted May 1, 2007
Significant rootworm injury to the roots of an HxXTRA hybrid from the DeKalb site in 2008. (University of Illinois)
Significant rootworm injury to the roots of a YieldGard VT hybrid from the DeKalb site in 2008. (University of Illinois)
All Bt (transgenic corn hybrids) have seed treated with a low rate of a neonicotinoid product (primarily clothianidin). The refuge (non-Bt hybrid) may be planted to seed treated with the higher rate of the same neonicotinoid insecticide.
Nicotinoid Seed Treatments for Corn

- **Cruiser 5FS**
  - (0.125 mg per kernel)
  - Chinch bug
  - Cutworms (suppression)
  - Flea beetles
  - Seedcorn maggot
  - Southern corn leaf beetle
  - White grubs
  - Wireworms

- **Cruiser 5FS**
  - (1.25 mg per kernel)
  - Billbugs
  - Corn rootworms

- **Poncho 250**
  - (0.25 mg per kernel)
  - Chinch bug
  - Corn flea beetle
  - Corn leaf aphid
  - Cutworm (black)
  - Grape colaspis
  - Seedcorn maggot
  - Southern corn leaf beetle
  - Stink bug
  - White grubs
  - Thrips
  - Wireworms

- **Poncho 1250**
  - (1.25 mg per kernel)
  - Corn rootworms
  - Southern corn billbug
Leverage® - imidacloprid + cyfluthrin from Bayer CropScience US
Endigo™ - thiamethoxam + lambda-cyhalothrin from Syngenta
Why does the U.S. E.P.A. mandate a resistance management strategy (high-dose refuge) for Bt products and not neonicotinoids?
Western corn rootworm resistance to methylparathion has been documented in several areas of Nebraska.
Western corn rootworms – immigrated into Illinois, 1964, Rock Island County
East central Illinois is believed to be the epicenter for the origin of the western corn rootworm variant. This is an area of intense rotation of maize and soybeans (89% of land area is cultivated; 98% of land is either maize or soybeans) and also serves as a site for many seed production fields (these typically mature earlier than commercial maize fields).
Fig. 4. Illinois and Indiana counties (shaded red) where western corn rootworm injury to corn planted after soybeans had been documented through 1995. Detailed map shows location of western corn rootworm sampling sites in east central Illinois, 1987 – 1996.

LaSalle County, IL, 2003 – Courtesy of Dale Baird
"In the struggle for survival, the fittest win out at the expense of their rivals because they succeed in adapting themselves best to their environment."

http://www.omniscopic.com/blog/uploaded_images/darwin-791061.jpg
Will scouting and the use of thresholds work within an IPM program designed to more selectively use transgenic hybrids for corn rootworms?
Frequency of CRW Infestations


- Kuhar et al. (1997) – only 19% of VA cornfields had economic losses due to CRWS
Frequency of CRW Infestations

- Bigger & Petty (1965) – 452 producers’ fields, 28% of Illinois fields infested with NCRS (1954-63)
- Turpin et al. (1972) – predicted that 36% of Iowa fields exceeded EIL of 2.5
Frequency of CRW Infestations

- Turpin & Thieme (1978) – CRWS found in 34% of 234 Indiana cornfields (1972-74); root ratings > 2.5 in 3.4% of fields

- Gray et al. (1993) – 26 of 58 Illinois fields (45%) had root injury ≥ 3.0
Scouting and thresholds have been the backbone of CRW management programs in many western states such as Nebraska for decades.
Predicting Economic Infestations of Corn Rootworms: A Precise Science?

If you intend to grow corn after corn and if rootworm beetles averaged 0.75 or more per plant in corn after corn or 0.5 per plant in first-year corn last summer, apply a rootworm soil insecticide at planting time.

Photo: Courtesy of L. Meinke

Gray & Steffey 1999
Predicting Economic Infestations of Corn Rootworms: A Precise Science?

- Godfrey & Turpin (1983) – first-year cornfields have more female WCRs, thresholds should be 50% less than in continuous cornfields
- Weiss & Mayo (1985) – adjusted adult thresholds based upon plant populations
- Naranjo & Sawyer (1989) – adjusted adult thresholds based upon planting dates of corn
- Riedell et al. (1992) – adjusted thresholds for irrigated corn & dryland corn
Densities of adult CRWS determined in each of 3 years (1979-1981), in 31, 43, and 44 Iowa cornfields, respectively.

Beetle counts correctly predicted that root damage would exceed the damage-rating threshold (2.5) 88% of the time.

Neither beetle counts nor root ratings were effective in predicting economic losses more than 50% of the time.
Our data suggest that the optimal management strategy for corn rootworms in continuous corn in Iowa is not to sample for adults, and always to apply a planting-time soil insecticide.

- 74 Nebraska fields; 3-year study (1978-80)
- 1 beetle/plant used as the ET
- Weekly sampling - last week of July - August
- Root injury index = 2.75
- IPM approach reliable more than 80% of time
- If ET reduced to 0.75 beetle/plant, predictive reliability increased to 90%
- Fields treated with soil insecticides declined from 90% to 28%
Mean Number of WCR in a Soybean Field
Versus Injury to First-Year Corn

Economic Threshold from
WCR Scouting/Root Ratings

\[ y = 1.97 + 0.219x \]
\[ R^2 = 0.28 \quad (\text{Prob}>F)=0.0003 \]
Farmers’ perspectives on IPM field scouting during a period of insect pest range expansion: a case study of variant western corn rootworm (Coleoptera: Chrysomelidae) in Wisconsin

Eileen M. Cullen, James K. Stute, Kara L. Raymond, and Heather Boyd – American Entomologistist Fall 2008

56.1% of southeastern Wisconsin cash grain farmers (n = 123) in October 2004 routinely treat for corn rootworms, with no scouting input.
“What factors might prevent you from adopting IPM field scouting in soybeans for Variant WCR?”

<table>
<thead>
<tr>
<th>Factor</th>
<th>%a</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra expense</td>
<td>23.3</td>
<td>.260</td>
</tr>
<tr>
<td>Too much time</td>
<td>50.9</td>
<td>.059</td>
</tr>
<tr>
<td>Not willing to walk entire field</td>
<td>28.4</td>
<td>.036</td>
</tr>
<tr>
<td>Too many other on-farm obligations</td>
<td>30.2</td>
<td>.890</td>
</tr>
<tr>
<td>Do not trust the threshold</td>
<td>6.9</td>
<td>.867</td>
</tr>
<tr>
<td>Trap grid does not fit my contoured fields</td>
<td>8.6</td>
<td>.436</td>
</tr>
<tr>
<td>Other</td>
<td>6.9</td>
<td>.503</td>
</tr>
<tr>
<td>None of the above, I want to scout my soybean fields if it’s in my county</td>
<td>24.1</td>
<td>.167</td>
</tr>
</tbody>
</table>

*Respondents checked all adoption barriers that applied to them

*All cross tabulation comparisons between farmer categories were made at $\alpha = 0.05$. 
If we continue to ignore the importance of the letter “I” in IPM, increasing selection pressure will result in the loss of valuable pest management tools in the corn and soybean fields of the Corn Belt.
How many are optimistic that IPM (integration of diverse tactics) will continue to be relevant in commercial corn and soybean production?

How many of you are 48 or younger?

How many of you are 48 or older?
The man who is a pessimist before 48 knows too much; if he is an optimist after it, he knows too little.

- Mark Twain's Notebook, 1902-1903
It remains to be seen whether or not political support for IPM programs will continue at the Federal level. Political backing from environmental groups and increasingly from urban and suburban voters may continue to shift from IPM and increasingly towards organic or sustainable agriculture programs.